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Underground Injection Control
Carbon Sequestration
Class VI Permit Application

TESTING AND MONITORING PLAN
40 CFR 146.90
Section 8.0

NexGen Carbon Oklahoma, LLC
Vanguard CCS Hub

June 2025

8.0 TESTING AND MONITORING PLAN

VANGUARD CCS HUB

Facility Information

Facility name: Vanguard CCS Hub
Vanguard I-1
Vanguard I-2
Vanguard I-3
Vanguard I-4
Vanguard I-5
Vanguard I-6
Vanguard I-8
Vanguard I-9
Vanguard I-10
Vanguard I-12

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Well locations: Osage County, Oklahoma

Vanguard I-1: Lat 36.633288°N, Lon -96.571029°W (NAD 83)
Vanguard I-2: Lat 36.660083°N, Lon -96.534652°W (NAD 83)
Vanguard I-3: Lat 36.664329°N, Lon -96.586951°W (NAD 83)
Vanguard I-4: Lat 36.710244°N, Lon -96.542370°W (NAD 83)
Vanguard I-5: Lat 36.744047°N, Lon -96.533843°W (NAD 83)
Vanguard I-6: Lat 36.724157°N, Lon -96.489526°W (NAD 83)
Vanguard I-8: Lat 36.823356°N, Lon -96.620496°W (NAD 83)
Vanguard I-9: Lat 36.849167°N, Lon -96.592912°W (NAD 83)
Vanguard I-10: Lat 36.893849°N, Lon -96.578026°W (NAD 83)
Vanguard I-12: Lat 36.785641°N, Lon -96.594085°W (NAD 83)

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ACRONYMS AND ABBREVIATIONS

A	
AoR	Area of Review
ASTM	American Society for Testing Materials
B	
BHL	bottomhole location
C	
CBL	cement bond log
CFR	Code of Federal Regulations
CO_2	carbon dioxide
D	
DTS	distributed temperature sensing
DAS	distributed acoustic sensing
E	
EOS	equation-of-state
EPA	U.S. Environmental Protection Agency
M	
MASP	maximum allowable surface injection pressure
MIT	mechanical integrity test
MFL	magnetic flux log
P	
PNL	pulsed neutron log
psi	pounds per square inch
psig	pounds per square inch, gauge
Q	
QASP	Quality Assurance and Surveillance Plan
R	
RCA	routine core analyses
S	
SCAL	special core analyses
SCADA	supervisory control and data acquisition
SP	spontaneous potential log
T	
TCS	triaxial compressive strength
TD	total depth
TEC	tubing encapsulated conductor
TVD	true vertical depth
TVDSS	true vertical depth subsea
U	
UIC	underground injection control
USDW	underground source of drinking water
USIT	ultrasonic imager tool
V	
VDL	variable density log

8.0 TESTING AND MONITORING PLAN [40 CFR 146.90]

NexGen Carbon Oklahoma, LLC has developed this Testing and Monitoring Plan for the Vanguard CCS Hub to satisfy all applicable local, state, and federal requirements (including 40 CFR 146.82(a)(15) and 146.90). Its objectives are to verify proper well performance, track the movement of the injected CO_2 plume and pressure front, and confirm that no underground sources of drinking water are compromised. Collected monitoring results will also feed back into the site's geological and reservoir simulation models—ensuring their accuracy and informing both periodic AoR updates and the formal non-endangerment demonstration.

This plan incorporates *Section 11—Emergency and Remediation Response Plan* (ERRP), and the results of the testing and monitoring activities described below may trigger actions as outlined in the NexGen ERRP.

8.1 Overall Strategy and Approach for Testing and Monitoring

NexGen proposes drilling and completing ten (10) carbon sequestration injection wells (Vanguard I-1, Vanguard I-2, Vanguard I-3, Vanguard I-4, Vanguard I-5, Vanguard I-6, Vanguard I-8, Vanguard I-9, Vanguard I-10 and Vanguard I-12) and ten (10) above-zone monitoring wells (Vanguard AZM-1, Vanguard AZM-2, Vanguard AZM-3, Vanguard AZM-4, Vanguard AZM-5, Vanguard AZM-6, Vanguard AZM-8, Vanguard AZM-9, Vanguard AZM-10 and Vanguard AZM-12) and seven (7) in-zone monitoring wells (Vanguard IZM-1 – Vanguard IZM-7), located 250 ft from the injection well, for the safe sequestration of carbon dioxide (CO_2) in Osage County, Oklahoma. NexGen' plans to drill a stratigraphic test well that will be repurposed as the Vanguard I-5 injection well. This section's testing and monitoring strategy is structured to fulfill the mandates of 40 CFR 146.82(a)(15) and 146.90. Its purpose is to supply empirical evidence that the Project behaves in line with model forecasts and that underground sources of drinking water remain protected. Should monitoring data diverge from those predictions, those observations will drive updates to this plan and corresponding adjustments to future projections.

