

INJECTION WELL PLUGGING PLAN

40 CFR 146.82(a)(16), 40 CFR 146.92(b)

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
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

Lambda will drill two Class VI CO₂ injection wells for the Brown 4 Geologic Sequestration Project (Figure 1). The wells will be constructed with components that are compatible with the injectate and formation fluids encountered, ensuring that corrosion rates and cumulative corrosion over the duration of the project are acceptable. The well materials will be sufficient to withstand all loads encountered throughout the life of the well, with an acceptable safety factor incorporated into the design. Because USDW wells are present within the AoR, surface and intermediate casing strings will provide multiple barriers of protection for shallow formations. The casing set point depths will be determined by trained, onsite, state-licensed geologists using mudlogging methodologies and later verified by open- and/or case hole wireline logs. The design, composition, and location of wellbore construction cement will also be compatible with associated formation fluids and reservoir pressures and temperatures to ensure isolation of the injection zone and protection of shallow formations.

Injection Well Plugging

The well plugging and abandonment (P&A) plan to be followed by Lambda is described below. The plan is designed to ensure all materials and methodologies for P&A to meet all appropriate state and federal guidelines.

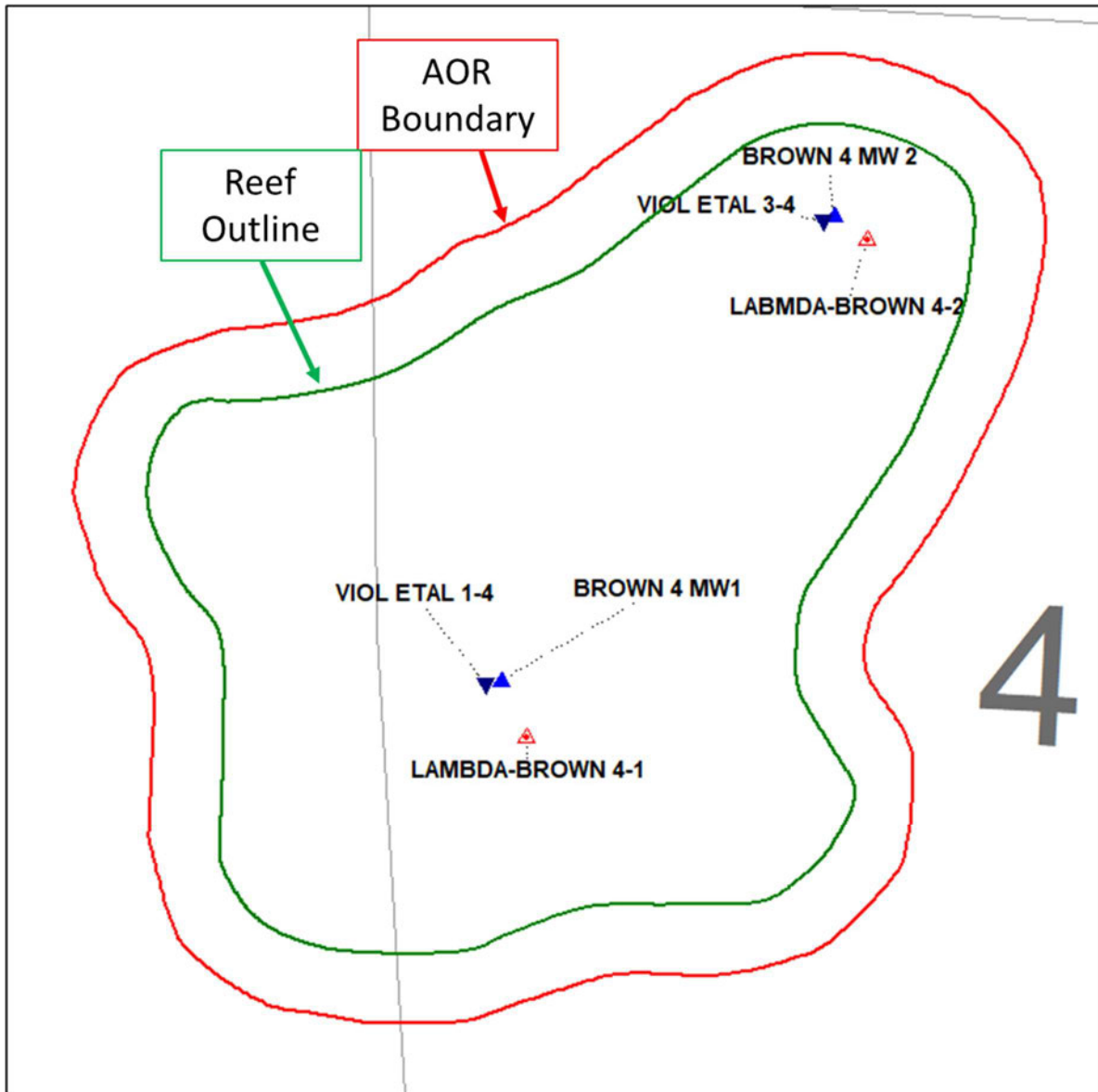


Figure 1: Map showing the location of both CO₂ injection wells, above zone monitoring wells, and USDW monitoring wells.

Planned Tests or Measures to Determine Bottom-Hole Reservoir Pressure

To satisfy 40 CFR 146.92(b)(1), bottomhole pressure will be measured via downhole gauges prior to performing P&A activities. During injection, downhole pressure gauges will continuously monitor the reservoir pressure, and at the conclusion of injection will be used to obtain the final reservoir pressure in the injection zone. In the event that the originally installed gauges are not functioning properly after cessation of injection, wireline-conveyed pressure and temperature gauges will be run to capture the final bottomhole reservoir pressure.

Planned External Mechanical Integrity Test

Prior to P&A, Lambda will conduct a mechanical integrity test (MIT) to verify external integrity of the injection casing string prior to plugging the well as required by 40 CFR 146.92(a). Lambda will utilize a wireline-conveyed noise log or other EPA-approved external MIT tool for all tests (Table 1). The procedure will be consistent with procedures outlined in the Testing and Monitoring Plan. This will be compared to baseline pre-injection data and/or other data acquired throughout the injection phase, which the EPA has deemed acceptable.

Table 1: External Mechanical Integrity Testing Methods

Test Description	Location
Noise Log	Along wellbore using wireline well log
Temperature Log	Along wellbore using wireline well log
Oxygen Activation Log	Along wellbore using wireline well log

