

Attachment 8A: Injection Well #1 Plugging Plan
40 CFR 146.92(b)
Vervain Project, McLean County, Illinois
24 March 2023



Plan revision number: 1.1
Plan revision date: 24 March 2023

Project Information

Project Name: Vervain

Project Operator: Heartland Greenway Carbon Storage, LLC:

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Project Location: McLean, McLean County, IL

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List of Acronyms

BOP	blow out preventer
CO ₂	carbon dioxide
CBL	cement bond log
HGCS	Heartland Greenway Carbon Storage, LLC
LD	lay down
MIT	mechanical integrity test
ND	nipple down
NV_INJ1	Vervain Injection Well #1
NU	nipple up
P&A	plugging and abandonment
PNL	Pulsed Neutron Log
POOH	pull out of hole
PU	pick up
QASP	Quality Assurance and Surveillance Plan
RAT	radioactive tracer log
RIH	run in hole
RU	rig up
TD	total depth

Change Log

Item Changed	Date	Version	Description
Pg 5 Sec 1	3/24/2023	V1.1	Added details as to the tests and measures to determine bottomhole reservoir pressure.
Pg 7 Table 2	3/24/2023	V1.1	Corrected table values

Plan revision number: 1.1
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Heartland Greenway Carbon Storage, LLC (HGCS) will conduct injection well plugging and abandonment (P&A) according to the procedures below at a time during the project following the cessation of injection that is deemed appropriate.

1. Planned Tests or Measures to Determine Bottomhole Reservoir Pressure

As required by 40 CFR 146.92(b)(1), prior to any plugging operations, bottomhole pressure data from the bottomhole gauges set in the Vervain Injection Well #1 (NV_INJ1) will be used to determine the reservoir pressure and calculate an appropriate kill weight fluid. Should the gauges be inoperative the bottomhole pressure will be obtained by conducting a static gradient survey using a memory pressure gauge run on slickline.

2. Planned External Mechanical Integrity Test(s)

HGCS will conduct at least one of the tests listed in Table 1 to verify external mechanical integrity prior to plugging the injection wells as required by 40 CFR 146.92(a).

Following the operations to kill the well, testing of the external mechanical integrity will be performed. This testing will include one or more of the following:

- Temperature Log,
- Radioactive Tracer (RAT) Log,
- Cement Bond Log (CBL),
- Pulsed Neutron Log (PNL).

Prior to any field mobilization or operations, proper notification will be given to the agency. Within this notification, the specific logs and/or tests to be run to determine external mechanical integrity will be provided. The list above is an example of logs that would likely be run to confirm external mechanical integrity and should not be considered as a comprehensive or final list for this project.

Note the following:

- i. Example procedures for the logging techniques provided above can be found in the Pre-Operational Testing Program or the Testing and Monitoring Plan sections of this application (Attachment 5: Pre-Op Testing Program, 2023) and (Attachment 7: Testing And Monitoring, 2023).
- ii. Specifications on the tools that will be used for this testing can also be found in these same sections or the Quality Assurance Surveillance Plan (QASP) section of this application. (Attachment 11: QASP, 2023)
- iii. Criteria for acceptable logging results can be found in the Testing and Monitoring Plan as well as the QASP section of the permit application.

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Table 1: Potential MITs for NV_INJ1

Test Description	Location
Temperature Log	Along wellbore via wireline well log
RAT Log	Along wellbore via wireline well log
CBL	Along wellbore via wireline well log
PNL	Along wellbore via wireline well log

3. Information on Plugs

HGCS will use the materials and methods noted in Table 2 to plug the injection well. The volume and depth of the plug or plugs will depend on the final geology and downhole conditions of the well as assessed during construction. The cement(s) formulated for plugging will be compatible with the carbon dioxide (CO₂) stream (Attachment 4A: NV_INJ1 Well Construction Plan, 2023). The cement formulation and required certification documents will be submitted to the agency with the well plugging plan. The owner or operator will report the wet density and will retain duplicate samples of the cement used for each plug.

