Underground Injection Control
Carbon Sequestration
Class VI Permit Application

POST-INJECTION SITE CARE AND SITE CLOSURE PLAN
40 CFR 146.93(a)
Section 10.0

Four Corners Carbon Storage, LLC
San Juan Basin, New Mexico Carbon Sequestration Project

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40 CFR 146.93(a)

Four Corners Carbon Storage, LLC – Injector 1

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Injector 1

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[redacted]

[1] North American Datum 1983

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ACRONYMS AND ABBREVIATIONS

%	percent
2D	two dimensional
A	
AoR	area of review
C	
$CaCO_2$	calcium carbonate
CFR	Code of Federal Regulations
CO_2	carbon dioxide
D	
DAS	distributed acoustic sensing
DTS	distributed temperature sensing
E	
EPA	United States Environmental Protection Agency
M	
MEM	mechanical earth model
mg/L	milligrams per liter
P	
PISC	post-injection site care
PNL	pulsed-neutron log
psi	pounds per square inch
Q	
QASP	quality assurance surveillance plan
S	
SWD	saltwater disposal
T	
TVD	total vertical depth
U	
UIC	Underground Injection Control
USDW	underground source of drinking water

10 POST-INJECTION SITE CARE AND SITE CLOSURE PLAN [40 CFR 146.93(a)]

Four Corners Carbon proposes drilling and completing a carbon sequestration injection well (Injector 1) and monitoring well (Monitor 1) for the safe sequestration of carbon dioxide (the "Project") in northern San Juan County, [redacted]. Strat 1[2] is utilized as the project characterization well. This Post-Injection Site Care (PISC) and Site Closure Plan describes the activities that Four Corners Carbon Storage, LLC (Four Corners Carbon) will perform to meet the 40 CFR 146.93 requirements. Four Corners Carbon will monitor groundwater quality and track the position of the carbon dioxide (CO_2) plume and pressure front for [redacted]. The monitoring plan will support demonstration of non-endangerment of underground source(s) of drinking water (USDW). Following approval of site closure, Four Corners Carbon will plug all monitoring wells at the site and submit a site closure report and associated documentation.

10.1 Pre- and Post-Injection Pressure Differential

Based on modeling of downhole injection pressure, pressure at the injection well is expected decrease [redacted] after injection ceases (**Figure 10.1**). During the injection phase, a maximum differential of approximately [redacted] psi is predicted, based on the maximum injection pressure. As soon as injection ceases, the pressure will drop off, initially rapidly, and then as time progresses, the rate will decrease. Additional information on the projected post-injection pressure declines and differentials is presented in the narrative and the AoR and Corrective Action Plan.

[redacted]

[redacted]

Figure 10.1—Injection zone pressure at the injection well during the three phases of the Project: pre-injection, active injection, and post injection.

10.2 Predicted Position of the CO_2 Plume at Site Closure

Figure 10.2 shows the predicted extent of the plume at the end of the PISC timeframe. The plume is defined as the region [redacted]. This map is based on the final AoR delineation modeling results submitted pursuant to 40 CFR 146.84. The AoR is based on the extent of the plume in [redacted] (dark red line) and was selected based on the declining growth of the plume at that time.

[redacted]

Figure 10.2—Map of the predicted extent of the CO_2 plume at the end of the injection phase [redacted], site closure ([redacted], and growth of the plume after site closure.

10.3 Post-Injection Monitoring Plan

Continuous pressure and temperature monitoring are planned until measurements indicate the plume is stabilized. Additional monitoring, as detailed in **Table 10.1** and as described in the following sections, will meet the requirements of 40 CFR 146.93(b)(1). The results of all post-injection phase testing and monitoring will be submitted annually, within 45 days of the anniversary of injection ending, as described in the following text under Schedule for Submitting Post-Injection Monitoring Results.

Table 10.1—Summary of plume surveillance activities.

Type of Monitoring	Frequency	Comments
Geophysical Monitoring		
[redacted]	[redacted]	

10.3.1 Monitoring Above the Confining Zone

Table 10.2 presents the monitoring methods, locations, and frequencies for monitoring above the confining zone.

Table 10.2—Monitoring of ground water quality and geochemical changes above the confining zone.

Target Formation	Monitoring Activity	Monitoring Location(s)	Spatial Coverage	Frequency
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

PNL=pulsed neutron log

Table 10.3 highlights wells that will be equipped with pressure monitoring in order to collect data confirm dynamic modeling is providing a realistic representation of plume growth.

