Class VI UIC Area of Review and Corrective Action

This submission is for:

Project ID: R09-CA-0010

Project Name: Ex. 4 CBI Storage Project

Current Project Phase: Pre-Injection Prior to Construction

Overview

Simulator Used for AoR delineation modeling: GEM

Version Used: GEM 2019.10

Simulator Description/Documentation: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CMG_GEM_Simulator--Documentation.pdf

Total Simulation Time From Start of Injection: 128 yrs

Additional AoR Delineation Information: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----AoR_CA--AoR--Delineation.pdf

Model Domain

Coordinate System: State Plane

Horizontal Datum: NAD27

Coordinate System Units: ft

Vertical Datum: Mean Sea Level

Describe Vertical Datum: Mean Sea Level

Zone: 2

FIPSZONE: 402 ADSZONE: 3301

Mesh Type: Other

Describe Mesh Type: Tartan

Domain Size in Global Units Specified Above

Domain Coordinates File: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----Confidentiality-----Domain--Coord.pdf

Grid Size

Number of Nodes in x: 125 y: 125 z: 133

Grid Spacing: Variable

Grid File Format: ASCII file containing vertices and elements

Grid File Description: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----AoR_CA--Grid--File--Description.pdf

Grid Data File: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----Confidentiality-----Grid.pdf

Faults Modeled: No

Caprock Modeled: No

Image File(s) for Model Domain Grid: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----Confidentiality-----Grid--image.pdf

Processes Modeled by Simulator

Reservoir Conditions:

Supercritical CO_2 Conditions

Phases Modeled:

Aqueous Supercritical CO_2

Aqueous Phase:

Phase Compressibility: Compressible

Compressibility Value: 0.000003 1/psi

Phase Composition: Compositional

Aqueous Phase Components:

CO_2 Water

Supercritical CO2 Phase:

Phase Compressibility: Compressible

Phase Composition: Compositional

Supercritical CO2 Phase Components:

CO2

Equation of State Description Including Reference: CMG GEM uses Peng Robinson EOS

File with EOS Reference or Documentation: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/EOS--SPE-89343_Reservoir-Simulation-of-CO2-Storage-in-Deep-Saline-Aquifers.pdf

Multifluid Flow Processes:

Advection Dispersion Diffusion Buoyancy

Non-wetting Fluid Trapping Pore Compressibility

Thermal Conditions: Isothermal

Heat Transport Processes:

Geochemistry Modeled: No

Geomechanical/Structural Deformations Modeled: No

Rock Properties and Constitutive Relationships

Porosity/Permeability Model

Single Porosity

Porosity Distribution: Heterogeneous

Spatially Variable Porosity File: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----Confidentiality-----Porosity.pdf

File Describing how Porosity was Determined and Assigned to Numerical Model: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----AoR_CA--Porosity--determination.pdf

Image Files for Porosity Distributions: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----AoR_CA--Porosity--distribution.pdf

Permeability Distribution: Heterogeneous

Spatially Variable Permeability File: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----Confidentiality-----Permeability.pdf mD

File Describing how Permeability was Determined and Assigned to Numerical Model: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----AoR_CA--Permeability--determination.pdf

Image Files for Permeability Distributions: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----AoR_CA--Permeability--distribution.pdf

Number of Rock Types Modeled: 1

Description of Rock Type Selection and Assignment: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----AoR_CA--Rock--type--determination.pdf

Rock Type Distribution Data File: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----Confidentiality-----Rock--type.pdf

Image Files for Rock Type Distribution: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----AoR_CA--Rock--type--distribution.pdf

Rock Type #1

Rock Compressibility: Pore

Rock Compressibility Distribution: Single Value

Compressibility Value: 0.000003 1/psi

Constitutive Relationships

Aqueous Saturation vs. Capillary Pressure: Functional Form

File Describing Functional Form Used for Aqueous Saturation vs Capillary Pressure: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----AoR_CA--Capillary--Pressure.pdf

Aqueous Trapped Gas Modeled: Yes

Hysteresis other than non-wetting fluid trapping: No

Aqueous Relative Permeability: Functional Form

File Describing Functional Form Used for Aqueous Relative Permeability: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-

0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----AoR_CA--Relative--permeability-----Water.pdf

Hysteresis other than non-wetting fluid trapping: No

Gas Relative Permeability: Functional Form

File Describing Functional Form Used for Gas Relative Permeability: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----AoR_CA--Relative--permeability-----Gas.pdf

Hysteresis other than non-wetting fluid trapping: No

Porosity and Permeability Reduction Due to Salt Precipitation

Boundary Conditions

Attach Boundary Conditions Description File: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----AoR_CA--Boundary--conditions.pdf

