APPENDIX F-1: Groundwater Monitoring Plan for Quaternary and Shallow Pennsylvanian Strata

Groundwater Monitoring Plan for the Quaternary and Shallow Pennsylvanian Strata.
Illinois Industrial Carbon Capture & Sequestration (IL-ICCS) Project
Decatur, Illinois

F1.1. Purpose, Number of Wells, and Well Placement

The purpose of this voluntary (non-regulatory) groundwater monitoring plan is to observe the local spatial and temporal variability of groundwater quality in the Quaternary and Shallow Pennsylvanian strata which are commonly used as private water sources within the application's AoR.

Four (4) monitoring wells are proposed and Figure F1-1 shows the planned locations of the wells. Two wells will be located within 200 feet of the injection well (denoted by the yellow circle), while the other two wells will be located approximately 400 and 2,000 feet from the injection well (denoted by the orange and blue circles, respectively). The exact location of the two closest wells will depend on the final location of the injection well and related infrastructure.

Placement of the two distant wells will be based on the groundwater flow direction and the predicted movement of the CO_2 plume within the Mt. Simon Sandstone. The less dense CO_2 is expected to move upward and updip within the Mt. Simon Sandstone. Regional maps of the Precambrian and the Mt. Simon (e.g., Figures 2-5 through 2-7 in Section 2 of this application) indicate that the updip direction of the Cambrian rocks is northwest.

F1.2. Type of Wells

All groundwater monitoring wells will be installed and eventually abandoned according to Illinois Department of Public Health regulations. During drilling, representative cores will be collected at selected monitoring well locations and archived at the Illinois State Geological Survey. Field descriptions of the cores will be taken and the desired monitoring interval identified. Monitoring wells will be constructed with 2-inch PVC or similar suitable materials using threaded connections. Slotted well screen (e.g., 0.010 inch slot or similar as appropriately sized for formation and sand pack conditions) will be used. The screened interval will have a sand pack of appropriate thickness based on the monitoring interval identified from core samples. Bentonite will be used as the annular fill above the sand pack to near land surface. Concrete and a well protector will be placed at the surface. The locations and elevations of the monitoring wells will be determined by standard land surveying methods based on at least one local benchmark. After well construction and prior to implementing the sampling schedule, all wells will be developed with an inertial-lift pump, electric centrifugal submersible pump, positive air displacement pump, or similar equipment.

Figure F1-1. Approximate IL-ICCS Injection Site Showing Shallow Groundwater Monitoring Target Areas.

Base: November 2010 Aerial Imagery, Illinois Department of Transportation

Proposed Injection Well

200 feet

400 feet

2,000 feet

N

0 0.1 0.2 Miles

Original Printed Scale 1:8,000

IL-ICCS Site, Decatur, IL, showing proposed injection well and distance radii, in feet, from proposed well.

To ensure sample integrity and reduce the introduction of atmospheric CO_2 into the groundwater monitoring wells during sampling, dedicated pumps will be installed. After assembly, the pumps, tubing, and any other downhole accessories will be rinsed with deionized water and placed in plastic bags until deployment. During pump deployment and storage, care will be taken to ensure that equipment to be used inside the monitoring wells remains clean and does not come in contact with potentially contaminating materials.

F1.3. Initiation, Frequency and Duration of Monitoring

After installation of the monitoring wells, pre-injection sampling will be initiated after sufficient well development has occurred to remove as much visible turbidity from the produced water as is practical. After well development, sampling will be conducted at least quarterly and continue through the injection operational period. During the injection period, the sample frequency may be maintained or adjusted (i.e., increased or decreased) based on operational parameters and sample analysis results. Sampling will continue through the first year of the post-injection period, after which, sampling frequency may be greatly reduced (e.g., annually).

F1.4. Sampling Parameters, Sampling Methods, and Analytical Methods

We propose to analyze shallow groundwater samples for the following:

Field Parameters:

- pH
- Specific Conductance
- Temperature
- Dissolved Oxygen

Indicator Parameters:

- Alkalinity
- Bromide
- Calcium
- Chloride
- Sodium
- Total CO_2

All indicator parameters of interest are inorganic and have been selected based on known chemical reactions of CO_2 in aqueous media. These parameters are expected to be key indicators in determining whether injected CO_2 has or has not impacted groundwater quality either 1) directly by introduction of CO_2 into shallow groundwater or 2) indirectly by CO_2-induced migration of groundwater with differing chemical compositions (e.g., brine) into shallow groundwater. As with the sample frequency, the permit holder may revise the list of analytes at

any time for this voluntary monitoring based on the consistency of operational parameters and groundwater chemistry results obtained from the wells.

Sample Containers

All sample bottles will be new. Sample bottles and bags for analytes will be used as received from the vendor or contract analytical laboratory or cleaned prior to use as appropriate for the analyte of interest.

