5.0 PRE-OPERATIONAL TESTING PROGRAM

40 CFR 146.82(a)(8), 40 CFR 146.87

MARQUIS BIOCARBON PROJECT

Facility Information

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Well name: MCI CCS 3

Well location: PUTNAM COUNTY, ILLINOIS
S2 T32N R2W
Latitude: 41.27026520 N, Longitude: 89.30939322 W

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5.0 Pre-Operational Testing Program

5.1 Introduction

This section describes the pre-operational formation testing program that has been and will be implemented to characterize the chemical and physical properties of the injection zone and confining zone at the Marquis BioCarbon Project. The pre-operational testing program meets the testing requirements of Title 40 of the U.S. Code of Federal Regulations Section 146.87 (40 CFR 146.87) and well construction requirements of 40 CFR 146.86. The pre-operational testing program provides the depth, thickness, mineralogy, lithology, porosity, permeability, and geomechanical information of the Mt. Simon Sandstone (carbon dioxide (CO_2) storage formation), the overlying Eau Claire Shale (confining layer), and other relevant geologic formations. Additional pre-operational testing data collected will be used to provide baseline information for the site that will be used for comparative purposes throughout the project. For example, fluid samples collected during the pre-operation testing will be used as a reference to identify geochemical changes in samples collected during operation that may result from the injection of CO_2.

Well (MCI MW 1) was drilled in the 4th Quarter of 2021 (Illinois Department of Natural Resources Permit No. 010858) and was used to provide the initial pre-operational testing information. This information combined with the information from a nearby regional well, J&L Well, that was drilled in the 1960s, helps to characterize the project site. The MCI MW 1 well is located 1.2 miles northwest of the proposed injection location, and the J&L Well is located 1.25 miles southwest of the proposed MCI CCS 3 well. See **Figure 5-1**. Marquis will use the MCI MW 1 well as a far field monitoring well under the Class VI program. Additional pre-operational testing data will be generated during the installation of the MCI CCS 3 well to confirm homogeneity across the site. The data gathered in the MCI CCS 3 well will be combined with the data from the MCI MW 1 well for use in the model and simulations that will be used to monitor the CO_2 plume and refine the AoR.

This document describes the extensive and complete logging, coring, fluid sampling, and formation hydrogeologic testing that was performed in the MCI MW 1 well. The data generated from the pre-operational testing performed on MCI MW 1 has been provided in the Project Narrative (Permit **Section 1**), the Appendices to the permit application, and has been incorporated into the site static earth and dynamic models (Permit **Section 2**). This section also describes the planned program for pre-operational testing and data gathering in the MCI CCS 3 well. Additional pre-operational testing data collected during the drilling of MCI CCS 3, along with existing data from MCI MW 1, provides baseline information for the characteristics of the site and relate to the baseline monitoring program. Details of the baseline monitoring are provided in the Testing and Monitoring Plan (Permit **Section 7**).

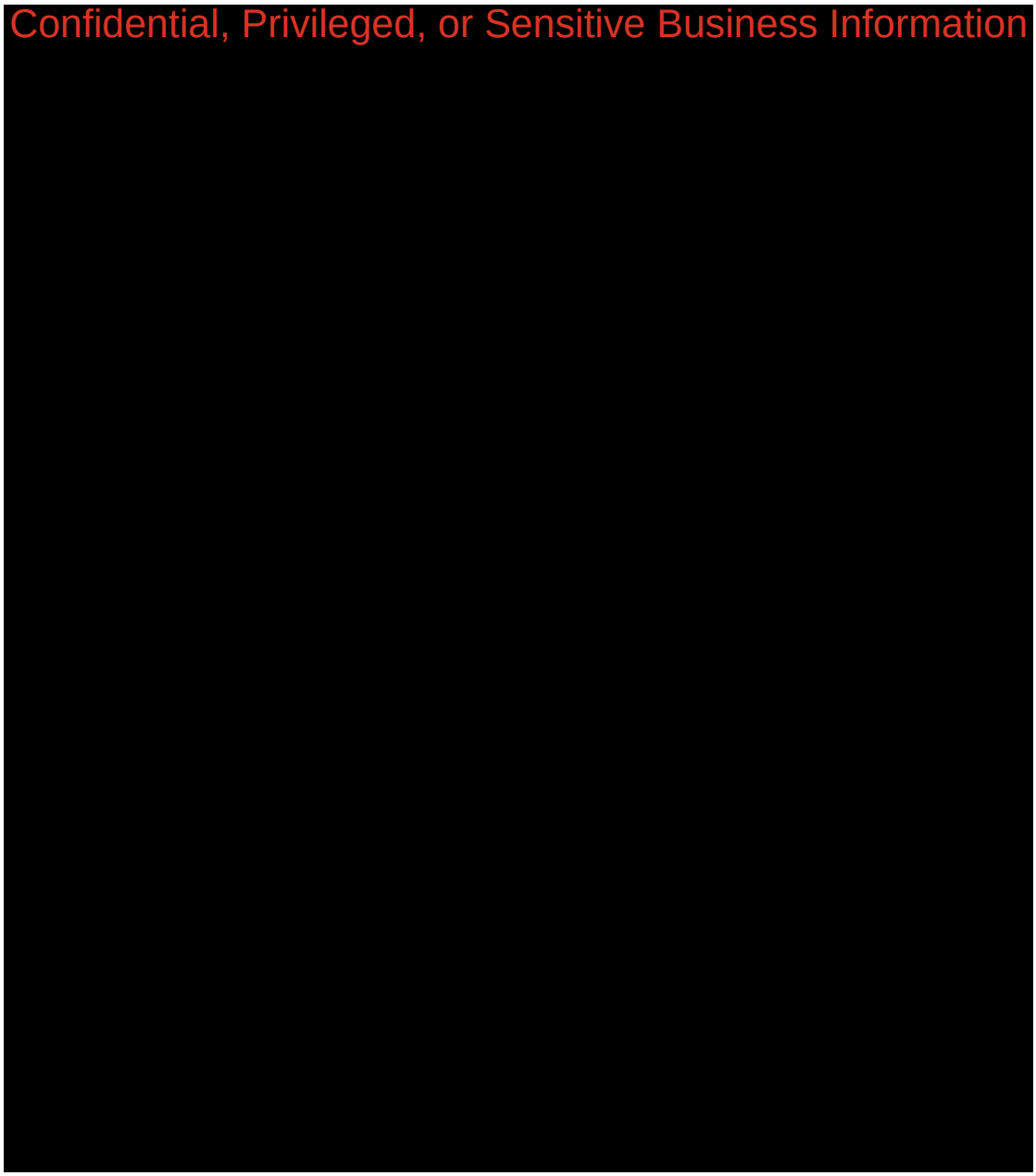

Figure 5 - 1: Locations of the proposed injection well (MCI CCS 3), the characterization/monitoring well (MCI MW-1,2), and an above confining zone (ACZ) monitor well (MCI ACZ 1).

