POST-INJECTION SITE CARE AND SITE CLOSURE PLAN
40 CFR 146.93(a)

One Earth CCS

Facility Information

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OES #1

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Well locations: McLean County, IL
40.845427°N, -88.480010°W (NAD 1983)

This Post-Injection Site Care and Site Closure (PISC) plan describes the activities that One Earth Sequestration, LLC will perform to meet the requirements of 40 CFR 146.93. One Earth Sequestration, LLC will monitor ground water quality and track the position of the carbon dioxide plume and pressure front for 10 years after the end of injection operations. One Earth Sequestration, LLC may not cease post-injection monitoring until a demonstration of non-endangerment of USDWs has been approved by the UIC Program Director pursuant to 40 CFR 146.93(b)(3). Following approval for site closure, One Earth Sequestration, LLC will plug all monitoring wells, restore the site to its original condition, and submit a site closure report and associated documentation.

Pre- and Post-Injection Pressure Differential [40 CFR 146.93(a)(2)(i)]

The predicted CO_2 saturation plume and pressure front at the end of injection operations are shown in Figure 1. A differential (threshold) pressure of 86 psi is used to define the pressure boundary for the AoR. Based on the modeling of the differential pressure front, the formation pressure at the injection wells is predicted to decline rapidly following cessation of injection. Additional information on the projected post-injection pressure decline and differentials is presented in the permit application modeling discussion and in the Area of Review and Corrective Action Plan. Figure 2 shows a pressure profile of the injection wells through the end of the injection phase and through 50 years post-injection. As Figure 2 demonstrates, the pressure differential at the injection wells decreases to less than threshold pressure in approximately 6 years after the end of injection operations.

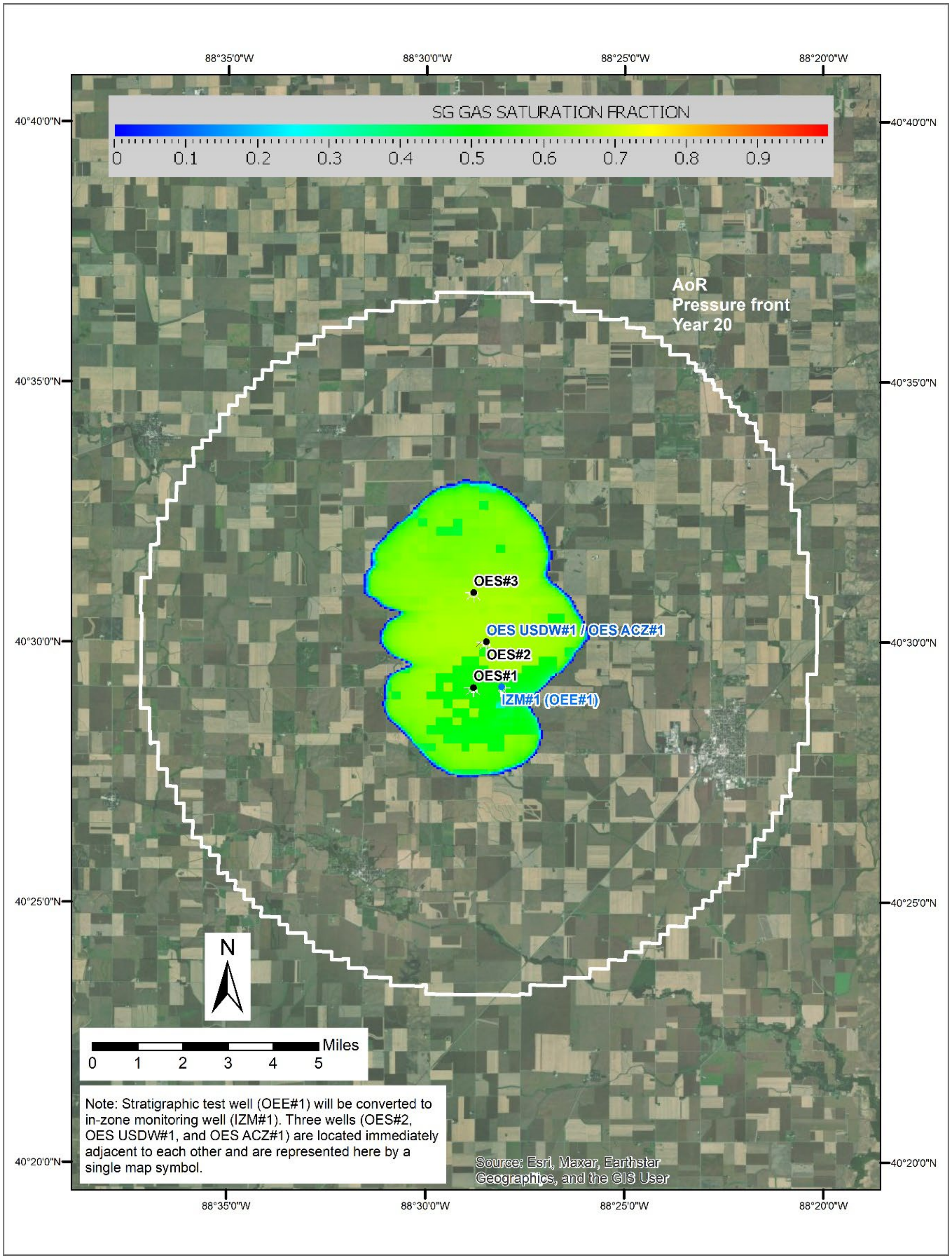

Figure 1. *One Earth CCS map of the predicted extent of the CO_2 plume and pressure front at the end of injection operations.*

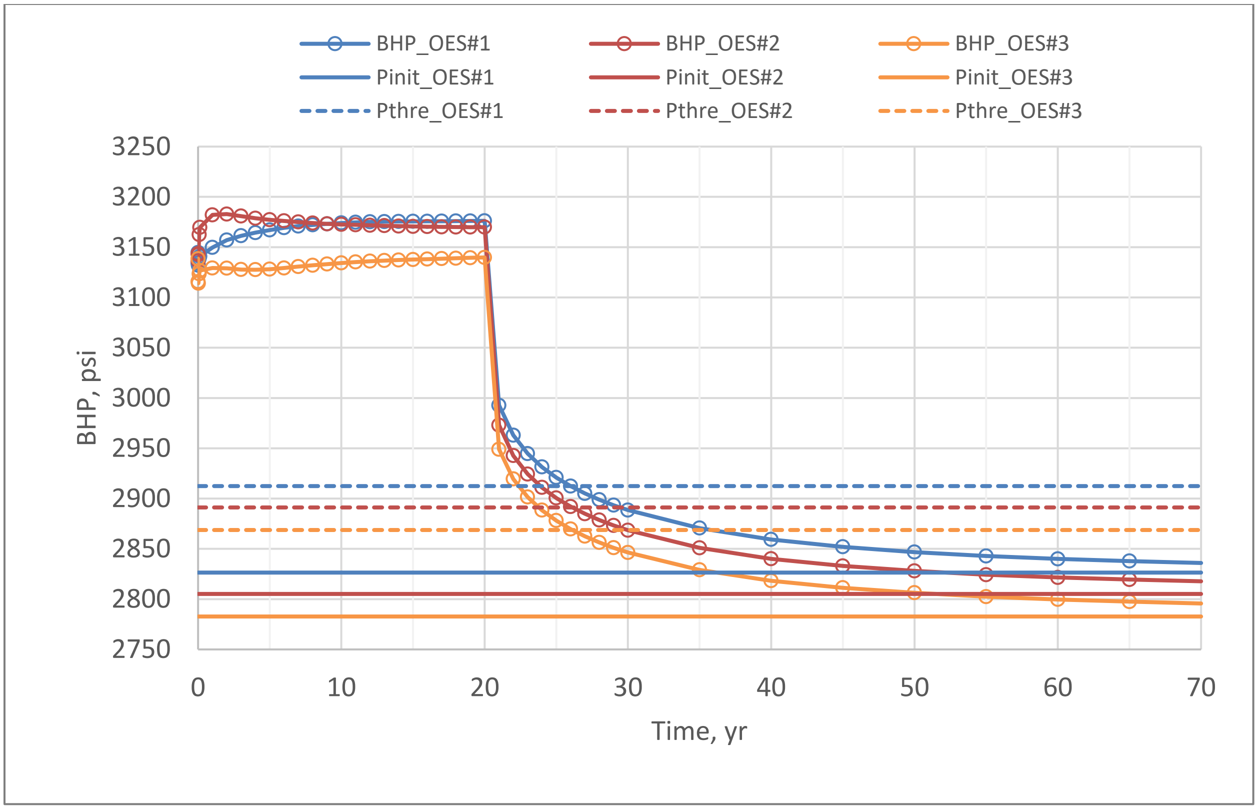

Figure 2. *Pressure profile for injection wells. Dashed lines represent baseline pressure differential (threshold pressure) datum for defining AoR. Solid lines represent formation baseline pressure.*

Predicted Position of the CO_2 Plume and Associated Pressure Front at Site Closure [40 CFR 146.93(a)(2)(ii)]

Figure 1 shows the predicted extent of the plume and pressure front at the end of the injection operations. This map is based on the final AoR delineation modeling results submitted pursuant to 40 CFR 146.84.

Figure 3 shows the predicted position of the CO_2 plume 10 years after the end of injection operations. This map is based on the final AoR delineation modeling results pursuant to 40 CFR 146.84. The figures demonstrate the stability of the CO_2 plume during the PISC phase.

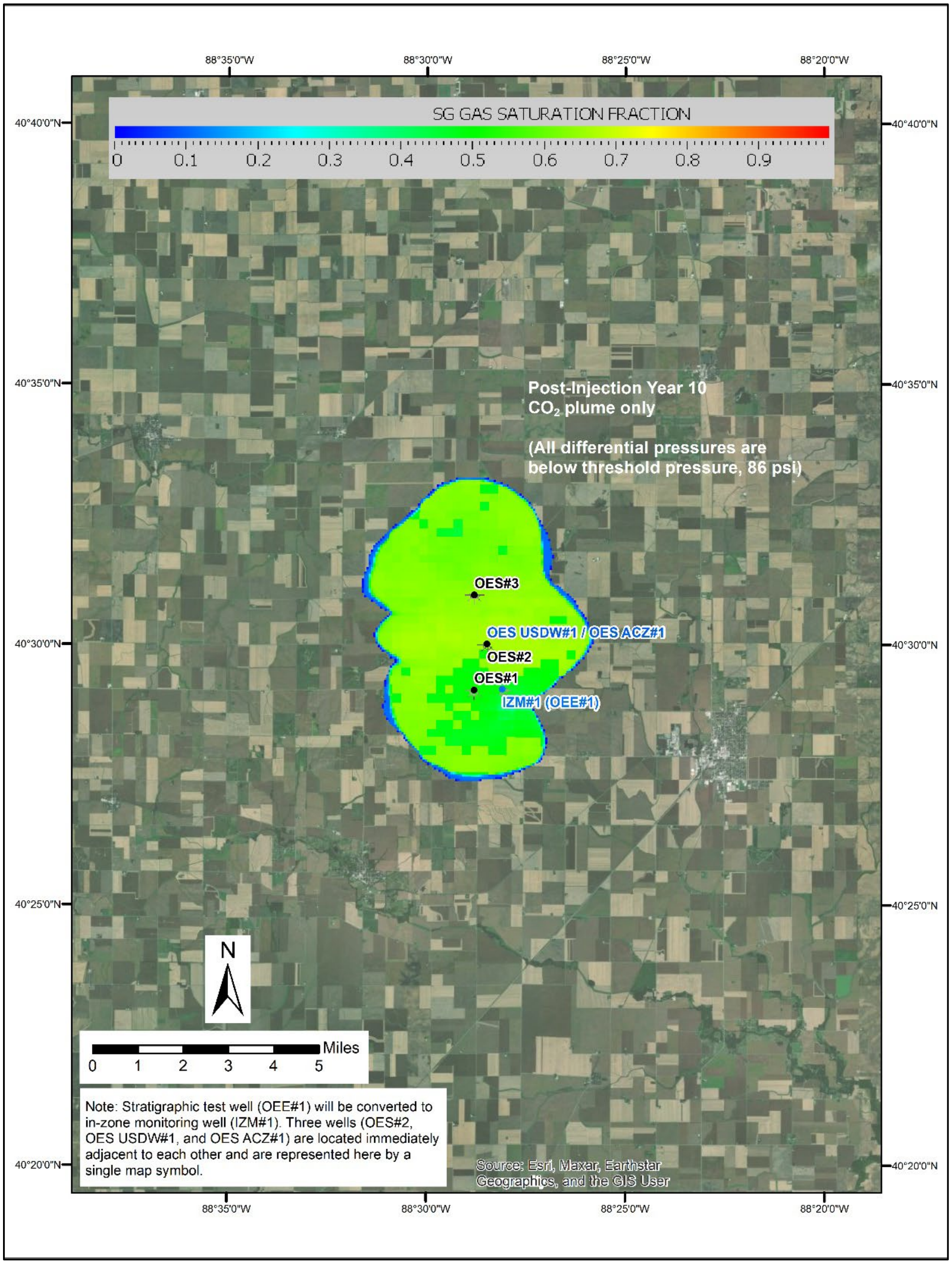

Figure 3. *Monitoring locations and predicted position of CO_2 plume 10 years after the end of injection operations.*

Post-Injection Monitoring Plan [40 CFR 146.93(b)(1)]

Performing groundwater quality monitoring and plume and pressure front tracking as described in the following sections during the post-injection phase will meet the requirements of 40 CFR 146.93(b)(1). The results of all post-injection phase testing and monitoring will be submitted annually, within 60 days after the anniversary of the date on which injection ceased, as described under "Schedule for Submitting Post-Injection Monitoring Results," below.

A quality assurance and surveillance plan (QASP) for all testing and monitoring activities during the injection and post injection phases is provided in the Appendix to the Testing and Monitoring Plan.

To date, One Earth Sequestration, LLC has successfully negotiated surface land access for purposes of drilling the stratigraphic well, and pre-injection (baseline) monitoring activities such as 2D and 3D seismic testing. One Earth Sequestration, LLC's proven ability to work with local landowners and public entities to obtain access to surface and subsurface areas for activities related to the project should be sufficient to demonstrate One Earth Sequestration, LLC's ability to obtain access for monitoring, and corrective actions (if they are necessary) in the future. One Earth Sequestration, LLC may acquire, by lease or purchase, additional land parcel areas and surface entry rights for the injection, monitoring, and surface and sub-surface infrastructure. Monitoring well locations could change slightly but only to the extent that they retain their monitoring intent as described in the Testing and Monitoring Plan and QASP. Monitoring locations will also consider access routes that minimize property damage, crop loss, and property owner inconvenience, and to assure safe access to each location.

Table 1 provides a summary of PISC monitoring activities. Figure 1 shows the location of the injection and monitoring wells.

The project will continue to monitor the well integrity of the injection and in zone monitoring (IZM) wells annually using temperature, noise, or oxygen activation logs to ensure that there is no migration of CO_2 up the wellbores. In addition, the project will monitor the annular pressures and fluid volumes in the injection well on a continuous basis until the well is plugged and abandoned. Refer to the Well Operations Plan and the Testing and Monitoring Plan for more information on the well integrity and operational monitoring plans.

Pulsed neutron (PNC) logging will continue in the IZM and the above confining zone (ACZ) monitoring wells each year of the PISC phase. This will allow the project to continue to observe the vertical plume development in the Mt. Simon Sandstone and further verify that CO_2 is not migrating past the confining zone and into ACZ aquifers; thereby endangering underground sources of drinking water (USDWs). Refer to the Testing and Monitoring Plan for more information on the PNC logging plans in the injection phase of the project (Permit Sections 7.0).

The project will continue to monitor pressures within the injection well until it is abandoned. The injection well pressure measurements are expected to verify the pressure decrease, and these data will be used to history match the computational modelling in the PISC phase.

Pressures will also continue to be monitored in the ACZ wells including the Ironton-Galesville Sandstone and the St. Peter Sandstone to confirm the continued containment of CO_2 within the

storage formation. Fluid samples will be taken from OES ACZ#1 and OES USDW#1annually for geochemical and isotopic analysis to further verify CO_2 containment.

The possibility of induced seismicity is expected to decline rapidly during the post-injection period. DAS system monitoring will continue for 5 years post-injection in the monitoring wells and in the injection wells until they are plugged and abandoned. The UIC Program Director will be notified prior to discontinuing data acquisition in the DAS.

The project proposes to acquire two time-lapse 2D surface seismic surveys in the PISC phase of the project. One will be acquired within five years of the most recent injection operations survey; the second within 9 years after the end of injection. The objectives of the surveys include:

- Demonstrate the stability of the CO_2 plume after the injection phase of the project
- Provide data for the calibration and verification of computational modelling
- Demonstrate non-endangerment of USDWs at the end of the PISC phase.

Table 1. *Summary of PISC monitoring.*

Monitoring Activity	Post-injection Phase Frequency	Location
	Injection Wells	
Annular Pressure	Continuous until P&A	Injection Wellhead
Annular Fluid Volume	Continuous until P&A	Injection Wellhead
Temperature or Noise or Oxygen Activation Log	Annually until P&A	Injection Well
DTS, DAS	Continuous until P&A	Injection Well Downhole, above perforations
Pulsed Neutron Logging	Annual until P&A	Injection Well
	Verification Monitoring	
Fluid Sampling and Analysis		
St. Peter sandstone	Annually	ACZ well
Ironton Galesville formations	Annually	ACZ Well
Mt. Simon	Annually*	IZM Wells
Isotope Analysis	Annually*	ACZ and IZM wells
Pressure, DTS, DAS		
St. Peter Sandstone	Continuous	ACZ well
Ironton Galesville formations	Continuous	ACZ well
IZM Mt. Simon Sandstone	Continuous	IZM wells
Pulsed Neutron Logging	Annually	IZM Wells
Time-lapse 2D Surface Seismic Data	Initial PISC survey 5 years from most recent. Additional PISC survey within 9 years after end of injection	Surface

*Fluid samples will not be collected in the IZM wells if there is breakthrough of CO_2 at the well location.

Monitoring Above the Confining Zone

Groundwater Quality Monitoring

Table 2 presents the monitoring methods, locations, and frequencies for monitoring above the confining zone. Table 2 identifies the parameters to be monitored and the analytical methods One Earth Sequestration, LLC will employ. This includes lowermost USDW (St. Peter Sandstone), and from above confining zone well (Ironton-Galesville). Table 3 identifies the parameters to be monitored and the analytical methods One Earth Sequestration, LLC will employ, and Figure 3 shows the locations of the monitoring wells.

Table 2. *Monitoring above the confining zone* [(1, 2)].

Target Formation	MonitoringActivity	Monitoring Location(s)	Frequency
Lowermost USDW (St. Peter Sandstone)	Fluid sampling	OES USDW#1	Annual
	Pressure/ DTS monitoring	OES USDW#1	Continuous
	PNC Logging	OES USDW#1	Annual
Above Confining Zone (Ironton-Galesville)	Fluid sampling	OES ACZ#1	Annual
	Pressure/ DTS monitoring	OES ACZ#1	Continuous
	PNC Logging	OES ACZ#1	Annual

Note 1: Collection and recording of continuous monitoring data will occur at the frequencies described in Table 4.

Note 2: Annual sampling and monitoring will occur up to 45 days before the anniversary date of cessation of injection or alternatively scheduled with the prior approval of the Director.

Table 3. *Summary of analytical and field parameters for ground water samples.*

Parameters	**Analytical Methods** [(1)]
Cations: Al, Ba, Mn, As, Cd, Cr, Cu, Pb, Sb Se, and Tl	ICP-MS, EPA Method 6020
Cations: Ca, Fe, K, Mg, Na, and Si	ICP-OES, EPA Method 6010B
Anions: Br, Cl, F, NO3, and SO_4	Ion Chromatography, EPA Method 300.0
Dissolved CO_2	Coulometric titration, ASTM D513-11
Isotopes: $\delta^{13}C$ of DIC	Isotope ratio mass spectrometry
Total Dissolved Solids	Gravimetry; APHA 2540C
Water Density (field)	Oscillating body method
Alkalinity	APHA 2320B
pH (field)	EPA 150.1
Specific conductance (field)	APHA 2510
Temperature (field)	Thermocouple

Note 1: ICP = inductively coupled plasma; MS = mass spectrometry; OES = optical emission spectrometry; GC-P =gas chromatography - pyrolysis. An equivalent method may be employed with prior approval of the Director.

A quality assurance and surveillance plan (QASP) for all testing and monitoring activities, required pursuant to 146.90(k), is provided as an Appendix to the Testing and Monitoring Plan.

Sampling will be performed as described in Section B.2 of the QASP; this section of the QASP describes the groundwater sampling methods to be employed, including sampling standard operating procedures (SOPs) (Section B.2 a/b), and sample preservation (Section B.2.f).

A qualified, commercial laboratory will be selected to provide analytical services in accordance with the methods and standards included here and in the QASP. Sample handling and custody will

be performed as described in Section B.3 of the QASP. Quality control will be ensured using the methods described in Section B.5 of the QASP: Carbon Dioxide Plume and Pressure Front Tracking [40 CFR 146.93(a)(2)(iii)].

One Earth Sequestration, LLC will employ direct and indirect methods to track the extent of the carbon dioxide plume and the presence or absence of elevated pressure.

Table 4 presents the in zone monitoring that One Earth Sequestration, LLC will use to monitor the CO_2 plume, including the activities, locations, and frequencies. The parameters to be analyzed as part of fluid sampling in the Mt. Simon sandstone (and associated analytical methods) are presented in Table 3.

Table 4 includes the direct and indirect methods that One Earth Sequestration, LLC will use to monitor the pressure front, including monitoring activities, locations, and frequencies. One Earth Sequestration, LLC will deploy pressure/temperature monitors and distributed temperature and acoustic sensors to directly monitor in zone and above zone conditions. Quality assurance procedures for seismic monitoring methods will meet industry standards and will be established for the project at the time seismic acquisition and processing contractors are selected.

A quality assurance and surveillance plan (QASP) for all testing and monitoring activities, required pursuant to 146.90(k), is provided as an Appendix to the Testing and Monitoring Plan.

Sampling will be performed as described in Section B.2 of the QASP; this section of the QASP describes the groundwater sampling methods to be employed, including sampling standard operating procedures (SOPs) (Section B.2 a/b), and sample preservation (Section B.2.f).

A qualified, commercial laboratory will be selected to provide analytical services in accordance with the methods and standards included here and in the QASP. Sample handling and custody will be performed as described in Section B.3 of the QASP. Quality control will be ensured using the methods described in Section B.5 of the QASP.