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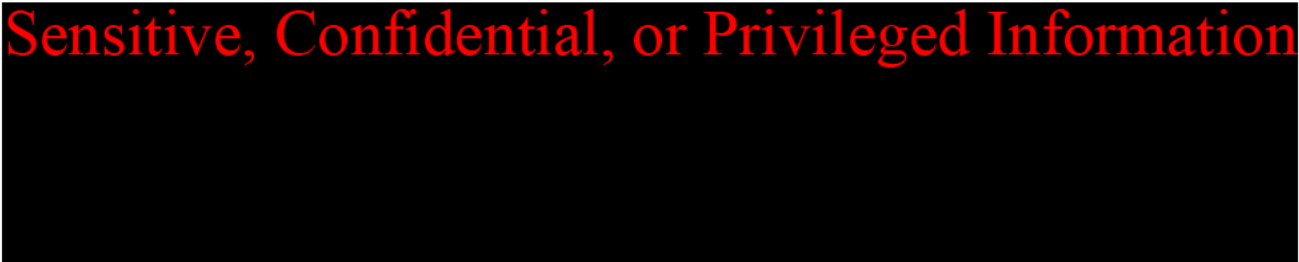


Table 2: Plugging details for NV_INJ1

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4. Narrative Description of Plugging Procedures

4.1 Notifications, Permits, and Inspections

In compliance with 40 CFR 146.92(c), HGCS will notify the regulatory agency at least 60 days before plugging the wells and provide updated procedure for NV_INJ1, if applicable.

4.2 Plugging Procedures

In compliance with 40 CFR 146.92, the following will be done:

1. The regulatory agency will be notified at least 60 days before any field activity begins with an updated plugging plan.
2. Move in the workover rig and rig up (RU) on the injection well.
3. CO₂ pipelines will be marked and noted with the rig supervisor and facility manager.
4. Hold safety meeting with all available rig crew, contractors, and facility personnel.
5. Based on the calculated kill fluid weight needed from the bottom hole pressure survey, kill the well.

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6. Ensure that rig pump or another suitable pump is rigged up to the well. Pressure test all lines to minimum 2,500 psi. Perform annulus pressure test.
7. Fill tubing and cased hole volume with kill brine. Monitor tubing pressure to ensure the well is dead.
8. Once the casing and tubing are dead, nipple down (ND) the well head.
9. Nipple up (NU) and test blow out preventers (BOPs).
10. Latch onto and remove tubing hanger from wellhead.
11. Lay down (LD) tubing hanger.
12. Latch onto injection string.
13. Unlatch from packer
 - a. Note that, at this time, the well is likely to u-tube. Ensure rig pump is connected to the top side, close the BOPs, and slowly circulate out the annulus fluid while maintaining a full column of fluid (as feasible).
14. Pull out of hole (POOH) with tubing and LD same.
 - a. Fill hole as necessary.
15. Pick up (PU) work string with packer pulling tool and run in hole (RIH).
16. Latch onto Packer and remove same.
17. POOH with work string and packer. LD same.
18. RIH with open end work string.
19. Tag bottom. Note tag depth
20. Pump plug #1.
 - a. Pump 10 feet off bottom.
 - b. **Sensitive, Confidential, or Privileged Information** Plug volume should be as detailed in Table 2.
 - c. Slowly pull out of hole while pumping plug.

21. **Sensitive, Confidential, or Privileged Information**
 - a. Wait time is dependent on hardening time for cement.
 - b. Wet samples of cement should be taken.
22. RIH and tag top of cement. Note top of cement. Ensure cement top has not moved.
23. Repeat steps 20 through 22 plugs 2 through 5.
 - a. Note that cement used in plugs one through five will be CO₂ resistant.
 - b. **Sensitive, Confidential, or Privileged Information**
24. Flush wellbore with brine.
25. RIH with work string and tag top of cement. Note top of cement.
26. Pump plug #6.
Sensitive, Confidential, or Privileged Information
Sensitive, Confidential, or Privileged Information Plug volume should be as detailed in Table 2. Plug to be pumped as balance plug.
 - c. Slowly pull out of hole as necessary while pumping plug.
27. Trip out work string **Sensitive, Confidential, or Privileged Information** above projected top with cement. Wait two hours.
 - a. Wait time is dependent on hardening time for cement.
 - b. Wet samples of cement should be taken.
28. RIH and tag top with cement. Note top of cement.
29. Pump remaining **Sensitive, Confidential, or Privileged Information** plugs by repeating steps 25 through 27.
30. Ensure cement is to surface. Fill from surface if necessary.
31. ND BOPs
32. Rig down rig. All casing should be cut per local policies/standards and have a plate with well information welded on top.
33. Fill and level ground as necessary.

Note that the procedure presented above assumes that no contingencies are necessary. Cement volumes, pumping pressures and weights are subject to change based on geologic and field conditions. This plan will be updated following the drilling and completion of both injection wells.

All materials and equipment to be used in this procedure are to be cement resistant **Sensitive, Confidential, or Privileged Information** above the Eau Claire Formation.

Any contingency plans that are necessary will be provided for as part of the formal procedure submitted 60 days before any field activities.

Following the completion of field activities, a report detailing the procedures and process followed to plug this well will be submitted to the agency. This report will be submitted within 60 days of the completion of plugging.

