

Class VI Injection Well Application

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**Attachment 06: Testing And Monitoring Plan
40 CFR §146.90**

Maple Project
Putnam County, Ohio

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Project Information

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Table of Contents

1. Overall Strategy and Approach for Testing and Monitoring	8
1.1. Testing and Monitoring Plan Strategy	8
1.2. Storage Complex.....	10
1.3. AoR and Project Wells.....	12
1.4. Summary of Testing and Monitoring Plan Components	17
1.4.1. CO ₂ Stream Analysis and Corrosion Monitoring.....	19
1.4.2. Shallow Groundwater Sampling and Monitoring	19
1.4.3. MPL INJ1 Monitoring.....	19
1.4.4. MPL OBS1 Monitoring.....	20
1.4.5. MPL ACZ1 Monitoring	20
1.4.6. Mechanical Integrity Testing	21
1.4.6.1. Internal Mechanical Integrity Testing.....	21
1.4.6.2. External Mechanical Integrity Testing.....	21
1.4.7. Pressure and Temperature Monitoring.....	21
1.4.8. CO ₂ Plume and Pressure Front Monitoring	22
1.4.8.1. Injection Zone Response and CO ₂ Trapping	23
1.4.9. Passive Seismic Monitoring.....	24
1.4.10. General Testing and Monitoring Activity Frequency	24
1.5. Quality Assurance Procedures	26
1.6. Reporting Procedures.....	26
2. CO₂ Stream Analysis (40 CFR §146.90 (a))	26
2.1. Sampling Location and Frequency	26
2.2. Analytical Parameters	27
2.3. Sampling Method – CO ₂ Injection Stream Gases.....	27
2.4. Laboratory to be Used, Chain of Custody, and Analysis Procedures.....	28
3. Continuous Recording of Operational Parameters	29
3.1. Monitoring Location and Frequency	29
3.2. Monitoring Details	30
3.2.1. Continuous Recording of Injection Pressure.....	30
3.2.2. Continuous Recording of Injection Flow Rate.....	31
3.2.3. Injection Volume.....	32
3.2.4. Continuous Recording of Annular Pressure.....	32
3.2.5. Continuous Recording of Annulus Fluid Volume	32
3.2.6. Continuous Recording of CO ₂ Stream Temperature.....	33
3.2.7. BHP and Temperature.....	33
4. Corrosion Monitoring (40 CFR §146.90 (c))	33
4.1. Monitoring Location and Frequency	33
4.2. Sample Description.....	34
4.3. Monitoring Details	34

- 5. Above Confining Zone Monitoring (40 CFR §146.90 (d))..... 36**
 - 5.1. Monitoring Location and Frequency 36
 - 5.2. Analytical Parameters 39
 - 5.3. Monitoring and Sampling Methods 41
 - 5.4. Laboratory to be Used/Chain of Custody Procedures..... 41
- 6. Mechanical Integrity Testing..... 41**
 - 6.1. Internal Mechanical Integrity Testing 41
 - 6.1.1. Annulus Pressure Testing..... 42
 - 6.1.2. Annulus Pressure Monitoring 43
 - 6.2. External Mechanical Integrity Testing (40 CFR §146.90 (e)) 43
 - 6.2.1. Testing Methodology and Frequency..... 43
 - 6.2.2. Testing Details 44
- 7. Pressure Falloff Testing (40 CFR §146.90 (f))..... 45**
 - 7.1. Testing Location and Frequency 45
 - 7.2. Testing Details..... 45
- 8. CO₂ Plume and Pressure Front Tracking (40 CFR §146.90 (g)) 46**
 - 8.1. CO₂ Plume Monitoring Location and Frequency..... 46
 - 8.2. CO₂ Plume Monitoring Details 47
 - 8.3. Pressure Front Monitoring Location and Frequency..... 48
 - 8.4. Pressure Front Monitoring Details 49
- 9. Passive Seismic Monitoring..... 49**
- 10. Construction of Monitoring Wells..... 50**
 - 10.1. MPL OBS1 Construction Details..... 50
 - 10.2. MPL ACZ1 Construction Details..... 62
 - 10.3. MPL USDW1 Construction Details 69
- 11. References..... 71**

List of Figures

Figure 1: Site-specific stratigraphic column.....	11
Figure 2: Map of Maple Project proposed locations of wells.....	13
Figure 3: PBI Map of Maple Project location.....	14
Figure 4: PBI Time-lapse CO ₂ plume development map over 4, 8, 12, and 62	15
Figure 5: A-A' cross section of CO ₂ year 62 along MPL INJ1 and MPL OBS1	16
Figure 6: Atlantic Analytical Laboratory gas sampling instruction sheet	28
Figure 7: Corrosion coupon illustration in pipeline (Cosasco, 2022).....	35
Figure 8: Type of corrosion coupons to be used for corrosion monitoring (Cosasco, 2022).	35
Figure 9: Shallow groundwater wells within the AoR.....	38
Figure 10: MPL OBS1 well construction proposed schematic (not to scale).....	59
Figure 11: Schematic of the proposed wellhead for MPL OBS1.	60
Figure 12: Schematic of the proposed wellhead tree for MPL OBS1.	61
Figure 13: MPL ACZ1 well construction proposed schematic (not to scale).....	67
Figure 14: Schematic of the proposed wellhead for MPL ACZ1.	68
Figure 15: MPL USDW1 well construction schematic (not to scale).	70

List of Tables

Table 1: Summary of general monitoring strategy for the Maple Project 10

Table 2: **PBI** Location and depth of all Maple Project proposed wells 12

Table 3: Summary of testing and monitoring activities..... 18

Table 4: General schedule and spatial extent for the testing and monitoring activities 25

Table 5: Sampling devices, locations, and frequencies for continuous monitoring. 29

Table 6: Summary of BHP and MAIP for MPL INJ1. 31

Table 7: **PBI** List of equipment coupon with material of construction..... 34

Table 8: Schedule for monitoring of pressure and aqueous geochemistry 36

Table 9: Summary of analytical and field parameters for groundwater samples 40

Table 10: Internal mechanical integrity monitoring details..... 41

Table 11: External mechanical integrity tests 44

Table 12: Temperature logging schedule for well integrity..... 44

Table 13: CO₂ plume and pressure front monitoring activities. 46

Table 14: Pressure front monitoring activities..... 48

Table 15: Hole section diameters and intervals for MPL OBS1. 52

Table 16: Casing and tubing details for MPL OBS1. 53

Table 17: Cement system details for each hole section. 54

Table 18: Casing safety factors for design..... 54

Table 19: Casing safety factor loads for design..... 55

Table 20: Tubing and packer setting depth, diameters, and specifications. 55

Table 21: Casing and tubing design parameters. 56

Table 22: Centralizer spacing program for MPL OBS1. 57

Table 23: Hole section diameters and intervals for MPL ACZ1. 62

Table 24: Casing and tubing details for MPL ACZ1. 62

Table 25: Cement system details for each hole section for MPL ACZ1. 63

Table 26: Casing safety factors for design..... 63

Table 27: Casing safety factor loads for design for MPL ACZ1..... 64

Table 28: Tubing and packer setting depth, diameters, and specifications for MPL ACZ1..... 64

Table 29: Casing and tubing design parameters for MPL ACZ1. 65

Table 30: Centralizer spacing program for MPL ACZ1..... 65

List of Acronyms and Abbreviations

13Cr	13-Chrome
13Cr80	13-Chrome with minimum yield strength of 80,000 pounds per square inch
25Cr	25-Chrome
25Cr125	25-Chrome with minimum yield strength of 125,000 pounds per square inch
ACZ	above confining zone
AoR	Area of Review
APT	annulus pressure test
ASTM	American Society of Testing and Materials
BHP	bottomhole pressure
BS	bow spring
CFR	Code of Federal Regulations
CO ₂	carbon dioxide
Director	EPA UIC Program Director
EPA	Environmental Protection Agency
ERRP	Emergency and Remedial Response Plan
FOT	falloff test
GR	gamma ray
ksi	kilopounds per square inch
MAIP	maximum allowable injection pressure
Mc	magnitude of completeness
MD	measured depth
MIT	mechanical integrity test
MPL ACZ1	Maple Above Confining Zone Monitoring Well 1
MPL INJ1	Maple Injection Well 1
MPL OBS1	Maple Deep Observation Well 1
MPL USDW1	Maple USDW Monitoring Well 1
N/A	not applicable
NAD	North American Datum
PBI	proprietary business information
pH	acidity or alkalinity measurement
PISC	Post-injection Site Care and Site Closure
PNL	pulsed neutron logging
psi	pounds per square inch
PSM	passive seismic monitoring
QA	Quality Assurance
QASP	Quality Assurance and Surveillance Plan
RAT	radioactive tracer
SCADA	supervisory control and data acquisition
SM	standard method
TBD	to be determined
TD	total depth
UIC	Underground Injection Control
USDW	underground source of drinking water
UTM	Universal Transverse Mercator

1. Overall Strategy and Approach for Testing and Monitoring

The Testing and Monitoring Plan presented in this document provides details on how the Maple Project will monitor the site pursuant to 40 CFR §146.90.

1.1. Testing and Monitoring Plan Strategy

The Maple Project uses a risk-based Testing and Monitoring Plan that includes operational, verification, and environmental assurance components per regulatory requirements of 40 CFR §146.90 (Attachment 01: Narrative, 2025). This Testing and Monitoring Plan is based on monitoring at other approved Class VI projects as well as extensive geologic evaluation and computational modeling.

Goals of the monitoring strategy include:

- Fulfillment of the regulatory and reporting requirements of 40 CFR §146.90 and 40 CFR §146.91,
- Protection of underground sources of drinking water (USDW),
- Ensure operational performance and enable risk mitigation over the life of the project,
- Confirmation that Maple Injection Well 1 (MPL INJ1) is operating as planned while maintaining mechanical integrity,
- Confirmation that Maple Deep Observation Well 1 (MPL OBS1) and that Maple Above Confining Zone Monitoring Well 1 (MPL ACZ1) are operating as planned while maintaining mechanical integrity per 40 CFR §146.90(e),
- Acquire data to validate and calibrate the models used to predict the distribution of carbon dioxide (CO₂) within the injection zone per 40 CFR §146.90(g) and §146.84(c), and
- Support Area of Review (AoR) re-evaluations over the course of the project per 40 CFR §146.90(i) and §146.84(b) and (c).

The Testing and Monitoring Plan will be adaptive over time and is subject to alteration should one of the following potential scenarios occur:

- Project risks evolve over the course of the project outside of those envisioned at the beginning of the project,
- Significant differences between the monitoring data and predicted computational modeling results are identified,
- Key monitoring techniques indicate anomalous results related to well integrity or the loss of containment.

The monitoring activities fall within three categories based on project objectives: operational, verification, and assurance monitoring.

- **Operational monitoring** focuses on day-to-day injection operations such as system performance.
- **Verification monitoring** confirms that the injected CO₂ remains contained within the selected injection zone. The CO₂ plume and pressure front development are tracked over time to provide data for model calibration. Integration of verification monitoring data into project models allows the project to demonstrate conformance between the computational modeling and the testing and monitoring data collected during the operations and post injection phases of the project's lifecycle.
- **Assurance monitoring** is performed at surface and near-surface (i.e., soil, shallow groundwater, USDWs, etc.) to monitor for any changes from baseline sample data that might indicate CO₂ or injection zone fluid migration towards surface.

The three monitoring categories cover a range of monitoring objectives including:

- Well operations,
- Containment,
- Non-endangerment of USDWs,
- Capacity,
- Injectivity,
- Injection pressure, and
- Conformance.

Table 1 provides a summary of the general monitoring strategy with subcategories.

Table 1: Summary of general monitoring strategy for the Maple Project

Monitoring Action	Monitoring Objectives	Monitoring Technology
CO ₂ stream analysis	Purity of the CO ₂ stream	Lab analysis.
CO ₂ plume monitoring	Verification/ conformance, containment, non-endangerment of USDWs	Time-lapse seismic data, pulsed neutron logging (PNL).
Pressure front monitoring	Injection pressure, injectivity, verification/ conformance	Downhole pressure sensors in MPL INJ1 and MPL OBS1, seismic monitoring
Above confining zone (ACZ) changes	Containment, non-endangerment of USDWs	Downhole pressure sensors in MPL ACZ1, fluid sampling with aqueous geochemistry, PNL, time-lapse seismic data.
Project well integrity	Containment, non-endangerment of USDWs	Temperature logging, PNL, annular pressure monitoring, mechanical integrity tests (MIT), pressure falloff tests (FOTs), corrosion monitoring, testing of emergency shut-down systems.
Reservoir performance	Injectivity	Wellhead and downhole pressure sensors and flow meter in MPL INJ1.
Induced seismicity monitoring	Containment, non-endangerment of USDWs, induced seismicity	Surface-based or downhole seismic monitoring arrays.
Shallow groundwater monitoring	Containment, non-endangerment of USDWs, assurance	Fluid sampling with aqueous geochemistry.

1.2. Storage Complex

A site-specific stratigraphic chart of the geologic formations present in MPL INJ1 is shown in Figure 1.

The specific intervals to be monitored are as follows:

- Mt. Simon Sandstone and Rome Silt (injection zone),
- Rome and Conasauga Formations (primary confining zone),
- Kerbel Formation (above confining zone [ACZ] monitoring interval),
- Lockport Dolomite (lowermost USDW),
- Shallow groundwater.

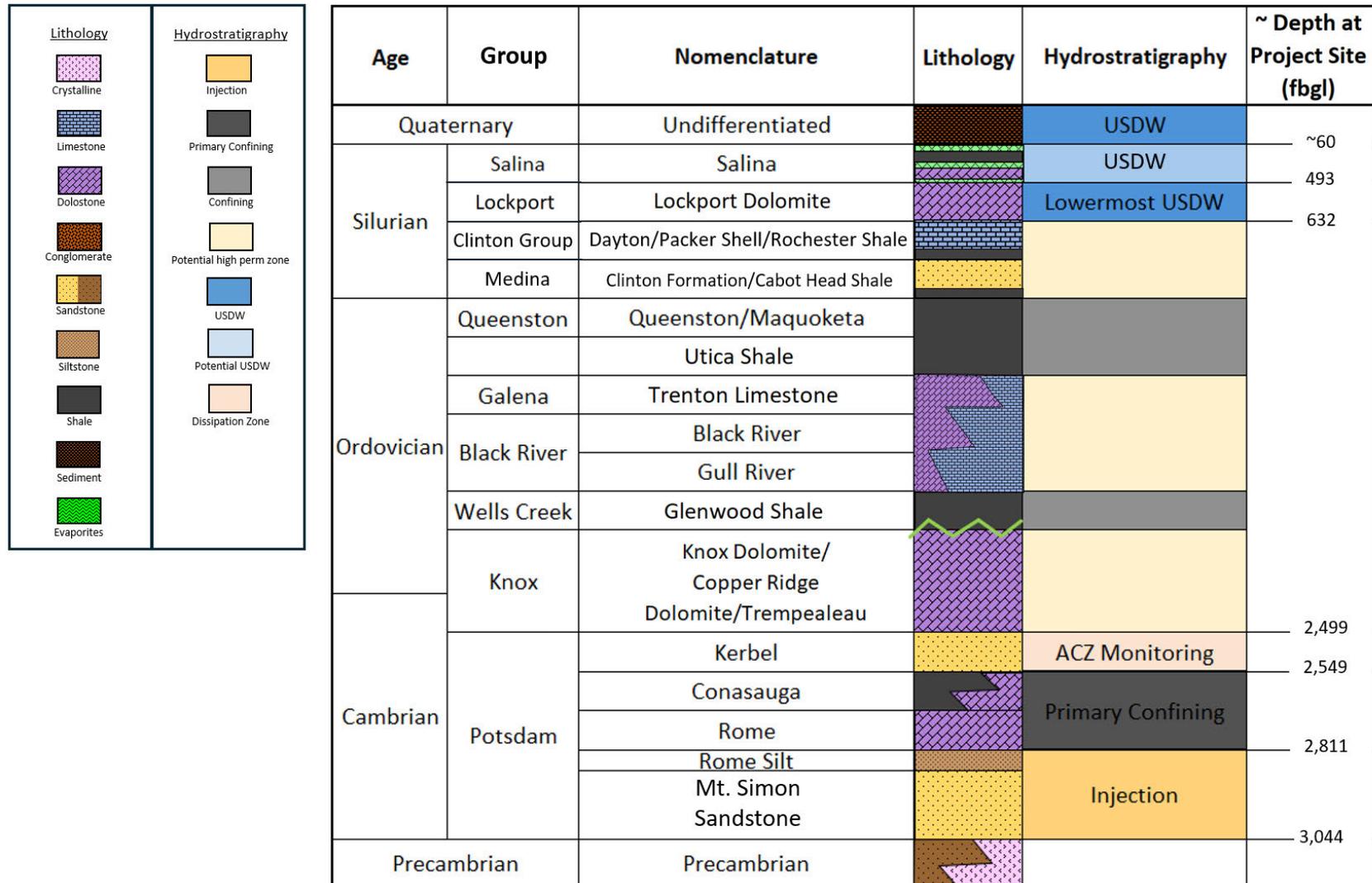


Figure 1: Site-specific stratigraphic column with age, nomenclature, generalized lithology, and zone of use. (fbgl=feet below ground level).