__Table 4.__ Post-injection phase plume and pressure front monitoring.

Target Formation	Monitoring Activity	Monitoring Location(s)	Spatial Coverage	Frequency
Mt. Simon	Fluid sampling	IZM #1 IZM #2		Annual
	Pressure/ DTS monitoring	IZM #1, IZM #2		Continuous
		OES #1, OES #2, OES #3		Continuous until P&A
	Pulse Neutron Logging	IZM #1 IZM #2		Annual
		OES #1		Annual until P&A
		OES #2		Annual until P&A
		OES #3		Annual until P&A
	2D seismic survey	AOR Surface		Initial PISC survey 5 years from most recent. Additional PISC survey within 9 years after end of injection

Sampling and geophysical surveys will occur within 60 days before the anniversary date of cessation of injection or alternatively scheduled with the prior approval of the Director. Seismic surveys will be performed in the 4th quarter before, or the 1st quarter of the year or alternatively scheduled with the prior approval of the Director.

Subsurface monitoring locations relative to the predicted location of the CO_2 plume and pressure front at 10 years after the end of injection operations are shown in Figure 3.

Schedule for Submitting Post-Injection Monitoring Results [40 CFR 146.93(a)(2)(iv)]

All post-injection site care monitoring data and monitoring results collected using the methods described above will be submitted to the Director in annual reports. These reports will be submitted annually, within 60 days following the anniversary date of the date on which injection ceases or alternatively with the prior approval of the Director.

The reports will contain information and data generated during the reporting period, i.e., well-based monitoring data, sample analysis, and the results from updated site models.

Alternative Post-Injection Site Care Timeframe [40 CFR 146.93(c)]

One Earth Sequestration, LLC will conduct post-injection monitoring for 10 years following the cessation of injection operations. One Earth Sequestration, LLC will demonstrate that an alternative PISC timeframe is appropriate, pursuant to 40CFR 146.93(c)(1). Regardless of the alternative PISC timeframe, monitoring and reporting as described in the sections above will continue until One Earth Sequestration, LLC demonstrates, based on monitoring and other site-specific data, that no additional monitoring is needed to ensure that the project does not pose an endangerment to any USDWs, per the requirements at 40 CFR 146.93(b)(2) or (3).

One Earth Sequestration, LLC will conduct all of the monitoring described under "Groundwater Quality Monitoring" and "Carbon Dioxide Plume and Pressure Front Tracking" above and report the results as described under the "Schedule for Submitting Post-Injection Monitoring Results."

If any of the information on which the demonstration was based changes or the actual behavior of the site varies significantly from modeled predictions (e.g., because of an AoR reevaluation) One Earth Sequestration, LLC may update this PISC and Site Closure Plan pursuant to 40 CFR 146.93(a)(4). If revisions are required, One Earth Sequestration, LLC will update the PISC and Site Closure Plan within six months of reporting the unexpected monitoring results

A summary of all previous monitoring data collected at the site, pursuant to the Testing and Monitoring Plan and this PISC and Site Closure Plan, including data collected during the injection and PISC phases of the project, will be submitted to help demonstrate non-endangerment. Data submittals will be in a format acceptable to the Director [40 CFR 146.91(e)], and will include a narrative explanation of monitoring activities, including the dates of all monitoring events, changes to the monitoring program over time, and an explanation of all monitoring infrastructure that has existed at the site. Data will be compared with baseline data collected during site characterization [40 CFR 146.82(a)(6) and 146.87(d)(3)].

Computational Modeling Results – 40 CFR 146.93(c)(1)(i)

The results of computational modeling used for AoR delineation and for demonstration of an alternative PISC timeframe will be compared to monitoring data collected during the operational and the PISC period. The data will include the results of time-lapse temperature and pressure monitoring, groundwater quality analyses, seismic monitoring, and geophysical surveys (i.e., logging, operating-phase 2D surface seismic surveys) used to update the computational model and to monitor the site. Data generated during the PISC period will be used to help show that the computational model accurately represents the storage site and can be used as a proxy to determine the plume's properties and size. The operator will demonstrate this degree of accuracy by comparing the monitoring data obtained during the PISC period against the model's predicted properties (i.e., plume location, rate of movement, and pressure decay). Statistical methods will be employed to correlate the data and confirm the model's ability to accurately represent the storage site. The validation of the computational model with the large volume of available data will be a significant element to support the non-endangerment demonstration.

Modeling scenarios, including sensitivity analysis and evaluation of the post-injection phase of the project are discussed in detail in the AoR and Corrective Action Plan.

As part of the modeling, two major CO_2 trapping mechanisms were considered: structural/stratigraphic trapping, and residual trapping. Solubility trapping was not modeled due to a limitation in software; however, the modeled plume size and resulting AoR are larger than if solubility trapping was included as some CO_2 will dissolve into the formation water (Mehnert et al., 2014). The solubility trapping of CO_2 in water may be included during AoR reevaluations and in the post-injection site care updates. Mineral trapping was considered negligible because the storage unit is primarily quartz. These processes allow the prediction of CO_2 movement in terms of gas saturation, reservoir pressure change with time to delineate the Area of Review (AoR), and the corresponding tubing head pressure during and after injection.

Structural/stratigraphic trapping for the post-injection period, along with sensitivity to variations in porosity and permeability were also considered in the site model (see AoR and Corrective Action Plan). A summary of these results by AoR extent is shown in Figure 4.

Data collected during drilling of the injection wells will provide an opportunity to further refine modeling with site-specific injection well borehole data. These data will be used to update the computational model. In addition, downhole pressure monitoring during and after injection can provide near-continuous information to compare the predicted and actual pressure response to CO_2 injection. These data will be used to recalculate the AoR as new data is incorporated for reevaluation. A summary of the schedule for model updates is included in the AoR and Corrective Action Plan.

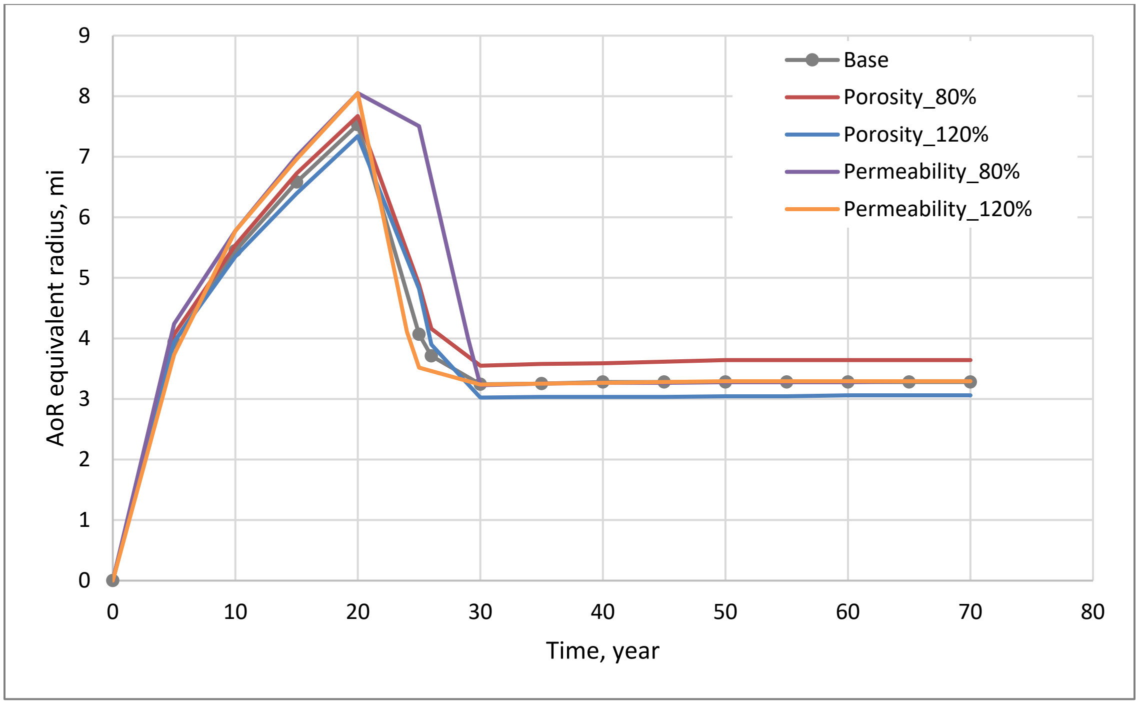

Figure 4. *Area of Review equivalent radius change over time at varying porosity and permeability.*

Predicted Timeframe for Pressure Decline – 40 CFR 146.93(c)(1)(ii)

Figure 5 and Table 5 summarize the CO_2 plume, differential pressure, and AoR evolution with time. The CO_2 plume radius increased from 3.2 (5.1 kilometers) miles at the end of injection to 3.3 miles (5.3 kilometers) at 50 years post injection.

Differential pressure radius reached its maximum of 7.5 miles (12.1 kilometers) at the end of injection, dropped to 3.2 miles (5.1 kilometers) at 6 years post injection and 1 mile (1.6 kilometers) at 7 years post injection, and then diminished within 8 years post injection to below the established critical threshold. The AoR was determined solely by the differential pressure front until 5 years post injection, with a maximum radius of 7.5 miles (12.1 kilometers) at the end of injection.

A comparison of the pressure time series from the sensitivity analysis demonstrates that the that the pressure build-up during the injection phase and rapid decline during the PISC phase are similar to base case for a range of geologic parameters (Figure 4).

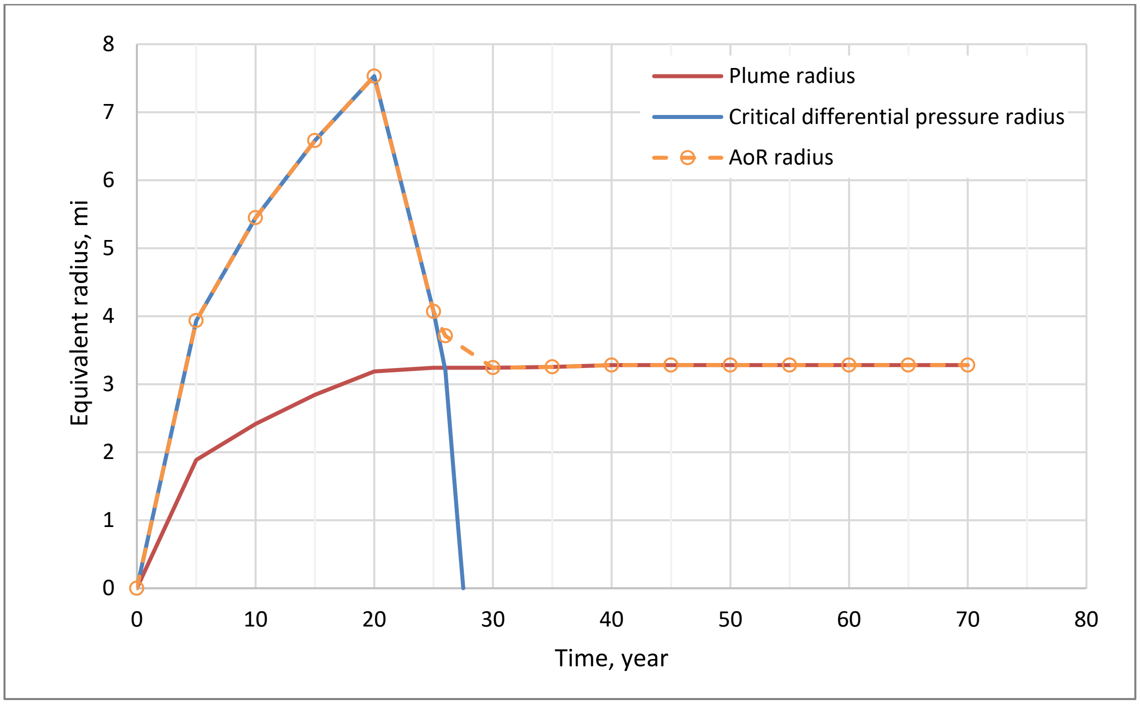

Figure 5*. Equivalent radius of plume, differential pressure, and AoR change with time.*

Table 5*. Summary of plume size, differential pressure radius, and AoR change with time.*

Time, yr.		CO_2 plume size			Differential pressure equivalent radius, mi	AoR	
		Plume equivalent radius, mi	Width, mi	Length, mi		AoR equivalent radius, mi	AoR, mi^2
Injection	5	1.9	2.5	4.5	3.9	3.9	49
	10	2.4	3.5	5.3	5.4	5.4	93
	15	2.8	4.3	6.0	6.6	6.6	136
	20	3.2	4.9	6.5	7.5	7.5	178
Post injection	5	3.2	5.0	6.6	4.1	4.1	52
	6	3.2	5.0	6.6	3.2	3.7	43
	10	3.2	5.0	6.6	0.0	3.2	33
	50	3.3	5.1	6.7	0.0	3.3	34

Continuous pressure measurements will be acquired from the Mt. Simon Sandstone though the injection and PISC phases of the project (see Testing and Monitoring Plan). The pressure data obtained during the injection phase of the project will be used to update the computational modelling every six months as per the reporting requirements in 40 CFR 146.91. Pressure data

acquired during the PISC phase of the project is expected to verify the rapid decline in pressure in the Mt. Simon Sandstone predicted by the computational modelling.

Predicted Rate of Plume Migration – 40 CFR 146.93(c)(1)(iii)

At 6 years post injection, the AoR radius diminished to 3.6 miles (5.8 kilometers) and was established by the plume boundary and pressure differential front (Figure 6). By 7 years post injection, the differential pressure front has further diminished such that it is situated within the lateral extent of the CO_2 plume. The site modeling shows that the CO_2 plume will expand slightly during the PISC period from 3.2 miles (5.1 kilometers) at the end of injection to 3.3 miles (5.3 kilometers) 50 years after injection ceases (Table 5).

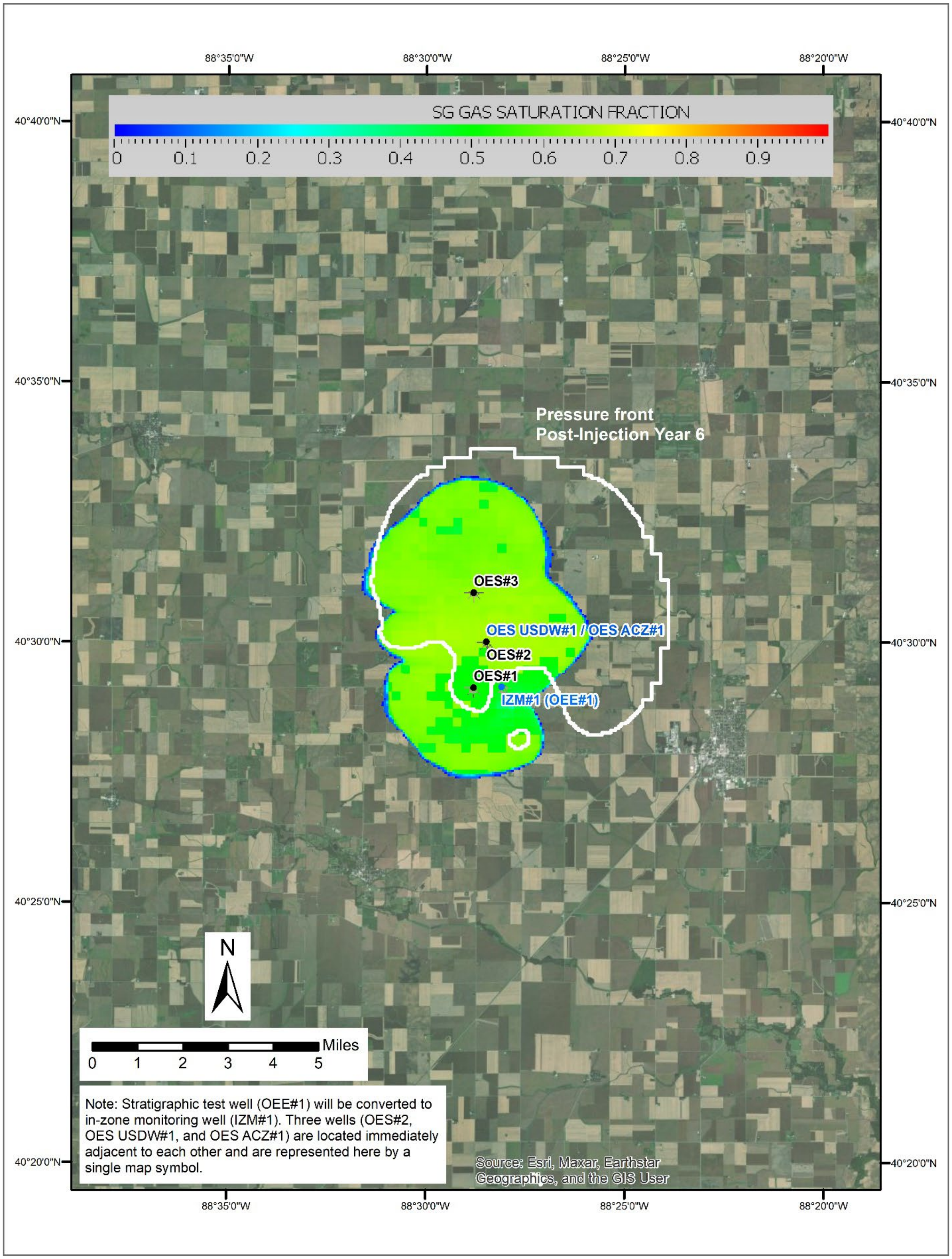

Figure 6*. Pressure differential and plume boundary 6 years post injection.*

Figure 7 shows the time-series distance between the plume front and the in-zone monitoring well IZM #1, converted from OEE #1, in all four cardinal directions. At the end of 20 years of injection, the plume front in relation to IZM #1 was 3.0 miles (4.8 kilometers) west, 1.9 miles (3.1 kilometers) east, 4.5 miles (7.2 kilometers) north, and 2.0 miles (3.2 kilometers) south. The plume migrated in all directions after injection but stopped migrating to the west and south 5 years post injection and to the east and the north 20 years post injection. At 50 years post injection, the plume had migrated to 3.1 miles (4.9 kilometers) west, 2.0 miles (3.2 kilometers) east, 4.7 miles (7.6 kilometers) north, and 2.0 miles (3.2 kilometers) south of IZM #1.

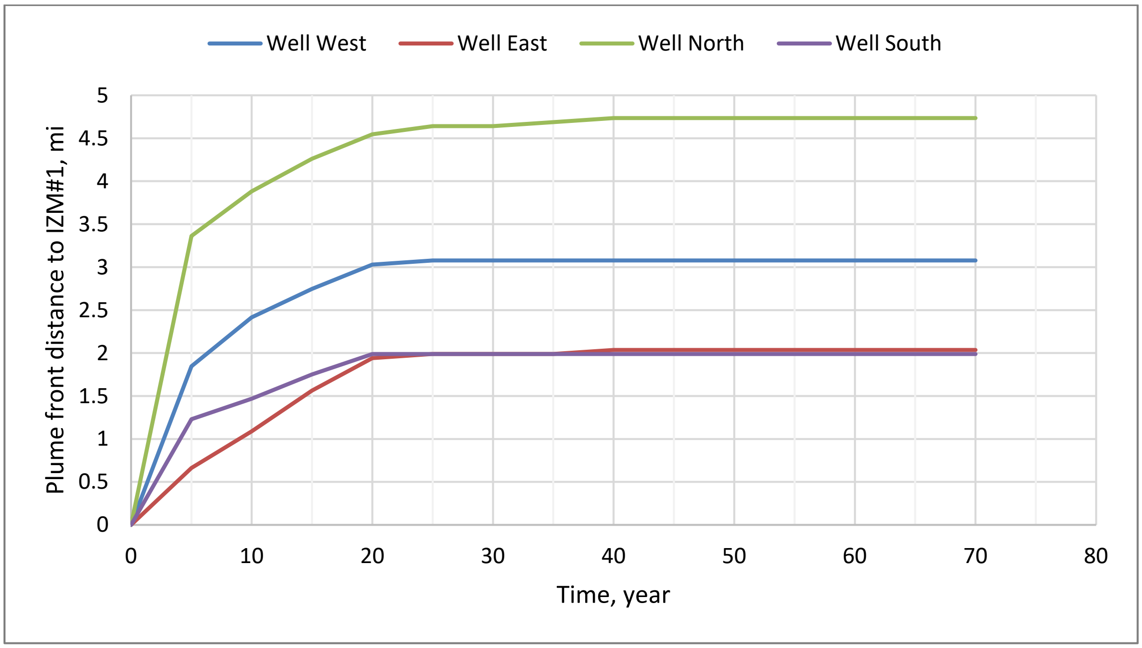

***Figure** 7. Plume front distance from in-zone monitoring well IZM #1 (OEE #1 converted) over time, based on a 1% CO_2 saturation cutoff*

The CO_2 plume height is highest at the injectors. During injection, the plume is confined within the Lower Mt. Simon (LMS) at OES #2 and OES #3 but reaches the bottom portion of the Middle Mt. Simon (MMS) at OES #1. At 50 years post injection (Figure 8), the plume remains within or below the MMS. At this point, there is no further horizontal or vertical expansion of the CO_2 plume. Additional discussion is provided in the Narrative and in the AoR and Corrective Action Plan.

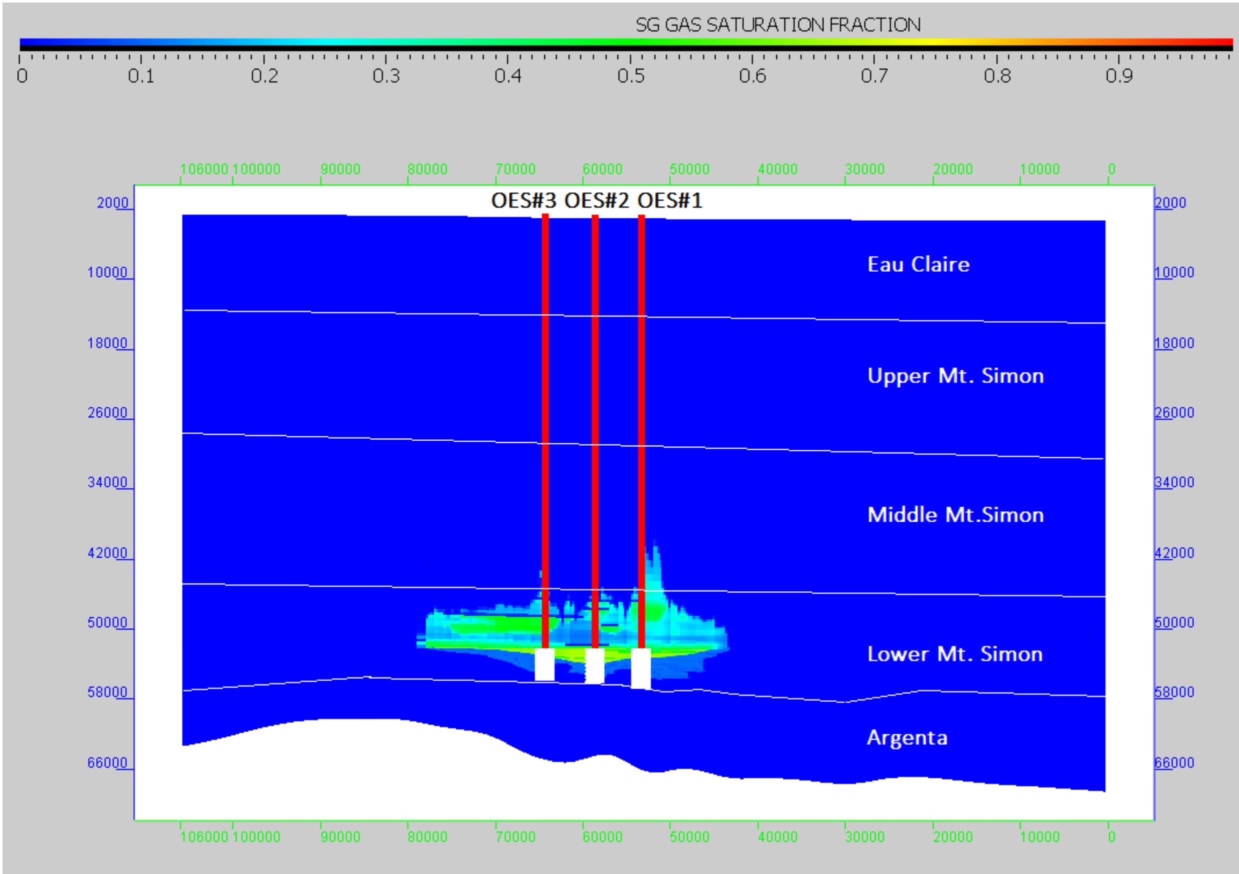

Figure 8. *Cross-sectional view of CO_2 saturation at 50 years post injection. Blue background in cross-sectional view shows the model area.*

A combination of time-lapse pulsed neutron logs and 2D seismic surveys will be used to locate and track the extent of the CO_2 plume. The series of pulsed neutron logs collected in the Mt. Simon interval during the operational and post-injection phases of the project will be compared against the model's predicted vertical extent at specified time intervals. The data will be compared against the model using statistical methods to validate the model's ability to accurately represent the storage site. A good correlation between the two data sets will help provide strong evidence in validating the model's ability to represent the storage system.