Well Purging and Sampling

Static water levels in each well will be determined using an electronic water level indicator before any purging or sampling activities. Dedicated pumps (e.g., bladder pumps) will be installed in each monitoring well to minimize potential cross contamination between wells.

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 (e.g., APHA, 2005) given sufficient flow rates and volumes. Field chemistry probes will be calibrated at the beginning of each sampling day according to equipment manufacturer procedures using standard reference solutions. When a flow-through cell is used, field parameters will be continuously monitored and will be considered stable when three successive measurements made three minutes apart meet the criteria listed in Table F1-1. It is anticipated that purging will primarily be conducted based on stabilization of the field parameters using a low-flow method. However, conditions (e.g., low well productivity) may require the use of other methods consistent with ASTM D6452-99 (2005) or Puls and Barcelona (1996). If a flow through cell is not used, field parameters will be measured in grab samples.

Table F1-1. Stabilization criteria of water quality parameters during groundwater monitoring well purging

FIELD PARAMETER	STABILIZATION CRITERIA
pH	+ / - 0.2 units
Temperature	+ / - 1° C
Specific Conductance	+ / - 3% of reading in µS/cm
Dissolved Oxygen	+ / - 10% of reading or 0.3 mg/L whichever is greater

Samples will be filtered through 0.45 µm flow-through filters as appropriate and consistent with ASTM D6564-00. Prior to sample collection, filters will be purged with a minimum of 100 milliliters of well water (or more if required by the filter manufacturer). For alkalinity and total CO_2 samples, efforts will be made to minimize exposure to the atmosphere during filtration, collection in sample containers, and analysis. Sample preservation techniques (Table F1-2) 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.

Table F1-2. Sample preservation and containers

ANALYTE	PRESERVATION[1]	HOLDING TIME[1]	CONTAINER[1]	METHOD
Alkalinity	Filtration, 4° C	In field, 14 days	HDPE bottle	EPA 310.1 APHA[2] 2320
Dissolved Anions: Bromide, Chloride	Filtration, 4° C	28 days	HDPE bottle	EPA 300.0 APHA 4110B
Dissolved Metals: Calcium, Sodium	Filtration, 4° C, HNO_3 < pH 2	6 months	HDPE bottle	EPA 200.8 APHA 3120B
Total CO_2	Filtration, 4° C	14 days	HDPE bottle	APHA 4500-CO_2D Orion, 1990 or ASTM D513-06

Note 1: USEPA, Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020
Note 2: American Public Health Association, Standard Methods for the Examination of Water and Wastewater

Sample Analysis

Anion concentrations will be determined by ion chromatography (O'Dell et al., 1984, EPA Method 300.0), and cation concentrations will be determined by inductively coupled plasma (ICP) spectrophotometry, (e.g., EPA Method 200.8; APHA, 2005). Alkalinity will be determined using APHA Method 2320. Total CO_2 concentrations will be determined preferentially by coulometry per ASTM D513-06 or alternatively by other methods (e.g., Orion, 1990; APHA, 2005).

Quality Assurance/Quality Control (QA/QC)

Field quality assurance will primarily include periodic field duplicates and field blanks. One field duplicate and one field blank will be used per sampling event. Additional field QA/QC measures will be implemented according to ASTM Method D7069-04 (2004) as needed based on data analysis of historical results and laboratory performance during the monitoring program.

Sample Chain of Custody

All sample bottles will be labeled with durable labels and indelible markings. A unique sample identification number, sampling date, and analyte(s) will be recorded on the sample bottles as well as sampling records written for each well. Sampling records (e.g., a field logbook,

individual well sampling sheet) will indicate the sampling personnel, date, time, sample location/well, unique sample identification number, collection procedure, measured field parameters, and additional comments as needed.

A chain-of-custody record shall be completed and accompany every sample or group of samples collected during an individual sampling event to track sample custody. This record should include: sampler name(s), their affiliation, address, phone number, project identification and project location, sample(s) identification number(s), sampling date and time, signature of person(s) involved in chain-of-custody possession, and remarks regarding sample(s). Where appropriate, ASTM Method D6911-03 (2003) will be followed for packaging and shipping of samples. Immediately upon sample collection, containers shall be placed in an insulated cooler and cooled to 4 degrees Celsius. Samples will either be shipped or hand delivered. Shipment priority will be determined by the holding times or need to expedite sample analysis. Upon receipt at the laboratory, the samples will be accepted and tracked by the laboratory from arrival through completed analysis.

Groundwater Quality Evaluation

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. Analytical results will be kept on file by the permit holder for the duration of the project, and will be provided to the agency if requested. Analytical data will be evaluated in graphical and tabular formats as appropriate to characterize general groundwater quality and identify intrawell variability with time.

F1.5. References

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