1.3. *AoR and Project Wells*

Table 2 and Figure 2 identify the proposed well locations for the project. Figure 3 shows the predicted CO₂ plume extent 50-years post injection, the pressure front at the end of 12 years of injection, and the project AoR. Figure 4 and Figure 5 illustrate the map view and a cross section of the modeled CO₂ plume development up to 50-years post injection. The CO₂ plume and pressure front computational modeling predictions have been used to inform the spatial extent of the Testing and Monitoring Plan.



The AoR and Corrective Action Plan includes a discussion of the technical basis for determination of the current AoR as well as how the monitoring data will be used to re-evaluate the AoR over the injection phase of the project (Attachment 02: AoR and Corrective Action Plan, 2025). Once MPL INJ1 has been drilled, data gathered during the Pre-operational Testing Program will be used to update the current static model and the computational modeling (Attachment 05: Pre-operational Testing Program, 2025). The updated models will be used to verify or re-evaluate the current AoR, and the associated Testing and Monitoring Plan should it be necessary.

The primary objective of MPL OBS1 is to monitor injection zone pressures at a distance from MPL INJ1. The project intends to locate the deep observation well such that the CO₂ plume will intersect the well between 10 and 12 years after the injection operations commence based on the computational modeling. The proposed location of MPL OBS1 is approximately 3,395 feet to the north-northeast of MPL INJ1 (Figure 2).

The project will use pulsed neutron logging (PNL) to characterize the vertical development of the CO₂ plume over time at a distance from MPL INJ1. The far-field pressure measurements will be used to calibrate the computational modeling during the operations phase of the project.

The MPL OBS1, MPL ACZ1, and MPL USDW1 well construction details and schematics are presented in Section 10 *Construction of Monitoring Wells*.

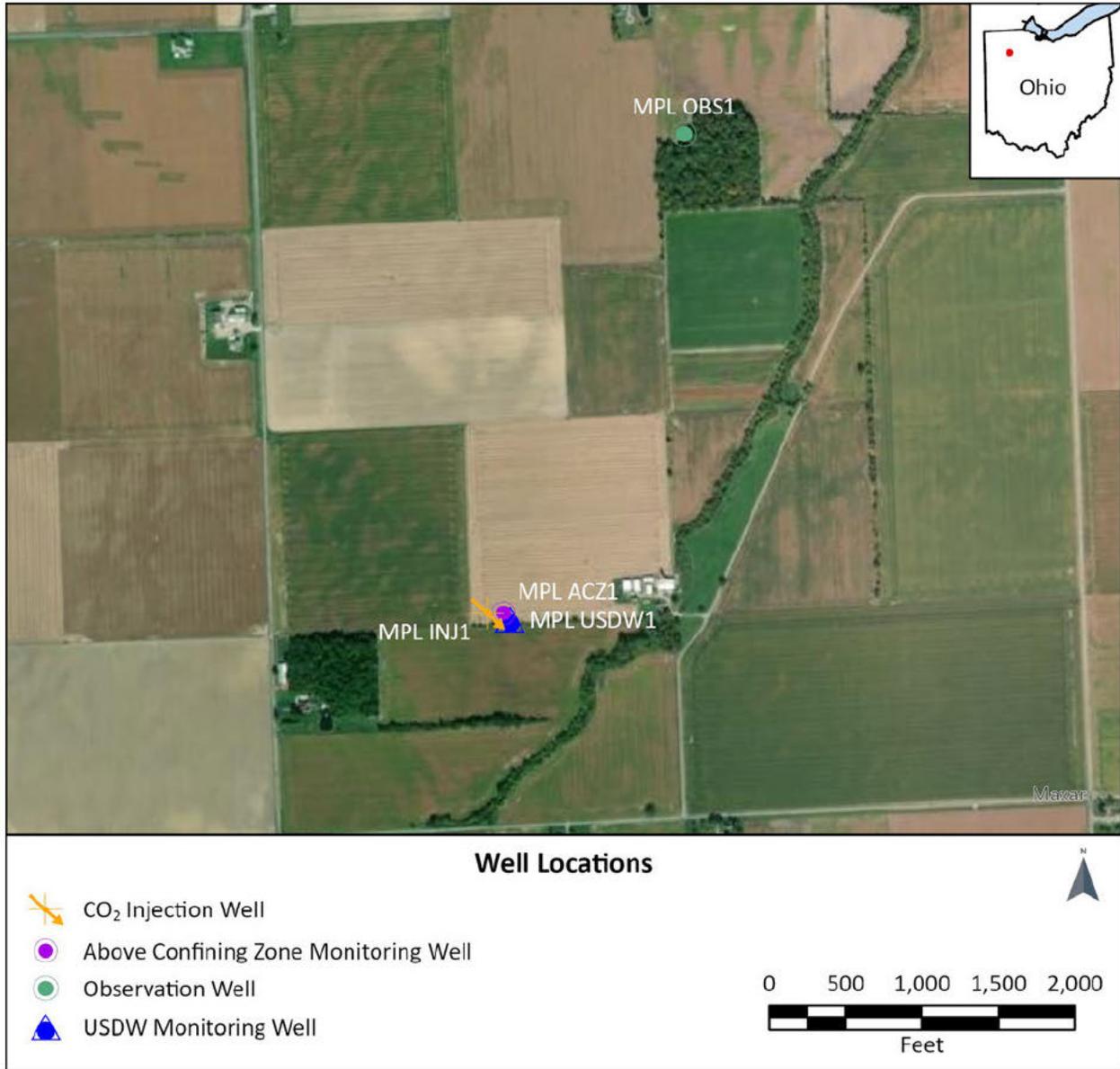


Figure 2: Map of Maple Project proposed locations of MPL INJ1, MPL OBS1, MPL USDW1, and MPL ACZ1 wells.

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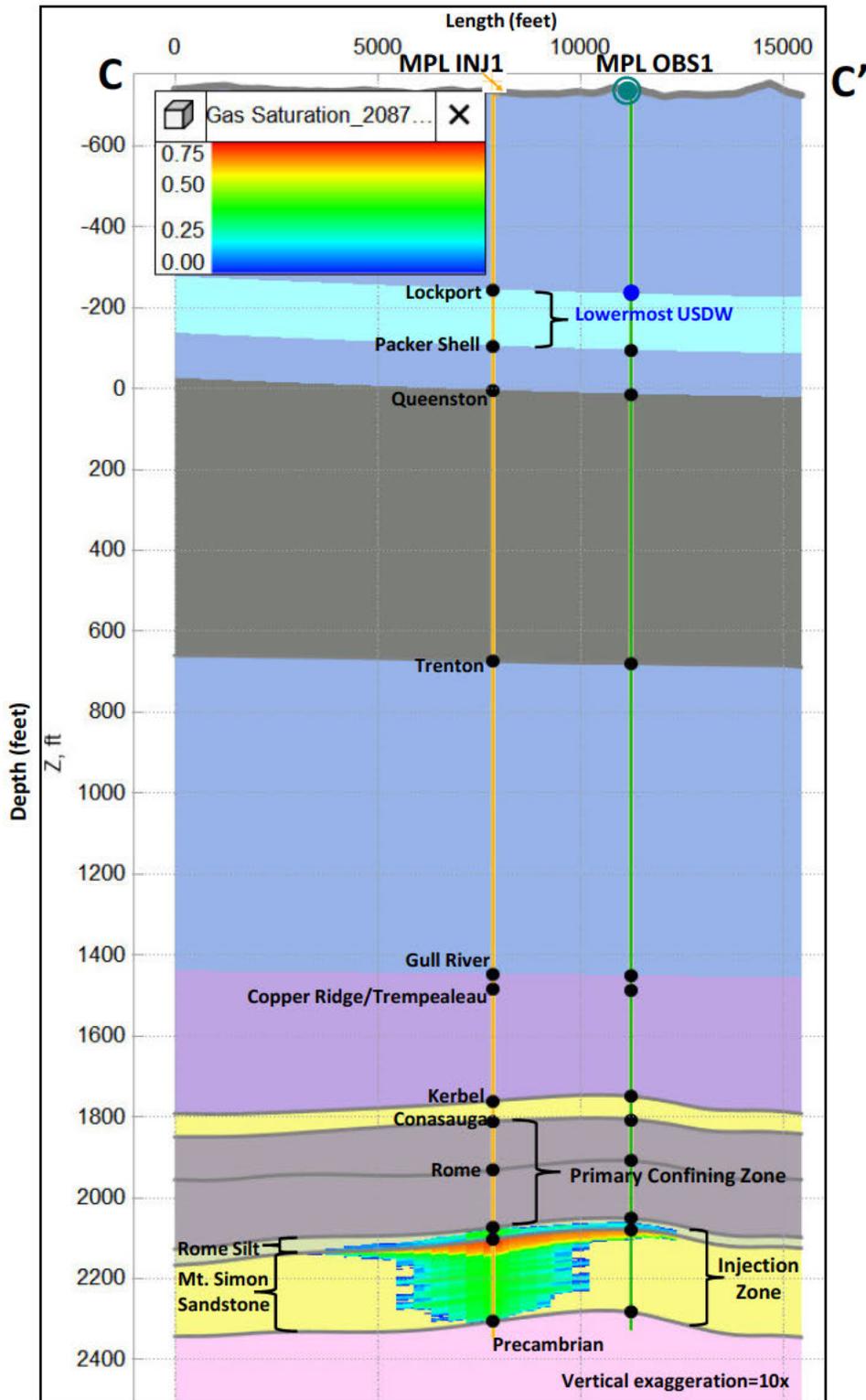


Figure 5: Cross section C-C' (location shown in Figure 4) with the predicted year 62 (50-year post-injection). CO2 plume represented as gas saturation. Vertical exaggeration=10x.

1.4. Summary of Testing and Monitoring Plan Components

Operational monitoring serves to ensure all procedures and processes associated with the project are being conducted safely and confirms that well integrity is maintained. Continuously recorded data that will monitor the response of the injection zone include:

- Injection rate and volume,
- Wellhead injection pressure,
- MPL INJ1 annulus pressure and fluid volume,
- MPL OBS1 annulus and wellhead pressure,
- MPL ACZ1 wellhead and downhole pressure, and,
- Mt. Simon Sandstone pressure and temperature.

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The assurance monitoring component of the program will monitor the shallow groundwater aquifers for any indications that injection zone fluids have migrated into the near surface. Fluid samples will be taken from shallow groundwater aquifers on a regular basis to analyze the aqueous geochemistry.

One of the primary goals of the Testing and Monitoring Plan is to continue to demonstrate that the activities of this project are safe for the health of the public and environment. In order to help facilitate this demonstration, the Quality Assurance and Surveillance Plan (QASP) (Attachment 10: Quality Assurance and Surveillance Plan, 2025) has been developed to ensure that the quality of the demonstration methods meet the requirements of the Environmental Protection Agency (EPA) Underground Injection Control (UIC) Program for Class VI wells.

Table 3 shows a summary of the activities, monitoring points, and purpose of each activity as outlined in the Testing and Monitoring Plan per 40 CFR §146.90. The activities are discussed in more detail in sections that follow in this document.

Table 3: Summary of testing and monitoring activities.

Activity	Location(s)	Purpose
CO₂ Stream Analysis		
CO ₂ sample analysis	CO ₂ delivery pipeline	Monitor injectate quality and composition
Continuous Recording		
Injection rate	MPL INJ1 wellhead	Monitoring injection rate
Injection volume	MPL INJ1 wellhead	Calculated injection volume
Wellhead pressure	MPL INJ1 MPL OBS1 MPL ACZ1	Monitoring injection pressure Monitoring injection zone pressure Monitoring ACZ
Annular pressure	MPL INJ1 wellhead MPL OBS1 wellhead	Monitoring annulus pressure and calculated differential across the packer
Annular fluid volume	MPL INJ1 wellhead	Indirect measurement of annulus fluid volume changes
Downhole pressure ¹	MPL INJ1 injection interval MPL OBS1 injection interval MPL ACZ1	Monitoring injection zone Monitoring injection zone Monitoring ACZ interval
Downhole temperature	MPL INJ1 wellbore	Monitoring injection zone, wellbore integrity
Passive seismic monitoring	Various monitoring stations (location to be determined [TBD])	Injection zone and confining zone integrity
Well Integrity		
Corrosion monitoring	CO ₂ delivery pipeline	Monitoring injectate, wellbore integrity
Annular fluid volume	MPL INJ1 Wellhead	Monitoring annulus fluid volume changes
Mechanical integrity (internal)	MPL INJ1 wellhead MPL OBS1 wellhead	Wellbore integrity
Mechanical integrity (external)	MPL INJ1 wellbore MPL OBS1 wellbore	Wellbore integrity
CO₂ Plume and Pressure Front Tracking		
PNL	MPL INJ11 wellbore MPL OBS1 wellbore	CO ₂ saturation, vertical CO ₂ plume development
Downhole pressure ¹	MPL INJ1 – Injection interval MPL OBS1 – Injection interval	Monitoring injection zone pressure, confining zone integrity
Passive seismic monitoring	Minimum of five stations (locations TBD)	Injection zone and confining layer integrity
Time-lapse seismic data	Area sufficient to image modeled area of CO ₂ plume	Indirect measurement of CO ₂ plume development and overburden
Fluid Sampling		
Shallow groundwater sampling	Shallow wells spatially distributed throughout the AoR	Detection of changes in aqueous geochemistry for the shallow groundwater aquifers
Lowermost USDW sampling (Lockport Dolomite)	MPL USDW1	Detection of changes in the aqueous geochemistry in the lowermost USDW
Above Confining Zone sampling (Kerbel Formation)	MPL ACZ1	Detection of changes in aqueous geochemistry above the primary confining zone
Injection Zone sampling (Mt. Simon Sandstone)	MPL INJ1 or MPL OBS1	Baseline determination of Mt. Simon Sandstone fluid composition.
¹ These gauges are not considered to be a part of the operational Testing and Monitoring Plan, but for gradient calibration and computational modeling verification.		

1.4.1. CO₂ Stream Analysis and Corrosion Monitoring

The chemical composition of the CO₂ stream will be monitored downstream of the final compression unit and upstream of MPL INJ1 (40 CFR §146.90 (a)). Corrosion coupons composed of the same material as the well components and CO₂-delivery pipeline will be placed in the delivery pipeline and analyzed on a quarterly basis for signs of corrosion and loss of mass that may be indicative of future potential well integrity issues (40 CFR §146.90 (c)). If signs of corrosion are identified in the coupons, this may trigger further well integrity testing (Section 1.4.6.2 *External Mechanical Integrity Testing*).

1.4.2. Shallow Groundwater Sampling and Monitoring

The shallow groundwater monitoring program will use shallow groundwater utilization wells spatially distributed within the AoR in near-surface groundwater aquifers, and one dedicated lowermost USDW monitoring well that will be drilled into the lowermost USDW, Lockport Dolomite (40 CFR §146.90 (d)). The top of the Lockport Dolomite is located at 493 feet below ground level at the project site and is considered the lowermost USDW based on nearby well data and reports from the Ohio Department of Natural Resources (Attachment 01: Narrative, 2025).