Table 10.3—Direct pressure monitoring activities.

Parameter	Device(s)	Location	Min. Sampling Frequency	Min. Recording Frequency
Pressure	Pressure transducer	Monitor 1	Under Review	Yearly

Notes:
Sampling frequency refers to how often the monitoring device obtains data from the well for a particular parameter. For example, a recording device might sample a pressure transducer monitoring injection pressure once every two seconds and save this value in memory.
Recording frequency refers to how often the sampled information gets recorded to digital format (such as a computer hard drive). For example, the data from the injection pressure transducer might be recorded to a hard drive once every minute.

10.3.2 Carbon Dioxide Plume and Pressure Front Tracking

Four Corners Carbon will employ direct and indirect methods to track the extent of the carbon dioxide plume and the presence or absence of elevated pressure.

Table 10.4 presents the direct and indirect methods that Four Corners Carbon will employ to monitor the CO_2 plume. Injector No.1 will be converted to a pressure monitoring well until plume stabilization has been observed and verified with simulator. Monitor 1 will continue gathering direct samples and pressure data during the post injection phase until the plume is stable. Pressure gauges installed in the monitoring well as detailed in **Table 10.5** will be used to monitor pressure conditions during the post-injection phase of Project. These data will be compared to dynamic simulation results and used to inform if dynamic simulation model needs to be refined.

Quality assurance procedures for seismic monitoring methods are presented in section 8.9, the Quality Assurance Surveillance Plan (QASP).

Table 10.4—Post-injection phase plume monitoring.

Target Formation	Monitoring Activity	Monitoring Location(s)	Spatial Coverage	Frequency
Indirect Plume Monitoring				
[redacted]	[redacted]		[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

PNL=pulsed neutron log

Table 10.5—Post-injection phase pressure-front monitoring.

Target Formation	Monitoring Activity	Monitoring Location(s)	Spatial Coverage	Frequency
Direct Pressure-Front Monitoring				
[redacted]	[redacted]	[redacted]	[redacted]	[redacted] yearly
Indirect Pressure-Front Monitoring				
[redacted]	[redacted]		[redacted]	[redacted]

10.3.3 Schedule for Submitting Post-Injection Monitoring Results

All post-injection site care monitoring data and monitoring results, collected using the methods described above, will be submitted to the U.S. Environmental Protection Agency (EPA) in reports submitted within 60 days of the anniversary of injection cessation. The reports will contain all data collected, their interpretation, and any new findings that may need further review.

10.4 Alternative Post-Injection Site Care Timeframe

Four Corners Carbon will conduct post-injection monitoring for [redacted] years, following the cessation of injection operations. A justification for this alternative PISC timeframe is provided below. Regardless of the alternative PISC timeframe, monitoring and reporting, as described in the sections above, will continue until it is determined that no additional monitoring is needed—ensuring that the Project does not endanger USDWs, per the requirements at 40 CFR 146.93(b)(2) or (3).

10.4.1 Computational Modeling Results

Post shut-in the plume is expected to [redacted]. The change in plume dimensions decreases rapidly from [redacted] and is forecasted to grow by [redacted] during the proposed PISC time period. The plume radius in [redacted] is forecasted to be [redacted] as shown in **Figure 10.3**. The dimensions of the CO_2 plume are forecasted to change during the postproduction shut-in period as shown in **Figure 10.4**. CO_2 not trapped by hysteresis of the gas-brine relative permeabilities, or the stratigraphy of the section remains mobile, and continues to rise with gravity Figure 10.4. At the time of this permit application, no sensitivity analysis has been performed to further quantify the change in plume dimensions through time.

[redacted]

Figure 10.3—Forecasted change in plume radius through time.

[redacted]

Figure 10.4—Gas saturation profile time lapse ([redacted])

10.4.2 Predicted Timeframe for Pressure Decline [40 CFR 146.93(c)(1)(ii)]

Once injection ceases, the pressure will drop from a peak of ~4,200 psi at the top of [redacted] to [redacted] psi in the first year, and by the end of the proposed post injection site care timeframe [redacted] i.

10.4.3 Predicted Rate of Plume Migration [40 CFR 146.93(c)(1)(iii)]

Figure 10.5 highlights growth of plume from [redacted] Once injection ceases [redacted], the plume growth slows significantly and only expands in areas where the plume can [redacted]). Site-Specific Trapping

Processes [40 CFR 146.93(c)(1)(iv)-(vi)]. **Figure 10.5** highlights the injection zone pressure at the injector leading up to and following shut-in.

