Natural State
RENEWABLES

POST INJECTION SITE CARE AND SITE CLOSURE PLAN

40 CFR 146.93(a)

NATURAL STATE RENEWABLES INC.
NIMBUS ARCCS INC.
Ouachita County, Arkansas

Prepared By:
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1.0 FACILITY INFORMATION

Facility/project Name: Natural State Renewables Inc.
Nimbus ARCCS Inc.
Class VI Injection Well Nos. 1-4

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[redacted]

This Post-Injection Site Care (PISC) and Site Closure plan describes the activities that NSR-Nimbus ARCCS will perform to meet the requirements of 40 CFR 146.93. To achieve this, NSR-Nimbus ARCCS plans to implement a PISC over a 50-year timeframe to demonstrate conformance and containment. Data will be gathered to track the position of the CO_2 plume, declining pressure front and to demonstrate that the Underground Source of Drinking Water (USDW) is not endangered, using an adaptive, sustainable, risk-based monitoring approach. Depending on project performance during the project life cycle, NSR-Nimbus ARCCS may consider requesting an alternative PISC timeframe at a future date.

Prior to authorization for site closure, NSR-Nimbus ARCCS will demonstrate that no additional monitoring is needed to ensure that the geologic sequestration project does not pose an endangerment to USDWs as per 40 CFR 146.93(b)(3). Following approval for site closure, NSR-Nimbus ARCCS will plug remaining wells as needed, restore the site, and submit a site closure report and associated documentation.

NOTE: When used in this document and associated diagrams, the term "gauge" is synonymous with a pressure and temperature sensor and a pressure transducer.

1.1 PROJECT WELL DESIGNATION

A tabulation of the well naming convention used in this permit application is shown below:

NIMBUS ARCCS PROJECT WELL NAMING TABLE	
Well Identification	**Well Name**
Nimbus ARCCS Injection Well No. 1	Nimbus INJ-1
Nimbus ARCCS Injection Well No. 2	Nimbus INJ-2
Nimbus ARCCS Injection Well No. 3	Nimbus INJ-3
Nimbus ARCCS Injection Well No. 4	Nimbus INJ-4
Nimbus ARCCS Above Confining Zone Monitor Well	Nimbus SM-1
Nimbus ARCCS In Zone Monitor Well No. 1	Nimbus DM-1
Nimbus ARCCS In Zone Monitor Well No. 2	Nimbus DM-2
Nimbus ARCCS In Zone Monitor Well No. 3	Nimbus DM-3
Nimbus ARCCS In Zone Monitor Well No. 4	Nimbus DM-4

2.0 PRESSURE DIFFERENTIALS

Pressure differentials at the Injection Wells are presented in this Section per the 40 CFR 146.93(a)(2)(i) standard. Module B discusses the Area of Review (AoR) and delineation of the Pressure Front. Modeling shows pressure in, and around, the Injection Wells reach a maximum value during the injection period and decrease, approaching the pre-injection initial pressure during the extended 50 year shut-in period.

Pressure does not reach initial pressure after 50 years closure in all zones, however, all pressures fall below the critical pressure used to define the pressure Front before the end of the 50-year PISC timeframe.

The data presented in this section is based on information provided in the Static model, and results obtained from the Dynamic model. The Static and Dynamic models are covered thoroughly in Module B.

A discussion of each zone's pressure response following injection is included below [40 CFR 146.93(c)(1)(ii)]. Additional information on the projected post-injection pressure declines and differentials is presented in "*AoR and Corrective Action Plan*" submitted in Module B.

2.1 HOSSTON INJECTION ZONE

The initial pressure in the Hosston reservoir estimated at the top of the planned perforations in the Nimbus ARCCS Injection Well No.4 (Nimbus INJ-4) is 1,281 psi prior to commencement of CO_2 injection (year 2028). The final grid block pressure at end of the 20-year modeled injection time (year 2048) is 1,604 psi. This equates to a maximum differential pressure increase of 323 psi in the Hosston Injection Zone.

Once CO_2 injection ceases, the pressure declines to a value of 1,519 psi within 5 years of the end of injection (year 2053) and slowly decreases to 1,406 psi at the end of the observation period (year 2098). The difference in final and initial pressure, after 50 years of shut-in, is 126 psi (1406 – 1281 psia).

The pressure decline in the Hosston is muted for several reasons. The Well is located between two no-flow boundaries South and North of the site. In addition, the lateral distribution of porosity and permeability is not homogeneous. The pressure profiles in the North-South and East-West direction are shown in Appendix-1P, Pages 5 and 6. Page 7 in Appendix 1P displays the line of pressure in layer 7 with the porosity in the layer.

The profiles run through the top layer (7) in the Hosston injection zone through Injection Well No. 4. The spatial progression, and regression, of the Pressure Front is shown in Appendix-1P, Pages 8 through 17. The Pressure front is calculated using the Maximum Equivalent Mud Weight which is described in detail in Module B.

2.2 COTTON VALLEY A - INJECTION ZONE

The initial pressure in the Cotton Valley A reservoir estimated at the top of the planned perforations in the Nimbus ARCCS Injection Well No.3 (Nimbus INJ-3) is 1,613 psi prior to commencement of CO_2 injection (year 2028). The final grid block pressure at end of the 20-year modeled injection time (year 2048) is 2,163 psi. This equates to a maximum differential pressure increase of 550 psi in the Cotton Valley A - Injection Zone.

Once CO_2 injection ceases, the pressure declines to a value of 1,955 psi within 5 years of the end of the injection (year 2053) and slowly decreases to 1,708 psi at the end of the observation period (year 2098). The difference in final and initial pressure, after 50 years of shut-in, is 95 psi (1708 – 1613 psia).