Site-Specific Trapping Processes – 40 CFR 146.93(c)(1)(iv)-(vi)

In addition to carbon dioxide, mobilized fluids may pose a risk to USDWs. These include native fluids that are high in TDS and therefore may impair a USDW, and fluids containing mobilized drinking water contaminants (e.g., arsenic, mercury, hydrogen sulfide). The geochemical data collected from monitoring wells will be used to identify if mobilized fluids are present and evaluate if there is any risk to USDWs. For demonstration of non-endangerment One Earth Sequestration, LLC will compare the operational and PISC period samples collected from the ACZ wells, including the lowermost USDW, against the pre-injection baseline samples. This comparison will demonstrate whether significant changes in the fluid properties of the overlying formations have occurred and, if not, that no mobilized formation fluids have migrated above the seal formation.

The validation of seal integrity will help demonstrate that the injectate and or mobilized fluids would not represent an endangerment to any USDWs.

Additionally, RST logs will be used to monitor the salinity of the reservoir fluids in the Ironton-Galesville observation zone above the Eau Claire Formation seal. By comparing the time-lapse pulsed neutron logs against the pre-injection baseline logs, One Earth Sequestration, LLC will be able to monitor changes in reservoir fluid salinity. Logs indicating steady salinity levels within each zone would indicate no movement of fluids out of the storage unit, confirming the integrity of the well and seal formation.

Other trapping mechanisms have been evaluated and are discussed in more detail in the Narrative. Following are brief summaries of these mechanisms:

- Laboratory and modeling studies for mineral trapping in the Mt. Simon Sandstone of the Illinois Basin suggest that the bulk of the mineralogy is inert and that brine compositions showed little change within the time scale of laboratory experiments (within a year) (Carroll et al., 2013; Yoksoulian et al., 2014; Peter et al., 2019). Yoksoulian et al. (2014) conducted batch experiments for up to 9 months and did not observe the precipitation of carbonate minerals. Numerical simulations with both TOUGHREACT and PHREEQC 2.17.0 geochemical codes indicate that calcite ($CaCO_3$) or siderite ($FeCO_3$) may precipitate as a result of feldspar dissolution which buffer pH, but it generally takes hundreds of years to see significant mineral trapping (Carroll et al., 2013; Peter et al., 2019).

- The Eau Claire Formation is a laminated shale to silty shale. Advective flow from the Mt. Simon Sandstone into the Eau Claire is expected to be insignificant (Roy et al 2014). Modeling of ionic diffusion into the Eau Claire has also shown this to be insignificant (Roy et al 2014).

- Numerical simulations with PHREEQC 2.17.0 geochemical code suggested that the geochemical alteration of the Mt. Simon sandstone and Eau Claire shale can be modeled by incongruent dissolution of annite, illite, K-feldspar, and formation of montmorillonite, amorphous silica, and kaolinite. However, the formation of these secondary minerals was not confirmed with available characterization techniques.

Confining Zone Characterization – 40 CFR 146.93(c)(1)(vii)

As described in the Narrative, the Eau Claire Formation is the primary confining unit of the Mt. Simon Storage Complex at the One Earth CCS project site. The Eau Claire Formation is present across all of Illinois, ranging from less than 300 feet (91 meters) thick in the western part of the state to more than 1000 feet (305 meters) in the southeast (Buschbach, T. C., 1964).

Sensitive, Confidential, or Privileged Information

[redacted]

Sensitive, Confidential, or Privileged Information [redacted]

The Eau Claire Formation has been the subject of numerous investigations into sealing characteristics, and it is the primary sealing strata for an existing carbon storage project at Decatur, IL. Roy et al. (2014) determined that both advective flow and ionic diffusion from the Mt. Simon Sandstone into the Eau Claire is insignificant.

Sensitive, Confidential, or Privileged Information [redacted]

Sensitive, Confidential, or Privileged Information [redacted]

Within the AoR, there are no faults identified on seismic that transect the Mt. Simon storage complex, nor are any faults identified in the overlying Eau Claire primary seal interval. The lack of transecting faults in both the reservoir and the seal indicate that containment would not be compromised by faulting. In addition, due to the Eau Claire formation having such a low density of few small, isolated fractures, containment would not be compromised by fractures.

Assessment of Fluid Movement Potential – 40 CFR 146.93(c)(1)(viii)-(ix)

One of the primary forces driving CO_2 or brine migration out of the storage formation is pressure increases in the storage formation above threshold pressure. Dynamic simulation indicates that after cessation of injection the pressure in the Mt. Simon Sandstone will decrease to below threshold pressure within about seven years, and that formation pressures will continue to steadily decrease toward the pre-injection static pressure. Figure 1 illustrates the simulated decrease in pressure in the Mt. Simon Sandstone once the injection phase of the project ends. Pressure decline toward pre-injection levels is a significant indicator of USDW non-endangerment. Additional discussion is provided in the Narrative and in the AoR and Corrective Action Plan.

During the PISC period, the operator will collect formation pressure data that will be used to evaluate pressure decline and resulting non-endangerment to USDWs. The operator will monitor the downhole reservoir pressure at various locations and intervals using a combination of surface and downhole pressure gauges. The measured pressure at a specific depth interval will be compared against the pressure predicted by the numerical simulation. Comparison of actual and predicted values will help validate the accuracy of the model and demonstration of non-endangerment.

Sensitive, Confidential, or Privileged Information

[redacted]

Sensitive, Confidential, or Privileged Information

[redacted]

Figure 10. *OEE #1 (IZM #1) as built schematic.*

Location of USDWs – 40 CFR 146.93(c)(1)(x)

Sensitive, Confidential, or Privileged Information [redacted]

<u>**Non-Endangerment Demonstration Criteria**</u>

Prior to approval of the end of the post-injection phase, One Earth Sequestration, LLC will submit a demonstration of non-endangerment of USDWs to the UIC Program Director, per 40 CFR 146.93(b)(2) and (3).

The owner or operator will issue a report to the UIC Program Director that will make a demonstration of USDW non-endangerment based on the evaluation of the site monitoring data used in conjunction with the project's computational model. The report will detail how the non-endangerment demonstration evaluation uses site-specific conditions to confirm and demonstrate non-endangerment. The report will include all relevant monitoring data and interpretations upon which the non-endangerment demonstration is based, model documentation and all supporting data, and any other information necessary for the UIC Program Director to review the analysis. The report will include the following sections:

Introduction and Overview

A summary of relevant background information will be provided, including the operational history of the injection project, the date of the non-endangerment demonstration relative to the post-injection period outlined in this PISC and Site Closure Plan, and a general overview of how monitoring and modeling results will be used together to support a demonstration of USDW non-endangerment.

Summary of Existing Monitoring Data

A summary of all previous monitoring data collected at the site, pursuant to the Testing and Monitoring Plan (Attachment C of this permit) and this PISC and Site Closure Plan, including data collected during the injection and post-injection phases of the project, will be submitted to help demonstrate non-endangerment. Data submittals will be in a format acceptable to the UIC Program Director [40 CFR 146.91(e)], and will include a narrative explanation of monitoring activities, including the dates of all monitoring events, changes to the monitoring program over time, and an

explanation of all monitoring infrastructure that has existed at the site. Data will be compared with baseline data collected during site characterization [40 CFR 146.82(a)(6) and 146.87(d)(3)].

Summary of Computational Modeling History

The results of computational modeling used for AoR delineation and for demonstration of an alternative PISC timeframe will be compared to the monitoring data collected during the injection and PISC phases of the project. The monitoring data used to update and calibrate the computational modeling and to demonstrate non-endangerment of USDWs will include:

- Temperature, pressure, and acoustic monitoring data from the Mt. Simon Sandstone, Ironton-Galesville Sandstone, and the St. Peter Sandstone, the deepest USDW
- Groundwater quality analyses
- Seismic data
- Pulsed neutron logs that characterize CO_2 saturations and vertical plume development along the well bores
- Time-lapse 2D surface seismic data

Data generated during the PISC period will be used to help show that the computational model accurately represents the storage site and can be used as a proxy to determine the CO_2 and pressure plume's properties and size. One Earth Sequestration LLC will demonstrate this degree of accuracy by comparing the monitoring data obtained during the PISC period against the model's predicted properties such as plume location, rate of movement, and pressure decay. The validation of the computational model with the large volume of available data will be a significant element to support the non-endangerment demonstration. Statistical methods will be employed to correlate the data and confirm the model's ability to accurately represent the storage site. The validation of the computational modeling results over the areas and zones where monitoring data have been collected will help to ensure confidence in those areas of the model.

Evaluation of Reservoir Pressure

One of the primary forces driving CO_2 or brine migration out of the storage formation is pressure increases in the storage formation above threshold pressure. Dynamic simulation indicates that after cessation of injection the pressure in the Mt. Simon Sandstone will decrease to below threshold pressure within about seven years, and that formation pressures will continue to steadily decrease toward the pre-injection static pressure. Figure 1 illustrates the simulated decrease in pressure in the Mt. Simon Sandstone once the injection phase of the project ends. Pressure decline toward pre-injection levels is a significant indicator of USDW non-endangerment. Additional discussion is provided in the Narrative and in the AoR and Corrective Action Plan.

During the PISC period the operator will collect formation pressure data that will be used to evaluate pressure decline and resulting non-endangerment to USDWs. The operator will monitor the downhole reservoir pressure at various locations and intervals using a combination of surface and downhole pressure gauges. The measured pressure at a specific depth interval will be compared against the pressure predicted by the numerical simulation. Comparison of actual and

the predicted values will help validate the accuracy of the model and demonstration of non-endangerment.

Evaluation of Carbon Dioxide Plume

The site modeling shows that the CO_2 plume will expand slightly during the PISC period. The CO_2 plume radius increases to 3.2 miles (5.1 kilometers) at the end of injection. The plume migrated in all directions after injection but stopped migrating to the west and south 5 years post injection and to the east and the north 20 years post injection. At 50 years post injection, the plume had migrated to 3.1 miles (4.9 kilometers) west, 2.0 miles (3.2 kilometers) east, 4.7 miles (7.6 kilometers) north, and 2.0 miles (3.2 kilometers) south of IZM #1. See Figure 7. Additional discussion is provided in the Narrative and in the AoR and Corrective Action Plan.

Other than the project wells, there are no identified potential conduits for fluid movement or leakage pathways within the AoR. The nearest well that penetrates the Eau Claire shale is associated with the Manlove Gas Storage field and is approximately 10.3 miles (16.6 kilometers) SSE of the IZM#1 well. The well is recorded as R.S. Hinton #1; drilled in 1959 and serves as a Mt. Simon observation well. Based on the computational model, and forecast migration (Figure 8), the plume will not reach this location. Based on this information, the potential for fluid movement through artificial penetrations of the seal formation does not present a risk of endangerment to any USDWs.

One Earth Sequestration, LLC will use a combination of time-lapse pulsed neutron logs and time lapse 2D seismic methods to locate and track the extent of the CO_2 plume. Pulsed neutron logging will be used to monitor the distribution and saturation of CO_2 adjacent to the injection well and IZM monitoring wells. A good correlation between pulsed neutron data sets and modeled plume thicknesses will help provide strong evidence in validating the model's ability to represent the storage system.

The time-lapse 2D surface seismic data will be acquired at longer time intervals and track the development of the CO_2 plume over a larger spatial extent. The data will be compared against the model using statistical methods to validate the model's ability to accurately represent the storage site.

Both the pulsed neutron logs and seismic data will be used to verify the computational model's ability to predict the CO_2 behavior in the PISC phase of the project and support a demonstration of non-endangerment of USDWs at the end of the project.

Evaluation of Emergencies or Other Events

During the injection operations and post-injection phases of the project, measurement of water quality parameters from the ACZ monitoring wells will be used to demonstrate that the storage formation fluids have not migrated above the confining formations. Assuming there is no such detectable movement of injection zone fluids, they are not anticipated to pose a risk to USDWs. To demonstrate non-endangerment, the project will compare the results of the fluid sampling from the Ironton-Galesville Sandstone and St. Peter Sandstone USDW from the injection and PISC phases to the pre-injection baseline samples. This comparison will demonstrate whether significant

changes in the fluid properties of the overlying formations have occurred and whether mobilized storage formation fluids have moved through the confining layer.

During injection operations, the site will be monitored with DAS to assess induced seismic events, if they occur. This monitoring will continue in the post injection project phase. However, the monitoring capabilities from the injection wells will be eliminated once these wells are plugged and abandoned.

Artificial penetrations include wells associated with the project. The injection wells will be plugged and abandoned with the permit P&A plan. The ACZ and IZM monitoring wells will be plugged and abandoned in accordance with the procedures outlined below. No other wells penetrate the confining zone within the AoR.

Site Closure Plan

One Earth Sequestration, LLC will conduct site closure activities to meet the requirements of 40 CFR 146.93(e) as described below. One Earth Sequestration, LLC will submit a final Site Closure Plan and notify the permitting agency at least 120 days prior of its intent to close the site. Once the permitting agency has approved closure of the site, One Earth Sequestration, LLC will plug the monitoring wells and submit a site closure report to EPA. The activities, as described below, represent the planned activities based on information provided to EPA. The actual site closure plan may employ different methods and procedures. A final Site Closure Plan will be submitted to the UIC Program Director for approval with the notification of the intent to close the site.

Plugging Monitoring Wells

The IZM and ACZ monitoring wells will be flushed with a kill weight brine fluid. A minimum of three tubing volumes will be injected without exceeding fracture pressure. A final external MIT will be conducted to ensure mechanical integrity. A summary of plugging procedures is provided below; detailed procedures for the deep monitoring wells will be the same as for the injection well (See Injection Well Plugging Plan). All casing in the wells will be cemented to surface and will not be retrievable at abandonment. After injection ceases and after the appropriate post-injection monitoring period is finished, the completion equipment will be removed from the well.

Type and Quantity of Plugging Materials, Depth Intervals

Commercially available well cementing software will be used to model the plugging and aid in the plug design. The cements used for plugging will be tested in the lab prior to plugplacement and both wet and dry samples will be collected during plugging for each plug to ensure quality of the plug.

The casing strings will be cut off at least 3 feet below the surface, below the plow line. A blanking plate with the required permit information will be welded to the top of the cutoff casing.

Volume Calculations

Volumes will be calculated for the specific abandonment wellbore environment based on desired plug diameter and length required. The methodology employed will be to:

1) Choose the following:

    a. Length of the cement plug desired.

    b. Desired setting depth of base of plug.

    c. Amount of spacer to be pumped ahead of the slurry.

2) Determine the following:

    a. Number of sacks of cement required.

    b. Volume of spacer to be pumped behind the slurry to balance the plug.

    c. Plug length before the pipe is withdrawn.

    d. Length of mud freefall in drill pipe.

    e. Displacement volume required to spot the plug.

<u>Plugging and Abandonment Procedure</u>
At the end of the serviceable life of the deep monitoring wells, they will be plugged and abandoned. In summary, the plugging procedure will consist of removing all components of the completion system and then placing cement plugs along the entire length of the well. Prior to placing the cement plugs, casing inspection and temperature logs will be run confirming externalmechanical integrity. If a loss of integrity is discovered, then a plan to repair using the cement squeeze method will be prepared and submitted to the agency for review and approval. At the surface, the well head will be removed; and the casing will be cut off 3 feet below surface.

<u>Planned Remedial/Site Restoration Activities</u>
To restore the site to its pre-injection condition following site closure, One Earth Sequestration, LLC will be guided by the state rules for plugging and abandonment of wells located on leased property under The Illinois Oil and Gas Act: Title 62: Mining Chapter I: Department of Natural Resources - Part 240, Section 240.1170 - Plugging Fluid Waste Disposal and Well Site Restoration.

The following steps will be taken:

1. The free liquid fraction of the plugging fluid waste, which may consist of produced water and/or crude oil, shall be removed from the pit and disposed of in accordance with state and federal regulations (e.g., injection or in above ground tanks or containers pending disposal) prior to restoration. The remaining plugging fluid wastes shall be disposed of byon-site burial.
2. All plugging pits shall be filled and leveled in a manner that allows the site to be returnedto original use with no subsidence or leakage of fluids, and where applicable, with sufficient compaction to support farm machinery.
3. All drilling and production equipment, machinery, and equipment debris shall be removed from the site.
4. Casing shall be cut off at least four (4) feet below the surface of the ground, and a steel plate welded on the casing or a mushroomed cap of cement approximately one (1) foot in thickness shall be placed over the casing so that the top of the cap is at least

three (3) feetbelow ground level.

5. Any drilling rat holes shall be filled with cement to no lower than four (4) feet and no higher than three (3) feet below ground level.
6. The well site and all excavations, holes and pits shall be filled, and the surface leveled.

Site Closure Report

A site closure report will be prepared and submitted within 90 days following site closure, documenting the following:

- Plugging of the verification and geophysical wells (and the injection well if it has not previously been plugged),
- Location of sealed injection well on a plat of survey that has been submitted to the local zoning authority,
- Notifications to state and local authorities as required at 40 CFR 146.93(f)(2),
- Records regarding the nature, composition, and volume of the injected CO_2, and
- Post-injection monitoring records.

One Earth Sequestration, LLC will record a notation to the property's deed on which the injection well was located that will indicate the following:

- That the property was used for carbon dioxide sequestration,
- The name of the local agency to which a plat of survey with injection well location was submitted,
- The volume of fluid injected,
- The formation into which the fluid was injected, and
- The period over which the injection occurred.

The site closure report will be submitted to the permitting agency and maintained by the owner or operator for a period of 10 years following site closure. Additionally, the owner or operator will maintain the records collected during the post-injection period for a period of 10 years after which these records will be delivered to the UIC Program Director.

Quality Assurance and Surveillance Plan (QASP)

The Quality Assurance and Surveillance Plan is presented in the Appendix of the Testing and Monitoring Plan.

POST-INJECTION SITE CARE AND SITE CLOSURE PLAN
40 CFR 146.93(a)

One Earth CCS

Facility Information

Facility name: One Earth Sequestration, LLC
OES #2

Facility contact: Mark Ditsworth, VP of Technology and Special Projects
One Earth Sequestration, LLC, 202 N Jordan Drive, Gibson City, IL 60936, (217) 784-5321 ext. 215

Well location: McLean County, IL
40.500096°N, -88.474625°W (NAD 1983)

This Post-Injection Site Care and Site Closure (PISC) plan describes the activities that One Earth Sequestration, LLC will perform to meet the requirements of 40 CFR 146.93. One Earth Sequestration, LLC will monitor ground water quality and track the position of the carbon dioxide plume and pressure front for 10 years after the end of injection operations. One Earth Sequestration, LLC may not cease post-injection monitoring until a demonstration of non-endangerment of USDWs has been approved by the UIC Program Director pursuant to 40 CFR 146.93(b)(3). Following approval for site closure, One Earth Sequestration, LLC will plug all monitoring wells, restore the site to its original condition, and submit a site closure report and associated documentation.

Pre- and Post-Injection Pressure Differential [40 CFR 146.93(a)(2)(i)]

The predicted CO_2 saturation plume and pressure front at the end of injection operations are shown in Figure 1. A differential (threshold) pressure of 86 psi is used to define the pressure boundary for the AoR. Based on the modeling of the differential pressure front, the formation pressure at the injection wells is predicted to decline rapidly following cessation of injection. Additional information on the projected post-injection pressure decline and differentials is presented in the permit application modeling discussion and in the Area of Review and Corrective Action Plan. Figure 2 shows a pressure profile of the injection wells through the end of the injection phase and through 50 years post-injection. As Figure 2 demonstrates, the pressure differential at the injection wells decreases to less than threshold pressure in approximately 6 years after the end of injection operations.

