E.1. TESTING AND MONITORING PLAN
40 CFR 146.90

[redacted]

Facility Information

Facility name: [redacted]

[redacted]

Facility contact: Ronald T. Evans, tevans@capturepointllc.com
1101 Central Expy S, Suite 150, Allen, TX 75013
832-300-8225

Well locations: [redacted]

[redacted]

[redacted]

[redacted]

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1. Overall Strategy and Approach for Testing and Monitoring

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Table 1. Testing and monitoring reporting items.

Parameters Monitored	Monitoring Program	Target Structure/ Project area	Monitoring & Reporting Frequency
I. CO_2 stream Analysis			
1. Chemical Composition of CO_2 Stream	**T1.** Compositional analysis of the injected CO_2 stream using non-destructive Chromatographic detector	Injection metering point in the Inlet Meter	Quarterly or as additional sources are included in the injection stream
II. Continuous Recording of Operational Parameters			
2. Physical Characteristics of CO_2 Stream	**T2.** (**T2.a**) Pressure and (**T2.b**) temperature gauge, flow meter with alarms for measurements outside of the normal operating conditions	Injection metering point	Continuous monitoring. Summary Monthly statistics prepared and reported quarterly.
3. Well Annulus Fluid	**T3**. Annuler pressure gauge	Between tubing and production casing annulus at Wellhead	
	T4. Annular Fluid volume measurements	Record if additional volume is required to fill Annulus and maintain positive pressure on the annulus.	
III. Corrosion monitoring			
4. Coupon Test	**T5**. Flow-through corrosion coupon using injection well construction materials **T6**. Utilize Corrosion inhibitors in all fluids during well workovers	Injection metering point just prior to the Wellhead.	Quarterly analysis during injection operations
IV. **Above confining zone monitoring**			

Parameters Monitored	Monitoring Program	Target Structure/ Project area	Monitoring & Reporting Frequency
5. Monitoring Well	**T7**. Temperature, pressure, and fluid analysis	Monitoring well located in the center of injection wells Multiple monitoring wells monitoring the first permeable layer above the confining zone	Monthly fluid sampling during the first year of operations to determine baseline and then annual for 3 years shifting to once every 2 years in case of no deviation (Continuous pressure and temperature monitoring) during injection. Post injection samples every 5 years.
6. Near Surface Monitoring	**T8**. Fresh water analysis [redacted]	AoR	Monthly sampling during the first year of operations to determine baseline and then annual for 3 years shifting to once every 2 years in case of no deviation during injection. Post injection samples every 5 years.
	T9. CO_2 leak detection equipment with auto warning systems	At Wellhead and key wellsite locations (e.g. Flowline riser)	Event summaries in quarterly reports Inspection and testing semi-annually.
V. **Mechanical integrity testing (MIT)**			
8. Internal Tests	**T11**. Tubing – casing annulus pressure testing	At the Wellhead	8a. Annulus Pressure Test – annually Temperature Log – annually
	T12. Ultrasonic, CCL (casing collar locator), VDL (variable-density-log), GR and Temperature log	To be done if the Pressure testing in 8a above suggests deviations that needs further investigation.	

Parameters Monitored	Monitoring Program	Target Structure/ Project area	Monitoring & Reporting Frequency
9. External Tests	**T13**. Casing Integrity Tools – Ultrasonic imager tool (USIT) or EM casing inspection tool	To be done if the pressure testing in 8a above suggests deviations that need further investigation	Annually
VI. **Pressure fall-off testing**			
10. Pressure Fall-off Tests		All injection wells	First test at completion of well(s), thereafter, once every 5 years during injection operations
VII. **CO_2 plume and pressure front tracking**			
11. Direct Reservoir Monitoring	**T.14**. Wireline based downhole pressure and temperature gauges, injection profile surveys and saturation logs	In-zone monitoring and injection wells	Quarterly. Baseline taken during completion of in-zone monitoring wells and all injection wells. Annual measurements until plume stabilization post injection.
	T.15. Pulsed Neutron- Log (PNL) or Oxygen Activation Log to ensure fluids are contained with the storage interval **T.15.a**. DTS/DAS casing conveyed temperature and pressure	Observation Well for Storage reservoir monitoring and injection wells Monitoring Well for Primary sealing formation monitoring	Baseline at completion, every 2 years during injection operations, every 5 years post injection for 10 years
12. Indirect Reservoir Monitoring	**T.16**. Gravity surveys	AoR	Baseline, one during operations after adequate mass change, one post injection
	T.17. Monitor Pressure to detect the progression of pressure front	Monitoring well	Quarterly measurements, quarterly summary reporting