The pressure decline in the Cotton Valley A is also muted for several reasons. The Well is located between two no-flow boundaries South and North of the site. In addition, the lateral distribution of porosity and permeability is not homogeneous. The pressure profiles in the North-South and East-West direction are shown in Appendix-1P, Pages 18 and 19. Page 20 in Appendix 1P displays the line of pressure in layer 31 with the porosity in the layer.

The profiles run through the top layer (31) in the Cotton Valley A injection zone through Injection Well No. 3. The spatial progression, and regression, of the Pressure Front is shown in Appendix-1P, Pages 21 through 30. The Pressure front is calculated using the Maximum Equivalent Mud Weight which is described in detail in Module B.

2.3 COTTON VALLEY B - INJECTION ZONE

The initial pressure in the Cotton Valley B reservoir estimated at the top of the planned perforations in the Nimbus ARCCS Injection Well No.2 (Nimbus INJ-2) is 1,842 psi prior to commencement of CO_2 injection (year 2028). The final grid block pressure at end of the 20-year modeled injection time (year 2048) is 2,225 psi. This equates to a maximum differential pressure increase of 383 psi in the Cotton Valley B - Injection Zone.

Once CO_2 injection ceases, the pressure declines to a value of 2,076 psi within 5 years of the end of the injection (year 2053) and slowly decreases to 1,937 psi at the end of the observation period (year 2098). The difference in final and initial pressure, after 50 years of shut-in, is 95 psi (1937 – 1842 psia).

The pressure decline in the Cotton Valley B is also muted for several reasons. The Well is located between two no-flow boundaries South and North of the site. In addition, the lateral distribution of porosity and permeability is not homogeneous. The pressure profiles in the North-South and East-West direction are shown in Appendix-1P, Pages 31 and 32. Page 33 in Appendix 1P displays the line of pressure in layer 57 with the porosity in the layer.

The profiles run through the top layer (57) in the Cotton Valley B injection zone through Injection Well No. 2. The spatial progression, and regression, of the Pressure Front is shown in Appendix-1P, Pages 34 through 40. The Pressure front is calculated using the Maximum Equivalent Mud Weight which is described in detail in Module B.

2.4 UPPER SMACKOVER INJECTION ZONE

The initial pressure in the Smackover reservoir estimated at the top of the planned perforations in the Nimbus ARCCS Injection Well No.1 (Nimbus INJ-1) is 2,146 psi prior to commencement of CO_2 injection (year 2028). The final grid block pressure at end of the 20-year modeled injection time (year 2048) is 2,915 psi. This equates to a maximum differential pressure increase (in the grid block) of 769 psi in the Smackover - Injection Zone.

Once CO_2 injection ceases, the pressure declines to a value of 2,426 psi within 5 years of the end of the injection (year 2053) and slowly decreases to 2,276 psi at the end of the observation period (year 2098). The difference in final and initial pressure, after 50 years of shut-in, is 130 psi (2276 – 2146 psia).

The pressure decline in the Smackover is also muted for several reasons. The Well is located between two no-flow boundaries South and North of the site. In addition, the lateral distribution of porosity and permeability is not homogeneous. The pressure profiles in the North-South and East-West direction are shown in Appendix-1P, Pages 41 and 42. Page 43 in Appendix 1P displays the line of pressure in layer 79 with the porosity in the layer.

The profiles run through the top layer (79) in the Smackover injection zone through Injection Well No. 1. The spatial progression, and regression, of the Pressure Front is shown in Appendix-1P, Pages 44 through 53. The Pressure front is calculated using the Maximum Equivalent Mud Weight which is described in detail in Module B.

3.0 PREDICTED POSITION OF PLUME AND PRESSURE AT CLOSURE

The predicted plume and pressure front at time of closure for the NSR Nimbus ARCCS site is presented in the following section per the 40 CFR 146.93(a)(2)(ii) standard.

Due to the density contrast between the free-phase CO_2 and the formation brine, CO_2 will tend to migrate to the top of the storage reservoir. The following mechanisms will act to stop this migration and immobilize the CO_2 plume within the storage complex:

- Dissolution of CO_2 into unsaturated or partially saturated formation brine.
- Trapping by capillary forces at the deep/receding edge of the plume as brine invades the pore space previously occupied by CO_2 (after injection ceases).
- *In-situ* mineralization of the CO_2 dissolved in the formation water (expected to be an important mechanism over an extended timescale and ignored in the current model.)

Based on the dynamic modeling, which considers dissolution of CO_2 into formation brine and capillary trapping (but not mineralization), it is expected that the plume will remain within the storage complex, in each of the Injection Zones.

Note: The Lower Cretaceous Sequence Boundary (LCSB) Confining Zone is expected to act as a barrier to CO_2 migration. This will be verified via data acquisition activities (in particular – estimation of capillary entry pressure).

The Figure on Page 4 of Appendix-1P, and Appendix 9-1, 9-2, 9-3, 9-4 submitted with Module B, provide a detailed review of the time series plume expansion for each injection zone.

The Figure on Page 4 of Appendix- shows the plume front at the end of the 50-year PISC timeframe for each injection zone at year2098. These maps are based on the final AoR delineation and modeling results (submitted in **Module B**) pursuant to 40 CFR 146.84.