Information on Plugs

Lambda will use the materials and methods noted in Table 2 to plug the injection wells. The volume and depth of the plug or plugs will depend on the final assessment of the geology and downhole conditions of the well during construction. The cement(s) formulated for plugging will be compatible with the CO₂ stream and composition. Required certification documents will be submitted to the UIC Director along with the well-plugging plan. Lambda will also report the wet density and retain duplicate samples of the cement used for each plug. The cement volumes are to be calculated using yield of cement (cubic feet/sack), volume of the casing string (barrels), and desired height (feet). The information requested in 40 CFR 146.92(b)(3-6) is included in Table 2 below.

Table 1. Plugging details

Plug Information	Plug #1	Plug #2
Diameter of boring in which plug will be placed (inches)	6 & 6.276	6.276
Depth to bottom of tubing or drill pipe (feet)	4,300	4
Sacks of cement to be used	73	782
Slurry volume to be pumped (cu. Ft.)	86	923
Slurry weight (lb./gal)	15.6	15.6
Calculated top of plug (feet)	4,300	4
Bottom of plug (feet)	4,732	4,300
Type of cement or other material	API Class A	API Class A
Method of emplacement (e.g., balance method, retainer method, or two-plug method)	Retainer	Balanced

Narrative Description of Plugging Procedures

Notifications, Permits, and Inspections

In compliance with 40 CFR 146.92(c), Lambda will notify the UIC Director and appropriate regulatory agencies at least 60 days before plugging the well and will provide an updated Injection Well Plugging Plan, if applicable.

Plugging Procedures

Lambda will conduct injection well P&A according to the procedures below. The well bore schematic for the plugged well is shown in Figure 2.

PROCEDURE: Permanently Abandon Well

1. Notify EPA Region Five and State of Michigan Area Geologist of upcoming work.
2. Hold on-site Job Safety Analysis/Safety Meetings with Lambda and service company personnel daily and before each change in operation.
3. Prior to moving in the equipment, check the area around the wellhead and take the necessary steps to provide a safe working area.
4. Take necessary precautions to avoid any fluid spill on or run off the location.
5. Check the working pressure on all tree and tubing head equipment.
6. Check the outer and inner diameter and the length of all tools on each bottom hole assembly to be run in the well.
7. Rig up the P&A service company. Pump the appropriate kill weight mud as necessary to stabilize the well downhole. Nipple down the wellhead and nipple up the blowout preventer.
8. Release the packer and pull out of the hole with tubing and lay down the tubing.
9. Make up and run in the hole with 7" K-1 cast iron cement retainer (CICR) on work string, set the retainer at 4,300'.
10. Rig up the cementing service company. Establish injection to pump 73 sacks of 15.6 ppg Class A cement below the CICR.
11. Sting out of the CICR and circulate the hole with fresh water.
12. Mix and spot 782 sacks 15.6 ppg Class A cement on top of the CICR to four feet below surface.