Baseline groundwater samples will be acquired from these utilization wells to help characterize the variations in aqueous geochemistry within the AoR prior to the start of CO₂ injection. The water samples will be analyzed for their geochemical compositions including stable isotopic compositions.

Throughout the injection and PISC phases of the project, the results of the aqueous geochemistry analyses will be compared to the baseline conditions for any indication of CO₂ or brine migration into the shallow groundwater aquifers. If indications of CO₂ or brine are found in the shallow groundwater aquifer, it will trigger the emergency response actions found in the Emergency and Remedial Response Plan (Attachment 09: Emergency and Remedial Response Plan, 2025)

Throughout the injection and PISC phases of the project, the results of the aqueous geochemistry will be compared to the baseline conditions for any indication of CO₂ or injection zone fluid migration into the shallow groundwater aquifers. If indications of CO₂ or injection zone fluid are found in the USDWs, it will trigger the emergency response actions found in the Emergency and Remedial Response Plan (ERRP) (Attachment 09: Emergency and Remedial Response Plan, 2025).

1.4.3. MPL INJI Monitoring

Injection operations will be monitored through a range of continuous, daily, and quarterly techniques (Attachment 01: Narrative, 2025). These data will be linked into a supervisory control and data acquisition (SCADA) system to record the operations data, control injection rates, or initiate system shutdown, if needed.

Continuous recording devices will monitor wellhead injection pressure, temperature, and mass flow rate (40 CFR §146.90 (b)). The injection mass flow rate will be monitored using an orifice meter prior to entering the wellhead. The injection volume will be calculated using the mass flowrate combined with the pressure and temperature conditions at the flow meter. The measured mass flow will be used to update the computational models at regular intervals throughout the injection phase of the project (Attachment 02: AoR and Corrective Action Plan, 2025).

The annular pressure between the tubing and the injection casing strings will be monitored on a continuous basis (40 CFR §146.90 (b)), and annular fluid volumes will be measured indirectly. The SCADA system will be used to monitor pressure (and by proxy, fluid volume) in the annulus. This information can be used to adjust the pressure of the annular fluid in the annular space to meet the operational and regulatory objectives. The pressure differential between the annulus and the tubing at the depth of the packer will be calculated by the operator.

1.4.4. MPL OBS1 Monitoring

Continuous recording devices will monitor wellhead and in-zone pressure. These data will be used to update the computational models at regular intervals throughout the injection phase of the project. (Attachment 02: AoR and Corrective Action Plan, 2025). The annular pressure between the tubing and the long string casing will be monitored on a continuous basis (40 CFR §146.90 (b)). The SCADA system can also be used to adjust the volume of annular fluid, and thereby pressure, in the annular space to meet the operational and regulatory objectives. Pressure differential between the annulus and the tubing at the depth of the packer will be calculated by the operator.

The primary objectives of the MPL OBS1 well are the direct measurement of pressure behavior in the injection zone related to CO₂ plume evolution at a distance from MPL INJ1 per 40 CFR §146.90(g)(1), and to conduct repeat PNL per 40 CFR §146.90(g)(2). The continuous, far field pressure measurements will be used to calibrate the computational modeling during the operations phase of the project. The repeat PNL will be used to identify the arrival of the CO₂ at MPL OBS1, and subsequently to characterize the vertical development of the CO₂ plume within the injection zone over time at a distance from MPL INJ1.

In-zone fluid samples will be collected using MPL OBS1 or MPL INJ1 during the Pre-operational Testing Program for baseline determination of the injection zone fluid composition per 40 CFR §146.82(a)(6) (Attachment 05: Pre-operational Testing Program, 2025). Injection zone fluid sampling is not proposed during the injection period; however, the well design will allow for an in-zone fluid sample to be collected if needed. The MPL OBS1 construction details and schematics are presented in Section 10.1 *MPL OBS1 Construction Details*.

1.4.5. MPL ACZ1 Monitoring

MPL ACZ1 will be drilled into the Kerbel Formation, which is above the confining zone for the project. The MPL ACZ1 well location will be adjacent MPL INJ1 to monitor the deep saline formation immediately above the confining layer assuming that fluid migration from the injection zone is most likely to occur along a wellbore.

Continuous recording devices will monitor wellhead and ACZ pressure, which will be recorded and transmitted to the SCADA system. The primary objective of this data is to identify potential leakage above the confining zone. Injection zone fluid migration past the confining layer and into the ACZ monitoring zone will most likely be identified through pressure changes in the formation.

MPL ACZ1 will also be used to take fluid samples in the ACZ monitoring zone (40 CFR §146.90 (d)). Section 10.2 *MPL ACZ1 Construction Details* contains the details of the MPL ACZ1 well construction and schematics.

1.4.6. Mechanical Integrity Testing

In addition to the annular pressure and fluid volume monitoring, the well integrity of MPL INJ1 and MPL OBS1 will be monitored using a range of internal and external mechanical integrity evaluation methods. The same methods of mechanical integrity tests (MIT) will be performed on each well.

1.4.6.1. Internal Mechanical Integrity Testing

The regulatory standard for an internal MIT is performing an annulus pressure test (APT). This test will be run to regulatory requirements after the initial well completion to confirm internal integrity as per Attachment 05: Pre-operational Testing Program, (2025). The APT will be performed after the initial completion and after subsequent workovers. Further details on the APT standards and methods of performing it are provided in Section 6.1.1 *Annulus Pressure Testing*.

1.4.6.2. External Mechanical Integrity Testing

The external mechanical integrity of the injection well will be confirmed through annual temperature decay logs. These logs will be compared to baseline logs to identify any deviations that could indicate CO₂ flow or accumulations behind the casing above the injection zone (40 CFR §146.90 (e)). Further details on these logs and the methods of performing them are provided in Section 6.2 *External Mechanical Integrity Testing*.

1.4.7. Pressure and Temperature Monitoring



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1.4.8. CO₂ Plume and Pressure Front Monitoring

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1.4.8.1. Injection Zone Response and CO₂ Trapping

The baseline measurements collected during the Pre-operational Testing Program and the monitoring data collected during operations will be integrated to predict the development of the CO₂ plume and pressure front during operations and through the PISC phase of the project to site closure. This integration and evaluation of data will occur at least every five years, as required for re-evaluation of AoR per 40 CFR §146.84(e). The purpose of this activity is to provide a temporal and spatial prediction of CO₂ plume evolution and trapping mechanisms involved per 40 CFR §146.84(c)(1). The primary trapping mechanisms expected to occur in the injection zone are:

- a) Structural trapping of free-phase supercritical CO₂ by lithological heterogeneities including low-porosity or low-permeability zones or baffles, and by the Eau Claire Shale primary confining zone,
- b) Residual trapping of CO₂ that effectively immobilizes the injected supercritical CO₂ as it displaces brine and becomes disconnected and trapped by capillary forces in pore space,
- c) Dissolution of the supercritical CO₂ into the formation brine, and
- d) Reaction of the dissolved CO₂ with the brine and sandstone matrix to form solid carbonate minerals.

Current predictions regarding CO₂ trapping mechanisms and expected mineralization can be found in the Project Narrative and the AoR and Correction Action Plan (Attachment 01: Narrative, 2025; Attachment 02: AoR and Corrective Action Plan, 2025).

The baseline data collected during the Pre-operational Testing Program will include the mineralogical composition of the injection and confining zones per 40 CFR §146.87(b), fluid composition including carbon isotopic compositions of the injection zone per 40 CFR §146.87(a), composition of the CO₂ stream per 40 CFR §146.90(a), and the injection zone pressure and temperature per 40 CFR §146.87(c). These data will be used in the geochemical modeling to evaluate the interactions of the injected CO₂ with the brine and rock matrix, and to determine the extent that mineral trapping may occur over the duration of the project including PISC phase of the project.

Wireline logging, petrophysical evaluation, and core analyses will be used to evaluate the impact of injection zone porosity, permeability, and heterogeneity on residual trapping and structural trapping. These data will be used to update the static model and computational modeling that provide an evaluation and prediction of the relative contribution of the different trapping mechanisms during the project per 40 CFR §146.84(c)(1).

The repeat PNL measurements will be used to calibrate the models with the arrival time of the CO₂ plume at OBS1, and its vertical distribution within the injection zone; this information will help determine storage efficiency. The repeat 3D seismic surveys will provide additional data that addresses injection zone heterogeneity and will determine the temporal and spatial

development of the CO₂ plume. The direct pressure measurements within the injection zone will additionally calibrate the models. The integration of the testing and monitoring and subsequent computational modeling will constrain the pressure front and CO₂ plume development and predict how CO₂ trapping mechanisms will evolve over time. This information will enable accurate estimates of the injection zone behavior post-injection including the stabilization of the CO₂ plume and reduction in pressure that will lead to site closure.

1.4.9. Passive Seismic Monitoring

The project site is located in an area with low rates of natural seismic activity and risk (Attachment 01: Narrative, 2025). It is not expected that natural seismicity will affect the Maple Project. The Maple Project plans to inject in the Mt. Simon Sandstone and will monitor related seismic activity to assist in the management of project risks (Attachment 09: Emergency and Remedial Response Plan, 2025).

Passive seismic monitoring will be used to accurately determine the locations and magnitudes of natural and injection-induced seismic events with the primary goals:

- To address potential public and stakeholder concerns related to induced seismicity,
- Qualitatively monitor the spatial extent of the pressure front based on the distribution of seismic events around the injection well and as the pressure front expands,
- Identify any activity that may indicate failure of the confining zone and possible containment loss.

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1.4.10 General Testing and Monitoring Activity Frequency

Table 4 presents the general schedule and spatial extent for the monitoring activities in the baseline and injection phases of the project based on the current understanding of the site. Refer to the PISC and Site Closure Plan for discussion on the PISC monitoring plans (Attachment 08: Post-injection Site Care and Site Closure, 2025).

The depth of testing and monitoring ranges will be updated once the data from MPL INJ1 and MPL OBS1 has been analyzed, and the static model has been updated. Changes to the monitoring schedule may occur over time as the project evolves. Any such changes to the Testing and Monitoring Plan will be made in consultation with the EPA UIC Program Director (Director) (40 CFR §146.90 (j)).

Table 4: General schedule and spatial extent for the testing and monitoring activities for the Maple Project.

Monitoring Activity	Baseline Data Frequency	Injection Phase Frequency ¹	Location	Depth Range Measured Depth (fagl) ²
Groundwater Monitoring				
Shallow groundwater sampling	Quarterly	Biannual (twice per year)	Shallow groundwater wells MPL USDW1	45 to 535 Lockport Dolomite (496-635)
Injection Well Monitoring				
Injection pressure	Not Applicable (N/A)	Continuous	MPL INJ1	Surface Above packer (2,820)
Injection temperature	N/A	Continuous	MPL INJ1	Surface Above packer (2,820)
Injection rate	N/A	Continuous	MPL INJ1	Surface
Injection volume (calculated)	N/A	Continuous	MPL INJ1	Mt. Simon Sandstone and Rome Silt (2,811-3,044)
Annular pressure	N/A	Continuous	MPL INJ1	Surface
Annular fluid volume ³	N/A	Continuous	MPL INJ1	Surface
Deep Observation Well Monitoring				
Injection zone pressure	N/A	Continuous	MPL OBS1	Surface Above packer (2,807)
ACZ Well Monitoring				
ACZ pressure	N/A	Continuous	MPL ACZ1	Surface Kerbel Formation (2,501-2,551)
Deep fluid sampling	Once	Annual	MPL ACZ1	Kerbel Formation (2,501-2,551)
Mechanical Integrity Testing				
MIT (Internal) APT	Once	As required	MPL INJ1 MPL OBS1 (run to 500 psi)	Surface Surface
FOT	Once	Every 5 years	MPL INJ1	Mt. Simon Sandstone and Rome Silt (2,811 to 3,044)
MIT (External) Temperature Log	Once Once	Annually Annually	MPL INJ1 MPL OBS1	Top of the Trempealeau Formation (2,220) to above the casing shoe
Emergency Shut-down System Test	N/A	Annually	MPL INJ1	Surface
Pressure Monitoring				
Annular Pressure	N/A	Continuous	MPL INJ1 MPL OBS1	Surface Surface
Wellhead Pressure	N/A	Continuous	MPL INJ1 MPL OBS1 MPL ACZ1	Surface Surface Surface
Downhole Pressure	Once	Continuous ⁶	MPL INJ1	Above packer (2,820)
	N/A		MPL OBS1	Above packer (2,807)
	N/A		MPL ACZ1	Kerbel Formation (2,501 to 2,551)
CO₂ Stream Analysis				
CO ₂ stream analysis	Once	Quarterly	CO ₂ Delivery Pipeline	Surface
Corrosion coupon analysis	N/A	Quarterly	Surface	Surface
CO₂ Plume and Pressure Front Verification Monitoring				
Pressure and temperature sensors	Once – prior to injection	Continuous	MPL OBS1 ⁴ MPL ACZ1 ⁴	Above packer (2,820)
	N/A	Continuous		Above packer (2,807)
	N/A	Continuous		Kerbel Formation (2,501 to 2,551)
PNL	Once Once	Annually Annually	MPL INJ1 ⁵ MPL OBS1	Mt. Simon Sandstone Rome Formation Conasauga Formation, Kerbel Formation
Deep fluid sampling	Once	N/A	MPL INJ1 or MPL OBS1	Mt. Simon Sandstone
Passive seismic monitoring	Six months prior to injection	Continuous	Minimum five stations within the AoR	Conasauga Formation Rome Formation Mt. Simon Sandstone Precambrian Basement
Time-lapse seismic data	Once	Every six years (Q1 or Q4)	Area sufficient to image modeled CO ₂ plume extent	Imaging of CO ₂ plume and overburden

¹ Minimum frequency displayed in table.

² To be confirmed after well is drilled.

³ Annular fluid volume will be monitored indirectly through changes in annulus pressure. Any fluid additions or offtake will be measured.

⁴ Temperature data will not be collected.

⁵ PNL to be run until the Mt. Simon Sandstone is saturated with CO₂, then log will be run from the top of the packer through the ACZ monitoring interval.

⁶ These gauges are not considered to be a part of the routine testing and monitoring program, but for gradient calibration and computational modeling verification.

1.5. Quality Assurance Procedures

Data quality assurance and surveillance protocols adopted by the project have been designed to facilitate compliance with the requirements specified in 40 CFR §146.90 (k). Quality Assurance (QA) requirements for direct measurements within the injection zone, above the confining zone, and within the shallow USDW aquifers are described in the QASP (Attachment 10: Quality Assurance and Surveillance Plan, 2025). These measurements will be performed based on industry best practices and the QA protocols recommended by the service contractors selected to perform the work.

1.6. Reporting Procedures

The Maple Project will report the results of all testing and monitoring activities to the EPA in compliance with the requirements under 40 CFR §146.91. Reports will be submitted every six months from the date CO₂ injection operations commence.

2. CO₂ Stream Analysis (40 CFR §146.90 (a))

The project will analyze the CO₂ stream during the injection phase of the project to provide data representative of its chemical characteristics and to meet the requirements of 40 CFR §146.90 (a). This section describes the measurements and sampling methodologies that will be used to monitor the chemical characteristics of the CO₂ injection stream. Additional details on technical standards, QA/Quality control policy, sample collection and storage policies, and analytical methods are provided in the QASP (Attachment 10: Quality Assurance and Surveillance Plan, 2025).

2.1. Sampling Location and Frequency

Prior to the start of the injection phase, the post-compression CO₂ stream will be sampled for analysis during regular plant operations in order to obtain representative CO₂ samples that will serve as a baseline dataset. Once the injection phase commences, samples of the CO₂ injection stream will be regularly collected from the CO₂ delivery pipeline for analysis. Quarterly sampling of the CO₂ injection stream will be sufficient to accurately track the composition of the stream.

Section 4.5 *QC* of the QASP document details the quality control mechanisms and activities to be performed should there be a statistically significant variance in an analyte measurement (Attachment 10: Quality Assurance and Surveillance Plan, 2025).

2.2. Analytical Parameters

Samples of the injection stream will be collected for chemical analysis of its composition. The samples will be analyzed for CO₂ purity, water content, total hydrocarbons, methane, carbon monoxide, moisture, nitrogen oxides, nitrogen, oxygen, hydrogen sulfide, sulfur dioxide, acetaldehyde, and ethanol.