Figure 1 displays the theoretical plugging schematic for NV_INJ1. The diagram will be updated with drilled depths at a later time.

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Figure 1: Injection Well Plugging Schematic for NV_INJ1.

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5. References

- (2023). *Attachment 11: QASP*. Class VI Permit Application Quality Assurance and Surveillance Plan; Vervain.
- (2023). *Attachment 4A: NV_INJ1 Well Construction Plan*. Class VI Permit Application Injection Well #1 Construction Plan; Vervain.
- (2023). *Attachment 5: Pre-Op Testing Program*. Class VI Permit Application Pre-Operational Formation Testing Program; Vervain.
- (2023). *Attachment 7: Testing And Monitoring*. Class VI Permit Application Testing And Monitoring Plan; Vervain.

Attachment 8B: Injection Well #2 Plugging Plan
40 CFR 146.92(b)
Vervain Project, McLean County, Illinois
24 March 2023



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Project Information

Project Name: Vervain

Project Operator: Heartland Greenway Carbon Storage, LLC

Project Contact: Tyler Durham, SVP and Chief Development Officer
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List of Acronyms

BOP	blow out preventer
CO ₂	carbon dioxide
CBL	cement bond log
HGCS	Heartland Greenway Carbon Storage, LLC
LD	lay down
MIT	mechanical integrity test
ND	nipple down
NV_INJ2	Vervain Injection Well #2
NU	nipple up
P&A	plugging and abandonment
PNL	Pulsed Neutron Log
POOH	pull out of hole
PU	pick up
QASP	Quality Assurance and Surveillance Plan
RAT	radioactive tracer log
RIH	run in hole
RU	rig up
TD	total depth

Change Log

Item Changed	Date	Version	Description
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Pg 7 Table 2	3/24/2023	V1.1	Corrected table values

Plan revision number: 1.1
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Heartland Greenway Carbon Storage, LLC (HGCS) will conduct injection well plugging and abandonment (P&A) according to the procedures below at a time during the project following the cessation of injection that is deemed appropriate.

1. Planned Tests or Measures to Determine Bottomhole Reservoir Pressure

As required by 40 CFR 146.92(b)(1), prior to any plugging operations, bottomhole pressure data from the bottomhole gauges set in the Vervain Injection Well #2 (NV_INJ2) will be used to determine the reservoir pressure and calculate an appropriate kill weight fluid. Should the gauges be inoperative the bottomhole pressure will be obtained by conducting a static gradient survey using a memory pressure gauge run on slickline.

2. Planned External Mechanical Integrity Test(s)

HGCS will conduct at least one of the tests listed in Table 1 to verify external mechanical integrity prior to plugging the injection wells as required by 40 CFR 146.92(a).

Following the operations to kill the well, testing of the external mechanical integrity will be performed. This testing will include one or more of the following:

- Temperature Log,
- Radioactive Tracer (RAT) Log,
- Cement Bond Log (CBL),
- Pulsed Neutron Log (PNL).

Prior to any field mobilization or operations, proper notification will be given to the agency. Within this notification, the specific logs and/or tests to be run to determine external mechanical integrity will be provided. The list above is an example of logs that would likely be run to confirm external mechanical integrity and should not be considered as a comprehensive or final list for this project.

Note the following:

- i. Example procedures for the logging techniques provided above can be found in the Pre-Operational Testing Program or the Testing and Monitoring Plan sections of this application (Attachment 5: Pre-Op Testing Program, 2023) and (Attachment 7: Testing And Monitoring Plan, 2023).
- ii. Specifications on the tools that will be used for this testing can also be found in these same sections or the Quality Assurance Surveillance Plan (QASP) section of this application. (Attachment 11: QASP, 2023)
- iii. Criteria for acceptable logging results can be found in the Testing and Monitoring Plan as well as the QASP section of the permit application.

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Table 1: Potential MITs for NV_INJ2

Test Description	Location
Temperature Log	Along wellbore via wireline well log
RAT Log	Along wellbore via wireline well log
CBL	Along wellbore via wireline well log
PNL	Along wellbore via wireline well log

3. Information on Plugs

HGCS will use the materials and methods noted in Table 2 to plug the injection well. The volume and depth of the plug or plugs will depend on the final geology and downhole conditions of the well as assessed during construction. The cement(s) formulated for plugging will be compatible with the carbon dioxide (CO₂) stream (Attachment 4B: NV_INJ2 Well Construction Plan, 2023). The cement formulation and required certification documents will be submitted to the agency with the well plugging plan. The owner or operator will report the wet density and will retain duplicate samples of the cement used for each plug.