NexGen will continuously analyze the injected fluid stream to ensure it matches our design specifications—verifying that water content, sulfur species, and any other impurities stay below established thresholds. Throughout both the active injection phase and the subsequent post-injection site care period, we will record operational parameters (pressure, temperature, flow rate, and total injected volume) in real time, in full compliance with 40 CFR 146.90(b). Corrosion levels will be monitored for all types and grades of metal that contact the injectate (CFR§146.90[c]). The groundwater quality of the first permeable zone above the confining zone will be monitored and compared with baseline data (CFR §146.90[d], §146.90[b]). Mechanical integrity testing of the injection wells' components will be conducted regularly and compared with baseline surveys to identify any areas of concern before they result in potential integrity failures (CFR §146.87[a][4], §146.89, §146.90[e], §146.92[a]). Pressure fall-off testing will be performed to measure any potential reduction in injectivity (CFR §146.90[f]). Direct monitoring of injection zone pressure will be conducted via DTS and DAS fiber optics in the injection zone of the injection wells. The lateral extent of the CO_2 plume will be indirectly monitored with periodic two-dimensional (2D) seismic surveys. Near-surface groundwater and seismic monitoring will be conducted with ten (10) shallow dual-purpose wells as described in *Section 8.5.1*.

All monitoring results will be evaluated against baseline measurements and prior observations to track plume evolution. These findings will then be contrasted with the original static and dynamic

model forecasts to decide if the geological or reservoir models require adjustment (per 40 CFR 146.90(g) and 146.93(b)) or if any leak-response actions must be implemented. **Table 8.1** summarizes the monitoring program, target, and frequency of data collection.

Table 8.1—Summary of the monitoring program, target, and frequency of data collection.

Requirement	Monitoring Description	Monitoring Program	Monitoring Targets	Frequency and Duration
146.90 (a)	CO_2 Injection Stream Composition	CO_2 sampling	Upstream or downstream of flowmeter	Continuous
146.90 (b)	Continuous Recording of Injection Pressure, Rate, and Volume	Surface pressure and temperature gauges Coriolis mass flowmeter at the wellhead	Surface-to-reservoir (injection wells)	Continuous
146.90 (b)	Well Annulus Pressure Between Tubing and Casing	Annular pressure gauge for continuous monitoring	Surface-to-reservoir (injection wells)	Continuous
146.90 (c)	Corrosion Monitoring	Corrosion coupon system	Capture facility to the well site	Quarterly
146.90 (d)	Near-Surface Monitoring	Groundwater well(s) in the AoR	Near-surface environment, USDWs	Annual
146.90 (d)	Above Confining Zone Monitoring	Fiber optic (DTS/DAS), temperature, and pulsed neutron logs	First permeable zone above confining zone (ten (10) Vanguard AZM wells)	Annual PNL & Temp Log; Continuous Fiber
146.90 (e)	Internal and External Mechanical Integrity	USIT, Caliper Log or equivalent	Well infrastructure	Every 5 years
146.90 (e)	Internal and External Mechanical Integrity	Annulus pressure test	Well infrastructure	During well installation
146.90 (e)	Internal and External Mechanical Integrity	Temperature log	Well infrastructure	Annual
146.90 (f)	Pressure Fall-Off Test	Pressure Fall-Off Test	Reservoir (injection wells)	Every 5 years
146.90 (g)(1)	Direct Reservoir Monitoring	Pulsed neutron logging;	Reservoir (injection wells)	Annual PNL;
146.90 (g)(2)	Indirect Reservoir Monitoring	2D time-lapse seismic surveys	AoR	Once baseline, once during injection, once during PISC

8.1.1 Quality Assurance Procedures

After the facility layout and equipment specifications receive final approval, NexGen will submit a revised Quality Assurance and Surveillance Plan (see Section 8.11) covering all testing and monitoring procedures, in accordance with 40 CFR 146.90(k).

