Class VI Injection Well Application

Attachment 10: Quality Assurance and Surveillance Plan

Aster Project
Madison County, Indiana

24 July 2024

Project Information

Project Name: Aster

Project Operator: Vault GSL CCS Holdings LP

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Aster Project Injection Well 1 (AST INJ1) Location:
Madison County, Indiana
Latitude : 40.30026° N
Longitude : -85.65565° W

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List of Acronyms

°F	degrees Fahrenheit
µS/cm	micro siemens per centimeter
ACZ	above confining zone
ANSI	American National Standards Institute
AoR	Area of Review
APT	annulus pressure test
AST ACZ1	Aster Project Above Confining Zone Monitoring Well 1
AST INJ1	Aster Project Injection Well 1
AST OBS1	Aster Project Deep Observation Well 1
AST USDW1	Aster Project USDW Monitoring Well 1
ASTM	American Society of Testing and Materials
CBL	cement bond log
CCS	carbon capture and sequestration
CO_2	carbon dioxide
DIC	dissolved inorganic carbon
EPA	Environmental Protection Agency
HDPE	high density polyethylene
MABHP	maximum allowable bottomhole pressure
Mg/L	milligrams per liter
MIT	mechanical integrity testing
mL	milliliter
MLB	multi-layer barrier
N/A	not applicable
PNL	pulsed neutron logging
QA	quality assurance
QASP	Quality Assurance Surveillance Plan
QC	quality control
RCRA	Resource Conservation and Recovery Act
SCADA	supervisory control and data acquisition
SM	standard method
SOP	standard operating procedure
TBD	to be determined
TDS	total dissolved solids
TOC	total organic carbon
UIC	Underground Injection Control
US	United States
USDW	underground source of drinking water

1. Title and Approval Sheet

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

____	_______________
Scott Rennie CEO	Date
____	_______________
Jennifer Jacobs Project Manager	Date

2. Distribution

The Project Manager will distribute the completed QASP and all future updates for the duration of the project and will be responsible for ensuring that all necessary personnel receive the most current version.

Jennifer Jacobs, Project Manager
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3. Project Management

3.1. Project/Task Organization

3.1.1. Key Individuals and Responsibilities

The project operator, Vault GSL CCS Holdings, LP, will be responsible for testing and monitoring responsibilities with support from various subcontractors (Attachment 06: Testing and Monitoring, 2024). Seven subcategories have been identified for the testing and monitoring program with varying responsibilities assigned.

1. Shallow groundwater sampling and monitoring,
2. Deep groundwater sampling and monitoring,
3. Injection well monitoring,
4. Mechanical integrity testing (MIT),
5. Pressure and temperature monitoring,
6. Carbon dioxide (CO_2) stream analysis,
7. CO_2 plume modeling.

3.1.2. Independence from Project Quality Assurance Manager and Data Gathering

The physical samples to be collected, and the data gathered as a part of the monitoring program will be, on occasion, analyzed, processed, and/or witnessed by third party contractors, independent of the project operator.

3.1.3. Project Quality Assurance Plan Responsibility

Vault GSL CCS Holdings LP will be responsible for maintaining and distributing the official, approved Project QASP. Vault GSL CCS Holdings LP will review the QASP periodically and discuss with the United States (US) Environmental Protection Agency (EPA) should any changes to the plan be warranted.

3.2. Problem Definition/Background (A.2.)

3.2.1. Reasoning (A.2.a.)

The Aster Project carbon capture and sequestration (CCS) project has a robust monitoring program, which includes operational, CO_2 plume and pressure front verification, and assurance monitoring components.

Operational monitoring serves to ensure that all procedures and processes associated with the injection operations are safe. Data will be collected to monitor the response of the injection zone and above confining zone (ACZ) intervals by monitoring the following parameters:

- Injection pressure,
- Injection well annulus pressure,
- Mt. Simon Sandstone pressure,
- ACZ monitoring zone pressure (porous, permeable interval within the Knox Supergroup to be identified during the Pre-operational Testing Program).

The operational monitoring includes parameters such as injection zone pressure, injection rate, total volume/mass injected, injection well temperature profile, and passive seismic data will be collected and evaluated.

The CO_2 plume monitoring component of the program will provide information to evaluate the extent to which the CO_2 plume has spread and whether any leakage of the CO_2 or injection zone fluids through the confining zone has occurred. The primary components of the CO_2 plume monitoring are pulsed neutron logging (PNL) and time-lapse surface seismic data, but additional data will also be gathered from pressure and temperature monitoring.

The assurance component of the plan monitors for potential CO_2 leakage into the shallow groundwater aquifers or the environment. The primary component of this monitoring consists of fluid sampling and analysis of aqueous geochemistry.

The robust monitoring program developed from this project is based on experience gained from other Class VI projects, as well as extensive geologic evaluation, computational modeling, and understanding of federal regulations. The result of this experience yields a high level of confidence that the Mt. Simon Sandstone is a suitable injection zone, and that the Eau Claire Shale is a sufficient confining zone that will ensure the injected CO_2 will remain permanently in the Mt. Simon Sandstone.

The primary goal of the monitoring program is to continue to demonstrate the activities of this project are safe for the health of the general public and environment. To help facilitate this demonstration, the QASP was developed to ensure the quality of the demonstration methods meet the requirements of the US EPA Underground Injection Control (UIC) Program for Class VI wells.

3.2.2. Reasons for Initiating the Project (A.2.b.)

The purpose of the Aster Project is to inject and sequester supercritical CO_2 deep in the Mt. Simon Sandstone. This project targets the reduction of CO_2 emissions into the atmosphere from the adjacent ethanol facility. In order to demonstrate the efficacy of this project and the long-term sequestration of CO_2, the rigorous testing and monitoring program presented in (Attachment 06: Testing and Monitoring, 2024) will be implemented. The QASP presented in this document provides additional information on the methodology and technical standards that will comprise the proposed Testing and Monitoring Plan.

3.2.3. Regulatory Information, Applicable Criteria, Action Limits (A.2.c.)

Class VI regulations stipulate that the owners or operators of Class VI well(s) perform several types of activities throughout the life of the project to ensure the following:

i. That the project well(s) maintain their mechanical integrity,
ii. That injected fluid migration and pressure changes are within the limits described in the permit application, and
iii. That underground sources of drinking water (USDWs) are not endangered during or after operations.

The activities to demonstrate the objectives detailed above consist of, but are not limited to, the following:

- MIT,
- Well tests performed on the injection well during operation,
- Groundwater monitoring from several zones,
- CO_2 and pressure plume tracking.

This document is intended to detail the methods of measurement and the steps that will be taken to ensure the quality of the collected data so that confident informed decisions can be made during the project.

3.3. Project/Task Description (A.3.)

3.3.1. Summary of Work to be Performed (A.3.a/b.)

Table 1 displays the major tasks for the Testing and Monitoring Plan (Attachment 06: Testing and Monitoring, 2024). This table displays the location of monitoring points, method of sampling, analytical technique applied, lab/custody procedures to be followed (if applicable), and the purpose of each item. Details on the frequency of the Testing and Monitoring Plan activities can be found in Attachment 05: Pre-operational Testing Program (2024) and Attachment 06: Testing and Monitoring (2024).

Table 2 and Table 3 display details of the instrumentation used at each monitoring location and geophysical surveys, respectively.

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3.3.2. Geographic Locations

The locations of the Aster Project wells are shown in Figure 1.