4.0 POST-INJECTION MONITORING PLAN

NSR-Nimbus ARCCS plans to implement a PISC over a 50-year timeframe to demonstrate conformance and containment. The PISC will utilize four In-Zone (IZ) Monitoring Wells (Nimbus DM-1-4), located up dip of the plume, and one Above Confining Zone (ACZ) Monitoring Well (Nimbus SM-1) (see section 1.1) for the following PISC monitoring plan. Depending on project performance during the project life cycle, NSR-Nimbus ARCCS may consider an Alternative PISC at a future date if supported by operational data.

NSR-Nimbus ARCCS will perform monitoring of the site during the post-injection phase to meet the requirement of 40 CFR 146.93(B)(1). The results of all post-injection testing and monitoring will be submitted annually, within 60 days of the anniversary date of cessation of injection operations, as described in Section 4.3 below.

Post injection monitoring will also include these activities which are described in sections 4.1 and 4.2 below.

- CO_2 Plume and Pressure Front Tracking
- Monitoring Above the Confining Zone

Additional monitoring activities, such as collection of fluid samples and laboratory analyses, may be implemented to verify there is no endangerment to USDW.

A key focus of the post-injection monitoring plan is to verify that the CO_2 plume and pressure front develop in accordance with model predictions. The static and dynamic models will be updated and calibrated using all acquired data, and particularly pressure data collected in the monitoring wells. The models will be calibrated to the injection pressure and possible plume response observed in these wells.

Regularly model updates (at least every five years) will be made during the injection phase of the project. The calibrated model will be used to reassess and validate the longer-term prediction of plume and pressure behavior. The calibrated model will help ensure containment and non-endangerment of USDW.

NSR-Nimbus ARCCS will follow QA/QC procedures for post-injection monitoring to ensure representative and reliable data are collected. Please refer to the quality assurance and surveillance plan (QASP) provided in Appendix 1 to **Module E**: "*E.1 - Testing and Monitoring Plan*".

4.1 MONITORING ABOVE THE CONFINING ZONE

The injection and post-injection monitoring plan includes a dedicated Above Confinement Zone (ACZ) Monitor Well (Nimbus SM-1). This well is completed in the saline Tokio Formation as outlined in the Testing and Monitoring Plan (TMP). The well will be used during the active injection period and in the post injection to collect continuous daily bottomhole pressures. This activity will continue during the first year of the PISC observation period. Continuation after 1-year post injection will be determined based on the evaluation of data collected during the first-year post-injection. This plan will ensure that any vertical pressure changes above the confining zone (nearest the point of injection) are monitored, as well as confirm there is no unexpected pressure breach out of the confining zone.

Table 1 below presents the monitoring methods, locations, and frequencies for monitoring above the confining zone.

Table 1: Monitoring of ground water quality and geochemical changes above the confining zone

Target Formation	Monitoring Activity	Monitoring Location(s)	Spatial Coverage	Frequency
Tokio Formation	Downhole Pressure/ Temperature Monitoring	1 ACZ Monitor Well (Nimbus SM-1)	Near point of injection	Real time daily read out
	Fluid Sampling			Annually, adaptive if triggered

Depending on data collected and evaluated from the in-well gauge and CO_2 plume and pressure tracking, additional investigations may be initiated. Groundwater quality monitoring may occur in the ACZ Monitoring Well (Nimbus SM-1) in the first permeable layer above the Confining Zone (the saline Tokio Formation). Sampling, chain of custody, analysis procedures and quality assurance for the post-injection groundwater quality monitoring will follow the protocols detailed in the TMP and the QASP.

Monitoring of the Tokio formation will signal potential loss of containment since it is just above the Confining Zone. Fluid samples from the Tokio will be analyzed to determine the constituents listed in Table 2.

If monitoring detects the presence of fluids from below the confining zone (CO_2, Brine), actions detailed in **Module E**: "*E.4 - Emergency and Remedial Response Plan*" will be initiated.

Table 2: Summary of potential analytical and field parameters for ground water samples

Parameters	**Analytical Methods**
Tokio and Wilcox Formations	
Cations: Al, Ba, Mn, As, Cd, Cr, Cu, Pb, Sb, Se, Sr, and Tl	ICP-MS, EPA Method 6020B
Cations: Ca*, Fe, K*, Mg*, Na*, and Si	ICP, EPA Method 6010D
Anions: Br*, Cl*, F, NO_3, and SO_4^*	Ion chromatography, EPA Method 300.0
Alkalinity (total and bicarbonate)*	SM 2320B
Total dissolved solids*	SM 2540C
Water density (lab)	SM 2710F
Water density (field)*	Calculated from Salinity, Temperature, and Pressure
pH (lab)*	SM 4500 H+B
pH (field)*	Standard Method 4500-H+ B-2000
Specific conductance (field)*	Standard Method 2510 B-1997
Temperature (field)*	Thermistor, Standard Method 2550 B-2000
Turbidity (field)*	Nephelometric - Optical, 90° Scatter
Oxidation-Reduction Potential (field)*	Platinum Button; Ag/AgCl Reference
Dissolved Oxygen (field)*	ASTM Method D888-09 (C)
Dissolved Inorganic Carbon (DIC)*	SM 5310B
Isotopic composition of selected major or minor constituents (e.g., $^{228}Ra/^{226}Ra$, $^{87}Sr/^{86}Sr$)	EPA Method 901.1, ICP-MS

Parameters	Analytical Methods
δ^{18}O and δ^{2}H of H_2O	Analyzed via CRDS
δ^{13}C of DIC	Gas Bench/CF-IRMS
^{14}C of DIC	AMS
Dissolved CO_2, N_2, Ar, O_2, He, C1-C6+, by headspace*	In-house Lab SOP, similar to RSK-175
δ^{13}C of dissolved Methane, Ethane, Propane, and CO_2, δ^{2}H of Methane	High precision (offline) analysis via Dual Inlet IRMS

* *Analytical parameters to be included during the baseline phase, and only as needed during* the *injection and post-injection phases of the project.*

4.2 CO_2 PLUME AND PRESSURE FRONT TRACKING

NSR-Nimbus ARCCS will employ direct and indirect plume and pressure front monitoring as described in the following sections during the post-injection phase to adhere to the requirements of 40 CFR 146.93(b)(1). The results of all post-injection phase testing and monitoring will be submitted annually, within 60 days of the anniversary date on which injection ceases, as described under "Schedule for Submitting Post-Injection Monitoring Results" below.