[redacted]

Figure 10.5—[redacted] post injection phase pore pressure at [redacted]

The dynamic reservoir model predicts the trapped amount of CO_2 via solubility and residual trapping mechanisms. As the Project matures, Four Corners Carbon will leverage the surveillance data collected to better tune the dynamic model and improve the reliability of future plume extent. For the operational and proposed post-injection time monitoring [redacted]), mineral trapping is predicted to be minimal and is therefore assumed to be zero. As the surveillance dataset and injection history grows, tuning of the dynamic model will ensure any surveillance data that are not matched by the simulation will in turn be used to fine tune the simulation model.

10.4.4 Confining Zone Characterization

[redacted] physical and geochemical sealing characteristics demonstrate that the alternative PISC timeframe is suitable. [redacted] is an ideal confining layer for injected CO_2. [redacted] **(Figure 10.6)**. [redacted]

[redacted]. The [redacted] (**Figure 10.7**) and will be in contact with the CO_2 plume and mobilized fluids.

[redacted]

Figure 10.6—Depositional extents of the [redacted] Solid-phase geochemical data was collected at sample sites shown on map [redacted]

Table 10.6—Average ELAN permeability for [redacted]

[redacted]	Gross Thickness (ft)	Net Confining Thickness (ft)	Total Porosity (v/v)	Permeability (mD)
Upper [redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

Figure 10.7—Geologic cross sections A and B running through Injector 1 extending from surface to below the base of [redacted]. The neares [redacted] penetrations are included. All significant zones are shown and USDWs are shown in blue. Well logs show gamma ray on the left track and resistivity on the right track.

[redacted] over extended periods. [redacted] our Corners Carbon does not expect caprock integrity to be comprised from this. [redacted] Core collected from Strat 1, located approximately [redacted] of the AoR, is being analyzed for mineralogy and elemental composition to confirm the geochemical suitability of [redacted].

Extensive site-specific data will be collected to better characterize the injection and confining zones during all phases of the Project, including pre-injection, injection, and post injection. These data will be used to tune the mechanical earth model (MEM), static geological model, and dynamic simulation model. Any indications of alternative timeframes for the PISC will be drawn from these data driven models.

10.4.5 Assessment of Fluid Movement Potential

Currently, there are no wells that penetrate the injection zone or confining layer within the AoR. Besides Monitor 1 associated with this injector, there are [redacted].

[redacted]

Figure 10.8—AoR [redacted] plume extent) around Injector 1 and [redacted]

[redacted] ***[40 CFR 146.93(c)(1)(x)]***

- The top of [redacted] ft total vertical depth (TVD) below the base of the lowermost USDW. [redacted] (**Figure 10.9**).
- The [redacted] laterally becomes a USDW [redacted] (**Figure 10.10**).
- Within the AoR there are [redacted] (**Figure 10.11**). Fluid samples were collected and analyzed from [redacted] locations within a 20-mile buffer around well Injector 1 (**Figure 10.12**). The TDS values in these wells range from [redacted] mg/L and average [redacted] mg/L. Based on these data, the [redacted] is a USDW. All zones below [redacted] have measured or calculated TDS values that are greater than 10,000 mg/L, signifying those intervals are not USDWs (see Section 2.8.1 Fluid Chemistry for details).