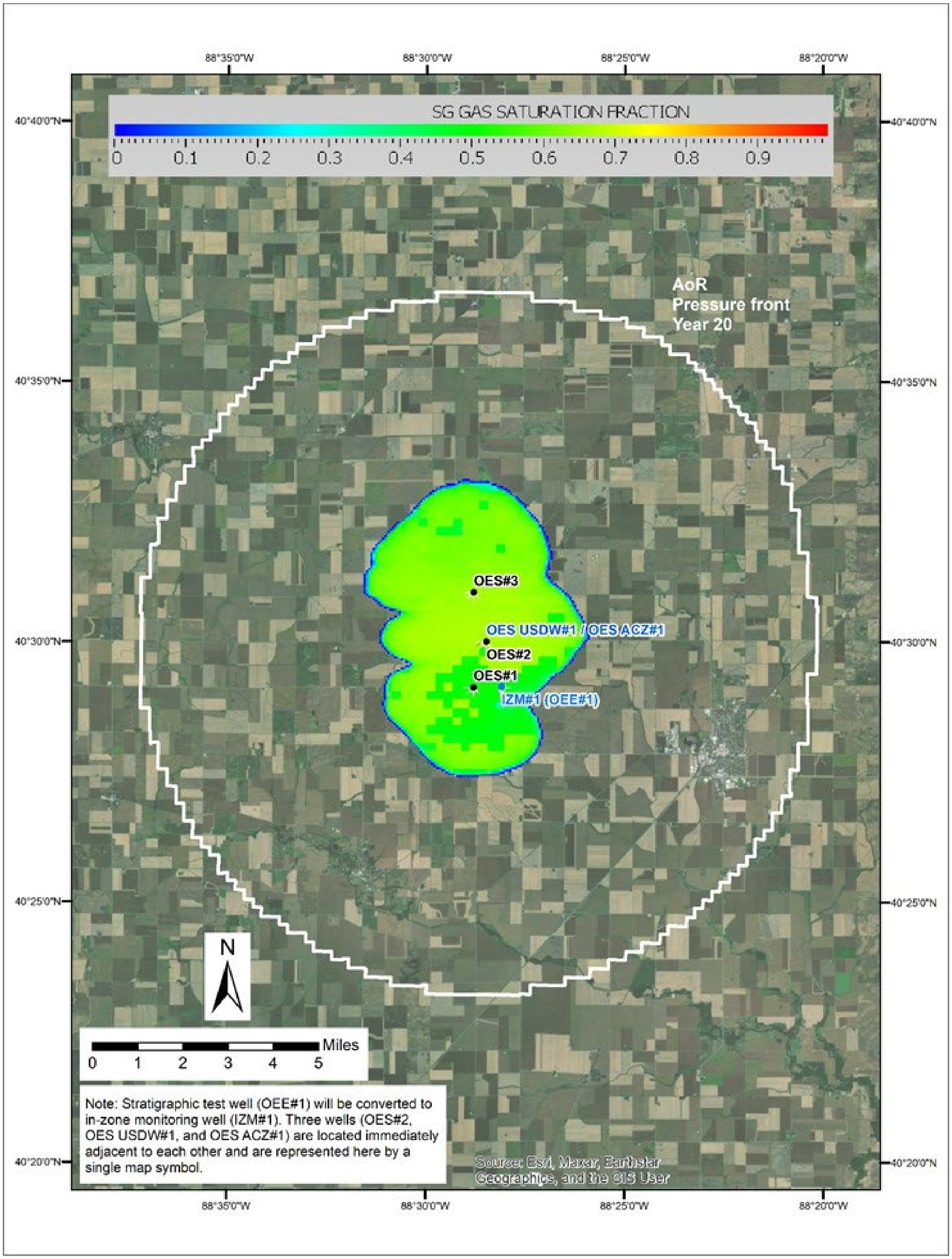

Figure 1. *One Earth CCS map of the predicted extent of the CO_2 plume and pressure front at the end of injection operations.*

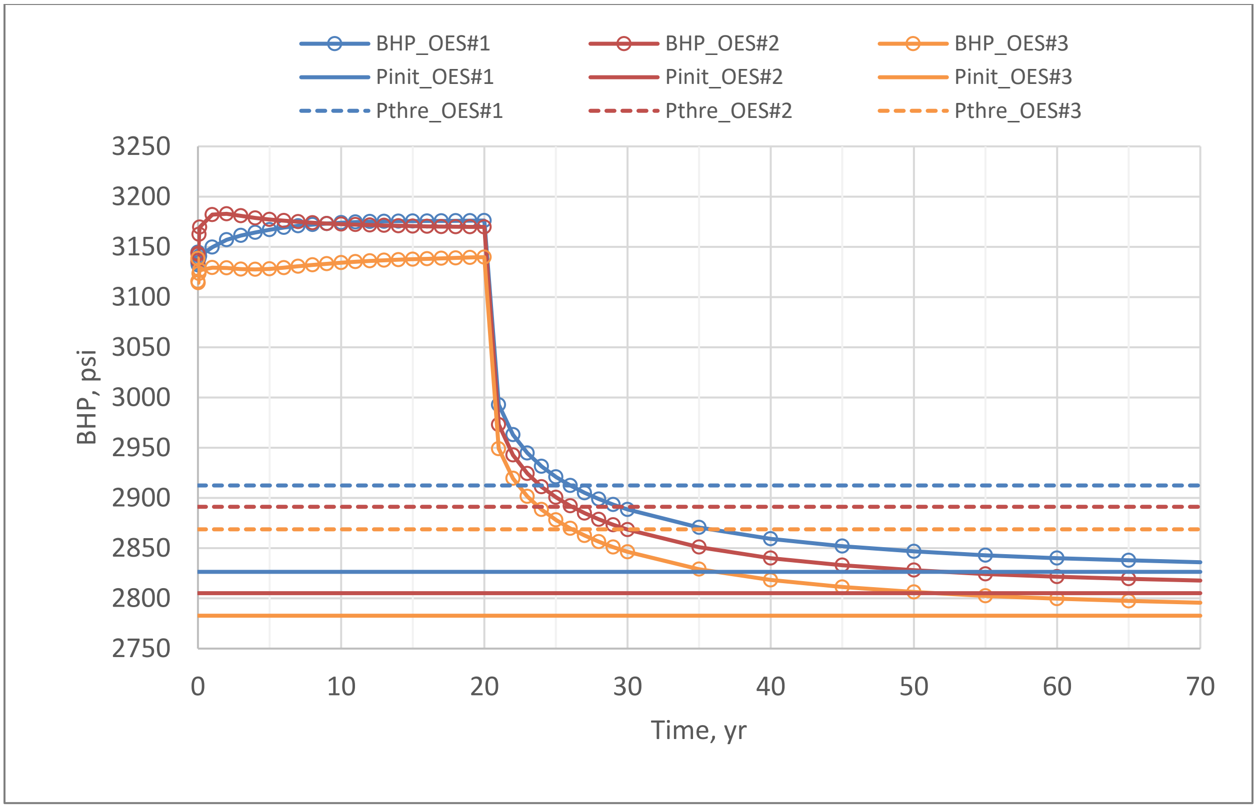

Figure 2. *Pressure profile for injection wells. Dashed lines represent baseline pressure differential (threshold pressure) datum for defining AoR. Solid lines represent formation baseline pressure.*

<u>Predicted Position of the CO_2 Plume and Associated Pressure Front at Site Closure [40 CFR 146.93(a)(2)(ii)]</u>

Figure 1 shows the predicted extent of the plume and pressure front at the end of the injection operations. This map is based on the final AoR delineation modeling results submitted pursuant to 40 CFR 146.84.

Figure 3 shows the predicted position of the CO_2 plume 10 years after the end of injection operations. This map is based on the final AoR delineation modeling results pursuant to 40 CFR 146.84. The figures demonstrate the stability of the CO_2 plume during the PISC phase.

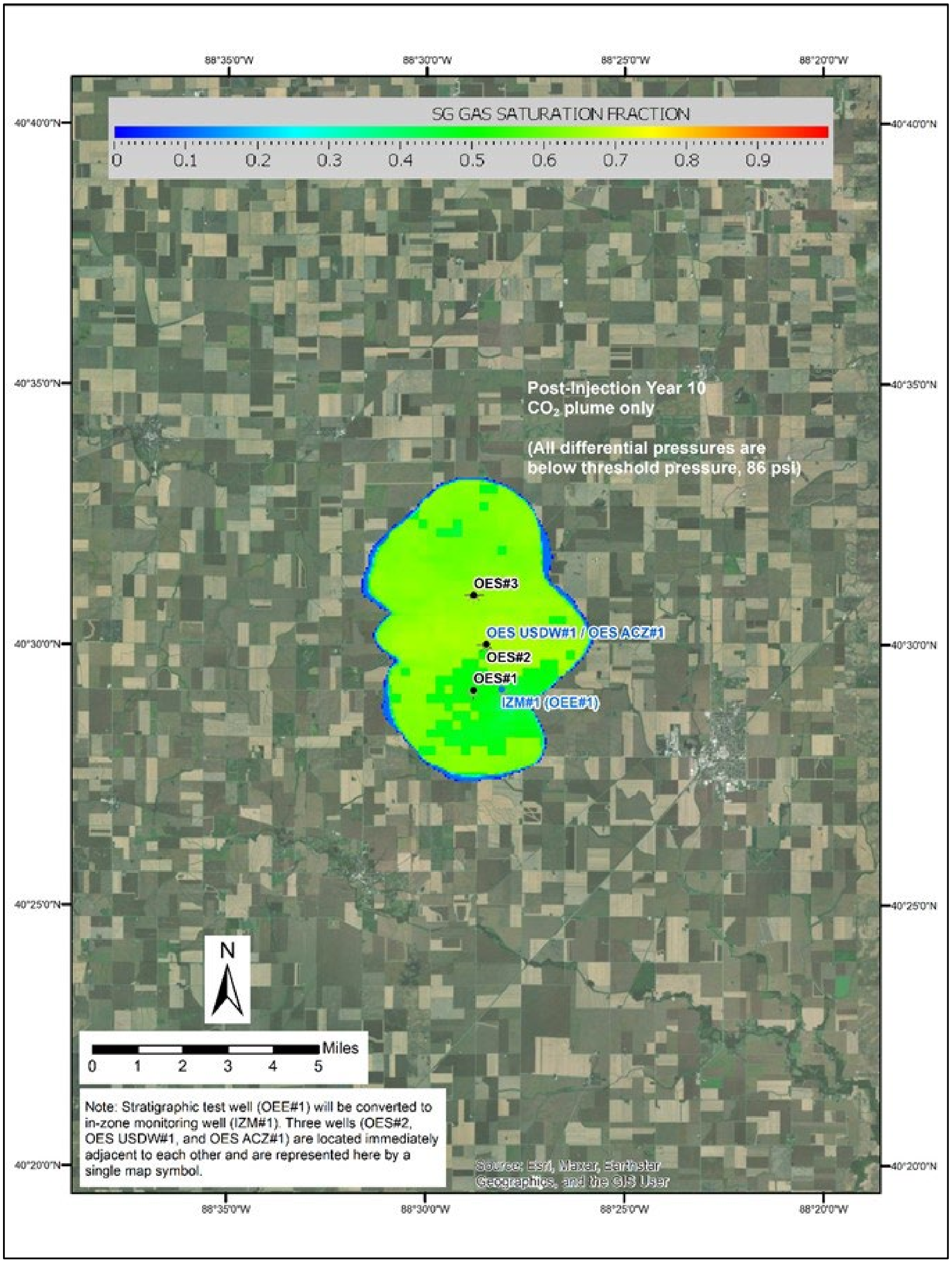

Figure 3. *Monitoring locations and predicted position of CO_2 plume 10 years after the end of injection operations.*

Post-Injection Monitoring Plan [40 CFR 146.93(b)(1)]

Performing groundwater quality monitoring and plume and pressure front tracking as described in the following sections during the post-injection phase will meet the requirements of 40 CFR 146.93(b)(1). The results of all post-injection phase testing and monitoring will be submitted annually, within 60 days after the anniversary of the date on which injection ceased, as described under "Schedule for Submitting Post-Injection Monitoring Results," below.

A quality assurance and surveillance plan (QASP) for all testing and monitoring activities during the injection and post injection phases is provided in the Appendix to the Testing and Monitoring Plan.

To date, One Earth Sequestration, LLC has successfully negotiated surface land access for purposes of drilling the stratigraphic well, and pre-injection (baseline) monitoring activities such as 2D and 3D seismic testing. One Earth Sequestration, LLC's proven ability to work with local landowners and public entities to obtain access to surface and subsurface areas for activities related to the project should be sufficient to demonstrate One Earth Sequestration, LLC's ability to obtain access for monitoring, and corrective actions (if they are necessary) in the future. One Earth Sequestration, LLC may acquire, by lease or purchase, additional land parcel areas and surface entry rights for the injection, monitoring, and surface and sub-surface infrastructure. Monitoring well locations could change slightly but only to the extent that they retain their monitoring intent as described in the Testing and Monitoring Plan and QASP. Monitoring locations will also consider access routes that minimize property damage, crop loss, and property owner inconvenience, and to assure safe access to each location.

Table 1 provides a summary of PISC monitoring activities. Figure 1 shows the location of the injection and monitoring wells.

The project will continue to monitor the well integrity of the injection and in zone monitoring (IZM) wells annually using temperature, noise, or oxygen activation logs to ensure that there is no migration of CO_2 up the wellbores. In addition, the project will monitor the annular pressures and fluid volumes in the injection well on a continuous basis until the well is plugged and abandoned. Refer to the Well Operations Plan and the Testing and Monitoring Plan for more information on the well integrity and operational monitoring plans.

Pulsed neutron (PNC) logging will continue in the IZM and the above confining zone (ACZ) monitoring wells each year of the PISC phase. This will allow the project to continue to observe the vertical plume development in the Mt. Simon Sandstone and further verify that CO_2 is not migrating past the confining zone and into ACZ aquifers; thereby endangering underground sources of drinking water (USDWs). Refer to the Testing and Monitoring Plan for more information on the PNC logging plans in the injection phase of the project (Permit Sections 7.0).

The project will continue to monitor pressures within the injection well until it is abandoned. The injection well pressure measurements are expected to verify the pressure decrease, and these data will be used to history match the computational modelling in the PISC phase.

Pressures will also continue to be monitored in the ACZ wells including the Ironton-Galesville Sandstone and the St. Peter Sandstone to confirm the continued containment of CO_2 within the

storage formation. Fluid samples will be taken from OES ACZ#1 and OES USDW#1 annually for geochemical and isotopic analysis to further verify CO_2 containment.

The possibility of induced seismicity is expected to decline rapidly during the post-injection period. DAS system monitoring will continue for 5 years post-injection in the monitoring wells and in the injection wells until they are plugged and abandoned. The UIC Program Director will be notified prior to discontinuing data acquisition in the DAS.

The project proposes to acquire two time-lapse 2D surface seismic surveys in the PISC phase of the project. One will be acquired within five years of the most recent injection operations survey; the second within 9 years after the end of injection. The objectives of the surveys include:

- Demonstrate the stability of the CO_2 plume after the injection phase of the project
- Provide data for the calibration and verification of computational modelling
- Demonstrate non-endangerment of USDWs at the end of the PISC phase.

Table 1. *Summary of PISC monitoring.*

Monitoring Activity	Post-injection Phase Frequency	Location
	Injection Wells	
Annular Pressure	Continuous until P&A	Injection Wellhead
Annular Fluid Volume	Continuous until P&A	Injection Wellhead
Temperature or Noise or Oxygen Activation Log	Annually until P&A	Injection Well
DTS, DAS	Continuous until P&A	Injection Well Downhole, above perforations
Pulsed Neutron Logging	Annual until P&A	Injection Well
	Verification Monitoring	
Fluid Sampling and Analysis		
St. Peter sandstone	Annually	ACZ well
Ironton Galesville formations	Annually	ACZ Well
Mt. Simon	Annually*	IZM Wells
Isotope Analysis	Annually*	ACZ and IZM wells
Pressure, DTS, DAS		
St. Peter Sandstone	Continuous	ACZ well
Ironton Galesville formations	Continuous	ACZ well
IZM Mt. Simon Sandstone	Continuous	IZM wells
Pulsed Neutron Logging	Annually	IZM Wells
Time-lapse 2D Surface Seismic Data	Initial PISC survey 5 years from most recent. Additional PISC survey within 9 years after end of injection	Surface

*Fluid samples will not be collected in the IZM wells if there is breakthrough of CO_2 at the well location.

Monitoring Above the Confining Zone

Groundwater Quality Monitoring

Table 2 presents the monitoring methods, locations, and frequencies for monitoring above the confining zone. Table 2 identifies the parameters to be monitored and the analytical methods One Earth Sequestration, LLC will employ. This includes lowermost USDW (St. Peter Sandstone), and from above confining zone well (Ironton-Galesville). Table 3 identifies the parameters to be monitored and the analytical methods One Earth Sequestration, LLC will employ, and Figure 3 shows the locations of the monitoring wells.

***Table 2**. Monitoring above the confining zone [1, 2].*

Target Formation	MonitoringActivity	Monitoring Location(s)	Frequency
Lowermost USDW (St. Peter Sandstone)	Fluid sampling	OES USDW#1	Annual
	Pressure/ DTS monitoring	OES USDW#1	Continuous
	PNC Logging	OES USDW#1	Annual
Above Confining Zone (Ironton-Galesville)	Fluid sampling	OES ACZ#1	Annual
	Pressure/ DTS monitoring	OES ACZ#1	Continuous
	PNC Logging	OES ACZ#1	Annual

Note 1: Collection and recording of continuous monitoring data will occur at the frequencies described in Table 4.

Note 2: Annual sampling and monitoring will occur up to 45 days before the anniversary date of cessation of injection or alternatively scheduled with the prior approval of the Director.

***Table 3**. Summary of analytical and field parameters for ground water samples.*

Parameters	Analytical Methods [1]
Cations: Al, Ba, Mn, As, Cd, Cr, Cu, Pb, Sb Se, and Tl	ICP-MS, EPA Method 6020
Cations: Ca, Fe, K, Mg, Na, and Si	ICP-OES, EPA Method 6010B
Anions: Br, Cl, F, NO3, and SO_4	Ion Chromatography, EPA Method 300.0
Dissolved CO_2	Coulometric titration, ASTM D513-11
Isotopes: $\delta^{13}C$ of DIC	Isotope ratio mass spectrometry
Total Dissolved Solids	Gravimetry; APHA 2540C
Water Density (field)	Oscillating body method
Alkalinity	APHA 2320B
pH (field)	EPA 150.1
Specific conductance (field)	APHA 2510
Temperature (field)	Thermocouple

Note 1: ICP = inductively coupled plasma; MS = mass spectrometry; OES = optical emission spectrometry; GC-P =gas chromatography - pyrolysis. An equivalent method may be employed with prior approval of the Director.

A quality assurance and surveillance plan (QASP) for all testing and monitoring activities, required pursuant to 146.90(k), is provided as an Appendix to the Testing and Monitoring Plan.

Sampling will be performed as described in Section B.2 of the QASP; this section of the QASP describes the groundwater sampling methods to be employed, including sampling standard operating procedures (SOPs) (Section B.2 a/b), and sample preservation (Section B.2.f).

A qualified, commercial laboratory will be selected to provide analytical services in accordance with the methods and standards included here and in the QASP. Sample handling and custody will

be performed as described in Section B.3 of the QASP. Quality control will be ensured using the methods described in Section B.5 of the QASP: Carbon Dioxide Plume and Pressure Front Tracking [40 CFR 146.93(a)(2)(iii)].

One Earth Sequestration, LLC will employ direct and indirect methods to track the extent of the carbon dioxide plume and the presence or absence of elevated pressure.

Table 4 presents the in zone monitoring that One Earth Sequestration, LLC will use to monitor the CO_2 plume, including the activities, locations, and frequencies. The parameters to be analyzed as part of fluid sampling in the Mt. Simon sandstone (and associated analytical methods) are presented in Table 3.

Table 4 includes the direct and indirect methods that One Earth Sequestration, LLC will use to monitor the pressure front, including monitoring activities, locations, and frequencies. One Earth Sequestration, LLC will deploy pressure/temperature monitors and distributed temperature and acoustic sensors to directly monitor in zone and above zone conditions. Quality assurance procedures for seismic monitoring methods will meet industry standards and will be established for the One Earth Sequestration, LLC project at the time seismic acquisition and processing contractors are selected.

A quality assurance and surveillance plan (QASP) for all testing and monitoring activities, required pursuant to 146.90(k), is provided as an Appendix to the Testing and Monitoring Plan.

Sampling will be performed as described in Section B.2 of the QASP; this section of the QASP describes the groundwater sampling methods to be employed, including sampling standard operating procedures (SOPs) (Section B.2 a/b), and sample preservation (Section B.2.f).

A qualified, commercial laboratory will be selected to provide analytical services in accordance with the methods and standards included here and in the QASP. Sample handling and custody will be performed as described in Section B.3 of the QASP. Quality control will be ensured using the methods described in Section B.5 of the QASP.

Table 4. *Post-injection phase plume and pressure front monitoring.*

Target Formation	Monitoring Activity	Monitoring Location(s)	Spatial Coverage	Frequency
Mt. Simon	Fluid sampling	IZM #1 IZM #2		Annual
	Pressure/ DTS monitoring	IZM #1, IZM #2		Continuous
		OES #1, OES #2, OES #3		Continuous until P&A
	Pulse Neutron Logging	IZM #1 IZM #2		Annual
		OES #1		Annual until P&A
		OES #2		Annual until P&A
		OES #3		Annual until P&A
	2D seismic survey	AOR Surface		Initial PISC survey 5 years from most recent. Additional PISC survey within 9 years after end of injection

Sampling and geophysical surveys will occur within 60 days before the anniversary date of cessation of injection or alternatively scheduled with the prior approval of the Director. Seismic surveys will be performed in the 4th quarter before, or the 1st quarter of the year or alternatively scheduled with the prior approval of the Director.

Subsurface monitoring locations relative to the predicted location of the CO_2 plume and pressure front at 10 years after the end of injection operations are shown in Figure 3.

Schedule for Submitting Post-Injection Monitoring Results [40 CFR 146.93(a)(2)(iv)]

All post-injection site care monitoring data and monitoring results collected using the methods described above will be submitted to the Director in annual reports. These reports will be submitted annually, within 60 days following the anniversary date of the date on which injection ceases or alternatively with the prior approval of the Director.

The reports will contain information and data generated during the reporting period, i.e., well-based monitoring data, sample analysis, and the results from updated site models.

Alternative Post-Injection Site Care Timeframe [40 CFR 146.93(c)]

One Earth Sequestration, LLC will conduct post-injection monitoring for 10 years following the cessation of injection operations. One Earth Sequestration, LLC will demonstrate that an alternative PISC timeframe is appropriate, pursuant to 40CFR 146.93(c)(1). Regardless of the alternative PISC timeframe, monitoring and reporting as described in the sections above will continue until One Earth Sequestration, LLC demonstrates, based on monitoring and other site-specific data, that no additional monitoring is needed to ensure that the project does not pose an endangerment to any USDWs, per the requirements at 40 CFR 146.93(b)(2) or (3).

One Earth Sequestration, LLC will conduct all of the monitoring described under "Groundwater Quality Monitoring" and "Carbon Dioxide Plume and Pressure Front Tracking" above and report the results as described under the "Schedule for Submitting Post-Injection Monitoring Results."

If any of the information on which the demonstration was based changes or the actual behavior of the site varies significantly from modeled predictions (e.g., because of an AoR reevaluation) One Earth Sequestration, LLC may update this PISC and Site Closure Plan pursuant to 40 CFR 146.93(a)(4). If revisions are required, One Earth Sequestration, LLC will update the PISC and Site Closure Plan within six months of reporting the unexpected monitoring results

A summary of all previous monitoring data collected at the site, pursuant to the Testing and Monitoring Plan and this PISC and Site Closure Plan, including data collected during the injection and PISC phases of the project, will be submitted to help demonstrate non-endangerment. Data submittals will be in a format acceptable to the Director [40 CFR 146.91(e)], and will include a narrative explanation of monitoring activities, including the dates of all monitoring events, changes to the monitoring program over time, and an explanation of all monitoring infrastructure that has existed at the site. Data will be compared with baseline data collected during site characterization [40 CFR 146.82(a)(6) and 146.87(d)(3)].

Computational Modeling Results – 40 CFR 146.93(c)(1)(i)

The results of computational modeling used for AoR delineation and for demonstration of an alternative PISC timeframe will be compared to monitoring data collected during the operational and the PISC period. The data will include the results of time-lapse temperature and pressure monitoring, groundwater quality analyses, seismic monitoring, and geophysical surveys (i.e., logging, operating-phase 2D surface seismic surveys) used to update the computational model and to monitor the site. Data generated during the PISC period will be used to help show that the computational model accurately represents the storage site and can be used as a proxy to determine the plume's properties and size. The operator will demonstrate this degree of accuracy by comparing the monitoring data obtained during the PISC period against the model's predicted properties (i.e., plume location, rate of movement, and pressure decay). Statistical methods will be employed to correlate the data and confirm the model's ability to accurately represent the storage site. The validation of the computational model with the large volume of available data will be a significant element to support the non-endangerment demonstration.