5.2 MCI MW 1 Well Testing and Wireline Logging

This section provides details for the collection of samples and data from the MCI MW 1 that was installed in the 4th Quarter of 2021. The results of the sample analysis and data processing are presented in the Project Narrative (Permit **Section 1**) and the results have been incorporated in the static and dynamic models provided in the Area of Review (AoR) section (Permit **Section 2**). Processed data and analytical results are available in the Appendices to the Permit Application.

5.2.1 Well Logging: Surface Section

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Figure 5 - 1: Locations of the proposed injection well (MCI CCS 3), the characterization/monitoring well (MCI MW-1,2), and an above confining zone (ACZ) monitor well (MCI ACZ 1).summarizes the well logs that were acquired before and after surface casing was set and the parameters obtained from each well log.

After setting surface casing and waiting 24 hours for the cement to set, a cement bond log - variable density log (CBL-VDL) was acquired with a gamma ray tool for depth correlation to evaluate the cement integrity (**Table 5 - 1**: Summary of wireline logs and associated parameters and depth intervals of logging tools ran before and after surface casing (surface to 394 ft) in the MCI MW 1 well.).

Open/ Cased Hole	Log Type	Parameters Obtained
Open Hole	[redacted]	[redacted]
	[redacted]	[redacted]
	[redacted]	[redacted]
	[redacted]	[redacted]
	[redacted]	[redacted]
	[redacted]	[redacted]
	[redacted]	[redacted]
Cased Hole	[redacted]	[redacted]

Table 5 - 1: Summary of wireline logs and associated parameters and depth intervals of logging tools ran before and after surface casing [redacted] the MCI MW 1 well.

5.2.2 Well Logging: Intermediate Section

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Table 5-2 summarizes the well logs acquired in the intermediate well section and the purpose of each well log.

After the intermediate casing string was cemented, a CBL-VDL and an advanced ultrasonic logging tool were run with a gamma ray tool for depth correlation to evaluate the quality of the cement behind the intermediate casing (Table 5-2).

Open/ Cased Hole	Log Type	Parameters Obtained
Open Hole	[redacted]	[redacted]
	[redacted]	[redacted]
	[redacted]	[redacted]
	[redacted]	[redacted]
	[redacted]	[redacted]
	[redacted]	[redacted]
	[redacted]	[redacted]
	[redacted]	[redacted]
Cased Hole	[redacted]	[redacted]
	[redacted]	[redacted]

Table 5 - 2: Summary of wireline logs and associated parameters of logging tools to be run before and after intermediate casing [redacted] MCI MW 1 well.

5.2.3 Well Logging: Deep Section

[redacted] **Table 5-3** summarizes the well logs that were acquired in the deep section of the borehole and the purpose of each well log. No casing was installed across the deep section of the borehole; therefore, no cased hole logs were acquired from the deep section of the well. The deep section of MCI MW1 will be completed for purposes of collecting monitoring data under the Class VI program. See Permit **Section 7.3.2** (Diagram of MCI MW 1 casing/tubing and monitoring information).

Open/ Cased Hole	Log Type	Parameters Obtained
Open Hole	Confidential, Privileged, or Sensitive Business Information	

Table 5 - 3: Summary of wireline logs and associated parameters of logging tools ran in the deep section Confidential, Privileged, or Sensitive Business Information of the MCI MW 1 well.

5.2.4 Core Program

Table 5 - 4 Whole core (upper) and sidewall core (lower) sample locations and sizes collected from the MCI MW 1 well. Confidential, Privileged, or Sensitive Business Information [redacted] the whole and sidewall core acquisition in the MCI MW 1 well. Eight intervals of whole, 4-inch core were acquired from the Eau Claire Formation and Mt. Simon Sandstone. Twenty-nine sidewall core locations were selected based on the open hole log data to fill any gaps in the whole core program. The sidewall cores collected provided a comprehensive set of rock property data for calibrating geophysical wireline logs and supplemented formation property data where whole core data were not available. Core depths were calibrated to wireline logs based on the gamma ray response.

Core testing provided information on rock properties (e.g., porosity, permeability, petrology, and mineralogy) that are representative of the injection and confining zones at the project site. **Table 5 - 5**: Summary of core analyses, associated parameters, and sample intervals in the MCI MW 1 well. details the laboratory testing, and the data from the core analyses are included in the Project Narrative and AoR sections (Permit **Sections 1** and **2**).

Whole Cores	Formation	Depth (ft, MDKB)	Notes
1	Confidential, Privileged, or Sensitive Business Information		
2			
3			
4			
5			
6			
7			
8			

Sidewall Cores					
Depth (ft, MDKB)	Formation	Comments	Depth (ft, MDKB)	Formation	Comments
2,920	Confidential, Privileged, or Sensitive Business Information				
3,014.5					
3,073					
3,150					
3,187					
3,268					
3,320					
3,437					
3,558					
3,600					
3,655					
3,975					
3,975					
4,045					
4,365					

Table 5 - 4: Whole core (upper) and sidewall core (lower) sample locations and sizes collected from the MCI MW 1 well. Note: Depths are in MDKB for consistency with lab work and reports. GL datum MD depths are 16 ft shallower.

Core Analysis Type	Sample/Test Interval	Parameters Obtained
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

Table 5 - 5: Summary of core analyses, associated parameters, and sample intervals in the MCI MW 1 well.

5.2.5 Fluid Sampling and Analysis

Samples were collected from the MCI MW 1 well in several formations to confirm the deepest underground source of drinking water (USDW)-bearing formation and to determine the baseline geochemistry of the subsurface fluids. USDWs are defined as having total dissolved solids (TDS) of less than 10,000 parts per million (ppm).