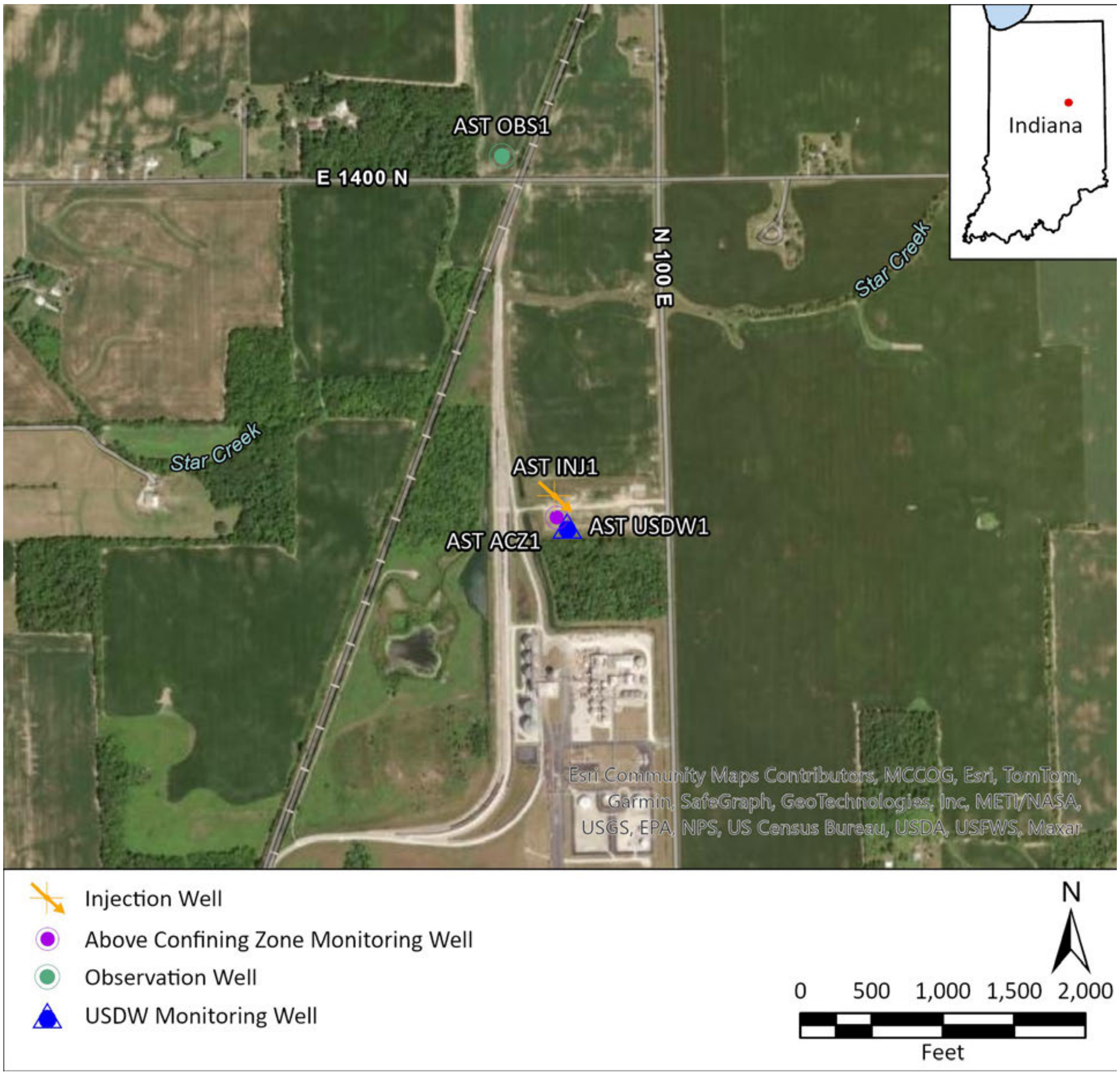

Figure 1: AST INJ1, AST OBS1, AST ACZ1, and AST USDW1 locations.

3.3.3. Resource and Time Constraints (A.3.d.)

No major time or resource constraints have been identified for the Aster Project. Wells drilled, tested, and monitored as laid out in the permit application will serve their purpose for pre-operation, active operations, and post injection closure care.

Following the full closure of the project and the post injection monitoring period, the Vault GSL CCS Holdings LP plans to plug and abandon all wells associated with the project in a manner consistent with federal regulations. As part of the financial assurance package, money will be allocated to ensure these activities are fully funded (Attachment 03: Financial Assurance Plan, 2024).

3.4. Quality Objectives and Criteria (A.4.)

3.4.1. Performance/Measurement Criteria (A.4.a.)

The objective of the quality assurance (QA) system for the monitoring program is to develop and utilize procedures for surface and subsurface monitoring, field samples, laboratory analysis, and routine reporting. The results of these activities will demonstrate the viability, characterization, and non-endangerment of USDWs objectives of the project.

Groundwater monitoring will be conducted:
- Before injection begins,
- During injection operations,
- Post-injection operations.

Specific monitoring frequency and timing is provided in Attachment 06: Testing and Monitoring, (2024), and Attachment 08: Post-injection Site Care and Site Closure, (2024) portions of the application. This monitoring will be performed on shallow and deep groundwater wells. Analytical and monitoring parameters for fluid samples are provided in Table 4. The list of analytes provided herein may be reassessed periodically and adjusted as necessary based on the effectiveness of the current testing and monitoring program with respect to its objectives.

Table 5 contains analytes may be analyzed in the CO_2 stream. Table 6 and Table 7 show other CO_2 and injection related parameters, instrumentation, and standards of analysis. Table 8 contains detail on the major monitoring outputs.

Key monitoring areas and corresponding methods and analytes include (but are not limited to):

i. Shallow Groundwater Sampling for shallow wells (Table 4).
ii. Deep fluid sampling for AST ACZ1 and AST INJ1 (baseline only) (Table 4).
iii. Well Logging
    a. PNL.
iv. MIT and Corrosion Monitoring
    a. PNL (external),
    b. Temperature (external),
    c. Annulus pressure test (APT) (internal, baseline only),
    d. Cement bond log – variable density log (CBL-VDL) (external),
    e. Corrosion coupon monitoring (Table 6).
v. Pressure and Temperature Monitoring
    a. In-situ pressure/temperature gauges (Table 7),
    b. Baseline data,
    c. Surface pressure/temperature gauges.
vi. CO_2 Stream Analysis (Table 5).
vii. Geophysical Monitoring
    a. Time-lapse reporting,
    b. Passive seismic monitoring.

Table 4: Summary of parameters for fluid samples from shallow and deep groundwater. All analysis to be performed by a designated third-party laboratory to be identified.