Post-injection monitoring will evaluate the pressure differential between the pre-injection and predicted post-injection pressures within the targeted Injection Zones (Hosston, Cotton Valley A, Cotton Valley B and Smackover Formations). Predicted post-injection pressures will be derived from the most up to date AoR model results and will be compared to measured/observed pressure readings. Pressure measurements will be continuously monitored via four (4) In-Zone (IZ) Monitoring Wells, Nimbus DM-1-4. The monitoring system design will consist of a downhole system that will provide pressure measurements during the injection and post-injection lifetime of the project. Potential future technology at the time of closure will also be considered and the PISC plan and Monitoring Well will be updated accordingly. The IZ Monitoring Wells DM-1-4 will be located up dip of the Injection Wells within the projected plume path. During the PISC in Nimbus DM-1-4, pressure and temperature will be continuously and independently measured in the Hosston, Cotton Valley A, Cotton Valley B and Upper Smackover zones, using gauges either installed in the well or installed on the casing string. The initial plan is to place instrumentation in each monitor well on the outside of the casing, but the final configuration will be determined.

No tracers will be injected during the PISC; however, all the previously injected CO_2 will have been tagged by a different tracer for each of the four injection zones (**Module E**: *"E1 - Testing and Monitoring Plan"*) in the injection wells.

Indirect monitoring of the CO_2 plume will continue to build upon the proposed time-lapse seismic survey method that will be performed during injection operations both for CO_2 plume migration monitoring and pressure front tracking, as described in **Module E**: *"E1 - Testing and Monitoring Plan",* section 9. NSR-Nimbus ARCCS is anticipating deployment of an autonomous, permanent source and receiver array within and beyond the dimensions of the carbon dioxide plume. The system will use one or more permanent surface sources and an autonomous receiver array with the receivers emplaced in the shallow underground, for maximum coupling and noise reduction. The receivers will be used to monitor ray paths that will allow for dense sampling over time. System flexibility allows for sensors and/or source geometry to be optimally redeployed further away from the injection wells as the plume pressures increase. Baseline and subsequent time-lapse surveys will be processed using a technique that will resolve the differences between the surveys, which will be mapped to show the change in plume extent over time. At end of injection the permanent seismic sources will be removed from the site, but the receiver array will stay in place. Once a year the seismic sources will be re-installed to shoot a single survey. If evidence suggests plume growth has slowed down significantly the frequency will be reduced (adapted), with prior approval from the EPA.

NSR-Nimbus ARCCS will employ direct and indirect methods to track the extent of the carbon dioxide plume and the presence or absence of elevated pressure in accordance with 40 CFR 146.93(a)(2)(iii). Table 3 presents the direct and indirect methods that NSR-Nimbus ARCCS will use to monitor the CO_2 plume, including the activities, locations, and frequencies which will be employed. The pressure is not expected to increase post injection but is expected to decrease as per the figures presented in Appendix-1P.

Table 3: Post-injection phase plume monitoring

Target Formation	Monitoring Activity	Monitoring Location(s)	Spatial Coverage	Frequency
DIRECT PLUME MONITORING				
Hosston Cotton Valley Smackover	Fluid Sampling	In Zone Monitoring Well Nimbus DM-1-4	AoR – Up dip of injection operations	Annually - adaptive, if triggered
INDIRECT PLUME MONITORING				
Sequestration Complex	Timelapse seismic method designed for plume tracking, also to detect any CO_2 above sequestration complex	Autonomous source and array seismic; there will be no well access required.	lateral extent of the CO_2 plume	Annually - adaptive, if triggered
Hosston Cotton Valley Smackover	Pulsed Neutron Log	In Zone Monitoring Well Nimbus DM-1-4	AoR – Up dip of injection operations	Adaptive

Monitoring of the CO_2 plume will be accomplished by collecting saturation logs in the In Zone Monitoring Wells Nimbus DM-1-4 periodically and through seismic data acquisition within the AoR during the 50-year PISC timeframe.

Table 4 presents the direct and indirect monitoring methods that NSR-Nimbus ARCCS will employ to monitor the pressure front, including the activities, locations, and frequencies for the site. Monitoring of pressure and temperature for both injection zones will include a system design (to be determined) within the In Zone Monitoring Wells DM-1-4 that will be robust and last throughout the injection and post-injection lifetime. NSR-Nimbus ARCCS will also consider the potential future technology at the time of closure that may be available, and the PISC plan and Monitoring Wells designs would be updated accordingly. Pressure monitoring results will be compared to modeling and simulation forecast predictions of expected pressure behavior for each zone. If there are significant deviations, the modeling will be updated to match the observed pressure data post-injection.