8.1.2 Reporting Procedures

NexGen will submit the results of all testing and monitoring activities to the U.S. Environmental Protection Agency (EPA) to comply with the requirements under 40 CFR §146.91.

8.2 Carbon Dioxide Stream Analysis [40 CFR 146.90(a)]

NexGen will on an ongoing basis sample the CO_2 injection stream and analyze it in accordance with 40 CFR 146.90(a), producing a continuous record of the injectate's physical and chemical properties. The purpose of analyzing the CO_2 stream is to evaluate potential interactions of CO_2 and other components of the injectate. The CO_2 stream must meet NexGen' pipeline specifications and is expected to be approximately 95% CO_2. NexGen will conduct monthly comparisons of this data against baseline, predicted, and average values to detect any significant deviations. The CO_2 will be analyzed for constituents identified in **Table 8.2** using the methods listed. Sampling frequency will be continuous, with records stored and federated every year.

8.2.1 Sampling Location and Frequency

Samples of the CO_2 stream will be drawn continuously from the main pipeline—via an in-line gas chromatograph installed upstream of the injection flowmeter—and tested under the approved QASP protocols. Annual archives of the chromatograph data will be maintained. Each month, NexGen will compare these new measurements against baseline, modeled, and historical averages to flag any meaningful divergence from expected injectate quality.

8.2.2 Analytical Parameters

NexGen will analyze the CO_2 stream for the constituents identified in **Table 8.2.** If additional labratory testing is required, NexGen will select a certified lab and follow all required chain of custody and analysis procedures as outlined in the QASP.

Table 8.2—Summary of analytical parameters for the carbon dioxide stream.

Parameter	Analytical Method(s)
Carbon Dioxide	Gas chromatograph
Nitrogen	Gas chromatograph
Oxygen	Gas chromatograph

8.2.3 Sampling Methods

NexGen will perform on-site analyses using regularly calibrated gas chromatographs. If confirmatory testing is needed, samples will be sent under chain-of-custody to a certified laboratory, and all procedures will adhere to the QASP protocols.

8.2.4 Laboratory to be Used/Chain of Custody and Analysis Procedures

NexGen will analyze samples on-site with calibrated gas chromatographs. If additional lab testing is required, NexGen will select certified laboratories and follow all required chain-of-custody and analysis procedures as outlined in the QASP.

8.3 Continuous Recording of Operational Parameters [40 CFR 146.88(e)(1), 146.89(b) and 146.90(b)]

NexGen will install and operate continuous recording devices to monitor injection pressure, rate, and volume; the pressure on the annulus between the tubing and the long casing string; the annulus

fluid volume added; and CO_2 stream temperature, as required at 40 CFR 146.88(e)(1), 146.89(b), and 146.90(b). The owner or operator will report the monthly average, maximum, and minimum values of injection pressure, flow rate, and volume to the UIC Program Director in semi-annual reports as required by CFR 146.91(a)(2).

8.3.1 Monitoring Location and Frequency

NexGen will perform activities identified in **Table 8.3** to monitor operational parameters and verify the injection wells' internal mechanical integrity. Monitoring will be performed at the exact points and intervals specified in that table.

Table 8.3—Sampling devices, locations, and frequencies for continuous monitoring.

Parameter	Device(s)	Location	Min. Sampling Frequency	Min. Recording Frequency
Injection Pressure	Pressure transmitter	Wellhead and Flowline	Daily	TBD
Injection Rate	Coriolis Flowmeter	Flowline	Continuous	TBD
Injection Volume	SCADA	Flowline	Continuous	TBD
Annulus Fluid Volume	Pressure gauge/ Visual Inspection	Wellhead	Continuous	TBD
Annular Pressure	Pressure gauge	Wellhead	Continuous	TBD
CO_2 Stream Temperature	Temperature transmitter	Flowline	Continuous	TBD

Sampling frequency specifies the interval at which a sensor is interrogated for a given parameter—for instance, polling an injection-pressure transducer every two seconds to read its current value. Recording frequency defines how often those sampled readings are logged to the data system—for example, writing the pressure reading to a database once per minute.

8.3.2 Monitoring Details

Injection stream parameters will be monitored initially at the flowline between the supply pipeline and the wellhead for quality, pressure, and temperature. The supervisory control and data acquisition (SCADA) system at injection sites will track injection volume. A pressure gauge will monitor the annular pressure of the injection wells at their respective wellhead, and reservoir pressure monitoring will take place with DAS fiber optic cables in the injection zone. Details on instrumentation, calibration standards, and conversion formulas will be provided as instrumentation details are finalized.