Modeling scenarios, including sensitivity analysis and evaluation of the post-injection phase of the project are discussed in detail in the AoR and Corrective Action Plan.

As part of the modeling, two major CO_2 trapping mechanisms were considered: structural/stratigraphic trapping, and residual trapping. Solubility trapping was not modeled due to a limitation in software; however, the modeled plume size and resulting AoR are larger than if solubility trapping was included as some CO_2 will dissolve into the formation water (Mehnert et al., 2014). The solubility trapping of CO_2 in water may be included during AoR reevaluations and in the post-injection site care updates. Mineral trapping was considered negligible because the storage unit is primarily quartz. These processes allow the prediction of CO_2 movement in terms of gas saturation, reservoir pressure change with time to delineate the Area of Review (AoR), and the corresponding tubing head pressure during and after injection.

Structural/stratigraphic trapping for the post-injection period, along with sensitivity to variations in porosity and permeability were also considered in the site model (see AoR and Corrective Action Plan). A summary of these results by AoR extent is shown in Figure 4.

Data collected during drilling of the injection wells will provide an opportunity to further refine modeling with site-specific injection well borehole data. These data will be used to update the computational model. In addition, downhole pressure monitoring during and after injection can provide near-continuous information to compare the predicted and actual pressure response to CO_2 injection. These data will be used to recalculate the AoR as new data is incorporated for reevaluation. A summary of the schedule for model updates is included in the AoR and Corrective Action Plan.

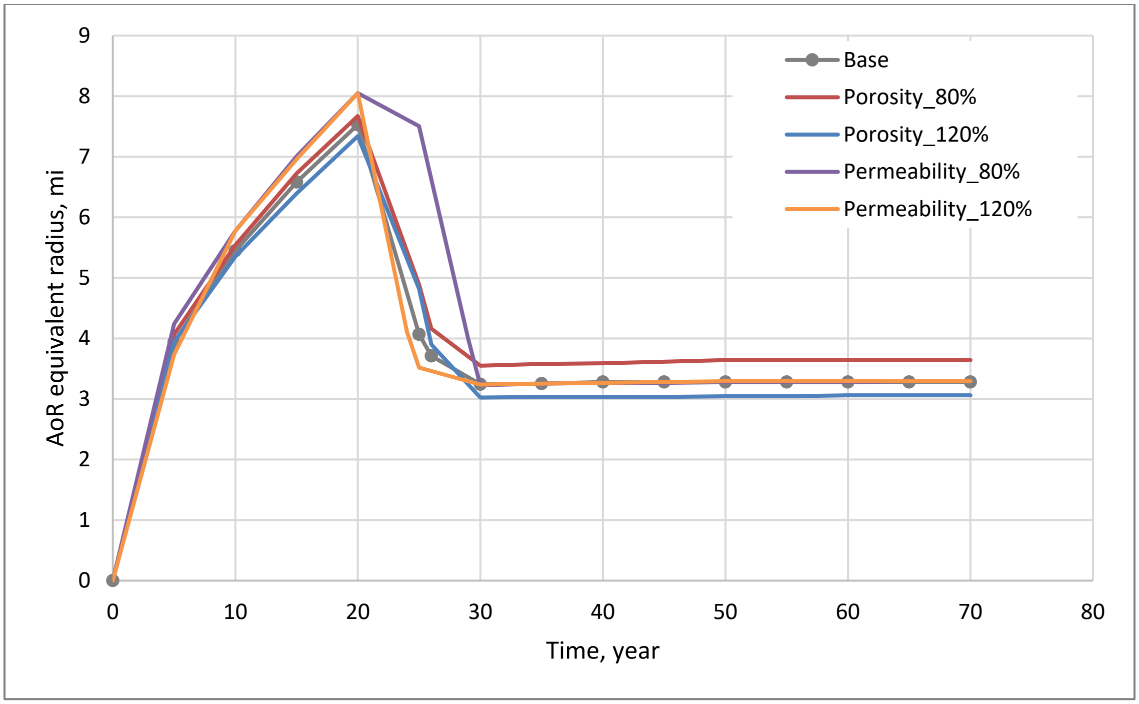

Figure 4. *Area of Review equivalent radius change over time at varying porosity and permeability.*

Predicted Timeframe for Pressure Decline – 40 CFR 146.93(c)(1)(ii)

Figure 5 and Table 5 summarize the CO_2 plume, differential pressure, and AoR evolution with time. The CO_2 plume radius increased from 3.2 (5.1 kilometers) miles at the end of injection to 3.3 miles (5.3 kilometers) at 50 years post injection.

Differential pressure radius reached its maximum of 7.5 miles (12.1 kilometers) at the end of injection, dropped to 3.2 miles (5.1 kilometers) at 6 years post injection and 1 mile (1.6 kilometers) at 7 years post injection, and then diminished within 8 years post injection to below the established critical threshold. The AoR was determined solely by the differential pressure front until 5 years post injection, with a maximum radius of 7.5 miles (12.1 kilometers) at the end of injection.

A comparison of the pressure time series from the sensitivity analysis demonstrates that the that the pressure build-up during the injection phase and rapid decline during the PISC phase are similar to base case for a range of geologic parameters (Figure 4).

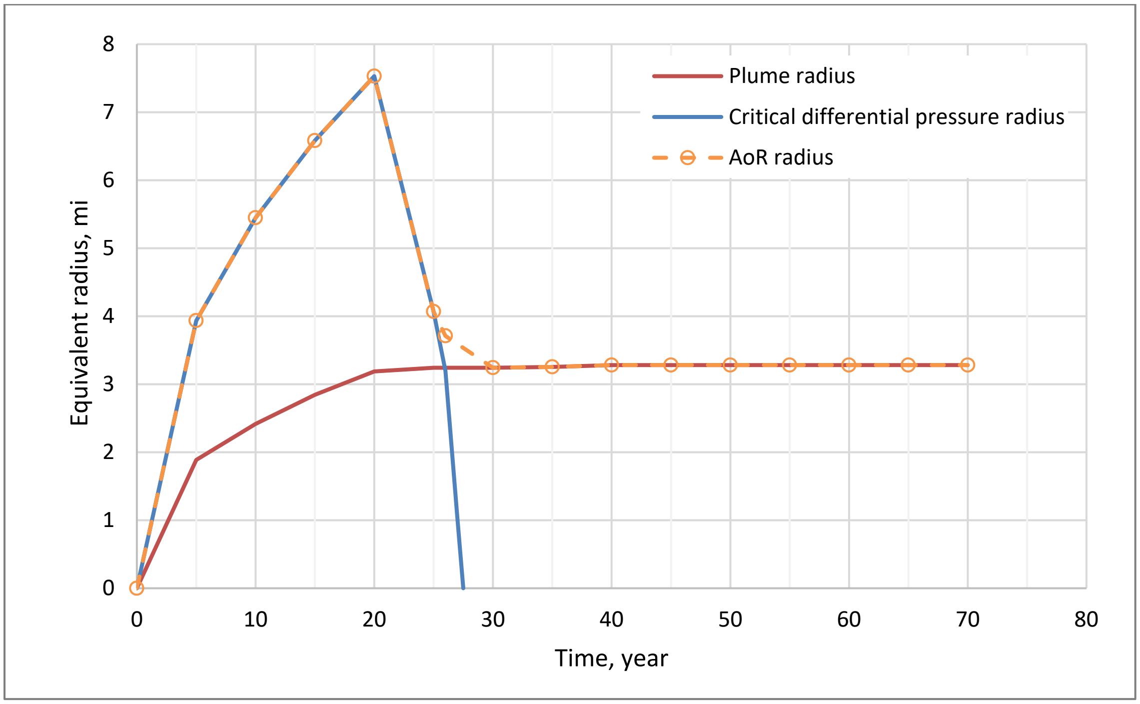

***Figure 5**. Equivalent radius of plume, differential pressure, and AoR change with time.*

***Table 5.** Summary of plume size, differential pressure radius, and AoR change with time.*

Time, yr		CO_2 plume size			Differential pressure equivalent radius, mi	AoR	
		Plume equivalent radius, mi	Width, mi	Length, mi		AoR equivalent radius, mi	AoR, mi^2
Injection	5	1.9	2.5	4.5	3.9	3.9	49
	10	2.4	3.5	5.3	5.4	5.4	93
	15	2.8	4.3	6.0	6.6	6.6	136
	20	3.2	4.9	6.5	7.5	7.5	178
Post injection	5	3.2	5.0	6.6	4.1	4.1	52
	6	3.2	5.0	6.6	3.2	3.7	43
	10	3.2	5.0	6.6	0.0	3.2	33
	50	3.3	5.1	6.7	0.0	3.3	34

Continuous pressure measurements will be acquired from the Mt. Simon Sandstone though the injection and PISC phases of the project (see Testing and Monitoring Plan). The pressure data obtained during the injection phase of the project will be used to update the computational modelling every six months as per the reporting requirements in 40 CFR 146.91. Pressure data

acquired during the PISC phase of the project is expected to verify the rapid decline in pressure in the Mt. Simon Sandstone predicted by the computational modelling.

Predicted Rate of Plume Migration – 40 CFR 146.93(c)(1)(iii)

At 6 years post injection, the AoR radius diminished to 3.6 miles (5.8 kilometers) and was established by the plume boundary and pressure differential front (Figure 6). By 7 years post injection, the differential pressure front has further diminished such that it is situated within the lateral extent of the CO_2 plume. The site modeling shows that the CO_2 plume will expand slightly during the PISC period from 3.2 miles (5.1 kilometers) at the end of injection to 3.3 miles (5.3 kilometers) 50 years after injection ceases (Table 5).

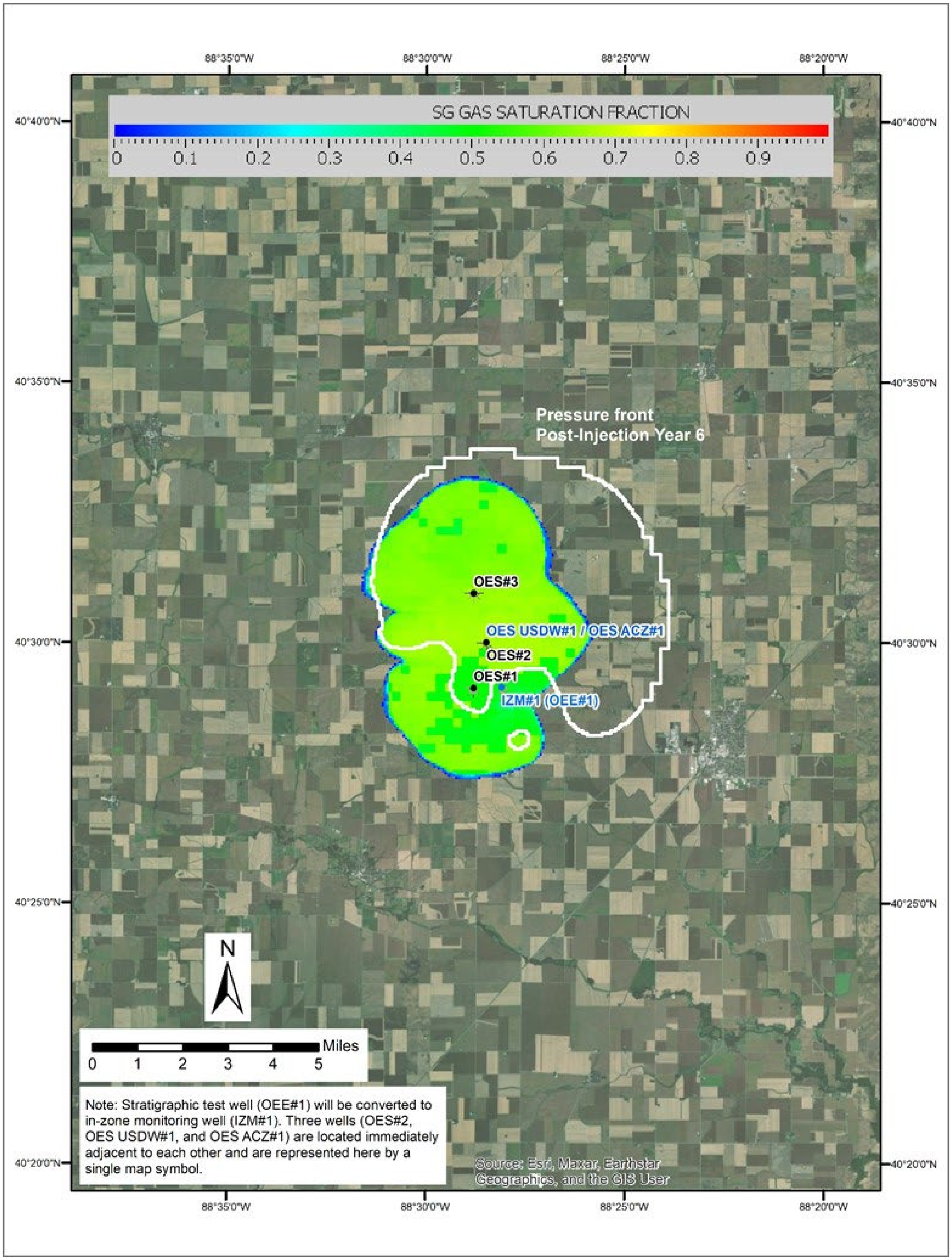

Figure 6. *Pressure differential and plume boundary 6 years post injection.*

Figure 7 shows the time-series distance between the plume front and the in-zone monitoring well IZM #1, converted from OEE #1, in all four cardinal directions. At the end of 20 years of injection, the plume front in relation to IZM #1 was 3.0 miles (4.8 kilometers) west, 1.9 miles (3.1 kilometers) east, 4.5 miles (7.2 kilometers) north, and 2.0 miles (3.2 kilometers) south. The plume migrated in all directions after injection but stopped migrating to the west and south 5 years post injection and to the east and the north 20 years post injection. At 50 years post injection, the plume had migrated to 3.1 miles (4.9 kilometers) west, 2.0 miles (3.2 kilometers) east, 4.7 miles (7.6 kilometers) north, and 2.0 miles (3.2 kilometers) south of IZM #1.

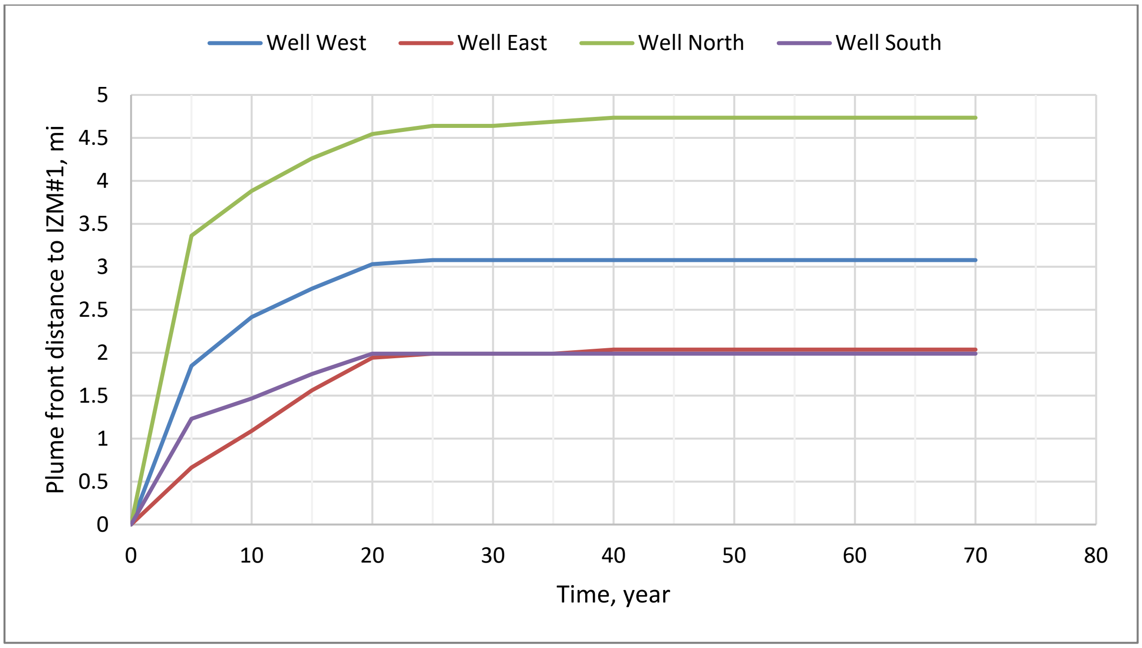

***Figure** 7. Plume front distance from in-zone monitoring well IZM #1 (OEE #1 converted) over time, based on a 1% CO_2 saturation cutoff*

The CO_2 plume height is highest at the injectors. During injection, the plume is confined within the Lower Mt. Simon (LMS) at OES #2 and OES #3 but reaches the bottom portion of the Middle Mt. Simon (MMS) at OES #1. At 50 years post injection (Figure 8), the plume remains within or below the MMS. At this point, there is no further horizontal or vertical expansion of the CO_2 plume. Additional discussion is provided in the Narrative and in the AoR and Corrective Action Plan.

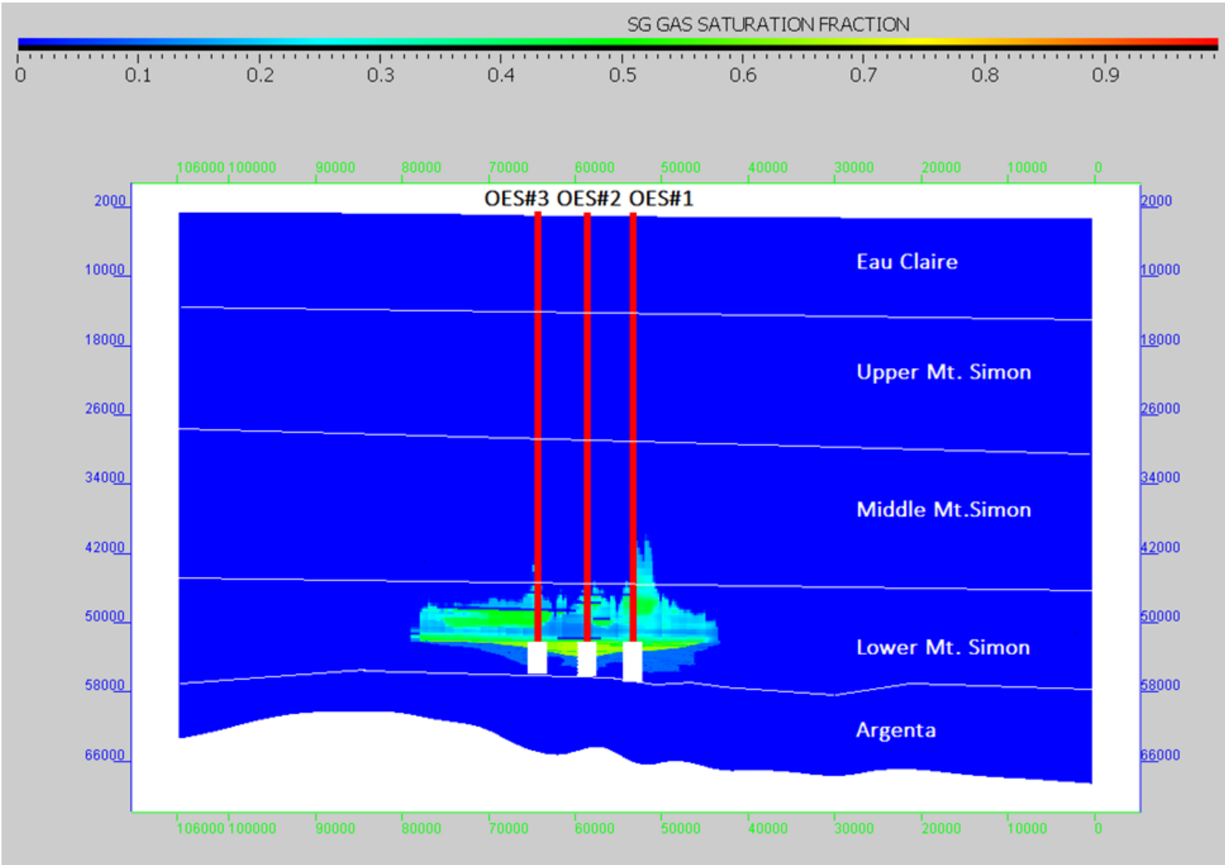

Figure 8. *Cross-sectional view of CO_2 saturation at 50 years post injection. Blue background in cross-sectional view shows the model area.*

A combination of time-lapse pulsed neutron logs and 2D seismic surveys to locate and track the extent of the CO_2 plume. The series of pulsed neutron logs collected in the Mt. Simon interval during the operational and post-injection phases of the project will be compared against the model's predicted vertical extent at specified time intervals. The data will be compared against the model using statistical methods to validate the model's ability to accurately represent the storage site. A good correlation between the two data sets will help provide strong evidence in validating the model's ability to represent the storage system.

Site-Specific Trapping Processes – 40 CFR 146.93(c)(1)(iv)-(vi)

In addition to carbon dioxide, mobilized fluids may pose a risk to USDWs. These include native fluids that are high in TDS and therefore may impair a USDW, and fluids containing mobilized drinking water contaminants (e.g., arsenic, mercury, hydrogen sulfide). The geochemical data collected from monitoring wells will be used to identify if mobilized fluids are present and evaluate if there is any risk to USDWs. For demonstration of non-endangerment One Earth Sequestration, LLC will compare the operational and PISC period samples collected from the ACZ wells, including the lowermost USDW, against the pre-injection baseline samples. This comparison will demonstrate whether significant changes in the fluid properties of the overlying formations have occurred and, if not, that no mobilized formation fluids have migrated above the seal formation.

The validation of seal integrity will help demonstrate that the injectate and or mobilized fluids would not represent an endangerment to any USDWs.

Additionally, RST logs will be used to monitor the salinity of the reservoir fluids in the Ironton-Galesville observation zone above the Eau Claire Formation seal. By comparing the time-lapse pulsed neutron logs against the pre-injection baseline logs, One Earth Sequestration, LLC will be able to monitor changes in reservoir fluid salinity. Logs indicating steady salinity levels within each zone would indicate no movement of fluids out of the storage unit, confirming the integrity of the well and seal formation.

Other trapping mechanisms have been evaluated and are discussed in more detail in the Narrative. Following are brief summaries of these mechanisms:

- Laboratory and modeling studies for mineral trapping in the Mt. Simon Sandstone of the Illinois Basin suggest that the bulk of the mineralogy is inert and that brine compositions showed little change within the time scale of laboratory experiments (within a year) (Carroll et al., 2013; Yoksoulian et al., 2014; Peter et al., 2019). Yoksoulian et al. (2014) conducted batch experiments for up to 9 months and did not observe the precipitation of carbonate minerals. Numerical simulations with both TOUGHREACT and PHREEQC 2.17.0 geochemical codes indicate that calcite ($CaCO_3$) or siderite ($FeCO_3$) may precipitate as a result of feldspar dissolution which buffer pH, but it generally takes hundreds of years to see significant mineral trapping (Carroll et al., 2013; Peter et al., 2019).