Table 4: Post-injection phase direct pressure-front monitoring

Target Formation	Monitoring Activity	Monitoring Location(s)	Spatial Coverage	Frequency
DIRECT PRESSURE FRONT MONITORING				
All Injection Zones: • Hosston • Cotton Valley • Upper Smackover	IZ Pressure and Temperature Monitoring	Up dip In Zone Monitor Wells	AoR – Up dip of injection operations	Continuous
INDIRECT PRESSURE FRONT MONITORING				
Sequestration Complex	Time-lapse Seismic changes due to pressure changes	Autonomous source and array seismic; there will be no well access required.	lateral extent of the CO_2 plume	Annually - adaptive, if triggered

Plume and pressure front monitoring information regarding equipment used (*i.e.*, logging procedures) is detailed in the TMP and in the QASP. If a deviation from the predicted plume and or pressure front behavior occurs, protocols detailed in **Module E**: "*E.4 - Emergency and Remedial Response Plan*" will be implemented.

4.3 SCHEDULE FOR SUBMITTING POST-INJECTION MONITORING RESULTS

All post-injection site monitoring data, and monitoring results, using the methods described above will be submitted to EPA in annual reports, within 60 days following the anniversary date on which injection operations ceased. The reports will contain information and data generated during the reporting period, *i.e.*, well-based monitoring data, sample analysis, and the results from updated site models.

If a change to the post-injection site care plan is deemed necessary, at any time during the life of the project, a request will be submitted to the UIC Program director at least 30 days prior to making the change.

5.0 ALTERNATIVE PISC TIMEFRAME

NSR-Nimbus ARCCS is not currently requesting an Alternative PISC timeframe as part of this initial submittal. Depending on project performance, consideration will be given to an alternative PISC timeframe at a future date.

6.0 USDW NON-ENDANGERMENT DEMONSTRATION CRITERIA

Prior to approval of the end of the post-injection phase, NSR-Nimbus ARCCS will submit a demonstration of non-endangerment of USDWs to the UIC Program Director, per 40 CFR 146.93(b)(2) or (3).

NSR-Nimbus ARCCS 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.

6.1 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.

6.2 SUMMARY OF EXISTING MONITORING DATA

A summary of all previous monitoring data collected at the site, pursuant to **Module E**: "*E.1-Testing and Monitoring Plan*" and this PISC and Site Closure Plan, including data collected during the injection and post-injection phases of the project, will be submitted to 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 pre-injection data collected during site characterization (consideration will also be given to potential factors that might lead to changes compared to pre-injection data and which are not related to the proposed CO_2 injection project).

6.3 SUMMARY OF COMPUTATIONAL MODELING HISTORY

The modeling is intended to present a conservative estimate of pressure build-up and plume extent over the injection and post injection life of the project. The data used in the model is derived from regional data, and from wells in near proximity to the project site. Until information is obtained from the site-specific wells, input data is used to create a conservative estimate (larger) of pressure build-up and plume extent. The current model represents a preliminary scenario for computational modeling at the NSR-Nimbus ARCCS site and will be updated to a final simulation scenario following acquisition of additional data from the Injection Wells.

6.4 EVALUATION OF RESERVOIR PRESSURE

The current model assumes an initial reservoir pressure for each injection zone as described in Module B. Initial static pressures will be obtained in the Injection Wells and Monitoring Wells for the NSR-Nimbus ARCCS site. The initial static pressures will be collected in all targeted Injection Zones; the Hosston, Cotton Valley A, Cotton Valley B, and Smackover. The pre-injection pressures will be used as a basis for comparison during injection and post-closure operations.

Annual reservoir pressures will be collected during Mechanical Integrity Testing (MIT) for the Injection Wells and evaluated against the initial static pressures in the Injection Zones and compared to the computational modeling results. The collected reservoir pressure data will be used to update and re-evaluate the model at the required five-year intervals to provide an operational model and a new projected modeled pressure for a future time-series and post-closure period.

6.5 EVALUATION OF CO_2 PLUME

The location and migration rate of the CO_2 plume will be monitored indirectly using seismic geophysical methods (autonomous source and receiver array). Following the injection phase plume monitoring philosophy, the timing of each survey will be adaptive, and will be determined in response to the previous surveys, the updated AoR model and updated risk assessment (e.g., subsequent repeats planned to ensure timely identification of the plume reaching any identified risks). Additional repeats may be triggered in response to anomalous monitoring data (e.g., anomalous pressures or surveys) samples from ACZ Nimbus SM-1 or IZ Monitor Wells Nimbus DM-1-4.

As a minimum, sufficient geophysical repeats will be performed to demonstrate the migration rate of the plume at the end of the PISC period (or lack of continuing migration) and confirm a lack of seismic indicators for leaked CO_2 within the overburden. All monitoring data will be used to calibrate the dynamic model and reduce predictive uncertainty. After calibration (history matching) the model will be used to update its predictions of the development of the AoR, declining pressure and CO_2 plumes. Since the current model is conservative and uses a "worst-case" scenario approach, the actual predicted pressure data is expected to be less than the modeled pressure. The collected reservoir pressure data will be used to update and re-evaluate the model at the required five-year intervals to provide an operational model and a new projected modeled pressure for a future time-series and post-closure period.

The final models will be used to support non-endangerment of the USDW, demonstrating that pressure has declined below that which is required to push brine up an open conduit into the USDW and that the plume has either stopped or slowed to a rate at which it will not reach any potential leak pathway to a USDW within a reasonable timeframe.

6.6 EVALUATION OF EMERGENCIES OR OTHER EVENTS

NSR-Nimbus ARCCS has developed a plan to evaluate emergencies related to the site as detailed in **Module E**: "*E.4 – Emergency and Remedial Response Plan*." This plan accounts for potential emergencies and events at three phases of the project: 1) during the construction of the Injection Well, 2) during the operation of the Injection Well, and 3) during the site closure and post closure monitoring of the site.