Initial Conditions

Initial Phases in Domain: Aqueous

Initial Aqueous Pressure: Varying with Depth, Temperature, and Salinity

Initial Aqueous Pressure: 2860 psi at Reference Elevation: 6900 ft

Initial Temperature: Varying with Depth

Initial Temperature: 151 F at Reference Elevation: 6900 ft Gradient: 0.013 deg F/ft

Initial Salinity: Spatially Constant

Initial Salinity: 15500 ppm

Operational Information

Number of Injection Wells: 6

Injection Well #1

Well Direction: Vertical

Location: X: 0 Model Units Y: 0 Model Units

Wellbore Diameter: Variable

Wellbore Diameter File: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----Injector--C1-----Wellbore--Dia.pdf

Well Screen Interval Provided as: Single Interval

Elevation of Top of Screened Interval: 0 Elevation of Bottom of Screened Interval: 0 ft

Mass Rate of Injection: 1 MMT/yr

Total Mass of Injection: 28.2 MMT

Fracture Gradient: 0.76 psi/ft

Maximum Injection Pressure: 4224 psi Elevation Corresponding to Pressure: 6178 ft

Description of How Fracture Gradient and Maximum Injection Pressure were Determined File: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----Injector--C1-----Frac--gradient.pdf

Composition of Injectate: Pure CO2

Injection Schedule Provided as: Single Injection Period

Injection Start Date: 01/01/2026 Stop Date: 01/01/2054

Injection Well #2

Well Direction: Vertical

Location: X: 0 Model Units Y: 0 Model Units

Wellbore Diameter: Variable

Wellbore Diameter File: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----Injector--C2-----Wellbore--Dia.pdf

Well Screen Interval Provided as: Single Interval

Elevation of Top of Screened Interval: 0 Elevation of Bottom of Screened Interval: 0 ft

Mass Rate of Injection: 1 MMT/yr

Total Mass of Injection: 28.2 MMT

Fracture Gradient: 0.76 psi/ft

Maximum Injection Pressure: 4919 psi Elevation Corresponding to Pressure: 7192 ft

Description of How Fracture Gradient and Maximum Injection Pressure were Determined File: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----Injector--C2-----Frac--gradient.pdf

Composition of Injectate: Pure CO2

Injection Schedule Provided as: Single Injection Period

Injection Start Date: 01/01/2026 Stop Date: 01/01/2054

Injection Well #3

Well Direction: Vertical

Location: X: 0 Model Units Y: 0 Model Units

Wellbore Diameter: Variable

Wellbore Diameter File: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----Injector--E1-----Wellbore--Dia.pdf

Well Screen Interval Provided as: Single Interval

Elevation of Top of Screened Interval: 0 Elevation of Bottom of Screened Interval: 0 ft

Mass Rate of Injection: 0.25 MMT/yr

Total Mass of Injection: 2.5 MMT

Fracture Gradient: 0.76 psi/ft

Maximum Injection Pressure: 4111 psi Elevation Corresponding to Pressure: 6011 ft

Description of How Fracture Gradient and Maximum Injection Pressure were Determined File: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----Injector--E1-----Frac--gradient.pdf

Composition of Injectate: Pure CO2

Injection Schedule Provided as: Single Injection Period

Injection Start Date: 01/01/2026 Stop Date: 01/01/2036

Injection Well #4

Well Direction: Vertical

Location: X: 0 Model Units Y: 0 Model Units

Wellbore Diameter: Variable

Wellbore Diameter File: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----Injector--E2-----Wellbore--Dia.pdf

Well Screen Interval Provided as: Single Interval

Elevation of Top of Screened Interval: 0 Elevation of Bottom of Screened Interval: 0 ft

Mass Rate of Injection: 0.25 MMT/yr

Total Mass of Injection: 3.5 MMT

Fracture Gradient: 0.76 psi/ft

Maximum Injection Pressure: 4774 psi Elevation Corresponding to Pressure: 6984 ft

Description of How Fracture Gradient and Maximum Injection Pressure were Determined File: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----Injector--E2-----Frac--gradient.pdf

Composition of Injectate: Pure CO2

Injection Schedule Provided as: Single Injection Period

Injection Start Date: 01/01/2026 Stop Date: 01/01/2040

Injection Well #5

Well Direction: Vertical

Location: X: 0 Model Units Y: 0 Model Units

Wellbore Diameter: Variable

Wellbore Diameter File: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----Injector--W1-----Wellbore--Dia.pdf

Well Screen Interval Provided as: Single Interval

Elevation of Top of Screened Interval: 0 Elevation of Bottom of Screened Interval: 0 ft

