One Earth CCS

Class VI Injection Well: Quality Assurance and Surveillance Plan

September 2022
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Submitted by:
One Earth Sequestration, LLC

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Title and Approval Sheet

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

Signature Mark Ditsworth VP of Technology and Special Projects	Date
Signature [TBD] [OES CO_2 Unit Manager]	Date
Signature [TBD] [OEE Ethanol Plant Operations Manager]	Date

Distribution List

The following project participants should receive the completed Quality Assurance and Surveillance Plan(QASP) and all future updates for the duration of the project. The One Earth Sequestration, LLC VP of Technology and Special Projects (see contact information below) will be responsible for ensuring that all those on the distribution list will receive the most current copy of the approved Quality Assurance and Surveillance Plan.

One Earth Sequestration, LLC
OES CO_2 Unit Manager
OEE Ethanol Plant Operations Manager
OEE Ethanol Plant Environmental Manager
Third Party Contractors TBD

One Earth Sequestration, LLC
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A. Project Management

A.1 Project/Task Organization

A.1. a/b. Key Individuals and Responsibilities

The project, led by One Earth Sequestration, LLC, includes participation from several subcontractors. The Testing and Monitoring Activities responsibilities will be shared between One Earth Sequestration, LLC, and its designated subcontractor. The monitoring program includes six subcategories:

1) Deep Groundwater Monitoring
2) Well Logging
3) Mechanical Integrity Testing (MIT)
4) Pressure/Temperature Monitoring
5) CO_2 Stream Analysis
6) Geophysical Monitoring

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

Most of the physical samples collected and data gathered as part of the monitoring program will be acquired, analyzed, processed, or witnessed by third parties independently and outside of the project management structure.

A.1.d QA Project Plan Responsibility

One Earth Sequestration, LLC will be responsible for maintaining and distributing the official, approved QA Project Plan. One Earth Sequestration, LLC will periodically review this QASP and consult with U. S. EPA if/when changes to the plan are warranted.

A.1.e Organizational Chart for Key Project Personnel

Figure 1 shows the organizational structure of the project. One Earth Sequestration, LLC will provide the UIC Program Director with a contact list of individuals fulfilling these roles.

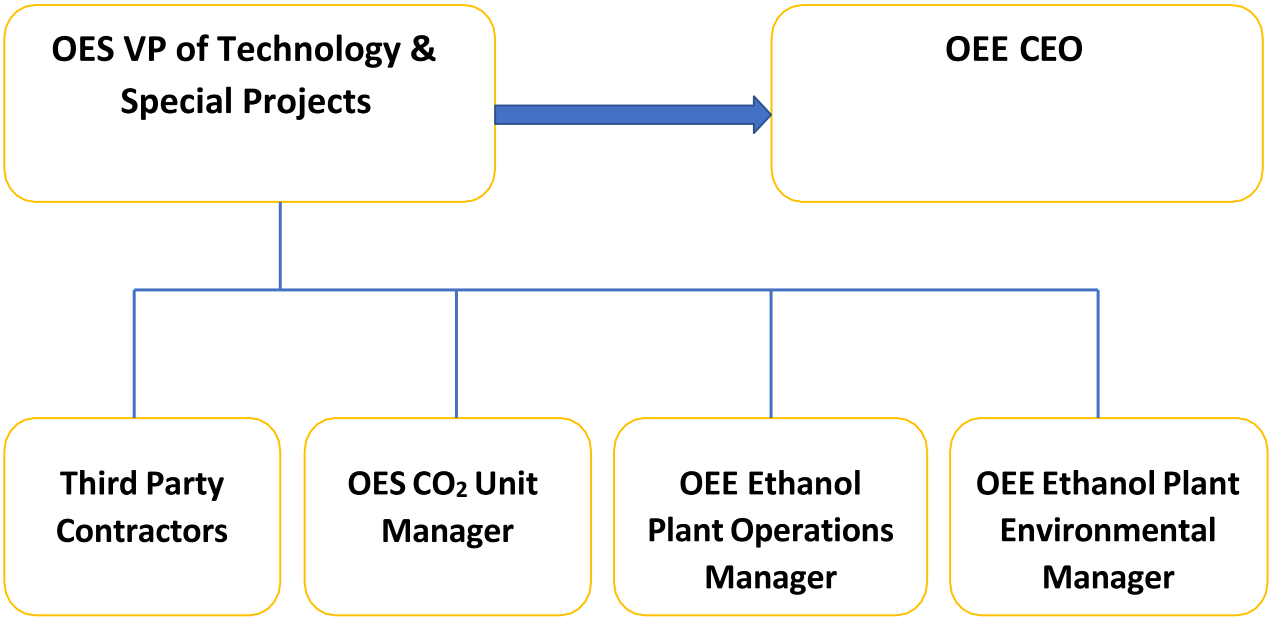

Figure 1. *One Earth Sequestration, LLC organization structure.*

A.2 Problem Definition/Background

A.2.a Reasoning

The One Earth CCS monitoring program has operational monitoring, verification, and environmental monitoring components. Operational monitoring is used to ensure safety with procedures associated with fluid injection monitoring the response of the storage unit, and the movement of the CO_2. Key monitoring parameters include the pressure of injection well tubing & annulus, storage unit, above seal strata, and the lowermost USDW reservoir. Other monitoring parameters include injection rate, total mass & volume injected, and injection well temperature profile. The verification component will provide information to evaluate whether CO_2 is leaking through the caprock. This includes pulse neutron logging, pressure, and temperature monitoring, acoustic monitoring, repeat 2D seismic monitoring, and groundwater sampling and analysis.

A robust monitoring program has been developed for the One Earth CCS project. The primary goal of the One Earth CCS monitoring program is to demonstrate that project activities are protective of human health and the environment. To help achieve this goal, this Quality Assurance Surveillance Plan (QASP) was developed to ensure that the testing and monitoring program meets the quality standards required by the U.S. Environmental Protection Agency's (USEPA) Underground Injection Control (UIC) Program for Class VI wells.

A.2.b. Reasons for Initiating the Project

The goal of the One Earth CCS project is to inject and retain industrial-scale volumes of CO_2 for permanent geologic sequestration in the Mt Simon Sandstone and to reduce atmospheric concentrations of CO_2. To demonstrate that this is done safely, a rigorous monitoring plan is proposed to ensure the injected CO_2 is retained within the storage reservoir.

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

The Class VI Rule requires owners or operators of Class VI wells to perform several types of activities during the lifetime of the project to ensure that the injection well maintains its mechanical integrity, that fluid migration and the extent of pressure elevation are within the limits described in the permit application, and that underground sources of drinking water (USDWs) are not endangered. These monitoring activities include mechanical integrity tests (MITs), injection well testing during operation, monitoring of ground water quality in several zones, tracking of the CO_2 plume and associated pressure front. This document details both the measurements that will be taken as well as the steps to ensure that the quality of the data is such that the data can be used with confidence in making decisions during the life of the project.

A.3 Project/Task Description

A.3. a/b. Summary of Work to be Performed and Work Schedule

Table 1 describes the Testing and Monitoring tasks, reasoning, responsible parties, locations, and testing frequency. Tables 2 and 3 summarize the instrumentation and geophysical surveys, respectively.

Table 1. Summary of testing and monitoring direct measurements.

Parameter	Location	Method	Frequency			Analytical Technique	Lab and Custody	Purpose
			Pre-injection Baseline	Operation Period	PISC Period			
CO_2 Injectate compositional and Isotopic Analysis	After CO_2 dehydration	Direct sampling	Once	Quarterly	None	Chemical analysis	TBD	Monitor injectate
Injection rate and volume	After compression	Flow meter	N/A	Continuous	N/A	Direct measurement	N/A	Monitor rate and volume
Injection pressure	Injection wellheads	Pressure gauge	N/A	Continuous	N/A	Direct measurement	N/A	Monitor injection pressure
Annular pressure	Injection wellheads	Pressure gauge	N/A	Continuous	N/A	Direct measurement	N/A	Monitor annular pressure
DTS Fiber Optic Temperature	ACZ and IZM Wells	Fiber optic cable	Continuous	Continuous	Continuous	Direct measurement	N/A	Storage integrity
DAS Fiber Optic Seismic	ACZ and IZM Wells	Fiber optic cable	Continuous	Continuous	Continuous	Direct measurement	N/A	Storage integrity
Downhole pressure and temperature	IZM Wells	Downhole gauge	N/A	Continuous	Continuous	Direct measurement	N/A	Monitor reservoir and Model validation
Corrosion monitoring	After compression	Coupon	N/A	Quarterly years 1 and 2; annually thereafter	N/A	Physical analysis	TBD	Monitor injection well and pipeline integrity
Mechanical Integrity	Injection Wells	Various	Prior to the operation	Annually	Prior to P/A	§ 146.87 (a)(4) § 146.89 (c)(2)	N/A	Monitor injection, well integrity
DTS/DAS Fiber Optic	Injection Wells (above perforations)	Fiber optic cables	Continuous	Continuous	Prior to P/A	Direct measurement	N/A	Injection well integrity; storage integrity; Continuous plume-adjacent temperature and acoustic monitoring for model validation and plume-behavior evaluation
Cement evaluation	Injection Wells	Logging	Baseline	N/A	N/A	Cement evaluation log	N/A	Injection well integrity
Pressure fall off testing	Injection Wells Mt. Simon arkosic zone	Pressure gauge	Once	Every five years and at the end of the injection period.	N/A	Direct measurement	N/A	Formation hydrogeologic conditions; injection well integrity

Table 1a. Summary of testing and monitoring – direct measurements (continued).

Level	Location Depth**	Method	Frequency			Analytical Technique	Parameters	Purposes
			Pre-injection Baseline	Operation Period	PISC Period			
ACZ - Lowermost USDW – St. Peter Sandstone	OES USDW #1 Depth ~2,215 – 2,447 ft.	*Swab valve or other method	Minimum 1 year Quarterly	Annually	Annually	Chemical analysis	Table 5	Detection of changes in groundwater quality in lowermost USDW.
ACZ - Above confining zone - Ironton-Galesville	OES-ACZ #1 and #2 Depth ~3,733 – 3,921 ft	*Swab valve or other method	1 sample	Annually	Annually	Chemical analysis	Table 6	Detection of changes in groundwater quality for the reservoir directly above the confining zone.
IZM – Mt. Simon Sandstone	IZM#1 Depth ~ 4,455 – 6,469 ft IZM #2 Depth TBD	*Swab valve or other method	1 sample	Annually.	None	Chemical analysis	Table 7	Detection of changes in groundwater quality, geochemical monitoring, and CO_2 detection in storage reservoir.

Notes

* Samples collected using a downhole sampling tool run into the well on wireline.
* Swab samples collected at the surface after the well has been swabbed with ample volume to ensure reservoir fluid at the surface. Fluid sampling will be discontinued at each respective monitoring well once there is a breakthrough of CO_2 in the well(s)

***Depth based on formation interval at OEE#1; actual perforation depths TBD.*

Table 1b. Summary of testing and monitoring indirect CO_2 plume tracking.

Method	Location	Pre-injection Baseline	Operation Period	PISC Period	Purpose
Pulsed Neutron Logging	Injection and ACZ and IZM Wells	Once	Annually	Annually	Plume Location
Time-lapse 2D	Injection area	Baseline survey	1st after 4 years of injection, 2nd after 9 years of injection, Every 10 Mt thereafter	Initial PISC survey 5 years from most recent. Additional PISC survey 9 years after the end of injection	Indirect measurement of plume size

DTS/DAS fiber-optic data collected in the project wells provide continuous temperature and acoustic information adjacent to the plume and are used to support the evaluation of plume behavior and model validation.

Table 2. *Instrumentation summary. T = temperature; P = Pressure; DTS = Distributed Temperature System; DAS = Distributed Acoustic System; F = Flow.*

			Operational Period		PISC Period		
Monitoring Location	**Instrument Type**	**Monitoring Target (Formation or Other)**	**Data Collection Location(s)**	**Frequency**	**Data Collection Location(s)**	**Frequency**	**Explanation**
CO_2 Facility	T, P, F	Surface	Discharge High-Pressure Pumps	Continuous	Discharge high pressure pumps	NA	Monitoring the operational, equipment, and permit parameters
Injection wells and IZM wells	DTS and DAS	All strata	Pending final completion	Continuous	Pending final completion	Continuous until P&A (minimum one year)	Used for operational monitoring, well integrity, seismicity detection, and evaluation of CO_2 plume behavior adjacent to the wells
	T, P	Mt. Simon injection zone	Pending final completion	Continuous	Pending final completion	Continuous until P&A (minimum one year)	Monitoring operational and equipment parameters
ACZ Wells	T, P	Ironton Galesville	Pending final completion	Continuous	Pending final completion	None	Monitoring seal formation integrity
		Lowermost USDW – St. Peter	Pending final completion	Continuous	Pending final completion	None	Monitoring seal formation integrity

Table 3. Well logging surveys summary.

Monitoring Activity	Well	Tools or Survey Description	Pre-Injection - Baseline	Operation Period	PISC Period	Explanation
Wireline Logging	ACZ and IZM Wells	Cement evaluation tool	1 Baseline	None	None	Mechanical Integrity
		Pulse neutron	1 Baseline	Annually	Annually	Fluid movement, salinity, CO_2 detection, and mechanical integrity
	Inj wells	Pulse neutron	1 Baseline	Annually	Annually until P&A	Fluid movement, salinity, CO_2 detection, and mechanical integrity
		Casing inspection	1 Baseline	None	None	Mechanical Integrity
		Cement evaluation tool	1 Baseline	None	None	Mechanical Integrity

A.3.c. Geographic Locations

Figure 2 shows the One Earth CCS site and monitoring infrastructure. Table 4 summarizes the injection and monitoring wells. Figure 3 shows the location of the 2D lines acquired as part of site characterization. The repeat 2D seismic will follow Line 1 and the 2019 Gibson line. Geophysical monitoring will be conducted using the permanent DTS/DAS fiberoptic array installed in the existing injection, IZM, ACZ, and USDW monitoring wells, as summarized in Table 4.

Table 4. *One Earth CCS project well summary.*

Well Type	Well ID	Notes
Injection	OES #1	
	OES #2	
	OES #3	
In-Zone Monitoring (IZM)	IZM #1	Convert stratigraphic test well OEE #1
	IZM #2	Mt Simon Sandstone completion
Above-Confining-Zone Monitoring	OES ACZ #1 OES ACZ#2	Ironton Galesville completion
USDW Monitoring	OES USDW #1	St. Peter Sandstone completion
Geophysical monitoring instrumentation in project wells (DAS/DTS)	OES #1 OES #2 OES #3 IZM #1 IZM #2 OES ACZ #1 OES ACZ#2 OES USDW #1	Permanent array in project wells

A.3.d. Resource and Time Constraints

No resource or time constraints have been identified for the One Earth CCS project testing and monitoring plan beyond the proposed timeline.

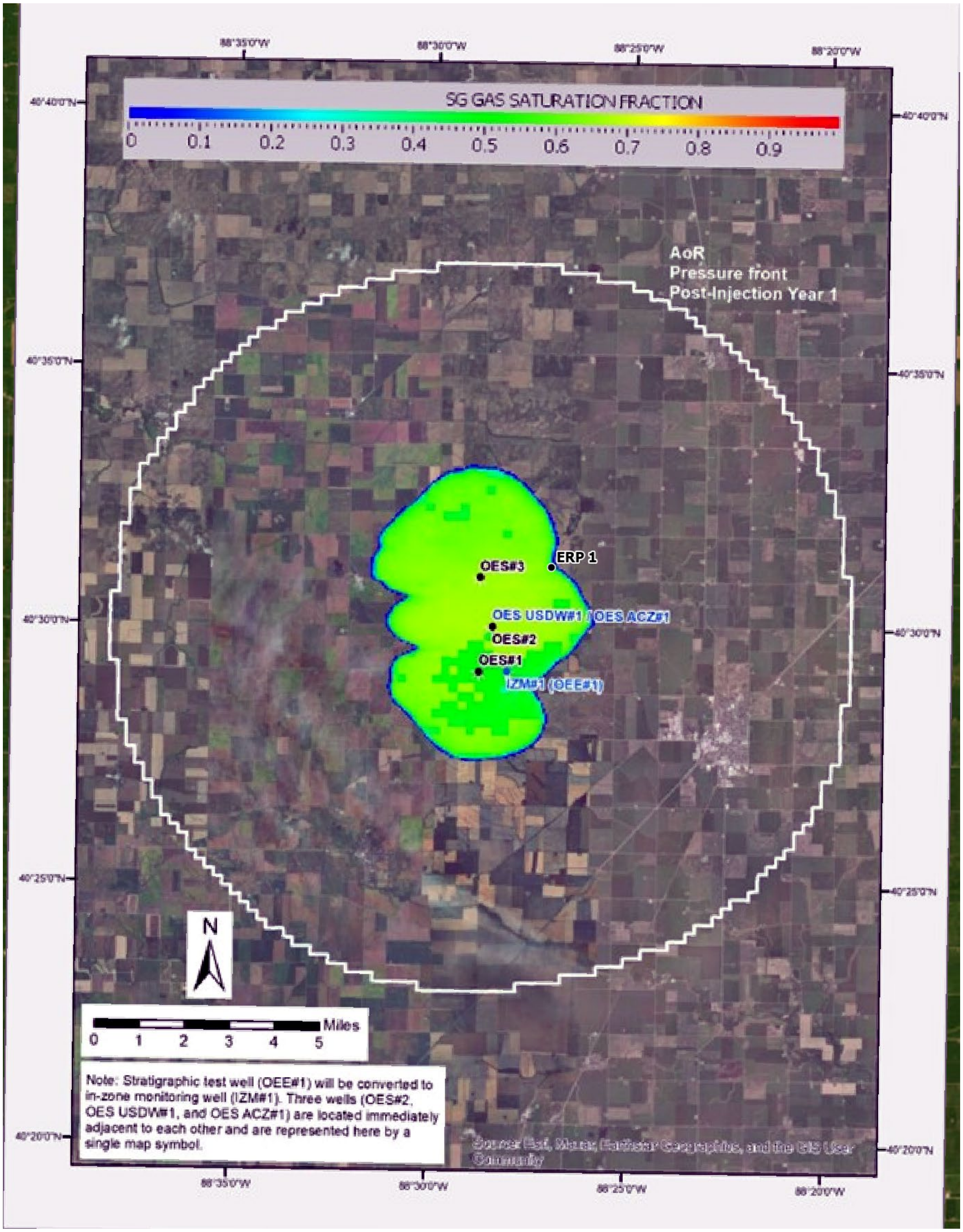

***Figure 2**. One Earth CCS area showing location of ACZ #1 and IZM #1 monitoring wells. Pressure front is indicated by the white line, and maximum CO_2 saturation plume is shown in green with blue border.*

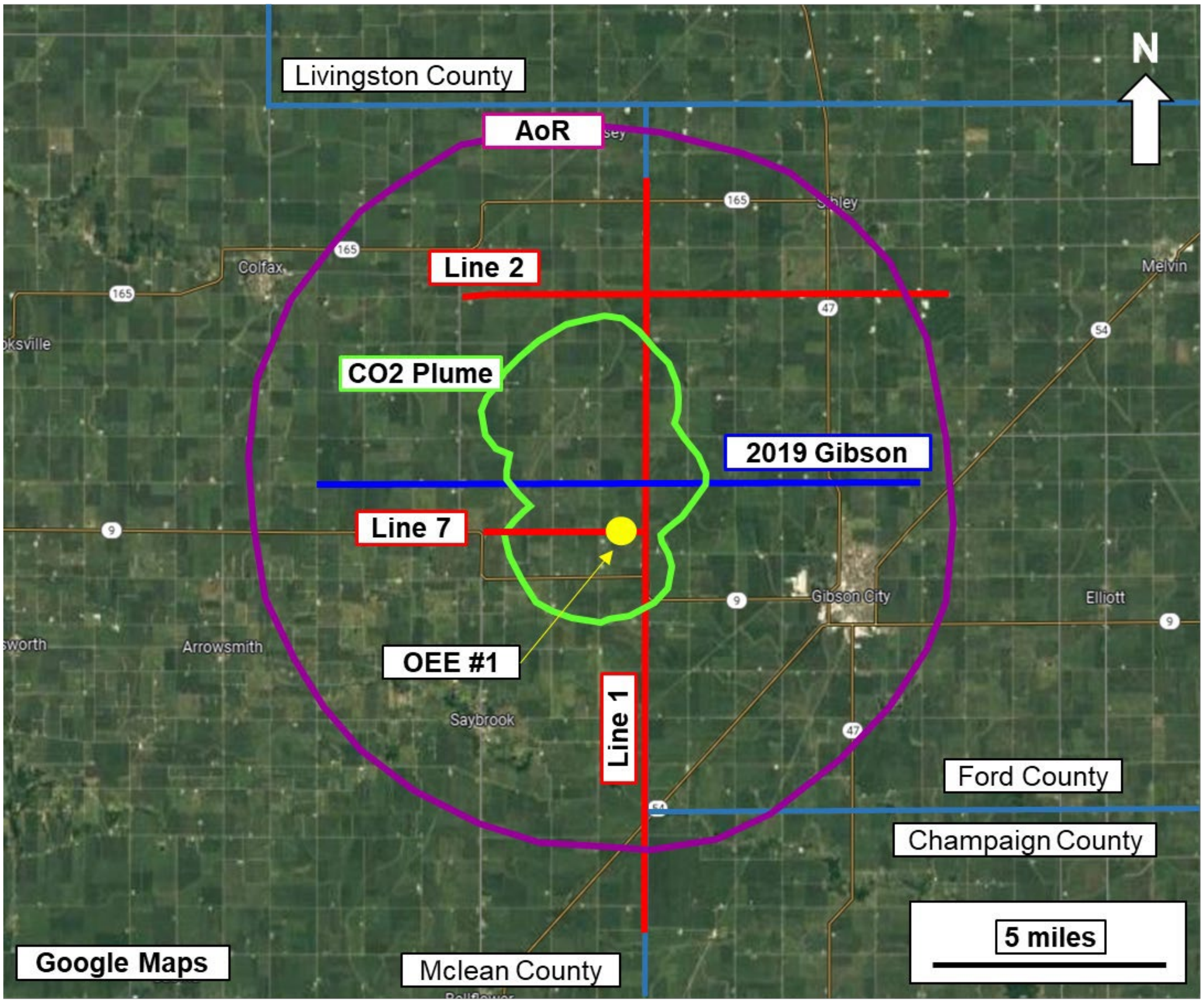

Figure 3. *2D seismic lines acquired during site characterization. Note CO_2 plume (in green) and AoR (purple) outlines have been generalized.*

A.4 Quality Objectives and Criteria

A.4.a Performance/Measurement Criteria

The overall QA objective for monitoring is to develop and implement procedures for subsurface monitoring, field sampling, laboratory analysis, and reporting that will provide results that meet the characterization and non-endangerment goals of this project. Groundwater monitoring will be conducted during the pre-injection, injection, and post-injection phases of the project. Deep groundwater monitoring wells will be used to gather water-quality samples and pressure data. All groundwater analytical and field-monitoring parameters for each interval are listed in Tables 5-8. Tables 9 and 10 show analytical parameters for CO_2 stream gas monitoring, corrosion coupon assessment, and gauge specifications. Table 11 shows the monitoring outputs.

The list of analytes may be reassessed periodically and adjusted to include or exclude analytes based on their effectiveness to the overall monitoring program goals.

Key testing and monitoring areas include:

1. Formation Fluid Sampling
   a. Aqueous chemical concentrations
2. Well Logging
   a. pulse neutron
3. Mechanical Integrity Testing (MIT)
   a. Pulsed neutron, temperature, cement evaluation logging
4. Pressure/Temperature Monitoring
   a. Pressure/temperature from in-situ gauges and DTS
   b. Pressure/temperature from surface gauges
5. Acoustic monitoring - DAS
   a. Well Integrity
   b. Seismic monitoring
6. CO_2 Stream Analysis
   a. CO_2 Purity (% v/v, [GC])
   b. Other trace components
   c. Carbon Isotopes
7. Geophysical Monitoring
   a. Seismic data files
   b. Processed time-lapse report
8. Fiber-Optic Monitoring (DTS/DAS)
   a. Continuous distributed temperature sensing (DTS) measurements for detection of thermal anomalies associated with CO_2 movement
   b. Distributed acoustic sensing (DAS) for detection of acoustic/strain signatures related to plume migration, pressure dissipation, and geomechanical response
   c. Integration of DTS/DAS data with pulsed neutron logs, pressure monitoring, and seismic surveys to support plume tracking and model validation

Table 5. *Summary of analytical and field parameters for lowermost USDW (St. Peter) groundwater samples. A designated third-party laboratory will perform all analyses. ICP = inductively coupled plasma; MS = mass spectrometry; OES = optical emission spectrometry; GC-P = gas chromatography-pyrolysis.*

Parameters	**Analytical Methods[1]**	**Detection Limit/Range**	**Typical Precisions**	**QC Requirements**
Cations: Al, Ba, Mn, As, Cd, Cr, Cu, Pb, Sb Se, and Tl	ICP-MS, EPA Method 6020	0.001 to 0.1 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-OES, EPA Method 6010B	0.005 to 0.5 mg/L (Analyte, dilution, and matrix dependent)	±15%	Daily calibration; blanks, duplicates, and matrix spikes at 10% or greater frequency
Anions: Br, Cl, F, NO3, and SO4	Ion Chromatography, EPA Method 300.0	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 D513-11	25 mg/L	±15%	Duplicate measurement; standards at10% or greater frequency
Isotopes: $\delta^{13}C$ of DIC	Isotope ratio mass spectrometry[2]	12.2 mg/L HCO3- for δ13C	±0.15‰ for $\delta^{13}C$	10% duplicates; 4 standards/batch
Total Dissolved Solids	Gravimetry; APHA 2540C	12 mg/L	±10%	Balance calibration, duplicate analysis
Water Density(field)	Oscillating body method	0.0000 to 2.0000	±0.0002 g/mL	Duplicate measurements
Alkalinity	APHA 2320B	4 mg/L	±3 mg/L	Duplicate analysis
pH (field)	EPA 150.1	2 to 12 pH units	±0.2 pH unit	User calibration per manufacturer recommendation
Specific conductance (field)	APHA 2510	0 to 200 mS/cm	±1% of reading	User calibration per manufacturer recommendation
Temperature (field)	Thermocouple	-5 to 50°C	±0.2°C	Factory calibration

Note 1: An equivalent method may be employed with the prior approval of the UIC Program Director.
Note:2: Gas evolution technique by Atekwana and Krishnamurthy (1998), with modifications made by Hackley et al. (2007)

***Table 6**. Summary of analytical and field parameters for Ironton-Galesville groundwater samples. Note: cation, anion, TDS, and alkalinity measurements will be performed by a third-party laboratory using published analytical methods. Isotope and dissolved CO_2 analyses will be performed by a designated laboratory. ICP = inductively coupled plasma; MS = mass spectrometry; OES = optical emission spectrometry; GC-P = gas chromatography-pyrolysis.*

Parameters	Analytical Methods[(1)]	Detection Limit/Range	Typical Precisions	QC Requirements
Cations: Al, Ba, Mn, As, Cd, Cr, Cu, Pb, Sb, Se,and Tl	ICP-MS, EPA Method 6020	0.001 to 0.1 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-OES, EPA Method 6010B	0.005 to 0.5 mg/L (Analyte, dilution, and matrix dependent)	±15%	Daily calibration; blanks, duplicates, and matrix spikes at 10% or greater frequency
Anions: Br, Cl, F, NO_3, and SO_4	Ion Chromatography,EPA Method 300.0	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 D513-11	25 mg/L	±15%	Duplicate measurement; standards at10% or greater frequency
Isotopes: $\delta^{13}C$ of DIC	Isotope ratio mass spectrometry[2]	12.2 mg/L HCO3- for δ13C	±0.15‰ for $\delta^{13}C$	10% duplicates; 4 standards/batch
Total Dissolved Solids	Gravimetry; APHA 2540C	12 mg/L	±10%	Balance calibration, duplicate analysis
Water Density(field)	Oscillating body method	0.0000 to 2.0000	±0.0002 g/mL	Duplicate measurements
Alkalinity	APHA 2320B	4 mg/L	±3 mg/L	Duplicate analysis
pH (field)	EPA 150.1	2 to 12 pH units	±0.2 pH unit	User calibration per manufacturer recommendation
Specific conductance (field)	APHA 2510	0 to 200 mS/cm	±1% of reading	User calibration per manufacturer recommendation
Temperature (field)	Thermocouple	-5 to 50°C	±0.2°C	Factory calibration

Note 1: An equivalent method may be employed with the prior approval of the UIC Program Director.