13. Trip out of the hole and lay down the work string.
14. Cut the remaining casing string at no less than 4' below the surface grade. Weld a 1/2-inch steel plate onto the outer casing string, with the permit number welded on top of the steel plate.
15. Rig down the plugging company and related equipment and remove all of the injection equipment and restore location.

For the final abandonment of the injection wells, Lambda intends to fill the entire wellbores with cement. By doing so, Lambda meets and exceeds all state and federal standards for plugging operations referenced in Michigan Administrative Code R. 324.902 and EPA “Plugging and Abandoning Injection Wells Region 5 Guidance #4”. Within 60 days of plugging, Lambda will submit a plugging report to the UIC Director in accordance with 40 CFR 146.92(d).

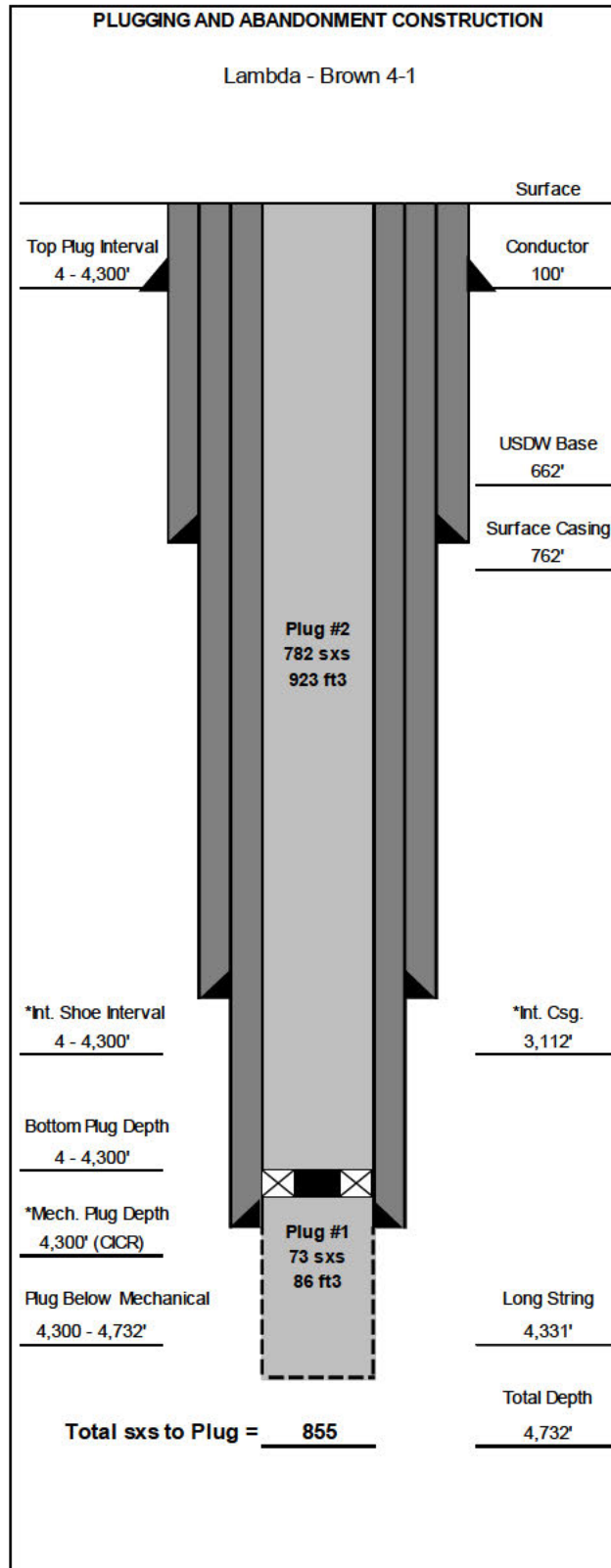


Figure 2: Proposed well bore schematic for plugged and abandoned Lambda Brown 4-1 injection well.