SECTION 3 – AREA OF REVIEW AND CORRECTIVE ACTION PLAN

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3.1 Introduction

Title 16 of the Texas Administrative Code (TAC) **§5.203(d)(1)** [Title 40, U.S. Code of Federal Regulations (40 CFR) **§146.84(b)**] requires that an area of review (AOR) be conducted for a Class VI carbon sequestration well application. The Environmental Protection Agency (EPA) defines the AOR as the greater of either the maximum extent of the separate-phase plume (pore occupancy plume) or the pressure front where the pressure buildup is of sufficient magnitude to force fluids from the injection zone into the formation matrix of an Underground Source of Drinking Water (USDW). Both parts of this definition were analyzed for the Orchard [redacted] AOR.

3.2 Model Background

Model Name and Version: **GEM 2022.10**

Model Authors/Institution: Computer Modelling Group, Ltd.

Description of model: Equation-of-state (EOS) reservoir simulator for compositional, chemical, and unconventional reservoir modeling.

3.3 Model Inputs and Assumptions

The input parameters for the GEM model are summarized in Table 3-1. These parameters are based on the values estimated at the Orchard [redacted] location.

[redacted]

3.4 Site Geology and Hydrology

A 3D computational model of the geologic layers from [redacted] was constructed using Schlumberger's Petrel™ software. The results from the site characterization work were used as inputs to create static (geologic) and dynamic (simulation) models.

3.4.1 Surfaces

[redacted]

3.4.2 Mesh

The 3D mesh (or grid) was created using the surfaces as inputs. The horizontal (I-J) grid dimensions in the static model are [redacted] Table 3-2 shows the cell count and average thickness for the vertical cells in the static model within the Orchard area. Figure 3-1 shows a map of the static model grid boundary.

[redacted]

[redacted]

3.4.3 Property Distribution

Properties (e.g., porosity, permeability) were populated in all cells [redacted] layers in the 3D static model. [redacted]

3.4.3.1 Facies

The site characterization results incorporate facies determinations to build the porosity and permeability models [redacted]

3.4.3.2 Porosity

Cross-plot porosity was calculated for wells with both neutron and density well logs. The porosity was upscaled from well logs (resolution approximately 0.25') to grid cells [redacted] via arithmetic averaging. Figure 3-2 shows a comparison of the well logs and the upscaled porosity values within grid cells for the type well. A normalized score of the porosity data using all the upscaled porosity data was completed prior to distributing porosity between well locations in the grid.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

3.4.3.3 Permeability

Permeability was calculated for each cell with porosity for the injection zone within the 3D static model by applying [redacted]

Figures 3-9 and 3-10 show selected snapshots of cross sections (approximately north-south and east-west) of the permeability 3D property from the static model.

[redacted]

[redacted]

3.4.3.4 Water Saturation

Water saturation was initiated in the dynamic simulation model.

[redacted]

[redacted]

3.5 Area of Review: Pore Occupancy Plume

The first component of the AOR is delineated using computational plume modeling of an injected CO_2 stream. Computational modeling accounts for the physical and chemical properties of all phases of the injectate and is constructed based on available site characterization, operational, and monitoring data. *Section 2 – Plume Model* discusses the methodology and process in detail. The pore occupancy plume is considered and reviewed based on three primary details: artificial penetrations, subsurface features, and pore space rights.

Any artificial penetrations located within the AOR must be evaluated for proper completions, plugging, and construction materials. These wellbores must be constructed and/or plugged using appropriate materials to support long-term storage of carbon oxides. Most legacy wells in North America, however, were not constructed with the intent of CO_2 storage in mind. Thus, most wellbores located within the pore occupancy plume, that penetrate the gross injection zone, would require a corrective action or a contingency plan to ensure that stored gases do not risk escaping containment by way of these penetrations. Any wells that are identified within this AOR but that do not penetrate the gross injection zone would not pose a threat to the containment integrity. Those wells would be excluded from any corrective action or contingency plan considerations.

Subsurface features identified within the AOR will be assessed for their expected impact to the gross injection zone. Such features could include faults, folds, mapped fractures, steeply dipping formations, and salt diapirs. Should any structural anomalies be discovered within the AOR, efforts to assess their sealing nature will be conducted. These features can act as either barriers aiding in containing the stored CO_2, or conversely as conduits moving the CO_2 out of the containment zone. [redacted]

Pore space rights are critically important when evaluating a project's potential due to the classification of carbon injection wells as storage wells rather than disposal wells. To mitigate the risk of an uneconomically viable project, operating strategies and reservoir management practices were designed with the utmost care to maintain control of the resulting subsurface injectate plume extent.