Parameters	Analytical Methods [1]	Detection Limit/ Range	Typical Precisions	Quality Control Requirements
Cations: Ca, Fe, K, Mg, Na, Si	EPA 6010B	0.005 to 0.5 milligrams per liter (mg/L) [2]	±15 %	Daily calibration, blanks, duplicates, and matrix spikes at 10% or greater.
Cations: Al, Sb, As, Ba, Cd, Cr, Cu, Pb, Mn, Hg, Se, Tl	EPA 200.8, EPA 245.1	0.001 to 0.1 mg/L [2]	±15%	
Anions: Br, Cl, F, NO_3, and SO_4	EPA 300.0	0.02 to 0.13 mg/L [2]	±15%	Daily calibration, blanks, and duplicated at 10% or greater frequency
Alkalinity	SM 2320B	4 mg/L	±3 mg/L	Duplicate analysis
Total dissolved solids (TDS)	SM 2540C	12 mg/L	±10%	Balance calibration, duplicate analysis
Total organic carbon (TOC)	SM 5310C	0.1 mg/ L		
Dissolved inorganic carbon (DIC)	SM 5310C	0.1 mg/ L		
Total and dissolved CO_2	ASTM D513-06B	2 mg/L	±15%	Daily calibration, blanks, and duplicated at 10% or greater frequency
Stable isotopes of δ13C [3]	Isotope Ratio Mass Spectrometry [4]		±0.2%	Duplicate analysis
pH	Field with multi-probe system	2 to 12 pH units	±0.2 pH units	Calibration per manufacturer specifications
Conductivity/resistivity	Field with multi-probe system	0 to 200 mS/cm	±3% of reading	Calibration per manufacturer specifications
Temperature	Field with multi-probe system	-5 to 50°C	±0.2°C	Calibration per manufacturer specifications

[1] An equivalent method may be employed with the prior approval of the UIC Program Director.
[2] Analyte, dilution, and matrix dependent
[3] Isotope Analysis is contingent
[4] Gas evolution technique by Atekwana and Krishnamurthy, (1998) with modifications by Hackley et al., (2010)

Table 5: Summary of potential analytical parameters for CO_2 stream. All analysis to be performed a designated third-party laboratory to be identified.

Parameters	Analytical Methods [1]	Detection Limit/Range	Typical Precisions	Quality Control Requirements
CO_2 purity	ISBT 2.0	5 % v/v	±10 % of reading	Calibration per manufacturer specifications
Total hydrocarbons as methane	ISBT 10.0	0.1 ppm v/v as CH_4	5 to 10% of reading	Daily blank, daily standard within 10% of calibration, secondary standard after calibration
Total non-methane hydrocarbons	ISBT 10.1	0.1 ppm v/v as CH_4		
Carbon monoxide (CO)	ISBT 5.0	0.5 ppm v/v	±20% of reading	Duplicate analysis
Oxides of nitrogen (NO_x)	ISBT 7.0	0.5 ppm v/v	±20% of reading	Duplicate analysis
Non-condensable gases: Nitrogen (N_2) Oxygen (O_2)	ISBT 4.0 ISBT 4.0	4.0 ppm v/v 4.0 ppm v/v	±10% of reading ±10% of reading	Daily standard within 10% of calibration, secondary standard after calibration
Volatile hydrocarbons: Methane	ISBT 10.1	0.5 ppm v/v	5 to10% of reading	Daily blank, daily standard within 10% of calibration, secondary standard after calibration
Volatile sulfur compounds: Hydrogen sulfide (H_2S) Sulfur dioxide (SO_2)	ISBT 14.0 ISBT 14.0	0.02 ppm v/v 0.02 ppm v/v	5 to 10% of reading 5 to10% of reading	Daily blank, daily standard within 10% of calibration, secondary standard after calibration
Volatile oxygenates: Acetaldehyde (AA) Ethanol	ISBT 11.0 ISBT 11.0	0.05 ppm v/v 0.2 ppm v/v	5 to10% of reading 5 to10% of reading	Daily blank, daily standard within 10% of calibration, secondary standard after calibration

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

Table 6: Summary of analytical parameters for corrosion coupons.

Parameters	Analytical Methods	Detection Limit/Range	Typical Precisions	QC Requirements
Mass	NACE RP0775-2005	0.005 mg	±2%	Annual third-party calibration of scale (certification number to be provided)
Thickness	NACE RP0775-2005	0.001 mm	±0.005	Factory calibration

Table 7: Summary of measurement parameters for field gauges.

Parameters	Methods [1]	Detection Limit/Range	Typical Accuracy	QC Requirements
Injection tubing temperature	ANSI Z540-1-1994	±0.001 °F, 0-500 °F	±0.01 °F	Annual third-party calibration of scale (certification number to be provided)
Injection tubing pressure	ANSI Z540-1-1994	±0.001 psi, 0-3,000 psi	±0.01 psi	Annual third-party calibration of scale (certification number to be provided)
Injection flow rate	N/A	0-200,000 pounds/hour	< 2%	Annual third-party calibration of scale (certification number to be provided)
AST INJ1 annulus pressure	ANSI Z540-1-1994	±0.001 psi, 0-3,000 psi	±0.01 psi	Annual third-party calibration of scale (certification number to be provided)
AST INJ1 downhole pressure	ANSI Z540-1-1994	±0.001 psi, 0-10,000 psi	±0.01 psi	
AST INJ1 downhole temperature	ANSI Z540-1-1994	±0.001 °F, 0-300 °F	±0.01 °F	
AST OBS1 wellhead pressure[2]	ANSI Z540-1-1994	±0.001 psi, 0-3,000 psi	±0.01 psi	
AST OBS1 downhole pressure	ANSI Z540-1-1994	±0.001 psi, 0-10,000 psi	±0.01 psi	
AST ACZ1 wellhead pressure	ANSI Z540-1-1994	±0.001 psi, 0-3,000 psi	±0.01 psi	Annual third-party calibration of scale (certification number to be provided)
AST ACZ1 downhole pressure	ANSI Z540-1-1994	±0.001 psi, 0-3,000 psi	±0.01 psi	

[1] An equivalent method may be employed with the prior approval of the UIC Program Director.
[2] Annulus pressure will also be collected using a similar gauge should the well have tubing.
Note: Standards, detection limits/ranges, and precision parameters are subject to change based on the finalization of equipment.

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3.4.2. Precision (A.4.b.)

For fluid sampling, data accuracy will be assessed regularly by the collection and analysis of blanks to test procedures and matrix spikes to test lab and sampling procedures. Field blanks will be taken no less than one per sampling event to spot check for sample container contamination. Laboratory assessment of the precision of the analytes will be the responsibility of the laboratory chosen to analyze the field samples based on acceptable operating procedures.

Table 9 presents the specifications and precision information for the downhole pressure and temperature gauges to be used for downhole pressure and temperature monitoring in the injection and above confining zone intervals.

Table 10 presents the parameters and specifications for the logging tools to be used as part of Attachment 05: Pre-operational Testing Program, (2024), Attachment 06: Testing and Monitoring, (2024), and Attachment 08: Post-injection Site Care and Site Closure, (2024).

3.4.3. Bias (A.4.c.)

Assessments of the analytical biases present in analysis are the responsibility of the contracted laboratories based on acceptable operating procedures. It is assumed there are no measurement biases for direct temperature, pressure, or logging measurements.

3.4.4. Representativeness (A.4.d.)

For fluid sampling, data representativeness expresses the degree to which data accurately and precisely represents a characteristic of a sample population, parameter variations at a specific sampling point, a process condition, or an environmental condition. The sampling network laid out in the Testing and Monitoring Plan is designed to provide data that is representative of site conditions.

For analytical results of individual fluid samples, representativeness will be estimated by ion and mass balance determination. Ion balance determinations with ±10 % error, or less, will be considered valid. Mass balance determinations will be used in cases where the ion balance is great that the ±10 % threshold to attempt to determine the source of the measurement error.

For samples (and their duplicates) if the relative % difference varies by more than 10%, the sample may be considered not representative.