Note:2: Gas evolution technique by Atekwana and Krishnamurthy (1998), with modifications made by Hackley et al. (2007).

***Table 7**. Summary of analytical and field parameters for Mt. Simon groundwater samples. All analyses will be performed by a designated third-party laboratory. ICP = inductively couple plasma; MS = mass spectrometry; OES = optical emission spectrometry; GC-P = gas chromatography-pyrolysis.*

Parameters	Analytical Methods[1]	Detection Limit/Range	Typical Precisions	QC Requirements
Cations: Al, Ba, Mn, As, Cd, Cr, Cu, Pb, Sb Se,and Tl	ICP-MS, EPA Method 6020	0.001 to 0.1 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-OES, EPA Method 6010B	0.005 to 0.5 mg/L (Analyte, dilution, and matrix dependent)	±15%	Daily calibration; blanks, duplicates, and matrix spikes at 10% or greater frequency
Anions: Br, Cl, F, NO3, and SO4	Ion Chromatography,EPA Method 300.0	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 D513-11	25 mg/L	±15%	Duplicate measurement; standards at10% or greater frequency
Isotopes: $\delta^{13}C$ of DIC	Isotope ratio mass spectrometry[2]	12.2 mg/L HCO3- for δ13C	±0.15‰ for $\delta^{13}C$	10% duplicates; 4 standards/batch
Total Dissolved Solids	Gravimetry; APHA 2540C	12 mg/L	±10%	Balance calibration, duplicate analysis
Water Density(field)	Oscillating body method	0.0000 to 2.0000	±0.0002 g/mL	Duplicate measurements
Alkalinity	APHA 2320B	4 mg/L	±3 mg/L	Duplicate analysis
pH (field)	EPA 150.1	2 to 12 pH units	±0.2 pH unit	User calibration per manufacturer recommendation
Specific conductance (field)	APHA 2510	0 to 200 mS/cm	±1% of reading	User calibration per manufacturer recommendation
Temperature (field)	Thermocouple	-5 to 50°C	±0.2°C	Factory calibration

Note 1: An equivalent method may be employed with the prior approval of the UIC Program Director.

Note:2: Gas evolution technique by Atekwana and Krishnamurthy (1998), with modifications made by Hackley et al. (2007)

Table 8. *Summary of analytical parameters for CO_2 gas stream. All analyses will be performed by a designated third-party laboratory.*

Parameters	Analytical Methods[1]	Detection Limit/Range	Typical Precisions	QC Requirements
Oxygen	ISBT 4.0 (GC/DID)	1 uL/L to 5,000 uL/L (ppm by volume)	± 10 % of reading	daily standard within 10 % of calibration, secondary standard after calibration
	GC/TCD	0.1 % to 100 %	5 - 10 % relative across the range, RT ± 0.1 min	daily standard, duplicate analysis within 10 % of each other
Nitrogen	ISBT 4.0 GC/DID	1 uL/L to 5,000 uL/L (ppm by volume)	± 10 % of reading	daily standard within 10 % of calibration, secondary standard after calibration
	GC/TCD	0.1 % to 100 %	5 - 10 % relative across the range, RT ± 0.1 min	daily standard, duplicate analysis within 10 % of each other
Carbon Monoxide	ISBT 5.0 Colorimetric	5 uL/L to 100 uL/L (ppm by volume)	± 20 % of reading	duplicate analysis
	ISBT 4.0 (GC/DID)	1 uL/L to 5,000 uL/L (ppm by volume)	± 10 % of reading	daily standard within 10 % of calibration, secondary standard after calibration
Oxides of Nitrogen	ISBT 7.0 Colorimetric	0.2 uL/L to 5 uL/L (ppm by volume)	± 20 % of reading	duplicate analysis
Total Hydrocarbons	ISBT 10.0 THA (FID)	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
Methane	ISBT 10.1 GC/FID)	0.1 uL/L to 1,000 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
Acetaldehyde	ISBT 11.0 (GC/FID)	0.1 uL/L to 100 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
Sulfur Dioxide	ISBT 14.0 (GC/SCD)	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
Hydrogen Sulfide	ISBT 14.0 (GC/SCD)	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
Ethanol	ISBT 11.0 (GC/FID)	0.1 uL/L to 100 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
Isotopes: $\delta^{13}C$ of DIC	Isotope ratio mass spectrometry[2]	12.2 mg/L HCO3- for δ13C	±0.15‰ for $\delta^{13}C$	10% duplicates; 4 standards/batch
CO_2 Purity	ISBT 2.0 Caustic absorption Zahm-Nagel	99.00% to 99.99%	± 10 % of reading	User calibration per manufacturer recommendation
	ALI method SAM 4.1 subtraction method (GC/DID)	1 ppm for each target analyte (analyte dependent) - refer to Oxygen and Nitrogen analysis.	5-10 % relative across the range	duplicate analysis within 10 % of each other
	GC/TCD	0.1 % to 100 %	5-10 % relative across the range, RT ± 0.1 min	standard with every sample, duplicate analysis within 10 % of each other

Note 1: An equivalent method may be employed with the prior approval of the UIC Program Director.

Note 2: Gas evolution technique by Atekwana and Krishnamurthy (1998), with modifications made by Hackley et al. (2007).

Table 9. *Summary of analytical parameters for corrosion coupons.*

Parameters	Analytical Methods	Detection Limit/Range	Typical Precisions	QC Requirements
Mass	NACE RP0775-2005	.005mg	+/-2%	Annual Calibration of Scale
Thickness	NACE RP0775-2005	.001mm	+/-005mm	Factory calibration

Table 10. *Summary of measurement parameters for field gauges*[1].

Parameters[1]	Methods[1]	Detection Limit/Range[1]	Typical Precisions[1]	QC Requirements
Compression discharge pressure	ANSI Z540-1-1994	+/- 0.001 psi / 0-3000 psi	+/- 0.01 psi	Annual Calibration of Scale (3rd party)
Injection Tubing Temperature	ANSI Z540-1-1994	+/- 0.001 F / 0-500 F	+/- 0.01 F	Annual Calibration of Scale (3rd party)
Annulus Pressure	ANSI/UL 61010-1 or ANSI/UL 61010-2-30	+/- 0.1 psi / 0-7200 psi	+/- (0.004 URL/ span)% of Span	Annual Calibration of Scale (3rd party)
Injection Tubing Pressure	ANSI Z540-1-1994	+/- 0.001 psi / 0-3000 psi	+/- 0.01 psi	Annual Calibration of Scale (3rd party)
Injection Mass Flow Rate	ISO 17025/IEC 17025	+/- 0.10% of rate / up to 13,060 tonne/day	+/-0.10% of rate for liquid +/-0.25% of rate for gas	Annual Calibration of Scale (3rd party)

[1] *Actual hardware will determine final detection limits/ranges, precision, and standards used. These will be finalized and submitted prior to authorization to inject.*

Table 11. *Actionable testing and monitoring outputs.*

<table>
<tr><th>Monitoring Type</th><th>Project Action Limit</th><th>Detection Limit</th><th colspan="2">Anticipated Reading</th></tr>
<tr><td>MIT—Pulse neutron logging</td><td>Action taken when RST indicates CO_2 outside of the expected range</td><td>+/- 0.5 SIGM</td><td colspan="2">Brine saturated ~ 60 CO_2 saturated ~ 8</td></tr>
<tr><td>Wellbore integrity—annular pressure gauge</td><td>>3% annulus pressure loss over 1 hour during a stabilized/holding condition (integrity diagnostic; separate from operational MASAP setpoints in TM Table 15)</td><td>Refer to Appendix A (annular pressure gauge table)</td><td colspan="2">>3% pressure loss over 1 hour</td></tr>
<tr><td rowspan="6">Surface pressure gauges</td><td rowspan="6">Action will be taken when pressures are well outside of the modeled/expected range</td><td rowspan="6">See Table 10.</td><td colspan="2">Injection Pressure (psig) (Low thresholds = % of Average; High thresholds = % of Maximum)</td></tr>
<tr><td>OES #1</td><td>Alarm: 1,017 psig (90%) & 1,368 psig (80% of max)
Shutdown: 904 psig (80%) & 1,539 psig (90% of max)</td></tr>
<tr><td>OES #2</td><td>Alarm: 1,044 psig (90%) & 1,480 psig (80% of max)
Shutdown: 928 psig (80%) & 1,665 psig (90% of max)</td></tr>
<tr><td>OES #3</td><td>Alarm: 1,044 psig (90%) & 1,460 psig (80% of max)
Shutdown: 928 psig (80%) & 1,643 psig (90% of max)</td></tr>
<tr><td colspan="2">Annulus pressure (psig)</td></tr>
<tr><td>OES #1, OES #2, OES #3</td><td>Alarm: 150 psig (+50 psig) & 4,140 psig (80% of max)
Shutdown: 100 psig & 4,658 psig (90% of max)</td></tr>
<tr><td rowspan="3">Downhole pressure gauges</td><td rowspan="3">Action will be taken when pressures are well outside of the modeled/expected range</td><td rowspan="3">See Table 12</td><td>OES #1</td><td>> 3,782 psig</td></tr>
<tr><td>OES #2</td><td>> 3,962 psig</td></tr>
<tr><td>OES #3</td><td>> 3,932 psig</td></tr>
<tr><td>Flow Rate</td><td>Action will be taken when flow rate is well outside of the modeled/expected range</td><td>See Table 10</td><td>OES #1, OES #2, OES #3</td><td>Alarm: 3,380 MT/day (80% of max)
Shutdown: 3,169 MT/day (75% of max) & 4,160 MT/day (+50 of avg.)</td></tr>
<tr><td>Wellbore integrity— DTS fiber optic temperature</td><td>Action will be taken when an anomaly in the temperature profile is detected.</td><td>Refer to Appendix A</td><td colspan="2">DTS provides a continuous temperature profile. Baseline profile is TBD and will be identified post-deployment.</td></tr>
<tr><td>Seismic datafiles</td><td>Interpreted area of CO_2 plume greater than 50% of the simulated area of CO_2 plume or any single edge of the CO_2 plume exceeding 80% of the radius of the simulated plume edge, as measured from analysis and interpretation of the 2D time-lapse seismic data.</td><td>Dependent on fluid saturation and formation velocities</td><td colspan="2">CO_2 plume migration is similar to the modeled outcome</td></tr>
</table>

Note. Operational alarm and shutdown setpoints are defined in TM Table 15; Table 11 summarizes the corresponding actionable monitoring outputs and associated QC response triggers. Values reflect pre-operational modeling/design assumptions and may be refined *based on site-specific baseline and operational data, in consultation with the UIC Director and consistent with permit conditions.*

A.4.b Precision

For groundwater sampling, data accuracy will be assessed by the collection and analysis of field blanks to test sampling procedures and matrix spikes to test lab procedures. Field blanks will be taken no less than one per sampling event to spot check for sample bottle contamination. Laboratory assessment of analytical precision will be the responsibility of the individual laboratories per their standard operating procedures.

Table 12 summarizes the specifications of the downhole quartz gauge for pressure and temperature, while Table 13 presents representative Logging tool specifications.

A.4.c Bias

Laboratory assessment of analytical bias will be the responsibility of the individual laboratories per their standard operating procedures and analytical methodologies. For direct pressure or logging measurements, there is no bias.

A.4.d Representativeness

For groundwater sampling, data representativeness expresses 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 sampling network has been designed to provide data representative of site conditions. For analytical results of individual groundwater samples, representativeness will be estimated by ion and mass balances. Ion balances with ±10% error or less will be considered valid. A mass balance assessment will be used when the ion balance is greater than ±10% to help determine the source of error. For a sample and its duplicate, if the relative percent difference exceeds 10%, the sample may be considered non-representative.

A.4.e Completeness

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

A.4.f Comparability

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

Table 12. *Pressure and temperature – downhole quartz gauge specifications.*

Specification	Sensitivity
Calibrated working pressure range	Atmospheric to 10,000 psi
Initial pressure accuracy	<+/-2 psi over full scale
Pressure resolution	0.005 psi at 1-s sample rate
Pressure drift stability	<+/-1 psi per year over full scale
Calibrated working temperature range	77–266°F
Initial temperature accuracy	<+/-0.9°F per +/-0.27°F
Temperature resolution	0.009°F at 1-s sample rate
Temperature drift stability	<+/-0.1°F per year at 302
Max temperature	302°F

Table 13. *Representative Logging tool specifications.*

Specification	RST	CBL	USI	Isolation Scanner
Logging speed	1,800 ft/hr	3,600 ft/hr	Standard resolution: 2,700ft/hr High resolution: 563 ft/hr	Standard resolution: 2,700ft/hr High resolution: 563 ft/hr
Vertical resolution	15 inches	3 ft	Standard resolution: 0.6 in High speed: 6 in	High resolution: 0.6 in High speed: 6 in
Investigation	Formation	Casing, annulus, and formation	Casing and annulus	Casing and annulus
Temperature rating	302°F	350°F	350°F	350°F
Pressure rating	15,000 psi	20,000 psi	20,000 psi	20,000 psi

A.4.g Method Sensitivity

Tables 14 through 19 provide additional details on gauge specifications and sensitivities.

Table 14. *Pressure field gauge – injection tubing pressure.*

Specification	Sensitivity
Calibrated working pressure range	0 to 3000 psi and 4–20 mA
Initial pressure accuracy	< 0.04375%
Pressure resolution	0.001 psi and 0.00001 mA
Pressure drift stability	To be determined after first year

Table 15. *Pressure field gauge – annulus pressure.*

Specification	Sensitivity
Calibrated working pressure range	0 to 7200 psi and 4–20 mA
Initial pressure accuracy	< 0.02500%

Pressure resolution	0.001 psi and 0.00001 mA
Pressure drift stability	To be determined after first year

***Table 16**. Surface discharge pressure.*

Specification	**Sensitivity**
Calibrated working pressure range	0 to 3000 psi and 4–20 mA
Initial pressure accuracy	< 0.03125%
Pressure resolution	0.001 psi and 0.00001 mA
Pressure drift stability	To be determined after first year

***Table 17.** Temperature field gauge – injection tubing temperature.*

Specification	**Sensitivity**
Calibrated working temperature range	0 to 500°F and 4–20 mA
Initial temperature accuracy	< 0.0055 %
Temperature resolution	0.001°F and 0.0001 mA
Temperature drift stability	To be determined after first year

***Table 18.** Mass flow rate field gauge – CO_2 mass flow rate.*

Parameters1	Methods1
Compression discharge pressure	ANSI Z540-1-1994
Injection Tubing Temperature	ANSI Z540-1-1994
Annulus Pressure	ANSI/UL 61010-1 or ANSI/UL 61010-2-30
Injection Tubing Pressure	ANSI Z540-1-1994

A.5 Special Training/Certifications

A.5.a Specialized Training and Certifications

The geophysical survey equipment and wireline logging tools will be operated by trained, qualified, and certified personnel, as specified by the service company that provides the equipment. The subsequent data will be processed and analyzed in accordance with industry standards (Appendix B). No specialized certifications are required for personnel conducting groundwater sampling, but field sampling will be conducted by trained personnel. Groundwater sampling will be conducted by personnel trained to understand and follow the project-specific sampling procedures. Upon request, One Earth Sequestration, LLC will provide the agency with all laboratory SOPs for the specific parameter, developed using the appropriate standard method. Each laboratory technician conducting the analysis on the samples will be trained on the SOP developed for each standard method. One Earth Sequestration, LLC will include the technician's training certification with the biannual report.

A.5. b/c. Training Provider and Responsibility

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

A.6 Documentation and Records

A.6.a Report Format and Package Information

A semi-annual report from One Earth Sequestration, LLC to U. S. EPA will contain all required project data, including testing and monitoring information as specified by the UIC Class VI permit. Data will be provided in electronic or other formats as required by the UIC Program Director.

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

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

A.6. c/d. Data Storage and Duration

One Earth Sequestration, LLC, or a designated contractor, will maintain the required project data as provided elsewhere in the permit.

A.6.e. QASP Distribution Responsibility

The One Earth Sequestration, LLC VP of Technology and Special Projects will be responsible for ensuring that all those on the distribution list will receive the most current copy of the approved Quality Assurance and Surveillance Plan.

B. Data Generation and Acquisition

B.1 Sampling Process Design (Experimental Design)

Discussion in this section is focused on groundwater and fluid sampling and does not address monitoring methods that do not gather physical samples (e.g., logging, seismic monitoring, and pressure/temperature monitoring). During the pre-injection and injection phases, groundwater sampling is planned to include an extensive set of chemical parameters to establish aqueous geochemical reference data. Parameters will include selected constituents that: (1) have primary and secondary USEPA drinking water maximum contaminant levels, (2) are the most responsive to interaction with CO_2 or brine, (3) are needed for quality control, and (4) may be needed for geochemical modeling. The full set of parameters for each sampling interval is given in Tables 5 – 10. After a sufficient baseline is established, the monitoring scope may shift to a subset of indicator parameters that are (1) the most responsive to interaction with CO_2 or brine and (2) are needed for quality control.

Implementation of a reduced set of parameters would be done in consultation with the U. S. EPA. Isotopic analyses will be performed on baseline samples to the degree that the information helps verify a condition or establish an understanding of non-project related variations. For non-baseline samples, isotopic analyses may be reduced in all monitoring wells if a review of the historical project results or other data determines that further sampling for isotopic analyses is unnecessary. During any period where a reduced set of analytes is used, if statistically significant trends are observed that are the result of unintended CO_2 or brine migration, the analytical list would be expanded to the full set of monitoring parameters. The Ironton-Galesville groundwater samples will be analyzed by 3rd party using published analytical methods. Dissolved CO_2 will be analyzed by methods consistent with Test Method B of ASTM D 513-06, “Standard Test Methods for Total and Dissolved Carbon Dioxide in Water” or equivalent. Isotopic analysis will be conducted using established methods.

B.1.a Design Strategy

CO_2 Stream Monitoring Strategy

The primary purpose of analyzing the carbon dioxide stream is to evaluate the potential interactions of carbon dioxide 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 the determination of whether the injectate meets the qualifications of hazardous waste under the Resource Conservation and Recovery Act (RCRA), 42 U.S.C. 6901 et seq. (1976), and/or the Comprehensive Environmental Response, Compensation, and Liability Act, (CERCLA) 42 U.S.C. 9601 et seq. (1980). Additionally, monitoring the chemical and physical characteristics of the carbon dioxide (e.g., isotopic signature, other constituents) may help distinguish the injectate from the native fluids and gases if unintended leakage from the storage reservoir occurred. Injectate monitoring is required at a sufficient frequency to detect changes to any physical and chemical properties that may result in a deviation from the permitted specifications.

Calibration of transmitters used to monitor pressures, temperatures, and flow rates of CO_2 into the injection well at the injection well and at the verification well shall be conducted annually by a third-party vendor. Reports shall contain test equipment used to calibrate the transmitters, including test equipment manufacturers, model numbers, serial numbers, calibration dates and expiration dates.

Corrosion Monitoring Strategy

Corrosion coupon analyses will be conducted quarterly to aid in ensuring the mechanical integrity of the equipment in contact with the carbon dioxide. Coupons shall be sent quarterly to a company for analysis and an analysis conducted in accordance with NACE Standard RP-0775 (or similar) to determine and document corrosion wear rates based on mass loss.

Deep Groundwater Monitoring Strategy

Monitoring of the St. Peter sandstone (the lowermost USDW) and the Ironton-Galesville will be used for early leakage detection in formations that are much closer to the Mt. Simon injection reservoir. Fluid sampling at the St. Peter and ACZ wells in combination with pressure monitoring, temperature monitoring, and pulse neutron logging will be used to determine if leakage is occurring at or near the injection well. In addition, the Ironton-Galesville has sufficient permeability such that pressure monitoring would detect a failure of the confining zone should it occur. MIT testing and DTS monitoring at the injection well will also provide data to ensure the mechanical integrity of the injection wells are maintained. With the planned sampling and monitoring frequencies, it is expected that baseline conditions can be documented, natural variability in conditions can be characterized, unintended brine or CO_2 leakage could be detected if it occurred, and sufficient data will be collected to demonstrate that the effects of CO_2 injection are limited to the intended storage reservoir. No groundwater fluid sampling is planned for the Mt. Simon intervals where free-phase CO_2 has broken through.

ACZ Sampling

The ACZ verification wells, OES ACZ#1 and ACZ#2, will be used to monitor the pressure and temperature in the Ironton-Galesville formation. This is above the Eau Claire Formation, the primary reservoir seal. This well will serve as an early leak detection system by allowing the operator to monitor for changes above the primary caprock. Groundwater samples will be collected and analyzed for constituents listed in Table 6 to document baseline fluid chemistry and to detect changes in fluid chemistry that could result from the movement of brine or CO_2 from the storage interval through the seal formation.

Lowermost USDW Sampling

ACZ (OES USDW#1) well will allow monitoring within the St. Peter sandstone, the lowermost USDW. This well will serve as an additional leak detection system by allowing the operator to monitor for changes above the primary caprock. The well will be equipped with a pressure and temperature monitoring system set within the perforated interval. Pressure and temperature will be continuously monitored and recorded. Groundwater samples will be collected and analyzed for constituents listed in Table 6 to document baseline fluid chemistry and to detect changes in fluid chemistry that could result from the movement of brine or CO_2 from the storage interval through the seal formation.

Injection Zone Monitoring

The stratigraphic test well OEE#1 will be converted to an injection zone monitoring well (IZM#1). A second in-zone well (IZM#2), location to be determined, is also planned for installation. The location will be identified after 5 years of injection operations or when 10 million tonnes have been injected at the site. The location will be determined from the plume's position using OEE1 data and the results of the first time-lapse 2D survey. The second in-zone monitoring well location will be proposed to the director following completion of the updated dynamic model. Upon the Director's concurrence, the well will be installed within 18 months.

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

Groundwater sampling frequencies are detailed in Table 1.
CO_2 gas stream and corrosion coupon) frequencies are detailed in Table 1.

B.1.c Site/Sampling Locations

ACZ wells, and the location of OEE#1 (in-zone monitoring well IZM#1) are shown on Figure 2 and noted in Section B.1.a. The location of the second IZM well is TBD as noted in Section B.1.a.

CO_2 gas stream and corrosion coupon sampling locations will occur in the compressor building after the last stage of compression.

B.1.d Sampling Site Contingency

The deep groundwater monitoring wells are located on the One Earth CCS project site or on land where One Earth Sequestration, LLC has access permissions have already been granted. No problems of site inaccessibility are anticipated. If inclement weather makes site access difficult, sampling schedules will be reviewed, and alternative dates may be selected that would still meet permit-related conditions.

No problems of site inaccessibility are anticipated for CO_2 gas stream or corrosion coupon sampling. If inclement weather makes site access difficult, sampling schedules will be reviewed, and alternative dates may be selected that would still meet permit-related conditions.

B.1.e Activity Schedule

The groundwater sampling activities and frequencies are summarized in Table 1.
The CO_2 gas stream and corrosion coupon sampling activities and frequencies are summarized in Table 1.

B.1.f Critical/Informational Data

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

B.1.g Sources of Variability

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

Activities to eliminate, reduce, or reconcile variability related to monitoring activities include (1) collecting long-term baseline data to observe and document natural variation in monitoring parameters, (2) evaluating data in timely manner after collection to observe anomalies in data that

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

B.2 Sampling Methods

Logging, geophysical monitoring, and pressure/temperature monitoring does not apply to this section and is omitted.

B.2. a/b Sampling SOPs

ACZ and IZM wells will be developed and purged at the time of completion. Prior to sampling, each zone will be purged to ensure representative samples are collected. Purge water will be disposed of in accordance with One Earth Sequestration, LLC policy for waste management

It is anticipated that air lifting with nitrogen may be used to draw fluid into the deep wells for purging. A gas lift valve will be placed in the tubing string at the time of completion. The sampler will be positioned at the same elevation as the discrete perforated interval, and a sample would be collected after sufficient purging.

B.2.c In-situ Monitoring

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

B.2.d Continuous Monitoring

Pressure data will be collected from ACZ and IZM wells on a periodic basis (e.g., hourly to daily) using pressure gauges, DTS, and DAS.

B.2.e Sample Homogenization, Composition, Filtration

Described in section B.2.b.

B.2.f Sample Containers and Volumes

For CO_2 stream monitoring, samples will be collected in a clean sample container rated for the appropriate collection pressure.

Assay for CO_2 Quarterly Gas Analysis:

- CO_2 Purity (% v/v, [GC])
- Oxygen (O_2, ppm v/v)
- Nitrogen (N_2, ppm v/v)
- Carbon Monoxide (CO, ppm v/v)
- Oxides of Nitrogen (NOx, ppm v/v)
- Total Hydrocarbons (THC, ppm v/v as CH4)
- Methane (CH_4, ppm v/v)
- Acetaldehyde (AA, ppm v/v)
- Sulfur Dioxide (SO_2, ppm v/v)
- Hydrogen Sulfide (H_2S ppm v/v)
- Ethanol (ppm v/v)
- Carbon Isotopes

All fluid sample bottles will be new. Sample bottles and bags for analytes will be used as received (ready for use) from the vendor or contract analytical laboratory for the analyte of interest. A summary of sample containers is presented in Table 20.

B.2.g Sample Preservation

No preservation is required or used for CO_2 gas stream, and additional details of sampling requirements are shown in Table 19. For groundwater and other aqueous samples, the preservation methods in Table 20 will be used.

Corrosion coupon sampling only requires that the coupons be physically separated (e.g., sleeves, baggies) during transportation to prevent physical abrasion.

Table 19. *Summary of sample containers, preservation treatments, and holding times for CO_2 gas stream analysis.*

Target Parameters	Volume/Container Material	PreservationTechnique	Sample Holding time(max)
CO_2 gas stream	2L MLB Polybags 75 cc MiniCylinder	Sample Storage Cabinets	5 Business Days

B.2.h Cleaning/Decontamination of Sampling Equipment

Wireline sampling equipment will be power washed prior to use at each monitoring well. As described in b.2.a/b the wells (and sampling equipment) will be purged until field parameters have stabilized. All field glassware (pipets, beakers, filter holders, etc.) are cleaned with tap water to remove any loose dirt, washed in a dilute nitric acid solution, and rinsed three times with deionized water before use.

CO_2 gas stream sampling containers will be either disposed of or decontaminated by the analytical lab.

No sampling equipment will be utilized with the corrosion coupons or annual field gauge calibrations.

B.2.i Support Facilities

For groundwater sampling, the following are required: an air compressor, a vacuum pump, a generator, a multi-electrode water-quality sonde, and analytical meters (pH, specific conductance, etc.). Field activities are usually conducted in field vehicles and on-site portable laboratory trailers.

Sampling tubing, connectors, and valves required to sample the CO_2 gas stream will be supplied by the analytical lab, which will also provide the sampling containers. Sampling will occur at the wellhead if possible, or at the surface facility discharge if necessary.

Similarly, corrosion coupons will be removed from the CO_2 injection line at the CO_2 compression building.

Field gauges will be removed from the injection well and verification well, utilizing existing standard industry tools and equipment. Deployment and retrieval of verification well gauges will be done using procedures and equipment recommended by the vendor, subcontractor, or is standard per industry practice.