During the installation of the MCI MW 1 well, representative fluid samples were collected via drill stem tests (DSTs) and pumping from deeper water-bearing formations. Target geologic formations for water sampling included the St. Peter Sandstone, New Richmond Sandstone, Gunter Sandstone, Galesville Sandstone, and the Mt. Simon Sandstone. The analytical results for the samples collected from above the caprock (Eau Claire Formation) were used to confirm the deepest USDW formation and the primary analyte for these samples was TDS.

Additional analyses, Confidential, Privileged, or Sensitive Business Information [redacted], were performed on the above confining zone samples as well as the samples collected from the Mt. Simon Sandstone to provide baseline geochemical data for these formation fluids as part of the Testing and Monitoring Plan (Permit **Section 7**).

Through the chemical analyses on the fluid samples collected above the caprock formation, it has been determined that the Gunter Sandstone is the deepest USDW with a Confidential, Privileged, or Sensitive Business [redacted]
Additional discussion of the analytical results is provided in the Project Narrative (Permit **Section 1**). These measurements will be confirmed in the MCI CCS 3 well.

Fluid Sample Depth (ft, MDKB)	Formation	Analytical Parameters
[redacted]	[redacted]	Confidential, Privileged, or Sensitive Business Information [redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

Table 5 - 6: Sampling intervals and analytical parameters from the MCI MW 1 well.

Note: Depths are in MDKB for consistency with lab work and reports. GL datum MD depths are 16 ft shallower.

5.2.6 Geomechanical Testing

The objective of the geomechanical characterization program is to use data from the wireline logs, core analyses, and field geomechanical testing to provide information regarding the direction and magnitude of the three principal components of the stress field (σ_h, σ_H, σ_V), confined compressive strength, ductility, and fracture pressure for the project site.

Well logs were used to constrain geomechanical characteristics of the Eau Claire and Mt. Simon Formations. The well logs that were used to derive geomechanical properties include gamma ray, image, elemental spectroscopy, and dipole sonic log [redacted]

Whole core samples collected from the Eau Claire and Mt. Simon Formations were used in laboratory analyses for triaxial testing to determine parameters such as confined compressive strength, tensile strength, and ductility.

Field geomechanical tests (minifrac testing) were conducted to provide an accurate measurement of the fracture pressure in both the overlying confining zone and storage formation (**Table 5 - 7**: Geomechanical characterization in-situ field tests conducted, and parameters collected during the installation of the MCI MW 1 well.). The data from the in-situ field tests were integrated with the well log data and laboratory measurements of mechanical properties from selected core samples to characterize the confining layer and injection zones.

The key objective of the mini-frac tests is to determine the magnitude of the minimum horizontal principal stress, S_h, which is required to determine the maximum acceptable pressure for injecting CO_2 into reservoir and to avoid hydraulic fracturing within the injection reservoir and within the overlying caprock or underlying zones crystalline basement sequences.

Mini-frac testing was performed at six depth intervals in the MCI MW 1 (two intervals in the Eau Claire and four intervals in the Mt. Simon Sandstone) using a multiple injection cycle approach. The mini-frac test data were then analyzed to determine the Formation Breakdown Pressure (FBP), Instantaneous Shut-In Pressure (ISIP), Fracture Propagation Pressure (FPP), and Fracture Closure Pressure (FCP). Based on the test data, the FPP gradient was [redacted] This value is consistent with other measurements in the basin. Data from the geomechanical testing performed on the MCI MW 1 well has been incorporated into the static and dynamic models detailed in the AoR and Corrective Action Plan (Permit **Section 2**) and the data are presented in the Project Narrative (Permit **Section 1**).

Formation	Target Depth (ft, MDKB)	Test	Parameters Obtained
Eau Claire Shale	[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]	[redacted]
Mt. Simon Sandstone	[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]	[redacted]

Table 5 - 7: Geomechanical characterization in-situ field tests conducted, and parameters collected during the installation of the MCI MW 1 well.

Note: Depths are in MDKB for consistency with reports. GL datum MD depths are 16 ft shallower.