Baseline samples of the injection stream will be collected prior to the start of injection and the analytes included for analysis may be expanded depending on the results of those analyses. Gas concentration analyses will be done by a contracted third-party lab. The lab will specialize in gas analyses and routinely perform specialized analyses on CO₂ for industrial clients. Samples of the CO₂ stream will be collected on a quarterly basis for chemical analysis.

2.3. Sampling Method – CO₂ Injection Stream Gases

Gas samples of the CO₂ stream will be obtained to analyze the components present in the injection stream. Samples of the CO₂ stream will be collected at a location in the system where the material is representative of the material injected (i.e., between the compression system and MPL INJ1), using a ¼-inch sampling port in the flowline. Fittings will be consistent with those used by the contracted third-party laboratory who will be performing the analysis.

The CO₂ stream will flow from the pipeline through an open ball valve, a pressure reducer (regulator), and into the cylinder. The pressure regulator will reduce the pressure of the CO₂ stream to approximately 250 pound-force per square inch (psi) to ensure the CO₂ is in a gaseous state rather than as a super-critical liquid.

Figure 6 provides an example of the sampling procedures used by Atlantic Analytical Laboratory. Cylinders will be purged with sample gas (i.e., CO₂) at least five times prior to sample collection to remove laboratory-added helium gas and ensure a representative sample. The QASP contains more information on sampling methods (Attachment 10: Quality Assurance and Surveillance Plan, 2025).

<p>Introduction Atlantic Analytical Laboratory (AAL) provides pre-cleaned and conditioned stainless steel and sulfur-inerted sampling cylinders as a convenience to our customers. Rental cylinders are available in a variety of sizes, including 75cc, 300cc, 500cc, and 1 liter. All cylinders are DOT rated for 1,800 psig service, and are equipped with a burst-disc type relief valve set to approximately this pressure. All cylinders are dual ended, with 1/4" NPT valve port fittings. Cylinders are normally shipped with approximately 10 psig UHP grade helium backfill gas to prevent atmospheric contamination during shipment. Cylinders can be shipped under vacuum upon request.</p> <p>Safety Before sampling, review all MSDS information related to the gases present. Always wear safety glasses, protective gloves, and other necessary safety equipment. Sampling cylinders are only to be used by personnel trained in handling pressurized gases. For safety, always assume any cylinder or gas line contains the maximum amount of pressure possible in the system. Whenever possible, ensure that the sampling cylinder outlet port is attached to an appropriate vent line to avoid a potentially hazardous buildup of the gas being sampled, especially for oxygen and flammable gases. Refer to the back of this page for a diagram of a typical sampling setup.</p> <ul style="list-style-type: none"> ➤ DO NOT sample toxic, corrosive, pyrophoric, or extremely reactive gases with these cylinders. ➤ DO NOT sample cryogenic or liquefied gases using these instructions; instead, refer to separate instructions available from AAL for proper sampling techniques for these gases. ➤ DO NOT EXCEED the MAXIMUM 1,800 PSIG fill pressure. If the relief valve burst disc ruptures, the cylinder cannot be used for sampling - return to AAL immediately for repairs, cleaning, and recertification. <p>Equipment Sampling cylinder, 1/4" NPT brass end cap, 1/4" NPT brass plug, ID tag.</p> <p>Sampling Procedure</p> <ol style="list-style-type: none"> 1) Remove the brass cylinder end cap and plug and store them in a clean, secure location. 2) Loosely connect the inlet valve of the sampling cylinder to the gas source valve. 3) Carefully open the gas source valve and purge the connecting fittings of air - then tighten these fittings. Keep the gas source valve open until step 11. 4) Carefully open the cylinder inlet valve to allow the sample gas to fill the cylinder. 5) Close the cylinder inlet valve. Do not over tighten, as this may damage the valve seat and cause leakage. 6) Open the cylinder outlet valve, and allow a majority of the cylinder gas to vent. DO NOT blow down completely to atmospheric pressure, as this may cause outside contaminants to diffuse into the cylinder. 7) Close the cylinder outlet valve. 8) Repeat steps 4 - 7 a minimum of 5 times to ensure the cylinder has been purged of all fill gas and conditioned with the sample gas. 9) Open the cylinder inlet valve and partially open the cylinder outlet valve to allow the sample gas to flow through the cylinder for at least 2 minutes. 10) Close the cylinder outlet valve and wait at least 30 seconds for the cylinder to fully pressurize. 11) Close both the cylinder inlet and gas source valves - then carefully disconnect the cylinder. Beware of excess gas pressure trapped between the two valves which may release suddenly when disconnecting the cylinder. 12) Apply new teflon tape to the NPT threads on the inlet valve of the cylinder and the brass outlet plug and securely cap both ends of the cylinder. DO NOT over tighten fittings or thread damage may result. 13) Record all sample data on the cylinder ID tag – please do not affix labels to the cylinder body. 14) Package the cylinder in a DOT/ATA approved shipping box or container and insert a completed AAL "Analytical Testing Request" form. Follow all applicable shipping regulations including affixing the proper sample UN designation, shipping name, hazard labels, and identification of the sample contents on all courier paperwork. 15) Ship the sample to AAL via an express air (if eligible) or qualified ground courier as soon as possible.
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Figure 6: Atlantic Analytical Laboratory gas sampling instruction sheet .

2.4. Laboratory to be Used, Chain of Custody, and Analysis Procedures

A contracted third-party laboratory will analyze the CO₂ stream samples. The lab will specialize in gas analyses and routinely perform specialized analyses on CO₂ for industrial clients. The contracted laboratory will follow standard sample handling and chain-of custody guidance (EPA 540-R-09-03, or equivalent) (EPA, 2011).

The relevant QASP sections in Attachment 10: Quality Assurance and Surveillance Plan, (2025) detail the following:

- Section 4.3.5 Sample Chain of Custody (B.3.e),
- Section 4.4.1 Analytical Standard Operating Procedures. (B.4.a)

3. Continuous Recording of Operational Parameters

The project will install and use continuous recording devices to monitor injection pressure; injection rate (and volume [calculated]); the pressure on the annulus; the annulus fluid volume; and the temperature of the CO₂ stream, as required at 40 CFR §146.88 (e)(1), 40 CFR §146.89 (b), and 40 CFR §146.90 (b). The details are described in the following sections. These data will be linked into a supervisory control and data acquisition (SCADA) system to record the operations data, control injection rates, or initiate system shutdown, if needed.

3.1 Monitoring Location and Frequency

The project will perform the activities identified in Table 4 to monitor operational parameters and verify internal mechanical integrity of MPL INJ1. All monitoring will take place at the locations and frequencies shown in Table 5. All data recorded on a continuous basis will be connected to the main facility through a SCADA system.

Table 5: Sampling devices, locations, and frequencies for continuous monitoring.

Parameter	Device(s) ¹	Location	Minimum Sampling Frequency ²	Minimum Recording Frequency ³
Wellhead injection pressure	Pressure gauge	Wellhead	Every 10 seconds	Every 10 seconds
Formation injection pressure	Pressure gauge	Above packer (2,820)	Every 10 seconds	Every 10 seconds
Wellhead injection temperature	Thermocouple	Wellhead	Every 10 seconds	Every 10 seconds
Formation temperature	Temperature sensor	Above packer (2,820)	Every 10 seconds	Every 10 seconds
Injection rate	Orifice meter	Upstream of wellhead	Every 10 seconds	Every 10 seconds
Annular pressure	Pressure gauge	Wellhead	Every 10 seconds	Every 10 seconds
Annulus fluid volume ⁴	Annulus Pressure Gauge	Wellhead	Every 10 seconds	Every 10 seconds

¹ All calibration standards, methods of conformance, precision, and tolerance parameters are provided for the devices listed in the QASP (Attachment 10: Quality Assurance and Surveillance Plan, 2025).

² Sampling frequency refers to how often the monitoring device obtains data from the well for a particular parameter. For example, a recording device might sample a pressure transducer monitoring injection pressure once every two seconds and save this value in memory.

³ Recording frequency refers to how often the sampled information gets recorded to digital format (such as a computer hard drive). For example, the data from the injection pressure transducer might be recorded to a hard drive once every minute.

⁴ Annular fluid volume will be monitored continuously indirectly through changes in annulus pressure. Any fluid additions or offtake will be measured.

3.2 Monitoring Details

3.2.1. Continuous Recording of Injection Pressure

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Table 6: Summary of BHP and MAIP for MPL INJ1.

Parameter		MPL INJ1
Measured depth (MD) (feet)	Mt. Simon Sandstone	2,840
	Rome Silt	2,811
Maximum allowable BHP ¹ (psi)	Mt. Simon Sandstone	1,968
	Rome Silt	1,948
Year 1 BHP (psi)	Mt. Simon Sandstone	1,588
	Rome Silt	1,581
Year 5 BHP (psi)	Mt. Simon Sandstone	1,590
	Rome Silt	1,583
MAIP, surface (psi) ¹		1,982
¹ Calculated to the top of the Mt. Simon Sandstone, as detailed in Attachment 01: Narrative (2025). The same calculation performed relative to the top of the Rome Silt results in a surface MAIP of 1,983 psi.		

Pressure will be continuously monitored by an electronic pressure transducer to ensure that the MAIP is not exceeded during injection operations. This electronic pressure transducer will feed into the SCADA system.

To assist with the proper hydrostatic gradient evaluations, permanent downhole gauges will be used. The data gathered from the permanent downhole gauges will help calibrate the surface pressure readings. The CO₂ injection rate and density will vary under actual injection operations, and the downhole gauges will be used to establish a calibration curve among the injection rate, fluid properties, frictional pressure drop, and downhole pressure. Establishing this correlation is important during the early stages of injection as rates ramp up and flow conditions stabilize. Once the relationship between injection rate, CO₂ fluid properties, and downhole pressure has been determined, the calibration curve can be used in the absence of downhole data to ensure operations remain 90% or below the injection zone fracture pressure.

Any anomalies outside of the normal operating specifications may indicate that an issue has occurred within the well, such as a loss of mechanical integrity or blockage in the tubing. Anomalous pressure measurements would trigger the need for further investigation of the cause of the change (40 CFR §146.89 (b)). The wellhead and downhole injection pressures will also be used to calibrate the computational modeling throughout the injection phase and PISC phases of the project.

3.2.2. Continuous Recording of Injection Flow Rate

The volumetric flow rate of CO₂ injected into the well will be measured by a volumetric flow meter and flow computer. The mass flow rate will be calculated based on pressure the differential, temperature, and pressure data. The flow meter will be placed in the CO₂ delivery line near the injection well.

The flow computer will have a digital output. The flow meter be connected to the SCADA system for continuous monitoring and control of the CO₂ injection rate into the well. The flow meter will be calibrated at the frequency recommended by the manufacturer.

3.2.3. Injection Volume

The injection volume will be measured by a volumetric flowmeter and flow computer. The volume will be used in the computational models to determine injection zone capacity and flow.

3.2.4. Continuous Recording of Annular Pressure

The pressure on the annulus between the injection tubing and the long-string casing will be measured by an electronic pressure transducer with analog output that is mounted on the wellhead. The transmitter will be connected to the well control system and the SCADA system to regulate the annular pressure.

Annular pressures are expected to vary during normal operations due to atmospheric and CO₂ stream temperature fluctuations; however, the well control system will be designed to maintain the annular pressure differential around 100 psi relative to the difference between the annulus and tubing at the packer with a maximum annulus pressure of 1,500 psi (Attachment 01: Narrative, 2025).

The annular pressure is expected to fluctuate during start-up and shut-in operations as the tubing naturally expands and contracts in response to pressure and temperature changes related to CO₂ flow, or lack thereof, in the tubing. Sudden changes in the annular pressure during routine injection operations are a sign of potential tubing or tubing-packer integrity issues that will trigger further investigation through mechanical integrity testing.

3.2.5. Continuous Recording of Annulus Fluid Volume

The volume of the annulus fluid between the injection tubing and the long-string casing will be monitored continuously by changes in annulus pressure. Any fluid additions or offtake will be measured.

Similar to the annular pressure, the annular fluid volume is expected to fluctuate as atmospheric and wellbore temperatures change. These changes are expected to be most dramatic during start-up and shutdown operations. A significant change in the fluid pressure and volume during routine injection operations may be an indication of well integrity problems, as the fluid volumes would normally remain relatively constant, and will require further investigation.

3.2.6. Continuous Recording of CO₂ Stream Temperature

The temperature of the CO₂ injection stream will be continuously measured by an electronic thermocouple. The thermocouple will be mounted in a temperature probe in the CO₂ line at a location close to the pressure transmitter near the wellhead. The transmitter will be electronically connected to the SCADA system.

3.2.7. BHP and Temperature

BHP and temperature will be monitored during the injection phase of the project. These data will be used to assist with the calibration of the wellhead pressure measurements to determine the response of the formation to the injected CO₂.

The downhole gauge(s) will be set at the bottom of the injection string at approximately [REDACTED] feet, just above the packer set at approximately [REDACTED] feet and will be programmed to continuously record the pressure and temperature and transmit it to surface.

After the wellhead/injection zone pressure relationship has been defined, the wellhead pressure measurement will be the point of compliance for maintaining injection pressure below 90% of formation fracture pressure as per 40 CFR §146.88 (a). The downhole pressure and temperature data will also be used to calibrate the computational models.

4. Corrosion Monitoring (40 CFR §146.90 (c))

To meet the requirements of 40 CFR §146.90 (c), the project will monitor well materials and components during the operational period for loss of mass, thickness, cracking, pitting, and other signs of corrosion to ensure that the well components meet the minimum standards for material strength and performance (Table 7). This section discusses the measures that will be taken to monitor the corrosion of well materials used in the casing and tubing. For Class VI injection wells, corrosion monitoring of the well materials is required on a quarterly basis (40 CFR §146.90 (c)).

4.1. Monitoring Location and Frequency

The corrosion coupons will be retrieved and analyzed every three months after the date that injection commences. Once injection operations have stabilized, it is not expected that there will be large fluctuations in injection volumes, so there are no plans to monitor the coupons based on injection volumes. If the coupons show evidence of corrosion, MPL INJ1 can be assessed for signs of corrosion using commercially available logging or other inspection tools.

4.2. Sample Description

The coupons will be made from the same materials as the long string casing, injection tubing, and other components in regular contact with the CO₂ stream for both injection and monitoring wells (Table 7). Prior to placement of the corrosion coupons in the CO₂ stream, they will be weighed and measured for thickness, width, and length as a baseline measurement.



4.3. Monitoring Details

Corrosion monitoring of well materials will be conducted using coupons placed in the CO₂ pipeline (Figure 7). The coupons will be made of the same materials that are listed in Table 7. An example of one such coupon is provided in Figure 8. The coupons will be removed quarterly and assessed for corrosion using American Society for Testing and Materials (ASTM) G1-03: Standard Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens (ASTM G1-03, 2017). This method measures the corrosivity of steel to both aqueous and non-aqueous liquid wastes.

Upon removal, coupons will be photographed and inspected visually for evidence of corrosion, which may include pitting, cracking, and loss of mass or thickness (NACE Standard RP0775 2005). The weight and size (thickness, width, length) of the coupons will also be measured and recorded each time they are removed and compared to the baseline measurements. Corrosion rate will be calculated as the weight loss during the exposure period divided by the duration (i.e., weight loss method).

If the coupons show evidence of significant corrosion, MPL INJ1 and MPL OBS1 can be assessed for signs of corrosion using commercially available logging or other inspection tools. The inspection log frequency will be contingent on the corrosion data from the coupon monitoring program.