This includes, but is not limited to, adaptive (triggered) sampling analysis of the USDW and other groundwater systems within the AoR.

6.7 NEAREST POTENTIAL CONDUITS

The structure, isopach maps and the seismic data used to construct the Nimbus ARCCS project AoR [40 CFR 146.82(a)(3)(ii)] indicate that there are faults to the South and North of the injection site. These faults are part of the *South Arkansas Fault Zone*, a system of horsts and grabens. These systems are documented in stratigraphy from the Jurassic through the Tertiary. The largest faults are [redacted] of the Nimbus ARCCS project site. A smaller fault is located [redacted] of the Nimbus ARCCS project Site. These faults are considered sealing and are not expected to permit the vertical migration of CO_2 or formation fluids into USDWs.

The confining unit is thicker than the observed offset of the faults, so the shale/clay rich confining unit is juxtaposed against itself, and containment is preserved. Based on the lithology of units, sufficient clay smear should exist along the fault zone to seal the fault. Additionally, the same faults have acted as traps for nearby oil fields. All artificial penetrations (active/abandoned) contained within the modeled pressure and plume containment, were evaluated as to the adequacy of construction, and plugging to determine the potential of the penetration to convey fluid from an injection zone into the overlying USDWs (non-endangerment) and the potential of the penetration to convey injected effluent out of the injection zone (no migration) [40 CFR 146.84 (c)(3)].

The artificial penetrations in the delineated AoR have been evaluated per the protocol outlined in the "*Area of Review and Corrective Action Plan*" submitted in **Module B**. A total of 328 wells are contained within the AoR, however, only 43 wells extend deep enough to penetrate the Hosston Injection Zone. A thorough evaluation of each of these wells, using well records, scout tickets, and logs was performed. Twenty-three (23) wells are improperly constructed or improperly plugged that fail the conservative modeling screening evaluation. Therefore, the corrective action program is to remediate these wells depending on year of failure due to plume front or pressure front (see Table 38 in Module B) as all other artificial penetrations are either properly constructed, plugged and abandoned (e.g., for CO_2 and brine vertical movement), or have sufficient resistant borehole material as to prevent the movement of brine into or between USDWs. Six wells will be re-plugged prior to the initiation of CO_2 injection. These wells include:

[redacted]

A reevaluation schedule for AoR delineation is set at 5-year intervals during injection operations. This plan will be updated as the project is developed to be consistent with the data derived from the injection wells, as well as collected through the operation and testing of the wells over the life of the project.

The AoR model during injection operations will be regularly updated and calibrated to the monitoring data (minimum every five years). The artificial penetration risk assessment and required corrective measures will likewise be updated in line with each update to the pressure and plume prediction, and adjustments made to the TMP, PISC, and injection schedule to ensure project goals (e.g., non-endangerment of USDW) are continued to be met.

7.0 SITE CLOSURE PLAN

NSR-Nimbus ARCCS will conduct site closure activities to meet the requirements of 40 CFR 146.93 as described below. NSR-Nimbus ARCCS will submit a final Site Closure Plan and notify the permitting agency at least 120 days prior to the intent for site closure. Once the permitting agency has approved closure of the site, NSR-Nimbus ARCCS will plug the Monitoring Wells and submit a site closure report to 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.

7.1 PLUGGING MONITORING WELLS

Prior to the plugging and abandonment of Monitoring Wells [In-Zone and Above Confining Zone (ACZ)], the bottomhole pressure will be determined. This will be accomplished via the external pressure device(s) in the In-Zone Deep Monitoring Wells and by the in-hole pressure device(s) in the Above Confining Shallow Monitoring Well. Should the in-hole pressure device(s) be damaged, then a slickline pressure gauge will be run in the hole to measure the bottomhole pressure.

To confirm external mechanical integrity prior to commencing plugging operations in any monitoring well, NSR will conduct a temperature log to register any fluid movement external to the long string casing. If distributed temperature sensing fiber is run in the monitor wells, the fiber will be used for the temperature testing, otherwise, a wireline truck will be used. Additional logs will be run as required by the Director at the time of plugging. Usage of available technologies to examine well integrity at the time of the plugging will also be considered.

A successful temperature log will "PASS" if there are no observed, unexplained anomalies outside of the permitted injection zone(s). If temperature anomalies are observed outside the permitted zone(s), additional logging may be conducted to determine whether loss of mechanical integrity or containment has occurred. Depending on the nature of the suspected movement, radioactive tracer, noise, oxygen activation, or other approved logs approved by the UIC Program Director may be required to further define the nature of the fluid movement or to diagnose a potential leak.

The Plug & Abandonment (P&A) plans of the In-Zone Deep Monitoring Wells are based on the following general placement of plugs:

1. CO_2 resistant cement plug is set from 100 feet below the Upper Confining Zone to 100 feet above the Upper Confining Zone.
2. Class "H" cement plug set from 100 feet below the surface casing shoe to surface.

Because of its intrinsic low permeability, carbon dioxide-resistant cement will be used due to the injection of supercritical carbon dioxide and water saturated with carbon dioxide conditions. Accelerated reaction kinetics can lead to a stabilized matrix within days of exposure to the carbon dioxide environment, leading to stabilized mechanical properties. This makes the carbon dioxide-resistant cement applicable for plugging across Injection Zone(s) and at the top of the sequestration complex.

The Plug & Abandonment (P&A) plans of the ACZ Shallow Monitoring Well is based on the following general placement of plugs:

1. Class "H" cement plug set from the bottom of the perforations to 200 feet above the top perforation.
2. Class "H" cement plug set from 100 feet below the surface casing shoe to surface.