8.4 Corrosion Monitoring

During operations, NexGen will routinely inspect well components for any material degradation—such as loss of mass or wall thickness, cracking, pitting, or other corrosion phenomena—in order to verify that all casing, tubing, packers, and related materials continue to meet strength and performance criteria as required by 40 CFR 146.90(c).

The composition of the injectate stream is shown in **Table 8.4**. The final injectate stream will have impurities within the limits shown. The injection formation fluids will be considered to determine the appropriate metallurgy required for the tubing and long casing string. NexGen will also employ CO_2-resistant cement compositions and packer fluids to reduce corrosion risk in the injection well.

Table 8.4—Composition of the injectate stream.

Constituent	Limit
CO_2	≥ 95 mol%
CO	< 0.4 mol%
H_2	< 0.5 mol%
H_2S	< 20 ppm
Total Sulfur	< 35 ppm
Total NO_2	< 10 ppm
O_2	≤ 1 mol%
H_2O	< 150 ppm
Hydrocarbons	< 4 mol%
Glycol	0.3 gallons/MMcf
Maximum dew point at 400 psig	30°F
Non condensable gases	< 3 mol%

NexGen will monitor corrosion coupons and collect samples according to the methods described in the following subsections. This monitoring will occur quarterly, as described in *Section 8.4.1*.

In addition to routine coupon inspection, casing inspection logs, annulus pressure tests, and temperature logs will be run, as outlined in *Section 8.6*.

8.4.1 Monitoring Location and Frequency

Corrosion test coupons fabricated from the same steel grades as the production casing and injection tubing will be installed in the CO_2 feedline immediately upstream of any surface processing equipment. These coupons will be retrieved on a quarterly schedule at the following intervals after injection begins:

- 3 months
- 6 months
- 9 months
- 12 months

8.4.2 Sample Description

The list of the materials to be monitored for corrosion is included in **Table 8.5**. Initial weights and photographic records will be documented for each corrosion coupon. These baseline data will be compared against the coupon's condition and mass during each quarterly inspection.

Table 8.5—List of equipment and construction materials.

Equipment Coupon	Material of Construction
Pipeline	Carbon steel
Production Casing	L-80 mild steel
Stainless Production Casing	Stainless Steel (25CR)
Tubing	Stainless Steel (25CRW)

8.4.3 Monitoring Details

Each quarter, coupons will be pulled from the upstream CO_2 feed line and given a visual inspection for corrosion indicators—pitting, surface etching, etc. Their dimensions and mass will be measured before being shipped to an independent, ASTM-accredited laboratory for standardized corrosion testing. The corrosion rate will be determined by dividing the mass loss over the exposure interval by the length of that interval (typically expressed in mils per year). Initial weights and photographs will serve as baselines for each subsequent inspection. If any accelerated corrosion rates emerge, we will increase the sampling frequency in proportion to the projected injection volume until rates return to acceptable levels.

To meet the 40 CFR §146.90 (c)(1) and (2) requirements, NexGen will also conduct corrosion monitoring of the wells' materials using a corrosion coupon monitoring system. **Table 8.5** lists the materials that will be monitored for corrosion. By evaluating changes in coupon mass and thickness, as well as identifying any cracking, pitting, or other corrosion features, this protocol confirms that all pipeline materials continue to satisfy the strength and performance requirements of 40 CFR §146.86(b).

8.5 Above Confining Zone Monitoring

Ten dedicated above-zone monitoring wells will be installed roughly 250 ft east of each injector to track conditions in the first permeable horizon above the primary seal—the upper Mississippian Limestone—and any intervening permeable intervals up toward the surface. Each well will be equipped with pressure and temperature gauges. By watching for deviations from baseline in those readings—and for any indirect signs of CO_2 saturation—these AZM wells provide an early warning should the CO_2 plume or pressure front migrate beyond the intended storage interval, allowing prompt intervention before any USDW is impacted.

The monitoring wells layout and configuration is provided in **Figure 8.1** showing the Vanguard I-1, Vanguard I-2, Vanguard I-3, Vanguard I-4, Vanguard I-5, Vanguard I-6, Vanguard I-8, Vanguard I-9, Vanguard I-10 and Vanguard I-12, injection wells, the Vanguard AZM-1, Vanguard AZM-2, Vanguard AZM-3, Vanguard AZM-4, Vanguard AZM-5, Vanguard AZM-6, Vanguard AZM-8, Vanguard AZM-9, Vanguard AZM-10 and Vanguard AZM-12 and the Vanguard IZM-1 through Vanguard IZM-7 monitoring wells, and the maximum pressure front and plume extent (the AoR).