The area determined for pore space rights was used to identify landowners within the CO_2 plume area. [redacted]

[redacted]

3.6 Area of Review: Pressure Front

A second component of the AOR delineation considers the pressure front created by the injection of fluids into a previously stable reservoir. Both calculation and computational modeling determine this AOR. The pressure buildup that could cause potential fluid migration is determined for either insufficiently plugged and abandoned artificial penetrations, or subsurface features that are found to penetrate the upper confining interval of the gross injection zone.

The worst-case scenario for moving reservoir fluids to the USDW would be through an improperly plugged and abandoned wellbore or subsurface feature that is open both at the base of the USDW and at the top of the injection interval. This resultant pressure is referred to as the critical pressure. The methodology for finding critical pressure was sourced from EPA Method 1 guidance for calculations based on displacing fluid initially present in the borehole in the hydrostatic case.

Nearby Texas Railroad Commission (TRRC) Groundwater Advisory Unit (GAU) letters [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Calculations for the pressure at the base of the USDW are determined from the hydraulic head [redacted]

The complete AOR for Orchard is the total area covered by both pore space and pressure front areas. Any features identified within the AOR were assessed for appropriate USDW protection and, if deemed insufficient, included in the corrective action or contingency plan.

3.7 Reevaluation of AOR

Per 16 TAC **§5.203(d)(2)(B)** [40 CFR **§146.84(b)(2)**] requirements, Orchard Storage will reevaluate the AOR at each of the following intervals:

- A minimum frequency of five years

- Upon detection of a significant change in the plume
- As otherwise warranted by routine monitoring or operational conditions

Wells identified requiring corrective action within the reevaluated AOR will be addressed in an amended AOR and corrective action plan that will be submitted to the EPA Underground Injection Control (UIC) Program Director for approval. Once approved, all amendments and corrective plans will be incorporated into the permit and subjected to permit alteration requirements.

If the evaluation does not result in changes to the AOR or the corrective action plan, Orchard Storage will demonstrate to the UIC Program Director that such changes are not needed, by providing the supporting monitoring data and model results. All model inputs and data used in AOR reevaluations will be retained for 10 years.

3.8 Operating Strategies Influencing Reservoir Modeling Results

[redacted]

[redacted]

[redacted]

The shape and lateral extent of the stabilized plume for the proposed well is illustrated in Figure 3-15. This extent was used to determine the initial project AOR.

These plume extents were digitized from the GEM output and imported into ArcGIS for use as the defined area of influence from which the Orchard AOR was established. Orchard Storage conducted a review to identify any artificial penetrations or other features that may endanger the lowermost USDW as a result of injection activity or operations per 16 TAC **§5.203(d)(1)(C)** [40 CFR **§146.84(c)(3)**]. Orchard Storage also generated maps showing the area of influence and any man-made structures found within the AOR.

[redacted]

3.9 Area of Review Results

[redacted]

[redacted] No faults, other geologic features, or other man-made structures were found within the AOR that could affect the integrity of the disposal intervals for permanent CO_2 sequestration.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

3.10 Corrective Action Plan and Schedule

As discussed above, the AOR is described as the maximum area covered by the plume extent and pressure front boundaries. The plume extent considers the pore space occupied by the CO_2 plume as determined by the reservoir modeling results, as explained in *Sections 3.5* and *3.6*. The pressure front covers a calculated distance where the injected CO_2 could pressure up the reservoir enough to allow brine and other formation fluids to be pushed upward into a USDW. The calculations for determining this area were included in *Section 3.6*. No wells were found to be present within the bounds of the AOR.

Upon each reevaluation of the AOR, a new review of all artificial penetrations and other geologic structures will be performed and the corrective action plan updated as needed.

3.11 Area of Review Revaluation Plan and Schedule

3.11.1 Proposed Reevaluation Cycle

In accordance with 16 TAC **§5.203(d)(2)(B)(i)** [40 CFR **§146.84(b)(2)(i)**], Orchard Storage will reevaluate the AOR at least every five years or upon a triggering event. Table 3-8 provides a list of these possible triggers. The evaluations will be used to validate the plume model against actual, empirical results.

[redacted]

[redacted]

3.12 Conclusion

The results of this AOR investigation validate the favorable conditions for carbon sequestration at the proposed Orchard [redacted] area. [redacted] Unless otherwise triggered by one of the cases above, the AOR investigation will be reevaluated at least every five years.

[redacted]