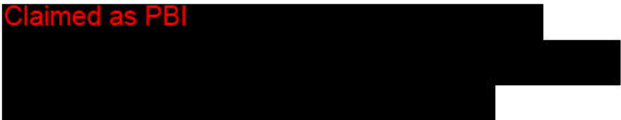


**PRE-OPERATIONAL TESTING PROGRAM
40 CFR 146.87**

Brown 4 Geologic Sequestration Project

Facility Information

Facility name: Brown 4 Geologic Sequestration Project
Lambda-Brown 4-1 & Lambda-Brown 4-2

Facility contact: Claimed as PBI 

Well location: Lambda-Brown 4-1: Brown, Manistee County, Michigan
44.3361397, -86.1393888, NAD 27
Lambda-Brown 4-2: Brown, Manistee County, Michigan
44.3418411, -86.1342111, NAD 27

Introduction

The testing activities at the Lambda-Brown 4-1 and Lambda-Brown 4-2 Class VI wells detailed in this attachment are restricted to the pre-injection phase. Testing and monitoring activities during the injection and post-injection phases are described in the Testing and Monitoring Plan, which also covers other non-well related, pre-injection baseline activities.

Lambda will construct two new wells, Lambda-Brown 4-1 and Lambda-Brown 4-2, for the injection of CO₂ into the Brown 4 Geologic Sequestration Project (GSP). Data acquired during the drilling and completion of the Viol 1-4 and Viol 3-4 wells will be used to compare data obtained during the drilling and completion of the new injection wells. The Viol 1-4 is located approximately 280 feet from the Lambda-Brown 4-1, and the Viol 3-4 is located approximately 195 feet from the Lambda-Brown 4-2. Pre-operational testing will be performed in sequence with the well construction activities. A different suite of tests will be performed as each portion of the well is constructed, based on the bore hole conditions.

Pre-Injection Testing Plan – Injection Well

The following tests and logs will be conducted during drilling, casing installation, and after casing installation, in accordance with the testing required under 40 CFR 146.87(a), (b), (c), and (d). The tests and procedures are described below and in the Construction Details section of the permit application. While drilling both the Lambda-Brown 4-1 and Lambda-Brown 4-2 wells, a qualified mud logging company will capture samples at a frequency adequate to allow for the identification of the formation tops. This will help determine the setting depths for the different casing sections.

Deviation Checks

Deviation measurements will be conducted approximately every 500 feet during construction of the surface and intermediate strings via wireline conveyed gyroscope. Upon drilling the long string section of the well, deviation measurements will be conducted approximately every 30 feet.

Conductor Pipe

The conductor casing will be driven to a depth of approximately 100 feet. No pre-operational testing is proposed for this section of the well.

Surface Casing

The surface casing set point will be approximately 100 feet below the base of the Glacial Drift, which is the local USDW. This section will be cemented with Class A cement to surface. Lambda does not propose open-hole testing due to the shallow nature of the surface casing. Table 1 below outlines all testing planned for this section.

Table 1: Test to be conducted at depths corresponding with surface casing.

Test Performed	Purpose
Mud Logging	Formation Tops
Cement Bond Log	Cement Integrity
Pressure Test	Casing Integrity

Intermediate Casing

The intermediate casing set point will be located approximately 50 feet below the top of the Bass Island Dolomite formation. The set point will be identified via real time mud logs and correlated to mud and open-hole logs from the offset Viol 1-4 and Viol 3-4 wells. Once the casing set depth is confirmed, Lambda will run an open-hole triple combination log that will include gamma ray, resistivity, and neutron and density porosity. Following the open-hole logging, the casing will be cemented to surface, and cement integrity tests will be performed. Table 2 below outlines all testing and logging planned for this section of the well.

Table 2: Tests to be conducted at depths corresponding with intermediate casing.

Test Performed	Purpose
Mud Logging	Formation Tops
Borehole Temperature Log	Formation Temperature Profile
Caliper Log	Bore Hole Diameter & Volume
Gamma Ray	Characterize Geology
Neutron & Density Porosity Logs	Characterize Geology
Resistivity Log	Characterize Geology
Cement Bond Log	Cement Integrity
Leak off Test	Cement Integrity
Pressure Test	Casing Integrity

Long String

The long string casing set point will be located approximately 15 feet below the base of the A2 Evaporite (the Brown 4 GSP confining zone) to ensure that casing extends to the injection zone as required per 40 CFR 146.86(b)(3). Mud logging will be conducted during drilling to provide information to the drilling crew about formation tops and pertinent depths. Table 3 below outlines all testing planned for this section of the well.

Lambda will make every reasonable effort to run open-hole logs across this section. However, due to the high probability of encountering extremely low reservoir pressure (9 psig), it is unlikely that open-hole logging or core retrieval tools can be deployed into the wellbore. It is widely recognized across Michigan's Northern Niagaran Pinnacle Reef Trend (NRT) that a total loss of fluid occurs in the low-pressure reservoirs while drilling. Therefore, there will not be a column of fluid in the wellbore by which to run wireline logging tools. To potentially offset this risk, Lambda will drill a few feet below the base of the confining zone, and if the wellbore fluids are sustained, Lambda will deploy open-hole logs to ensure accuracy of the confining zone depths. If fluid loss is present but minimal, Lambda will attempt to run a cased hole neutron log through drill pipe. If fluid loss is present and significant, Lambda will run a cased hole neutron log after casing is set. Retrieval of core data from the either the confining and injection zones is also unlikely due to the presence of extremely low pressure in the sequestration zone. Lambda is confident in the sustained integrity of the confining zone and believes coring operations are unnecessary for the following reasons:

- 1) The A2 Evaporite (A2E) has zero permeability and has contained the upward migration of hydrocarbons within the confinement zone for hundreds of millions of years.
- 2) The A2E confining zone is present across the Brown 4 reef and the entirety of the NRT.
- 3) The Brown 4 reef has a limited areal extent, and as such depositional degradation or changes of evaporites in such short distances is highly unlikely.
- 4) The A2E has acted as a competent confinement layer prior to and during production of the Brown 4 reef since discovery over 40 years ago.