- The Eau Claire Formation is a laminated shale to silty shale. Advective flow from the Mt. Simon Sandstone into the Eau Claire is expected to be insignificant (Roy et al 2014). Modeling of ionic diffusion into the Eau Claire has also shown this to be insignificant (Roy et al 2014).

- Numerical simulations with PHREEQC 2.17.0 geochemical code suggested that the geochemical alteration of the Mt. Simon sandstone and Eau Claire shale can be modeled by incongruent dissolution of annite, illite, K-feldspar, and formation of montmorillonite, amorphous silica, and kaolinite. However, the formation of these secondary minerals was not confirmed with available characterization techniques.

Confining Zone Characterization – 40 CFR 146.93(c)(1)(vii)

As described in the Narrative, the Eau Claire Formation is the primary confining unit of the Mt. Simon Storage Complex at the One Earth CCS project site. The Eau Claire Formation is present across all of Illinois, ranging from less than 300 feet (91 meters) thick in the western part of the state to more than 1000 feet (305 meters) in the southeast (Buschbach, T. C., 1964).

Sensitive, Confidential, or Privileged Information

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Sensitive, Confidential, or Privileged Information [redacted]

The Eau Claire Formation has been the subject of numerous investigations into sealing characteristics, and it is the primary sealing strata for an existing carbon storage project at Decatur, IL. Roy et al. (2014) determined that both advective flow and ionic diffusion from the Mt. Simon Sandstone into the Eau Claire is insignificant.

Sensitive, Confidential, or Privileged Information [redacted]

[redacted]

Within the AoR, there are no faults identified on seismic that transect the Mt. Simon storage complex, nor are any faults identified in the overlying Eau Claire primary seal interval. The lack of transecting faults in both the reservoir and the seal indicate that containment would not be compromised by faulting. In addition, due to the Eau Claire formation having such a low density of few small, isolated fractures, containment would not be compromised by fractures.

Assessment of Fluid Movement Potential – 40 CFR 146.93(c)(1)(viii)-(ix)

One of the primary forces driving CO_2 or brine migration out of the storage formation is pressure increases in the storage formation above threshold pressure. Dynamic simulation indicates that after cessation of injection the pressure in the Mt. Simon Sandstone will decrease to below threshold pressure within about seven years, and that formation pressures will continue to steadily decrease toward the pre-injection static pressure. Figure 1 illustrates the simulated decrease in pressure in the Mt. Simon Sandstone once the injection phase of the project ends. Pressure decline toward pre-injection levels is a significant indicator of USDW non-endangerment. Additional discussion is provided in the Narrative and in the AoR and Corrective Action Plan.

During the PISC period, the operator will collect formation pressure data that will be used to evaluate pressure decline and resulting non-endangerment to USDWs. The operator will monitor the downhole reservoir pressure at various locations and intervals using a combination of surface and downhole pressure gauges. The measured pressure at a specific depth interval will be compared against the pressure predicted by the numerical simulation. Comparison of actual and predicted values will help validate the accuracy of the model and demonstration of non-endangerment.

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Figure 10. *OEE #1 (IZM #1) as built schematic.*

Location of USDWs – 40 CFR 146.93(c)(1)(x)

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<u>Non-Endangerment Demonstration Criteria</u>

Prior to approval of the end of the post-injection phase, One Earth Sequestration, LLC will submit a demonstration of non-endangerment of USDWs to the UIC Program Director, per 40 CFR 146.93(b)(2) and (3).

The owner or operator will issue a report to the UIC Program Director that will make a demonstration of USDW non-endangerment based on the evaluation of the site monitoring data used in conjunction with the project's computational model. The report will detail how the non-endangerment demonstration evaluation uses site-specific conditions to confirm and demonstrate non-endangerment. The report will include all relevant monitoring data and interpretations upon which the non-endangerment demonstration is based, model documentation and all supporting data, and any other information necessary for the UIC Program Director to review the analysis. The report will include the following sections:

Introduction and Overview

A summary of relevant background information will be provided, including the operational history of the injection project, the date of the non-endangerment demonstration relative to the post-injection period outlined in this PISC and Site Closure Plan, and a general overview of how monitoring and modeling results will be used together to support a demonstration of USDW non-endangerment.

Summary of Existing Monitoring Data

A summary of all previous monitoring data collected at the site, pursuant to the Testing and Monitoring Plan (Attachment C of this permit) and this PISC and Site Closure Plan, including data collected during the injection and post-injection phases of the project, will be submitted to help demonstrate non-endangerment. Data submittals will be in a format acceptable to the UIC Program Director [40 CFR 146.91(e)], and will include a narrative explanation of monitoring activities, including the dates of all monitoring events, changes to the monitoring program over time, and an

explanation of all monitoring infrastructure that has existed at the site. Data will be compared with baseline data collected during site characterization [40 CFR 146.82(a)(6) and 146.87(d)(3)].

Summary of Computational Modeling History

The results of computational modeling used for AoR delineation and for demonstration of an alternative PISC timeframe will be compared to the monitoring data collected during the injection and PISC phases of the project. The monitoring data used to update and calibrate the computational modeling and to demonstrate non-endangerment of USDWs will include:

- Temperature, pressure, and acoustic monitoring data from the Mt. Simon Sandstone, Ironton-Galesville Sandstone, and the St. Peter Sandstone, the deepest USDW
- Groundwater quality analyses
- Seismic data
- Pulsed neutron logs that characterize CO_2 saturations and vertical plume development along the well bores
- Time-lapse 2D surface seismic data

Data generated during the PISC period will be used to help show that the computational model accurately represents the storage site and can be used as a proxy to determine the CO_2 and pressure plume's properties and size. One Earth Energy LLC will demonstrate this degree of accuracy by comparing the monitoring data obtained during the PISC period against the model's predicted properties such as plume location, rate of movement, and pressure decay. The validation of the computational model with the large volume of available data will be a significant element to support the non-endangerment demonstration. Statistical methods will be employed to correlate the data and confirm the model's ability to accurately represent the storage site. The validation of the computational modeling results over the areas and zones where monitoring data have been collected will help to ensure confidence in those areas of the model.

Evaluation of Reservoir Pressure

One of the primary forces driving CO_2 or brine migration out of the storage formation is pressure increases in the storage formation above threshold pressure. Dynamic simulation indicates that after cessation of injection the pressure in the Mt. Simon Sandstone will decrease to below threshold pressure within about seven years, and that formation pressures will continue to steadily decrease toward the pre-injection static pressure. Figure 1 illustrates the simulated decrease in pressure in the Mt. Simon Sandstone once the injection phase of the project ends. Pressure decline toward pre-injection levels is a significant indicator of USDW non-endangerment. Additional discussion is provided in the Narrative and in the AoR and Corrective Action Plan.

During the PISC period the operator will collect formation pressure data that will be used to evaluate pressure decline and resulting non-endangerment to USDWs. The operator will monitor the downhole reservoir pressure at various locations and intervals using a combination of surface and downhole pressure gauges. The measured pressure at a specific depth interval will be compared against the pressure predicted by the numerical simulation. Comparison of actual and

the predicted values will help validate the accuracy of the model and demonstration of non-endangerment.

Evaluation of Carbon Dioxide Plume

The site modeling shows that the CO_2 plume will expand slightly during the PISC period. The CO_2 plume radius increases to 3.2 miles (5.1 kilometers) at the end of injection. The plume migrated in all directions after injection but stopped migrating to the west and south 5 years post injection and to the east and the north 20 years post injection. At 50 years post injection, the plume had migrated to 3.1 miles (4.9 kilometers) west, 2.0 miles (3.2 kilometers) east, 4.7 miles (7.6 kilometers) north, and 2.0 miles (3.2 kilometers) south of IZM #1. See Figure 7. Additional discussion is provided in the Narrative and in the AoR and Corrective Action Plan.

Other than the project wells, there are no identified potential conduits for fluid movement or leakage pathways within the AoR. The nearest well that penetrates the Eau Claire shale is associated with the Manlove Gas Storage field and is approximately 10.3 miles (16.6 kilometers) SSE of the IZM#1 well. The well is recorded as R.S. Hinton #1; drilled in 1959 and serves as a Mt. Simon observation well. Based on the computational model, and forecast migration (Figure 8), the plume will not reach this location. Based on this information, the potential for fluid movement through artificial penetrations of the seal formation does not present a risk of endangerment to any USDWs.

One Earth Sequestration, LLC will use a combination of time-lapse pulsed neutron logs and time lapse 2D seismic methods to locate and track the extent of the CO_2 plume. Pulsed neutron logging will be used to monitor the distribution and saturation of CO_2 adjacent to the injection well and IZM monitoring wells. A good correlation between pulsed neutron data sets and modeled plume thicknesses will help provide strong evidence in validating the model's ability to represent the storage system.

The time-lapse 2D surface seismic data will be acquired at longer time intervals and track the development of the CO_2 plume over a larger spatial extent. The data will be compared against the model using statistical methods to validate the model's ability to accurately represent the storage site.

Both the pulsed neutron logs and seismic data will be used to verify the computational model's ability to predict the CO_2 behavior in the PISC phase of the project and support a demonstration of non-endangerment of USDWs at the end of the project.

Evaluation of Emergencies or Other Events

During the injection operations and post-injection phases of the project, measurement of water quality parameters from the ACZ monitoring wells will be used to demonstrate that the storage formation fluids have not migrated above the confining formations. Assuming there is no such detectable movement of injection zone fluids, they are not anticipated to pose a risk to USDWs. To demonstrate non-endangerment, the project will compare the results of the fluid sampling from the Ironton-Galesville Sandstone and St. Peter Sandstone USDW from the injection and PISC phases to the pre-injection baseline samples. This comparison will demonstrate whether significant

changes in the fluid properties of the overlying formations have occurred and whether mobilized storage formation fluids have moved through the confining layer.

During injection operations, the site will be monitored with DAS to assess induced seismic events, if they occur. This monitoring will continue in the post injection project phase. However, the monitoring capabilities from the injection wells will be eliminated once these wells are plugged and abandoned.

Artificial penetrations include wells associated with the project. The injection wells will be plugged and abandoned with the permit P&A plan. The ACZ and IZM monitoring wells will be plugged and abandoned in accordance with the procedures outlined below. No other wells penetrate the confining zone within the AoR.

Site Closure Plan

One Earth Sequestration, LLC will conduct site closure activities to meet the requirements of 40 CFR 146.93(e) as described below. One Earth Sequestration, LLC will submit a final Site Closure Plan and notify the permitting agency at least 120 days prior of its intent to close the site. Once the permitting agency has approved closure of the site, One Earth Sequestration, LLC will plug the monitoring wells and submit a site closure report to EPA. The activities, as described below, represent the planned activities based on information provided to EPA. The actual site closure plan may employ different methods and procedures. A final Site Closure Plan will be submitted to the UIC Program Director for approval with the notification of the intent to close the site.

Plugging Monitoring Wells

The IZM and ACZ monitoring wells will be flushed with a kill weight brine fluid. A minimum of three tubing volumes will be injected without exceeding fracture pressure. A final external MIT will be conducted to ensure mechanical integrity. A summary of plugging procedures is provided below; detailed procedures for the deep monitoring wells will be the same as for the injection well (See Injection Well Plugging Plan). All casing in the wells will be cemented to surface and will not be retrievable at abandonment. After injection ceases and after the appropriate post-injection monitoring period is finished, the completion equipment will be removed from the well.

Type and Quantity of Plugging Materials, Depth Intervals

Commercially available well cementing software will be used to model the plugging and aid in the plug design. The cements used for plugging will be tested in the lab prior to plugplacement and both wet and dry samples will be collected during plugging for each plug to ensure quality of the plug.

The casing strings will be cut off at least 3 feet below the surface, below the plow line. A blanking plate with the required permit information will be welded to the top of the cutoff casing.

Volume Calculations

Volumes will be calculated for the specific abandonment wellbore environment based on desired plug diameter and length required. The methodology employed will be to:

1) Choose the following:
    a. Length of the cement plug desired.
    b. Desired setting depth of base of plug.
    c. Amount of spacer to be pumped ahead of the slurry.
2) Determine the following:
    a. Number of sacks of cement required.
    b. Volume of spacer to be pumped behind the slurry to balance the plug.
    c. Plug length before the pipe is withdrawn.
    d. Length of mud freefall in drill pipe.
    e. Displacement volume required to spot the plug.

<u>Plugging and Abandonment Procedure</u>

At the end of the serviceable life of the deep monitoring wells, they will be plugged and abandoned. In summary, the plugging procedure will consist of removing all components of the completion system and then placing cement plugs along the entire length of the well. Prior to placing the cement plugs, casing inspection and temperature logs will be run confirming externalmechanical integrity. If a loss of integrity is discovered, then a plan to repair using the cement squeeze method will be prepared and submitted to the agency for review and approval. At the surface, the well head will be removed; and the casing will be cut off 3 feet below surface.

<u>Planned Remedial/Site Restoration Activities</u>

To restore the site to its pre-injection condition following site closure, One Earth Sequestration, LLC will be guided by the state rules for plugging and abandonment of wells located on leased property under The Illinois Oil and Gas Act: Title 62: Mining Chapter I: Department of Natural Resources - Part 240, Section 240.1170 - Plugging Fluid Waste Disposal and Well Site Restoration.

The following steps will be taken:

1. The free liquid fraction of the plugging fluid waste, which may consist of produced water and/or crude oil, shall be removed from the pit and disposed of in accordance with state and federal regulations (e.g., injection or in above ground tanks or containers pending disposal) prior to restoration. The remaining plugging fluid wastes shall be disposed of byon-site burial.
2. All plugging pits shall be filled and leveled in a manner that allows the site to be returnedto original use with no subsidence or leakage of fluids, and where applicable, with sufficient compaction to support farm machinery.
3. All drilling and production equipment, machinery, and equipment debris shall be removed from the site.

4. Casing shall be cut off at least four (4) feet below the surface of the ground, and a steel plate welded on the casing or a mushroomed cap of cement approximately one (1) foot in thickness shall be placed over the casing so that the top of the cap is at least three (3) feetbelow ground level.
5. Any drilling rat holes shall be filled with cement to no lower than four (4) feet and no higher than three (3) feet below ground level.
6. The well site and all excavations, holes and pits shall be filled, and the surface leveled.

Site Closure Report

A site closure report will be prepared and submitted within 90 days following site closure, documenting the following:

- Plugging of the verification and geophysical wells (and the injection well if it has not previously been plugged),
- Location of sealed injection well on a plat of survey that has been submitted to the local zoning authority,
- Notifications to state and local authorities as required at 40 CFR 146.93(f)(2),
- Records regarding the nature, composition, and volume of the injected CO_2, and
- Post-injection monitoring records.

One Earth Sequestration, LLC will record a notation to the property's deed on which the injection well was located that will indicate the following:

- That the property was used for carbon dioxide sequestration,
- The name of the local agency to which a plat of survey with injection well location was submitted,
- The volume of fluid injected,
- The formation into which the fluid was injected, and
- The period over which the injection occurred.

The site closure report will be submitted to the permitting agency and maintained by the owner or operator for a period of 10 years following site closure. Additionally, the owner or operator will maintain the records collected during the post-injection period for a period of 10 years after which these records will be delivered to the UIC Program Director.

Quality Assurance and Surveillance Plan (QASP)

The Quality Assurance and Surveillance Plan is presented in the Appendix of the Testing and Monitoring Plan.

POST-INJECTION SITE CARE AND SITE CLOSURE PLAN
40 CFR 146.93(a)

One Earth CCS

Facility Information

Facility name:	One Earth Sequestration, LLC OES #3
Facility contact:	Mark Ditsworth, VP of Technology and Special Projects One Earth Sequestration, LLC, 202 N Jordan Drive, Gibson City, IL 60936, (217) 784-5321 ext. 215
Well location:	McLean County, IL 40.515829°N, -88.479947°W, (NAD 1983)

This Post-Injection Site Care and Site Closure (PISC) plan describes the activities that One Earth Sequestration, LLC will perform to meet the requirements of 40 CFR 146.93. One Earth Sequestration, LLC will monitor ground water quality and track the position of the carbon dioxide plume and pressure front for 10 years after the end of injection operations. One Earth Sequestration, LLC may not cease post-injection monitoring until a demonstration of non-endangerment of USDWs has been approved by the UIC Program Director pursuant to 40 CFR 146.93(b)(3). Following approval for site closure, One Earth Sequestration, LLC will plug all monitoring wells, restore the site to its original condition, and submit a site closure report and associated documentation.

Pre- and Post-Injection Pressure Differential [40 CFR 146.93(a)(2)(i)]

The predicted CO_2 saturation plume and pressure front at the end of injection operations are shown in Figure 1. A differential (threshold) pressure of 86 psi is used to define the pressure boundary for the AoR. Based on the modeling of the differential pressure front, the formation pressure at the injection wells is predicted to decline rapidly following cessation of injection. Additional information on the projected post-injection pressure decline and differentials is presented in the permit application modeling discussion and in the Area of Review and Corrective Action Plan. Figure 2 shows a pressure profile of the injection wells through the end of the injection phase and through 50 years post-injection. As Figure 2 demonstrates, the pressure differential at the injection wells decreases to less than threshold pressure in approximately 6 years after the end of injection operations.

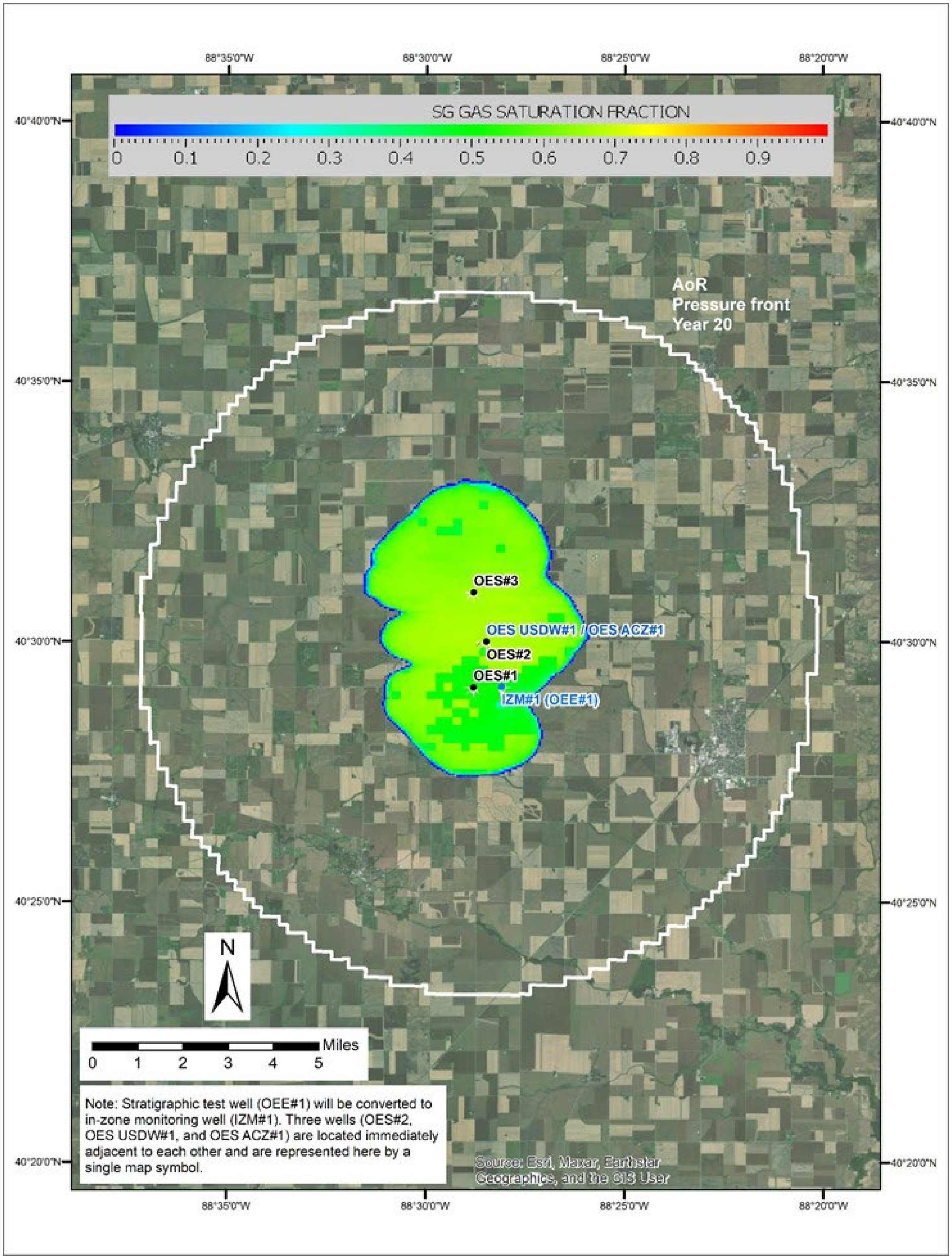

Figure 1. *One Earth CCS map of the predicted extent of the CO_2 plume and pressure front at the end of injection operations.*

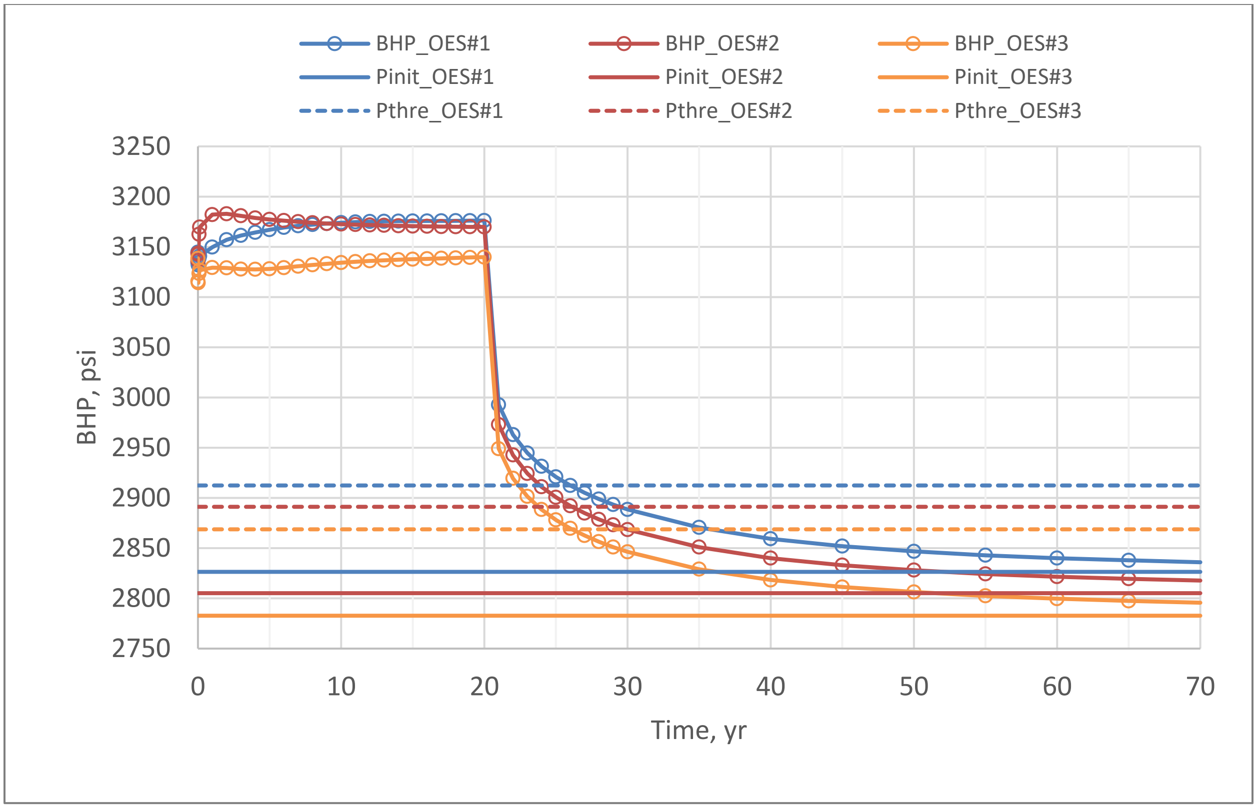

Figure 2. *Pressure profile for injection wells. Dashed lines represent baseline pressure differential (threshold pressure) datum for defining AoR. Solid lines represent formation baseline pressure.*

<u>Predicted Position of the CO_2 Plume and Associated Pressure Front at Site Closure [40 CFR 146.93(a)(2)(ii)]</u>

Figure 1 shows the predicted extent of the plume and pressure front at the end of the injection operations. This map is based on the final AoR delineation modeling results submitted pursuant to 40 CFR 146.84.

