ATTACHMENT I: PRE-OPERATIONAL TESTING PLAN
CTV V

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Document Version History

Version	Revision Date	File Name	Description of Change
1	5/31/2023	Att I Pre-Operational Testing Plan_v1	Original Submission
2	7/11/2024	Att I Pre-Operational Testing Plan_v2	Revised in response to EPA May 2024 comments

1. Facility Information

Facility Name: CTV V

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Well Location(s): CTV V, San Joaquin County, CA
38.08 / -121.42

2. Testing Summary

Carbon TerraVault Holdings, LLC (CTV) plans to drill three new injection wells (KI-I-S1, KI-I-S2, and KI-I-S3) in the Lower Injection Zone and three new injection wells in the Upper Injection Zone (KI-I-M1, KI-I-M2, and KI-I-M3) for a total of six injection wells for the CTV V storage project. Pre-operational formation testing will include a suite of logging, coring, geohydrologic testing, and other activities during the drilling and completion or conversion of these injection wells detailed below.

Electrical logging will support reservoir rock and fluid properties characterization. Formation pressure testing will determine current reservoir pressure and permeability. The other pre-operational tests will confirm the depth, thickness, mineralogy, lithology, porosity, permeability, and geomechanical attributes of the Upper Confining Zone, Upper Injection Zone, Internal Barrier, and Lower Injection Zone as defined in **Attachment A.**

Methods for tests will be consistent with U.S. Environmental Protection Agency (EPA) standards (EPA, 2013), and testing methods listed in the Testing and Monitoring Plan (**Attachment C**). Well-specific Construction and Plugging (CP) Plans (**Attachment G1 through G6**) are submitted for each individual well. This Pre-Operational Testing Plan summarizes planned pre-operational testing activities, schedule, and reporting to the EPA.

3. Schedule and Reporting

Results of testing will be documented in a report submitted to the EPA after new well drilling and testing activities have been completed, but before carbon dioxide (CO_2) injection commences.

CTV will notify the Director at least 30 days prior to conducting any testing.

4. Injection Well Testing

Wireline logging of the injection wells will consist of conventional and advanced open-hole logs of the surface, intermediate, and injection hole sections. Cement-bond logs will be run on the surface, intermediate, and injection casing sections to verify cement integrity and zonal isolation. A pulsed neutron capture log will be run on the injection hole to provide a baseline water-to-gas saturation to support saturation and injection modeling over the life of the project.

All tests listed below will be performed for new injection wells.

4.1 Wireline Logs Prior to Running Casing

The following will be run for the surface, intermediate, and long-string sections:

- Deviation Checks
- Spontaneous Potential Log
- Dual Induction Laterolog
- Gamma Ray Log
- Caliper Log
- Compensated Neutron Log
- Formation Density Log
- Mud Log

4.2 Wireline Logs After Running Casing

The following will be conducted for surface, intermediate, and long-string sections:

- Cement Bond Log
- Casing Inspection Log

4.3 Additional Injection Well Testing

Additional injection well testing will include the following:

- Internal mechanical integrity/standard annulus pressure test (SAPT) on all injection wells and on monitoring wells that penetrate the confining zone and are configured with tubing and a packer (**Attachment C**).
- External mechanical integrity (at least one of): oxygen activation log, noise log, temperature log. **Attachment C** lists testing methods that may be utilized for MIT on injection and monitoring wells associated with the project.
- Pressure fall-off testing as described in the Testing and Monitoring Plan (**Attachment C**)

5. Coring Program

Several whole and sidewall cores will be taken from at least one newly drilled injection well in the northern CO_2 plume area and one newly drilled injection well in the southern CO_2 plume area to evaluate fluid and rock properties and calibrate against open-hole logs. The objective of the coring zones is to determine the nature of sand reservoir containers and their transitions to shales. Cores will be taken across sealing interfaces and across the injection zones. Targets include the Upper Confining Zone, Upper Injection Zone, Internal Barrier, and Lower Injection Zone as defined in **Attachment A**.