3.4.5. Completeness (A.4.e.)

Data completeness is a measure of the amount of valid data obtained from a measurement point compared to the amount of data that was expected to be obtained from the data point under normal conditions. It is anticipated that 90 % data completeness for fluid samples will be considered acceptable to meet monitoring objectives.

For direct pressure, temperature, and logging measurements, it is anticipated that data will be recorded no less than 90 % of the time.

3.4.6. Comparability (A.4.f.)

Data comparability expresses the confidence with which one data set can be compared to others. The data sets generated by this project are anticipated to be comparable to future data sets because of the use of standard methods of measurement and the high levels of quality assurance/quality control (QA/QC) of data.

Historical groundwater quality data will be assessed for their level of quality, and assuming they are of high enough quality, will be used for comparative purposes. Direct pressure, temperature and logging measurements will be directly comparable to previously collected data.

3.4.7. Method Sensitivity (A.4.g.)

Table 9, Table 10, Table 11, Table 12, and Table 13, provide additional information on gauge and sensor sensitivities as well as logging and downhole tool specifications.

Table 9: Pressure and temperature– downhole gauge specifications for AST OBS1/AST ACZ1/ AST INJ1.[1]

Parameter	Value
Calibrated working pressure range	14.7 to 10,000 psi
Initial pressure accuracy	± 0.015% over full scale
Pressure resolution	0.006 psi/second
Pressure drift stability	0.01% full scale/year
Calibrated working temperature range	to 300°F
Initial temperature accuracy	±0.01 °F
Temperature resolution	0.01 °F/second
Temperature drift stability	0.2% °F/year
Max temperature	300 °F
Instrument calibration frequency	From manufacturer
[1] An equivalent method may be employed with the prior approval of the UIC Program Director.	

Table 10: Representative logging tool specifications. [1]

Parameter	PNL	CBL	Ultrasonic Imaging Tool (or equivalent)	Temperature Log
Logging speed	1,000 feet per hour	1,800 feet per hour	2,700 feet per hour	900 feet per hour
Investigation Target	Knox Supergroup interval, Eau Clarie, and Mt. Simon Formations	Formation, casing, cement bond quality	Formation, casing, cement bond quality	Formation
Temperature rating		Up to 350°F	Up to 350°F	Up to 350°F

[1] A suitable replacement tool could be used pending tool availability; updated specifications will be provided should such a change occur.

Table 11: Temperature field probe – flowline, injection tubing. [1]

Parameter	Value
Calibrated working temperature range	0 to 500°F
Initial temperature accuracy	0.01°F
Temperature resolution	0.001°F

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

Table 12: Pressure field probe – flowline, injection tubing, AST INJ1 annulus, AST OBS1 wellhead. [1]

Parameter	Value
Calibrated working pressure range	0 to 3,000 psi
Initial pressure accuracy	0.01 psi
Pressure resolution	0.001 psi

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

Table 13: Flow rate field flowmeter – injection tubing. [1]

Parameter	Value
Calibrated working flow rate range	0 to 200,000 pounds per hour
Initial flow rate accuracy	< 2%
Flow rate resolution	0.001

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

3.5. Special Training/Certifications (A.5.)

3.5.1. Specialized Training and Certifications (A.5.a.)

Geophysical surveying equipment and wireline logging tools will be operated by trained, qualified, and certified personnel. This will be verified by the respective contracted service company that provides the equipment and services. The data collected as a result of these activities will be analyzed according to industry standards.

There are currently no special certifications required for personnel to collect groundwater samples. Qualified personnel will still perform these activities. Fluid sampling will be performed by personnel trained to understand and follow the specific and detailed sampling procedures.

If requested, Vault GSL CCS Holdings LP will provide the US EPA with all the laboratory Standard Operating Procedures (SOPs) for the specific parameters for the approved methods. Each laboratory technician conducting analysis on the samples will be trained in these SOPs for the standard method they are using. Technician certifications will be provided with the regular reports.

3.5.2. Training Provider and Responsibility (A.5.b/c)

Training will be provided by the contracted operator or subcontractor responsible for the collection of data.

3.6. Documentation and Records (A.6.)

3.6.1. Report Format and Package Information (A.6.a.)

A report from Vault GSL CCS Holdings LP to the US EPA will contain all required project data, sampling results, and analytical analysis results. The frequency of this report is defined the Attachment 06: Testing and Monitoring, (2024). Data will be provided in digital formats unless otherwise requested.

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

Other files (i.e., well logs, reports, test results, etc.) will be provided as required by the UIC Program Director and Class VI Permit.

3.6.3. Data Storage and Duration (A.6.c/d.)

Vault GSL CCS Holdings LP will maintain digital copies of all relevant files for the project as stipulated in the Testing and Monitoring Plan.

3.6.4. QASP Distribution Responsibility (A.6.e.)

Vault GSL CCS Holdings LP will be responsible for ensuring that all people listed on the distribution list below will receive the current copy of the approved QASP.

4. Data Generation and Acquisition (B.)

4.1. Sampling Process Design (B.1.)

Discussion in this section is focused on fluid sampling, CO_2 stream monitoring, and corrosion monitoring and does not discuss monitoring methods associated with non-physical samples (logging, seismic, pressure/ temperature monitoring, etc.).

During the pre-operation and injection phases, fluid sampling analysis is planned to include an extensive set of chemical analytes to aid in establishing a quality baseline data set. These analytes will include:

i. Primary and secondary US EPA drinking water maximum contaminant levels,
ii. Those most responsive to CO_2 or brine contact,
iii. Those necessary for quality control (QC) and,
iv. Those which might be necessary for geochemical modeling.

The full set of monitoring parameters is provided in Table 4. After a sufficient baseline dataset is established, the scope of the monitored analyte may shift to a more detailed subset of parameters that are:

i. the most responsive to interaction with CO_2 or brine contact, and
ii. are necessary for QC.

Implementation of a reduced set of parameters will be done in conjunction with consultation with the US EPA. During a period where a reduced set of analytes is used, should statistically significant trends develop that are presumed to be a result of unintended CO_2 or brine migration, the analytical list will be expanded to the initial, full set of analytical parameters.

All groundwater samples will be analyzed using a laboratory that meets the requirements laid out in the US EPA Environmental Laboratory Accreditation Program. Dissolved CO_2 will be analyzed by methods consistent with *Test Method B of ASTM D513-11e1, "Standard Test Methods for Total and Dissolved Carbon Dioxide in Water"* or a suitable equivalent.

4.1.1. Design Strategy (B.1.a)

4.1.1.1. CO_2 Stream Monitoring Strategy

The primary purpose of analyzing the CO_2 stream is to evaluate the potential interactions of CO_2 and other potential constituents of the injected with formation solids. The analysis performed can also identify or potentially rule out interactions with well materials of construction. Establishing the chemical composition of the injectate will also help to support the determination of whether this injectate meets the qualifications of hazardous waste described under the Resource

Conservation and Recovery Act (RCRA) from 1976. In addition to those stipulations laid out in the RCRA, this determination will be made with respect to the Comprehensive Environmental Response, Compensation and Liability Act of 1980.

Additional monitoring of chemical and physical characteristics of the CO_2 may help distinguish the injectate from native brine and gases if potential unintended leakage from the injection zone occurs. Injectate monitoring will occur at such frequency to detect potential changes to any physical or chemical properties that may result in deviation from the permit specifications and baseline data.