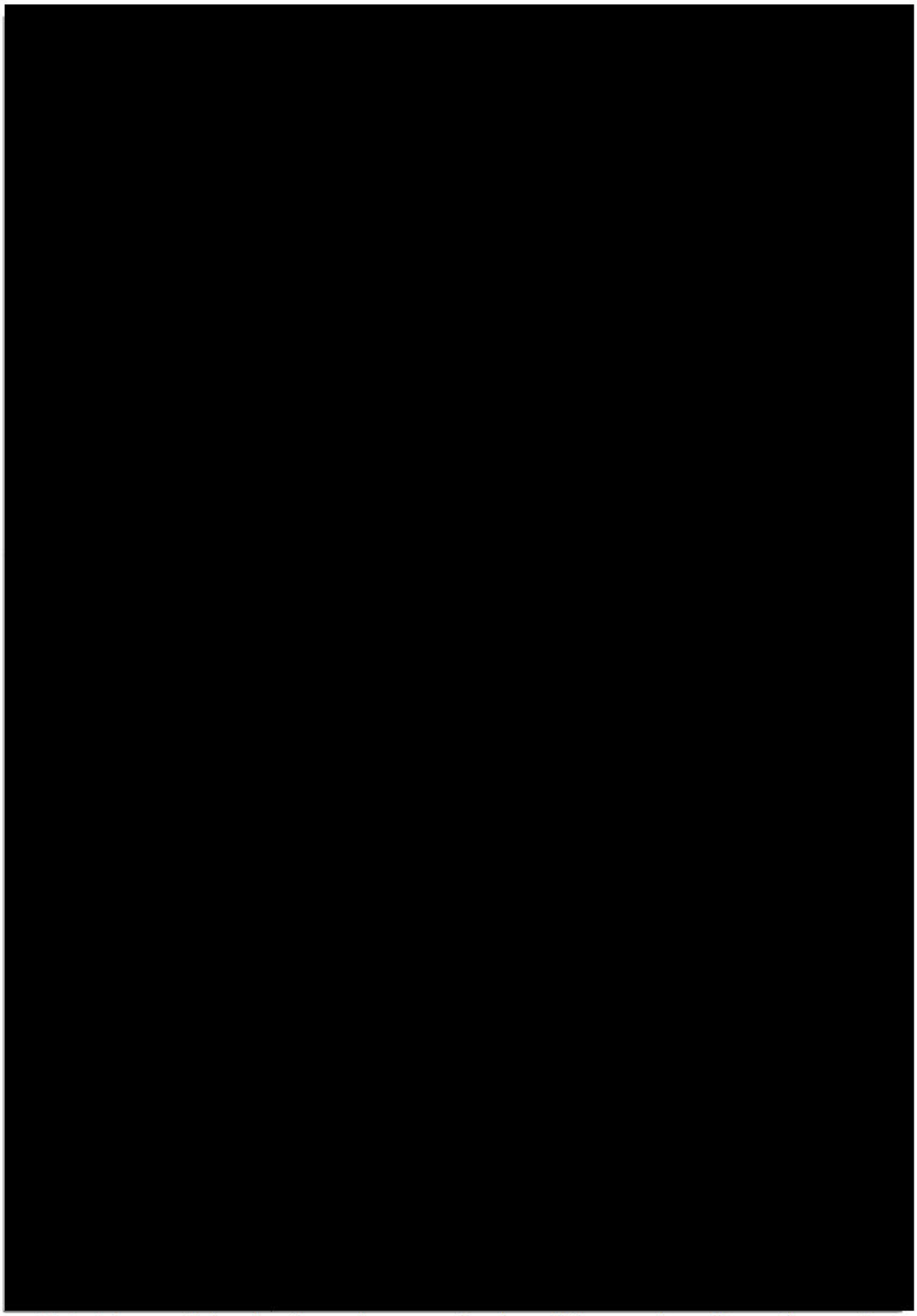

Figure 10.9—Type well log for the project area showing all key stratigraphic markers and zones from surface down to the lower confining zone. Track 1 indicates period and zone, track 2 shows gamma ray (GR), and track three contains shallow (ILS) and deep resistivity.

[redacted]

Figure 10.10[redacted] Salinity map showing [redacted]

[redacted]

Figure 10.11—AoR specific stratigraphic column and UIC significance.

[redacted]

Figure 10.12— [redacted] TDS values within 20 miles of Injector 1. Structural contours [redacted]

10.5 Non-Endangerment Demonstration Criteria

Prior to approval to end the post-injection phase, Four Corners Carbon will submit a demonstration of non-endangerment of USDWs to the UIC Program Director, per 40 CFR 146.93(b)(2) and (3).

Four Corners Carbon will issue a report to the UIC Program Director. This report will make a demonstration of USDW non-endangerment based on the evaluation of the site monitoring data used in conjunction with the Project's computational model. The report will detail how the non-endangerment demonstration evaluation uses site-specific conditions to confirm and demonstrate non-endangerment. The report will include all relevant monitoring data and interpretations upon which the non-endangerment demonstration is based, model documentation and all supporting data, and any other information necessary for the UIC Program Director to review the analysis. The report will include the following sections:

10.5.1 Introduction and Overview

A summary of relevant background information will be provided, including the operational history of the injection Project, the date of the non-endangerment demonstration relative to the post-injection period outlined in this PISC and Site Closure Plan, and a general overview of how monitoring and modeling results will be used together to support a demonstration of USDW non-endangerment.