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

Field staff will be responsible for properly testing equipment and performing corrective actions on broken or malfunctioning field equipment. If corrective action cannot be taken in the field, then equipment will be returned to the manufacturer for repair or replaced. Significant corrective actions affecting analytical results will be documented in field notes.

B.3 Sample Handling and Custody

Logging, geophysical monitoring, and pressure/temperature monitoring does not apply to this section and is omitted.

Each sample will be logged on a sampling form and will document the chain of custody. The form will note:

- Sampling date
- Location the sample was collected
- Type of container
- Sampler name and signature
- Other comments/notes
- Shipping information (name, address, and point of contact at laboratory, including phone number)
- Laboratory received by name and signature.

Sample holding times (Table 20) will be consistent with those described in US EPA (1974), American Public Health Association (APHA, 2005), Wood (1976), and ASTM Method D6517-00 (2005). After collection, samples will be placed in ice chests in the field and maintained thereafter at approximately 4°C until analysis. The samples will be maintained at their preservation temperature and sent to the designated laboratory within 24 hours. Analysis of the samples will be completed within the holding time listed in Table 20. As appropriate, alternative sample containers and preservation techniques approved by the UIC Program Director will be used to meet analytical requirements.

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

See Table 20.

B.3.b Sample Transportation

See description at the beginning of Section B.3.

B.3.c Sampling Documentation

Field notes will be collected for all groundwater samples collected. These forms will be retained and archived as reference. The sample documentation is the responsibility of groundwater sampling personnel.

An analysis authorization form shall be provided with each CO_2 gas stream sample provided for analysis.

B.3.d Sample Identification

All sample bottles will have waterproof labels with information denoting project, sampling date, sampling location, sample identification number, sample type (freshwater or brine), analyte, volume, filtration used (if any), and preservative used (if any). See Figure 4 for an example of a label.

Table 20*. Summary of anticipated sample containers, preservation treatments, and holding times.*

Target Parameters	Volume/Container Material	Preservation Technique	Sample Holding time	Relative Sampling Depth
Dissolved CO_2	60 ml/HDPE	Filtered, cool 4°C	14 days	Deep
Isotopes: $\delta^{34}S$	250 ml/HDPE	Filtered, cool 4°C	4 weeks	Deep
Isotopes: δD, $\delta^{18}O$, $\delta^{13}C$	60 ml/HDPE	Filtered, cool 4°C	4 weeks	Deep
Field Confirmation: Temperature, dissolved oxygen, specific conductance, pH	200 ml/glass jar	None	< 1 hour	Deep

Field Confirmation: Density	60 ml/HDPE	Filtered	< 1 hour	Deep

XXXX_X_X (fresh water)
01-15-2022
Metals, 60 ml, filtered, HNO_3

Figure 4*. Example label for groundwater sample bottles.*

B.3.e Sample Chain-of-Custody

For CO_2 stream analysis, an analysis authorization form (Figure 4) will accompany the sample to the lab, at which point a chain-of-custody will accompany the sample through their processes.

For groundwater samples, the chain of custody will be documented using a standardized form. A typical form is shown in Figure 5, and it or a similar form will be used for all groundwater sampling. Copies of the form will be provided to the person/lab receiving the samples as well as the person/lab transferring the samples. These forms will be retained and archived to allow simplified tracking of sample status. The chain-of-custody form and record keeping is the responsibility of groundwater sampling personnel.

B.4 Analytical Methods

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

B.4.a Analytical SOPs

Analytical SOPs are referenced in Tables 5-8. Other laboratory-specific SOPs utilized by the laboratory will be determined after a contract laboratory has been selected. Upon request, One Earth Sequestration, LLC will provide the agency with all laboratory SOPs developed for the specific parameter using the appropriate standard method. Each laboratory technician conducting the analysis on the samples will be trained on the SOP developed for each standard method. One Earth Sequestration, LLC will include the technician's training certification with the biannual report.

B.4.b Equipment/Instrumentation Needed

Equipment and instrumentation are specified in the individual analytical methods referenced in Tables 5-8.

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 5-8 will be responsible for appropriately addressing analytical failure according to their individual SOPs.

B.4.e Sample Disposal

Each laboratory conducting the analyses in Tables 5-8 will be responsible for appropriate sample disposal according to their individual SOPs.

B.4.f Laboratory Turnaround

Laboratory turnaround time varies by laboratory, but generally, verified analytical results within 1 month are suitable for project needs.

B.4.g Method Validation for Nonstandard Methods

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

Airborne Labs International, Inc.

22C World's Fair Drive, Somerset, NJ 08873 Fax: 732-302-3035 Phone: 732-302-1950
E-mail: airbornelabs@aol.com Website: www.airbornelabs.com

Analysis Authorization

*This form **MUST** be completed & returned with a sample shipment*

1.) Report Results to*:

Company:	____________	**Sampled On (mm/dd/yy):**	____________
Address:	____________	**P.O. #:**	____________
Address:	____________	**Credit Card:**	Visa Amex MasterCard Discover
Address:	____________	**Card #:**	____________
Address:	____________	**Cardholder:**	____________
Attention:	____________	**Exp. Date:**	____________
Telephone:	(_____)____________	**Check #:**	____________
Fax:	(_____)____________	**Other:**	____________
E-Mail:	____________	**Pricing Discussed/Quoted? Y N**	

*Please attach complete billing address if different from reporting address.

2.) Number of Samples Submitted: ________ Container Type(s): __________________

3.) Sample Description (circle): Liquid CO_2 CO2 (Final) Vapor CO2 Feedgas* CO_2 In-Process Food Grade CO_2 LIN LOX LAR RELOX (Reboiler) ABO

*IF CO_2 Feedgas –Identify source (e.g. Ethanol/Ammonia/Nat. Well/Ethylene/Combustion, Self-Gen, etc.) ________________

Aviator Breathing Oxygen (ABO) Natural Gas Refinery Gas Syn Gas Propane Butane Air Oxygen Nitrogen Argon Hydrogen Helium Neon Xenon Krypton Freon® Refrigerant Gas Mixture Fuel Oil Lubricant

Other (Describe): ____

4.) Sample Type (Check) : Industrial____Medical______ MilSpec_____ Other_____
(attach a log for multiple samples)

5.) Sample ID: ____

6.) Potential Hazards/Safety Issues: ______________________________

7.) Analytical Test(s) Requested (check program or select individual tests required where applicable):

Std ISBT/Vendor CO_2 Test Program_____ Std CO_2 Feedgas Program_____ Std CGA Test Program_____ Std Medical Gas_____
Std Contract Program_____ Std ASTM Test Program____ MIL Spec Test Program____

%Purity THC CH_4 TNMHC Vol Hydrocarbons (C1-C6) BTEX Water Vapor NVR/NVOR Oil/Grease Total Sulfur H_2S SO_2 COS MeSH t-Butyl Mercaptan Vol Sulfur Compnds Odorants Total Nitrogen N_2 NO_x NH_3 NO NO_2 HCN Nitrous Oxide (N_2O) PH_3 Oxygen Argon Hydrogen Helium CO CO_2 Xenon Neon Krypton Vinyl Chloride Acetaldehyde Vol Oxygenates GC/MS Scan IR Scan IR Microscope Halogenated Hydrocarbons SF_6 Gas Mixture% Btu (Heat) Content % CHNO Sediment Wt Patch Test Viscosity Flash/Fire Point Density Specific Gravity Trace Metals TAN TBN XRF SEM-XRF Scan Light Microscope

Other Testing: ____

8.) Sample Disposition

Retain for ______ Period Perform Clean-up/Maintenance Actions & Return* ____ Report for Instructions ____

Other: ____

*Supply all return address & shipping instructions

9.) Report Disposition (circle one): E-Mail Fax Mail Telephone Other:__________________
(Reports will be sent to the address & contact(s) specified at the top of this form)

10.) Priority Conditions (circle), Note: Additional fees will apply for non-std test scheduling:

Standard 2-Work Day 1-Work Day Same Day Emergency Other:______________________

Analytical testing cannot be performed unless this form is completed & returned

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***Figure 5**. Example of CO_2 gas stream analysis authorization form.*

CHAIN OF CUSTODY RECORD (Page __ of __)

PRAIRIE RESEARCH INSTITUTE

Illinois State Water Survey – Analytical Services Group
Illinois State Geological Survey – Geochemistry Section

For Midwest Geological Sequestration Consortium (MGSC) Projects

	MGSC ID	ISGS MVA ID	Matrix	Date Collected	Time Collected	Sampling Team	Circle analyses to be performed
1							anions, cations, TDS, alk, NH_3, NVOC
2							anions, cations, TDS, alk, NH_3, NVOC
3							anions, cations, TDS, alk, NH_3, NVOC
4							anions, cations, TDS, alk, NH_3, NVOC
5							anions, cations, TDS, alk, NH_3, NVOC
6							anions, cations, TDS, alk, NH_3, NVOC
7							anions, cations, TDS, alk, NH_3, NVOC
8							anions, cations, TDS, alk, NH_3, NVOC
9							anions, cations, TDS, alk, NH_3, NVOC
10							anions, cations, TDS, alk, NH_3, NVOC
11							anions, cations, TDS, alk, NH_3, NVOC
12							anions, cations, TDS, alk, NH_3, NVOC
12							

CHAIN OF CUSTODY		
Relinquished by:	Print Name:	Date and Time:
Received by:	Print Name:	Date and Time:
General Remarks: - Field parameters are to be recorded on separate sheets by sampling teams. - Any special laboratory instructions or remarks should be made below.		
Data Contacts:	Fund:	
Billing Contact:	Billing Address:	
Send Data To:		

Remarks:

Rev. Oct. 2011 (RL)

***Figure 6**. Example chain-of-custody form.*

B.5 Quality Control

Geophysical monitoring and pressure/temperature monitoring do not apply to this section and are omitted. For log quality control, please refer to Appendix B.

B.5.a QC activities

Blanks

Field blanks will be utilized for deep groundwater sampling and analyzed for the inorganic analytes in Tables 5 - 8 at a frequency of 10% or greater. Field blanks will be exposed to the same field and transport conditions as the groundwater samples. Field blanks will be used to detect contamination resulting from the collection and transportation process.

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 be done by evaluating the ratio of the measured total dissolved solids (TDS) to the calculated TDS (i.e., mass balance) per 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 interlaboratory results, if available. Suspect ion analyses are then brought to the attention of the analytical laboratory for confirmation and/or reanalysis. The ion balance is recalculated, and if the error is still not resolved, suspect data are identified and may be given less importance in data interpretations.

B.5.c Calculating Applicable QC Statistics

Charge Balance

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

$$\% \, difference = 100 \quad \frac{(\Sigma cations + \Sigma anions)}{(\Sigma cations - \Sigma anions)} \qquad \text{(Equation 1)}$$

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:

$$1.0 < \frac{measured\ TDS}{calculated\ TDS} < 1.2, \qquad \text{(Equation 2)}$$

where the anticipated values are between 1.0 and 1.2.

Outliers
The determination of one or more statistical outliers is essential prior to the statistical evaluation of groundwater. This project will use the U. S. EPA's Unified Guidance (March 2009) as a basis for selecting recommended statistical methods to identify outliers in groundwater chemistry datasets, as appropriate. These techniques include Probability Plots, Box Plots, Dixon's test, and Rosner's test. The EPA-1989 outlier test can also serve as another screening tool to identify potential outliers.

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

Logging tool equipment will be maintained as per wireline industry best practices (Appendix B).

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

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

B.7 Instrument/Equipment Calibration and Frequency

Geophysical monitoring does not apply to this section and is omitted.

B.7.a Calibration and Frequency of Calibration

Pressure/temperature gauge calibration information is in Table 12 and Tables 14 - 18. Logging tool calibration will be at the discretion of the service company providing the equipment, in accordance with standard industry practices outlined in Appendix B.

For groundwater sampling, portable field meters or multiprobe sondes used to determine field parameters (e.g., pH, temperature, specific conductance, dissolved oxygen) are calibrated according to manufacturer recommendations and equipment manuals (Hach, 2006) each day before sample collection begins. Recalibration is performed if any components yield atypical values or fail to stabilize during sampling.

B.7.b Calibration Methodology

Logging tool calibration methodology will follow standard industry practices in Appendix B.

For groundwater sampling, standards used for calibration are typically 7 and 10 for pH, a potassium chloride solution yielding a value of 1413 microseimens per centimeter (µS/cm) at 25°C for specific conductance, and a 100% dissolved O_2 solution for dissolved oxygen. Calibration is performed for the pHmeters per manufacturer's specifications using a 2-point calibration bounding the range of the sample. For coulometry, sodium carbonate standards (typically yielding a concentration of 4,000 mg CO_2/L) are routinely analyzed to evaluate instrument precision.

B.7.c Calibration Resolution and Documentation

Logging tool calibration resolution and documentation will follow standard industry practices in Appendix B.

For groundwater sampling, calibration values are recorded in daily sampling records, and any errors in calibration are noted. For parameters where calibration is not acceptable, redundant equipment may be used so loss of data is minimized.

B.8 Inspection/Acceptance for Supplies and Consumables

B.8.a/b. Supplies, Consumables, and Responsibilities

Supplies and consumables for field and laboratory operations will be procured, inspected, and accepted as required from vendors approved by One Earth Sequestration, LLC, or the respective subcontractor responsible for the data collection activity. Acquisition of supplies and consumables related to groundwater analyses will be the responsibility of the laboratory per established standard methodology or operating procedures.

B.9 Nondirect Measurements

Seismic Monitoring Methods

B.9.a Data Sources

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

B.9.b Relevance to Project

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

In-zone pressure monitoring data will be used in numerical modeling to predict plume and pressure front behavior and confirm the plume stage within the AOR.

B.9.c Acceptance Criteria

Following standard industry practices will ensure that the gathered seismic data will be used for accurate modeling and monitoring. Similar ground conditions shot points located within tolerable limits, functional geophones, and similar seismic input signal will be used from survey to survey to ensure repeatability.

When processing seismic data, several QA checks will be done in accordance with industry standards including reformatting to Omega structured files, geometry application, amplitude compensation, predictive deconvolution, elevation statics correction, RMS amplitude gain, velocity analysis every 2 km, NMO application using picked velocities, CMP stacking, random noise attenuation, and instantaneous gain.

B.9.d Resources/Facilities Needed

One Earth Sequestration, LLC will subcontract all necessary resources and facilities for seismic monitoring, in-zone pressure monitoring, and groundwater sampling.

B.9.e Validity Limits and Operating Conditions

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

B.10 Data Management

B.10.a Data Management Scheme

One Earth Sequestration, LLC, or a designated contractor, will maintain the required project data as provided elsewhere in the permit. Data will be backed up on tape or held on secure servers.

B.10.b Record-keeping and Tracking Practices

All records of gathered data will be securely held and properly labeled for auditing purposes.

B.10.c Data Handling Equipment/Procedures

All equipment used to store data will be properly maintained and operated according to proper industry techniques. One Earth Sequestration, LLC SCADA system and vendor data acquisition systems will interface with one another, and all subsequent data will be held on a secure server.

B.10.d Responsibility

The primary project managers will be responsible for ensuring proper data management is maintained.

B.10.e Data Archival and Retrieval

All data will be held by One Earth Sequestration, LLC. These data will be maintained and stored for auditing purposes as described in section B. 10. a.

B.10.f Hardware and Software Configurations

All One Earth Sequestration, LLC and vendor hardware and software configurations will be appropriately interfaced.

B.10.g Checklists and Forms

Checklists and forms will be procured and generated as necessary.

C. Assessment and Oversight

C.1 Assessments and Response Actions

C.1.a Activities to be Conducted

Please refer to Table 1 in section A.3.a/b. (Summary of work to be performed and work schedule); groundwater quality data will be collected at the frequency outlined in that table. After completion of sample analysis, results will be reviewed for QC criteria as noted in section B.5. If the data quality fails to meet criteria set in section B.5., samples will be reanalyzed, if still within holding time criteria. If outside of holding time criteria, additional samples may be collected, or sample results may be excluded from data evaluations and interpretations. Evaluation of data consistency will be performed according to the procedures described in the U.S. EPA 2009 Unified Guidance (USEPA, 2009).

C.1.b Responsibility for Conducting Assessments

Organizations gathering data will be responsible for conducting their internal assessments. All stop work orders will be handled internally within individual organizations.

C.1.c Assessment Reporting

All assessment information should be reported to the individual organizations' project manager, as outlined in A.1.a/b.

C.1.d Corrective Action

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

C.2 Reports to Management

C.2. a/b. QA status Reports

QA status reports should not be needed. If any testing or monitoring techniques are changed, the QASP will be reviewed and updated as appropriate in consultation with U. S. EPA. Revised QASPs will be distributed by One Earth Sequestration, LLC to the full distribution list 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

Groundwater quality data validation will include the review of the concentration units, sample holding times, and the review of duplicate, blank, and other appropriate QA/QC results. All groundwater quality results will be entered into a database or spreadsheet with periodic data review and analysis. One Earth Sequestration, LLC will retain copies of the laboratory analytical test results and/or reports. Analytical results will be reported on a frequency based on the approved UIC permit conditions. In the periodic reports, data will be presented in graphical and tabular formats as appropriate to characterize general groundwater quality and identify intrawell variability with time. After sufficient data have been collected, additional methods, such as those described in the U. S. EPA 2009 Unified Guidance (USEPA, 2009), will be used to evaluate 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 Method

D.2.a Data Verification and Validation

Process. See Sections D.1.a. and B.5.

Appropriate statistical software will be used to determine data consistency.

D.2.b Data Verification and Validation Responsibility

One Earth Sequestration, LLC or its designated subcontractor will verify and validate groundwater sampling data.

D.2.c Issue Resolution Process and Responsibility

One Earth Sequestration, LLC or its designated Coordinator will overview the groundwater data handling, management, and assessment process. Staff involved in these processes will consult with the coordinator to determineactions required to resolve issues.

D.2.d Checklist, Forms, and Calculations

Checklists and forms will be developed specifically to meet permit requirements. Table 21 provides anexample of the type of information used for data verification of groundwater quality data.

Table 21. Example table of criteria used to evaluate data quality.

Well ID	Anion charge	Cation charge	Charge balance	CB rating	Calculated TDS	Measured TDS	TDS ratio	TDS rating
IZM#1	14.4	13.60	-2.84	pass	760.50	785	1.0	pass
IZM#2	14.26	15.06	2.73	pass	783.03	777	1.0	pass
OES USDW#1	14.39	14.96	1.94	pass	786.86	806	1.0	pass
OES ACZ#1	14.39	14.79	1.38	pass	780.15	777	1.0	pass
OES ACZ#2	14.39	14.79	1.38	pass	780.15	777	1.0	pass

D.3 Reconciliation with User Requirements

D.3.a Evaluation of Data Uncertainty

Statistical software will be used to determine groundwater data consistency using methods consistent with U. S. EPA 2009 Unified Guidance (USEPA, 2009).

D.3.b Data Limitations Reporting

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

References

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Appendices (See pdf files)

APPENDIX A. Examples of DTS, DAS, and Down-hole Pressure Gauge Information

(See Attached)

APPENDIX B. Example of Wireline Log Quality Control *

(See Attached)

***Wireline Quality Control Reference Manual (LQCRM) included with permission of Schlumberger.**

One Earth CCS

Class VI Injection Well: Quality Assurance and Surveillance Plan

September 2022
Modified 2026

Submitted by:
One Earth Sequestration, LLC

Table of Contents

Title and Approval Sheet

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

Signature Mark Ditsworth VP of Technology and Special Projects	Date
Signature [TBD] [OES CO_2 Unit Manager]	Date
Signature [TBD] [OEE Ethanol Plant Operations Manager]	Date

Distribution List

The following project participants should receive the completed Quality Assurance and Surveillance Plan(QASP) and all future updates for the duration of the project. The One Earth Sequestration, LLC VP of Technology and Special Projects (see contact information below) will be responsible for ensuring that all those on the distribution list will receive the most current copy of the approved Quality Assurance and Surveillance Plan.

One Earth Sequestration, LLC
OES CO_2 Unit Manager
OEE Ethanol Plant Operations Manager
OEE Ethanol Plant Environmental Manager
Third Party Contractors TBD

One Earth Sequestration, LLC
Contact: Mark Ditsworth
VP of Technology and Special Projects,
One Earth Sequestration, LLC.
202 N Jordan Drive, Gibson City, IL. 60936
(217) 784-5321 ext. 215

A. Project Management

A.1 Project/Task Organization

A.1. a/b. Key Individuals and Responsibilities

The project, led by One Earth Sequestration, LLC, includes participation from several subcontractors. The Testing and Monitoring Activities responsibilities will be shared between One Earth Sequestration, LLC, and its designated subcontractor. The monitoring program includes six subcategories:

1) Deep Groundwater Monitoring
2) Well Logging
3) Mechanical Integrity Testing (MIT)
4) Pressure/Temperature Monitoring
5) CO_2 Stream Analysis
6) Geophysical Monitoring

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

Most of the physical samples collected and data gathered as part of the monitoring program will be acquired, analyzed, processed, or witnessed by third parties independently and outside of the project management structure.

A.1.d QA Project Plan Responsibility

One Earth Sequestration, LLC will be responsible for maintaining and distributing the official, approved QA Project Plan. One Earth Sequestration, LLC will periodically review this QASP and consult with U. S. EPA if/when changes to the plan are warranted.

A.1.e Organizational Chart for Key Project Personnel

Figure 1 shows the organizational structure of the project. One Earth Sequestration, LLC will provide the UIC Program Director with a contact list of individuals fulfilling these roles.

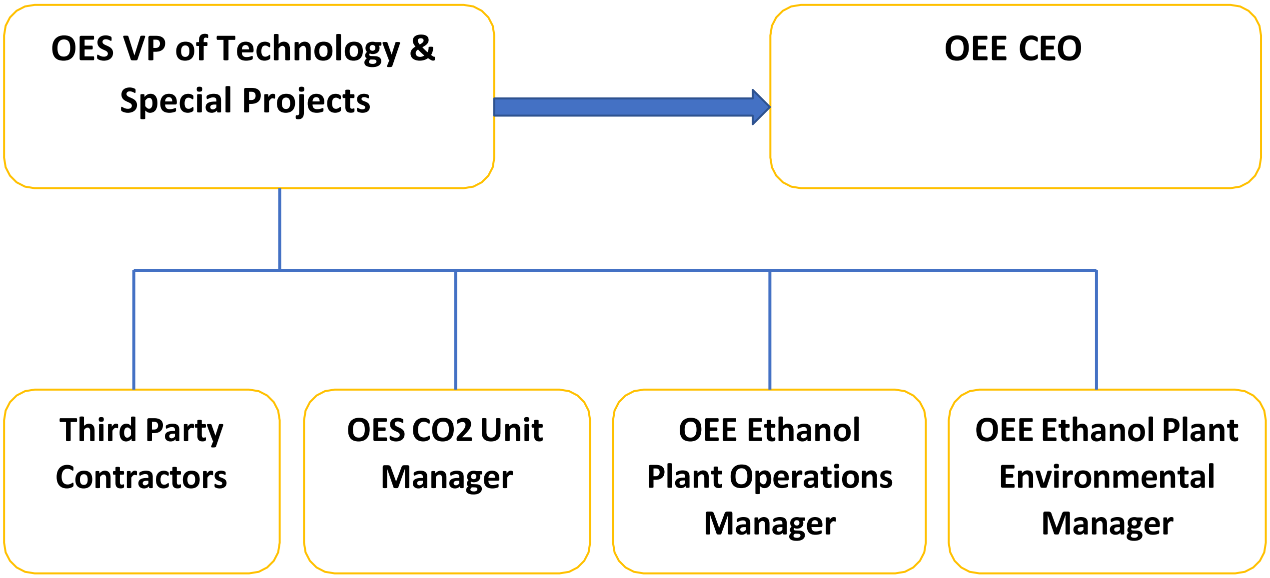

Figure 1. *One Earth Sequestration, LLC organization structure.*

A.2 Problem Definition/Background

A.2.a Reasoning

The One Earth CCS monitoring program has operational monitoring, verification, and environmental monitoring components. Operational monitoring is used to ensure safety with procedures associated with fluid injection monitoring the response of the storage unit, and the movement of the CO_2. Key monitoring parameters include the pressure of injection well tubing & annulus, storage unit, above seal strata, and the lowermost USDW reservoir. Other monitoring parameters include injection rate, total mass & volume injected, and injection well temperature profile. The verification component will provide information to evaluate whether CO2 is leaking through the caprock. This includes pulse neutron logging, pressure, and temperature monitoring, acoustic monitoring, repeat 2D seismic monitoring, and groundwater sampling and analysis.

A robust monitoring program has been developed for the One Earth CCS project. The primary goal of the One Earth CCS monitoring program is to demonstrate that project activities are protective of human health and the environment. To help achieve this goal, this Quality Assurance Surveillance Plan (QASP) was developed to ensure that the testing and monitoring program meets the quality standards required by the U.S. Environmental Protection Agency's (USEPA) Underground Injection Control (UIC) Program for Class VI wells.

A.2.b. Reasons for Initiating the Project

The goal of the One Earth CCS project is to inject and retain industrial-scale volumes of CO_2 for permanent geologic sequestration in the Mt Simon Sandstone and to reduce atmospheric concentrations of CO_2. To demonstrate that this is done safely, a rigorous monitoring plan is proposed to ensure the injected CO_2 is retained within the storage reservoir.

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

The Class VI Rule requires owners or operators of Class VI wells to perform several types of activities during the lifetime of the project to ensure that the injection well maintains its mechanical integrity, that fluid migration and the extent of pressure elevation are within the limits described in the permit application, and that underground sources of drinking water (USDWs) are not endangered. These monitoring activities include mechanical integrity tests (MITs), injection well testing during operation, monitoring of ground water quality in several zones, tracking of the CO_2 plume and associated pressure front. This document details both the measurements that will be taken as well as the steps to ensure that the quality of the data is such that the data can be used with confidence in making decisions during the life of the project.

A.3 Project/Task Description

A.3. a/b. Summary of Work to be Performed and Work Schedule

Table 1 describes the Testing and Monitoring tasks, reasoning, responsible parties, locations, and testing frequency. Tables 2 and 3 summarize the instrumentation and geophysical surveys, respectively.

Table 1. *Summary of testing and monitoring direct measurements.*

Parameter	Location	Method	Frequency			Analytical Technique	Lab and Custody	Purpose
			Pre-injection Baseline	Operation Period	PISC Period			
CO_2 Injectate compositional and Isotopic Analysis	After CO_2 dehydration	Direct sampling	Once	Quarterly	None	Chemical analysis	TBD	Monitor injectate
Injection rate and volume	After compression	Flow meter	N/A	Continuous	N/A	Direct measurement	N/A	Monitor rate and volume
Injection pressure	Injection wellheads	Pressure gauge	N/A	Continuous	N/A	Direct measurement	N/A	Monitor injection pressure
Annular pressure	Injection wellheads	Pressure gauge	N/A	Continuous	N/A	Direct measurement	N/A	Monitor annular pressure
DTS Fiber Optic Temperature	ACZ and IZM Wells	Fiber optic cable	Continuous	Continuous	Continuous	Direct measurement	N/A	Storage integrity
DAS Fiber Optic Seismic	ACZ and IZM Wells	Fiber optic cable	Continuous	Continuous	Continuous	Direct measurement	N/A	Storage integrity
Downhole pressure and temperature	IZM Wells	Downhole gauge	N/A	Continuous	Continuous	Direct measurement	N/A	Monitor reservoir and Model validation
Corrosion monitoring	After compression	Coupon	N/A	Quarterly years 1 and 2; annually thereafter	N/A	Physical analysis	TBD	Monitor injection well and pipeline integrity
Mechanical Integrity	Injection Wells	Various	Prior to the operation	Annually	Prior to P/A	§ 146.87 (a)(4) § 146.89 (c)(2)	N/A	Monitor injection, well integrity
DTS/DAS Fiber Optic	Injection Wells (above perforations)	Fiber optic cables	Continuous	Continuous	Prior to P/A	Direct measurement	N/A	Injection well integrity; storage integrity; Continuous plume-adjacent temperature and acoustic monitoring for model validation and plume-behavior evaluation
Cement evaluation	Injection Wells	Logging	Baseline	N/A	N/A	Cement evaluation log	N/A	Injection well integrity
Pressure fall off testing	Injection Wells Mt. Simon arkosic zone	Pressure gauge	Once	Every five years and at the end of the injection period.	N/A	Direct measurement	N/A	Formation hydrogeologic conditions; injection well integrity

Table 1a. Summary of testing and monitoring – direct measurements (continued).