[redacted]

Preliminary estimates of the CO_2 plume size were determined using equation 1 and are based on the volume of injectate, its viscosity, water saturation, formation volume factor and matrix porosity:

$$\text{Equation 1} \rightarrow R_{plume} = \sqrt{\frac{V_i \cdot B_g}{(1-S_w)\cdot \emptyset \cdot \pi \cdot H}}$$

Pressure front radius estimates (a measure of transient pressure) resulting from injection were determined using equation 2 and are based on time and matrix properties such as pore compressibility, porosity and permeability:

$$\text{Equation 2} \rightarrow R_{pf} = \frac{kt}{\emptyset(uc_t)r_w^2}$$

Pressure differential estimates for AoR evaluation were developed using equation 3.

$$\text{Equation 3} \rightarrow P = P_u + \rho_i g(Z_u - Z_i)$$

[redacted]

[redacted]

Figure 1. General Location Map of Project Site

[redacted]

Figure 2. Plume after 5 years of injection

[redacted]

Figure 3. Plume after 10 years of injection

[redacted]

Figure 4. Plume after 15 years of injection

[redacted]

Figure 5. Plume after 20 years of injection

[redacted]

Figure 6. Plume 5 years post-injection

[redacted]

Figure 7. Plume 25 years post-injection

[redacted]

Figure 8. Map of AoR, Plume Migration and Well Locations

Figure 9. [redacted]

[redacted]

CAPTUREPOINT

Legend

- Injection Wells
- Plugged Water Well
- CO2 Monitoring Welll
- Dry Hole
- Groundwater Well
- Groundwater Monitoring Well
- Legacy Wells

N

[redacted]

[redacted]

1.1 Quality assurance procedures

[redacted]

1.2 Reporting procedures

[redacted]

2 Carbon Dioxide Stream Analysis

[redacted]

2.1 Sampling location and frequency

[redacted]

2.2 Analytical parameters

[redacted]

Table 2. Summary of analytical parameters for CO_2 stream.

Parameter	Analytical Method(s)
Water	ISBT and or ASTM will be required, details are described in the attached QASP
Oxygen	
Nitrogen	
Carbon Monoxide	
Oxides of Nitrogen	
Sulfur Dioxide	
Total Hydrocarbon	
Hydrocarbons	
Acetaldehyde	
Hydrogen Sulfide	
Carbon Dioxide	
Isotopic ^{13}C and ^{14}C ratio	

[redacted]

Table 3. CO_2 specifications at Capture Sites

Parameter	Limit
Pressure	2,200 psi at transfer point
CO_2:	96.0 mole % minimum;
Methane (C1)	< 3.0%
Ethane plus (C2+)	< 1.0%
Hydrogen Sulfide (H_2S)	< 20 ppm by weight
Total Inerts and Nitrogen:	< 4.0 mole % maximum;
Water (H_2O):	< 30 lbs. per MMSCF;
Temperature:	100°F maximum.
Hydrocarbons	< 76 ppm by vol.;
Sulfur	< 35 ppm by weight
Oxygen	< 10.0 ppm by weight.;
Carbon Monoxide	< 20 ppm vol.

2.3 Sampling methods

[redacted]

[redacted].

2.4 Laboratory to be used/chain of custody and analysis procedures

[redacted]

3 Continuous Recording of Operational Parameters

[redacted]

- [redacted]
- [redacted]
- [redacted]

[redacted]

3.1 Monitoring location and frequency

[redacted]

[redacted]

[redacted]

[redacted]

Table 4. Sampling devices, locations, and frequencies for continuous monitoring.