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Table 2: Plugging details for NV_INJ2

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* EverCrete Cement - Mark of Schlumberger, WellLock Resin - Mark of Halliburton, both of which are CO₂ resistant

4. Narrative Description of Plugging Procedures

4.1 Notifications, Permits, and Inspections

In compliance with 40 CFR 146.92(c), HGCS will notify the regulatory agency at least 60 days before plugging the wells and provide updated procedure for NV_INJ2, if applicable.

4.2 Plugging Procedures

In compliance with 40 CFR 146.92, the following will be done:

1. The regulatory agency will be notified at least 60 days before any field activity begins with an updated plugging plan.
2. Move in the workover rig and rig up (RU) on the injection well.
3. CO₂ pipelines will be marked and noted with the rig supervisor and facility manager.
4. Hold safety meeting with all available rig crew, contractors and facility personnel.
5. Based on the calculated kill fluid weight needed from the bottom hole pressure survey, kill the well.

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6. Ensure that rig pump or another suitable pump is rigged up to the well. Pressure test all lines to minimum 2,500 psi. Perform annulus pressure test.
7. Fill tubing and cased hole volume with kill brine. Monitor tubing pressure to ensure the well is dead.
8. Once the casing and tubing are dead, nipple down (ND) the well head.
9. Nipple up (NU) and test blow out preventers (BOPs).
10. Latch onto and remove tubing hanger from wellhead.
11. Lay down (LD) tubing hanger.
12. Latch onto injection string.
13. Unlatch from packer
 - a. Note that, at this time, the well is likely to u-tube. Ensure rig pump is connected to the top side, close the BOPs, and slowly circulate out the annulus fluid while maintaining a full column of fluid (as feasible).
14. Pull out of hole (POOH) with tubing and LD same.
 - a. Fill hole as necessary.
15. Pick up (PU) work string with packer pulling tool and run in hole (RIH).
16. Latch onto Packer and remove same.
17. POOH with work string and packer. LD same.
18. RIH with open end work string.
19. Tag bottom. Note tag depth
20. Pump plug #1.

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Plug volume should be as detailed in Table 2.

- c. Slowly pull out of hole while pumping plug.

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- a. Wait time is dependent on hardening time for cement.
- b. Wet samples of cement should be taken.
22. RIH and tag top of cement. Note top of cement. Ensure cement top has not moved.
23. Repeat steps 20 through 22 plugs 2 through 5.
 - a. Note that cement used in plugs one through five will be CO₂ resistant.
 - b. **Sensitive, Confidential, or Privileged Information**
24. Flush wellbore with brine.
25. RIH with work string and tag top of cement. Note top of cement.
26. Pump plug #6.
Sensitive, Confidential, or Privileged Information
Plug volume should be as detailed in Table 2. Plug to be pumped as balance plug.
 - c. Slowly pull out of hole as necessary while pumping plug.
27. Trip out work string **Sensitive, Confidential, or Privileged Information** above projected top with cement. Wait two hours.
 - a. Wait time is dependent on hardening time for cement.
 - b. Wet samples of cement should be taken.
28. RIH and tag top with cement. Note top of cement.
29. Pump remaining **Sensitive, Confidential, or Privileged Information** plugs by repeating steps 25 through 27.
30. Ensure cement is to surface. Fill from surface if necessary.
31. ND BOPs
32. Rig down rig. All casing should be cut per local policies/standards and have a plate with well information welded on top.
33. Fill and level ground as necessary.

Note that the procedure presented above assumes that no contingencies are necessary. Cement volumes, pumping pressures and weights are subject to change based on geologic and field conditions. This plan will be updated following the drilling and completion of both injection wells.

All materials and equipment to be used in this procedure are to be cement resistant **Sensitive, Confidential, or Privileged Information** above the Eau Claire Formation.

Any contingency plans that are necessary will be provided for as part of the formal procedure submitted 60 days before any field activities.

Following the completion of field activities, a report detailing the procedures and process followed to plug this well will be submitted to the agency. This report will be submitted within 60 days of the completion of plugging.

Figure 1 displays the theoretical plugging schematic for NV_INJ2. The diagram will be updated with drilled depths at a later time.

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Figure 1: Injection Well Plugging Schematic for NV_INJ2.

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5. References

- (2023). *Attachment 11: QASP*. Class VI Permit Application Quality Assurance and Surveillance Plan; Vervain.
- (2023). *Attachment 4B: NV_INJ2 Well Construction Plan*. Class VI Permit Application Injection Well #2 Construction Plan; Vervain.
- (2023). *Attachment 5: Pre-Op Testing Program*. Class VI Permit Application Pre-Operational Formation Testing Program; Vervain.
- (2023). *Attachment 7: Testing And Monitoring Plan*. Class VI Permit Application Testing And Monitoring Plan; Vervain.