Yearly calibration of temperature, pressure, and flowrate probes and transponders meant to monitor the response of the injection of CO_2 into AST INJ1, will also be conducted annually at AST OBS1 and AST ACZ1. Calibration reports will contain information on the test equipment used to calibrate the probes, including equipment manufacturer information, serial numbers, calibration dates, and expiration dates of equipment and calibration.

4.1.1.2. Corrosion Monitoring Strategy

Corrosion coupon analysis will be conducted regularly to aid and ensure the mechanical integrity of all equipment that encounters the CO_2 stream. Coupons will be sent regularly to a third-party company for analysis. This analysis will be conducted in accordance with NACE Standard RP-0775, or similar, to determine and document any potential corrosion or wear rates based on mass loss.

4.1.1.3. Shallow Groundwater Monitoring Strategy

Several local shallow groundwater monitoring wells will be selected for the shallow groundwater monitoring program. In addition, one dedicated well will be drilled into the lowermost USDW adjacent to the injection well and will be sampled on a regular basis. These wells are intended to monitor all currently used aquifers in the area.

Further details on these wells and routine sampling are provided in Attachment 02: AoR and Corrective Action Plan, (2024), Attachment 06: Testing and Monitoring, (2024), and Attachment 08: Post-injection Site Care and Site Closure, (2024).

4.1.1.4. Deep Fluid Monitoring Strategy

AST ACZ1

One dedicated above confining zone monitoring well (AST ACZ1) will also be installed near the injection well. AST ACZ1 will be installed and completed within a porous and permeable interval within the Knox Supergroup above the confining zone and will serve as an early leakage detection point at or near the injection well.

With the planned sampling methods and outlined frequency, it is expected that baseline conditions can be documented, any natural variability in the conditions can be characterized, and that unintended brine or CO_2 leakage will be detected quickly if it occurs. Sufficient data will be collected from this well to demonstrate that the effects of CO_2 injection are limited to the intended injection zone.

AST INJ1

Fluid samples will be collected from the injection well as part of the Pre-operational Testing Program. Once injection begins no further fluid samples will be collected from the injection zone.

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

Table 1 contains a listing of type in number of samples that will be run and collected from each of the wells mentioned previously.

4.1.3. Site Sampling Locations (B.1.c.)

Fluid sampling locations have been provided previously and in the tables. Specific analytes for fluid sampling are provided in Table 4.

4.1.4. Sampling Site Contingency (B.1.d.)

Locations of off-site sampling and monitoring points have not been finalized. However, it is currently anticipated that no site access issues will occur. If weather makes well access difficult, sampling schedules will be adjusted as necessary to ensure that access and proper sampling may occur. The US EPA will be notified of any changes to the sampling schedule.

4.1.5. Activity Schedule (B.1.e.)

Sampling frequencies and occurrences are detailed in (Attachment 05: Pre-operational Testing Program, 2024), (Attachment 06: Testing and Monitoring, 2024), and (Attachment 08: Post-injection Site Care and Site Closure, 2024).

4.1.6. Critical Informational Data (B.1.f.)

Detailed documentation from field and laboratory activities will be taken during fluid sampling and analytical work. Important documentation to be collected during these times are as follows:

- Time and date of activity,
- Person(s) performing activity,
- Location of activity,
- Equipment calibration data, and
- Field parameter values.

During laboratory analysis much of the above-listed critical data are generated during the analysis and provided as part of the typical output reports from analysis. Additional noncritical data may be collected. This data may include appearance and odor of sample, problems with well or any sampling equipment, and any weather conditions which may impact sampling.

4.1.7. Sources of Variability (B.1.g.)

Potential sources of variability related to the aforementioned monitoring activities include:

- Natural variation in fluid quality, formation pressure and temperature, and seismic activity,
- Variation in fluid quality, formation pressure and temperature, and seismic activity due to injection operations,
- Changes in aquifer recharge due to rainfall, drought, or snowfall,
- Changes in instrument calibration during sampling or analytical activities,
- Changes in collection staff or analytical staff,
- Differences in environmental conditions during field sampling activities,
- Changes in analytical data quality during the life of the project, and
- Data entry errors related to maintaining a project database.

Activities that may serve to limit, reduce, or reconcile some of these sources of variability related to monitoring activities include:

- Collection of baseline data to observe and document natural variation in monitoring parameters,
- Evaluation of data in a timely manner after collection such that anomalies in the data can be observed, addressed, and re-sampling or re-analysis may occur,
- Statistical analysis of the collected data to determine whether variability and data set is a result of project activities or natural variation (i.e., determining if variation is biased or statistically significant),
- Maintenance of a database of weather-related data using on site and regional weather monitoring data or data collected from other near location sources,
- Instrument calibration before during and after sampling or analysis,
- Thoroughly training all staff to the standards that were detailed in sections 3.5.1 and 3.5.2,
- Routine quality assurance checks using third party reference materials and/or blind and or duplicate sample checks, and
- Development of a systematic review process of data that can include site and sample specific data quality checks.

4.2. Sampling Methods (B.2.)

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

4.2.1. Sampling SOPs (B.2.a/b.)

Shallow groundwater and fluid samples will be collected primarily using a low-flow sampling method that is consistent with ASTM D6452-99, (2018) or Puls and Barcelona, (1996). This method intends for a flow-through cell to be used. Should a flow through cell not be used, field parameters will be measured from grab samples. All groundwater wells will be purged to ensure samples are representative of formation water quality. Static water levels in each well will be determined using an electronic water level indicator before any purging or sampling activities occur.

The groundwater pH, temperature, specific conductance, and dissolved oxygen will be monitored in the field using portable probes and a flow-through cell consistent with standard methods given sufficient flow rates and volumes. Field chemistry probes will be calibrated at the beginning of each sampling day according to the given equipment manufacturer's procedures and will use standard reference solutions.

When a flow-through cell is used, field parameters will be continuously monitored and will be considered stable when three successive measurements made three minutes apart meet the criteria listed in Table 14.

Table 14: Stabilization criteria of water quality parameters during shallow well purging.

Field Parameter	Stabilization Criteria
pH	± 0.2 units
Temperature	± 1°C
Specific conductance	± 3% of reading in micro siemens per centimeter (µS/cm)
Dissolved oxygen	± 10% of reading or 0.3 mg/L, whichever is greater

After field parameters are stabilized per the above table, samples will be collected. Samples will be filtered through 0.45 µm through filter cartridges as appropriate and consistent with ASTM D6564-00, or suitable alternative.

Prior to sample collection, filters will be purged with a minimum of 100 mL of well water or more if required by the filter manufacturer. Methods such as air lifts or submersible pumps may be used to help purge fluid from the wells. For alkalinity and total CO_2 sampling, reasonable effort will be made to minimize exposure to atmospheric conditions during filtration, collection in sample containers, and analysis.

For deep fluid sampling, a wireline conveyed system with a sampling device capable of collecting downhole samples from discrete intervals will be utilized. Prior to sampling, any zones from these wells will be purged to ensure that stabilized criteria are met before taking representative samples. Standard methods, such as down hole submersible pumps or swabbing, will be used to develop these wells. The representative sample taken after the stabilization criteria have been met may be small relative to the total amount of fluid purged from the wells.

4.2.2. In-situ Monitoring (B.2.c.)

In-situ monitoring of aqueous geochemistry and analytes is not currently planned.

4.2.3. Continuous Monitoring (B.2.d.)

No continuous pressure monitoring is anticipated or planned at any of the shallow groundwater monitoring wells.