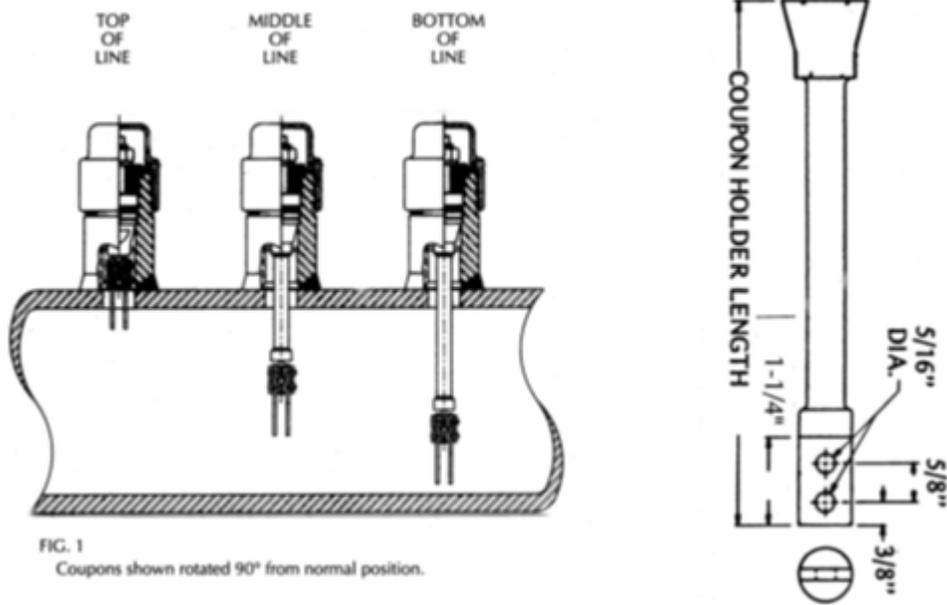


Figure 7: Corrosion coupon illustration in pipeline (Cosasco, 2022).

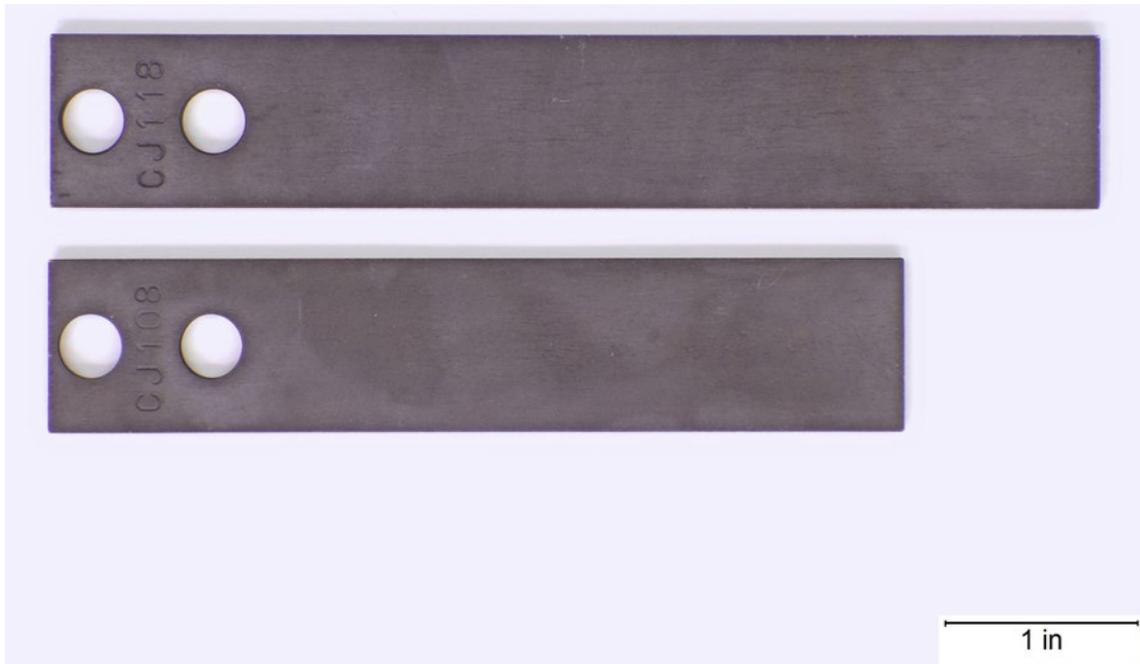


Figure 8: Type of corrosion coupons to be used for corrosion monitoring (Cosasco, 2022).

5. Above Confining Zone Monitoring (40 CFR §146.90 (d))

The project will monitor groundwater quality and geochemical conditions above the confining zone during the operational period to meet the requirements of 40 CFR §146.90 (d).

5.1. Monitoring Location and Frequency

Table 8 shows the deep ACZ monitoring zone, lowermost USDW, and shallow groundwater monitoring methods, depths, and frequencies. The project will acquire a minimum of one year of quarterly shallow groundwater data from shallow groundwater utilization wells before injection operations begin. MPL USDW1 and MPL ACZ1 will be installed after receipt of the Class VI permit and will be sampled according to the schedule in Table 8

Table 8: Schedule for monitoring of pressure and aqueous geochemistry for the MPL ACZ1 and shallow groundwater monitoring wells during the pre-operational and injection phases of the project.

Designated Wells	Target Formation	Monitoring Activity	Baseline Frequency	(Minimum) Injection Phase Frequency
Shallow Groundwater Wells MPL USDW1	Undifferentiated Quaternary Sediments Lockport Dolomite (Lowermost USDW)	Aqueous geochemistry	Quarterly	Biannual
MPL ACZ1	Kerbel Formation	Wellhead pressure	N/A	Continuous (every hour)
		Downhole pressure	N/A	Continuous (every hour)
		Aqueous geochemistry	Once	Annual

Given the thick and continuous nature of the Rome and Conasauga Formations, the highest risk of CO₂ or brine migration out of the injection zone is along the MPL INJ1 and MPL OBS1 wellbores that will penetrate the Rome and Conasauga Formations. As such, MPL ACZ1 will be drilled near MPL INJ1 where injection zone pressures are the highest to monitor for any CO₂ leakage or brine migration into the ACZ monitoring zone. Fluids from the Kerbel Formation and the lowermost USDW will be sampled at least once prior to the start of injection.

Migration of CO₂ or brine into the Kerbel Formation will likely first be identified through pressure changes in the formation. An increasing pressure trend in the ACZ monitoring zone could suggest that leakage across the primary confining zone has occurred. While any increasing trend in pressure will be evaluated, an increase in pressure that deviates more than two standard deviations above baseline values will warrant additional monitoring and inspections to rule out the possibility of fluid leakage out of the injection zone. Such a change in pressure would initiate more frequent fluid sampling and analysis for aqueous geochemistry from the ACZ monitoring zone as well as additional external well integrity investigations in the MPL INJ1 or MPL OBS1. Pressures in the ACZ monitoring interval will be monitored at the wellhead and downhole. A combination of anomalous pressure, anomalous geochemical, and well integrity testing results

may result in the decision to acquire a time-lapse seismic survey before scheduled surveys to characterize any potential leakage accumulations during the operations phase of the project.

The lowermost USDW is expected to be located at a depth of approximately 493 feet based on local well data (Attachment 01: Narrative, 2025). MPL USDW1 will be drilled near MPL INJ1 to be able to monitor the fluids in the lowermost USDW.

Figure 9 shows the distribution of the shallow groundwater wells within the AoR (Attachment 02: AoR and Corrective Action Plan, 2025). The shallow groundwater monitoring program will include utilization wells that will be spatially distributed within the AoR (40 CFR §146.90 (d)). Baseline shallow groundwater samples will be collected on a quarterly schedule starting at least one year before injection commencement to characterize the seasonal variations in groundwater quality within the AoR (Table 8). The number of wells and information about the wells, such as identification numbers and location information will be provided when the wells for testing have been finalized. Vault GSL CCS LP will have surface access rights to the land to sample these wells as part of the landowner leases for the project.

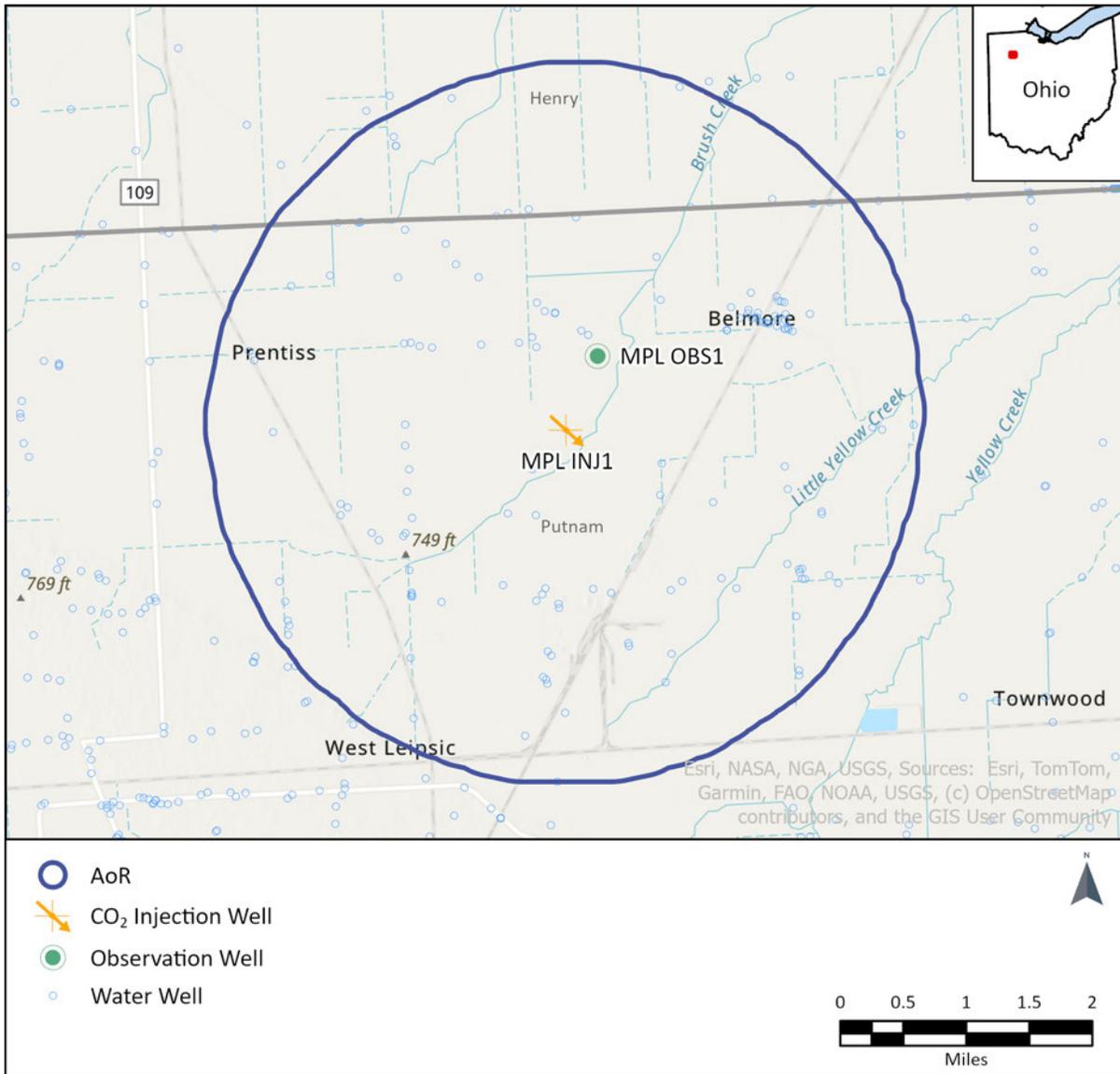


Figure 9: Shallow groundwater wells within the AoR.

The accumulation of CO₂ or brine in an overlying aquifer will likely result in changes to the following parameters:

- Aqueous geochemistry parameters such as pH and alkalinity,
- Reaction of cements, mineral surface coatings, and clay particles with the CO₂ that will liberate cations and anions into the aqueous phase,
- Carbon isotopes may be used to differentiate between existing CO₂ sources within the AoR and the injected CO₂ in the instance that there are sufficient differences in isotopic composition between the source of CO₂ and the native carbon isotopic composition of the fluids of the ACZ interval and the lowermost USDW.

If anomalous changes in the aqueous geochemistry, such as pH, alkalinity, dissolved solids, are observed in the ACZ monitoring interval or lowermost USDW, new samples will be obtained from the affected formation to verify the changes. Because of the natural variability of the aqueous geochemistry in shallow USDW aquifers, changes of greater than 25% in the value of the above parameters, not attributable to natural or seasonal fluctuations, will indicate the need to acquire new samples. Changes in the parameters may also trigger the need for analyses of isotopic compositions. The frequency with which fluid samples are obtained from each of the zones for analysis will also be increased as per 40 CFR 146.90(d).

During the Pre-operational Testing Program, the carbon isotopic composition of the CO₂ stream, the USDW, and the fluids of the ACZ zone will be measured to determine baseline values. If there are sufficient differences among their carbon isotopic compositions, carbon isotopes may provide a unique identification of the presence of injected CO₂ in the ACZ interval or USDWs. If collected water samples during monitoring show anomalous changes in geochemical parameters, such as pH, alkalinity, or dissolved solids, the samples will be further analyzed for a change in isotopic composition.

Anomalous changes may also trigger the need for additional well integrity testing in MPL INJ1 and/ or MPL OBS1 to ensure that no well integrity issues have developed since the last set of external mechanical integrity tests (Section 6.2 *External Mechanical Integrity Testing*).

A combination of anomalous pressure, geochemical, and well integrity testing results may result in the decision to acquire a time-lapse seismic survey to determine the size of a potential leakage accumulation. Further details on any remedial or emergency response are detailed in the ERRP portion of this permit application (Attachment 09: Emergency and Remedial Response Plan, 2025).

5.2. *Analytical Parameters*

Table 9 details the full suite of analytes that will be used to establish the baseline conditions from the injection zone, MPL ACZ1, and the shallow groundwater monitoring wells. During the injection phase of the project, fluids from the shallow groundwater monitoring wells will be sampled biannually, while MPL ACZ1 will be sampled annually, to identify any changes to parameters aqueous geochemistry.

Table 9: Summary of analytical and field parameters for groundwater samples

Parameters	Analytical Methods ¹
Cations: Ca, Fe, K, Mg, Na, Si	EPA 6010D
Cations: Al, Sb, As, Ba, Cd, Cr, Cu, Pb, Mn, Hg, Se, Tl	EPA 6020A EPA 7470A
Anions: Br, Cl, F, NO ₃ , and SO ₄	EPA 300.0
Alkalinity	Standard Method (SM) 2320B
Total dissolved solids	SM 2540C
Total Organic Carbon	Method 9060A
Dissolved Inorganic Carbon	Method 9060A
Total and Dissolved CO ₂	SM 4500
Stable Isotopes of δ ¹³ C	Isotope Ratio Mass Spectrometry ²
pH	Field with multi-probe system
Conductivity/Resistivity	Field with multi-probe system
Temperature	Field with multi-probe system
¹ An equivalent method may be employed with the prior approval of the Director.	
² Gas evolution technique by Atekwana and Krishnamurthy (1998) with modifications made by Hackley et al. (2007)	

Changes in these parameters during the injection phase of the project may provide an indication of CO₂ or brine movement above the confining layer. While pH and alkalinity may be indicators of CO₂ migration above the confining zone, the dissolved inorganic carbon analysis would provide direct evidence of CO₂ migration into these formations. δ¹³C values (of dissolved inorganic carbon) could provide an indication of fluid or CO₂ migration into the ACZ monitoring zone and may also provide information about the origin of any migrating fluids.

The relative benefit of each analytical measurement will be evaluated throughout the design and initial injection testing phase of the project to identify the analytes best suited to meeting project monitoring objectives under site-specific conditions. If some analytical measurements are shown to be of limited use, they will be removed from the analyte list and not carried forward through the operational phases of the project. Any modification to the parameter list in Table 9 will be made in consultation with the Director.

5.3. Monitoring and Sampling Methods

Pressure in the ACZ monitoring zone will be monitored from the wellhead and downhole gauges. The gauges will continuously record and transmit data to the SCADA system once every hour. The wellhead and downhole gauges will be installed in the ACZ well when the well is completed.

For ACZ fluid sampling, a bailer system will be used to collect the water samples. Prior to sample collection the well will be flushed to remove stagnant water to ensure a representative water sample is collected from the formation. The fluid removed from the well will be monitored for the field parameters listed in Table 9 such as pH, conductivity/resistivity, and temperature. . Once these parameters stabilize, the representative formation fluid in the well will be collected.