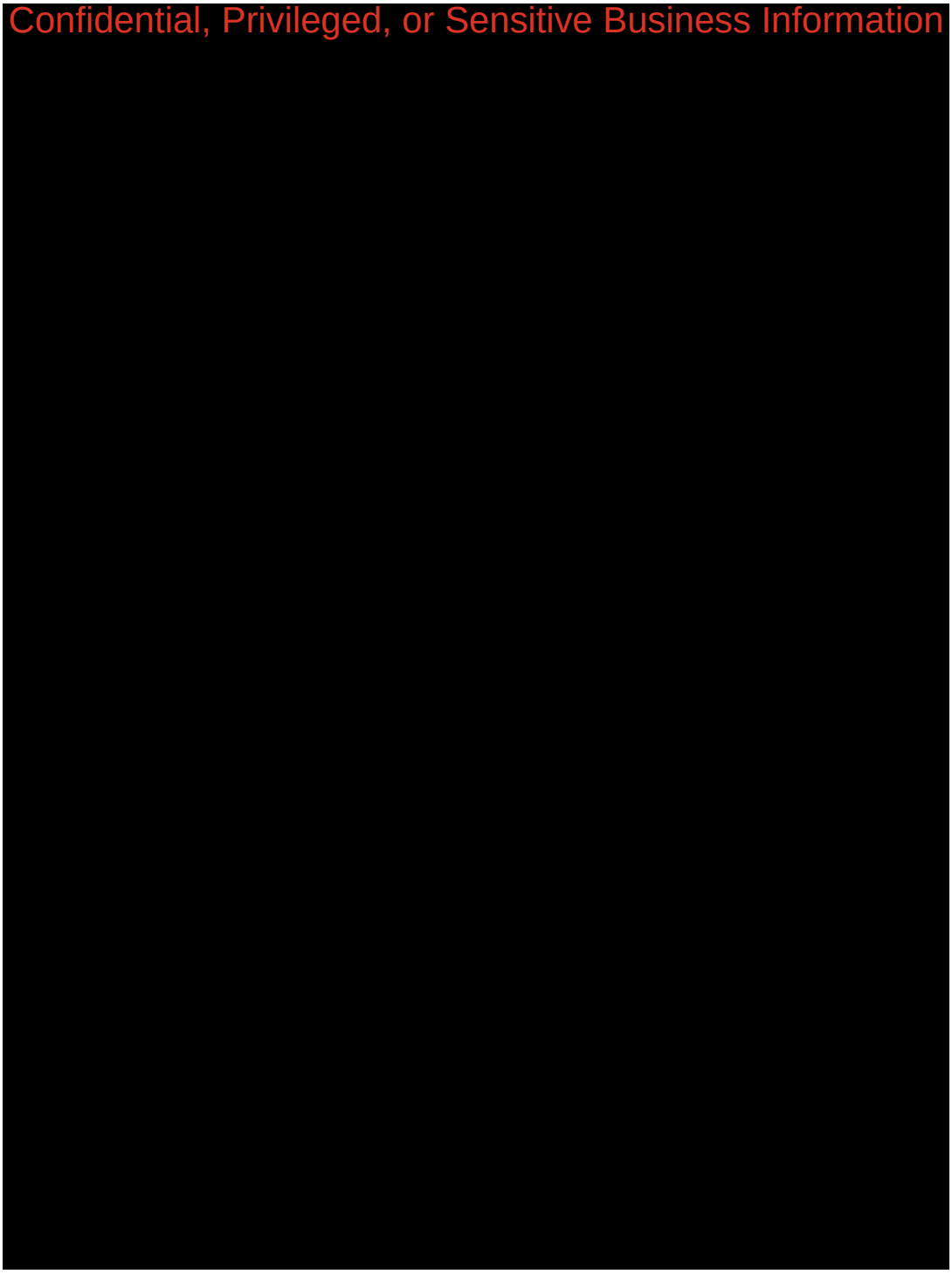

Figure 5 - 2: Sidewall core (SWC), Whole Core (Core), and Drill Stem Test (DST) sample locations with wireline log data from MCI MW 1. Note: Depths are in MDKB for consistency with lab work and reports. GL datum MD depths are 16 ft shallower.

5.2.7 Hydrogeologic Characteristics of the Mt. Simon Sandstone

The following tests were performed on the MCI MW 1 well to evaluate the hydrogeologic characteristics of the storage formation: Confidential, Privileged, or Sensitive Business Information

[redacted]

DSTs can be injection tests or pumping tests; both were performed as part of the MCI MW 1 characterization. These tests are performed by isolating the zone of interest with open borehole packers. These tests provide estimates of hydrologic properties in the region near the wellbore, such as initial formation pressure, transmissivity, average hydraulic conductivity, storativity, and borehole skin effects.

Four DSTs were performed for hydraulic characterization in the Mt. Simon Sandstone during the drilling of the MCI MW 1 (**Table 5 - 8**: Reservoir tests and parameters collected in the Mount Simon Sandstone during the installation of the MCI MW 1 well. Note: Depths are in MDKB for consistency with lab work and reports. GL datum MD depths are 16 ft shallower.). Additional DSTs were performed in the above confining zone formations. These DSTs were focused on the collection of fluid samples from these formations to confirm USDW depth and to have a baseline for future sample measurements.

Pressure fall-off (PFO) testing involves the measurement and analysis of pressure data from a zone in a well after it has been shut in following a period of injection. PFOs provide valuable information on parameters such as borehole skin effects, injectivity, transmissivity, formation boundary conditions, and average permeability that can be used to characterize the storage formation and constrain the dynamic model. PFO testing was performed at five intervals (including the composite Mt. Simon test) in the Mt. Simon formation to determine the hydraulic properties of the reservoir, as listed above. The PFO testing followed periods of injection, and the duration was dependent upon the time required for the pressure to return to near-baseline conditions. The data from the PFO were incorporated into the models for the injection site described in the AoR and Corrective Action Plan (Permit **Section 1**) and the Project Narrative (Permit **Section 2**) of this permit application.

Flowmeter logging is a method for identifying zones of fluid inflow or outflow within an open borehole. Two separate dynamic flow (flowmeter) tests were performed across the open borehole of the MCI MW 1 well following the other hydrogeologic testing. Confidential, Privileged, or Sensitive Business Information [redacted]. Both continuous and stationary surveys were performed during the testing. Following the injection/flowmeter phase of the testing, the pressure fall off was monitored, and temperature

logging was performed to identify the zones within the Mt. Simon that received most of the injected brine.

Table 5-8 summarizes the hydrogeologic testing that was performed in the MCI MW 1 well, and the hydrogeologic parameters that were obtained.

Formation	Target Depth (ft, MD)	Test	Parameters Obtained
Mt. Simon Sandstone	[redacted]	[redacted]	[redacted]
Mt. Simon Sandstone	[redacted]	[redacted]	[redacted]
Mt. Simon Sandstone	[redacted]	[redacted]	[redacted]
Mt. Simon Sandstone	[redacted]	[redacted]	[redacted]
Mt. Simon Sandstone	[redacted]	[redacted]	[redacted]
Eau Claire and Mt. Simon Sandstone	[redacted]	[redacted]	[redacted]

Table 5 - 8: Reservoir tests and parameters collected in the Mount Simon Sandstone during the installation of the MCI MW 1 well. Note: Depths are in MDKB for consistency with lab work and reports. GL datum MD depths are 16 ft shallower.

5.3 Pre-Operational Testing during the Installation of the MCI CCS 3, MCI MW2, and ACZ 1 Wells (146.87 (a))

The pre-operational testing performed in the MCI CCS 3 well will be focused on confirming the lowest USDW and confirming homogeneity between the MCI CCS 3 well and the MCI MW 1 well.

As part of the pre-operational characterization of the Marquis BioCarbon Project site, 3D seismic data was acquired over the project area. The 3D seismic tied the J&L well to the MCI MW 1 well and shows consistent geologic formations. Many of the logs and tests performed in the MCI CCS 3 establish the depths, aerial extents, and thicknesses of the injection and confining zones that traverse the project site and inform the static earth model. **Table 5 - 9**: Proposed Pre-Operational Testing Plan for Injection and Deep Monitoring Wells (*prepared by SLB*) provides a summary of the test data collected from MCI MW 1 and the data that will be collected from MCI CCS 3, MCI MW 2, and MCI ACZ 1. The information collected from MCI MW 1, the existing closed J&L deep well, and the new wells being installed will be used to confirm the geological homogeneity of Marquis site. See subsections for details of logs to be acquired, samples to be taken, and tests to be done.