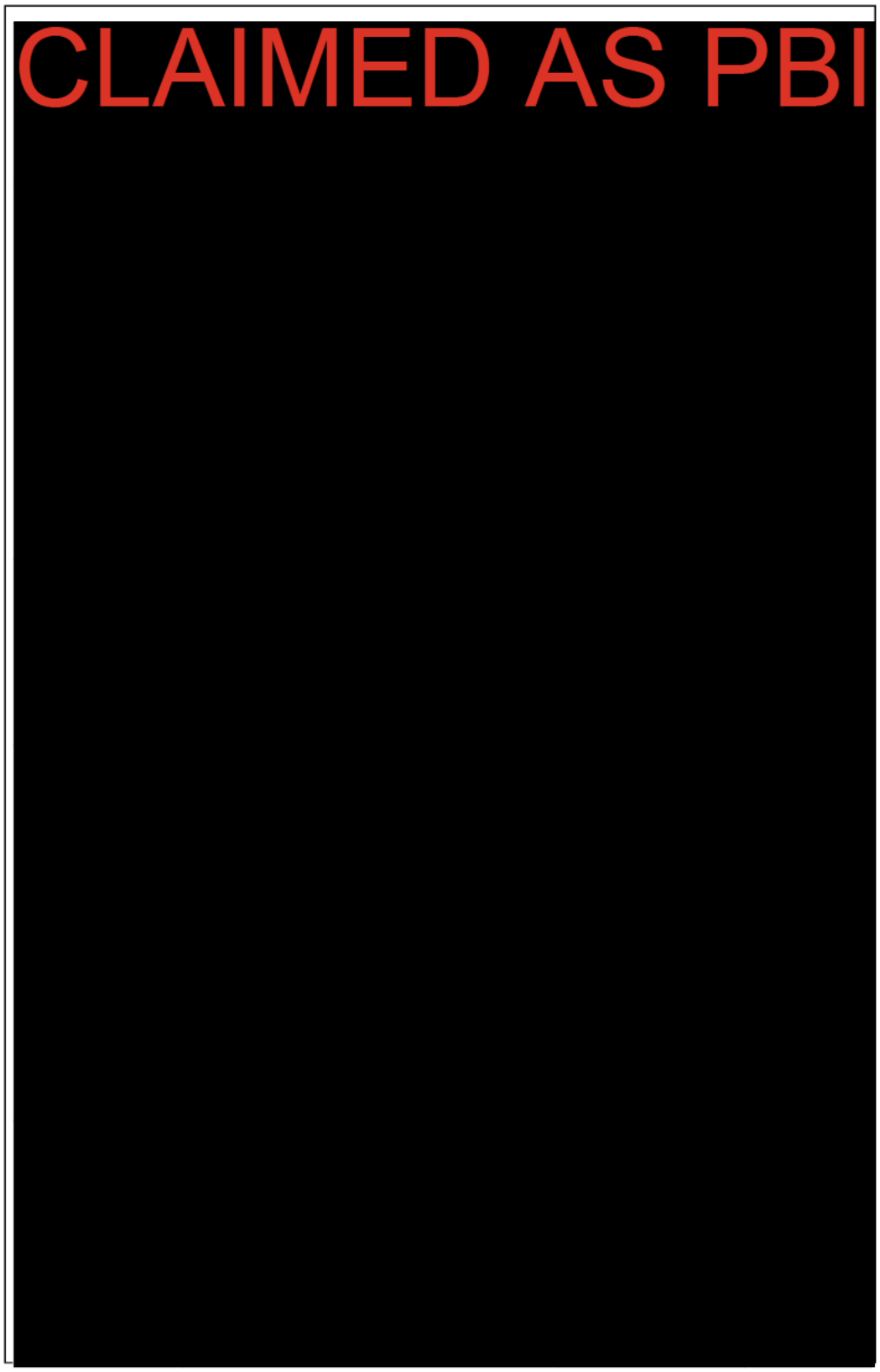

Figure 8.1—NexGen injection and monitoring well network – includes injection wells, in-zone, above-zone monitoring wells.