- 5) The close proximity of the two injection wells to the existing logged wellbores, Viol 1-4 and Viol 3-4, allows for highly confident correlations of both the reservoir and confinement zone log properties to be made.

Table 3: Test to be conducted at depths corresponding with long string casing.

Test Performed	Purpose
Mud Logging	Formation Tops
Borehole Temperature Log	Formation Temperature Profile
Caliper Log	Bore Hole Diameter & Volume
Compensate Sonic Log – Gamma Ray (if possible)	Characterize Geology
Neutron Porosity Log (if possible)	Characterize Geology
Resistivity Log (if possible)	Characterize Geology
Cement Bond Log	Class A Cement Integrity
Ultrasonic Scanner	WellLock® Cement Integrity
Leak off Test	Cement Integrity
Pressure Test	Casing Integrity

Open Hole Section

The final section of the wellbore will utilize an approximately 400-foot open hole completion within the sequestration zone, extending down to approximately 20 feet above the known gas-water contact. Following the placement and cementing of the long string casing to the surface and after allowing adequate time for the cement to cure, Lambda will drill out the casing shoe to the proposed total depth. Due to the presence of extremely low reservoir pressure, it is highly unlikely that fluid circulation will be possible. Thus, Lambda will not be able to conduct wireline or pipe-conveyed logging in this section. However, the close proximity of the two injection wells to the existing logged wellbores, Viol 1-4 and Viol 3-4, allows for highly confident correlations of reservoir and log properties to be made.

Pre-Operational Testing Schedule

Lambda will notify the UIC Director at least 30 days prior to conducting the tests noted in Table 4 and provide a detailed description of the testing procedures. Lambda will also provide notice and the opportunity to the EPA at least 48 hours in advance to witness these tests/logs. Lambda will submit any changes to the schedule 30 days prior to the next scheduled test.

Table 4: Description of pre-operational tests to be conducted.

Class VI Rule Citation	Rule Description	Test Description	Program Period
40 CFR 146.87(a)(1)	MIT - Internal	Long-String/Tubing Annulus	Prior to injection
40 CFR 146.87(a)(4)	MIT - External	Noise, Temperature, or Oxygen Activation Log	Prior to injection
40 CFR 146.87(e)(1)&(3)	Testing prior to operating	Fall-Off, Injection Rate Test	Injection Rate Test prior to injection. Fall-Off annual.
40 CFR 146.87(c)	Testing prior to operating	Fluid Temperature	Prior to injection
40 CFR 146.87(c)	Testing prior to operating	Fluid pH	Prior to injection
40 CFR 146.87(c)	Testing prior to operating	Conductivity	Prior to injection
40 CFR 146.87(c)	Testing prior to operating	Reservoir Pressure	Prior to injection
40 CFR 146.87(c)	Testing prior to operating	Static Fluid Level	Prior to injection

Data Analysis and Reporting

Lambda will submit to the UIC Director the results of all pre-operational testing and logging operations within 30 days of completion.

Pre-Injection Testing Plan – Above Zone Monitoring Wells

The existing Viol 1-4 and Viol 3-4 will be converted to above confinement zone monitoring wells. These wells will have internal and external mechanical integrity tests (MIT) performed prior to injection operations.

Deviation Checks

These are existing wells and no deviation checks are needed.

Tests and Logs

Gamma ray and casing collar locator logs will be run during and following conversion.

Demonstration of Mechanical Integrity

Below is a summary of the MIT to be performed on the above zone monitoring wells, after installation and prior to commencing CO₂ injection operations (Table 5). Notice and the opportunity to witness the test/log shall be provided to the EPA at least 48 hours in advance.

Table 5: Summary of tests to be performed prior to injection.

Test Name	Test Description	Program Period
MIT - Internal	Pressure Test	Prior to Injection Operation
MIT - External	Noise, Temperature, or Oxygen Activation Log	Prior to Injection Operation

Annulus Pressure Test Procedures for Injection and Above Zone Monitoring Wells:

- 1) Notify the EPA 48 hours prior to testing;
- 2) Move in and rig up the pump truck;
- 3) Perform the Job Safety Analysis;
- 4) Connect the lines from the pump truck to the long-string and the tubing annulus valves;
- 5) Hook up the chart recorder;
- 6) Pressure up on the annulus;
- 7) Hold and record the test for at least thirty minutes;
- 8) Bleed off the pressure and close the annulus valve; and
- 9) Disconnect the lines, rig down and demobilize the pump truck.

Pressure Fall-Off Test Procedures:

A fall-off test will be performed by shutting in the injection well for 24 hours. The data will be measured from downhole pressure and temperature gauges. Lambda will refer to the EPA's "UIC Pressure Falloff Testing Guideline" requirements for planning and conducting the testing as well as preparing and submitting the monitoring report. Pressure fall-off test results will be reported to the UIC Director within thirty days of testing.