Mass Rate of Injection: 0.25 MMT/yr

Total Mass of Injection: 1.3 MMT

Fracture Gradient: 0.76 psi/ft

Maximum Injection Pressure: 4207 psi Elevation Corresponding to Pressure: 6155 m

Description of How Fracture Gradient and Maximum Injection Pressure were Determined File: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----Injector--W1-----Frac--gradient.pdf

Composition of Injectate: Pure CO2

Injection Schedule Provided as: Single Injection Period

Injection Start Date: 01/01/2026 Stop Date: 01/01/2031

Injection Well #6

Well Direction: Vertical

Location: X: 0 Model Units Y: 0 Model Units

Wellbore Diameter: Variable

Wellbore Diameter File: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----Injector--W2-----Wellbore--Dia.pdf

Well Screen Interval Provided as: Single Interval

Elevation of Top of Screened Interval: 0 Elevation of Bottom of Screened Interval: 0 ft

Mass Rate of Injection: 0.5 MMT/yr

Total Mass of Injection: 7 MMT

Fracture Gradient: 0.76 psi/ft

Maximum Injection Pressure: 4802 psi Elevation Corresponding to Pressure: 7020 ft

Description of How Fracture Gradient and Maximum Injection Pressure were Determined File: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----Injector--W2-----Frac--gradient.pdf

Composition of Injectate: Pure CO2

Injection Schedule Provided as: Single Injection Period

Injection Start Date: 01/01/2026 Stop Date: 01/01/2042

Number of Production/Withdrawal Wells: 0

Model Output/Results

Provide file name and corresponding spatial location for each file: CBI

Time-Series File: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----AoR_CA--Computational--Modeling--time--series.pdf

Provide file name and corresponding variable and time stamp for each file: CBI

Snapshot File: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----Confidentiality-----Snapshot.pdf

Provide file name and corresponding description of surface for each file: CBI

Surface Flux File: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----Confidentiality-----Flux.pdf

AoR Pressure Front Delineation

Lowermost USDW:

Name of Lowermost USDW: Undifferentiated Non-Marine Sediments

Water Density: 999.6 kg/m^3 at Elevation: 2517 ft

Location of Measurement for Density: Regional assessment

Temperature: 94 F at Elevation: 2517 ft

Location of Measurement: Regional assessment

Pressure: 1090 psi at Elevation: 2517 ft

Location of Measurement: Regional assessment

Salinity: 7900 ppm at Elevation: 2517 ft

Location of Measurement: Regional assessment

Elevation of bottom of USDW: 2517 ft

Injection Zone:

Name of Injection Zone: Injection zone

Water Density: 993.8 kg/m^3 at Elevation: 5941 ft

Location of Measurement: Regional assessment

Temperature: 138 F at Elevation: 5941 ft

Location of Measurement: Regional assessment

Pressure: 2444 psi at Elevation: 5941 ft

Location of Measurement: Regional assessment

Salinity: 15500 ppm at Elevation: 5941 ft

Location of Measurement: Regional assessment

Elevation of top of Injection Zone: 5941 ft

Method of Estimating Critical Pressure: Other

File Describing Critical Pressure Estimation: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----AoR_CA--Critical--Pressure--Calculation.pdf

Estimated Critical Pressure: 2577 psi

Delineated AoR:

Shapefile or KML File Showing Delineated AoR: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/CTV--III-----Confidentiality-----AoR--shapefile.pdf

Corrective Action

Corrective Action Comments: CBI

Area of Review and Corrective Action Plan [40 CFR 146.82(a)(13) and 146.84(b) or applicable state requirements]

Are you making an Area of Review and Corrective Action Plan submission at this time?: Yes

Reason for Project Plan Submission: Permit application submission

Project Plan Upload

Attach the Area of Review and Corrective Action Plan: https://gsdt.pnnl.gov/alfresco/service/velo/getFile/no_wiki/shared/Submissions/R09-CA-0010/Phase1-PreConstruction/AoRModeling-05-03-2022-1838/Attachment--B-----CTV--III-----AoR_CA.pdf

Appendices and Supporting Materials Upload

Area of Review Reevaluation [40 CFR 146.84(e) or applicable state requirements]

Minimum fixed frequency of AoR reevaluation: 5 Years

Are you making an Area of Review reevaluation submission at this time?: No

Reevaluation Background

Reevaluation Materials

Please upload your amended AoR and Corrective Action Plan on the previous tab.

Complete Submission

Authorized submission made by: Siraj Moopen

For confirmation a read-only copy of your submission will be emailed to: travis.hurst@crc.com