8.5.1 Monitoring Location and Frequency

The monitoring strategy outlined in this section incorporates both continuous surveillance and scheduled annual sampling events. As specified in the Quality Assurance and Surveillance Plan (QASP), fiber optic Distributed Temperature Sensing (DTS) systems will be installed within the production casing of all ten (10) injection wells. These systems, along with integrated pressure gauges, will provide real-time monitoring of temperature and pressure variations that could signal the movement of formation fluids beyond the upper confining zone.

Each of the ten (10) injection wells will be equipped to monitor conditions within the injection interval (upper Arbuckle Group) as well as the first permeable zone immediately above the confining layer. Additionally, all ten (10) above-zone monitoring wells will contain gauges positioned in this upper permeable interval to detect any upward fluid migration.

A permanent fiber optic DTS system will also be installed behind casing in the injection, in-zone, and above-zone monitoring wells, enabling continuous, high-resolution surveillance across all zones situated above the confining layer. The sensitivity of these technologies will allow NexGen to promptly identify any unauthorized movement of carbon dioxide or saline formation fluids outside the injection zone.

A temperature log will be run annually in the injection wells to monitor for potential leak indicators. The well will be shut in until the temperatures have stabilized, approximately 36 hours before running the temperature log. The temperature profile will be compared to previous surveys, and any anomalies will be investigated.

Pulsed neutron logging (PNL) will be performed every year in the injection wells to monitor changes in the near-wellbore environment that could indicate out-of-zone migration of CO_2 based on observed changes in saturation from previous surveys (including a baseline survey).

Table 8.6 summarizes the methodology and details of the above confining zone monitoring plan.

Table 8.6—Monitoring of groundwater quality and geochemical changes above the upper confining zone.

Target Formation	Monitoring Activity	Monitoring Location(s)	Spatial Coverage	Frequency
USDWs	Pulsed neutron log, Temperature log	All ten (10) injection wells	wellbore	Annual
First permeable zone above the upper confining layer	DTS fiber optics	All ten (10) injection and above-zone monitoring wells	wellbore	Continuous
USDWs	DTS fiber optics	All ten (10) above-zone monitoring wells	wellbore	Continuous

8.6 External Mechanical Integrity Testing

NexGen will conduct at least one of the tests presented in **Table 8.7** periodically, as listed, during the injection phase to verify mechanical integrity as required in §146.89(c) and §146.90.

Table 8.7—Mechanical integrity tests.

Test Description	Location	Frequency
USIT, high-resolution caliper log, or equivalent	All ten (10) Vanguard injection wells	Every 5 years
Annulus pressure monitoring	All ten (10) Vanguard injection wells	Continuous
Annular pressure test	All ten (10) Vanguard injection wells	During initial construction
Temperature log	All ten (10) Vanguard injection wells	Annual

8.6.1 Testing Location and Frequency

An annual mechanical integrity test will be performed on the injection well each year within the 45-day window leading up to the anniversary of the first injection permit. These tests will continue on an annual cadence until the well is formally plugged and abandoned.

8.6.2 Testing Details

This annular pressure check confirms the integrity of the well's casing, tubing, and packer by isolating and holding the annulus at a defined test pressure. You begin by raising annular pressure to either 500 psi or the permitted maximum surface pressure—whichever is lower—then close all access points except the gauge port. After isolation via a block valve, you record pressure over 30 minutes with instrumentation capable of resolving a 10 percent decline. If pressure falls by more than 10 percent during that interval, that signals compromised mechanical integrity. The annulus pressure between long-string casing and tubing is also logged continuously; any abrupt or sustained deviation from normal values likewise flags a potential leak.

Temperature logs will be run annually in the ten (10) injection wells, as further discussed in *Section 8.5.1*, to ensure no significant fluid movement into a USDW through vertical channels adjacent to the injection wellbore. Each well will be taken offline and left idle for roughly 36 hours to allow downhole temperatures to reach equilibrium before logging. The resulting temperature profile will then be benchmarked against earlier surveys, and any unexpected deviations will be promptly examined.

High-definition caliper logs (or an equivalent tool) will be run alongside the above integrity tests to detect changes in casing diameter. As an optional complement, an ultrasonic cement evaluation log (USIT) may be deployed. These logging methods generate 360° cross-sectional images, enabling identification of localized corrosion, pitting, or cement sheath deterioration.

8.7 Pressure Fall-Off Tests

In accordance with 40 CFR 146.90(f), NexGen will carry out periodic pressure fall-off analyses throughout the injection campaign. Each of the ten injection wells will undergo an initial baseline fall-off test before CO_2 injection begins. Subsequent tests will occur every five years to track any evolution in injectivity or near-wellbore conditions.