Level	Location Depth**	Method	Frequency			Analytical Technique	Parameters	Purposes
			Pre-injection Baseline	Operation Period	PISC Period			
ACZ - Lowermost USDW – St. Peter Sandstone	OES USDW #1 Depth ~2,215 – 2,447 ft.	*Swab valve or other method	Minimum 1 year Quarterly	Annually	Annually	Chemical analysis	Table 5	Detection of changes in groundwater quality in lowermost USDW.
ACZ - Above confining zone - Ironton-Galesville	OES-ACZ #1 Depth ~3,733 – 3,921 ft	*Swab valve or other method	1 sample	Annually	Annually	Chemical analysis	Table 6	Detection of changes in groundwater quality for the reservoir directly above the confining zone.
IZM – Mt. Simon Sandstone	IZM#1 Depth ~ 4,455 – 6,469 ft IZM #2 Depth TBD	*Swab valve or other method	1 sample	Annually.	None	Chemical analysis	Table 7	Detection of changes in groundwater quality, geochemical monitoring, and CO_2 detection in storage reservoir.

Notes

* Samples collected using a downhole sampling tool run into the well on wireline.

* Swab samples collected at the surface after the well has been swabbed with ample volume to ensure reservoir fluid at the surface. Fluid sampling will be discontinued at each respective monitoring well once there is a breakthrough of CO_2 in the well(s)

***Depth based on formation interval at OEE#1; actual perforation depths TBD.*

Table 1b*. Summary of testing and monitoring indirect CO_2 plume tracking.*

Method	Location	Pre-injection Baseline	Operation Period	PISC Period	Purpose
Pulsed Neutron Logging	Injection and AZM and IZM Wells	Once	Annually	Annually	Plume Location
Time-lapse 2D	Injection area	Baseline survey	1st after 4 years of injection, 2nd after 9 years of injection, Every 10 Mt thereafter	Initial PISC survey 5 years from most recent. Additional PISC survey 9 years after the end of injection	Indirect measurement of plume size

Table 2*. Instrumentation summary. T = temperature; P = Pressure; DTS = Distributed Temperature System; DAS = Distributed Acoustic System; F = Flow.*

			Operational Period		**PISC Period**		
Monitoring Location	**Instrument Type**	**Monitoring Target (Formation or Other)**	**Data Collection Location(s)**	**Frequency**	**Data Collection Location(s)**	**Frequency**	**Explanation**
CO_2 Facility	T, P, F	Surface	Discharge High-Pressure Pumps	Continuous	Discharge high pressure pumps	NA	Monitoring the operational, equipment, and permit parameters
Injection wells and IZM wells	DTS and DAS	All strata	Pending final completion	Continuous	Pending final completion	Continuous until P&A (minimum one year)	Used for operational monitoring, well integrity, seismicity detection, and evaluation of CO_2 plume behavior adjacent to the wells
	T, P	Mt. Simon injection zone	Pending final completion	Continuous	Pending final completion	Continuous until P&A (minimum one year)	Monitoring operational and equipment parameters
ACZ Wells	T, P	Ironton Galesville	Pending final completion	Continuous	Pending final completion	None	Monitoring seal formation integrity
		Lowermost USDW – St. Peter	Pending final completion	Continuous	Pending final completion	None	Monitoring seal formation integrity

Table 3. Well logging surveys summary.

Monitoring Activity	Well	Tools or Survey Description	Pre-Injection - Baseline	Operation Period	PISC Period	Explanation
Wireline Logging	ACZ and IZM Wells	Cement evaluation tool	1 Baseline	None	None	Mechanical Integrity
		Pulse neutron	1 Baseline	Annually	Annually	Fluid movement, salinity, CO_2 detection, and mechanical integrity
	Inj wells	Pulse neutron	1 Baseline	Annually	Annually until P&A	Fluid movement, salinity, CO_2 detection, and mechanical integrity
		Casing inspection	1 Baseline	None	None	Mechanical Integrity
		Cement evaluation tool	1 Baseline	None	None	Mechanical Integrity

A.3.c. Geographic Locations

Figure 2 shows the One Earth CCS site and monitoring infrastructure. Table 4 summarizes the injection and monitoring wells. Figure 3 shows the location of the 2D lines acquired as part of site characterization. The repeat 2D seismic will follow Line 1 and the 2019 Gibson line. Geophysical monitoring will be conducted using the permanent DTS/DAS fiber-optic array installed in the existing injection, IZM, ACZ, and USDW monitoring wells, as summarized in Table 4.

Table 4. *One Earth CCS project well summary.*

Well Type	Well ID	Notes
Injection	OES #1	
	OES #2	
	OES #3	
In-Zone Monitoring (IZM)	IZM #1	Convert stratigraphic test well OEE #1
	IZM #2	Mt Simon Sandstone completion
Above-Confining-Zone Monitoring	OES ACZ #1	Ironton Galesville completion
USDW Monitoring	OES USDW #1	St. Peter Sandstone completion
Geophysical monitoring instrumentation in project wells (DAS/DTS)	OES #1 OES #2 OES #3 IZM #1 IZM #2 OES ACZ #1 OES USDW #1	Permanent array in project wells

A.3.d. Resource and Time Constraints

No resource or time constraints have been identified for the One Earth CCS project testing and monitoring plan beyond the proposed timeline.

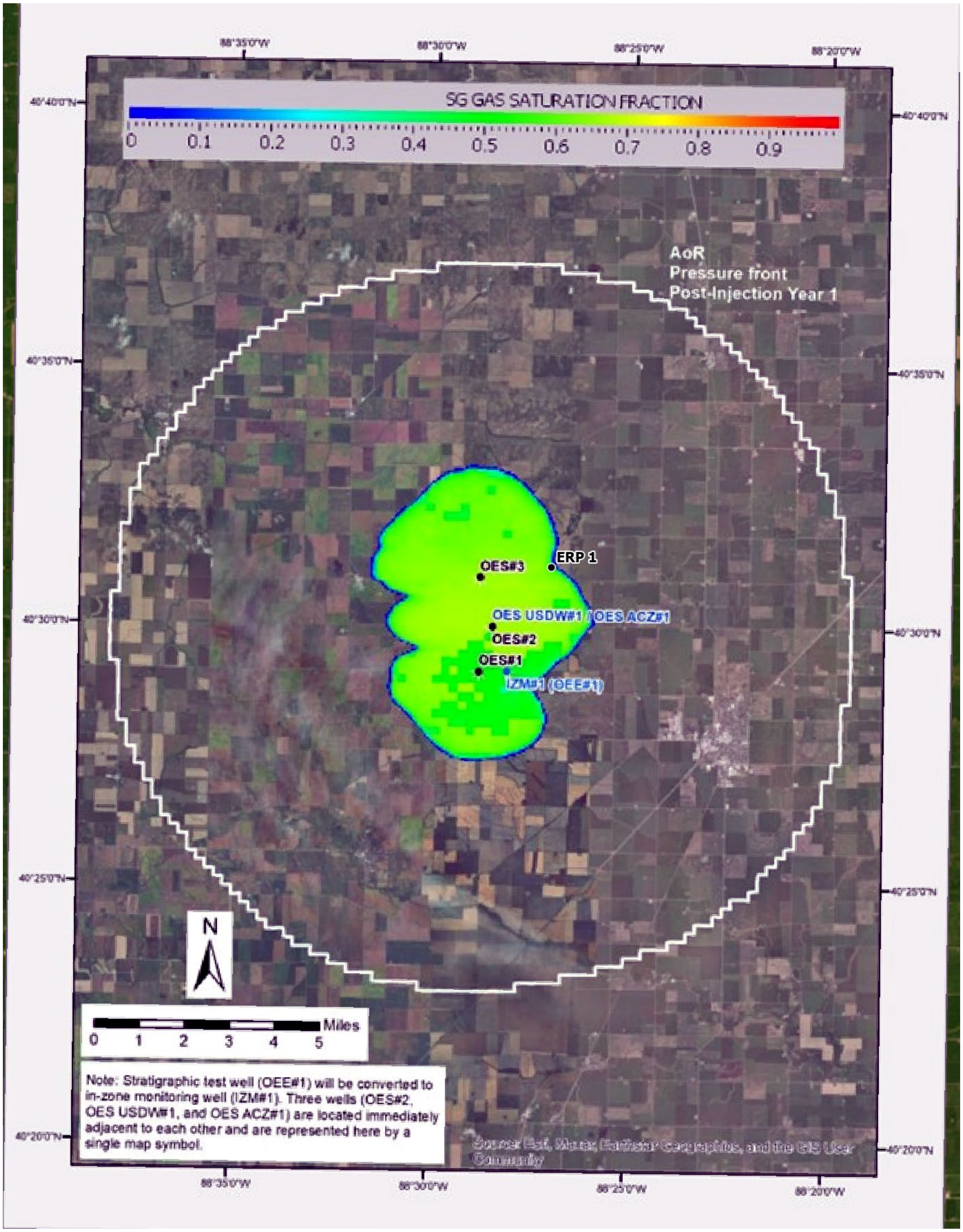

Figure 2. *One Earth CCS area showing location of ACZ #1 and IZM #1 monitoring wells. Pressure front is indicated by the white line, and maximum CO_2 saturation plume is shown in green with blue border.*

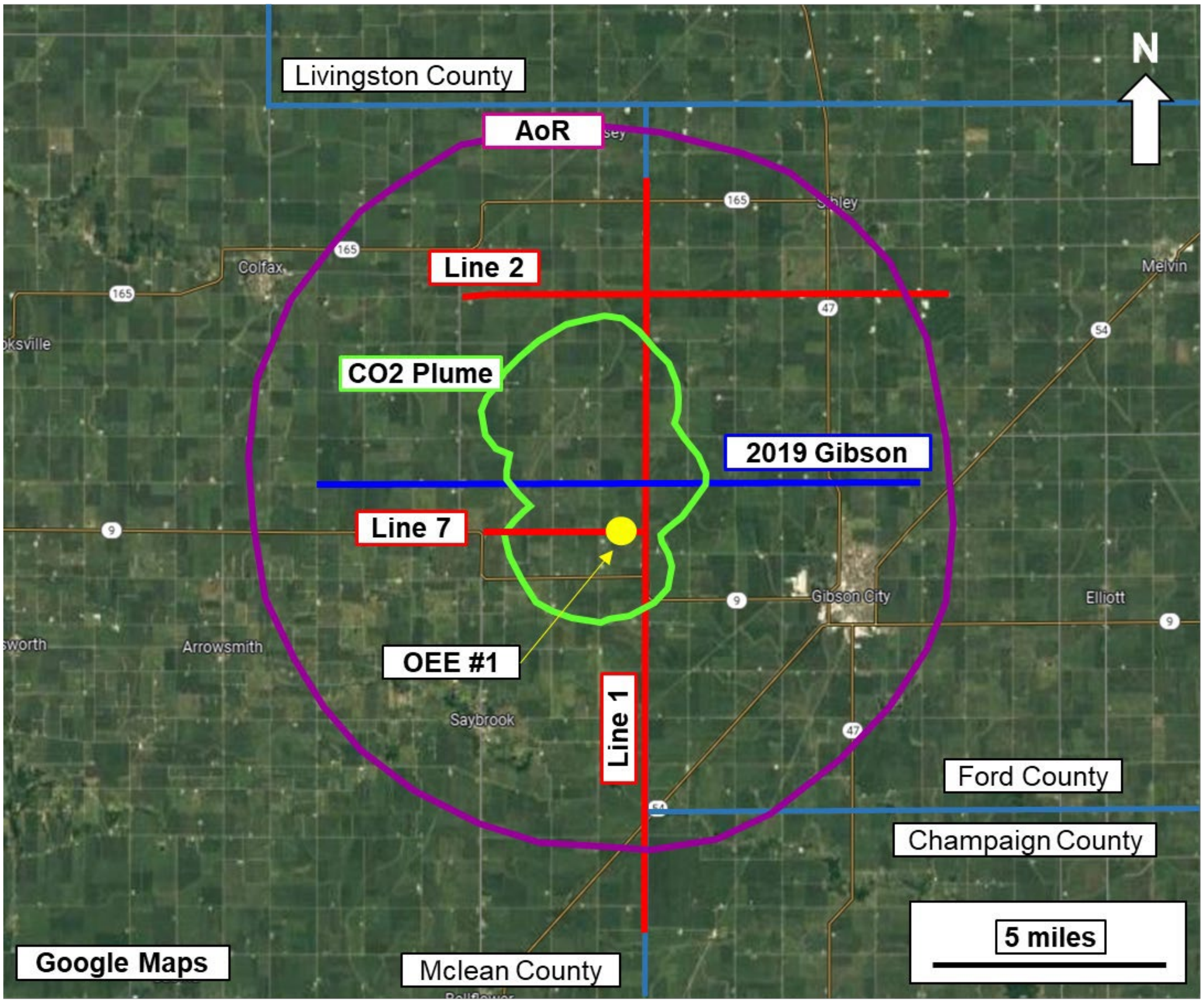

Figure 3. *2D seismic lines acquired during site characterization. Note CO_2 plume (in green) and AoR (purple) outlines have been generalized.*

A.4 Quality Objectives and Criteria

A.4.a Performance/Measurement Criteria

The overall QA objective for monitoring is to develop and implement procedures for subsurface monitoring, field sampling, laboratory analysis, and reporting that will provide results that meet the characterization and non-endangerment goals of this project. Groundwater monitoring will be conducted during the pre-injection, injection, and post-injection phases of the project. Deep groundwater monitoring wells will be used to gather water-quality samples and pressure data. All groundwater analytical and field-monitoring parameters for each interval are listed in Tables 5-8. Tables 9 and 10 show analytical parameters for CO_2 stream gas monitoring, corrosion coupon assessment, and gauge specifications. Table 11 shows the monitoring outputs.

The list of analytes may be reassessed periodically and adjusted to include or exclude analytes based on their effectiveness to the overall monitoring program goals.

Key testing and monitoring areas include:

1. Formation Fluid Sampling
    a. Aqueous chemical concentrations
2. Well Logging
    a. pulse neutron
3. Mechanical Integrity Testing (MIT)
    a. Pulsed neutron, temperature, cement evaluation logging
4. Pressure/Temperature Monitoring
    a. Pressure/temperature from in-situ gauges and DTS
    b. Pressure/temperature from surface gauges
5. Acoustic monitoring - DAS
    a. Well Integrity
    b. Seismic monitoring
6. CO_2 Stream Analysis
    a. CO_2 Purity (% v/v, [GC])
    b. Other trace components
    c. Carbon Isotopes
7. Geophysical Monitoring
    a. Seismic data files
    b. Processed time-lapse report
8. Fiber-Optic Monitoring (DTS/DAS)
    a. Continuous distributed temperature sensing (DTS) measurements for detection of thermal anomalies associated with CO_2 movement
    b. Distributed acoustic sensing (DAS) for detection of acoustic/strain signatures related to plume migration, pressure dissipation, and geomechanical response
    c. Integration of DTS/DAS data with pulsed neutron logs, pressure monitoring, and seismic surveys to support plume tracking and model validation

Table 5. *Summary of analytical and field parameters for lowermost USDW (St. Peter) groundwater samples. A designated third-party laboratory will perform all analyses. ICP = inductively coupled plasma; MS = mass spectrometry; OES = optical emission spectrometry; GC-P = gas chromatography-pyrolysis.*

Parameters	Analytical Methods[(1)]	Detection Limit/Range	Typical Precisions	QC Requirements
Cations: Al, Ba, Mn, As, Cd, Cr, Cu, Pb, Sb Se, and Tl	ICP-MS, EPA Method 6020	0.001 to 0.1 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-OES, EPA Method 6010B	0.005 to 0.5 mg/L (Analyte, dilution, and matrix dependent)	±15%	Daily calibration; blanks, duplicates, and matrix spikes at 10% or greater frequency
Anions: Br, Cl, F, NO3, and SO4	Ion Chromatography, EPA Method 300.0	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 D513-11	25 mg/L	±15%	Duplicate measurement; standards at10% or greater frequency
Isotopes: $\delta^{13}C$ of DIC	Isotope ratio mass spectrometry[2]	12.2 mg/L HCO3- for δ13C	±0.15‰ for $\delta^{13}C$	10% duplicates; 4 standards/batch
Total Dissolved Solids	Gravimetry; APHA 2540C	12 mg/L	±10%	Balance calibration, duplicate analysis
Water Density(field)	Oscillating body method	0.0000 to 2.0000	±0.0002 g/mL	Duplicate measurements
Alkalinity	APHA 2320B	4 mg/L	±3 mg/L	Duplicate analysis
pH (field)	EPA 150.1	2 to 12 pH units	±0.2 pH unit	User calibration per manufacturer recommendation
Specific conductance (field)	APHA 2510	0 to 200 mS/cm	±1% of reading	User calibration per manufacturer recommendation
Temperature (field)	Thermocouple	-5 to 50°C	±0.2°C	Factory calibration

Note 1: An equivalent method may be employed with the prior approval of the UIC Program Director.
Note:2: Gas evolution technique by Atekwana and Krishnamurthy (1998), with modifications made by Hackley et al. (2007)

***Table 6**. Summary of analytical and field parameters for Ironton-Galesville groundwater samples. Note: cation, anion, TDS, and alkalinity measurements will be performed by a third-party laboratory using published analytical methods. Isotope and dissolved CO_2 analyses will be performed by a designated laboratory. ICP = inductively coupled plasma; MS = mass spectrometry; OES = optical emission spectrometry; GC-P = gas chromatography-pyrolysis.*

Parameters	Analytical Methods(1)	Detection Limit/Range	Typical Precisions	QC Requirements
Cations: Al, Ba, Mn, As, Cd, Cr, Cu, Pb, Sb, Se,and Tl	ICP-MS, EPA Method 6020	0.001 to 0.1 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-OES, EPA Method 6010B	0.005 to 0.5 mg/L (Analyte, dilution, and matrix dependent)	±15%	Daily calibration; blanks, duplicates, and matrix spikes at 10% or greater frequency
Anions: Br, Cl, F, NO_3, and SO_4	Ion Chromatography,EPA Method 300.0	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 D513-11	25 mg/L	±15%	Duplicate measurement; standards at10% or greater frequency
Isotopes: $\delta^{13}C$ of DIC	Isotope ratio mass spectrometry[2]	12.2 mg/L HCO3- for δ13C	±0.15‰ for $\delta^{13}C$	10% duplicates; 4 standards/batch
Total Dissolved Solids	Gravimetry; APHA 2540C	12 mg/L	±10%	Balance calibration, duplicate analysis
Water Density(field)	Oscillating body method	0.0000 to 2.0000	±0.0002 g/mL	Duplicate measurements
Alkalinity	APHA 2320B	4 mg/L	±3 mg/L	Duplicate analysis
pH (field)	EPA 150.1	2 to 12 pH units	±0.2 pH unit	User calibration per manufacturer recommendation
Specific conductance (field)	APHA 2510	0 to 200 mS/cm	±1% of reading	User calibration per manufacturer recommendation
Temperature (field)	Thermocouple	-5 to 50°C	±0.2°C	Factory calibration

Note 1: An equivalent method may be employed with the prior approval of the UIC Program Director.
Note:2: Gas evolution technique by Atekwana and Krishnamurthy (1998), with modifications made by Hackley et al. (2007).

Table 7*. Summary of analytical and field parameters for Mt. Simon groundwater samples. All analyses will be performed by a designated third-party laboratory. ICP = inductively couple plasma; MS = mass spectrometry; OES = optical emission spectrometry; GC-P = gas chromatography-pyrolysis.*

Parameters	Analytical Methods[1]	Detection Limit/Range	Typical Precisions	QC Requirements
Cations: Al, Ba, Mn, As, Cd, Cr, Cu, Pb, Sb Se,and Tl	ICP-MS, EPA Method 6020	0.001 to 0.1 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-OES, EPA Method 6010B	0.005 to 0.5 mg/L (Analyte, dilution, and matrix dependent)	±15%	Daily calibration; blanks, duplicates, and matrix spikes at 10% or greater frequency
Anions: Br, Cl, F, NO3, and SO4	Ion Chromatography,EPA Method 300.0	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 D513-11	25 mg/L	±15%	Duplicate measurement; standards at10% or greater frequency
Isotopes: $\delta^{13}C$ of DIC	Isotope ratio mass spectrometry[2]	12.2 mg/L HCO3- for δ13C	±0.15‰ for $\delta^{13}C$	10% duplicates; 4 standards/batch
Total Dissolved Solids	Gravimetry; APHA 2540C	12 mg/L	±10%	Balance calibration, duplicate analysis
Water Density(field)	Oscillating body method	0.0000 to 2.0000	±0.0002 g/mL	Duplicate measurements
Alkalinity	APHA 2320B	4 mg/L	±3 mg/L	Duplicate analysis
pH (field)	EPA 150.1	2 to 12 pH units	±0.2 pH unit	User calibration per manufacturer recommendation
Specific conductance (field)	APHA 2510	0 to 200 mS/cm	±1% of reading	User calibration per manufacturer recommendation
Temperature (field)	Thermocouple	-5 to 50°C	±0.2°C	Factory calibration

Note 1: An equivalent method may be employed with the prior approval of the UIC Program Director.

Note:2: Gas evolution technique by Atekwana and Krishnamurthy (1998), with modifications made by Hackley et al. (2007)

Table 8. *Summary of analytical parameters for CO_2 gas stream. All analyses will be performed by a designated third-party laboratory.*

Parameters	Analytical Methods[(1)]	Detection Limit/Range	Typical Precisions	QC Requirements
Oxygen	ISBT 4.0 (GC/DID)	1 uL/L to 5,000 uL/L (ppm by volume)	± 10 % of reading	daily standard within 10 % of calibration, secondary standard after calibration
	GC/TCD	0.1 % to 100 %	5 - 10 % relative across the range, RT ± 0.1 min	daily standard, duplicate analysis within 10 % of each other
Nitrogen	ISBT 4.0 GC/DID	1 uL/L to 5,000 uL/L (ppm by volume)	± 10 % of reading	daily standard within 10 % of calibration, secondary standard after calibration
	GC/TCD	0.1 % to 100 %	5 - 10 % relative across the range, RT ± 0.1 min	daily standard, duplicate analysis within 10 % of each other
Carbon Monoxide	ISBT 5.0 Colorimetric	5 uL/L to 100 uL/L (ppm by volume)	± 20 % of reading	duplicate analysis
	ISBT 4.0 (GC/DID)	1 uL/L to 5,000 uL/L (ppm by volume)	± 10 % of reading	daily standard within 10 % of calibration, secondary standard after calibration
Oxides of Nitrogen	ISBT 7.0 Colorimetric	0.2 uL/L to 5 uL/L (ppm by volume)	± 20 % of reading	duplicate analysis
Total Hydrocarbons	ISBT 10.0 THA (FID)	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
Methane	ISBT 10.1 GC/FID)	0.1 uL/L to 1,000 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
Acetaldehyde	ISBT 11.0 (GC/FID)	0.1 uL/L to 100 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
Sulfur Dioxide	ISBT 14.0 (GC/SCD)	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
Hydrogen Sulfide	ISBT 14.0 (GC/SCD)	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
Ethanol	ISBT 11.0 (GC/FID)	0.1 uL/L to 100 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
Isotopes: $\delta^{13}C$ of DIC	Isotope ratio mass spectrometry[2]	12.2 mg/L HCO3- for δ13C	±0.15‰ for $\delta^{13}C$	10% duplicates; 4 standards/batch
CO_2 Purity	ISBT 2.0 Caustic absorption Zahm-Nagel	99.00% to 99.99%	± 10 % of reading	User calibration per manufacturer recommendation
	ALI method SAM 4.1 subtraction method (GC/DID)	1 ppm for each target analyte (analyte dependent) - refer to Oxygen and Nitrogen analysis.	5-10 % relative across the range	duplicate analysis within 10 % of each other
	GC/TCD	0.1 % to 100 %	5-10 % relative across the range, RT ± 0.1 min	standard with every sample, duplicate analysis within 10 % of each other

Note 1: An equivalent method may be employed with the prior approval of the UIC Program Director.

Note 2: Gas evolution technique by Atekwana and Krishnamurthy (1998), with modifications made by Hackley et al. (2007).

Table 9. *Summary of analytical parameters for corrosion coupons.*

Parameters	Analytical Methods	Detection Limit/Range	Typical Precisions	QC Requirements
Mass	NACE RP0775-2005	.005mg	+/-2%	Annual Calibration of Scale
Thickness	NACE RP0775-2005	.001mm	+/-005mm	Factory calibration

Table 10*. Summary of measurement parameters for field gauges*[1].

Parameters[1]	Methods[1]	Detection Limit/Range[1]	Typical Precisions[1]	QC Requirements
Compression discharge pressure	ANSI Z540-1-1994	+/- 0.001 psi / 0-3000 psi	+/- 0.01 psi	Annual Calibration of Scale (3rd party)
Injection Tubing Temperature	ANSI Z540-1-1994	+/- 0.001 F / 0-500 F	+/- 0.01 F	Annual Calibration of Scale (3rd party)
Annulus Pressure	ANSI/UL 61010-1 or ANSI/UL 61010-2-30	+/- 0.1 psi / 0-7200 psi	+/- (0.004 URL/ span)% of Span	Annual Calibration of Scale (3rd party)
Injection Tubing Pressure	ANSI Z540-1-1994	+/- 0.001 psi / 0-3000 psi	+/- 0.01 psi	Annual Calibration of Scale (3rd party)
Injection Mass Flow Rate	ISO 17025/IEC 17025	+/- 0.10% of rate / up to 13,060 tonne/day	+/-0.10% of rate for liquid	Annual Calibration of Scale (3rd party)

[1] *Actual hardware will determine final detection limits/ranges, precision, and standards used. These will be finalized and submitted prior to authorization to inject.*

Table 11. *Actionable testing and monitoring outputs.*

Monitoring Type	Project Action Limit	Detection Limit	Anticipated Reading	
MIT—Pulse neutron logging	Action taken when RST indicates CO_2 outside of the expected range	+/- 0.5 SIGM	Brine saturated ~ 60 CO_2 saturated ~ 8	
Wellbore integrity—annular pressure gauge	>3% pressure loss over 1hour	Refer to Appendix A (annular pressure gauge table)	>3% pressure loss over 1 hour	
Surface pressure gauges	Action will be taken when pressures are well outside of the modeled/expected range	See Table 10.	Injection Pressure (psig)	
			OES #1	Alarm: 1,017psig (90%) & 1,368 psig (80%) Shutdown: 904 psig (80%) & 1,539 psig (90%)
			OES #2	Alarm: 1,044 psig (90%) & 1,480 psig (80%) Shutdown: 928 psig (80%) & 1,665 psig (90%)
			OES #3	Alarm: 1,044 psig (90%) & 1,460 psig (80%) Shutdown: 928 psig (80%) & 1,643 psig (90%)
			Annulus pressure (psig)	
			OES #1, OES #2, OES #3	Alarm: 150 pig (+50 psig) & 4,140 psig (80%) Shutdown: 100 psig & 4,658 psig (90%)
Downhole pressure gauges	Action will be taken when pressures are well outside of the modeled/expected range	See Table 12	OES #1 > 3,782 psig	
			OES #2 > 3,962 psig	
			OES #3 > 3,932 psig	
Flow Rate	Action will be taken when pressures are well outside of the modeled/expected range	See Table 10	OES #1, OES #2, OES #3	Alarm: 3,380 MT/day (80% of max) Shutdown: 3,169 MT/day (75% of max) & 4,160 MT/day (+50 of avg.)
Wellbore integrity— DTS fiber optic temperature	Action will be taken when an anomaly in the temperature profile is detected.	Refer to Appendix A	DTS provides a continuous temperature profile. Baseline profile is TBD and will be identified post-deployment.	
Seismic datafiles	Area of CO_2 plume greater than 50% of the simulated area of CO_2 plume or any single edge of	Dependent on fluid saturation and formation velocities	CO_2 plume migration is similar to the modeled outcome	

	the CO_2 plume exceeding 80% of the radius of the simulated plume edge, as measured from analysis and interpretation of the 2D time-lapse seismic data.	