MCI will submit to the Director a descriptive report prepared by a knowledgeable log analyst that includes an interpretation of the results of the logs and tests performed pursuant to this Section. [40 CFR 146.87(a)]. The report will include any relevant updates, based on data obtained during logging and testing of MCI CCS 3 and the formation as required by Section 146.82(c)(3), (4), (6), (7), and (10), to the information on the geologic structure and hydrogeologic properties of the storage site and overlying formations based on the stratigraphic test well (MCI MW-1).

		MCI MW 1	MCI CCS3	MCI MW2	MCI ACZ 1	Comment on Requirement	Value of Information from MCI-CCS 3, MW 2 and/or ACZ 1
Deviation Survey		X	X	X	X		
LOGGING							**Confirm or delineate rock properties, range of variability, storage and injectivity.**
Resistivity (Res), Spontaneous Potential (SP), Caliper		X	X	X	X	Surface, Intermediate and Deep Sections. (No Deep Section for ACZ 1)	Quantify formation variability in reservoir properties over the interval. This will provide porosity and lithology. This testing will identify wellbore volumes for accurate calculations for cement programs.
Gamma Ray (GR), Density (RHOB), Neutron Porosity		X	X	X	X	Surface, Intermediate and Deep Sections. (No Deep Section for ACZ 1)	
Dipole Shear Sonic - Delta-T Compressional (DTC) & Delta-T Shear (DTS).		X	X			Surface, Intermediate and Deep Sections.	Applied in the Surface Section this testing will be used to tie in the 3D seismic data. The Intermediate and Deep Sections will also run Cross-Dipole Mode, which will quantify the key parameters necessary for geomechanical modelling and stress analysis.
Elemental Neutron Spectroscopy & Spectral Gamma Ray		X				Elemental Neutron Spectroscopy was run on Deep Section of MW1. Spectral Gamma Ray was run on Intermediate and Deep Sections of MW1. Due to the consistency of the Mt. Simon the testing will not be run on MCI CCS 3 or other wells unless unexpected formation results during drilling dictate further evaluation.	

		MCI MW 1	MCI CCS3	MCI MW2	MCI ACZ 1	Comment on Requirement	Value of Information from MCI-CCS 3, MW 2 and/or ACZ 1
Cement Bond Log		X	X	X	X	All Casing Strings	This testing will provide casing to formation depth correlation, identify cement bond quality, detect if any cement channel exists, and evaluate cement top and necessary zonal isolation.
Ultrasonic Cement Evaluation		X	X	X	X	Intermediate Casing Strings for all wells, long string for MCI CCS3 only. MCI MW 1 had ultrasonic cement evaluation performed on the intermediate casing string.	
Nuclear Magnetic Resonance (NMR)		X				NMR was ran on the Deep Section of MCI MW 1 to fill in any gaps for permeability based on core recovery and analysis. Due to the consistency of the Mt. Simon the testing will not be run on MCI CCS 3 or other wells unless unexpected formation results during drilling dictate further evaluation.	
Mini-Frac Testing		X				Mini-frac testing was performed at six depth intervals in MCI MW 1. Due to the consistency of the Mt. Simon the testing will not be run on MCI CCS 3 or other wells unless unexpected formation results during drilling dictate further evaluation.	

	MCI MW 1	MCI CCS3	MCI MW2	MCI ACZ 1	Comment on Requirement	Value of Information from MCI-CCS 3, MW 2 and/or ACZ 1
Temperature Log	X	X	X	X	Deep hole section and after casing set	Temperature profile related to depth
Pulsed Neutron Log (PNL)	X	X	X	X	Deep hole section and after casing set	Lithology, Fluid Saturation, Porosity
Borehole Imager	X				The image log was run on the Deep Section of MCI MW 1. Due to the consistency of the Mt. Simon the testing will not be run on MCI CCS 3 or other wells unless unexpected formation results during drilling dictate further evaluation.	
WATER						
Water sampling with fluid analysis (including temp, pH, conductivity)	X	X	X	X	Samples were collected from MCI MW 1 in several formations to confirm the deepest underground source of drinking water (USDW)-bearing formation and to determine the baseline geochemistry of the subsurface fluids.	Similar baseline testing will be conducted in all wells to confirm deepest USDW source and determine baseline geochemistry of the subsurface fluids in the monitoring wells.
CORING						
Sidewall and Whole Core	X				A significant amount of rotary cores and 8 section of whole cores were collect in MCI MW1 well. Due to the consistency of the Mt. Simon the testing will not be run on MCI CCS 3 or other wells unless unexpected formation results during drilling dictate further evaluation.	

		MCI MW 1	MCI CCS3	MCI MW2	MCI ACZ 1	Comment on Requirement	Value of Information from MCI-CCS 3, MW 2 and/or ACZ 1
CORE ANALYSIS							
Routine Core Analysis (RCA)		X				This testing was performed on core samples from MCI MW 1. Due to the consistency of the Mt. Simon the testing will not be run on MCI CCS 3 or other wells unless unexpected formation results during drilling dictate further evaluation.	
Threshold Entry Pressure		X					
X-Ray Fluorescence (XRF)		X					
Thin sections		X					
X-Ray Diffraction		X					
Core Gamma Ray Log		X					
Relative Permeability		X					
Mercury Injection Capillary Pressure		X					
Rock Compressibility		X					
Triaxial Compression tests, mechanical tests		X					

Table 5 - 9: Proposed Pre-Operational Testing Plan for Injection and Deep Monitoring Wells (*prepared by SLB*)

In addition to the characterization data collected during the installation of the MCI CCS 3 well, information will be collected that will serve as baseline data for the monitoring performed during the operation of the CO_2 injection system. A brief description of the baseline sampling/monitoring is provided in this section, and details are included in the Testing and Monitoring Plan (Permit **Section 7**).

5.3.1 Deviation Surveys (146.87 (a)(1))

Deviation surveys are obtained as wells are drilled to determine the wellbore path from the surface to the Total Depth of the well. Typically, the tool used to perform deviation surveys is placed in the drill string just above the drill bit and records the inclination of the tool and borehole.