During each test, dual bottomhole pressure gauges (primary and redundant) will record shut-in pressure over time. Data collection will continue until the pressure-vs. time semi-log plot

demonstrates a radial flow regime. Test reports, including injectivity and pressure-trend findings, will be forwarded to the EPA administrator within 30 days of completion.

8.7.1 Testing Location and Frequency

Prior to initiating CO_2 injection, NexGen will conduct pressure fall-off tests on all ten (10) injection wells to establish reservoir response baseline characteristics. These tests will be repeated every five (5) years throughout the operational life of the wells. Testing will continue on each well until it is either permanently abandoned or repurposed as a dedicated monitoring installation.

8.7.2 Testing Details

Data collected from these tests will be used to monitor and asses any changes in the permeability of the injection zone in the near wellbore environment that may impact injectivity. The pressure fall-off tests can also provide an additional indicator of injection zone pressure.

Two BHP gauges will also be used, as described in *Section 8.7*.

8.8 Carbon Dioxide Plume and Pressure Front Tracking

In line with 40 CFR 146.90(g), NexGen will employ both direct and indirect approaches to delineate the CO_2 plume and track injection-zone pressures throughout operations. Direct measurements will be captured via the injection, above-zone, and in-zone monitoring wells to observe pressure changes and plume expansion across the Area of Review. Complementary time-lapse 2D seismic surveys will provide an indirect means of mapping the subsurface CO_2 front.

8.8.1 Plume Monitoring Location and Frequency

NexGen will install fiber-optic DTS cables and high-accuracy downhole pressure gauges via the TEC line inside each injection well's target interval to provide continuous, real-time plume and pressure monitoring. In parallel, we will conduct a three-stage 2D time-lapse seismic program—one survey before injection to establish baseline conditions, a second during active injection to map the evolving CO_2 front, and a third after injection ceases to verify plume stabilization.

Table 8.8 presents the methods that NexGen will use to monitor the position of the CO_2 plume over time, including the activities, locations, and frequencies that will be employed. Quality assurance procedures for these methods are further described in the QASP (*Section 8.11*).

Table 8.8—Plume monitoring activities.

Target Formation	Monitoring Activity	Monitoring Location(s)	Spatial Coverage	Frequency
DIRECT PLUME MONITORING				
Arbuckle Group	Pressure/Temperature Gauges	All ten (10) injection wells	Wellbore	Continuously
INDIRECT PLUME MONITORING				
Arbuckle Group	2D seismic	CLAIMED AS PBI [redacted]	[redacted]	Once baseline, once during injection, once during PISC

8.8.2 Plume Monitoring Details

Distributed temperature sensing (DTS) and downhole pressure monitoring will be implemented through the TEC line in the injection interval of all ten (10) Class VI injection wells to enable direct observation of CO_2 plume behavior. These instruments will provide continuous measurements of thermal and pressure changes within the target zone, supporting validation of the reservoir simulation model and iterative refinement based on real-time field data.

In addition, NexGen will deploy time-lapse 2D seismic surveys to indirectly monitor plume evolution. An initial baseline survey will characterize the pre-injection subsurface conditions. Follow-up seismic acquisitions will occur during the injection period, with a final survey conducted post-injection to evaluate long-term plume stabilization. The mid-injection survey will incorporate twelve (12) seismic acquisition locations arranged radially—i.e., in a spoke-like pattern—across the project area to provide comprehensive lateral coverage of the expected plume extent (see **Figure 8.2**). These data will inform ongoing model updates and Area of Review (AoR) reevaluation.

Figure 8.2—Approximate 2D seismic survey placement for plume monitoring.

8.8.3 Pressure-Front Monitoring Location and Frequency

The Project is anticipated to generate a critical pressure front—a zone where there is a pressure differential is sufficient to cause the movement of injected fluids or formation fluids into a USDW—reservoir pressure will be continuously and directly monitored by pressure gauges placed via the TEC line in the injection zone of ten (10) injection wells.

Table 8.9 presents the methods that NexGen will use to monitor the pressures over time, including the activities, locations, and frequencies NexGen will employ.

Quality assurance procedures for these methods are presented in the QASP (*Section 8.11*).

Table 8.9—Reservoir pressure monitoring activities.