The action limits in Table 11 have been aligned with the operational alarm and shutdown thresholds specified in Table 15 of the Testing and Monitoring Plan to maintain consistency between monitoring, quality assurance, and operational response. These values reflect current pre-operational modeling and design assumptions and will be updated only as needed based on site-specific data collected during drilling, logging, baseline monitoring, and initial injectivity testing. Any revisions will remain within approved permit conditions and will be finalized prior to authorization to inject, in consultation with the UIC Director.

A.4.b Precision

For groundwater sampling, data accuracy will be assessed by the collection and analysis of field blanks to test sampling procedures and matrix spikes to test lab procedures. Field blanks will be taken no less than one per sampling event to spot check for sample bottle contamination. Laboratory assessment of analytical precision will be the responsibility of the individual laboratories per their standard operating procedures.

Table 12 summarizes the specifications of the downhole quartz gauge for pressure and temperature, while Table 13 presents representative Logging tool specifications.

A.4.c Bias

Laboratory assessment of analytical bias will be the responsibility of the individual laboratories per their standard operating procedures and analytical methodologies. For direct pressure or logging measurements, there is no bias.

A.4.d Representativeness

For groundwater sampling, data representativeness expresses 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 sampling network has been designed to provide data representative of site conditions. For analytical results of individual groundwater samples, representativeness will be estimated by ion and mass balances. Ion balances with ±10% error or less will be considered valid. A mass balance assessment will be used when the ion balance is greater than ±10% to help determine the source of error. For a sample and its duplicate, if the relative percent difference exceeds 10%, the sample may be considered non-representative.

A.4.e Completeness

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

A.4.f Comparability

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

Table 12. *Pressure and temperature – downhole quartz gauge specifications.*

Specification	Sensitivity
Calibrated working pressure range	Atmospheric to 10,000 psi
Initial pressure accuracy	<+/-2 psi over full scale
Pressure resolution	0.005 psi at 1-s sample rate
Pressure drift stability	<+/-1 psi per year over full scale
Calibrated working temperature range	77–266°F
Initial temperature accuracy	<+/-0.9°F per +/-0.27°F
Temperature resolution	0.009°F at 1-s sample rate
Temperature drift stability	<+/-0.1°F per year at 302
Max temperature	302°F

Table 13. *Representative Logging tool specifications.*

Specification	RST	CBL	USI	Isolation Scanner
Logging speed	1,800 ft/hr	3,600 ft/hr	Standard resolution: 2,700ft/hr High resolution: 563 ft/hr	Standard resolution: 2,700ft/hr High resolution: 563 ft/hr
Vertical resolution	15 inches	3 ft	Standard resolution: 0.6 in High speed: 6 in	High resolution: 0.6 in High speed: 6 in
Investigation	Formation	Casing, annulus, and formation	Casing and annulus	Casing and annulus
Temperature rating	302°F	350°F	350°F	350°F
Pressure rating	15,000 psi	20,000 psi	20,000 psi	20,000 psi

A.1.a Method Sensitivity

Tables 14 through 19 provide additional details on gauge specifications and sensitivities.

Table 14. *Pressure field gauge – injection tubing pressure.*

Specification	Sensitivity
Calibrated working pressure range	0 to 3000 psi and 4–20 mA
Initial pressure accuracy	< 0.04375%
Pressure resolution	0.001 psi and 0.00001 mA
Pressure drift stability	To be determined after first year

Table 15. *Pressure field gauge – annulus pressure.*

Specification	Sensitivity
Calibrated working pressure range	0 to 3000 psi and 4–20 mA

Initial pressure accuracy	< 0.02500%
Pressure resolution	0.001 psi and 0.00001 mA
Pressure drift stability	To be determined after first year

Table 16. *Pressure field gauge.*

Specification	Sensitivity
Calibrated working pressure range	0 to 3000 psi and 4–20 mA
Initial pressure accuracy	< 0.03125%
Pressure resolution	0.001 psi and 0.00001 mA
Pressure drift stability	To be determined after first year

Table 17. *Temperature field gauge – injection tubing temperature.*

Specification	Sensitivity
Calibrated working temperature range	0 to 500°F and 4–20 mA
Initial temperature accuracy	< 0.0055 %
Temperature resolution	0.001°F and 0.0001 mA
Temperature drift stability	To be determined after first year

Table 18. *Mass flow rate field gauge – CO_2 mass flow rate.*

Parameters1	Methods1
Compression discharge pressure	ANSI Z540-1-1994
Injection Tubing Temperature	ANSI Z540-1-1994
Annulus Pressure	ANSI/UL 61010-1 or ANSI/UL 61010-2-30
Injection Tubing Pressure	ANSI Z540-1-1994

A.2 Special Training/Certifications

A.2.a Specialized Training and Certifications

The geophysical survey equipment and wireline logging tools will be operated by trained, qualified, and certified personnel, as specified by the service company that provides the equipment. The subsequent data will be processed and analyzed in accordance with industry standards (Appendix B). No specialized certifications are required for personnel conducting groundwater sampling, but field sampling will be conducted by trained personnel. Groundwater sampling will be conducted by personnel trained to understand and follow the project-specific sampling procedures. Upon request, One Earth Sequestration, LLC will provide the agency with all laboratory SOPs for the specific parameter, developed using the appropriate standard method. Each laboratory technician conducting the analysis on the samples will be trained on the SOP developed for each standard method. One Earth Sequestration, LLC will include the technician's training certification with the biannual report.

A.5. b/c. Training Provider and Responsibility

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

A.3 Documentation and Records

A.3.a Report Format and Package Information

A semi-annual report from One Earth Sequestration, LLC to U. S. EPA will contain all required project data, including testing and monitoring information as specified by the UIC Class VI permit. Data will be provided in electronic or other formats as required by the UIC Program Director.

A.3.b Other Project Documents, Records, and Electronic Files

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

A.6. c/d. Data Storage and Duration

One Earth Sequestration, LLC, or a designated contractor, will maintain the required project data as provided elsewhere in the permit.

A.6.e. QASP Distribution Responsibility

The One Earth Sequestration, LLC VP of Technology and Special Projects will be responsible for ensuring that all those on the distribution list will receive the most current copy of the approved Quality Assurance and Surveillance Plan.

<u>B.1 Sampling Process Design (Experimental Design)</u>

Discussion in this section is focused on groundwater and fluid sampling and does not address monitoring methods that do not gather physical samples (e.g., logging, seismic monitoring, and pressure/temperature monitoring). During the pre-injection and injection phases, groundwater sampling is planned to include an extensive set of chemical parameters to establish aqueous geochemical reference data. Parameters will include selected constituents that: (1) have primary and secondary USEPA drinking water maximum contaminant levels, (2) are the most responsive to interaction with CO_2 or brine, (3) are needed for quality control, and (4) may be needed for geochemical modeling. The full set of parameters for each sampling interval is given in Tables 5 – 10. After a sufficient baseline is established, the monitoring scope may shift to a subset of indicator parameters that are (1) the most responsive to interaction with CO_2 or brine and (2) are needed for quality control.

Implementation of a reduced set of parameters would be done in consultation with the U. S. EPA. Isotopic analyses will be performed on baseline samples to the degree that the information helps verify a condition or establish an understanding of non-project related variations. For non-baseline samples, isotopic analyses may be reduced in all monitoring wells if a review of the historical project results or other data determines that further sampling for isotopic analyses is unnecessary. During any period where a reduced set of analytes is used, if statistically significant trends are observed that are the result of unintended CO_2 or brine migration, the analytical list would be expanded to the full set of monitoring parameters. The Ironton-Galesville groundwater samples will be analyzed by 3rd party using published analytical methods. Dissolved CO_2 will be analyzed by methods consistent with Test Method B of ASTM D 513-06, "Standard Test Methods for Total and Dissolved Carbon Dioxide in Water" or equivalent. Isotopic analysis will be conducted using established methods.

B.1.a Design Strategy

CO_2 Stream Monitoring Strategy

The primary purpose of analyzing the carbon dioxide stream is to evaluate the potential interactions of carbon dioxide 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 the determination of whether the injectate meets the qualifications of hazardous waste under the Resource Conservation and Recovery Act (RCRA), 42 U.S.C. 6901 et seq. (1976), and/or the Comprehensive Environmental Response, Compensation, and Liability Act, (CERCLA) 42 U.S.C. 9601 et seq. (1980). Additionally, monitoring the chemical and physical characteristics of the carbon dioxide (e.g., isotopic signature, other constituents) may help distinguish the injectate from the native fluids and gases if unintended leakage from the storage reservoir occurred. Injectate monitoring is required at a sufficient frequency to detect changes to any physical and chemical properties that may result in a deviation from the permitted specifications.

Calibration of transmitters used to monitor pressures, temperatures, and flow rates of CO_2 into the injection well at the injection well and at the verification well shall be conducted annually by a third-party vendor. Reports shall contain test equipment used to calibrate the transmitters, including test equipment manufacturers, model numbers, serial numbers, calibration dates and expiration dates.

Corrosion Monitoring Strategy

Corrosion coupon analyses will be conducted quarterly to aid in ensuring the mechanical integrity of the equipment in contact with the carbon dioxide. Coupons shall be sent quarterly to a company for analysis and an analysis conducted in accordance with NACE Standard RP-0775 (or similar) to determine and document corrosion wear rates based on mass loss.

Deep Groundwater Monitoring Strategy

Monitoring of the St. Peter sandstone (the lowermost USDW) and the Ironton-Galesville will be used for early leakage detection in formations that are much closer to the Mt. Simon injection reservoir. Fluid sampling at the St. Peter and ACZ wells in combination with pressure monitoring, temperature monitoring, and pulse neutron logging will be used to determine if leakage is occurring at or near the injection well. In addition, the Ironton-Galesville has sufficient permeability such that pressure monitoring would detect a failure of the confining zone should it occur. MIT testing and DTS monitoring at the injection well will also provide data to ensure the mechanical integrity of the injection wells are maintained. With the planned sampling and monitoring frequencies, it is expected that baseline conditions can be documented, natural variability in conditions can be characterized, unintended brine or CO_2 leakage could be detected if it occurred, and sufficient data will be collected to demonstrate that the effects of CO_2 injection are limited to the intended storage reservoir. No groundwater fluid sampling is planned for the Mt. Simon intervals where free-phase CO_2 has broken through.

ACZ Sampling

The ACZ verification well, OES ACZ#1, will be used to monitor the pressure and temperature in the Ironton-Galesville formation. This is above the Eau Claire Formation, the primary reservoir seal. This well will serve as an early leak detection system by allowing the operator to monitor for changes above the primary caprock. Groundwater samples will be collected and analyzed for constituents listed in Table 6 to document baseline fluid chemistry and to detect changes in fluid chemistry that could result from the movement of brine or CO_2 from the storage interval through the seal formation.

Lowermost USDW Sampling

ACZ (OES USDW#1) well will allow monitoring within the St. Peter sandstone, the lowermost USDW. This well will serve as an additional leak detection system by allowing the operator to monitor for changes above the primary caprock. The well will be equipped with a pressure and temperature monitoring system set within the perforated interval. Pressure and temperature will be continuously monitored and recorded. Groundwater samples will be collected and analyzed for constituents listed in Table 6 to document baseline fluid chemistry and to detect changes in fluid chemistry that could result from the movement of brine or CO_2 from the storage interval through the seal formation.

Injection Zone Monitoring

The stratigraphic test well OEE#1 will be converted to an injection zone monitoring well (IZM#1). A second in-zone well (IZM#2), location to be determined, is also planned for installation. The location will be identified after 5 years of injection operations or when 10 million tonnes have been injected at the site. The location will be determined from the plume's position using OEE1 data and the results of the first time-lapse 2D survey. The second in-zone monitoring well location will be proposed to the director following completion of the updated dynamic model. Upon the Director's concurrence, the well will be installed within 18 months.

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

Groundwater sampling frequencies are detailed in Table 1.
CO_2 gas stream and corrosion coupon) frequencies are detailed in Table 1.

B.1.c Site/Sampling Locations

ACZ wells, and the location of OEE#1 (in-zone monitoring well IZM#1) are shown on Figure 2 and noted in Section B.1.a. The location of the second IZM well is TBD as noted in Section B.1.a.

CO_2 gas stream and corrosion coupon sampling locations will occur in the compressor building after the last stage of compression.

B.1.d Sampling Site Contingency

The deep groundwater monitoring wells are located on the One Earth CCS project site or on land where One Earth Sequestration, LLC has access permissions have already been granted. No problems of site inaccessibility are anticipated. If inclement weather makes site access difficult, sampling schedules will be reviewed, and alternative dates may be selected that would still meet permit-related conditions.

No problems of site inaccessibility are anticipated for CO_2 gas stream or corrosion coupon sampling. If inclement weather makes site access difficult, sampling schedules will be reviewed, and alternative dates may be selected that would still meet permit-related conditions.

B.1.e Activity Schedule

The groundwater sampling activities and frequencies are summarized in Table 1.
The CO_2 gas stream and corrosion coupon sampling activities and frequencies are summarized in Table 1.

B.1.f Critical/Informational Data

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

B.1.g Sources of Variability

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

Activities to eliminate, reduce, or reconcile variability related to monitoring activities include (1) collecting long-term baseline data to observe and document natural variation in monitoring parameters, (2) evaluating data in timely manner after collection to observe anomalies in data that

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

B.2 Sampling Methods

Logging, geophysical monitoring, and pressure/temperature monitoring does not apply to this section and is omitted.

B.2. a/b Sampling SOPs

ACZ and IZM wells will be developed and purged at the time of completion. Prior to sampling, each zone will be purged to ensure representative samples are collected. Purge water will be disposed of in accordance with One Earth Sequestration, LLC policy for waste management

It is anticipated that air lifting with nitrogen may be used to draw fluid into the deep wells for purging. A gas lift valve will be placed in the tubing string at the time of completion. The sampler will be positioned at the same elevation as the discrete perforated interval, and a sample would be collected after sufficient purging.

B.2.c In-situ Monitoring

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

B.2.d Continuous Monitoring

Pressure data will be collected from ACZ and IZM wells on a periodic basis (e.g., hourly to daily) using pressure gauges, DTS, and DAS.

B.2.e Sample Homogenization, Composition, Filtration

Described in section B.2.b.

B.2.f Sample Containers and Volumes

For CO_2 stream monitoring, samples will be collected in a clean sample container rated for the appropriate collection pressure.

Assay for CO_2 Quarterly Gas Analysis:

- CO_2 Purity (% v/v, [GC])
- Oxygen (O_2, ppm v/v)
- Nitrogen (N_2, ppm v/v)
- Carbon Monoxide (CO, ppm v/v)
- Oxides of Nitrogen (NOx, ppm v/v)
- Total Hydrocarbons (THC, ppm v/v as CH4)
- Methane (CH_4, ppm v/v)
- Acetaldehyde (AA, ppm v/v)
- Sulfur Dioxide (SO_2, ppm v/v)
- Hydrogen Sulfide (H_2S ppm v/v)
- Ethanol (ppm v/v)
- Carbon Isotopes

All fluid sample bottles will be new. Sample bottles and bags for analytes will be used as received (ready for use) from the vendor or contract analytical laboratory for the analyte of interest. A summary of sample containers is presented in Table 20.

B.2.g Sample Preservation

No preservation is required or used for CO_2 gas stream, and additional details of sampling requirements are shown in Table 19. For groundwater and other aqueous samples, the preservation methods in Table 20 will be used.

Corrosion coupon sampling only requires that the coupons be physically separated (e.g., sleeves, baggies) during transportation to prevent physical abrasion.

Table 19. *Summary of sample containers, preservation treatments, and holding times for CO_2 gas stream analysis.*

Target Parameters	Volume/Container Material	PreservationTechnique	Sample Holding time(max)
CO_2 gas stream	2L MLB Polybags 75 cc MiniCylinder	Sample Storage Cabinets	5 Business Days

B.2.h Cleaning/Decontamination of Sampling Equipment

Wireline sampling equipment will be power washed prior to use at each monitoring well. As described in b.2.a/b the wells (and sampling equipment) will be purged until field parameters have stabilized. All field glassware (pipets, beakers, filter holders, etc.) are cleaned with tap water to remove any loose dirt, washed in a dilute nitric acid solution, and rinsed three times with deionized water before use.

CO_2 gas stream sampling containers will be either disposed of or decontaminated by the analytical lab.

No sampling equipment will be utilized with the corrosion coupons or annual field gauge calibrations.

B.2.i Support Facilities

For groundwater sampling, the following are required: an air compressor, a vacuum pump, a generator, a multi-electrode water-quality sonde, and analytical meters (pH, specific conductance, etc.). Field activities are usually conducted in field vehicles and on-site portable laboratory trailers.

Sampling tubing, connectors, and valves required to sample the CO_2 gas stream will be supplied by the analytical lab, which will also provide the sampling containers. Sampling will occur at the wellhead if possible, or at the surface facility discharge if necessary.

Similarly, corrosion coupons will be removed from the CO_2 injection line at the CO_2 compression building.

Field gauges will be removed from the injection well and verification well, utilizing existing standard industry tools and equipment. Deployment and retrieval of verification well gauges will be done using procedures and equipment recommended by the vendor, subcontractor, or is standard per industry practice.

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

Field staff will be responsible for properly testing equipment and performing corrective actions on broken or malfunctioning field equipment. If corrective action cannot be taken in the field, then equipment will be returned to the manufacturer for repair or replaced. Significant corrective actions affecting analytical results will be documented in field notes.

B.3 Sample Handling and Custody

Logging, geophysical monitoring, and pressure/temperature monitoring does not apply to this section and is omitted.

Each sample will be logged on a sampling form and will document the chain of custody. The form will note:

- Sampling date
- Location the sample was collected
- Type of container
- Sampler name and signature
- Other comments/notes
- Shipping information (name, address, and point of contact at laboratory, including phone number)
- Laboratory received by name and signature.

Sample holding times (Table 20) will be consistent with those described in US EPA (1974), American Public Health Association (APHA, 2005), Wood (1976), and ASTM Method D6517-00 (2005). After collection, samples will be placed in ice chests in the field and maintained thereafter at approximately 4°C until analysis. The samples will be maintained at their preservation temperature and sent to the designated laboratory within 24 hours. Analysis of the samples will be completed within the holding time listed in Table 20. As appropriate, alternative sample containers and preservation techniques approved by the UIC Program Director will be used to meet analytical requirements.

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

See Table 20.

B.3.b Sample Transportation

See description at the beginning of Section B.3.

B.3.c Sampling Documentation

Field notes will be collected for all groundwater samples collected. These forms will be retained and archived as reference. The sample documentation is the responsibility of groundwater sampling personnel.

An analysis authorization form shall be provided with each CO_2 gas stream sample provided for analysis.

B.3.d Sample Identification

All sample bottles will have waterproof labels with information denoting project, sampling date, sampling location, sample identification number, sample type (freshwater or brine), analyte, volume, filtration used (if any), and preservative used (if any). See Figure 4 for an example of a label.

Table 20. *Summary of anticipated sample containers, preservation treatments, and holding times.*

Target Parameters	Volume/Container Material	Preservation Technique	Sample Holding time	Relative Sampling Depth
Dissolved CO_2	60 ml/HDPE	Filtered, cool 4°C	14 days	Deep
Isotopes: $\delta^{34}S$	250 ml/HDPE	Filtered, cool 4°C	4 weeks	Deep
Isotopes: δD, $\delta^{18}O$, $\delta^{13}C$	60 ml/HDPE	Filtered, cool 4°C	4 weeks	Deep
Field Confirmation: Temperature, dissolved oxygen, specific conductance, pH	200 ml/glass jar	None	< 1 hour	Deep
Field Confirmation: Density	60 ml/HDPE	Filtered	< 1 hour	Deep

XXXX_X_X (fresh water)

01-15-2022

Metals, 60 ml, filtered, HNO_3

Figure 4. *Example label for groundwater sample bottles.*

B.3.e Sample Chain-of-Custody

For CO_2 stream analysis, an analysis authorization form (Figure 4) will accompany the sample to the labat which point a chain-of-custody accompanies the sample through their processes.

For groundwater samples, chain-of-custody will be documented using a standardized form. A typical form is shown in Figure 5, and it or a similar form will be used for all groundwater sampling. Copies of the form will be provided to the person/lab receiving the samples as well as the person/lab transferring the samples. These forms will be retained and archived to allow simplified tracking of sample status. The chain-of -custody form and record keeping is the responsibility of groundwater sampling personnel.

B.4 Analytical Methods

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

B.4.a Analytical SOPs

Analytical SOPs are referenced in Tables 5-8. Other laboratory-specific SOPs utilized by the laboratory will be determined after a contract laboratory has been selected. Upon request, One Earth Sequestration, LLC will provide the agency with all laboratory SOPs developed for the specific parameter using the appropriate standard method. Each laboratory technician conducting the analysis on the samples will be trained on the SOP developed for each standard method. One Earth Sequestration, LLC will include the technician's training certification with the biannual report.

B.4.b Equipment/Instrumentation Needed

Equipment and instrumentation are specified in the individual analytical methods referenced in Tables 5-8.

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 5-8 will be responsible for appropriately addressing analytical failure according to their individual SOPs.

B.4.e Sample Disposal

Each laboratory conducting the analyses in Tables 5-8 will be responsible for appropriate sample disposal according to their individual SOPs.

B.4.f Laboratory Turnaround

Laboratory turnaround time varies by laboratory, but generally, verified analytical results within 1 month are suitable for project needs.

B.4.g Method Validation for Nonstandard Methods

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

Airborne Labs International, Inc.

22C World's Fair Drive, Somerset, NJ 08873 Fax: 732-302-3035 Phone: 732-302-1950
E-mail: airbornelabs@aol.com Website: www.airbornelabs.com

Analysis Authorization

This form MUST be completed & returned with a sample shipment

1.) Report Results to*:

Company: ____________
Address: ____________
Address: ____________
Address: ____________
Address: ____________
Attention: ____________
Telephone: (____) ____________
Fax: (____) ____________
E-Mail: ____________

Sampled On (mm/dd/yy): ____________
P.O. #: ____________
Credit Card: Visa Amex MasterCard Discover
Card #: ____________
Cardholder: ____________
Exp. Date: ____________
Check #: ____________
Other: ____________
Pricing Discussed/Quoted? Y N

*Please attach complete billing address if different from reporting address.

2.) Number of Samples Submitted: ________ Container Type(s): ____________

3.) Sample Description (circle): Liquid CO_2 CO2 (Final) Vapor CO2 Feedgas* CO_2 In-Process
Food Grade CO_2 LIN LOX LAR RELOX (Reboiler) ABO

*If CO_2 Feedgas –Identify source (e.g. Ethanol/Ammonia/Nat. Well/Ethylene/Combustion, Self-Gen, etc.) ____________

Aviator Breathing Oxygen (ABO) Natural Gas Refinery Gas Syn Gas Propane Butane Air Oxygen
Nitrogen Argon Hydrogen Helium Neon Xenon Krypton Freon® Refrigerant
Gas Mixture Fuel Oil Lubricant
Other (Describe): ____________

4.) Sample Type (Check) : Industrial____ Medical______ MilSpec_____ Other_____
(attach a log for multiple samples)

5.) Sample ID: ____________

6.) Potential Hazards/Safety Issues: ____________

7.) Analytical Test(s) Requested (check program or select individual tests required where applicable):

Std ISBT/Vendor CO_2 Test Program_____ Std CO_2 Feedgas Program_____ Std CGA Test Program_____ Std Medical Gas______
Std Contract Program_____ Std ASTM Test Program____ MIL Spec Test Program____

%Purity THC CH_4 TNMHC Vol Hydrocarbons (C1-C5) BTEX Water Vapor NVR/NVOR Oil/Grease Total Sulfur H_2S SO_2
COS MeSH t-Butyl Mercaptan Vol Sulfur Compnds Odorants Total Nitrogen N_2 NO_x NH_3 NO NO_2 HCN Nitrous Oxide (N_2O)
PH_3 Oxygen Argon Hydrogen Helium CO CO_2 Xenon Neon Krypton Vinyl Chloride Acetaldehyde Vol Oxygenates GC/MS Scan
IR Scan IR Microscope Halogenated Hydrocarbons SF_6 Gas Mixture% Btu (Heat) Content % CHNO Sediment Wt Patch Test
Viscosity Flash/Fire Point Density Specific Gravity Trace Metals TAN TBN XRF SEM-XRF Scan Light Microscope

Other Testing: ____________

8.) Sample Disposition

Retain for ______ Period Perform Clean-up/Maintenance Actions & Return* ____ Report for Instructions ____

Other: ____________

*Supply all return address & shipping instructions

9.) Report Disposition (circle one): E-Mail Fax Mail Telephone Other: ____________
(Reports will be sent to the address & contact(s) specified at the top of this form)

10.) Priority Conditions (circle), Note: Additional fees will apply for non-std test scheduling:

Standard 2-Work Day 1-Work Day Same Day Emergency Other: ____________

Analytical testing cannot be performed unless this form is completed & returned

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Figure 5. *Example of CO_2 gas stream analysis authorization form.*

PRAIRIE RESEARCH INSTITUTE

CHAIN OF CUSTODY RECORD (Page __ of __)

Illinois State Water Survey – Analytical Services Group
Illinois State Geological Survey – Geochemistry Section

For Midwest Geological Sequestration Consortium (MGSC) Projects

	MGSC ID	ISGS MVA ID	Matrix	Date Collected	Time Collected	Sampling Team	Circle analyses to be performed
1							anions, cations, TDS, alk, NH_3, NVOC
2							anions, cations, TDS, alk, NH_3, NVOC
3							anions, cations, TDS, alk, NH_3, NVOC
4							anions, cations, TDS, alk, NH_3, NVOC
5							anions, cations, TDS, alk, NH_3, NVOC
6							anions, cations, TDS, alk, NH_3, NVOC
7							anions, cations, TDS, alk, NH_3, NVOC
8							anions, cations, TDS, alk, NH_3, NVOC
9							anions, cations, TDS, alk, NH_3, NVOC
10							anions, cations, TDS, alk, NH_3, NVOC
11							anions, cations, TDS, alk, NH_3, NVOC
12							anions, cations, TDS, alk, NH_3, NVOC
12							

CHAIN OF CUSTODY		
Relinquished by:	Print Name:	Date and Time:
Received by:	Print Name:	Date and Time:
General Remarks: - Field parameters are to be recorded on separate sheets by sampling teams. - Any special laboratory instructions or remarks should be made below.		
Data Contacts:	Fund:	
Billing Contact:	Billing Address:	
Send Data To:		

Remarks:

Rev. Oct. 2011 (RL)

Figure 6. *Example chain-of-custody form.*

B.5 Quality Control

Geophysical monitoring and pressure/temperature monitoring do not apply to this section and are omitted. For log quality control, please refer to Appendix B.

B.5.a QC activities

Blanks

Field blanks will be utilized for deep groundwater sampling and analyzed for the inorganic analytes in Tables 5 - 8 at a frequency of 10% or greater. Field blanks will be exposed to the same field and transport conditions as the groundwater samples. Field blanks will be used to detect contamination resulting from the collection and transportation process.