Preservation/preparation methods, container type, and holding times for the analyte classes are presented in the QASP section of this application (Attachment 10: Quality Assurance and Surveillance Plan, 2025).

5.4. Laboratory to be Used/Chain of Custody Procedures

The geochemical analyses will be performed by contracted third-party laboratories that meet the standards and guidelines set forth in the QASP. Samples will be tracked using appropriately formatted chain-of-custody forms (Attachment 10: Quality Assurance and Surveillance Plan, 2025).

6. Mechanical Integrity Testing

6.1. Internal Mechanical Integrity Testing

Internal MIT refers to the testing of the integrity of the seals within and between the injection string, the long casing string, the packer, and the wellhead. The quality of these seals can be confirmed with an APT and annular pressure monitoring. Both methods will be used during the injection phase of this project to monitor and confirm internal mechanical integrity after well workovers and as a contingent action during injection operations. Table 10 presents the details for conducting the annular pressure MIT and the annular pressure monitoring.

Table 10: Internal mechanical integrity monitoring details.

Testing/Monitoring Method	Frequency	Location of Monitoring	Parameters Measured
APT	After initial completion After well workover	MPL INJ1 Wellhead MPL OBS1 Wellhead	Pressure
Annular pressure monitoring	Continuous (every 10 seconds)	MPL INJ1 Wellhead MPL OBS1 Wellhead ¹	Pressure, temperature, annular fluid volume
¹ No continuous annular fluid volume monitoring.			

An APT will be performed after the initial completion of both the injection well and deep observation monitoring well. The annulus will be filled with a non-corrosive fluid with additives (Attachment 01: Narrative, 2025).

6.1.1. Annulus Pressure Testing

The APT is intended to demonstrate internal mechanical integrity whenever a component of the internal seals is broken or altered. The test will be performed in accordance with approved and accepted guidance and regulations (CFR §146.89 (a)). In addition, an APT may be performed following:

- An emergency shut-in triggered by an injection pressure which exceeds the maximum allowable injection pressure, or
- An emergency shut-in triggered by high annulus pressure, or
- A low annulus alarm should the cause of the alarm not be easily correlated to a change in temperature.

These set points are defined in Attachment 01: Narrative (2025).

Prior to beginning the APT, a calibrated digital gauge will be installed on the annulus. The APT will begin by pressuring up the annulus to 1,500 psi after the well has reached thermal equilibrium as defined below. A calibrated digital gauge will be installed on the annulus, and the pressure will be monitored for a period of no less than 60 minutes.

The following procedure will be followed for all APTs that will be run:

1. Install a calibrated digital gauge on the casing-tubing annulus. Note initial pressures on the tubing and annulus.
2. Ensure the well is in thermal equilibrium. Thermal equilibrium will be assumed under the following circumstances:
 - a. Injection has not occurred for approximately 24 hours, or sufficient data indicates the wellbore temperature is static. The scenario constitutes a static APT.
 - b. Injection is occurring at a constant rate ($\pm 5\%$), often referred to as a dynamic APT.
3. Increase annulus pressure to 1,500 psi.
 - a. Ensure to note the fluid level in the system prior to increasing the annulus pressure.
4. Disconnect the annulus system and ensure the annulus is isolated.
5. Monitor the annulus and tubing pressure for a period of one-hour, taking readings every 10-minutes.
6. Once the test has concluded, reconnect the annulus system.
7. Blow the pressure down to the normal operating pressure.
8. Record the fluid level in the system.

6.1.2. Annulus Pressure Monitoring

In addition to the APT, the annular pressure will be continuously monitored throughout the operational period in conjunction with the annular pressure monitoring and control system to ensure internal mechanical integrity. Once injection operations commence, injection pressure, annular pressure, and annular fluid volumes will be monitored continuously in order to ensure that internal well integrity and proper annular pressure are maintained (Attachment 01: Narrative, 2025).

If a change in the annular pressure or annular fluid volume is not correlated to a change in temperature or injection rate alteration, the cause of the change will be investigated. Changes in the temperature of the injection stream can result in changes in the temperature of the annular space and lead to variations in annular pressure. Initial investigations would likely look at correlations between the temperature of the injection stream and the variations in annular pressure.

6.2. External Mechanical Integrity Testing (40 CFR §146.90 (e))

The project will conduct an external MIT annually to meet the requirements of 40 CFR §146.89(c) and 40 CFR §146.90(e).

6.2.1. Testing Methodology and Frequency

External mechanical integrity refers to the absence of fluid movement through channels between the long casing string and the borehole or the intermediate casing string. Migration of fluids through this zone could result in contamination of USDWs; therefore, the external integrity of MPL INJ1 and MPL OBS1 will be confirmed throughout the injection phase of the project. External MIT activities will occur annually.

This project will use temperature logs to demonstrate external mechanical integrity. The use of temperature logs to demonstrate external mechanical integrity is a generally accepted method used in Class I and II wells across multiple EPA regions.

Table 11 shows the logs to be run to display external mechanical integrity, as well as the frequency with which they will be run, and the depth range they will be run over.

Table 11: External mechanical integrity tests

Test	Well	Depth Range (MD feet)	Schedule
Temperature log	MPL INJ1 MPL OBS1	Top of the Kerbel Formation to 50 feet below the casing shoe	Annually

It is important to note that, while PNL is not planned to be a direct method of displaying external mechanical integrity, it can be used to identify accumulations of CO₂ adjacent to the wellbore in intervals above the Mt. Simon Sandstone.

Temperature logging will be used to establish a temperature response profile to injection of the well and make year to year comparisons to determine if any unexpected variations are present. Multiple temperature logging runs will be acquired during each event to capture the temperature decay over a six-hour period (Table 12). Temperature logs will be run using a standard tool assembly that includes the following components (Attachment 10: Quality Assurance and Surveillance Plan, 2025):

- Casing collar locator,
- Gamma ray tool, and
- Temperature tool.

The well will be shut-in, and a baseline temperature log will be run as per schedule in Table 12. This will allow for four temperature curves to be plotted for each year that temperature logs will be performed. Temperature logs will be acquired from the bottom up.

Table 12: Temperature logging schedule for well integrity

Temperature Logging Run	Time Increment from Shut-in (hours)
Baseline	Shut-in
Second	1
Third	3
Fourth	6

6.2.2. Testing Details

The data from each annual temperature logging event will be compared to the baseline log to determine if there are any inconsistencies between the logs. If inconsistencies appear, the cause of the deviations will be determined, and additional logs will be performed over the entire depth of the well to substantiate the results of the MIT logging.

7. Pressure Falloff Testing (40 CFR §146.90 (f))

The project will perform pressure FOTs during the injection phase as described below to meet the requirements of 40 CFR §146.90(f).

Pressure falloff testing involves the measurement and analysis of pressure data from a well after it has been shut-in. FOTs provide the following information:

- Confirmation of injection zone properties such as flow capacity (KH), which is used to derive average permeability,
- Formation damage (skin) near the well bore, which can be used to diagnose the need for well remediation,
- Changes in injection zone performance over time, such as long-term pressure build-up in the injection zone.

Average injection zone pressure can be used to calibrate computational modeling predictions of injection zone pressure to verify that the operation is responding as modeled/predicted.

7.1. Testing Location and Frequency

FOTs will be run every five years on MPL INJ1 during injection operations. An initial FOT will be run as part of the Pre-operational Testing Program (Attachment 05: Pre-operational Testing Program, 2025). The permanent downhole pressure gauges set above the packer will be used to collect bottomhole data for the FOT. Alternatively, bottomhole data can be obtained using gauges run on wireline for the duration of the test.

7.2. Testing Details

To begin the FOT, a constant rate injection period lasting a minimum of 24 hours will be carried out. The rate will be kept within $\pm 5\%$ during this period and will be at a rate that is representative of the injection rate for normal operations.

Following this constant rate injection period, injection will cease, and the well will be shut-in at the wellhead. Pressure will be monitored for a period no longer than the constant rate injection period. Following the shut-in period, the well will be restarted, and routine injection operations will resume.

Surface monitoring equipment will be used to record the injection data. This test can be performed as a function of routine injection operations and will prevent any additional shut-in of the well other than what is necessary for the test. Pressure transient analysis will be performed on the collected test data. Analysis of the test data will be completed using pressure transient analysis techniques that are consistent with guidance for conducting FOTs.

8. CO₂ Plume and Pressure Front Tracking (40 CFR §146.90 (g))

The project will employ direct and indirect methods to track the extent of the CO₂ plume and the presence or absence of elevated pressure during the operation period to meet the requirements of 40 CFR §146.90 (g). Table 13 presents the methods that the project will use to monitor the position of the CO₂ plume and pressure front; this includes the activities, locations, and frequencies the project will employ.

Table 13: CO₂ plume and pressure front monitoring activities.

Target Formation	Monitoring Activity	Monitoring Location(s)	Spatial Coverage	Frequency
Direct CO₂ Plume and Pressure Front Monitoring				
Mt. Simon Sandstone	Fluid Sampling	MPL INJ1 or MPL OBS1	Mt. Simon Sandstone	Baseline only
	PNL	MPL INJ1 MPL OBS1	Mt. Simon Sandstone, Rome Formation, Conasauga Formation, Kerbel Formation	Annually ¹ Annually ¹
	Downhole pressure	MPL INJ1 MPL OBS1	Above packer (2,820) Above packer (2,807)	Continuous
Indirect CO₂ Plume and Pressure Front Monitoring				
Entire interval	Time-lapse seismic data	Over projected CO ₂ plume	Area sufficient to image modeled CO ₂ plume extent	Every six years (Q1 or Q4)
Entire interval	Passive seismic monitoring	Minimum of five stations	Events within the pressure front	Continuous
¹ Full interval will be monitored until the Mt. Simon Sandstone is saturated with CO ₂ to the upper detection limit at which point PNL will be run from the top of the packer through the ACZ monitoring interval.				

8.1. CO₂ Plume Monitoring Location and Frequency

Baseline fluid samples from the Mt. Simon Sandstone will be collected for analysis during the initial well completion and Pre-operational Testing Program (Attachment 05: Pre-operational Testing Program, 2025). MPL INJ1 and MPL OBS1 will be constructed in such a manner that fluid samples may be collected in the future if necessary. Should fluid samples be collected from the injection zone during the operational life of the project, the parameters to be analyzed and the associated analytical methods are presented in Table 9. Quality assurance procedures for these methods are presented in Attachment 10: Quality Assurance and Surveillance Plan, (2025).

Baseline PNL logs will be acquired in MPL INJ1 and MPL OBS1 prior to the start of injection operations. Once injection starts, PNL logs will be acquired in MPL INJ1 and MPL OBS1 once each year. PNL logs may be acquired in MPL ACZ1 as a contingency monitoring action.

A baseline three-dimensional surface seismic survey will be acquired prior to the start of injection operations. Subsequent time-lapse seismic surveys will be acquired every six years in Q1 or Q4 after injection operations commence.

At this time, no continuous CO₂ plume monitoring has been planned for the project. Likewise, no phased or adaptive monitoring has been planned for the project in terms of expanding the monitoring network. However, if during the re-assessment of the AoR during the injection phase of the project, the AoR is shown to have grown, the Testing and Monitoring Plan will be re-assessed (Attachment 02: AoR and Corrective Action Plan, 2025).

8.2. CO₂ Plume Monitoring Details

Claimed as PBI



8.3. Pressure Front Monitoring Location and Frequency

Table 14 presents the methods that the Maple Project will use to monitor the position of the pressure front; this includes the activities, locations, and frequencies that the project will employ. Quality assurance procedures for these methods have been presented in Attachment 10: Quality Assurance and Surveillance Plan, (2025).

Table 14: Pressure front monitoring activities

Target Formation	Monitoring Activity	Monitoring Location(s)	Spatial Coverage	Frequency
Direct Pressure Front Monitoring				
Mt. Simon Sandstone	Downhole Pressure Monitoring	MPL INJ1	Above packer (2,820)	Continuous
		MPL OBS1	Above packer (2,807)	
Indirect Pressure Front Monitoring				
Entire Interval	Passive Seismic Monitoring	Minimum of five stations	Events within the pressure front	Continuous

The downhole pressure sensors will be programmed to measure and record pressure and temperature readings every 10 seconds. The pressure sensor in the injection well will be set above the packer. The project will start continuously recording pressures in the injection zone in the injection well and the deep observation well when injection operations commence.

Passive seismic data will also be recorded on a continuous basis. Passive seismic monitoring details are discussed in Section 9 *Passive Seismic Monitoring*.

8.4. Pressure Front Monitoring Details

Claimed as PBI

9. Passive Seismic Monitoring

Claimed as PBI

10. Construction of Monitoring Wells

Claimed as PBI

Claimed as PBI

Claimed as PBI

Table 15 provides a summary of the proposed hole sections of MPL OBS1.

Table 15: Hole section diameters and intervals for MPL OBS1.

Section Name	Section Depth (fbgl)	Open Hole Diameter (inches)
Conductor	65	Not Applicable
Surface	695	17 1/2
Long String	2,869	8 1/2
Open hole	3,103	6 1/8

Table 16 provides details on the proposed casing program. It does not provide information on the contingency intermediate casing. Further details and specifications for the casing that will be used, if necessary, are provided in the Injection Well Construction section of the Narrative (Attachment 01: Narrative, 2025) and the Well Construction document (Attachment 04: Injection Well Construction Plan, 2025).

Table 16: Casing and tubing details for MPL OBS1.

Casing String	Casing Depth Shoe Interval (feet)	Borehole Diameter (inches)	External Diameter (inches)	Wall Thickness (inches)	Casing Material	String Weight ¹ (pounds)
Conductor	65	Not Applicable	20	0.438	94 pounds/foot, H-40, STC	6,200
Surface	685	17 1/2	13 3/8	0.38	54.5 pounds/foot, J-55, BTC	37,400
Long String (13Cr)	2,529	8 1/2	7	0.317	23 pounds/foot, 13Cr80, VAM	141,200 ²
Long String (25Cr)	2,859	8 1/2	7	0.408	29 pounds/foot, 25Cr125, VAM	83,000 ²
Tubing	2,807	6.184 ³	2.875	0.308	8.7 pounds/foot, L-80, VAM	24,500 ⁴
Tubing – Tail Joint ⁵	2,869	6.184 ³	2.875	0.308	8.7 pounds/foot, 25Cr110 ⁶ , VAM	500
¹ Rounded up to the nearest 100 lbs ² Total weight for 7-inch string is 141,200 lbs ³ Internal diameter of long string casing ⁴ Evaluated at top of packer (2,809 feet) ⁵ 25Cr tubing will be run below the packer ⁶ Minimum yield strength rating of the tubing will be 110 kilopounds per square inch (ksi).						

Table 17 provides details on the proposed cement system. It does not provide information on the contingency intermediate system. Further details and specifications for the casing that will be used, if necessary, are provided in the Injection Well Construction section of the Narrative (Attachment 01: Narrative, 2025).

Table 17: Cement system details for each hole section.

Casing String	Sacks of Cement	Yield (cubic-feet/sack)	Weight (lbs./ gal)	Cement Class	Additives
Surface	866	1.18	15.6	A	2% calcium chloride + 1/8 pounds/sack polyflake ¹
Long string (lead)	577	1.21	15.5	H	0.8% fluid loss + 1/8 pounds/sack polyflake + 2 pounds/sack coal seal ²
Long string (tail)	63	1.09	16.0	EverCRETE ³ or equivalent	Proprietary
¹ Polyflake is a lost circulation material. ² Coal seal is a lost circulation material. ³ EverCRETE is a mark of slb.					

Table 18 and Table 19 provide details on the design safety factors and resultant safety factor analysis, respectively. The tubing has not been analyzed in Table 19, as it is not anticipated to undergo any major, unbalanced pressure loading scenarios.

Table 18: Casing safety factors for design.

Burst	Collapse	Tensile
1.2	1.2	1.5

Table 19: Casing safety factor loads for design.