4.2.4. Sample Homogenization, Composition, Filtration (B.2.e.)

Information on the sampling, homogenization, composition, and filtration are provided in section 4.1. *Sampling Process Design*.

4.2.5. Sample Containers and Volumes (B.2.f.)

For CO_2 stream monitoring, samples will be collected using clean sample containers rated appropriately for sample collection pressure. To ensure a clean sample is taken, the collection cylinder(s) will be purged at least five times (with the sample gas) prior to sample collection. Information for the regular CO_2 gas analysis is provided in Table 5.

For shallow and deep groundwater samples, all sample bottles will be new sample bottles and bags. A summary of sample containers for use is presented in Table 15.

4.2.6. Sample Preservation (B.2.g.)

For all fluid samples, the preservation methods listed in Table 15 will be used. At this time, preservation of CO_2 gas stream samples is not currently anticipated; however, the details of the sampling requirements, if required, are shown in Table 16. Corrosion coupon sampling only requires that the coupons be physically separated during transportation to prevent physical abrasion.

Table 15: Summary of sample containers, preservation treatments, and holding times for CO_2 gas stream analysis.

Sample	Volume/Container Material	Preservation Technique	Sample Holding Time (maximum)
CO_2 gas stream	75 cm^3 mini gas cylinder 2-liter (L) multi-layer barrier (MLB) polybags	Sample storage cabinets	Five business days

4.2.7. Cleaning/Decontamination of Sampling Equipment (B.2.h.)

Any water pumps used that are not installed downhole will be cleaned on the outside with a non-phosphate detergent. Pumps will be rinsed a minimum of three times with deionized water. A minimum of 1 L of deionized water will then be pumped through the pump and sample tubing.

Once all pumps in their associated tubing are clean, they will be placed in plastic storage bags and transported for installation. All glassware to be used in the field will be cleaned first with tap water to remove any loose dirt, then washed in a dilute nitric acid solution, and finally rinsed with deionized water before use.

Gas stream sampling containers will be disposed of or decontaminated by the analytical lab. No sampling equipment will be utilized with the corrosion coupons or annual field calibrations.

4.2.8. Support Facilities (B.2.i.)

To conduct proper groundwater sampling the following equipment are required:

- Air compressor
- Vacuum pump
- Generator
- Multi-electrode water quality measurement tool
- Analytical meters

Sampling tubes, connections, and valves required to sample the gas stream will be supplied by the analytical lab.

Corrosion coupons will also be removed from the injection line.

4.2.9. Corrective Action, Personnel, and Documentation (B.2.j.)

Field staff are responsible for ensuring that all equipment is properly functioning. Corrective action will be performed on broken or malfunctioning equipment in the field as necessary. If corrective action cannot be taken in the field, the equipment will be uninstalled and returned to the manufacturer for repair or replacement. Any significant corrective actions that are required will be documented.

4.3. Sample Handling and Custody (B.3.)

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

Sample holding times provided in Table 16 will be consistent with those described by the US EPA guidelines and ASTM methods. After collection, all samples will be placed in an ice chest in the field, which will be maintained thereafter to approximately 4 °C until analysis can be performed. These samples will be maintained at this preservation temperature and sent to their designated laboratory within 24 hours of collection and storage. Analysis of the samples will be completed within the holding time listed in Table 16. As appropriate, alternative sample containers and preservation techniques approved by the UIC program director may be used to meet analytical requirements.

4.3.1. Maximum Hold Time/Time Before Retrieval (B.3.a.)

See Table 16 for maximum hold times for different samples.

4.3.2. Sample Transportation (B.3.b.)

See the beginning of Section 4.3 for sample transportation details and standards.

4.3.3. Sampling Documentation (B.3.c.)

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

An analytical authorization form will be provided for each gas stream sample provided for analysis as shown by the example in Appendix A, which will be provided at a later date after vendor selection.

4.3.4. Sample Identification (B.3.d.)

All sample bottles will have waterproof labels with the following information:

- Project name
- Sampling date
- Sampling location
- Sampling, identification number
- Sample type
- Analyte
- Volume
- Filtration used
- And preservative used

Appendix A will include examples of sample documentation including an example of such a label for a sample bottle.

Table 16: Summary of anticipated sample containers, preservation treatments, and holding times for fluid samples.

Parameters	Lab Method	Type of Container	Preservation Technique	Sample Holding Time
Cations: Ca, Fe, K, Mg, Na, Si	EPA 6010B	High density polyethylene (HDPE) 250 mL	Nitric acid, cool 4 °C	60 days
Cations: Al, Sb, As, Ba, Cd, Cr, Cu, Pb, Mn, Se, Tl	EPA 200.8	HDPE 250 mL	Nitric acid, cool 4 °C	60 days
Cations: Hg	EPA 245.1	HDPE 250 mL	Nitric acid, cool 4 °C	4 weeks
Anions: Br, Cl, F, NO_3, and SO_4	EPA 300.0	HDPE 250 mL	Filtered, cool 4 °C	14 days except NO_3 48 hours
Alkalinity	SM 2320B	HDPE 250 mL	Filtered, cool 4 °C	14 days
TDS	SM 2540C	HDPE 250 mL	Filtered, cool 4 °C	7 days
TOC	SM 5310C	Glass amber 500 mL	Sulfuric acid, cool 4 °C	4 weeks
DIC	SM 5310C	Glass amber 500 mL	Filtered, sulfuric acid, cool 4 °C	4 weeks
Total and Dissolved CO_2	ASTM D513-06B	Glass 40 mL vials	Base preservative, cool 4 °C	14 days
Stable Isotopes of δ13C	Isotope ratio mass spectrometry	HDPE 250 mL	0.5 micron filtered, cool 4 °C	14 days

4.3.5. Sample Chain of Custody (B.3.e.)

For gas stream analysis, an analysis authorization will accompany the sample to the lab, at which point this chain of custody form accompanies the sample throughout the analytical process.

For fluid samples, the chain of custody will be documented using a standard form. Copies of the form will be provided to the person or lab receiving the samples, as well as the person or 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 the fluid sampling personnel and all lab personnel involved in analysis.

4.4. Analytical Methods (B.4.)

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

4.4.1. Analytical Standard Operating Procedures (B.4.a.)

Analytical Standard Operating Procedures (SOPs) and their critical parameters are referenced in Table 4. Other laboratory specific SOPs utilized by the contracted laboratories will be determined after such laboratory has been selected.

Upon request, Vault GSL CCS Holdings LP will provide the agency with all laboratory SOPs developed for the specific parameters, using the appropriate standardized method. Each laboratory technician conducting the analysis on these samples will be trained on the SOPs developed for each standardized method. Vault GSL CCS Holdings LP will include the technicians training certification(s) with the regular reports.

4.4.2. Equipment/Instrumentation Needed (B.4.b.)

Any equipment and instrumentation that is needed is specified in the individual analytical methods which are referenced in Table 4.

4.4.3. Method Performance Criteria (B.4.c.)

It is not anticipated that any non-standard method of performance criteria will be necessary for this project.

4.4.4. Analytical Failure (B.4.d.)

Each contracted laboratory conducting the analysis laid out in Table 4 will be responsible for appropriately addressing any analytical failures according to their individual SOPs.

4.4.5. Sample Disposal (B.4.e.)

Each contracted laboratory conducting the analysis laid out in Table 4 will be responsible for appropriate sample disposal according to their individual SOPs.