Figure 3 shows the predicted position of the CO_2 plume 10 years after the end of injection operations. This map is based on the final AoR delineation modeling results pursuant to 40 CFR 146.84. The figures demonstrate the stability of the CO_2 plume during the PISC phase.

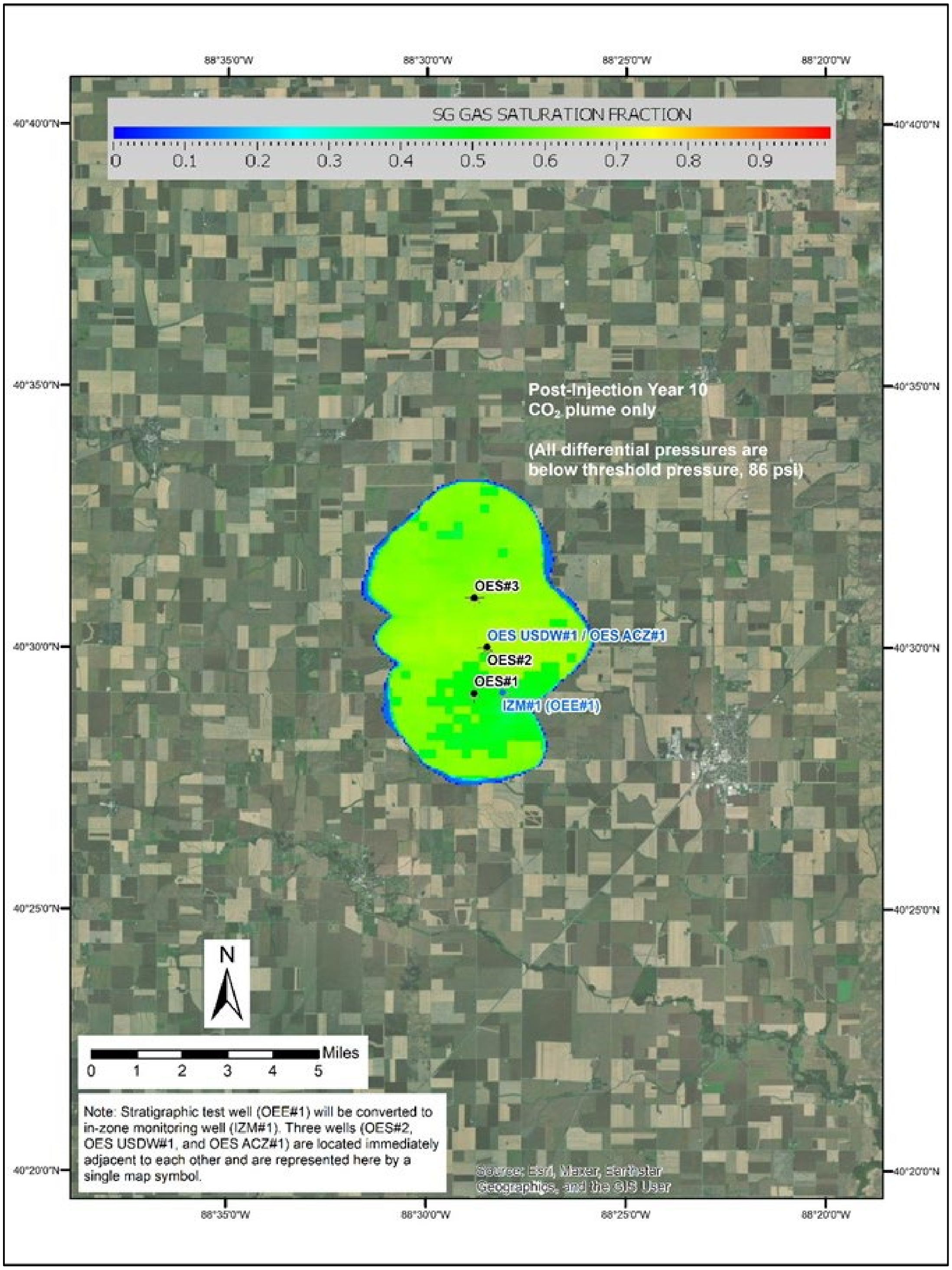

Figure 3. *Monitoring locations and predicted position of CO_2 plume 10 years after the end of injection operations.*

Post-Injection Monitoring Plan [40 CFR 146.93(b)(1)]

Performing groundwater quality monitoring and plume and pressure front tracking as described in the following sections during the post-injection phase will meet the requirements of 40 CFR 146.93(b)(1). The results of all post-injection phase testing and monitoring will be submitted annually, within 60 days after the anniversary of the date on which injection ceased, as described under "Schedule for Submitting Post-Injection Monitoring Results," below.

A quality assurance and surveillance plan (QASP) for all testing and monitoring activities during the injection and post injection phases is provided in the Appendix to the Testing and Monitoring Plan.

To date, One Earth Sequestration, LLC has successfully negotiated surface land access for purposes of drilling the stratigraphic well, and pre-injection (baseline) monitoring activities such as 2D and 3D seismic testing. One Earth Sequestration, LLC's proven ability to work with local landowners and public entities to obtain access to surface and subsurface areas for activities related to the project should be sufficient to demonstrate One Earth Sequestration, LLC's ability to obtain access for monitoring, and corrective actions (if they are necessary) in the future. One Earth Sequestration, LLC may acquire, by lease or purchase, additional land parcel areas and surface entry rights for the injection, monitoring, and surface and sub-surface infrastructure. Monitoring well locations could change slightly but only to the extent that they retain their monitoring intent as described in the Testing and Monitoring Plan and QASP. Monitoring locations will also consider access routes that minimize property damage, crop loss, and property owner inconvenience, and to assure safe access to each location.

Table 1 provides a summary of PISC monitoring activities. Figure 1 shows the location of the injection and monitoring wells.

The project will continue to monitor the well integrity of the injection and in zone monitoring (IZM) wells annually using temperature, noise, or oxygen activation logs to ensure that there is no migration of CO_2 up the wellbores. In addition, the project will monitor the annular pressures and fluid volumes in the injection well on a continuous basis until the well is plugged and abandoned. Refer to the Well Operations Plan and the Testing and Monitoring Plan for more information on the well integrity and operational monitoring plans.

Pulsed neutron (PNC) logging will continue in the IZM and the above confining zone (ACZ) monitoring wells each year of the PISC phase. This will allow the project to continue to observe the vertical plume development in the Mt. Simon Sandstone and further verify that CO_2 is not migrating past the confining zone and into ACZ aquifers; thereby endangering underground sources of drinking water (USDWs). Refer to the Testing and Monitoring Plan for more information on the PNC logging plans in the injection phase of the project (Permit Sections 7.0).

The project will continue to monitor pressures within the injection well until it is abandoned. The injection well pressure measurements are expected to verify the pressure decrease, and these data will be used to history match the computational modelling in the PISC phase.

Pressures will also continue to be monitored in the ACZ wells including the Ironton-Galesville Sandstone and the St. Peter Sandstone to confirm the continued containment of CO_2 within the

storage formation. Fluid samples will be taken from OES ACZ#1 and OES USDW#1 annually for geochemical and isotopic analysis to further verify CO_2 containment.

The possibility of induced seismicity is expected to decline rapidly during the post-injection period. DAS system monitoring will continue for 5 years post-injection in the monitoring wells and in the injection wells until they are plugged and abandoned. The UIC Program Director will be notified prior to discontinuing data acquisition in the DAS.

The project proposes to acquire two time-lapse 2D surface seismic surveys in the PISC phase of the project. One will be acquired within five years of the most recent injection operations survey; the second within 9 years after the end of injection. The objectives of the surveys include:

- Demonstrate the stability of the CO_2 plume after the injection phase of the project
- Provide data for the calibration and verification of computational modelling
- Demonstrate non-endangerment of USDWs at the end of the PISC phase.

Table 1. *Summary of PISC monitoring.*

Monitoring Activity	Post-injection Phase Frequency	Location
	Injection Wells	
Annular Pressure	Continuous until P&A	Injection Wellhead
Annular Fluid Volume	Continuous until P&A	Injection Wellhead
Temperature or Noise or Oxygen Activation Log	Annually until P&A	Injection Well
DTS, DAS	Continuous until P&A	Injection Well Downhole, above perforations
Pulsed Neutron Logging	Annual until P&A	Injection Well
	Verification Monitoring	
Fluid Sampling and Analysis		
St. Peter sandstone	Annually	ACZ well
Ironton Galesville formations	Annually	ACZ Well
Mt. Simon	Annually*	IZM Wells
Isotope Analysis	Annually*	ACZ and IZM wells
Pressure, DTS, DAS		
St. Peter Sandstone	Continuous	ACZ well
Ironton Galesville formations	Continuous	ACZ well
IZM Mt. Simon Sandstone	Continuous	IZM wells
Pulsed Neutron Logging	Annually	IZM Wells
Time-lapse 2D Surface Seismic Data	Initial PISC survey 5 years from most recent. Additional PISC survey within 9 years after end of injection	Surface

*Fluid samples will not be collected in the IZM wells if there is breakthrough of CO_2 at the well location.

Monitoring Above the Confining Zone

Groundwater Quality Monitoring

Table 2 presents the monitoring methods, locations, and frequencies for monitoring above the confining zone. Table 2 identifies the parameters to be monitored and the analytical methods One Earth Sequestration, LLC will employ. This includes lowermost USDW (St. Peter Sandstone), and from above confining zone well (Ironton-Galesville). Table 3 identifies the parameters to be monitored and the analytical methods One Earth Sequestration, LLC will employ, and Figure 3 shows the locations of the monitoring wells.

***Table 2**. Monitoring above the confining zone* [1, 2].

Target Formation	MonitoringActivity	Monitoring Location(s)	Frequency
Lowermost USDW (St. Peter Sandstone)	Fluid sampling	OES USDW#1	Annual
	Pressure/ DTS monitoring	OES USDW#1	Continuous
	PNC Logging	OES USDW#1	Annual
Above Confining Zone (Ironton-Galesville)	Fluid sampling	OES ACZ#1	Annual
	Pressure/ DTS monitoring	OES ACZ#1	Continuous
	PNC Logging	OES ACZ#1	Annual

Note 1: Collection and recording of continuous monitoring data will occur at the frequencies described in Table 4.

Note 2: Annual sampling and monitoring will occur up to 45 days before the anniversary date of cessation of injection or alternatively scheduled with the prior approval of the Director.

***Table 3**. Summary of analytical and field parameters for ground water samples.*

Parameters	Analytical Methods [1]
Cations: Al, Ba, Mn, As, Cd, Cr, Cu, Pb, Sb Se, and Tl	ICP-MS, EPA Method 6020
Cations: Ca, Fe, K, Mg, Na, and Si	ICP-OES, EPA Method 6010B
Anions: Br, Cl, F, NO3, and SO_4	Ion Chromatography, EPA Method 300.0
Dissolved CO_2	Coulometric titration, ASTM D513-11
Isotopes: $\delta^{13}C$ of DIC	Isotope ratio mass spectrometry
Total Dissolved Solids	Gravimetry; APHA 2540C
Water Density (field)	Oscillating body method
Alkalinity	APHA 2320B
pH (field)	EPA 150.1
Specific conductance (field)	APHA 2510
Temperature (field)	Thermocouple

Note 1: ICP = inductively coupled plasma; MS = mass spectrometry; OES = optical emission spectrometry; GC-P =gas chromatography - pyrolysis. An equivalent method may be employed with prior approval of the Director.

A quality assurance and surveillance plan (QASP) for all testing and monitoring activities, required pursuant to 146.90(k), is provided as an Appendix to the Testing and Monitoring Plan.

Sampling will be performed as described in Section B.2 of the QASP; this section of the QASP describes the groundwater sampling methods to be employed, including sampling standard operating procedures (SOPs) (Section B.2 a/b), and sample preservation (Section B.2.f).

A qualified, commercial laboratory will be selected to provide analytical services in accordance with the methods and standards included here and in the QASP. Sample handling and custody will

be performed as described in Section B.3 of the QASP. Quality control will be ensured using the methods described in Section B.5 of the QASP: Carbon Dioxide Plume and Pressure Front Tracking [40 CFR 146.93(a)(2)(iii)].

One Earth Sequestration, LLC will employ direct and indirect methods to track the extent of the carbon dioxide plume and the presence or absence of elevated pressure.

Table 4 presents the in zone monitoring that One Earth Sequestration, LLC will use to monitor the CO_2 plume, including the activities, locations, and frequencies. The parameters to be analyzed as part of fluid sampling in the Mt. Simon sandstone (and associated analytical methods) are presented in Table 3.

Table 4 includes the direct and indirect methods that One Earth Sequestration, LLC will use to monitor the pressure front, including monitoring activities, locations, and frequencies. One Earth Sequestration, LLC will deploy pressure/temperature monitors and distributed temperature and acoustic sensors to directly monitor in zone and above zone conditions. Quality assurance procedures for seismic monitoring methods will meet industry standards and will be established for the One Earth Sequestration, LLC project at the time seismic acquisition and processing contractors are selected.

A quality assurance and surveillance plan (QASP) for all testing and monitoring activities, required pursuant to 146.90(k), is provided as an Appendix to the Testing and Monitoring Plan.

Sampling will be performed as described in Section B.2 of the QASP; this section of the QASP describes the groundwater sampling methods to be employed, including sampling standard operating procedures (SOPs) (Section B.2 a/b), and sample preservation (Section B.2.f).

A qualified, commercial laboratory will be selected to provide analytical services in accordance with the methods and standards included here and in the QASP. Sample handling and custody will be performed as described in Section B.3 of the QASP. Quality control will be ensured using the methods described in Section B.5 of the QASP.

Table 4. *Post-injection phase plume and pressure front monitoring.*

Target Formation	Monitoring Activity	Monitoring Location(s)	Spatial Coverage	Frequency
Mt. Simon	Fluid sampling	IZM #1 IZM #2		Annual
	Pressure/ DTS monitoring	IZM #1, IZM #2		Continuous
		OES #1, OES #2, OES #3		Continuous until P&A
	Pulse Neutron Logging	IZM #1 IZM #2		Annual
		OES #1		Annual until P&A
		OES #2		Annual until P&A
		OES #3		Annual until P&A
	2D seismic survey	AOR Surface		Initial PISC survey 5 years from most recent. Additional PISC survey within 9 years after end of injection

Sampling and geophysical surveys will occur within 60 days before the anniversary date of cessation of injection or alternatively scheduled with the prior approval of the Director. Seismic surveys will be performed in the 4th quarter before, or the 1st quarter of the year or alternatively scheduled with the prior approval of the Director.

Subsurface monitoring locations relative to the predicted location of the CO_2 plume and pressure front at 10 years after the end of injection operations are shown in Figure 3.

Schedule for Submitting Post-Injection Monitoring Results [40 CFR 146.93(a)(2)(iv)]

All post-injection site care monitoring data and monitoring results collected using the methods described above will be submitted to the Director in annual reports. These reports will be submitted annually, within 60 days following the anniversary date of the date on which injection ceases or alternatively with the prior approval of the Director.

The reports will contain information and data generated during the reporting period, i.e., well-based monitoring data, sample analysis, and the results from updated site models.

Alternative Post-Injection Site Care Timeframe [40 CFR 146.93(c)]

One Earth Sequestration, LLC will conduct post-injection monitoring for 10 years following the cessation of injection operations. One Earth Sequestration, LLC will demonstrate that an alternative PISC timeframe is appropriate, pursuant to 40CFR 146.93(c)(1). Regardless of the alternative PISC timeframe, monitoring and reporting as described in the sections above will continue until One Earth Sequestration, LLC demonstrates, based on monitoring and other site-specific data, that no additional monitoring is needed to ensure that the project does not pose an endangerment to any USDWs, per the requirements at 40 CFR 146.93(b)(2) or (3).

One Earth Sequestration, LLC will conduct all of the monitoring described under "Groundwater Quality Monitoring" and "Carbon Dioxide Plume and Pressure Front Tracking" above and report the results as described under the "Schedule for Submitting Post-Injection Monitoring Results."

If any of the information on which the demonstration was based changes or the actual behavior of the site varies significantly from modeled predictions (e.g., because of an AoR reevaluation) One Earth Sequestration, LLC may update this PISC and Site Closure Plan pursuant to 40 CFR 146.93(a)(4). If revisions are required, One Earth Sequestration, LLC will update the PISC and Site Closure Plan within six months of reporting the unexpected monitoring results

A summary of all previous monitoring data collected at the site, pursuant to the Testing and Monitoring Plan and this PISC and Site Closure Plan, including data collected during the injection and PISC phases of the project, will be submitted to help demonstrate non-endangerment. Data submittals will be in a format acceptable to the Director [40 CFR 146.91(e)], and will include a narrative explanation of monitoring activities, including the dates of all monitoring events, changes to the monitoring program over time, and an explanation of all monitoring infrastructure that has existed at the site. Data will be compared with baseline data collected during site characterization [40 CFR 146.82(a)(6) and 146.87(d)(3)].

Computational Modeling Results – 40 CFR 146.93(c)(1)(i)

The results of computational modeling used for AoR delineation and for demonstration of an alternative PISC timeframe will be compared to monitoring data collected during the operational and the PISC period. The data will include the results of time-lapse temperature and pressure monitoring, groundwater quality analyses, seismic monitoring, and geophysical surveys (i.e., logging, operating-phase 2D surface seismic surveys) used to update the computational model and to monitor the site. Data generated during the PISC period will be used to help show that the computational model accurately represents the storage site and can be used as a proxy to determine the plume's properties and size. The operator will demonstrate this degree of accuracy by comparing the monitoring data obtained during the PISC period against the model's predicted properties (i.e., plume location, rate of movement, and pressure decay). Statistical methods will be employed to correlate the data and confirm the model's ability to accurately represent the storage site. The validation of the computational model with the large volume of available data will be a significant element to support the non-endangerment demonstration.

Modeling scenarios, including sensitivity analysis and evaluation of the post-injection phase of the project are discussed in detail in the AoR and Corrective Action Plan.

As part of the modeling, two major CO_2 trapping mechanisms were considered: structural/stratigraphic trapping, and residual trapping. Solubility trapping was not modeled due to a limitation in software; however, the modeled plume size and resulting AoR are larger than if solubility trapping was included as some CO_2 will dissolve into the formation water (Mehnert et al., 2014). The solubility trapping of CO_2 in water may be included during AoR reevaluations and in the post-injection site care updates. Mineral trapping was considered negligible because the storage unit is primarily quartz. These processes allow the prediction of CO_2 movement in terms of gas saturation, reservoir pressure change with time to delineate the Area of Review (AoR), and the corresponding tubing head pressure during and after injection.

Structural/stratigraphic trapping for the post-injection period, along with sensitivity to variations in porosity and permeability were also considered in the site model (see AoR and Corrective Action Plan). A summary of these results by AoR extent is shown in Figure 4.

Data collected during drilling of the injection wells will provide an opportunity to further refine modeling with site-specific injection well borehole data. These data will be used to update the computational model. In addition, downhole pressure monitoring during and after injection can provide near-continuous information to compare the predicted and actual pressure response to CO_2 injection. These data will be used to recalculate the AoR as new data is incorporated for reevaluation. A summary of the schedule for model updates is included in the AoR and Corrective Action Plan.

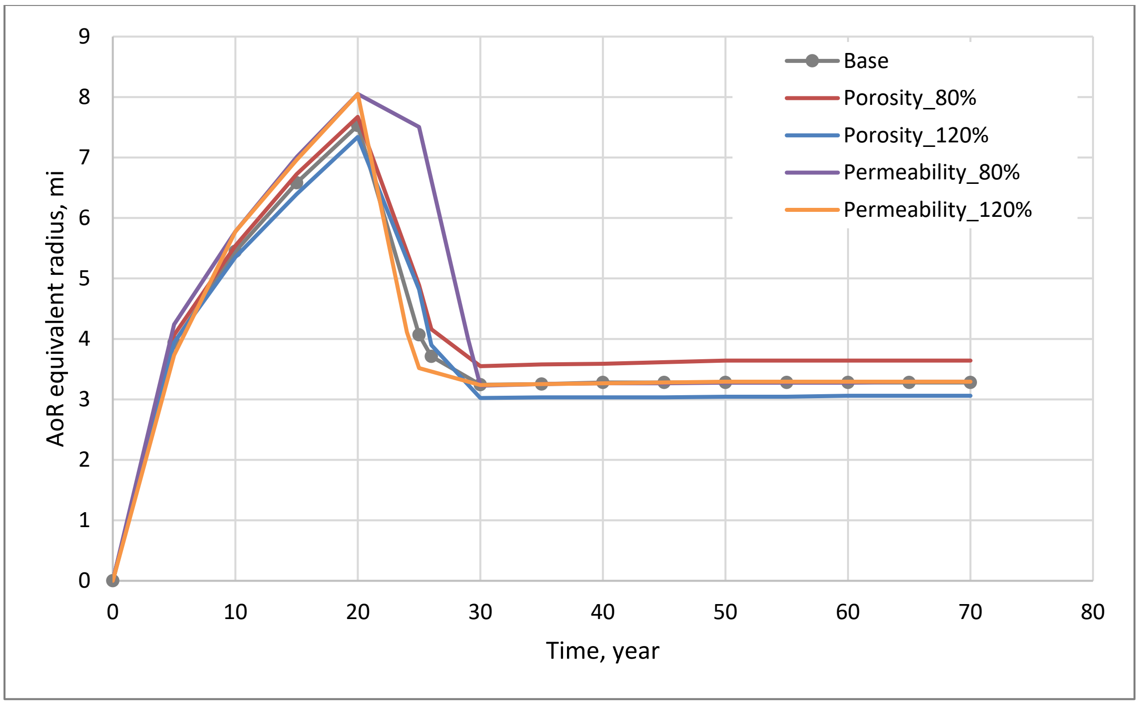

Figure 4. *Area of Review equivalent radius change over time at varying porosity and permeability.*

Predicted Timeframe for Pressure Decline – 40 CFR 146.93(c)(1)(ii)

Figure 5 and Table 5 summarize the CO_2 plume, differential pressure, and AoR evolution with time. The CO_2 plume radius increased from 3.2 (5.1 kilometers) miles at the end of injection to 3.3 miles (5.3 kilometers) at 50 years post injection.