Parameter	Device(s)	Location	Min. Sampling Frequency	Min. Recording Frequency
Annular Pressure Monitoring	Capacitance Gauge	Surface/wellhead	1 minute	30 minutes
Injection Pressure Monitoring (Surface)	Capacitance Gauge			
Injection Pressure Monitoring (Downhole)	Calculated from surface pressure and density of CO_2	Reservoir		
Injection Rate Monitoring	Flow Computer	Surface/wellhead		
Injection Volume Monitoring	Data from flow computer and density of the CO_2 will determine the volume			
Temperature Monitoring	Flow computer will have a continuous temperature reading		Every 10 seconds	
Annular fluid level		Surface/wellhead/fluid tank levels		

[redacted]

3.2 Monitoring Detail

[redacted]

[redacted]

[redacted]

[redacted]

4 Corrosion Monitoring

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

- [redacted]

4.1 Sample description

[redacted]

Table 5. List of equipment coupon with material of construction.

Equipment Coupon	Material of Construction
Pipeline	Carbon Steel or "as built CO_2 resistive materials"
Long String Casing	Carbon Steel or "as built CO_2 resistive materials"
Injection Tubing	Internally coated carbon steel
Wellhead	Carbon Steel with stainless steel trim
Packers	Carbon Steel with stainless steel trim
Packer Elements	Viton material

4.2 Monitoring details

[redacted]

[redacted]

5 Above Confining Zone Monitoring

[redacted]

Table 6. Monitoring parameters and baseline programs.

Monitoring Parameter	Baseline Data program		Baseline	Operational	Post-Operational
Groundwater Quality	USDW monitoring	TDS, pH, Specific Conductance, and Alkalinity	Prior to Injection	Quarterly sampling during	10-year increments

Monitoring Parameter	Baseline Data program		Baseline	Operational	Post-Operational
				injection phase	
Above Confining Zone	Pressure, Temperature and Fluid Analysis		Prior to Injection	Continuous P/T monitoring and annual fluid analysis	Fluid Analysis 5-year increments post injection
CO_2 Quality	Source analysis		Pre-Injection	As needed	N/A
	Injection stream analysis			Quarterly	
Injection Formation Properties	Injection zone	Saturation log and Injection Profile Survey		Annually	
				As necessary	
		Pressure fall-off and injectivity tests		5-year increments	Post-Injection until reservoir pressure is stable
Injection Zone Pressure	Injectivity tests, and pressure fall-off testing				None

[redacted]

5.1 Monitoring location and frequency

Table 7 shows the planned monitoring methods, locations, and frequencies for ground water quality and geochemical monitoring above the confining zone.

[redacted]

[redacted]

[redacted]

Table 7. Groundwater quality monitoring activities.

Phase	Evaluation Target	Description	Sampling and Monitoring Frequency
Pre-injection	USDW water quality	Sampling and analysis are described in the attached QASP.	Baseline
	Water quality in the first permeable layer above the confining zone and from identified USDWs within the AoR		
	Injection zone temperature, pressure and injectivity		
During Injection	Ground water quality	Sampling will occur at the monitoring well locations.	Semi-Annually
	First permeable formation above the confining zone pressure, temperature, and water quality		
	USDW water quality		Quarterly
Post-injection	Groundwater quality and pressure, temperature and water quality in the first permeable formation above the confining zone	Sampling will occur at the monitoring well locations.	Every 10 years
	USDW water quality		Every 5 years

[redacted]

[redacted]

[redacted]

[redacted]

5.2 Monitoring of groundwater quality and geochemical changes.

[redacted]

Table 8. Groundwater monitoring targets and activity.