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 be done by evaluating the ratio of the measured total dissolved solids (TDS) to the calculated TDS (i.e., mass balance) per 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 interlaboratory results, if available. Suspect ion analyses are then brought to the attention of the analytical laboratory for confirmation and/or reanalysis. The ion balance is recalculated, and if the error is still not resolved, suspect data are identified and may be given less importance in data interpretations.

B.5.c Calculating Applicable QC Statistics

Charge Balance

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

$$\% \ difference = 100 \frac{(\Sigma cations + \Sigma anions)}{(\Sigma cations - \Sigma anions)} \qquad \text{(Equation 1)}$$

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:

$$1.0 < \frac{measured\ TDS}{calculated\ TDS} < 1.2, \qquad \text{(Equation 2)}$$

where the anticipated values are between 1.0 and 1.2.

Outliers
The determination of one or more statistical outliers is essential prior to the statistical evaluation of groundwater. This project will use the U. S. EPA's Unified Guidance (March 2009) as a basis for selecting recommended statistical methods to identify outliers in groundwater chemistry datasets, as appropriate. These techniques include Probability Plots, Box Plots, Dixon's test, and Rosner's test. The EPA-1989 outlier test can also serve as another screening tool to identify potential outliers.

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

Logging tool equipment will be maintained as per wireline industry best practices (Appendix B).

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

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

B.7 Instrument/Equipment Calibration and Frequency

Geophysical monitoring does not apply to this section and is omitted.

B.7.a Calibration and Frequency of Calibration

Pressure/temperature gauge calibration information is in Table 12 and Tables 14 - 18. Logging tool calibration will be at the discretion of the service company providing the equipment, in accordance with standard industry practices outlined in Appendix B.

For groundwater sampling, portable field meters or multiprobe sondes used to determine field parameters (e.g., pH, temperature, specific conductance, dissolved oxygen) are calibrated according to manufacturer recommendations and equipment manuals (Hach, 2006) each day before sample collection begins. Recalibration is performed if any components yield atypical values or fail to stabilize during sampling.

B.7.b Calibration Methodology

Logging tool calibration methodology will follow standard industry practices in Appendix B.

For groundwater sampling, standards used for calibration are typically 7 and 10 for pH, a potassium chloride solution yielding a value of 1413 microseimens per centimeter (µS/cm) at 25°C for specific conductance, and a 100% dissolved O2 solution for dissolved oxygen. Calibration is performed for the pHmeters per manufacturer's specifications using a 2-point calibration bounding the range of the sample. For coulometry, sodium carbonate standards (typically yielding a concentration of 4,000 mg CO_2/L) are routinely analyzed to evaluate instrument precision.

B.7.c Calibration Resolution and Documentation

Logging tool calibration resolution and documentation will follow standard industry practices in Appendix B.

For groundwater sampling, calibration values are recorded in daily sampling records, and any errors in calibration are noted. For parameters where calibration is not acceptable, redundant equipment may be used so loss of data is minimized.

B.8 Inspection/Acceptance for Supplies and Consumables

B.8.a/b. Supplies, Consumables, and Responsibilities

Supplies and consumables for field and laboratory operations will be procured, inspected, and accepted as required from vendors approved by One Earth Sequestration, LLC, or the respective subcontractor responsible for the data collection activity. Acquisition of supplies and consumables related to groundwater analyses will be the responsibility of the laboratory per established standard methodology or operating procedures.

B.9 Nondirect Measurements

Seismic Monitoring Methods

B.9.a Data Sources

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

B.9.b Relevance to Project

Time lapse seismic surveys will be used to track changes in the CO_2 plume in the subsurface. Processing and comparing subsequent surveys to a baseline will allow project managers to monitor plume growth, as well as to ensure that the plume does not move outside of the intended storage reservoir. Numericalmodeling will be used to predict the CO_2 plume growth and migration over time by combining the processed seismic data with the existing geologic model.

In-zone pressure monitoring data will be used in numerical modeling to predict plume and pressure front behavior and confirm the plume stage within the AOR.

B.9.c Acceptance Criteria

Following standard industry practices will ensure that the gathered seismic data will be used for accurate modeling and monitoring. Similar ground conditions shot points located within tolerable limits,functional geophones, and similar seismic input signal will be used from survey to survey to ensure repeatability.

When processing seismic data, several QA checks will be done in accordance with industry standards including reformatting to Omega structured files, geometry application, amplitude compensation, predictive deconvolution, elevation statics correction, RMS amplitude gain, velocity analysis every 2 km, NMO application using picked velocities, CMP stacking, random noise attenuation, and instantaneous gain.

B.9.d Resources/Facilities Needed

One Earth Sequestration, LLC will subcontract all necessary resources and facilities for seismic monitoring, in-zone pressure monitoring, and groundwater sampling.

B.9.e Validity Limits and Operating Conditions

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

B.10 Data Management

B.10.a Data Management Scheme

One Earth Sequestration, LLC, or a designated contractor, will maintain the required project data as provided elsewhere in the permit. Data will be backed up on tape or held on secure servers.

B.10.b Record-keeping and Tracking Practices

All records of gathered data will be securely held and properly labeled for auditing purposes.

B.10.c Data Handling Equipment/Procedures

All equipment used to store data will be properly maintained and operated according to proper industry techniques. One Earth Sequestration, LLC SCADA system and vendor data acquisition systems will interface with one another, and all subsequent data will be held on a secure server.

B.10.d Responsibility

The primary project managers will be responsible for ensuring proper data management is maintained.

B.10.e Data Archival and Retrieval

All data will be held by One Earth Sequestration, LLC. These data will be maintained and stored for auditing purposes as described in section B. 10. a.

B.10.f Hardware and Software Configurations

All One Earth Sequestration, LLC and vendor hardware and software configurations will be appropriately interfaced.

B.10.g Checklists and Forms

Checklists and forms will be procured and generated as necessary.

C. Assessment and Oversight

C.1 Assessments and Response Actions

C.1.a Activities to be Conducted

Please refer to Table 1 in section A.3.a/b. (Summary of work to be performed and work schedule); groundwater quality data will be collected at the frequency outlined in that table. After completion of sample analysis, results will be reviewed for QC criteria as noted in section B.5. If the data quality fails to meet criteria set in section B.5., samples will be reanalyzed, if still within holding time criteria. If outside of holding time criteria, additional samples may be collected, or sample results may be excluded from data evaluations and interpretations. Evaluation of data consistency will be performed according to the procedures described in the U.S. EPA 2009 Unified Guidance (USEPA, 2009).

C.1.b Responsibility for Conducting Assessments

Organizations gathering data will be responsible for conducting their internal assessments. All stop work orders will be handled internally within individual organizations.

C.1.c Assessment Reporting

All assessment information should be reported to the individual organizations' project manager, as outlined in A.1.a/b.

C.1.d Corrective Action

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

C.2 Reports to Management

C.2. a/b. QA status Reports

QA status reports should not be needed. If any testing or monitoring techniques are changed, the QASP will be reviewed and updated as appropriate in consultation with U. S. EPA. Revised QASPs will be distributed by One Earth Sequestration, LLC to the full distribution list 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

Groundwater quality data validation will include the review of the concentration units, sample holding times, and the review of duplicate, blank, and other appropriate QA/QC results. All groundwater quality results will be entered into a database or spreadsheet with periodic data review and analysis. One Earth Sequestration, LLC will retain copies of the laboratory analytical test results and/or reports. Analytical results will be reported on a frequency based on the approved UIC permit conditions. In the periodic reports, data will be presented in graphical and tabular formats as appropriate to characterize general groundwater quality and identify intrawell variability with time. After sufficient data have been collected, additional methods, such as those described in the U. S. EPA 2009 Unified Guidance (USEPA, 2009), will be used to evaluate 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 Method

D.2.a Data Verification and Validation

Process. See Sections D.1.a. and B.5.

Appropriate statistical software will be used to determine data consistency.

D.2.b Data Verification and Validation Responsibility

One Earth Sequestration, LLC or its designated subcontractor will verify and validate groundwater sampling data.

D.2.c Issue Resolution Process and Responsibility

One Earth Sequestration, LLC or its designated Coordinator will overview the groundwater data handling, management, and assessment process. Staff involved in these processes will consult with the coordinator to determineactions required to resolve issues.

D.2.d Checklist, Forms, and Calculations

Checklists and forms will be developed specifically to meet permit requirements. Table 21 provides anexample of the type of information used for data verification of groundwater quality data.

Table 21. *Example table of criteria used to evaluate data quality.*

Well ID	Anion charge	Cation charge	Charge balance	CB rating	Calculated TDS	Measured TDS	TDS ratio	TDS rating
IZM#1	14.4	13.60	-2.84	pass	760.50	785	1.0	pass
IZM#2	14.26	15.06	2.73	pass	783.03	777	1.0	pass
OES USDW#1	14.39	14.96	1.94	pass	786.86	806	1.0	pass
OES ACZ#1	14.39	14.79	1.38	pass	780.15	777	1.0	pass

D.3 Reconciliation with User Requirements

D.3.a Evaluation of Data Uncertainty

Statistical software will be used to determine groundwater data consistency using methods consistent with U. S. EPA 2009 Unified Guidance (USEPA, 2009).

D.3.b Data Limitations Reporting

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

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Wood, W.W., 1976, Guidelines for collection and field analysis of groundwater samples for selected unstable constituents, In U.S. Geological Survey, Techniques for Water Resources Investigations, ChapterD-2, 24 p.

Appendices (See pdf files)

<u>APPENDIX A. Examples of DTS, DAS, and Down-hole Pressure Gauge Information</u>

(See Attached)

<u>APPENDIX B. Example of Wireline Log Quality Control *</u>

(See Attached)

<u>*Wireline Quality Control Reference Manual (LQCRM) included with permission of Schlumberger.</u>

One Earth CCS

Class VI Injection Well: Quality Assurance and Surveillance Plan

September 2022
Modified 2026

Submitted by:
One Earth Sequestration, LLC

Table of Contents

Title and Approval Sheet

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

Signature Mark Ditsworth VP of Technology and Special Projects	Date
Signature [TBD] [OES CO_2 Unit Manager]	Date
Signature [TBD] [OEE Ethanol Plant Operations Manager]	Date

Distribution List

The following project participants should receive the completed Quality Assurance and Surveillance Plan(QASP) and all future updates for the duration of the project. The One Earth Sequestration, LLC VP of Technology and Special Projects (see contact information below) will be responsible for ensuring that all those on the distribution list will receive the most current copy of the approved Quality Assurance and Surveillance Plan.

One Earth Sequestration, LLC
OES CO_2 Unit Manager
OEE Ethanol Plant Operations Manager
OEE Ethanol Plant Environmental Manager
Third Party Contractors TBD

One Earth Sequestration, LLC
Contact: Mark Ditsworth
VP of Technology and Special Projects,
One Earth Sequestration, LLC.
202 N Jordan Drive, Gibson City, IL. 60936
(217) 784-5321 ext. 215

A. Project Management

A.1 Project/Task Organization

A.1. a/b. Key Individuals and Responsibilities

The project, led by One Earth Sequestration, LLC, includes participation from several subcontractors. The Testing and Monitoring Activities responsibilities will be shared between One Earth Sequestration, LLC, and its designated subcontractor. The monitoring program includes six subcategories:

1) Deep Groundwater Monitoring
2) Well Logging
3) Mechanical Integrity Testing (MIT)
4) Pressure/Temperature Monitoring
5) CO_2 Stream Analysis
6) Geophysical Monitoring

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

Most of the physical samples collected and data gathered as part of the monitoring program will be acquired, analyzed, processed, or witnessed by third parties independently and outside of the project management structure.

A.1.d QA Project Plan Responsibility

One Earth Sequestration, LLC will be responsible for maintaining and distributing the official, approved QA Project Plan. One Earth Sequestration, LLC will periodically review this QASP and consult with U. S. EPA if/when changes to the plan are warranted.

A.1.e Organizational Chart for Key Project Personnel

Figure 1 shows the organizational structure of the project. One Earth Sequestration, LLC will provide the UIC Program Director with a contact list of individuals fulfilling these roles.

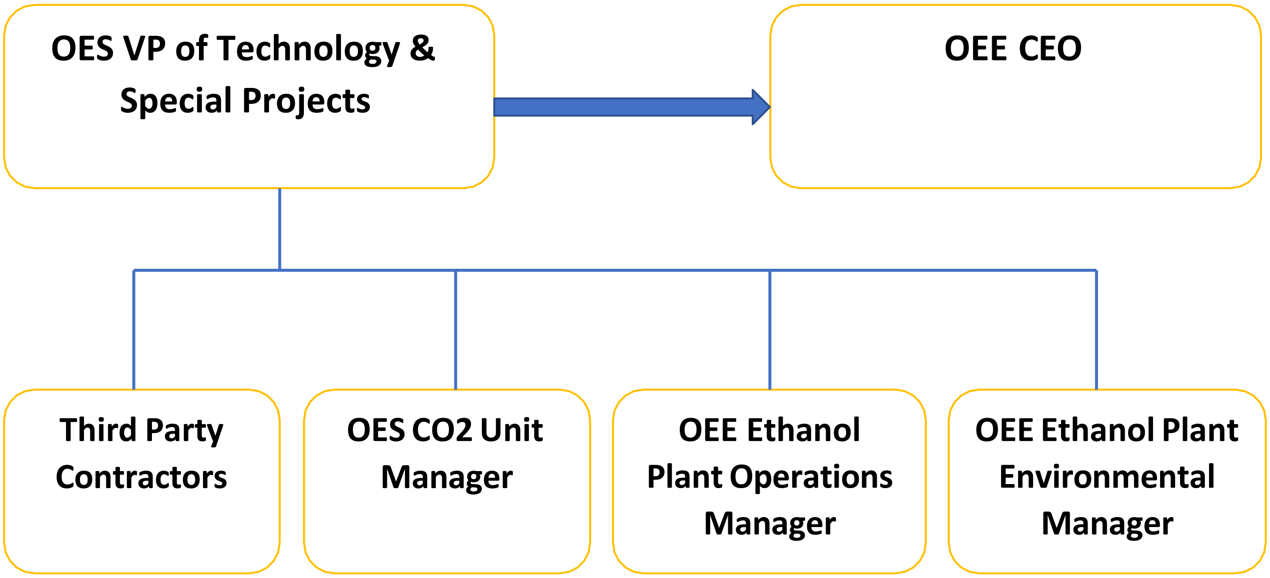

Figure 1. *One Earth Sequestration, LLC organization structure.*

A.2 Problem Definition/Background

A.2.a Reasoning

The One Earth CCS monitoring program has operational monitoring, verification, and environmental monitoring components. Operational monitoring is used to ensure safety with procedures associated with fluid injection monitoring the response of the storage unit, and the movement of the CO_2. Key monitoring parameters include the pressure of injection well tubing & annulus, storage unit, above seal strata, and the lowermost USDW reservoir. Other monitoring parameters include injection rate, total mass & volume injected, and injection well temperature profile. The verification component will provide information to evaluate whether CO_2 is leaking through the caprock. This includes pulse neutron logging, pressure, and temperature monitoring, acoustic monitoring, repeat 2D seismic monitoring, and groundwater sampling and analysis.

A robust monitoring program has been developed for the One Earth CCS project. The primary goal of the One Earth CCS monitoring program is to demonstrate that project activities are protective of human health and the environment. To help achieve this goal, this Quality Assurance Surveillance Plan (QASP) was developed to ensure that the testing and monitoring program meets the quality standards required by the U.S. Environmental Protection Agency's (USEPA) Underground Injection Control (UIC) Program for Class VI wells.

A.2.b. Reasons for Initiating the Project

The goal of the One Earth CCS project is to inject and retain industrial-scale volumes of CO_2 for permanent geologic sequestration in the Mt Simon Sandstone and to reduce atmospheric concentrations of CO_2. To demonstrate that this is done safely, a rigorous monitoring plan is proposed to ensure the injected CO_2 is retained within the storage reservoir.

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

The Class VI Rule requires owners or operators of Class VI wells to perform several types of activities during the lifetime of the project to ensure that the injection well maintains its mechanical integrity, that fluid migration and the extent of pressure elevation are within the limits described in the permit application, and that underground sources of drinking water (USDWs) are not endangered. These monitoring activities include mechanical integrity tests (MITs), injection well testing during operation, monitoring of ground water quality in several zones, tracking of the CO_2 plume and associated pressure front. This document details both the measurements that will be taken as well as the steps to ensure that the quality of the data is such that the data can be used with confidence in making decisions during the life of the project.

A.3 Project/Task Description

A.3. a/b. Summary of Work to be Performed and Work Schedule

Table 1 describes the Testing and Monitoring tasks, reasoning, responsible parties, locations, and testing frequency. Tables 2 and 3 summarize the instrumentation and geophysical surveys, respectively.

Table 1. *Summary of testing and monitoring direct measurements.*

Parameter	Location	Method	Frequency			Analytical Technique	Lab and Custody	Purpose
			Pre-injection Baseline	Operation Period	PISC Period			
CO_2 Injectate compositional and Isotopic Analysis	After CO_2 dehydration	Direct sampling	Once	Quarterly	None	Chemical analysis	TBD	Monitor injectate
Injection rate and volume	After compression	Flow meter	N/A	Continuous	N/A	Direct measurement	N/A	Monitor rate and volume
Injection pressure	Injection wellheads	Pressure gauge	N/A	Continuous	N/A	Direct measurement	N/A	Monitor injection pressure
Annular pressure	Injection wellheads	Pressure gauge	N/A	Continuous	N/A	Direct measurement	N/A	Monitor annular pressure
DTS Fiber Optic Temperature	ACZ and IZM Wells	Fiber optic cable	Continuous	Continuous	Continuous	Direct measurement	N/A	Storage integrity
DAS Fiber Optic Seismic	ACZ and IZM Wells	Fiber optic cable	Continuous	Continuous	Continuous	Direct measurement	N/A	Storage integrity
Downhole pressure and temperature	IZM Wells	Downhole gauge	N/A	Continuous	Continuous	Direct measurement	N/A	Monitor reservoir and Model validation
Corrosion monitoring	After compression	Coupon	N/A	Quarterly years 1 and 2; annually thereafter	N/A	Physical analysis	TBD	Monitor injection well and pipeline integrity
Mechanical Integrity	Injection Wells	Various	Prior to the operation	Annually	Prior to P/A	§ 146.87 (a)(4) § 146.89 (c)(2)	N/A	Monitor injection, well integrity
DTS/DAS Fiber Optic	Injection Wells (above perforations)	Fiber optic cables	Continuous	Continuous	Prior to P/A	Direct measurement	N/A	Injection well integrity; storage integrity; Continuous plume adjacent temperature and acoustic monitoring for model validation and plume behavior evaluation
Cement evaluation	Injection Wells	Logging	Baseline	N/A	N/A	Cement evaluation log	N/A	Injection well integrity
Pressure fall off testing	Injection Wells Mt. Simon arkosic zone	Pressure gauge	Once	Every five years and at the end of the injection period.	N/A	Direct measurement	N/A	Formation hydrogeologic conditions; injection well integrity

Table 1a. *Summary of testing and monitoring – direct measurements (continued).*

Level	Location Depth**	Method	Frequency			Analytical Technique	Parameters	Purposes
			Pre-injection Baseline	Operation Period	PISC Period			
ACZ - Lowermost USDW – St. Peter Sandstone	OES USDW #1 Depth ~2,215 – 2,447 ft.	*Swab valve or other method	Minimum 1 year Quarterly	Annually	Annually	Chemical analysis	Table 5	Detection of changes in groundwater quality in lowermost USDW.
ACZ - Above confining zone - Ironton-Galesville	OES-ACZ #1 and ACZ #2 Depth ~3,733 – 3,921 ft	*Swab valve or other method	1 sample	Annually	Annually	Chemical analysis	Table 6	Detection of changes in groundwater quality for the reservoir directly above the confining zone.
IZM – Mt. Simon Sandstone	IZM#1 Depth ~ 4,455 – 6,469 ft IZM #2 Depth TBD	*Swab valve or other method	1 sample	Annually.	None	Chemical analysis	Table 7	Detection of changes in groundwater quality, geochemical monitoring, and CO_2 detection in storage reservoir.

Notes

* Samples collected using a downhole sampling tool run into the well on wireline.

* Swab samples collected at the surface after the well has been swabbed with ample volume to ensure reservoir fluid at the surface. Fluid sampling will be discontinued at each respective monitoring well once there is a breakthrough of CO_2 in the well(s)

***Depth based on formation interval at OEE#1; actual perforation depths TBD.*

Table 1b. *Summary of testing and monitoring indirect CO_2 plume tracking.*

Method	Location	Pre-injection Baseline	Operation Period	PISC Period	Purpose
Pulsed Neutron Logging	Injection and AZM and IZM Wells	Once	Annually	Annually	Plume Location
Time-lapse 2D	Injection area	Baseline survey	1st after 4 years of injection, 2nd after 9 years of injection, Every 10 Mt thereafter	Initial PISC survey 5 years from most recent. Additional PISC survey 9 years after the end of injection	Indirect measurement of plume size

Table 2. *Instrumentation summary. T = temperature; P = Pressure; DTS = Distributed Temperature System; DAS = Distributed Acoustic System; F = Flow.*

			Operational Period		**PISC Period**		
Monitoring Location	**Instrument Type**	**Monitoring Target (Formation or Other)**	**Data Collection Location(s)**	**Frequency**	**Data Collection Location(s)**	**Frequency**	**Explanation**
CO_2 Facility	T, P, F	Surface	Discharge High-Pressure Pumps	Continuous	Discharge high pressure pumps	NA	Monitoring the operational, equipment, and permit parameters
Injection wells and IZM wells	DTS and DAS	All strata	Pending final completion	Continuous	Pending final completion	Continuous until P&A (minimum one year)	Used for operational monitoring, well integrity, seismicity detection, and evaluation of CO_2 plume behavior adjacent to the wells
	T, P	Mt. Simon injection zone	Pending final completion	Continu ous	Pending final completion	Continuous until P&A (minimum one year)	Monitoring operational and equipment parameters
ACZ Wells	T, P	Ironton Galesville	Pending final completion	Continuous	Pending final completion	None	Monitoring seal formation integrity
		Lowermost USDW – St. Peter	Pending final completion	Continuous	Pending final completion	None	Monitoring seal formation integrity

Table 3. *Well logging surveys summary.*

Monitoring Activity	Well	Tools or Survey Description	Pre-Injection - Baseline	Operation Period	PISC Period	Explanation
Wireline Logging	ACZ and IZM Wells	Cement evaluation tool	1 Baseline	None	None	Mechanical Integrity
		Pulse neutron	1 Baseline	Annually	Annually	Fluid movement, salinity, CO_2 detection, and mechanical integrity
	Inj wells	Pulse neutron	1 Baseline	Annually	Annually until P&A	Fluid movement, salinity, CO_2 detection, and mechanical integrity
		Casing inspection	1 Baseline	None	None	Mechanical Integrity
		Cement evaluation tool	1 Baseline	None	None	Mechanical Integrity

A.3.c. Geographic Locations

Figure 2 shows the One Earth CCS site and monitoring infrastructure. Table 4 summarizes the injection and monitoring wells. Figure 3 shows the location of the 2D lines acquired as part of site characterization. The repeat 2D seismic will follow Line 1 and the 2019 Gibson line.

Table 4. *One Earth CCS project well summary.*

Well Type	Well ID	Notes
Injection	OES #1	
	OES #2	
	OES #3	
In-Zone Monitoring (IZM)	IZM #1	Convert stratigraphic test well OEE #1
	IZM #2	Mt Simon Sandstone completion
Above-Confining-Zone Monitoring	OES ACZ #1 OES ACZ #2	Ironton Galesville completion
USDW Monitoring	OES USDW #1	St. Peter Sandstone completion
Geophysical monitoring instrumentation in project wells (DAS/DTS)	OES #1 OES #2 OES #3 IZM #1 IZM #2 OES ACZ #1 OES ACZ #2 OES USDW #1	Permanent array in project wells

A.3.d. Resource and Time Constraints

No resource or time constraints have been identified for the One Earth CCS project testing and monitoring plan beyond the proposed timeline.