String	Pressure Profile		Burst (unitless)	Pressure Profile		Collapse (unitless)	Overpull (pounds, lbs)		Tensile ¹ (unitless)
	Internal	External		Internal	External		Evaluated	Maximum ¹	
Surface	8.5 ppg +800 psi	15.6 ppg +0 psi	2.73	8.5 ppg +0 psi	15.6 ppg +0 psi	4.37	100,000	645,000	6.50
Long String ^{2,3}	8.5 ppg +1,500 psi	15.56 ppg +0 psi	3.38	8.5 ppg +0 psi	15.56 ppg +0 psi	3.35	100,000	284,400	2.62

¹ Based on standard 20% derating factor.
² Average cement weight for string.
³ Utilized lowest rating

Table 20 provides information on the tubing and packer specifications.

Table 20: Tubing and packer setting depth, diameters, and specifications.

Equipment	Setting Depth (feet)	External Diameter (inches)	Tubing Material
Tubing	2,807	2.875	8.7 pounds/foot, internally coated L-80
Tubing – Tail Joint ¹	2,869	2.875	8.7 pounds/ft, 25Cr110 ²
Packer	2,809 ¹	6.184	25Cr for wetted surfaces, Nickel

¹ 25Cr tubing will be run below the packer
² Minimum yield strength rating of the tubing will be 110 ksi.

Table 21 provides the material specifications of the casing, tubing, and packer. The thermal conductivity for this pipe will be approximately 45 Watts/meter*Kelvin.

Table 21: Casing and tubing design parameters.

Material	Setting Depth (feet)	Tensile Strength ¹ (lbs)	80% of Tensile Strength (lbs)	Burst Strength (psi)	80% of Burst Strength (psi)	Collapse Strength (psi)	80% of Collapse Strength (psi)	Material of Construction
Conductor casing	65	581,000	464,800	1,530	1,224	520	416	94 pounds/foot, H-40, STC
Surface casing	685	853,000	682,400	2,730	2,184	1,130	904	54.5 pounds/foot, J-55, BTC
Long string casing (13Cr)	2,529	532,000	425,600	6,340	5,072	3,830	3,064	23 pounds/foot, 13Cr80, VAM
Long string casing (25Cr)	2,859	1,056,000	844,800	13,110	10,488	9,110	7,288	29 pounds/foot, 25Cr125, VAM
Tubing	2,809 ²	198,700	158,960	15,000	12,000	15,300	12,240	8.7 pounds/foot, L-80, VAM
Tubing – Tail Joint ³	2,869	273,200	218,560	20,620	16,496	21,040	16,832	8.7 pounds/foot, 25Cr110 ⁴ , VAM
¹ Lesser of body and joint tensile strength ² Packer setting depth ³ 25Cr tubing will be run below the packer ⁴ Minimum yield strength rating of the tubing will be 110 ksi.								

Table 22 outlines the centralizer program to be utilized for the well. Further details on the determination of the centralizer program are provided in Attachment 01: Narrative, 2025).

Table 22: Centralizer spacing program for MPL OBS1.

Well Name	Hole Section	Centralizer Program ¹
MPL OBS1	Surface	One bow spring (BS) every third joint
	Long String	13Cr Section: One BS every other joint 25Cr Section: One BS every joint
¹ Assumed joint length is 40 feet		

Figure 10 displays a schematic of the proposed well construction for MPL OBS1. Figure 11 and Figure 12 display the schematics of the proposed wellhead for MPL OBS1. Figure 11 displays the wellhead schematic, while Figure 12 displays the wellhead tree schematic.

Following completion and prior to operations, the wellhead tree components would be attached to the rest of the wellhead, resulting in a fully constructed wellhead.

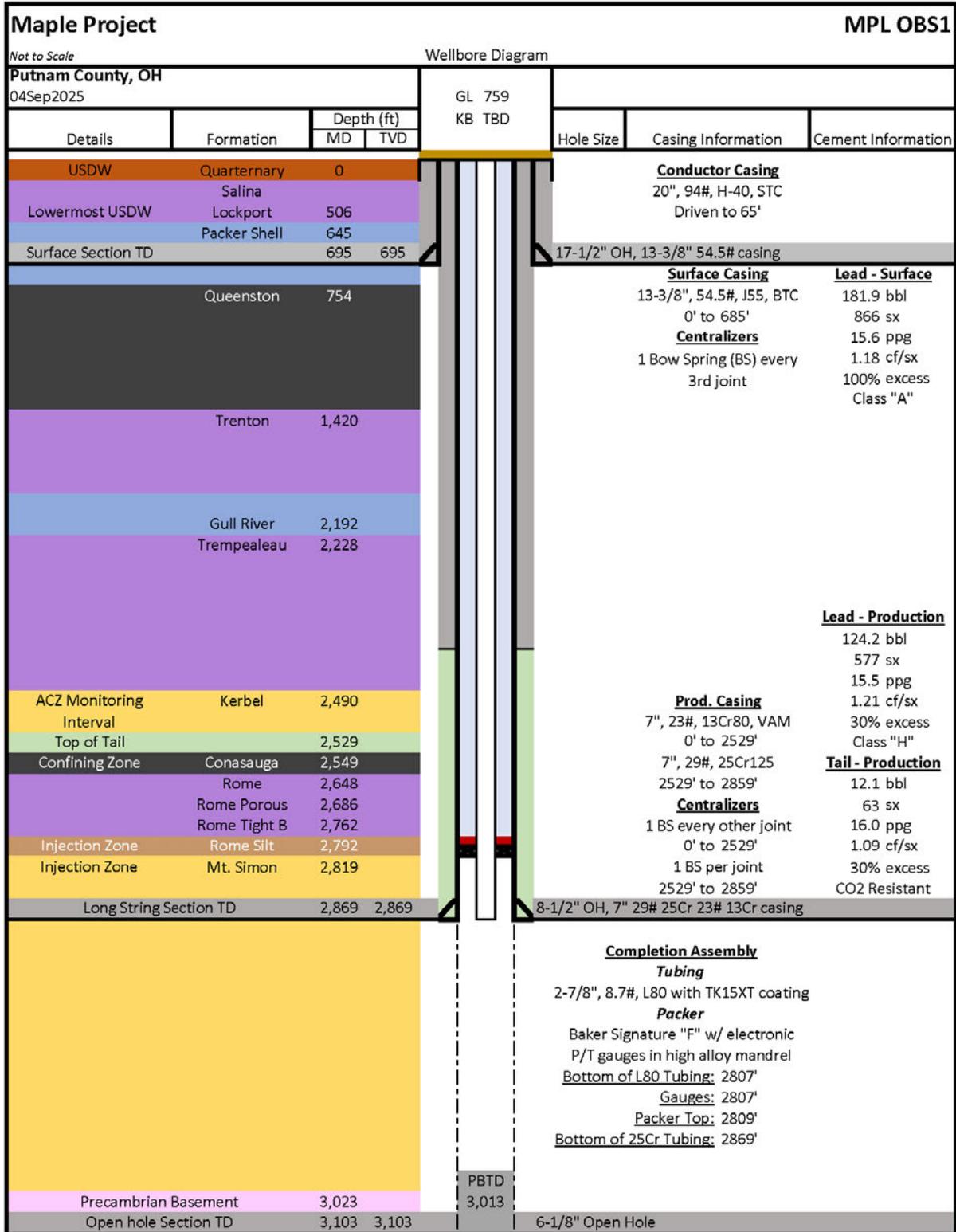


Figure 10: MPL OBS1 well construction proposed schematic (not to scale).

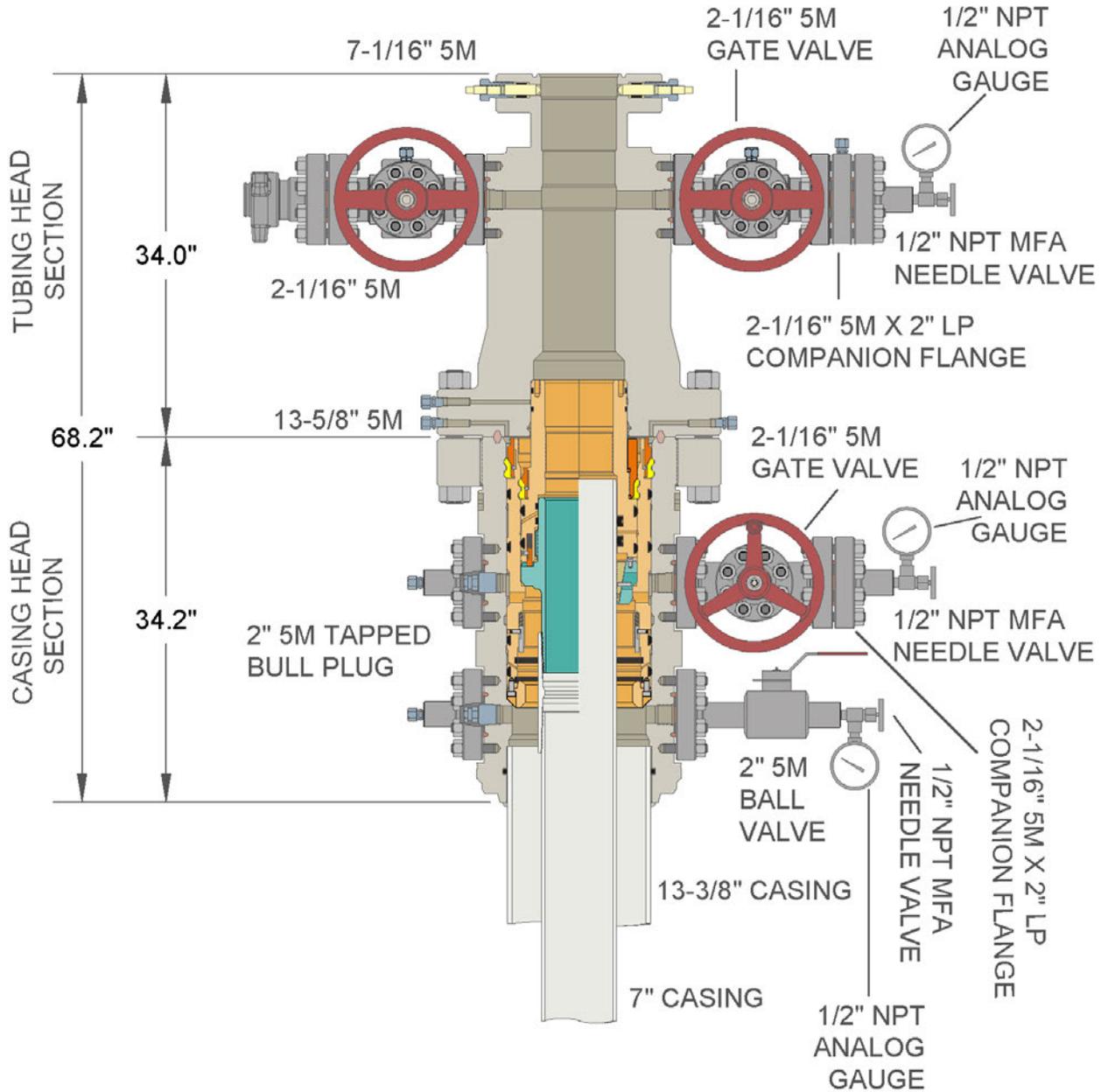


Figure 11: Schematic of the proposed wellhead for MPL OBS1.

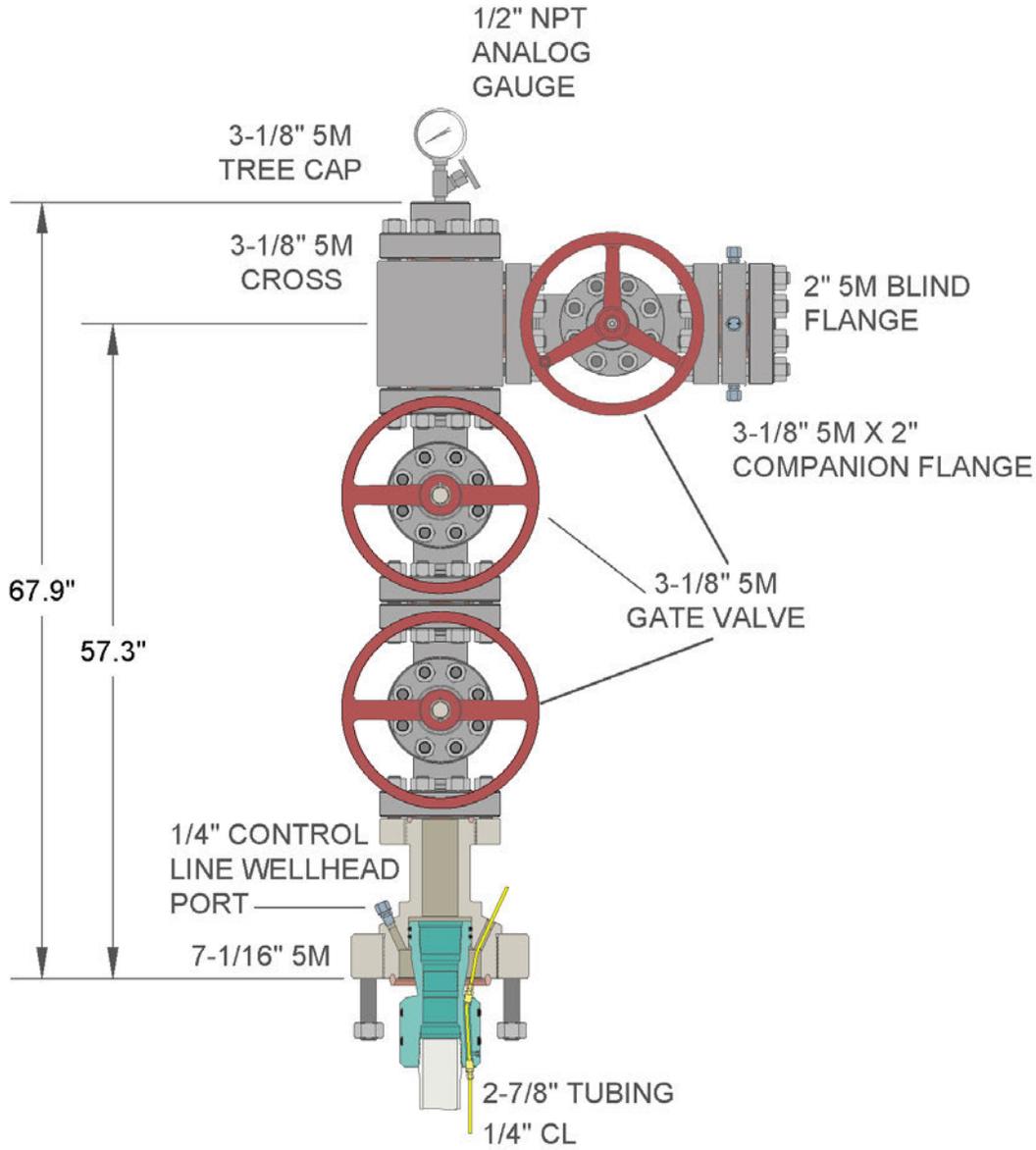


Figure 12: Schematic of the proposed wellhead tree for MPL OBS1.

10.2. MPL ACZ1 Construction Details

The methods used to drill and complete MPL ACZ1 will be similar to those detailed in the Injection Well Construction section of the Project Narrative (Attachment 01: Narrative, 2025) and Section 10.1 *MPL OBS1 Construction Details*. As the well is not expected to come in contact with any of the injected fluids, standard carbon steel and Portland cement are used for the well construction (40 CFR §146.86(b)(1)). **Claimed as PBI**

Table 23 provides a summary of the proposed hole sections of MPL ACZ1.

Table 23: Hole section diameters and intervals for MPL ACZ1.

Section Name	Section Depth (fbgl)	Open Hole Diameter (inches)
Conductor	65	Not Applicable
Surface	685	11
Long String	2,601	6.5

Table 24 provides details on the proposed casing program. It does not provide information on the contingency intermediate casing. Further details and specifications for the casing that will be used, if necessary, are provided in the Injection Well Construction section of the Narrative (Attachment 01: Narrative, 2025).

Table 24: Casing and tubing details for MPL ACZ1.