Hole deviation of CCS 3, MW 2, and ACZ 1 well will be maintained to less than 5 degrees off vertical, and the maximum allowable deviation in the well is 5 degrees. If necessary, the wellbore will be steered back to allowable deviation with directional tools (downhole motor or rotary steerable system). Surveys will be taken at the frequency shown in **Table 5 - 10**: Deviation Survey Frequencies to be Taken in the MCI CCS 3 Well In general, a deviation will be performed every 300 ft during the drilling of the borehole unless a deviation of >1 degree is measured. As the deviation becomes greater, more frequent surveys will be performed, and remedial actions will be performed to bring the well within specification. More frequent surveys will also be performed while drilling through zones that are known to cause the bit to "walk," creating a greater risk for deviation.

Range of Deviation	Frequency of Survey
<1 degree	1 survey per every 300 ft. of hole
>1 degree, but < 2 degrees	1 survey per every 240 ft. of hole
>2 degrees, but < 3 degrees	1 survey per every 120 ft. of hole
>3 degrees, but < 4 degrees	1 survey per every 90 ft. of hole
>4 degrees, but <5 degrees	1 survey per every 30 ft. of hole

Table 5 - 10: Deviation Survey Frequencies to be Taken in the MCI CCS 3 Well

5.3.2 Well Logging: Surface Section (146.87 (a)(2))

Open hole well logs will be acquired prior to setting surface casing as well as after surface casing (surface to approximately 350 ft) is set and cemented. Open hole logs conducted on MCI CCS 3, MCI MW2, and MCI ACZ 1 will include gamma ray, density, neutron porosity, spontaneous potential (SP), resistivity, and caliper logs. Additionally, MCI CCS 3 will have sonic testing. **Table 5 - 11**: Summary of Wireline Logs and Associated Parameters of Logging Tools to be Run Before and After Surface Casing [redacted] the MCI CCS 3 Well. summarizes the well logs that will be acquired before and after surface casing is set and the purpose of each well log.

The cased hole well logs will be acquired after the surface casing has been set and cemented. Cement integrity will be evaluated through a basic CBL-VDL with a gamma ray tool for depth correlation in addition to Temperature and Pulse Neutron Logs (PNL) (**Table 5 - 11**: Summary of Wireline Logs and Associated Parameters of Logging Tools to be Run Before and After Surface [redacted] MCI CCS 3 Well.).

Well	Log Type	Parameters Obtained
OPEN HOLE		
MCI CCS 3 **MCI MW 2** **MCI ACZ 1**	Confidential, Privileged, or Sensitive Business Information	
MCI CCS 3 **MCI MW 2** **MCI ACZ 1**		
MCI CCS 3 **MCI MW 2** **MCI ACZ 1**		
MCI CCS 3 **MCI MW 2** **MCI ACZ 1**		
MCI CCS 3 **MCI MW 2** **MCI ACZ 1**		
MCI CCS 3 **MCI MW 2** **MCI ACZ 1**		

Well	Log Type	Parameters Obtained
MCI CCS 3	Confidential, Privileged, or Sensitive Business Information	
CASED HOLE		
MCI CCS 3 **MCI MW 2** **MCI ACZ 1**	Confidential, Privileged, or Sensitive Business Information	

Table 5 - 11: Summary of Wireline Logs and Associated Parameters of Logging Tools to be Run Before and After Surface Casing Confidential, Privileged, or Sensitive Business Information MCI CCS 3 Well.

5.3.3 Well Logging: Intermediate Section (146.87 (a)(2))

Open hole well logs will be acquired in the intermediate section of MCI CCS 3, MW 2, and ACZ Confidential, Privileged, or Sensitive Business Information after the intermediate section of the well has been drilled to characterize the deeper geology at the proposed site. Open hole logs will include caliper, gamma ray, SP, resistivity, neutron porosity, and density. Sonic will be performed as well on MCI CCS 3. **Table 5 - 12**: Summary of Wireline Logs and Associated Parameters of Logging Tools to be run Before and After Confidential, Privileged, or Sensitive Business Information MCI CCS 3 Well. summarizes the well logs that will be acquired in the intermediate well section and the purpose of each well log. Data from the wireline logs will be used in conjunction with fluid samples to evaluate the thickness, depth, and salinity (Total Dissolved Solids) of the geologic formations above the caprock and will be used to confirm the deepest USDW.

After the intermediate casing string has been cemented, logs will be acquired to evaluate the cement integrity. Cement integrity will be evaluated through a CBL-VDL and an advanced ultrasonic logging tool that will be run with a gamma ray tool for depth correlation (**Table 5 - 12**: Summary of Wireline Logs and Associated Parameters of Logging Tools to be run Before and After Intermediate Confidential, Privileged, or Sensitive Business Information the MCI CCS 3 Well.).

Well	Log Type	Parameters Obtained
OPEN HOLE		
MCI CCS 3 MCI MW 2 MCI ACZ 1	Confidential, Privileged, or Sensitive Business Information	
MCI CCS 3 MCI MW 2 MCI ACZ 1		

Well	Log Type	Parameters Obtained
MCI CCS 3 MCI MW 2 MCI ACZ 1	Confidential, Privileged, or Sensitive Business Information	
MCI CCS 3 MCI MW 2 MCI ACZ 1		
MCI CCS 3 MCI MW 2 MCI ACZ 1		
MCI CCS 3 MCI MW 2 MCI ACZ 1		
MCI CCS 3		
CASED HOLE		
MCI CCS 3 MCI MW 2 MCI ACZ 1	Confidential, Privileged, or Sensitive Business Information	
MCI CCS 3 MCI MW 2 MCI ACZ 1		

Table 5 - 12: Summary of Wireline Logs and Associated Parameters of Logging Tools to be run Before and After Intermediate Casing Confidential, Privileged, or Sensitive Business Information the MCI CCS 3 Well.

5.3.4 Well Logging: Deep Section (146.87 (a)(3))

Open hole well logs will be acquired after drilling the deep section of the MCI CCS3 and MCI MW 2 Confidential, Privileged, or Sensitive Business Information) to characterize the deeper geology at the site. Open hole logs will include caliper, gamma ray, SP, resistivity, neutron porosity, and density. Sonic testing will be conducted in MCI CCS 3. **Table 5 - 13**: Summary of wireline logs and associated parameters of logging tools to be run before and after long string casing Confidential, Privileged, or Sensitive Business Information CCS 3 well. summarizes the well logs that will be acquired in the deep section and the purpose of each well log

After the long string casing has been cemented, logs will be acquired to evaluate cement quality and provide baseline data for external well integrity. Cement quality will be evaluated

through a CBL-VDL log and an advanced ultrasonic logging tool with a gamma ray tool for depth correlation (**Table 5 - 13**: Summary of wireline logs and associated parameters of logging tools to be run before and after long string Confidential, Privileged, or Sensitive Business Information MCI CCS 3 well.). Finally, a pulsed neutron log in sigma mode and a temperature log will be acquired to serve as a baseline dataset for the Testing and Monitoring Plan (Permit **Section 7**). The pulsed neutron capture log and temperature log will be performed after drilling muds are no longer present near the well and the temperature has stabilized to ensure accurate results from the logging effort.