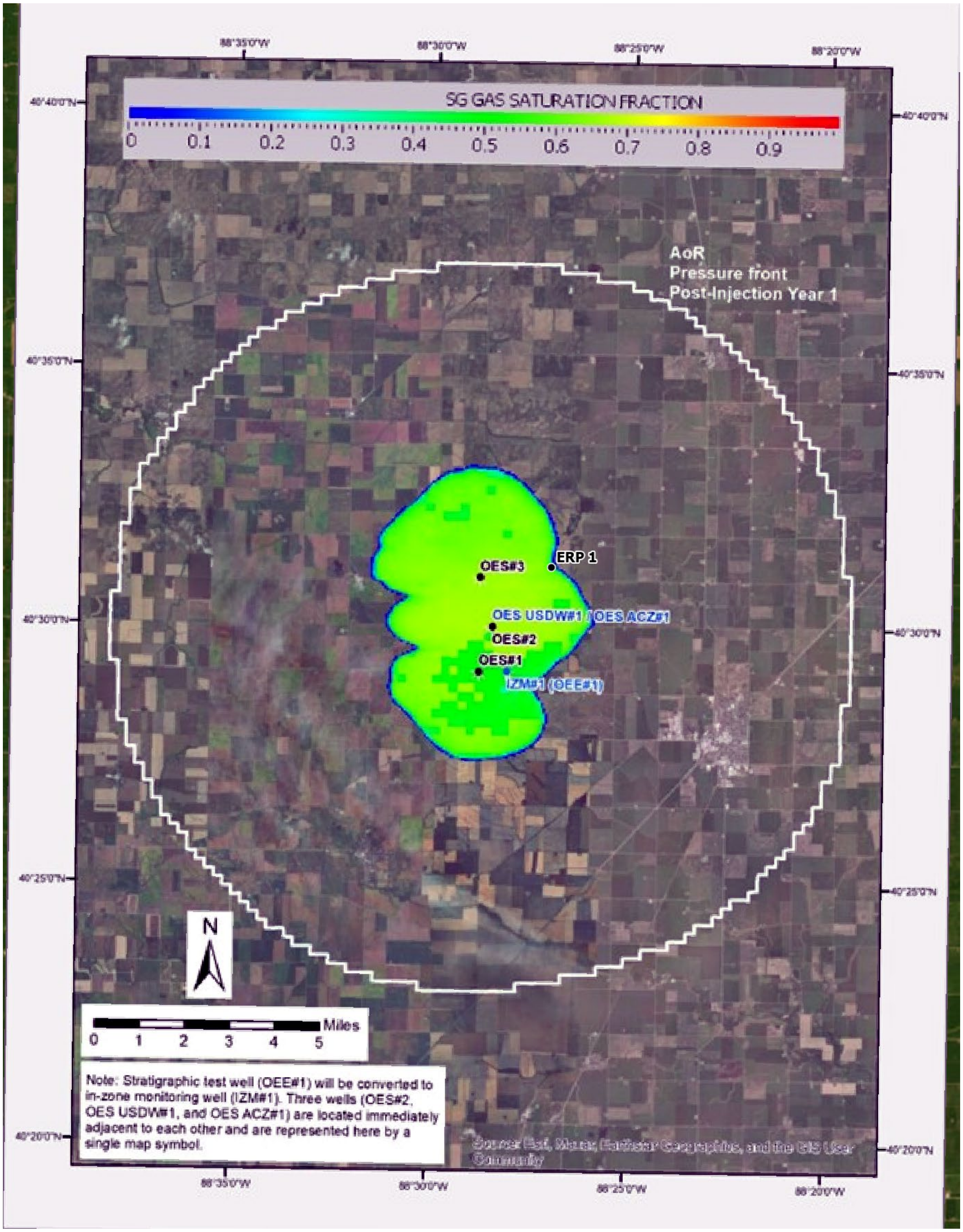

Figure 2. *One Earth CCS area showing location of ACZ #1 and IZM #1 monitoring wells. Pressure front is indicated by the white line, and maximum* CO_2 *saturation plume is shown in green with blue border.*

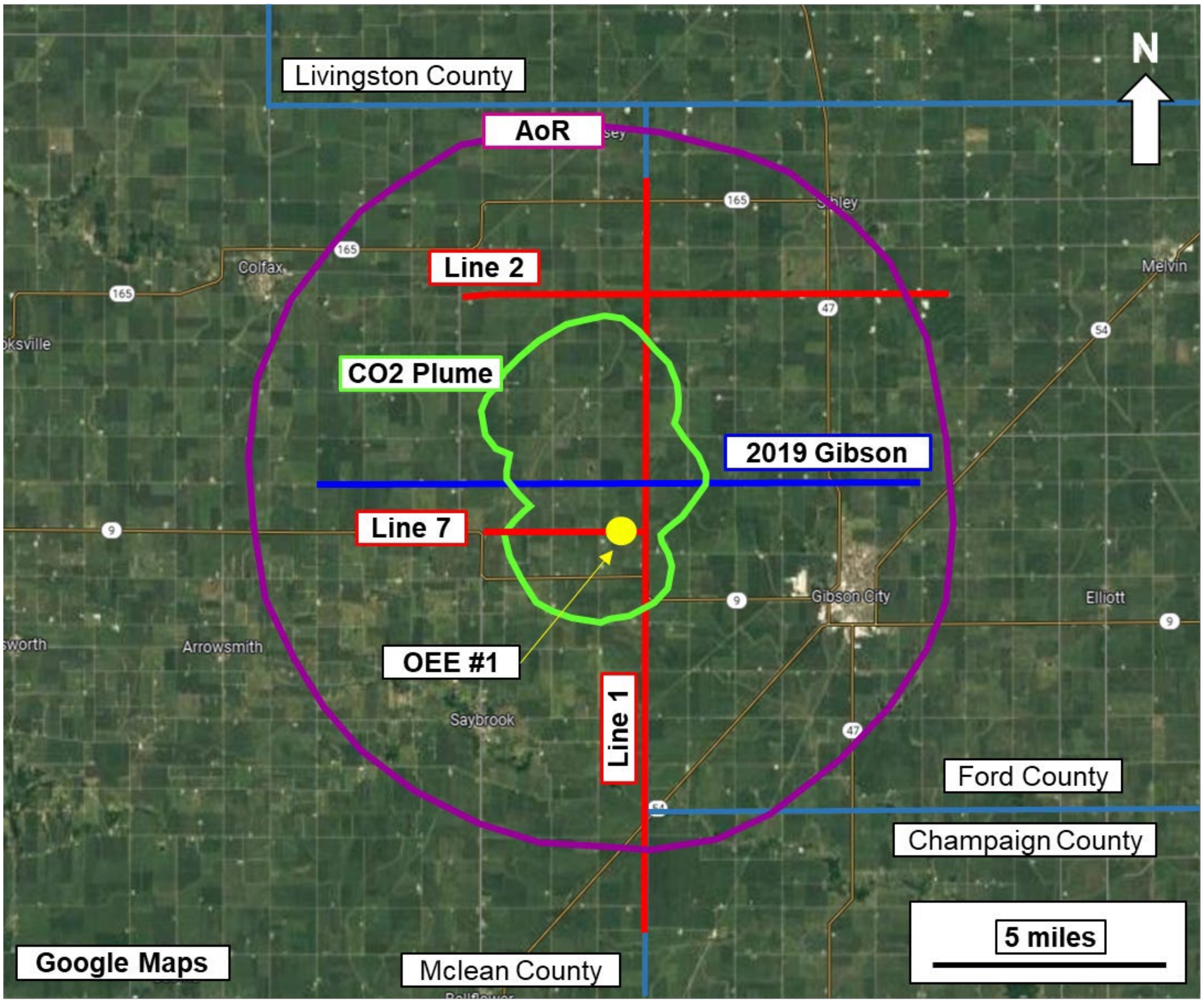

Figure 3. *2D seismic lines acquired during site characterization. Note CO_2 plume (in green) and AoR (purple) outlines have been generalized.*

A.4 Quality Objectives and Criteria

A.4.a Performance/Measurement Criteria

The overall QA objective for monitoring is to develop and implement procedures for subsurface monitoring, field sampling, laboratory analysis, and reporting that will provide results that meet the characterization and non-endangerment goals of this project. Groundwater monitoring will be conducted during the pre-injection, injection, and post-injection phases of the project. Deep groundwater monitoring wells will be used to gather water-quality samples and pressure data. All groundwater analytical and field-monitoring parameters for each interval are listed in Tables 5-8. Tables 9 and 10 show analytical parameters for CO_2 stream gas monitoring, corrosion coupon assessment, and gauge specifications. Table 11 shows the monitoring outputs.

The list of analytes may be reassessed periodically and adjusted to include or exclude analytes based on their effectiveness to the overall monitoring program goals.

Key testing and monitoring areas include:

1. Formation Fluid Sampling
    a. Aqueous chemical concentrations
2. Well Logging
    a. pulse neutron
3. Mechanical Integrity Testing (MIT)
    a. Pulsed neutron, temperature, cement evaluation logging
4. Pressure/Temperature Monitoring
    a. Pressure/temperature from in-situ gauges and DTS
    b. Pressure/temperature from surface gauges
5. Acoustic monitoring - DAS
    a. Well Integrity
    b. Seismic monitoring
6. CO_2 Stream Analysis
    a. CO_2 Purity (% v/v, [GC])
    b. Other trace components
    c. Carbon Isotopes
7. Geophysical Monitoring
    a. Seismic data files
    b. Processed time-lapse report
8. Fiber-Optic Monitoring (DTS/DAS)
    a. Continuous distributed temperature sensing (DTS) measurements for detection of thermal anomalies associated with CO_2 movement
    b. Distributed acoustic sensing (DAS) for detection of acoustic/strain signatures related to plume migration, pressure dissipation, and geomechanical response
    c. Integration of DTS/DAS data with pulsed neutron logs, pressure monitoring, and seismic surveys to support plume tracking and model validation

Table 5. *Summary of analytical and field parameters for lowermost USDW (St. Peter) groundwater samples. A designated third-party laboratory will perform all analyses. ICP = inductively coupled plasma; MS = mass spectrometry; OES = optical emission spectrometry; GC-P = gas chromatography-pyrolysis.*

Parameters	Analytical Methods[(1)]	Detection Limit/Range	Typical Precisions	QC Requirements
Cations: Al, Ba, Mn, As, Cd, Cr, Cu, Pb, Sb Se, and Tl	ICP-MS, EPA Method 6020	0.001 to 0.1 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-OES, EPA Method 6010B	0.005 to 0.5 mg/L (Analyte, dilution, and matrix dependent)	±15%	Daily calibration; blanks, duplicates, and matrix spikes at 10% or greater frequency
Anions: Br, Cl, F, NO3, and SO4	Ion Chromatography, EPA Method 300.0	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 D513-11	25 mg/L	±15%	Duplicate measurement; standards at10% or greater frequency
Isotopes: $\delta^{13}C$ of DIC	Isotope ratio mass spectrometry[2]	12.2 mg/L HCO3- for δ13C	±0.15‰ for $\delta^{13}C$	10% duplicates; 4 standards/batch
Total Dissolved Solids	Gravimetry; APHA 2540C	12 mg/L	±10%	Balance calibration, duplicate analysis
Water Density(field)	Oscillating body method	0.0000 to 2.0000	±0.0002 g/mL	Duplicate measurements
Alkalinity	APHA 2320B	4 mg/L	±3 mg/L	Duplicate analysis
pH (field)	EPA 150.1	2 to 12 pH units	±0.2 pH unit	User calibration per manufacturer recommendation
Specific conductance (field)	APHA 2510	0 to 200 mS/cm	±1% of reading	User calibration per manufacturer recommendation
Temperature (field)	Thermocouple	-5 to 50°C	±0.2°C	Factory calibration

Note 1: An equivalent method may be employed with the prior approval of the UIC Program Director.
Note:2: Gas evolution technique by Atekwana and Krishnamurthy (1998), with modifications made by Hackley et al. (2007)

Table 6*. Summary of analytical and field parameters for Ironton-Galesville groundwater samples. Note: cation, anion, TDS, and alkalinity measurements will be performed by a third-party laboratory using published analytical methods. Isotope and dissolved CO_2 analyses will be performed by a designated laboratory. ICP = inductively coupled plasma; MS = mass spectrometry; OES = optical emission spectrometry; GC-P = gas chromatography-pyrolysis.*

Parameters	Analytical Methods[(1)]	Detection Limit/Range	Typical Precisions	QC Requirements
Cations: Al, Ba, Mn, As, Cd, Cr, Cu, Pb, Sb, Se,and Tl	ICP-MS, EPA Method 6020	0.001 to 0.1 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-OES, EPA Method 6010B	0.005 to 0.5 mg/L (Analyte, dilution, and matrix dependent)	±15%	Daily calibration; blanks, duplicates, and matrix spikes at 10% or greater frequency
Anions: Br, Cl, F, NO_3, and SO_4	Ion Chromatography,EPA Method 300.0	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 D513-11	25 mg/L	±15%	Duplicate measurement; standards at10% or greater frequency
Isotopes: $\delta^{13}C$ of DIC	Isotope ratio mass spectrometry[2]	12.2 mg/L HCO3- for δ13C	±0.15‰ for $\delta^{13}C$	10% duplicates; 4 standards/batch
Total Dissolved Solids	Gravimetry; APHA 2540C	12 mg/L	±10%	Balance calibration, duplicate analysis
Water Density(field)	Oscillating body method	0.0000 to 2.0000	±0.0002 g/mL	Duplicate measurements
Alkalinity	APHA 2320B	4 mg/L	±3 mg/L	Duplicate analysis
pH (field)	EPA 150.1	2 to 12 pH units	±0.2 pH unit	User calibration per manufacturer recommendation
Specific conductance (field)	APHA 2510	0 to 200 mS/cm	±1% of reading	User calibration per manufacturer recommendation
Temperature (field)	Thermocouple	-5 to 50°C	±0.2°C	Factory calibration

Note 1: An equivalent method may be employed with the prior approval of the UIC Program Director.
Note:2: Gas evolution technique by Atekwana and Krishnamurthy (1998), with modifications made by Hackley et al. (2007).

Table 7*. Summary of analytical and field parameters for Mt. Simon groundwater samples. All analyses will be performed by a designated third-party laboratory. ICP = inductively couple plasma; MS = mass spectrometry; OES = optical emission spectrometry; GC-P = gas chromatography-pyrolysis.*

Parameters	**Analytical Methods**[1]	**Detection Limit/Range**	**Typical Precisions**	**QC Requirements**
Cations: Al, Ba, Mn, As, Cd, Cr, Cu, Pb, Sb Se,and Tl	ICP-MS, EPA Method 6020	0.001 to 0.1 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-OES, EPA Method 6010B	0.005 to 0.5 mg/L (Analyte, dilution, and matrix dependent)	±15%	Daily calibration; blanks, duplicates, and matrix spikes at 10% or greater frequency
Anions: Br, Cl, F, NO3, and SO4	Ion Chromatography,EPA Method 300.0	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 D513-11	25 mg/L	±15%	Duplicate measurement; standards at10% or greater frequency
Isotopes: $\delta^{13}C$ of DIC	Isotope ratio mass spectrometry[2]	12.2 mg/L HCO3- for δ13C	±0.15‰ for $\delta^{13}C$	10% duplicates; 4 standards/batch
Total Dissolved Solids	Gravimetry; APHA 2540C	12 mg/L	±10%	Balance calibration, duplicate analysis
Water Density(field)	Oscillating body method	0.0000 to 2.0000	±0.0002 g/mL	Duplicate measurements
Alkalinity	APHA 2320B	4 mg/L	±3 mg/L	Duplicate analysis
pH (field)	EPA 150.1	2 to 12 pH units	±0.2 pH unit	User calibration per manufacturer recommendation
Specific conductance (field)	APHA 2510	0 to 200 mS/cm	±1% of reading	User calibration per manufacturer recommendation
Temperature (field)	Thermocouple	-5 to 50°C	±0.2°C	Factory calibration

Note 1: An equivalent method may be employed with the prior approval of the UIC Program Director.

Note:2: Gas evolution technique by Atekwana and Krishnamurthy (1998), with modifications made by Hackley et al. (2007)

Table 8. *Summary of analytical parameters for CO_2 gas stream. All analyses will be performed by a designated third-party laboratory.*

Parameters	Analytical Methods[1]	Detection Limit/Range	Typical Precisions	QC Requirements
Oxygen	ISBT 4.0 (GC/DID)	1 uL/L to 5,000 uL/L (ppm by volume)	± 10 % of reading	daily standard within 10 % of calibration, secondary standard after calibration
	GC/TCD	0.1 % to 100 %	5 - 10 % relative across the range, RT ± 0.1 min	daily standard, duplicate analysis within 10 % of each other
Nitrogen	ISBT 4.0 GC/DID	1 uL/L to 5,000 uL/L (ppm by volume)	± 10 % of reading	daily standard within 10 % of calibration, secondary standard after calibration
	GC/TCD	0.1 % to 100 %	5 - 10 % relative across the range, RT ± 0.1 min	daily standard, duplicate analysis within 10 % of each other
Carbon Monoxide	ISBT 5.0 Colorimetric	5 uL/L to 100 uL/L (ppm by volume)	± 20 % of reading	duplicate analysis
	ISBT 4.0 (GC/DID)	1 uL/L to 5,000 uL/L (ppm by volume)	± 10 % of reading	daily standard within 10 % of calibration, secondary standard after calibration
Oxides of Nitrogen	ISBT 7.0 Colorimetric	0.2 uL/L to 5 uL/L (ppm by volume)	± 20 % of reading	duplicate analysis
Total Hydrocarbons	ISBT 10.0 THA (FID)	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
Methane	ISBT 10.1 GC/FID)	0.1 uL/L to 1,000 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
Acetaldehyde	ISBT 11.0 (GC/FID)	0.1 uL/L to 100 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
Sulfur Dioxide	ISBT 14.0 (GC/SCD)	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
Hydrogen Sulfide	ISBT 14.0 (GC/SCD)	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
Ethanol	ISBT 11.0 (GC/FID)	0.1 uL/L to 100 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
Isotopes: $\delta^{13}C$ of DIC	Isotope ratio mass spectrometry[2]	12.2 mg/L HCO3- for δ13C	±0.15‰ for $\delta^{13}C$	10% duplicates; 4 standards/batch
CO_2 Purity	ISBT 2.0 Caustic absorption Zahm-Nagel	99.00% to 99.99%	± 10 % of reading	User calibration per manufacturer recommendation
	ALI method SAM 4.1 subtraction method (GC/DID)	1 ppm for each target analyte (analyte dependent) - refer to Oxygen and Nitrogen analysis.	5-10 % relative across the range	duplicate analysis within 10 % of each other
	GC/TCD	0.1 % to 100 %	5-10 % relative across the range, RT ± 0.1 min	standard with every sample, duplicate analysis within 10 % of each other

Note 1: An equivalent method may be employed with the prior approval of the UIC Program Director.

Note 2: Gas evolution technique by Atekwana and Krishnamurthy (1998), with modifications made by Hackley et al. (2007).

Table 9. *Summary of analytical parameters for corrosion coupons.*

Parameters	Analytical Methods	Detection Limit/Range	Typical Precisions	QC Requirements
Mass	NACE RP0775-2005	.005mg	+/-2%	Annual Calibration of Scale
Thickness	NACE RP0775-2005	.001mm	+/-005mm	Factory calibration

Table 10*. Summary of measurement parameters for field gauges*[1].

Parameters[1]	Methods[1]	Detection Limit/Range[1]	Typical Precisions[1]	QC Requirements
Compression discharge pressure	ANSI Z540-1-1994	+/- 0.001 psi / 0-3000 psi	+/- 0.01 psi	Annual Calibration of Scale (3rd party)
Injection Tubing Temperature	ANSI Z540-1-1994	+/- 0.001 F / 0-500 F	+/- 0.01 F	Annual Calibration of Scale (3rd party)
Annulus Pressure	ANSI/UL 61010-1 or ANSI/UL 61010-2-30	+/- 0.1 psi / 0-7200 psi	+/- (0.004 URL/ span)% of Span	Annual Calibration of Scale (3rd party)
Injection Tubing Pressure	ANSI Z540-1-1994	+/- 0.001 psi / 0-3000 psi	+/- 0.01 psi	Annual Calibration of Scale (3rd party)
Injection Mass Flow Rate	ISO 17025/IEC 17025	+/- 0.10% of rate / up to 13,060 tonne/day	+/-0.10% of rate for liquid +/-0.25% of rate for gas	Annual Calibration of Scale (3rd party)

[1] *Actual hardware will determine final detection limits/ranges, precision, and standards used. These will be finalized and submitted prior to authorization to inject.*

Table 11. *Actionable testing and monitoring outputs.*

Monitoring Type	Project Action Limit	Detection Limit	Anticipated Reading
MIT—Pulse neutron logging	Action taken when RST indicates CO_2 outside of the expected range	+/- 0.5 SIGM	Brine saturated ~ 60 CO_2 saturated ~ 8
Wellbore integrity—annular pressure gauge	>3% pressure loss over 1hour	Refer to Appendix A (annular pressure gauge table)	>3% pressure loss over 1 hour
Surface pressure gauges	Action will be taken when pressures are well outside of the modeled/expected range	See Table 10.	Injection Pressure (psig) OES #1: Alarm: 1,017 psig (90%) & 1,368 psig (80%); Shutdown: 904 psig (80%) & 1,539 psig (90%) OES #2: Alarm: 1,044 psig (90%) & 1,480 psig (80%); Shutdown: 928 psig (80%) & 1,665 psig (90%) OES #3: Alarm: 1,044 psig (90%) & 1,460 psig (80%); Shutdown: 928 psig (80%) & 1,643 psig (90%) Annulus pressure (psig) OES #1, OES #2, OES #3: Alarm: 150 psig (+50 psig) & 4,140 psig (80%); Shutdown: 100 psig & 4,658 psig (90%)
Downhole pressure gauges	Action will be taken when pressures are well outside of the modeled/expected range	See Table 12	OES #1 > 3,782 psig OES #2 > 3,962 psig OES #3 > 3,932 psig
Flow Rate	Action will be taken when pressures are well outside of the modeled/expected range	See Table 10	OES #1, OES #2, OES #3: Alarm: 3,380 MT/day (80% of max); Shutdown: 3,169 MT/day (75% of max) & 4,160 MT/day (+50 of avg.)
Wellbore integrity— DTS fiber optic temperature	Action will be taken when an anomaly in the temperature profile is detected.	Refer to Appendix A	DTS provides a continuous temperature profile. Baseline profile is TBD and will be identified post-deployment.
Seismic datafiles	Area of CO_2 plume greater than 50% of the simulated area of CO_2 plume or any single edge of	Dependent on fluid saturation and formation velocities	CO_2 plume migration is similar to the modeled outcome

	the CO_2 plume exceeding 80% of the radius of the simulated plume edge, as measured from analysis and interpretation of the 2D time-lapse seismic data.	

The action limits in Table 11 have been aligned with the operational alarm and shutdown thresholds specified in Table 15 of the Testing and Monitoring Plan to maintain consistency between monitoring, quality assurance, and operational response. These values reflect current pre-operational modeling and design assumptions and will be updated only as needed based on site-specific data collected during drilling, logging, baseline monitoring, and initial injectivity testing. Any revisions will remain within approved permit conditions and will be finalized prior to authorization to inject, in consultation with the UIC Director.

A.4.b Precision

For groundwater sampling, data accuracy will be assessed by the collection and analysis of field blanks to test sampling procedures and matrix spikes to test lab procedures. Field blanks will be taken no less than one per sampling event to spot check for sample bottle contamination. Laboratory assessment of analytical precision will be the responsibility of the individual laboratories per their standard operating procedures.

Table 12 summarizes the specifications of the downhole quartz gauge for pressure and temperature, while Table 13 presents representative Logging tool specifications.

A.4.c Bias

Laboratory assessment of analytical bias will be the responsibility of the individual laboratories per their standard operating procedures and analytical methodologies. For direct pressure or logging measurements, there is no bias.

A.4.d Representativeness

For groundwater sampling, data representativeness expresses 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 sampling network has been designed to provide data representative of site conditions. For analytical results of individual groundwater samples, representativeness will be estimated by ion and mass balances. Ion balances with ±10% error or less will be considered valid. A mass balance assessment will be used when the ion balance is greater than ±10% to help determine the source of error. For a sample and its duplicate, if the relative percent difference exceeds 10%, the sample may be considered non-representative.

A.4.e Completeness

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

A.4.f Comparability

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

Table 12. *Pressure and temperature – downhole quartz gauge specifications.*

Specification	**Sensitivity**
Calibrated working pressure range	Atmospheric to 10,000 psi
Initial pressure accuracy	<+/-2 psi over full scale
Pressure resolution	0.005 psi at 1-s sample rate
Pressure drift stability	<+/-1 psi per year over full scale
Calibrated working temperature range	77–266°F
Initial temperature accuracy	<+/-0.9°F per +/-0.27°F
Temperature resolution	0.009°F at 1-s sample rate
Temperature drift stability	<+/-0.1°F per year at 302
Max temperature	302°F

Table 13. *Representative Logging tool specifications.*

Specification	**RST**	**CBL**	**USI**	**Isolation Scanner**
Logging speed	1,800 ft/hr	3,600 ft/hr	Standard resolution: 2,700ft/hr High resolution: 563 ft/hr	Standard resolution: 2,700ft/hr High resolution: 563 ft/hr
Vertical resolution	15 inches	3 ft	Standard resolution: 0.6 in High speed: 6 in	High resolution: 0.6 in High speed: 6 in
Investigation	Formation	Casing, annulus, and formation	Casing and annulus	Casing and annulus
Temperature rating	302°F	350°F	350°F	350°F
Pressure rating	15,000 psi	20,000 psi	20,000 psi	20,000 psi

A.1.a Method Sensitivity

Tables 14 through 19 provide additional details on gauge specifications and sensitivities.

Table 14. *Pressure field gauge – injection tubing pressure.*

Specification	**Sensitivity**
Calibrated working pressure range	0 to 3000 psi and 4–20 mA
Initial pressure accuracy	< 0.04375%
Pressure resolution	0.001 psi and 0.00001 mA
Pressure drift stability	To be determined after first year

Table 15. *Pressure field gauge – annulus pressure.*

Specification	**Sensitivity**
Calibrated working pressure range	0 to 3000 psi and 4–20 mA

Initial pressure accuracy	< 0.02500%
Pressure resolution	0.001 psi and 0.00001 mA
Pressure drift stability	To be determined after first year

***Table 16**. Pressure field gauge.*

Specification	Sensitivity
Calibrated working pressure range	0 to 3000 psi and 4–20 mA
Initial pressure accuracy	< 0.03125%
Pressure resolution	0.001 psi and 0.00001 mA
Pressure drift stability	To be determined after first year

***Table 17.** Temperature field gauge – injection tubing temperature.*

Specification	Sensitivity
Calibrated working temperature range	0 to 500°F and 4–20 mA
Initial temperature accuracy	< 0.0055 %
Temperature resolution	0.001°F and 0.0001 mA
Temperature drift stability	To be determined after first year

***Table 18.** Mass flow rate field gauge – CO_2 mass flow rate.*

Parameters1	Methods1
Compression discharge pressure	ANSI Z540-1-1994
Injection Tubing Temperature	ANSI Z540-1-1994
Annulus Pressure	ANSI/UL 61010-1 or ANSI/UL 61010-2-30
Injection Tubing Pressure	ANSI Z540-1-1994

A.2 Special Training/Certifications

A.2.a Specialized Training and Certifications

The geophysical survey equipment and wireline logging tools will be operated by trained, qualified, and certified personnel, as specified by the service company that provides the equipment. The subsequent data will be processed and analyzed in accordance with industry standards (Appendix B). No specialized certifications are required for personnel conducting groundwater sampling, but field sampling will be conducted by trained personnel. Groundwater sampling will be conducted by personnel trained to understand and follow the project-specific sampling procedures. Upon request, One Earth Sequestration, LLC will provide the agency with all laboratory SOPs for the specific parameter, developed using the appropriate standard method. Each laboratory technician conducting the analysis on the samples will be trained on the SOP developed for each standard method. One Earth Sequestration, LLC will include the technician's training certification with the biannual report.

A.5. b/c. Training Provider and Responsibility

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

A.3 Documentation and Records

A.3.a Report Format and Package Information

A semi-annual report from One Earth Sequestration, LLC to U. S. EPA will contain all required project data, including testing and monitoring information as specified by the UIC Class VI permit. Data will be provided in electronic or other formats as required by the UIC Program Director.

A.3.b Other Project Documents, Records, and Electronic Files

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

A.6. c/d. Data Storage and Duration

One Earth Sequestration, LLC, or a designated contractor, will maintain the required project data as provided elsewhere in the permit.

A.6.e. QASP Distribution Responsibility

The One Earth Sequestration, LLC VP of Technology and Special Projects will be responsible for ensuring that all those on the distribution list will receive the most current copy of the approved Quality Assurance and Surveillance Plan.

B.1 Sampling Process Design (Experimental Design)

Discussion in this section is focused on groundwater and fluid sampling and does not address monitoring methods that do not gather physical samples (e.g., logging, seismic monitoring, and pressure/temperature monitoring). During the pre-injection and injection phases, groundwater sampling is planned to include an extensive set of chemical parameters to establish aqueous geochemical reference data. Parameters will include selected constituents that: (1) have primary and secondary USEPA drinking water maximum contaminant levels, (2) are the most responsive to interaction with CO_2 or brine, (3) are needed for quality control, and (4) may be needed for geochemical modeling. The full set of parameters for each sampling interval is given in Tables 5 – 10. After a sufficient baseline is established, the monitoring scope may shift to a subset of indicator parameters that are (1) the most responsive to interaction with CO_2 or brine and (2) are needed for quality control.

Implementation of a reduced set of parameters would be done in consultation with the U. S. EPA. Isotopic analyses will be performed on baseline samples to the degree that the information helps verify a condition or establish an understanding of non-project related variations. For non-baseline samples, isotopic analyses may be reduced in all monitoring wells if a review of the historical project results or other data determines that further sampling for isotopic analyses is unnecessary. During any period where a reduced set of analytes is used, if statistically significant trends are observed that are the result of unintended CO_2 or brine migration, the analytical list would be expanded to the full set of monitoring parameters. The Ironton-Galesville groundwater samples will be analyzed by 3rd party using published analytical methods. Dissolved CO_2 will be analyzed by methods consistent with Test Method B of ASTM D 513-06, "Standard Test Methods for Total and Dissolved Carbon Dioxide in Water" or equivalent. Isotopic analysis will be conducted using established methods.

B.1.a Design Strategy

CO_2 Stream Monitoring Strategy

The primary purpose of analyzing the carbon dioxide stream is to evaluate the potential interactions of carbon dioxide 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 the determination of whether the injectate meets the qualifications of hazardous waste under the Resource Conservation and Recovery Act (RCRA), 42 U.S.C. 6901 et seq. (1976), and/or the Comprehensive Environmental Response, Compensation, and Liability Act, (CERCLA) 42 U.S.C. 9601 et seq. (1980). Additionally, monitoring the chemical and physical characteristics of the carbon dioxide (e.g., isotopic signature, other constituents) may help distinguish the injectate from the native fluids and gases if unintended leakage from the storage reservoir occurred. Injectate monitoring is required at a sufficient frequency to detect changes to any physical and chemical properties that may result in a deviation from the permitted specifications.

Calibration of transmitters used to monitor pressures, temperatures, and flow rates of CO_2 into the injection well at the injection well and at the verification well shall be conducted annually by a third-party vendor. Reports shall contain test equipment used to calibrate the transmitters, including test equipment manufacturers, model numbers, serial numbers, calibration dates and expiration dates.