5.1 Proposed Core Analyses

The following testing and analyses are proposed for the core samples:

- Porosity
- Permeability to air
- Saturations
- Grain density – to calibrate porosity logs
- Gamma ray – to correlate to open-hole logs
- Core descriptions

5.2 Proposed Special Core Analysis:

The following special testing and analyses are proposed for the core samples:

- Capillary pressure on select plugs to determine pore throats and relate water saturations to permeability (K) and porosity (φ)
- X-ray diffractograms (XRD) to determine clay mineralogy and validate petrophysical clay volume calculations
- CO_2 to water relative permeability
- Geomechanical measurements of containment and injection zones
    - Triaxial compressive tests to determine static and dynamic mechanical properties (Young's modulus, Poisson's ratio) and failure criteria (unconfined compressive strength, friction angle)
- Pore compressibility
- Thin-section and scanning electron microscopy (SEM) analyses

6. Additional Pre-Operational Testing

Additional pre-operational testing will address hydrologic and hydrogeologic information, geochemistry and geochemical data, seismic history and risk, facies changes in injection or confining zones, CO_2 stream compatibility with subsurface fluids and minerals, confining zone integrity, and injection well construction.

6.1 Hydrologic and Hydrogeologic Information

Groundwater sample collection and analysis during well construction will establish the depth of the lowermost underground source of drinking water (USDW) within the Area of Review (AoR) (analytes and testing methods in the Testing and Monitoring Plan).

6.2 Geochemistry/Geochemical Data

Baseline geochemistry of the USDW and the Upper and Lower Injection Zones will be characterized for all parameters (and monitoring locations and methods) described in the **Testing and Monitoring Plan** to: (1) confirm the inputs to the geochemical modeling, and (2) establish a baseline for monitoring.

6.3 Seismic History and Seismic Risk

Seismic history and seismic risk will be evaluated in order to: (1) establish pressure in the injection zone (anticipated testing methods: pressure gauge measurement), and (2) continue to establish baseline seismicity using methods listed in the Narrative Application Report (**Attachment A**).

6.4 Facies Changes in the Injection or Confining Zones

Testing will confirm the thickness of the Upper and Lower Injection Zones at the location of the injection wells to provide additional information on their suitability for injection, including facies changes that could facilitate preferential flow (anticipated testing methods: cores and well logging data, see Sections 4 and 5).

6.5 CO_2 Stream Compatibility with Subsurface Fluids and Minerals

The CO_2 stream will be evaluated to confirm the composition of the CO_2 injectate as part of baseline sampling and to provide verification that it will not react with the formation matrix (anticipated testing methods: injectate analysis and core testing, geochemical modeling).

Properties of the CO_2 stream will be analyzed for consistency with the AoR delineation model inputs (anticipated testing methods: various geochemical analyses) and to confirm that the analytes for the injectate and ground water quality monitoring are appropriate based on the results of the geochemical modeling evaluation (anticipated testing methods: various geochemical analyses).

6.6 Confining Zone Integrity

Confining zone integrity will be tested to confirm the fracture pressure of both the injection zone and the confining zone, via site-specific step rate testing (SRT) in the project area. SRT procedures will follow U.S. EPA (1999). Direct in-situ formation stress testing will consist of SRT and Diagnostic Fracture Injection Tests (DFIT) of select intervals in the confining zone and injection zones. These tests provide direct measurement of the minimum horizontal stress.

6.7 Injection Well Construction

Following pre-construction measurement of the composition, properties, and corrosiveness of the injectate, well construction materials and cement will be reviewed in the context of the results of these tests (anticipated testing methods: various geochemical analyses).

6.8 Reservoir Modeling

AoR delineation modeling (see **Attachment B AoR and Corrective Action Plan**) will be revised based on newly collected data during the pre-operational period. Grid inputs will be revised as necessary to reflect any heterogeneities identified and reduce uncertainty.

7. References

United States Environmental Protection Agency (U.S. EPA). 1999. Step-Rate Test Procedure. January 12, 1999.

United States Environmental Protection Agency (U.S. EPA). 2013. *Underground Injection Control (UIC) Program Class Six Well Testing and Monitoring Guidance, EPA 816-R-13-001*. Office of Water (4606M). March 2013.