4.4.6. Laboratory Turnaround (B.4.f.)

Turnaround time will vary by laboratory. It is generally anticipated that the turnaround time of verified analytical results will be received within one month for project needs.

4.4.7. Method Validation for Non-standard Methods (B.4.g.)

It is not anticipated that any nonstandard methods of validation will be necessary for this project. Should this change in the future, the US EPA will be consulted on additional appropriate actions to be taken.

4.5. QC (B.5.)

Logging, geophysical monitoring, and pressure and temperature monitoring do not apply to this section and is, therefore, omitted. Appendix B will include standard industry practices and will be populated at a later date after vendor selection.

4.5.1. QC Activities (B.5.a.)

4.5.1.1. Blanks

For shallow groundwater sampling, a field blank will be collected and analyzed for the inorganic analytes detailed in Table 4 at a frequency of 10% or greater. It is noted that field blanks will be exposed to the same field and transportation conditions as the groundwater samples described in Section 4.3 *Sample Handling and Custody* will also be utilized for deep fluid sampling and analyzed for the same inorganic analytes detailed in Table 4 at a frequency of 10% or greater. Field blanks will be used to detect contamination, resulting from the collection and transportation processes.

4.5.1.2. Duplicates

For shallow groundwater sampling, a duplicate groundwater sample will be collected from a well on a rotating schedule. Duplicate samples are collected from the same source immediately after the original sample is taken. These samples will be kept in different storage containers and process the same as other samples. Duplicate samples are used to assess sample heterogeneity and analytical precision.

4.5.2. Exceeding Control Limits (B.5.b.)

If the analytical results exceed control limits, further examination of the analytical results will be done by evaluating the ratio of the measured total dissolved solids (TDS) count to the calculated TDS count per the American Public Health Association method.

This method indicates which ion analysis 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 then recalculated and if the error is still not resolved, suspect data are identified and may be given less importance and data interpretation.

4.5.3. Calculating Applicable QC Statistics (B.5.c.)

4.5.3.1. Charge Balance

The analytical results are evaluated to determine the correctness of the applied analysis based on anion-cation charge balance calculation. Due to the fact that potable waters are electrically neutral, the chemical analysis should yield equally negative and positive ionic activity. The anion-cation charge balance is calculated using the following formula:

$$\% \, difference = 100 \frac{\sum cations - \sum anions}{\sum cations + \sum anions'} \quad (1)$$

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

4.5.3.2. Mass Balance

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

$$1.0 < \frac{measured\ TDS}{calculated\ TDS} < 1.2 \quad (2)$$

Wherein the anticipated values are between 1.0 and 1.2.

4.5.3.3. Outliers

It is essential to determine the presence of any statistical outliers when performing evaluation and analytical analysis of groundwater. This project will utilize the US EPA's guidance (EPA, 2009) as the basis for selection of recommended statistical methods to identify outliers and groundwater chemistry datasets as appropriate.

The techniques detailed in this documentation include:

- Probability plots,
- Box plots,
- Dixon's test,
- Rosner's test.

4.6. Instrument/Equipment Testing, Inspection, and Maintenance (B.6.)

Logging tool equipment will be maintained and cared for, as detailed in the wireline industry best practices which will be provided in Appendix B at a later date.

Shallow groundwater and fluid sampling field equipment will be maintained, serviced, and calibrated per manufacturer recommendation. Spare parts that may be needed during sampling will be included and supplied during field sampling.

The contracted laboratories will be responsible for providing all testing, inspection, and maintenance of all laboratory equipment used for analytical purposes. Standard practice and method specific control should be followed during these activities.

4.7. Instrument/Equipment Calibration and Frequency (B.7.)

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

4.7.1. Calibration and Frequency of Calibration (B.7.a.)

Pressure and temperature gauges as well as flowmeter information is provided in Table 9, Table 10, Table 11, Table 12, and Table 13.

Logging tool calibration will be the responsibility of the contracted service company providing the equipment, following standard industry practices.

For fluid sampling, the portable field meters or multiprobe sondes that will be used to determine field parameters are calibrated according to manufacturer recommendations and equipment manuals each day before sampling begins. Recalibration will be performed if any components yield atypical values or fail to stabilize during sampling.

4.7.2. Calibration Methodology (B.7.b.)

Logging tool calibration methods will follow standard industry practices and will be provided in Appendix B at a later date.

For fluid sampling, the standards for calibration are typically as follows:

- For pH -7 to 10.
- For specific conductance - potassium chloride solution yielding a value of 1,413 µS/cm at 25 °C.
- For dissolved oxygen - a 100% dissolved O_2 solution.

Calibration is performed for the pH meters per manufacturer specification.

Coulometry instrumentation will be routinely evaluated using sodium carbonate standards.

4.7.3. Calibration Resolution and Documentation (B.7.c.)

Logging tools, calibration, resolution, and documentation will follow the standard industry practice and will be provided in Appendix B at a later date.

For fluid sampling tools, calibration values will be noted in daily sampling recordings, as well as errors in calibration, should there be any. For parameters where calibration is not acceptable, redundant equipment may be used to ensure that any potential loss of data is minimized.

4.8. Inspection/Acceptance for Supplies and Consumables (B.8.)

4.8.1. Supplies, Consumables, and Responsibilities (B.8.a/b.)

As required by approved vendors, supplies and consumables for field and laboratory operations will be procured, inspected, and accepted as appropriate. Acquisition of such supplies and consumables related to groundwater analysis will be the responsibility of each laboratory per the established method or operating procedures.

4.9. Non-direct Measurements – Seismic Monitoring (B.9.)

4.9.1. Data Sources (B.9.a.)

For time-lapse surface seismic surveys, repeatability is paramount for accurate differential comparison. To ensure survey quality, the locations for the surface shots and acquisition method of sequential surveys must be consistent. Once these surveys have been conducted, they will be compared to a baseline survey to track and monitor plume development.

For Mt. Simon Sandstone pressure monitoring downhole gauges in the AST OBS1 well will be used to gather pressure data.

4.9.2. Relevance to Project (B.9.b.)

Seismic surveys will be used to track changes in the CO_2 plume in the injection formation. Processing and comparing the subsequent surveys to the baseline survey taken before injection starts allows for the assessment and monitoring of plume growth. It will also help to ensure that the plume does not extend outside of the intended injection zone. Additional modeling will be used to predict plume growth and migration over time by combining the seismic data and the existing geologic model.

The Mt. Simon Sandstone time-lapse seismic data will also be used in this additional modeling to predict CO_2 plume and pressure front behavior and to confirm the CO_2 plume stays within the AoR.

4.9.3. Acceptance Criteria (B.9.c.)

Standard industry practices will be used to ensure that the seismic data accurate and appropriate for modeling purposes. Replicated shot point locations, functional geophones, and similar seismic input data will be used from survey to survey to ensure repeatability.

When the seismic data is processed, several quality assurance checks will be done in accordance with industry standards. Further detail on the industry standard methods of reformatting, structuring and application will be provided in (Attachment 06: Testing and Monitoring, 2024).

4.9.4. Resources/Facilities Needed (B.9.d.)

Vault GSL CCS Holdings LP will provide all resources, equipment, and facilities needed for all passive seismic monitoring. A third-party contractor will provide all resources, equipment, and facilities needed for surface seismic surveys. Downhole pressure monitoring will be performed in wells associated with the project. A third-party contractor will perform shallow groundwater sampling.