As part of the pre-operational testing program, pulsed neutron capture and temperature logging will also be conducted in the deep monitoring wells to provide baseline data for external well integrity. These logs will also be performed after the wells have returned to static conditions following the installation of the wells. Additional details for baseline monitoring of external well integrity are provided in the Testing and Monitoring Plan (Permit **Section 7**).

Once the logs, as shown in **Table 5 - 13**: Summary of wireline logs and associated parameters of logging tools to be run before and after long Confidential, Privileged, or Sensitive Business Information MCI CCS 3 well., are acquired, the dipole sonic log from the MCI CCS 3 well will be examined to determine if any faults or fractures are present. Any formations with fractures will be compared to similar formations from the MCI MW 1 well to determine consistency of findings. Any indication of faulting or fracture networks that would compromise the seal will be tied to the 3D seismic analysis to determine if they impact the integrity of the seal or may lead to heterogeneities in the injection zone that could affect plume development. Special attention will be given to such zones during the monitoring operations.

Well	Log Type	Parameters Obtained
OPEN HOLE		
MCI CCS 3 **MCI MW 2** **MCI ACZ 1**	Confidential, Privileged, or Sensitive Business Information	
MCI CCS 3 **MCI MW 2** **MCI ACZ 1**		
MCI CCS 3 **MCI MW 2** **MCI ACZ 1**		
MCI CCS 3 **MCI MW 2** **MCI ACZ 1**		

Well	Log Type	Parameters Obtained
MCI CCS 3 **MCI MW 2** **MCI ACZ 1**	Confidential, Privileged, or Sensitive Business Information	
MCI CCS 3 **MCI MW 2** **MCI ACZ 1**		
MCI CCS 3		
CASED HOLE		
MCI CCS 3 **MCI MW 2** **MCI ACZ 1**	Confidential, Privileged, or Sensitive Business Information	
MCI CCS 3		
MCI CCS 3 **MCI MW 2**		
MCI CCS 3 **MCI MW2**		

Table 5 - 13: Summary of wireline logs and associated parameters of logging tools to be run before and after long string casing [redacted] MCI CCS 3 well.

5.3.5 MCI CCS 3 Well Mechanical Integrity Testing (146.87 (a)(4))

Mechanical integrity tests and evaluation will be conducted to satisfy the requirements of 40 CFR 146.88(f).

5.3.5.1 Internal Mechanical Integrity Testing (146.87 (a)(4)(i))

Internal mechanical integrity refers to the integrity or seal within the long casing string (i.e., between the long casing string, tubing, and packer). The quality of this seal can be confirmed with a mechanical integrity test (MIT) and annular pressure monitoring. Corrosion of the tubing string can result in internal mechanical issues, and inspection of the tubing will be performed to monitor the tubing for corrosion (Testing and Monitoring Plan, Permit **Section 7**).

After the packer, tubing, and downhole equipment have been installed, and the tubing/casing annulus has been filled with a corrosion-inhibited fluid (see Permit **Section 4**), a MIT test will

be conducted on the annular space of all the deep wells to ensure that there are no leaks in the tubing, casing, or packer. The MIT will be performed by pumping additional annular fluid into the annulus to increase the pressure to the maximum allowable injection pressure. [redacted], the cause of the poor mechanical integrity will be identified and corrected.

Once injection commences, injection pressure, annular pressure, and annular fluid volumes will be monitored continuously to ensure internal well integrity and proper annular pressure is maintained (Testing and Monitoring Plan, Permit **Section 7**).

5.3.5.2 External Mechanical Integrity (146.87 (a)(4) (ii – iv))

External mechanical integrity refers to the absence of fluid movement/leaks through channels between the long casing string and the borehole or the intermediate casing string. Migration of fluids through this zone could result in contamination of USDWs. The external integrity of the wells that penetrate the caprock will be confirmed throughout the project.

Generally accepted methods for evaluating external mechanical integrity include the following:

- Temperature or noise log
- Oxygen-activation logging or radioactive tracer logging

A baseline temperature measurement will be acquired from 0 to TD using the DTS of the MCI CCS 3 casing string to provide initial temperature conditions. Temperature measurements acquired after injection has started will be compared to this log to determine if anomalies are present in the subsequent logging events that may be attributed to external integrity issues (Testing and Monitoring Plan, Permit **Section 7**). If the temperature measurement data suggest an issue with external well integrity exists, an oxygen-activation logging run will be performed to evaluate external well integrity with greater sensitivity.

In addition to the baseline temperature log, a CBL-VDL and an advanced ultrasonic cement evaluation log will be run over the entire depth of the long casing string shortly after completion of the MCI CCS 3 well to confirm that the casing string was properly cemented. CBL-VDLs are recorded with sonic tools that detect the bond of the casing and formation to the cement between the casing and wellbore to identify damage. Ultrasonic tools provide higher accuracies and resolutions for cement evaluation.

5.4 MCI CCS 3 Well Core Program (146.87 (b – d))

Whole and side wall cores were collected from the MCI MW 1. These core analyses will serve as the primary geologic characterization for the injection site as they represent the properties of the injection and confining zones near the CCS 3 site and provide sufficient and representative information on their porosities, permeabilities, petrologies, and mineralogies to inform geology review, AoR delineation, modeling evaluations, and assessment of the potential for mobilization of contaminants. Unless unexpected formations are observed during the drilling and logging, no further whole core or side wall core testing will be conducted. The data from the core analyses performed on the samples collected from MCI MW 1 have been incorporated into the Static Earth Model and Dynamic Reservoir Model discussed in the Project Narrative (Permit **Section 1**) and the AoR and Corrective Action Plan (Permit **Section 2**).