A pressure test of the first plug in the ACZ Shallow Monitoring Well will be conducted to confirm integrity and isolation of the test interval. The cement plugs will be tagged and loaded to confirm location and integrity. A fluid (brine/mud/salt gel) of at least 9.5 lb/gal will be placed throughout the wellbore between the cement plugs. The wellhead and casings will be cut and removed at least 3 feet below ground level and capped with a steel plate.

Prior to plugging the Monitoring Wells, NSR-Nimbus ARCCS will consider the operational and monitoring history of the sequestration project and identify whether any information or events warrant amendment of the original well plugging plan. The final volume and depth of the plug(s) will depend on the final geology and "as built" well completion, in addition to the final conditions of the well as assessed during the mechanical integrity testing prior to closure.

These wells will be plugged at the end of the PISC timeframe (year-end 2098 if start of injection in 2028) using general plugging procedures as outline below for the monitoring wells Nimbus SM-1 and Nimbus DM-1, DM-2, DM-3, and DM-4. These plans are expected to meet the objective of well plugging, which is minimizing the chance of leaks to the environment and unintended flow of fluid underground. Verification of meeting the objective will be conducted at the end of each plugging operation, by assessing the sealing effectiveness and position of the permanent isolation. Direct verification methods such as tagging the top of the plug, weight testing, dressing-off, inflow testing, pressure testing, or indirect verification methods such as volume/losses records, cementing pressure records, laboratory slurry testing (e.g., compressive strength development), surface cement sampling, logging, and long-term monitoring may be performed.

7.1.1 Plugging Procedures – ACZ Shallow Monitoring Well (Nimbus SM-1)

In compliance with 40 CFR 146.92(c), notify the EPA UIC Program Director at least 60 days before plugging the well and provide updated plugging plan. All depths in the outlined procedure are referenced to the kelly bushing (KB), which is estimated at 20.0 ft above ground level. A schematic of the proposed P&A for the ACZ Shallow Monitoring Well (Nimbus SM-1) is included as Figure 10.

1. Bottom hole reservoir pressure will be obtained prior to well plugging.
2. Well will be flushed or circulated with brine to displace the well fluids. Normally the well is flushed/circulated by pumping 2 times well volume brine at pressure lower than 80% of frac pressure.
3. Allow a minimum of 26 hours for temperature stabilization. Conduct a Temperature log and compare with the baseline temperature log in addition to temperature logs during injection and post-injection to assess external mechanical integrity. In addition, either a noise log or oxygen activation log could also be run and evaluated for external mechanical integrity.

   Note: If the external well integrity was found to be poorer than expected, then a proper *risk assessment will be conducted to determine the proper number, size, and placement methods for plugs sufficient to meet well plugging objectives.*

4. Pull out/remove tubing from the well.
5. Pull out/remove packer from the well. If the packer cannot be removed, a revised plugging plan to leave the packer in place will be submitted and approved prior to moving forward.
6. Run workstring to PBTD and confirm test interval is free of solids. Circulate out fill if necessary.
7. Spot the end of the workstring at the bottom perforation. Rig up cementing equipment. Pump a fluid spacer followed by Class "H" cement mixed at a minimum density of 16.4 pounds per gallon (ppg). Circulate cement and displace to spot a balanced cement plug in the 9-5/8-inch casing from the bottom perforation to at least 200 ft above the top perforation (105 ft^3, 100 sx).
8. Pull the end of the workstring ±250 above the calculated top of cement and reverse-circulate wellbore until fluid returns are clean.
9. After waiting enough time for the cement to harden, lower the workstring to the top of cement and load test to confirm competency. Record the top of cement depth. Pressure test the cement plug to confirm integrity.
10. Displace the wellbore with 9.5 lb/gal brine/mud/salt gel.
11. Pick up the workstring to ±1,100 ft (100 ft below the surface casing shoe). Pump a fluid spacer followed by Class "H" cement mixed at a minimum density of 16.4 ppg. Circulate cement and displace to spot a balanced cement plug in the 9-5/8-inch casing from ±1,100 to surface (460 ft^3, 434 sx). Confirm cement returns to surface.
12. Lay down the workstring. Top off the 9-5/8-inch casing with Class "H" cement to bring the top of cement to surface.
13. Remove wellhead, cut casings three feet below the ground surface, and weld a steel plate on top of the 13-3/8-inch surface casing.
14. Erect a permanent marker on the well with the permit number, date of plugging, and company name identified on the marker.

15. In accordance with the requirements of 40 CFR 146.92(d), within 60 days of plugging and closure, a plugging report will be submitted to the UIC director. This report will be certified as accurate by the owner or operator, and by the person who has performed the plugging operations. The owner / operator will retain the well plugging report for 10 years following the site closure.

7.1.2 Plugging Procedures – Southern In-Zone Deep Monitoring Wells (Nimbus DM-1, DM-2, DM-3)

In compliance with 40 CFR 146.92(c), notify the EPA UIC Program Director at least 60 days before plugging the well and provide updated plugging plan. All depths in the outlined procedure are referenced to the kelly bushing (KB), which is estimated at 20.0 ft above ground level. A schematic of the proposed P&A for the Southern In-Zone Deep Monitoring Wells (Nimbus DM-1, DM-2, DM-3) is included as Figure 11.

1. Bottom hole reservoir pressure will be obtained via the external casing pressure device(s).
2. Conduct a Temperature log and compare with the baseline temperature log in addition to temperature logs during injection and post-injection to assess external mechanical integrity. In addition, either a noise log or oxygen activation log could also be run and evaluated for external mechanical integrity.