4.9.5. Validity Limits and Operating Conditions (B.9.e.)

Trained personnel will be responsible for the review and analysis of all collected data to be used for the seismic surveys and numerical modeling. These checks will be done according to industry standard practices.

4.10. Data Management (B.10.)

4.10.1. Data Management Scheme (B.10.a.)

Vault GSL CCS Holdings LP or a designated third-party contractor will maintain the required data as provided elsewhere in the permit application. Data will be digitally backed up or backed up via hard copy as necessary.

4.10.2. Recordkeeping and Tracking Practices (B.10.b.)

All records and gathered data will be held securely and organized properly.

4.10.3. Data Handling Equipment/Procedures (B.10.c)

All equipment used to collect and store data will be properly maintained and operated according to industry standard practices. All supervisory control and data acquisition (SCADA) system(s) and other data acquisition systems will interface with each other as necessary. All data will be held and stored securely.

4.10.4. Responsibility (B.10.d.)

The project manager, as outlined in this document and in the permit application, will be responsible for ensuring proper data management is maintained.

4.10.5. Data Archival and Retrieval (B.10.e.)

All data will be held by Vault GSL CCS Holdings LP. These data will be maintained and stored for review as necessary as detailed previously in Section 4.10.1.

4.10.6. Hardware and Software Configurations (B.10.f.)

All Vault GSL CCS Holdings LP and vendor hardware/software configurations will be interfaced appropriately.

4.10.7. Checklists and Forms (B.10.g.)

All required checklists and forms will be generated and produced for usage as necessary.

5. Assessment and Oversight (C.)

5.1. Assessments and Response Actions (C.1.)

5.1.1. Activities to be Conducted (C.1.a.)

Please refer to Attachment 06: Testing and Monitoring, (2024) and Attachment 08: Post-injection Site Care and Site Closure, (2024) sections of this permit application to see the frequency of data collection for the activities listed in Table 1 of this document.

After completion of sample analysis and data collection, the results will be QC'd for criteria as noted in Section 4.5 of this QASP document. If the collected data and sample analysis are not found to be consistent with these standards of QC, they will be reanalyzed as detailed in the section. All evaluations of data consistency will be performed according to industry standard methods and those described in the US EPA Unified Guidance (EPA, 2009).

5.1.2. Responsibility for Conducting Assessments (C.1.b.)

Third-party organizations gathering and analyzing data will be responsible for conducting their own internal assessments.

5.1.3. Assessment Reporting (C.1.c.)

All assessment information should be reported to the individual project managers as outlined in this document.

5.1.4. Corrective Action (C.1.d.)

Corrective action that is taken to improve any individual organization's data collection responsibility should be addressed, verified, and documented by the project manager that the issue is reported to. After this, the individual project manager will communicate this information to the other project managers, as necessary.

Corrective actions that impact multiple organizations should be addressed by all members of the project leadership and communicated to the other members on the distribution list as outlined above for the QASP.

It is noted that the results of the corrective action may impact multiple sources of monitoring data/equipment and/or multiple organizations. It is, therefore, the responsibility of Vault GSL CCS Holdings LP to ensure the most cost-effective and efficient action is implemented across the project.

5.2. Reports to Management (C.2.)

5.2.1. QA Status Reports (C.2.a/b.)

It is currently anticipated that QA status reports will not be necessary. If any of the aforementioned testing or monitoring techniques are altered, the QASP will be reviewed and updated, as necessary, in consultation with the US EPA. Revised QASPs will then be distributed to the full distribution list detailed at the beginning of this document.

6. Data Validation and Usability (D.)

6.1. Data Review, Verification, and Validation (D.1.)

6.1.1. Criteria for Accepting, Rejecting, or Qualifying Data (D.1.a.)

All formation fluid sampling results will be entered into a database for periodic review and analysis. Formation fluid quality data validation will include the review of the following:

- Concentration units
- Sample holding times
- Review of duplicate Blank and other appropriate QA/QC results

Copies of this analysis, laboratory analytical test results, and/or reports will be kept. In the regular periodic reports, data will be presented in graphical and tabular formats as appropriate to characterize general groundwater quality data and identify intra well variability. After sufficient data has been collected, additional methods might be used to evaluate inter-well variations for formation fluid constituents and to evaluate if significant changes have occurred that could result in the leakage of CO_2 or brine beyond the intended injection zone.

6.2. Verification and Validation Methods (D.2.)

6.2.1. Data Verification and Validation Processes (D.2.a.)

See Sections 6.1.1 and 4.5. Appropriate statistical software will be utilized to determine data consistency.

6.2.2. Data Verification and Validation Responsibility (D.2.b.)

Vault GSL CCS Holdings LP or the designated third-party contractor will verify and validate formation fluid data.

6.2.3. Issue Resolution Process and Responsibility (D.2.c.)

Vault GSL CCS Holdings LP or the designated third-party contractor will review the groundwater data handling management and assessment processes as necessary. Staff involved in these processes will consult with the Project Manager to determine if any actions are required to resolve issues.

6.2.4. Checklist, Forms and Calculations (D.2.d.)

Checklists and forms will be developed specifically to meet permit requirements. These checklists or forms will be developed as needed and provided as part of regular reports, if necessary.

6.3. Reconciliation with User Requirements (D.3.)

6.3.1. Evaluation of Data Uncertainty (D.3.a.)

Software will be used to determine groundwater data consistency using methods consistent with the US EPA (EPA, 2009).

6.3.2. Data Limitations Reporting (D.3.b.)

Data that are collected and evaluated will be presented using appropriate data-use limitations.

7. References

ASTM D6452 : Standard Guide for Purging Methods for Wells Used for Ground Water Quality Investigations, 2018, ASTM Standard D6452: ASTM International.

Atekwana, E. A., and R. V. Krishnamurthy, 1998, Seasonal variations of dissolved inorganic carbon and δ13C of surface waters: application of a modified gas evolution technique: Journal of Hydrology, v. 205, no. 3, p. 265–278, doi:10.1016/S0022-1694(98)00080-8.

Attachment 02: AoR and Corrective Action Plan, 2024, Underground Injection Control Class VI Permit Application: Aster Project.

Attachment 03: Financial Assurance Plan, 2024, Underground Injection Control Class VI Permit Application: Aster Project.

Attachment 05: Pre-operational Testing Program, 2024, Underground Injection Control Class VI Permit Application: Aster Project.

Attachment 06: Testing and Monitoring, 2024, Underground Injection Control Class VI Permit Application: Aster Project.

Attachment 08: Post-injection Site Care and Site Closure, 2024, Underground Injection Control Class VI Permit Application: Aster Project.

EPA, 2009, Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities: Unified Guidance.

Hackley, K. C., S. V. Panno, and T. F. Anderson, 2010, Chemical and isotopic indicators of groundwater evolution in the basal sands of a buried bedrock valley in the midwestern United States: Implications for recharge, rock-water interactions, and mixing: Geological Society of America Bulletin, v. 122, no. 7–8, p. 1047–1066, doi:10.1130/B26574.1.

Puls, R. W., and M. J. Barcelona, 1996, Ground Water Issue: Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures: U.S. Environmental Protection Agency.

8. Appendix A - Sample Documentation

Sample documentation forms will be provided upon vendor selection.

9. Appendix B - Standard Industry Practices for Calibration

Industry practices will be provided upon selection of sensors and tools.