Casing String	Casing Depth Shoe Interval (feet)	Borehole Diameter (inches)	External Diameter (inches)	Wall Thickness (inches)	Casing Material	String Weight ¹ (pounds)
Conductor	65	Not Applicable	13 3/8	0.38	54.5 pounds/foot, J-55, BTC	3,600
Surface	675	11	8 5/8	0.264	24 pounds/foot, J-55, STC	16,300
Long String	2,591	6.5	4 1/2	0.25	11.6 pounds/foot, L-80, LTC	30,100
Tubing	2,480	4 ²	2.875	0.217	J-55 pounds/foot, J-55, EUE	16,200

¹ Rounded up to the nearest 100 lbs
² Internal diameter of long string casing 2,809

Table 25 provides details on the proposed cement system. Further details and specifications for the cement that will be used are provided in the Injection Well Construction section of the Narrative (Attachment 01: Narrative, 2025).

Table 25: Cement system details for each hole section for MPL ACZ1.

Casing String	Sacks of Cement	Yield (cu-ft/sack)	Weight (lbs./gal)	Cement Class	Additives
Surface	315	1.18	15.6	A	2% calcium chloride + 1/8 pounds/sack polyflake ¹
Long string	690	1.21	15.5	H	0.8% fluid loss + 1/8 pounds/sack polyflake + 2 pounds/sack coal seal ²

¹ Polyflake is a lost circulation material.
² Coal seal is a lost circulation material.

Table 26 and Table 27 provide details about the design safety factors and resultant safety factor analysis, respectively. The tubing has not been analyzed in Table 26 as it is not anticipated to undergo any major, unbalanced pressure loading scenarios.

Table 26: Casing safety factors for design.

Burst	Collapse	Tensile
1.2	1.2	1.5

Table 27: Casing safety factor loads for design for MPL ACZ1.

String	Pressure Profile		Burst (unitless)	Pressure Profile		Collapse (unitless)	Overpull (pounds, lbs)		Tensile ¹ (unitless)
	Internal	External		Internal	External		Evaluated	Maximum ¹	
Surface	8.5 ppg +700 psi	15.6 ppg +0 psi	3.37	8.5 ppg +0 psi	15.6 ppg +0 psi	5.38	100,000	178,900	2.10
Long String	8.5 ppg +1,400 psi	15.5 ppg +0 psi	4.45	8.5 ppg +0 psi	15.5 ppg +0 psi	6.20	100,000	139,500	1.63

¹ Based on standard 20% derating factor.

Table 28 provides information on the tubing specifications.

Table 28: Tubing and packer setting depth, diameters, and specifications for MPL ACZ1.

Equipment	Setting Depth (feet)	External Diameter (inches)	Tubing Material
Tubing	2,480	2.875	6.5 pounds/foot, J-55

Table 29 provides the material specifications of the casing, tubing, and packer. The thermal conductivity for this pipe will be approximately 45 Watts/meter*Kelvin.

Table 29: Casing and tubing design parameters for MPL ACZ1.

Material	Setting Depth (feet)	Tensile Strength ¹ (lbs)	80% of Tensile Strength (lbs)	Burst Strength (psi)	80% of Burst Strength (psi)	Collapse Strength (psi)	80% of Collapse Strength (psi)	Material of Construction
Conductor casing	65	853,000	682,400	2,730	2,184	1,130	904	54.5 pounds/foot, J-55, BTC
Surface casing	675	244,000	195,200	2,950	2,360	1,370	1,096	24 pounds/foot, J-55, STC
Long string casing	2,591	212,000	169,600	7,780	6,224	6,350	5,080	11.6 pounds/foot, L-80, LTC
Tubing	2,480	99,660	79,728	7,260	5,808	7,680	6,144	6.5 pounds/foot, J-55, EUE

¹ Lesser of body and joint tensile strength

Table 30 outlines the centralizer program to be utilized for the well. Further details on the determination of the centralizer program are provided in Attachment 01: Narrative, (2025).

Table 30: Centralizer spacing program for MPL ACZ1.

Well Name	Hole Section	Centralizer Program ¹
MPL ACZ1	Surface	One BS every other joint
	Long String	One BS every 60 feet

¹ Assumed joint length is 40 feet

Figure 13 displays a schematic of the proposed well construction for MPL ACZ1. Figure 14 displays the schematic of the proposed wellhead for MPL ACZ1.

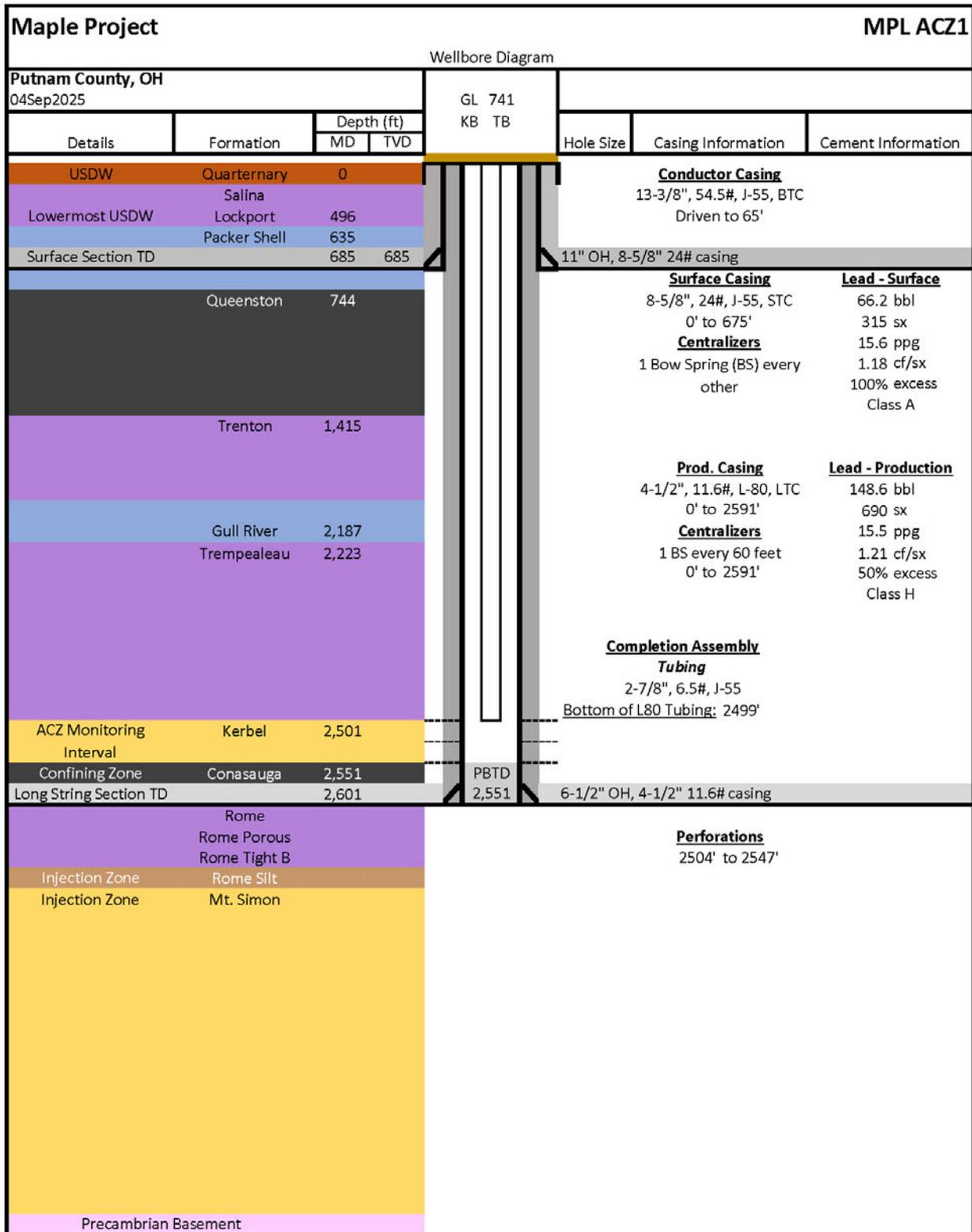


Figure 13: MPL ACZ1 well construction proposed schematic (not to scale).

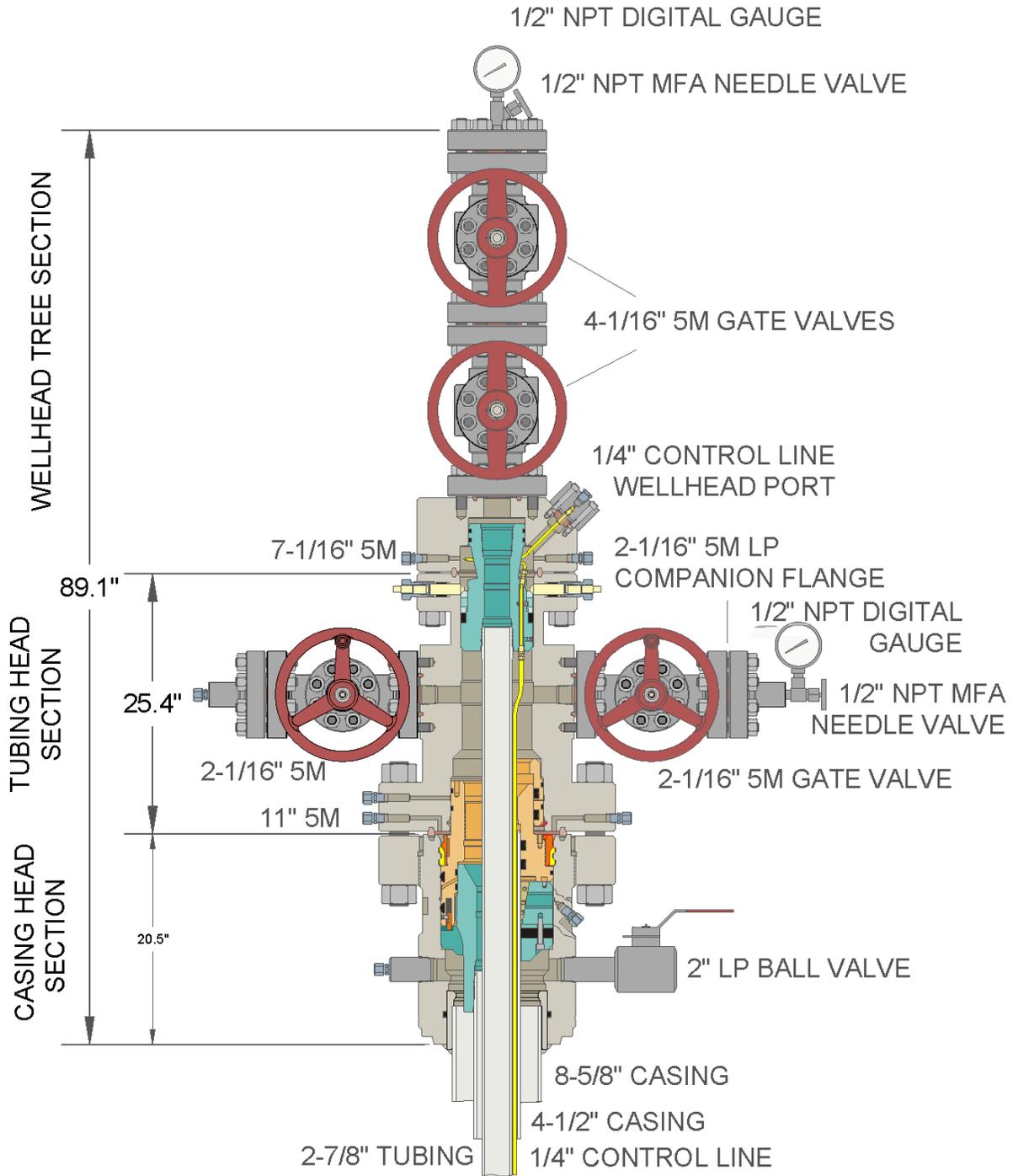


Figure 14: Schematic of the proposed wellhead for MPL ACZ1.

10.3. MPL USDW1 Construction Details

Construction methods and materials for the shallow MPL USDW1 will be consistent with those utilized for local shallow groundwater wells. The materials of construction are likely to include non-API tubulars (non-steel tubulars) such as PVC pipe, non-API grade cement and/or bentonite, as well as plastic screens or lines. Full detail on the construction of USDW1 will be provided to the EPA prior to any well installation activities. Further detail on the construction of the well will be provided to the Agency prior to any well installation activities. Figure 15 displays a schematic of the proposed well construction for MPL USDW1.

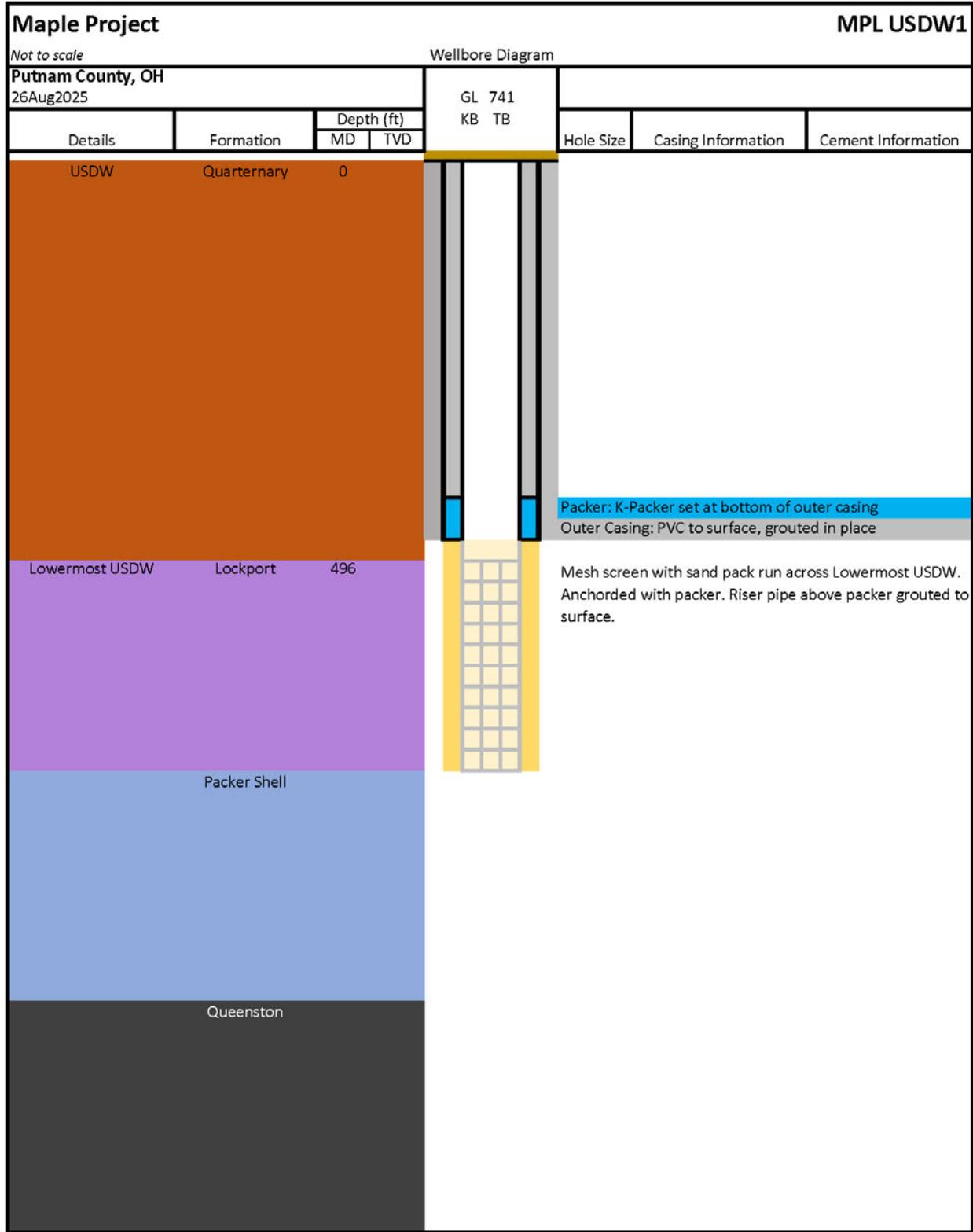


Figure 15: MPL USDW1 well construction schematic (not to scale).

11. References

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- Attachment 04: Injection Well Construction Plan, 2025, Underground Injection Control Class VI Permit Application: Maple.
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