   Note: If the external well integrity was found to be poorer than expected, then a proper risk assessment will be conducted to determine the proper number, size, and placement methods for plugs sufficient to meet well plugging objectives.
3. Run workstring to PBTD. Displace the wellbore with 9.5 lb/gal brine/mud/salt gel.
4. Pick up the workstring to ±3,290 ft (100 ft below the base of the Upper Confining Zone). Pump a fluid spacer followed by CO_2 resistant cement mixed at a minimum density of 14.5 ppg. Circulate cement and displace to spot a balanced plug in the 5-1/2-inch casing from ±3,290-2,950 ft (100 ft above the top of the Upper Confining Zone)(44.5 ft^3, 39 sx).
5. Pull the end of the work string ±250 feet above the calculated top of cement and reverse-circulate wellbore until fluid returns are clean.
6. After waiting enough time for the cement to harden, lower the workstring to the top of

cement and load test to confirm competency. Record the top of cement depth.

7. Pick up the workstring to ±1,100 ft (100 ft below the surface casing shoe). Pump a fluid spacer followed by Class "H" cement mixed at a minimum density of 16.4 ppg. Circulate cement and displace to spot a balanced cement plug in the 5-1/2-inch casing from ±1,100 to surface (144 ft^3, 136 sx). Confirm cement returns to surface.

8. Lay down the workstring. Top off the 5-1/2-inch casing with Class "H" cement to bring the top of cement to surface.

9. Remove wellhead, cut casings three feet below the ground surface, and weld a steel plate on top of the 9-5/8-inch surface casing.

10. Erect a permanent marker on the well with the permit number, date of plugging, and company name identified on the marker.

11. In accordance with the requirements of 40 CFR 146.92(d), within 60 days of plugging and closure, a plugging report will be submitted to the UIC director. This report will be certified as accurate by the owner or operator, and by the person who has performed the plugging operations. The owner / operator will retain the well plugging report for 10 years following the site closure.

7.1.3 Plugging Procedures – Northern In-Zone Deep Monitoring Well (Nimbus DM-4)

In compliance with 40 CFR 146.92(c), notify the EPA UIC Program Director at least 60 days before plugging the well and provide updated plugging plan. All depths in the outlined procedure are referenced to the kelly bushing (KB), which is estimated at 20.0 ft above ground level. A schematic of the proposed P&A for the Northern In-Zone Deep Monitoring Well (Nimbus DM-4) is included as Figure 12.

12. Bottom hole reservoir pressure will be obtained via the external casing pressure device(s).

13. Conduct a Temperature log and compare with the baseline temperature log in addition to temperature logs during injection and post-injection to assess external mechanical integrity. In addition, either a noise log or oxygen activation log could also be run and evaluated for external mechanical integrity.

    Note: If the external well integrity was found to be poorer than expected, then a proper *risk assessment will be conducted to determine the proper number, size, and placement methods for plugs sufficient to meet well plugging objectives.*

14. Run workstring to PBTD. Displace the wellbore with 9.5 lb/gal brine/mud/salt gel.

15. Pick up the workstring to ±3,385 ft (100 ft below the base of the Upper Confining Zone). Pump a fluid spacer followed by CO_2 resistant cement mixed at a minimum density of 14.5 ppg. Circulate cement and displace to spot a balanced plug in the 5-1/2-inch casing from ±3,385-2,980 ft (100 ft above the top of the Upper Confining Zone)(53 ft^3, 46 sx).

16. Pull the end of the work string ±250 feet above the calculated top of cement and reverse-circulate wellbore until fluid returns are clean.

17. After waiting enough time for the cement to harden, lower the workstring to the top of cement and load test to confirm competency. Record the top of cement depth.

18. Pick up the workstring to ±1,135 ft (100 ft below the surface casing shoe). Pump a fluid spacer followed by Class "H" cement mixed at a minimum density of 16.4 ppg. Circulate cement and displace to spot a balanced cement plug in the 5-1/2-inch casing from ±1,135 to surface (148.5 ft^3, 140 sx). Confirm cement returns to surface.

19. Lay down the workstring. Top off the 5-1/2-inch casing with Class "H" cement to bring the top of cement to surface.

20. Remove wellhead, cut casings three feet below the ground surface, and weld a steel plate on top of the 9-5/8-inch surface casing.

21. Erect a permanent marker on the well with the permit number, date of plugging, and company name identified on the marker.

22. In accordance with the requirements of 40 CFR 146.92(d), within 60 days of plugging and closure, a plugging report will be submitted to the UIC director. This report will be certified as accurate by the owner or operator, and by the person who has performed the plugging operations. The owner / operator will retain the well plugging report for 10 years following the site closure.

7.2 SITE RESTORATION

After the plugging of the Monitoring Wells, the wellhead and surface equipment shall be decommissioned and removed from the site. The well pad will be cleaned, and the access road will be left in place.

7.3 SITE CLOSURE REPORT

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

- Plugging of the Monitoring Wells (and the Injection Wells if not previously plugged),
- Location of sealed Injection Wells on a survey plat 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, and
- Post-injection monitoring records.

NSR-Nimbus ARCCS will record a notation to the property's deed on which the Injection Wells are located that will indicate the following**:**

- That the property was used for carbon dioxide sequestration,
- The name of the local agency to which a survey plat with the Injection Well locations was submitted,
- The volume of fluid injected,
- The formation(s) into which the fluid was injected, and
- 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 10 years following site closure. Additionally, the owner or operator will maintain the records collected during the post-injection period for a period of 10 years after which these records will be delivered to the UIC Program Director.