5.5 MCI CCS 3 Well: Fluid Sampling and Geochemical Analysis (146.87 (b – d))

Characterization of reservoir fluids was performed using samples acquired from the MCI MW 1. To determine the following:

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[redacted]

See **Appendix Y.**

The results of the geochemical analyses from MCI MW 1 are discussed and have been incorporated into the Project Narrative (Permit **Section 1**) the AoR and Corrective Action Plan (Permit **Section 2**), and the MCI CCS 3 well design (Permit **Section 4**).

These results provide baseline geochemical conditions of the aquifers at the injection site. These data will be used for comparative purposes to the samples collected at the MCI CCS 3, MCI MW 2 and MCI ACZ 1 and through the operational/injection and post-injection phases of the project. Additional details on the sampling and analysis of samples collected throughout the remainder of the project are provided in the Testing and Monitoring Plan and Post-Injection Site Closure Plan (**Sections 7** and **9** respectively).

[redacted] Starting at the St. Peter, each major water-bearing sandstone formation will be sampled and tested. Once a non-USDW formation is found, one formation deeper will be sampled and tested to confirm non-USDW status. Field testing of TDS/salinity will be the indicator of USDW status. Water samples will then be sent to a lab for further analysis. These results will be compared to the analyses done at MCI MW 1 to confirm consistency of the USDWs and other water bearing zones across the project site. As a final step, a petrophysical analysis will be performed to tie the water salinity to key log measurements such as resistivity, porosity and elemental analysis. MCI MW2 and MCI ACZ 1 water samples will also be analyzed to determine the baseline (**Table 5 - 9**: Proposed Pre-Operational Testing Plan for Injection and Deep Monitoring Wells (*prepared by SLB*)). Using these tie-in points the other water bearing zones can be confirmed as USDWs or non-USDWs.

The water sampling and analysis will continue into the injection zone.

During water sampling and analysis of the injection zone, the following parameters will be recorded in accordance with 40 CFR 146.88(f):

[redacted]

The lab results will be compared to those from the Mt. Simon in the MCI MW 1.

5.6 MCI CCS 3 Well Geomechanical Testing (146.87 (d))

The initial geomechanical characterization for the site was completed using data from the MCI MW 1 well. Because mini-frac testing was performed at six depth intervals in MCI MW 1, mini-frac testing will not be run on MCI CCS 3 unless unexpected formation results during drilling dictate further evaluation.

5.7 MCI CCS 3 Well Hydrogeologic Characteristics (146.87 (e))

Hydrogeologic characterization of the injection site was performed through testing conducted at the MCI MW 1 (discussed in **Section 5.2.7** Hydrogeologic Characteristics of the Mt. Simon Sandstone). Additional testing is planned for the MCI CCS 3 well. Data from the hydrogeologic testing on the MCI MW 1 well were used in the development of the DRM to determine the CO_2 plume geometry and distribution. These data are discussed in the AoR and Corrective Action Plan (Permit **Section 2**).

Injectivity testing is planned for the MCI CCS 3 well to confirm the flow of fluid into zones within the Mt. Simon Sandstone during injection. This data will be used to determine the best perforation strategy for the MCI CCS 3 well. The flowmeter testing will be performed by injecting brine into the open borehole after it has been drilled to TD and running a flowmeter tool across the open hole interval. Two flowmeter tests are planned for the MCI CCS 3 well. One test will examine the flow conditions across the entire open borehole (below the intermediate casing) and the other will focus on the Mt. Simon Sandstone by setting a packer at the base of the Elmhurst Formation.

Once the well is completed and perforated, a set of hydrogeologic tests will be performed. These include:

Confidential, Privileged, or Sensitive Business Information

[redacted]

[redacted]

5.8 MCI CCS 3 Well Schedule (146.87 (f))

Marquis Carbon Injection LLC will provide the UIC Director with the opportunity to witness all logging and testing by this subpart. Marquis Carbon Injection LLC will submit a schedule of such activities to the UIC Director 30 days prior to conducting the first test and submit any changes to the schedule 30 days prior to the next scheduled test. **Table 5 - 14**: Tentative drilling schedule for the MCI CCS 3 well. provides a tentative schedule based on the number of days to complete each task. It is anticipated that the drilling schedule will be updated once the Class VI permit is received.

Activity	Day	Depth (ft, MD)	Activity	Day	Depth (ft, MD)
Mix Spud Mud	Confidential, Privileged, or Sensitive Business Information				
Commence drilling surface hole to approximately 350'					
Run surface casing and break circulation.					
WOC 24 Hours and Run Cement Bond Log.					
Begin to nipple up BOP after Bond logging.					
Drill ahead					
Drill ahead					
Drill ahead					
Drill ahead					
DST USDW Gunter					
Drill ahead					
Drill ahead, major LCZ					
LCZ					
LCZ, drill ahead,					
DST Ironton Galesville					
Wireline log section, run casing, pump cement					

Table 5 - 14: Tentative drilling schedule for the MCI CCS 3 well.

5.9 Overview of Monitoring Well Pre-Operational Testing Program

As part of the Testing and Monitoring Plan (see Permit **Section 7**) two wells will be drilled for the purpose of monitoring the CO_2 plume, pressure plume and for above injection zone monitoring. The first will be the MCI ACZ 1 well, which will be drilled from the same well pad as the MCI CCS 3 injection well. It will be drilled within 100 ft of the injection well and will stop above the confining zone. The main purpose of this well is to ensure no brine or CO_2 leak above the seal in the near wellbore environment. With this purpose in mind, some of the data collected that is outlined above will be useful to add to the pre-operational testing data set.

[redacted] . The well will be used to identify changes in temperature, pressure and fluid makeup as the CO_2 flows in the formation. In addition to existing MCI MW 1 well, MCI MW2 well will serve as a second monitoring well. The monitoring well will provide a baseline dataset against which to compare changes during operations. As such, the characterization data are outlined above. See Permit **Section 7** for additional details on the use and placement of these wells.

The partial casing of the MCI MW 1 extended from the surface to the confining zone, top of the Eau Claire, thus sealing off all USDWs. The portion of the well that remained open was the area from the confining zone, Eau Claire, through the Mt. Simon, to the basement rock. The portion of the well that remained open will be completed and used as a deep monitoring well. See Permit **Section 7, Figure 7-4(b),** that includes a diagram of MCI MW 1 specifications for purposes of deep well monitoring.