10.5.2 Summary of Existing Monitoring Data

A summary of all previous monitoring data collected at the site, pursuant to the Testing and Monitoring Plan of this permit and this PISC and Site Closure Plan, including data collected during the injection and post-injection phases of the Project, will be submitted to help demonstrate non-endangerment. Data submittals will be in a format acceptable to the UIC Program Director [40 CFR 146.91(e)], and will include a narrative explanation of monitoring activities, including the dates of all monitoring events, changes to the monitoring program over time, and an explanation of all monitoring infrastructure that has existed at the site. Data will be compared with baseline data collected during site characterization [40 CFR 146.82(a)(6) and 146.87(d)(3)].

10.5.3 Summary of Computational Modeling History

The dynamic simulation outlined in section 3.3.2 demonstrates that at no point in time, or distance from the injection well is there an increase in reservoir pressure large enough to generate a hypothetical leakage through cement in a conduit in the annular space behind pipe at rate that would endanger the USDW. The maximum pressure of [redacted] psi shown **Figure 10.13** produces a [redacted]

[redacted]

Figure 10.13—Change in pressure due to the injection of CO_2.

As additional data becomes available, the static geomodel and dynamic reservoir simulation will be updated to include the most relevant information available. As outlined in Section 3.3.2, the models will be incrementally adjusted with new information and impacts to the AoR evaluated.

10.5.4 Evaluation of Reservoir Pressure

Reservoir pressure will be monitored in [redacted] at Monitor 1. Monitor 1 is located [redacted] from the injector and is predicted to be reached by the CO_2 plume within the [redacted] after the injection starts. [redacted] will be recorded every five years to further define the plume boundaries and quantify the rate of growth. Should a significant deviation from the model prediction occur, a workflow to address the discrepancy will be generated and provided to the UIC program Director. The nature of the deviation will dictate how the discrepancy is addressed.

10.5.5 Evaluation of Carbon Dioxide Plume

The monitoring well is located such that one should confirm the model prediction of the plume reaching it within [redacted].

10.5.6 Evaluation of Emergencies or Other Events

Within the AoR, [redacted] will provide indications of fluid movement in or above the confining zone.

10.6 Site Closure Plan

Four Corners Carbon will conduct site closure activities to meet the requirements of 40 CFR 146.93(e) as described below. Four Corners Carbon will notify the permitting agency at least 120 days prior to its intent to close the site. Once the permitting agency has approved closure of the site, Four Corners Carbon will develop and submit a site closure report to the EPA. The activities, as described below, represent the planned activities based on information provided to the EPA. The actual site closure plan may employ different methods and procedures. A final Site Closure Plan will be submitted to the UIC Program Director for approval with the notification of the intent to close the site.

10.6.1 Plugging Monitoring Wells

As part of the site closure activities, the Monitor 1 well will be abandoned. Four Corners Carbon intends to plug and abandon this well under the requirements of New Mexico OCD rules 19.15.25. In addition to regulatory requirements, normal and customary engineering and operational practices will be applied during this program to prevent fluid migration and contamination of any USDWs. All materials used during this plugging operation will be compatible with CO_2 and CO_2-water mixtures. For a detailed explanation and plugging procedure see Section 9.0—Injection and Monitoring Well Plugging Plan.

[redacted]

Figure 10.14—Monitor 1 – post P&A configuration.

Table 10.7—Summary of Cement Plugs, Monitor 1.

Cement Plug Number	Interval Range (ft)		Thickness (ft)	Volume (cu-ft)	Note
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

10.6.2 Site Closure Report

A site closure report will be prepared and submitted within 90 days following site closure, documenting the following:

- Plugging of the verification and geophysical wells (and the injection well if it has not previously been plugged).
- Location of sealed injection well on a plat survey that has been submitted to the local zoning authority.
- Notifications to state and local authorities as required at 40 CFR 146.93(f)(2).
- Records regarding the nature, composition, and volume of the injected CO_2.
    - Post-injection monitoring records. Four Corners Carbon will record a notation to the property's deed on which the injection well was located that will indicate the following: That the property was used for carbon dioxide sequestration.
    - The name of the local agency to which a plat of survey with injection well location was submitted.
    - The volume of fluid injected.
    - The formation into which the fluid was injected.
    - The period over which the injection occurred.

The site closure report will be submitted to the permitting agency and maintained by the owner or operator for a period of ten years following site closure. Additionally, the owner or operator will maintain the records collected during the post-injection period for a period of ten years after which these records will be delivered to the UIC Program Director.

10.7 <u>References</u>

[redacted]