Corrosion Monitoring Strategy
Corrosion coupon analyses will be conducted quarterly to aid in ensuring the mechanical integrity of the equipment in contact with the carbon dioxide. Coupons shall be sent quarterly to a company for analysis and an analysis conducted in accordance with NACE Standard RP-0775 (or similar) to determine and document corrosion wear rates based on mass loss.

Deep Groundwater Monitoring Strategy
Monitoring of the St. Peter sandstone (the lowermost USDW) and the Ironton-Galesville will be used for early leakage detection in formations that are much closer to the Mt. Simon injection reservoir. Fluid sampling at the St. Peter and ACZ wells in combination with pressure monitoring, temperature monitoring, and pulse neutron logging will be used to determine if leakage is occurring at or near the injection well. In addition, the Ironton-Galesville has sufficient permeability such that pressure monitoring would detect a failure of the confining zone should it occur. MIT testing and DTS monitoring at the injection well will also provide data to ensure the mechanical integrity of the injection wells are maintained. With the planned sampling and monitoring frequencies, it is expected that baseline conditions can be documented, natural variability in conditions can be characterized, unintended brine or CO_2 leakage could be detected if it occurred, and sufficient data will be collected to demonstrate that the effects of CO_2 injection are limited to the intended storage reservoir. No groundwater fluid sampling is planned for the Mt. Simon intervals where free-phase CO_2 has broken through.

ACZ Sampling
The ACZ verification well, OES ACZ#1 and OES ACZ #2, will be used to monitor the pressure and temperature in the Ironton-Galesville formation. This is above the Eau Claire Formation, the primary reservoir seal. This well will serve as an early leak detection system by allowing the operator to monitor for changes above the primary caprock. Groundwater samples will be collected and analyzed for constituents listed in Table 6 to document baseline fluid chemistry and to detect changes in fluid chemistry that could result from the movement of brine or CO_2 from the storage interval through the seal formation.

Lowermost USDW Sampling
ACZ (OES USDW#1) well will allow monitoring within the St. Peter sandstone, the lowermost USDW. This well will serve as an additional leak detection system by allowing the operator to monitor for changes above the primary caprock. The well will be equipped with a pressure and temperature monitoring system set within the perforated interval. Pressure and temperature will be continuously monitored and recorded. Groundwater samples will be collected and analyzed for constituents listed in Table 6 to document baseline fluid chemistry and to detect changes in fluid chemistry that could result from the movement of brine or CO_2 from the storage interval through the seal formation.

Injection Zone Monitoring
The stratigraphic test well OEE#1 will be converted to an injection zone monitoring well (IZM#1). A second in-zone well (IZM#2), location to be determined, is also planned for installation. The location will be identified after 5 years of injection operations or when 10 million tonnes have been injected at the site. The location will be determined from the plume's position using OEE1 data and the results of the first time-lapse 2D survey. The second in-zone monitoring well location will be

proposed to the director following completion of the updated dynamic model. Upon the Director's concurrence, the well will be installed within 18 months.

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

Groundwater sampling frequencies are detailed in Table 1.
CO_2 gas stream and corrosion coupon) frequencies are detailed in Table 1.

B.1.c Site/Sampling Locations

ACZ wells, and the location of OEE#1 (in-zone monitoring well IZM#1) are shown on Figure 2 and noted in Section B.1.a. The location of the second IZM well is TBD as noted in Section B.1.a.

CO_2 gas stream and corrosion coupon sampling locations will occur in the compressor building after the last stage of compression.

B.1.d Sampling Site Contingency

The deep groundwater monitoring wells are located on the One Earth CCS project site or on land where One Earth Sequestration, LLC has access permissions have already been granted. No problems of site inaccessibility are anticipated. If inclement weather makes site access difficult, sampling schedules will be reviewed, and alternative dates may be selected that would still meet permit-related conditions.

No problems of site inaccessibility are anticipated for CO_2 gas stream or corrosion coupon sampling. If inclement weather makes site access difficult, sampling schedules will be reviewed, and alternative dates may be selected that would still meet permit-related conditions.

B.1.e Activity Schedule

The groundwater sampling activities and frequencies are summarized in Table 1.
The CO_2 gas stream and corrosion coupon sampling activities and frequencies are summarized in Table 1.

B.1.f Critical/Informational Data

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

B.1.g Sources of Variability

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

Activities to eliminate, reduce, or reconcile variability related to monitoring activities include (1) collecting long-term baseline data to observe and document natural variation in monitoring parameters, (2) evaluating data in timely manner after collection to observe anomalies in data that

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

B.2 Sampling Methods

Logging, geophysical monitoring, and pressure/temperature monitoring does not apply to this section and is omitted.

B.2. a/b Sampling SOPs

ACZ and IZM wells will be developed and purged at the time of completion. Prior to sampling, each zone will be purged to ensure representative samples are collected. Purge water will be disposed of in accordance with One Earth Sequestration, LLC policy for waste management

It is anticipated that air lifting with nitrogen may be used to draw fluid into the deep wells for purging. A gas lift valve will be placed in the tubing string at the time of completion. The sampler will be positioned at the same elevation as the discrete perforated interval, and a sample would be collected after sufficient purging.

B.2.c In-situ Monitoring

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

B.2.d Continuous Monitoring

Pressure data will be collected from ACZ and IZM wells on a periodic basis (e.g., hourly to daily) using pressure gauges, DTS, and DAS.

B.2.e Sample Homogenization, Composition, Filtration

Described in section B.2.b.

B.2.f Sample Containers and Volumes

For CO_2 stream monitoring, samples will be collected in a clean sample container rated for the appropriate collection pressure.

Assay for CO_2 Quarterly Gas Analysis:

- CO_2 Purity (% v/v, [GC])
- Oxygen (O_2, ppm v/v)
- Nitrogen (N_2, ppm v/v)
- Carbon Monoxide (CO, ppm v/v)
- Oxides of Nitrogen (NOx, ppm v/v)
- Total Hydrocarbons (THC, ppm v/v as CH4)
- Methane (CH_4, ppm v/v)
- Acetaldehyde (AA, ppm v/v)
- Sulfur Dioxide (SO_2, ppm v/v)
- Hydrogen Sulfide (H_2S ppm v/v)
- Ethanol (ppm v/v)
- Carbon Isotopes

All fluid sample bottles will be new. Sample bottles and bags for analytes will be used as received (ready for use) from the vendor or contract analytical laboratory for the analyte of interest. A summary of sample containers is presented in Table 20.

B.2.g Sample Preservation

No preservation is required or used for CO_2 gas stream, and additional details of sampling requirements are shown in Table 19. For groundwater and other aqueous samples, the preservation methods in Table 20 will be used.

Corrosion coupon sampling only requires that the coupons be physically separated (e.g., sleeves, baggies) during transportation to prevent physical abrasion.

Table 19. *Summary of sample containers, preservation treatments, and holding times for CO_2 gas stream analysis.*

Target Parameters	Volume/Container Material	PreservationTechnique	Sample Holding time(max)
CO_2 gas stream	2L MLB Polybags 75 cc MiniCylinder	Sample Storage Cabinets	5 Business Days

B.2.h Cleaning/Decontamination of Sampling Equipment

Wireline sampling equipment will be power washed prior to use at each monitoring well. As described in b.2.a/b the wells (and sampling equipment) will be purged until field parameters have stabilized. All field glassware (pipets, beakers, filter holders, etc.) are cleaned with tap water to remove any loose dirt, washed in a dilute nitric acid solution, and rinsed three times with deionized water before use.

CO_2 gas stream sampling containers will be either disposed of or decontaminated by the analytical lab.

No sampling equipment will be utilized with the corrosion coupons or annual field gauge calibrations.

B.2.i Support Facilities

For groundwater sampling, the following are required: an air compressor, a vacuum pump, a generator, a multi-electrode water-quality sonde, and analytical meters (pH, specific conductance, etc.). Field activities are usually conducted in field vehicles and on-site portable laboratory trailers.

Sampling tubing, connectors, and valves required to sample the CO_2 gas stream will be supplied by the analytical lab, which will also provide the sampling containers. Sampling will occur at the wellhead if possible, or at the surface facility discharge if necessary.

Similarly, corrosion coupons will be removed from the CO_2 injection line at the CO_2 compression building.

Field gauges will be removed from the injection well and verification well, utilizing existing standard industry tools and equipment. Deployment and retrieval of verification well gauges will be done using procedures and equipment recommended by the vendor, subcontractor, or is standard per industry practice.

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

Field staff will be responsible for properly testing equipment and performing corrective actions on broken or malfunctioning field equipment. If corrective action cannot be taken in the field, then equipment will be returned to the manufacturer for repair or replaced. Significant corrective actions affecting analytical results will be documented in field notes.

B.3 Sample Handling and Custody

Logging, geophysical monitoring, and pressure/temperature monitoring does not apply to this section and is omitted.

Each sample will be logged on a sampling form and will document the chain of custody. The form will note:

- Sampling date
- Location the sample was collected
- Type of container
- Sampler name and signature
- Other comments/notes
- Shipping information (name, address, and point of contact at laboratory, including phone number)
- Laboratory received by name and signature.

Sample holding times (Table 20) will be consistent with those described in US EPA (1974), American Public Health Association (APHA, 2005), Wood (1976), and ASTM Method D6517-00 (2005). After collection, samples will be placed in ice chests in the field and maintained thereafter at approximately 4°C until analysis. The samples will be maintained at their preservation temperature and sent to the designated laboratory within 24 hours. Analysis of the samples will be completed within the holding time listed in Table 20. As appropriate, alternative sample containers and preservation techniques approved by the UIC Program Director will be used to meet analytical requirements.

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

See Table 20.

B.3.b Sample Transportation

See description at the beginning of Section B.3.

B.3.c Sampling Documentation

Field notes will be collected for all groundwater samples collected. These forms will be retained and archived as reference. The sample documentation is the responsibility of groundwater sampling personnel.

An analysis authorization form shall be provided with each CO_2 gas stream sample provided for analysis.

B.3.d Sample Identification

All sample bottles will have waterproof labels with information denoting project, sampling date, sampling location, sample identification number, sample type (freshwater or brine), analyte, volume, filtration used (if any), and preservative used (if any). See Figure 4 for an example of a label.

***Table 20**. Summary of anticipated sample containers, preservation treatments, and holding times.*

Target Parameters	Volume/Container Material	Preservation Technique	Sample Holding time	Relative Sampling Depth
Dissolved CO_2	60 ml/HDPE	Filtered, cool 4°C	14 days	Deep
Isotopes: $\delta^{34}S$	250 ml/HDPE	Filtered, cool 4°C	4 weeks	Deep
Isotopes: δD, $\delta^{18}O$, $\delta^{13}C$	60 ml/HDPE	Filtered, cool 4°C	4 weeks	Deep
Field Confirmation: Temperature, dissolved oxygen, specific conductance, pH	200 ml/glass jar	None	< 1 hour	Deep
Field Confirmation: Density	60 ml/HDPE	Filtered	< 1 hour	Deep

XXXX_X_X (fresh water)
01-15-2022
Metals, 60 ml, filtered, HNO_3

***Figure 4**. Example label for groundwater sample bottles.*

B.3.e Sample Chain-of-Custody

For CO_2 stream analysis, an analysis authorization form (Figure 4) will accompany the sample to the labat which point a chain-of-custody accompanies the sample through their processes.

For groundwater samples, chain-of-custody will be documented using a standardized form. A typical form is shown in Figure 5, and it or a similar form will be used for all groundwater sampling. Copies of the form will be provided to the person/lab receiving the samples as well as the person/lab transferring the samples. These forms will be retained and archived to allow simplified tracking of sample status. The chain-of -custody form and record keeping is the responsibility of groundwater sampling personnel.

B.4 Analytical Methods

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

B.4.a Analytical SOPs

Analytical SOPs are referenced in Tables 5-8. Other laboratory-specific SOPs utilized by the laboratory will be determined after a contract laboratory has been selected. Upon request, One Earth Sequestration, LLC will provide the agency with all laboratory SOPs developed for the specific parameter using the appropriate standard method. Each laboratory technician conducting the analysis on the samples will be trained on the SOP developed for each standard method. One Earth Sequestration, LLC will include the technician's training certification with the biannual report.

B.4.b Equipment/Instrumentation Needed

Equipment and instrumentation are specified in the individual analytical methods referenced in Tables 5-8.

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 5-8 will be responsible for appropriately addressing analytical failure according to their individual SOPs.

B.4.e Sample Disposal

Each laboratory conducting the analyses in Tables 5-8 will be responsible for appropriate sample disposal according to their individual SOPs.

B.4.f Laboratory Turnaround

Laboratory turnaround time varies by laboratory, but generally, verified analytical results within 1 month are suitable for project needs.

B.4.g Method Validation for Nonstandard Methods

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

Airborne Labs International, Inc.

22C World's Fair Drive, Somerset, NJ 08873 Fax: 732-302-3035 Phone: 732-302-1950
E-mail: airbornelabs@aol.com Website: www.airbornelabs.com

Analysis Authorization

This form MUST be completed & returned with a sample shipment

1.) Report Results to*:

Company:	______________	**Sampled On (mm/dd/yy):**	______________
Address:	______________	**P.O. #:**	______________
Address:	______________	**Credit Card:**	Visa Amex MasterCard Discover
Address:	______________	**Card #:**	______________
Address:	______________	**Cardholder:**	______________
Attention:	______________	**Exp. Date:**	______________
Telephone:	(_____)______________	**Check #:**	______________
Fax:	(_____)______________	**Other:**	______________
E-Mail:	______________	**Pricing Discussed/Quoted? Y N**	

*Please attach complete billing address if different from reporting address.

2.) Number of Samples Submitted: _______ **Container Type(s):** ________________

3.) Sample Description (circle): Liquid CO_2 CO2 (Final) Vapor CO2 Feedgas* CO_2 In-Process Food Grade CO_2 LIN LOX LAR RELOX (Reboiler) ABO

*If CO_2 Feedgas –Identify source (e.g. Ethanol/Ammonia/Nat. Well/Ethylene/Combustion, Self-Gen, etc.) _______________

Aviator Breathing Oxygen (ABO) Natural Gas Refinery Gas Syn Gas Propane Butane Air Oxygen Nitrogen Argon Hydrogen Helium Neon Xenon Krypton Freon® Refrigerant Gas Mixture Fuel Oil Lubricant

Other (Describe): ________________________________

4.) Sample Type (Check) : Industrial____Medical______ MilSpec_____ Other_____
(attach a log for multiple samples)

5.) Sample ID: ________________________________

6.) Potential Hazards/Safety Issues: ________________________________

7.) Analytical Test(s) Requested (check program or select individual tests required where applicable):

Std ISBT/Vendor CO_2 Test Program_____ Std CO_2 Feedgas Program_____ Std CGA Test Program_____ Std Medical Gas_____
Std Contract Program_____ Std ASTM Test Program____ MIL Spec Test Program____

%Purity THC CH_4 TNMHC Vol Hydrocarbons (C1-C6) BTEX Water Vapor NVR/NVOR Oil/Grease Total Sulfur H_2S SO_2 COS MeSH t-Butyl Mercaptan Vol Sulfur Compnds Odorants Total Nitrogen N_2 NO_x NH_3 NO NO_2 HCN Nitrous Oxide (N_2O) PH_3 Oxygen Argon Hydrogen Helium CO CO_2 Xenon Neon Krypton Vinyl Chloride Acetaldehyde Vol Oxygenates GC/MS Scan IR Scan IR Microscope Halogenated Hydrocarbons SF_6 Gas Mixture% Btu (Heat) Content % CHNO Sediment Wt Patch Test Viscosity Flash/Fire Point Density Specific Gravity Trace Metals TAN TBN XRF SEM-XRF Scan Light Microscope

Other Testing: ________________________________

8.) Sample Disposition

Retain for ______ Period Perform Clean-up/Maintenance Actions & Return* ____ Report for Instructions ____

Other: ________________________________

*Supply all return address & shipping instructions

9.) Report Disposition (circle one): E-Mail Fax Mail Telephone Other:______________
(Reports will be sent to the address & contact(s) specified at the top of this form)

10.) Priority Conditions (circle), Note: Additional fees will apply for non-std test scheduling:

Standard 2-Work Day 1-Work Day Same Day Emergency Other:______________

Analytical testing cannot be performed unless this form is completed & returned

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Figure 5*. Example of CO_2 gas stream analysis authorization form.*

PRAIRIE RESEARCH INSTITUTE

CHAIN OF CUSTODY RECORD (Page __ of __)

Illinois State Water Survey – Analytical Services Group
Illinois State Geological Survey – Geochemistry Section

For Midwest Geological Sequestration Consortium (MGSC) Projects

	MGSC ID	ISGS MVA ID	Matrix	Date Collected	Time Collected	Sampling Team	Circle analyses to be performed
1							anions, cations, TDS, alk, NH_3, NVOC
2							anions, cations, TDS, alk, NH_3, NVOC
3							anions, cations, TDS, alk, NH_3, NVOC
4							anions, cations, TDS, alk, NH_3, NVOC
5							anions, cations, TDS, alk, NH_3, NVOC
6							anions, cations, TDS, alk, NH_3, NVOC
7							anions, cations, TDS, alk, NH_3, NVOC
8							anions, cations, TDS, alk, NH_3, NVOC
9							anions, cations, TDS, alk, NH_3, NVOC
10							anions, cations, TDS, alk, NH_3, NVOC
11							anions, cations, TDS, alk, NH_3, NVOC
12							anions, cations, TDS, alk, NH_3, NVOC
12							

CHAIN OF CUSTODY		
Relinquished by:	Print Name:	Date and Time:
Received by:	Print Name:	Date and Time:
General Remarks: - Field parameters are to be recorded on separate sheets by sampling teams. - Any special laboratory instructions or remarks should be made below.		
Data Contacts:	Fund:	
Billing Contact:	Billing Address:	
Send Data To:		

Remarks:

Rev. Oct. 2011 (RL)

Figure 6. *Example chain-of-custody form.*

B.5 Quality Control

Geophysical monitoring and pressure/temperature monitoring do not apply to this section and are omitted. For log quality control, please refer to Appendix B.

B.5.a QC activities

Blanks

Field blanks will be utilized for deep groundwater sampling and analyzed for the inorganic analytes in Tables 5 - 8 at a frequency of 10% or greater. Field blanks will be exposed to the same field and transport conditions as the groundwater samples. Field blanks will be used to detect contamination resulting from the collection and transportation process.

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 be done by evaluating the ratio of the measured total dissolved solids (TDS) to the calculated TDS (i.e., mass balance) per 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 interlaboratory results, if available. Suspect ion analyses are then brought to the attention of the analytical laboratory for confirmation and/or reanalysis. The ion balance is recalculated, and if the error is still not resolved, suspect data are identified and may be given less importance in data interpretations.

B.5.c Calculating Applicable QC Statistics

Charge Balance

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

$$\% \, difference = 100 \quad \frac{(\boldsymbol{\Sigma} cations + \boldsymbol{\Sigma} anions)}{(\boldsymbol{\Sigma} cations - \boldsymbol{\Sigma} anions)} \qquad \text{(Equation 1)}$$

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:

$$1.0 < \frac{measured\ TDS}{calculated\ TDS} < 1.2, \qquad \text{(Equation 2)}$$

where the anticipated values are between 1.0 and 1.2.

Outliers
The determination of one or more statistical outliers is essential prior to the statistical evaluation of groundwater. This project will use the U. S. EPA's Unified Guidance (March 2009) as a basis for selecting recommended statistical methods to identify outliers in groundwater chemistry datasets, as appropriate. These techniques include Probability Plots, Box Plots, Dixon's test, and Rosner's test. The EPA-1989 outlier test can also serve as another screening tool to identify potential outliers.

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

Logging tool equipment will be maintained as per wireline industry best practices (Appendix B).

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

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

B.7 Instrument/Equipment Calibration and Frequency

Geophysical monitoring does not apply to this section and is omitted.

B.7.a Calibration and Frequency of Calibration

Pressure/temperature gauge calibration information is in Table 12 and Tables 14 - 18. Logging tool calibration will be at the discretion of the service company providing the equipment, in accordance with standard industry practices outlined in Appendix B.

For groundwater sampling, portable field meters or multiprobe sondes used to determine field parameters (e.g., pH, temperature, specific conductance, dissolved oxygen) are calibrated according to manufacturer recommendations and equipment manuals (Hach, 2006) each day before sample collection begins. Recalibration is performed if any components yield atypical values or fail to stabilize during sampling.

B.7.b Calibration Methodology

Logging tool calibration methodology will follow standard industry practices in Appendix B.

For groundwater sampling, standards used for calibration are typically 7 and 10 for pH, a potassium chloride solution yielding a value of 1413 microseimens per centimeter (µS/cm) at 25°C for specific conductance, and a 100% dissolved O2 solution for dissolved oxygen. Calibration is performed for the pHmeters per manufacturer's specifications using a 2-point calibration bounding the range of the sample. For coulometry, sodium carbonate standards (typically yielding a concentration of 4,000 mg CO_2/L) are routinely analyzed to evaluate instrument precision.

B.7.c Calibration Resolution and Documentation

Logging tool calibration resolution and documentation will follow standard industry practices in Appendix B.

For groundwater sampling, calibration values are recorded in daily sampling records, and any errors in calibration are noted. For parameters where calibration is not acceptable, redundant equipment may be used so loss of data is minimized.

B.8 Inspection/Acceptance for Supplies and Consumables

B.8.a/b. Supplies, Consumables, and Responsibilities

Supplies and consumables for field and laboratory operations will be procured, inspected, and accepted as required from vendors approved by One Earth Sequestration, LLC, or the respective subcontractor responsible for the data collection activity. Acquisition of supplies and consumables related to groundwater analyses will be the responsibility of the laboratory per established standard methodology or operating procedures.

B.9 Nondirect Measurements

Seismic Monitoring Methods

B.9.a Data Sources

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

B.9.b Relevance to Project

Time lapse seismic surveys will be used to track changes in the CO_2 plume in the subsurface. Processing and comparing subsequent surveys to a baseline will allow project managers to monitor plume growth, as well as to ensure that the plume does not move outside of the intended storage reservoir. Numericalmodeling will be used to predict the CO_2 plume growth and migration over time by combining the processed seismic data with the existing geologic model.

In-zone pressure monitoring data will be used in numerical modeling to predict plume and pressure front behavior and confirm the plume stage within the AOR.

B.9.c Acceptance Criteria

Following standard industry practices will ensure that the gathered seismic data will be used for accurate modeling and monitoring. Similar ground conditions shot points located within tolerable limits,functional geophones, and similar seismic input signal will be used from survey to survey to ensure repeatability.

When processing seismic data, several QA checks will be done in accordance with industry standards including reformatting to Omega structured files, geometry application, amplitude compensation, predictive deconvolution, elevation statics correction, RMS amplitude gain, velocity analysis every 2 km, NMO application using picked velocities, CMP stacking, random noise attenuation, and instantaneous gain.

B.9.d Resources/Facilities Needed

One Earth Sequestration, LLC will subcontract all necessary resources and facilities for seismic monitoring, in-zone pressure monitoring, and groundwater sampling.

B.9.e Validity Limits and Operating Conditions

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

B.10 Data Management

B.10.a Data Management Scheme

One Earth Sequestration, LLC, or a designated contractor, will maintain the required project data as provided elsewhere in the permit. Data will be backed up on tape or held on secure servers.

B.10.b Record-keeping and Tracking Practices

All records of gathered data will be securely held and properly labeled for auditing purposes.

B.10.c Data Handling Equipment/Procedures

All equipment used to store data will be properly maintained and operated according to proper industry techniques. One Earth Sequestration, LLC SCADA system and vendor data acquisition systems will interface with one another, and all subsequent data will be held on a secure server.

B.10.d Responsibility

The primary project managers will be responsible for ensuring proper data management is maintained.

B.10.e Data Archival and Retrieval

All data will be held by One Earth Sequestration, LLC. These data will be maintained and stored for auditing purposes as described in section B. 10. a.

B.10.f Hardware and Software Configurations

All One Earth Sequestration, LLC and vendor hardware and software configurations will be appropriately interfaced.

B.10.g Checklists and Forms

Checklists and forms will be procured and generated as necessary.

C. Assessment and Oversight

C.1 Assessments and Response Actions

C.1.a Activities to be Conducted

Please refer to Table 1 in section A.3.a/b. (Summary of work to be performed and work schedule); groundwater quality data will be collected at the frequency outlined in that table. After completion of sample analysis, results will be reviewed for QC criteria as noted in section B.5. If the data quality fails to meet criteria set in section B.5., samples will be reanalyzed, if still within holding time criteria. If outside of holding time criteria, additional samples may be collected, or sample results may be excluded from data evaluations and interpretations. Evaluation of data consistency will be performed according to the procedures described in the U.S. EPA 2009 Unified Guidance (USEPA, 2009).

C.1.b Responsibility for Conducting Assessments

Organizations gathering data will be responsible for conducting their internal assessments. All stop work orders will be handled internally within individual organizations.

C.1.c Assessment Reporting

All assessment information should be reported to the individual organizations' project manager, as outlined in A.1.a/b.

C.1.d Corrective Action

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

C.2 Reports to Management

C.2. a/b. QA status Reports

QA status reports should not be needed. If any testing or monitoring techniques are changed, the QASP will be reviewed and updated as appropriate in consultation with U. S. EPA. Revised QASPs will be distributed by One Earth Sequestration, LLC to the full distribution list 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

Groundwater quality data validation will include the review of the concentration units, sample holding times, and the review of duplicate, blank, and other appropriate QA/QC results. All groundwater quality results will be entered into a database or spreadsheet with periodic data review and analysis. One Earth Sequestration, LLC will retain copies of the laboratory analytical test results and/or reports. Analytical results will be reported on a frequency based on the approved UIC permit conditions. In the periodic reports, data will be presented in graphical and tabular formats as appropriate to characterize general groundwater quality and identify intrawell variability with time. After sufficient data have been collected, additional methods, such as those described in the U. S. EPA 2009 Unified Guidance (USEPA, 2009), will be used to evaluate 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 Method

D.2.a Data Verification and Validation

Process. See Sections D.1.a. and B.5.

Appropriate statistical software will be used to determine data consistency.

D.2.b Data Verification and Validation Responsibility

One Earth Sequestration, LLC or its designated subcontractor will verify and validate groundwater sampling data.

D.2.c Issue Resolution Process and Responsibility

One Earth Sequestration, LLC or its designated Coordinator will overview the groundwater data handling, management, and assessment process. Staff involved in these processes will consult with the coordinator to determineactions required to resolve issues.

D.2.d Checklist, Forms, and Calculations

Checklists and forms will be developed specifically to meet permit requirements. Table 21 provides an example of the type of information used for data verification of groundwater quality data.

Table 21. Example table of criteria used to evaluate data quality.

Well ID	Anion charge	Cation charge	Charge balance	CB rating	Calculated TDS	Measured TDS	TDS ratio	TDS rating
IZM#1	14.4	13.60	-2.84	pass	760.50	785	1.0	pass
IZM#2	14.26	15.06	2.73	pass	783.03	777	1.0	pass
OES USDW#1	14.39	14.96	1.94	pass	786.86	806	1.0	pass
OES ACZ#1	14.39	14.79	1.38	pass	780.15	777	1.0	pass
OES ACZ#2	14.39	14.79	1.38	pass	780.15	777	1.0	pass

D.3 Reconciliation with User Requirements

D.3.a Evaluation of Data Uncertainty

Statistical software will be used to determine groundwater data consistency using methods consistent with U. S. EPA 2009 Unified Guidance (USEPA, 2009).

D.3.b Data Limitations Reporting

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

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Appendices (See pdf files)

APPENDIX A. Examples of DTS, DAS, and Down-hole Pressure Gauge Information

(See Attached)

APPENDIX B. Example of Wireline Log Quality Control *

(See Attached)

***Wireline Quality Control Reference Manual (LQCRM) included with permission of Schlumberger.**