Target Formation	Monitoring Activity	Monitoring Location(s)	Spatial Coverage	Frequency
Williamson Creek	Fluid Sampling and Analysis	Groundwater Well 079-801 (B on figure 2-22 Site Characterization)	AoR	Quarterly for first year, annually during injection period and every 10 years post injection
Carnahan Bayou		Groundwater monitoring wells 1 and 2 (Injection site and in-zone monitoring well site)		

5.3 Analytical parameters

[redacted]

Table 9. Summary of analytical and field parameters for ground water samples.

Parameters	Analytical Methods
Carnahan Bayou	
TDS	Analytical methods for ground water analysis are described in the attached QASP.
pH	
Specific Conductance	

Parameters	Analytical Methods
Alkalinity	[redacted]
Sodium	
Chloride	
Sulfate	

5.4 Sampling methods

Sampling methods and procedures are described in section B.2 of the QASP.

5.5 Laboratory to be used/chain of custody procedures

[redacted]

6 External Mechanical Integrity Testing

[redacted]

6.1 Testing location and frequency

[redacted]

Table 10. MITs.

Test Description	Location	Frequency
Annulus Pressure Test (APT)	Injection string and casing annulus	Annually
Temperature Survey	Injection and monitoring well(s)	
Radioactive Tracer Survey		

[redacted]

[redacted]

6.2 Testing details

[redacted]

6.2.1 Annulus Pressure Test (APT)

[redacted]

6.2.2 Temperature Log

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

7 Pressure Fall-Off Testing

[redacted]

7.1 Testing location and frequency

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

7.2 Testing details

[redacted]

[redacted]

[redacted]

1. [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

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[redacted]

11 [redacted]

8 Carbon Dioxide Plume and Pressure Front Tracking

[redacted]

Table 11. Plume characterization methods.

Monitoring Location	Monitoring Method	Description	Monitoring Frequency
Direct Monitoring Methods During Injection Operations			
In-Zone Monitoring and Observation Well	Along Casing DTS/DAS Fiber-Optic Sensors	*Pressure and Temperature*	Continuous Monitoring
Injection Well(s)	Injection Profile Survey	*Fluid Dispersion and Temperature*	Annually
	Saturation Log	*Pulsed Neutron or Oxygen Activation logs for Determining Saturation*	
Indirect Monitoring Methods During Injection Operations			
AoR	Gravity Survey	*Surface Gravity Field Strength*	Baseline and then every 10 years

8.1 Plume monitoring location and frequency

Table 13 presents the methods that CapturePoint Solutions, LLC will use to monitor the position of the CO_2 plume, including the activities, locations, and frequencies. The parameters to be analyzed as part of

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Table 12. Plume Monitoring Activities.

Target Formation	Monitoring Activity	Monitoring Location(s)	Spatial Coverage	Frequency
DIRECT PLUME MONITORING				
Sparta	Pressure, Temperature, injectivity tests and saturation logs	At in-zone monitoring wells and at injection wells	Data will cover the area of the site that has been impacted by injection	Surface pressure and temperature will be monitored at the well head continuously, injectivity tests – baseline and every 5 years and gravity surveys – baseline and then every 10 years
Upper Wilcox				
Lower Wilcox				

Table 13. Summary of analytical and field parameters for fluid sampling in the injection zone.

Parameters	Analytical Methods
Sparta, Upper Wilcox, and Lower Wilcox Formations	
Standard water analysis	Analytical methods are described in the attached QASP **Note:** *Only baseline fluid samples are to be collected and methods are described in the Pre-Operations Testing and Logging Plan*
Isotopic analysis	
Hydrocarbon analysis	

8.3 Pressure-front monitoring location and frequency

[redacted]

8.4 Pressure-front monitoring details

[redacted]

[redacted]

[redacted]

[redacted]

Table 14 Pressure front monitoring activities.

Target Formation	Monitoring Activity	Monitoring Location(s)	Spatial Coverage	Frequency
DIRECT PRESSURE-FRONT MONITORING				
[redacted]	Pressure, temperature, saturation log and fluid levels	Offset In-Zone Monitoring well	AoR	Semi-annual reservoir temperature and pressure measurement

E.2 Quality Assurance and Surveillance Plan