Target Formation	Monitoring Activity	Monitoring Location(s)	Spatial Coverage	Frequency
DIRECT PRESSURE-FRONT MONITORING				
Arbuckle Group	Pressure Gauges	All ten (10) injection wells	Wellbore	Continuously

8.8.4 Pressure-Front Monitoring Details

Reservoir pressure will be continuously monitored using pressure sensors installed through the TEC line within the injection interval of each well. These instruments will capture real-time variations in both pressure and temperature, supporting model verification by aligning observed subsurface conditions with simulated plume behavior. The resulting data will also inform adjustments to future reservoir simulations. Upon completion of the injection phase, all ten (10) wells will be repurposed as in-zone monitoring wells to support ongoing surveillance during the post-injection monitoring period.

8.9 Soil Gas Monitoring/Other Testing and Monitoring

In support of comprehensive subsurface monitoring, NexGen plans to implement a near-surface groundwater monitoring program targeting the USDWs within the defined Area of Review (AoR). This will include the installation of twelve (12) monitoring wells spaced approximately 150 feet from each CO_2 injection well. These wells will allow for the periodic collection and analysis of groundwater samples from the principal USDW currently in use for both public supply and private consumption, supplementing data obtained from the CO_2 injection and dedicated monitoring wells.

Prior to the commencement of CO_2 injection activities, baseline groundwater sampling and analysis will be performed to characterize existing concentrations of CO_2 and other key geochemical indicators. This initial dataset will serve as a reference point for evaluating any potential changes in water quality over the life of the project. **Table 8.10** outlines the minimum parameters targeted for baseline testing.

Following the onset of CO_2 injection operations, groundwater samples will be collected and analyzed on an annual basis. These results will be evaluated against baseline conditions to detect any deviations potentially indicative of the presence or movement of project-related fluids. This monitoring schedule will be maintained throughout the post-injection site care (PISC) period until plume stabilization is confirmed and site closure is approved. Should any monitoring data suggest

an elevated risk of vertical or lateral migration of injected or formation fluids, the UIC Program Director reserves the authority to require an increase in groundwater sampling frequency..

8.10 Testing and Monitoring Plan Review and Updates

The groundwater monitoring and testing strategy will undergo formal review and evaluation at a minimum interval of every five years. NexGen will integrate newly acquired monitoring data into the reservoir simulation model to ensure it reflects current subsurface conditions. Based on the findings of each review cycle, NexGen will either submit a revised monitoring plan for approval or provide justification demonstrating that modifications are not warranted.

Table 8.10—Summary of baseline analytical and field parameters for fluid sampling of the primary USDW.

Chemical Parameters	Analytical Methods	Detection Limit/Range	Typical Precisions	QC Requirements
Cations: Al, Ba, Mn, As, Cd, Cr, Cu, Pb, Sb, Se, and Tl	ICP-MS, EPA Method 6020	0.001 to 0.1 mg/L (analyte, dilution, and matrix dependent)	± 15%	Daily calibration; blanks, duplicates and matrix spikes at 10% or greater frequency
Cations: Ca, Fe, K, Mg, Na, and Si	ICP-OES, EPA Method 6010B	0.005 to 0.5 mg/L (analyte, dilution, and matrix dependent)	± 15%	Daily calibration; blanks, duplicates and matrix spikes at 10% or greater frequency
Anions: Br, Cl, F, NO_3, and SO_4	Ion Chromatography, EPA Method 300.0	0.02 to 0.13 mg/L (analyte, dilution, and matrix dependent)	± 15%	Daily calibration; blanks and duplicates at 10% or greater frequency
Total Dissolved Solids	Gravimetry; APHA 2540C	12 mg/L	± 10%	Balance calibration, duplicate analysis
Dissolved CO_2	Coulometric titration, ASTM D513-11	25 mg/L	± 15%	Duplicate measurement; standards at 10% or greater frequency
pH (field)	EPA 150.3	2–12 pH units	± 0.2 pH unit	User calibration per manufacturer recommendation
Alkalinity	APHA 2320B	4 mg/L	± 3 mg/L	Duplicate analysis
Specific conductance (field)	APHA 2510	0–200 mS/cm	± 1% of reading	User calibration per manufacturer recommendation
Temperature (field)	Thermocouple	-5 to 50°C	± 0.2°C	Vendor / factory calibration

8.11 Quality Assurance and Surveillance Plan

The Quality Assurance and Surveillance Plan is included within the standalone document **8.11_QASP_NexGen_Vanguard.pdf**.