Differential pressure radius reached its maximum of 7.5 miles (12.1 kilometers) at the end of injection, dropped to 3.2 miles (5.1 kilometers) at 6 years post injection and 1 mile (1.6 kilometers) at 7 years post injection, and then diminished within 8 years post injection to below the established critical threshold. The AoR was determined solely by the differential pressure front until 5 years post injection, with a maximum radius of 7.5 miles (12.1 kilometers) at the end of injection.

A comparison of the pressure time series from the sensitivity analysis demonstrates that the that the pressure build-up during the injection phase and rapid decline during the PISC phase are similar to base case for a range of geologic parameters (Figure 4).

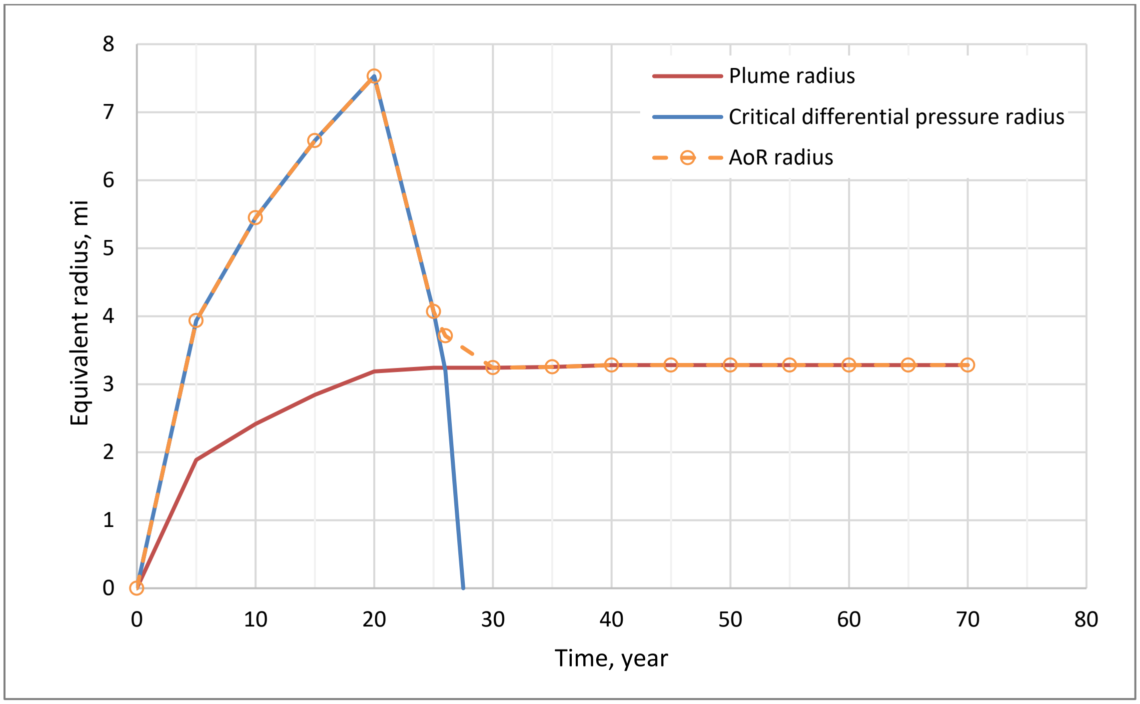

Figure 5*. Equivalent radius of plume, differential pressure, and AoR change with time.*

Table 5*. Summary of plume size, differential pressure radius, and AoR change with time.*

Time, yr		CO_2 plume size			Differential pressure equivalent radius, mi	AoR	
		Plume equivalent radius, mi	Width, mi	Length, mi		AoR equivalent radius, mi	AoR, mi^2
Injection	5	1.9	2.5	4.5	3.9	3.9	49
	10	2.4	3.5	5.3	5.4	5.4	93
	15	2.8	4.3	6.0	6.6	6.6	136
	20	3.2	4.9	6.5	7.5	7.5	178
Post injection	5	3.2	5.0	6.6	4.1	4.1	52
	6	3.2	5.0	6.6	3.2	3.7	43
	10	3.2	5.0	6.6	0.0	3.2	33
	50	3.3	5.1	6.7	0.0	3.3	34

Continuous pressure measurements will be acquired from the Mt. Simon Sandstone though the injection and PISC phases of the project (see Testing and Monitoring Plan). The pressure data obtained during the injection phase of the project will be used to update the computational modelling every six months as per the reporting requirements in 40 CFR 146.91. Pressure data

acquired during the PISC phase of the project is expected to verify the rapid decline in pressure in the Mt. Simon Sandstone predicted by the computational modelling.

Predicted Rate of Plume Migration – 40 CFR 146.93(c)(1)(iii)

At 6 years post injection, the AoR radius diminished to 3.6 miles (5.8 kilometers) and was established by the plume boundary and pressure differential front (Figure 6). By 7 years post injection, the differential pressure front has further diminished such that it is situated within the lateral extent of the CO_2 plume. The site modeling shows that the CO_2 plume will expand slightly during the PISC period from 3.2 miles (5.1 kilometers) at the end of injection to 3.3 miles (5.3 kilometers) 50 years after injection ceases (Table 5).

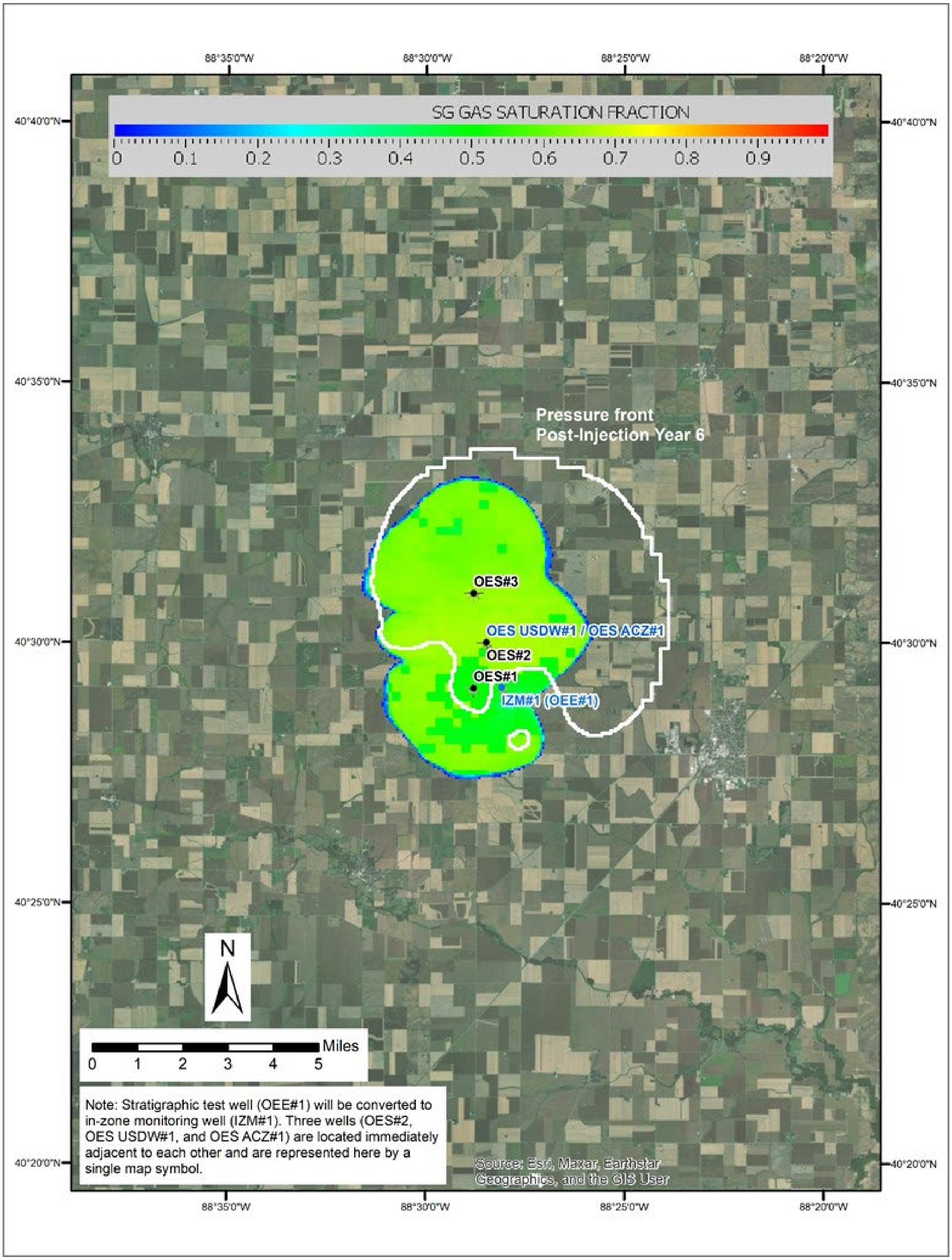

Figure 6. *Pressure differential and plume boundary 6 years post injection.*

Figure 7 shows the time-series distance between the plume front and the in-zone monitoring well IZM #1, converted from OEE #1, in all four cardinal directions. At the end of 20 years of injection, the plume front in relation to IZM #1 was 3.0 miles (4.8 kilometers) west, 1.9 miles (3.1 kilometers) east, 4.5 miles (7.2 kilometers) north, and 2.0 miles (3.2 kilometers) south. The plume migrated in all directions after injection but stopped migrating to the west and south 5 years post injection and to the east and the north 20 years post injection. At 50 years post injection, the plume had migrated to 3.1 miles (4.9 kilometers) west, 2.0 miles (3.2 kilometers) east, 4.7 miles (7.6 kilometers) north, and 2.0 miles (3.2 kilometers) south of IZM #1.

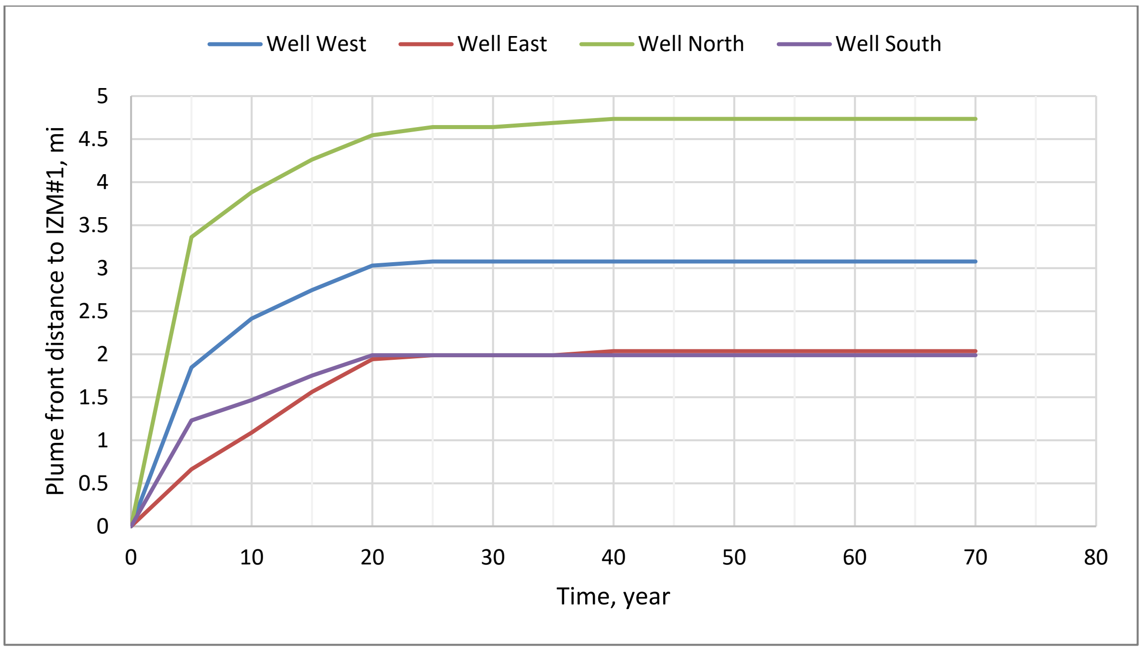

***Figure** 7. Plume front distance from in-zone monitoring well IZM #1 (OEE #1 converted) over time, based on a 1% CO_2 saturation cutoff*

The CO_2 plume height is highest at the injectors. During injection, the plume is confined within the Lower Mt. Simon (LMS) at OES #2 and OES #3 but reaches the bottom portion of the Middle Mt. Simon (MMS) at OES #1. At 50 years post injection (Figure 8), the plume remains within or below the MMS. At this point, there is no further horizontal or vertical expansion of the CO_2 plume. Additional discussion is provided in the Narrative and in the AoR and Corrective Action Plan.

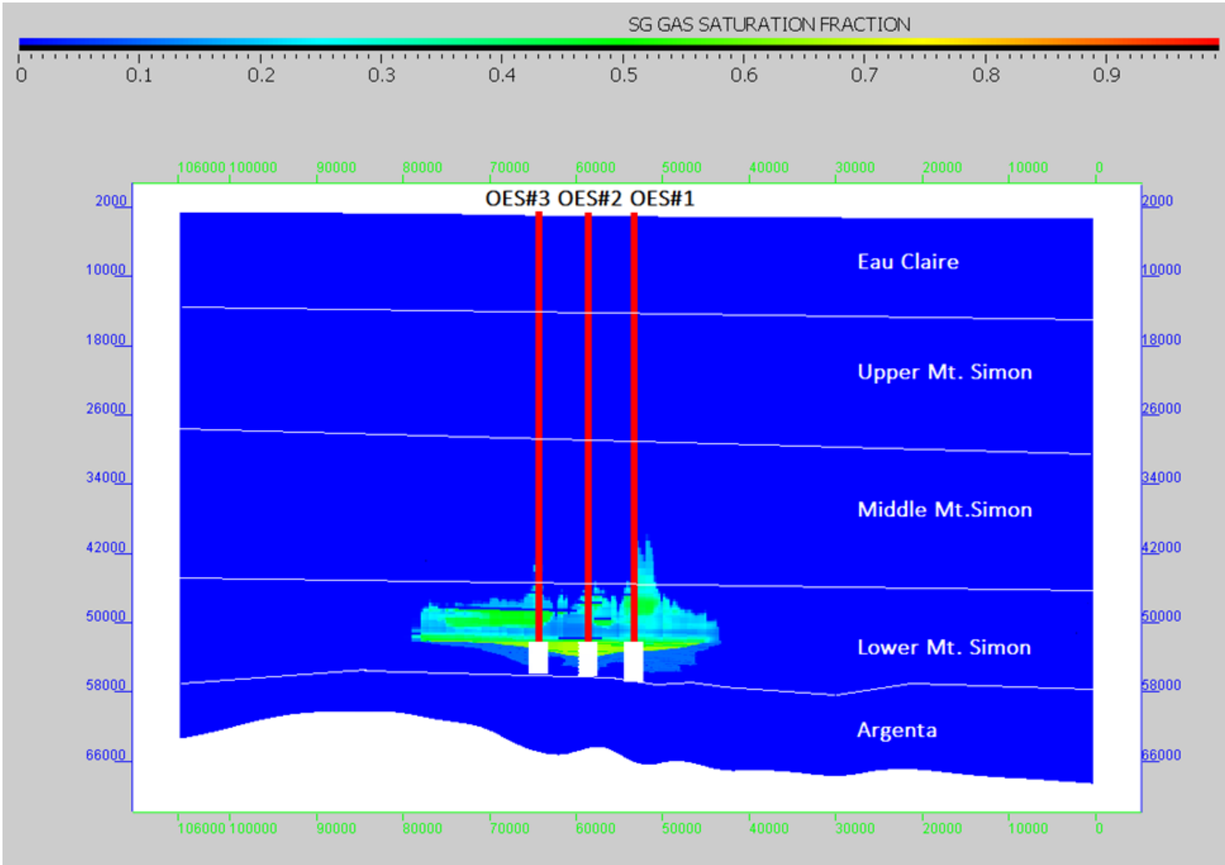

Figure 8*. Cross-sectional view of CO_2 saturation at 50 years post injection. Blue background in cross-sectional view shows the model area.*

A combination of time-lapse pulsed neutron logs and 2D seismic surveys will be used to locate and track the extent of the CO_2 plume. The series of pulsed neutron logs collected in the Mt. Simon interval during the operational and post-injection phases of the project will be compared against the model's predicted vertical extent at specified time intervals. The data will be compared against the model using statistical methods to validate the model's ability to accurately represent the storage site. A good correlation between the two data sets will help provide strong evidence in validating the model's ability to represent the storage system.

Site-Specific Trapping Processes – 40 CFR 146.93(c)(1)(iv)-(vi)

In addition to carbon dioxide, mobilized fluids may pose a risk to USDWs. These include native fluids that are high in TDS and therefore may impair a USDW, and fluids containing mobilized drinking water contaminants (e.g., arsenic, mercury, hydrogen sulfide). The geochemical data collected from monitoring wells will be used to identify if mobilized fluids are present and evaluate if there is any risk to USDWs. For demonstration of non-endangerment One Earth Sequestration, LLC will compare the operational and PISC period samples collected from the ACZ wells, including the lowermost USDW, against the pre-injection baseline samples. This comparison will demonstrate whether significant changes in the fluid properties of the overlying formations have occurred and, if not, that no mobilized formation fluids have migrated above the seal formation.

The validation of seal integrity will help demonstrate that the injectate and or mobilized fluids would not represent an endangerment to any USDWs.

Additionally, RST logs will be used to monitor the salinity of the reservoir fluids in the Ironton-Galesville observation zone above the Eau Claire Formation seal. By comparing the time-lapse pulsed neutron logs against the pre-injection baseline logs, One Earth Sequestration, LLC will be able to monitor changes in reservoir fluid salinity. Logs indicating steady salinity levels within each zone would indicate no movement of fluids out of the storage unit, confirming the integrity of the well and seal formation.

Other trapping mechanisms have been evaluated and are discussed in more detail in the Narrative. Following are brief summaries of these mechanisms:

- Laboratory and modeling studies for mineral trapping in the Mt. Simon Sandstone of the Illinois Basin suggest that the bulk of the mineralogy is inert and that brine compositions showed little change within the time scale of laboratory experiments (within a year) (Carroll et al., 2013; Yoksoulian et al., 2014; Peter et al., 2019). Yoksoulian et al. (2014) conducted batch experiments for up to 9 months and did not observe the precipitation of carbonate minerals. Numerical simulations with both TOUGHREACT and PHREEQC 2.17.0 geochemical codes indicate that calcite ($CaCO_3$) or siderite ($FeCO_3$) may precipitate as a result of feldspar dissolution which buffer pH, but it generally takes hundreds of years to see significant mineral trapping (Carroll et al., 2013; Peter et al., 2019).

- The Eau Claire Formation is a laminated shale to silty shale. Advective flow from the Mt. Simon Sandstone into the Eau Claire is expected to be insignificant (Roy et al 2014). Modeling of ionic diffusion into the Eau Claire has also shown this to be insignificant (Roy et al 2014).

- Numerical simulations with PHREEQC 2.17.0 geochemical code suggested that the geochemical alteration of the Mt. Simon sandstone and Eau Claire shale can be modeled by incongruent dissolution of annite, illite, K-feldspar, and formation of montmorillonite, amorphous silica, and kaolinite. However, the formation of these secondary minerals was not confirmed with available characterization techniques.

Confining Zone Characterization – 40 CFR 146.93(c)(1)(vii)

As described in the Narrative, the Eau Claire Formation is the primary confining unit of the Mt. Simon Storage Complex at the One Earth CCS project site. The Eau Claire Formation is present across all of Illinois, ranging from less than 300 feet (91 meters) thick in the western part of the state to more than 1000 feet (305 meters) in the southeast (Buschbach, T. C., 1964).

Sensitive, Confidential, or Privileged Information

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Sensitive, Confidential, or Privileged Information

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The Eau Claire Formation has been the subject of numerous investigations into sealing characteristics, and it is the primary sealing strata for an existing carbon storage project at Decatur, IL. Roy et al. (2014) determined that both advective flow and ionic diffusion from the Mt. Simon Sandstone into the Eau Claire is insignificant.

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Within the AoR, there are no faults identified on seismic that transect the Mt. Simon storage complex, nor are any faults identified in the overlying Eau Claire primary seal interval. The lack of transecting faults in both the reservoir and the seal indicate that containment would not be compromised by faulting. In addition, due to the Eau Claire formation having such a low density of few small, isolated fractures, containment would not be compromised by fractures.

Assessment of Fluid Movement Potential – 40 CFR 146.93(c)(1)(viii)-(ix)

One of the primary forces driving CO_2 or brine migration out of the storage formation is pressure increases in the storage formation above threshold pressure. Dynamic simulation indicates that after cessation of injection the pressure in the Mt. Simon Sandstone will decrease to below threshold pressure within about seven years, and that formation pressures will continue to steadily decrease toward the pre-injection static pressure. Figure 1 illustrates the simulated decrease in pressure in the Mt. Simon Sandstone once the injection phase of the project ends. Pressure decline toward pre-injection levels is a significant indicator of USDW non-endangerment. Additional discussion is provided in the Narrative and in the AoR and Corrective Action Plan.

During the PISC period, the operator will collect formation pressure data that will be used to evaluate pressure decline and resulting non-endangerment to USDWs. The operator will monitor the downhole reservoir pressure at various locations and intervals using a combination of surface and downhole pressure gauges. The measured pressure at a specific depth interval will be compared against the pressure predicted by the numerical simulation. Comparison of actual and predicted values will help validate the accuracy of the model and demonstration of non-endangerment.

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Figure 10. *OEE #1 (IZM #1) as built schematic.*

Location of USDWs – 40 CFR 146.93(c)(1)(x)

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<u>Non-Endangerment Demonstration Criteria</u>

Prior to approval of the end of the post-injection phase, One Earth Sequestration, LLC will submit a demonstration of non-endangerment of USDWs to the UIC Program Director, per 40 CFR 146.93(b)(2) and (3).

The owner or operator will issue a report to the UIC Program Director that will make a demonstration of USDW non-endangerment based on the evaluation of the site monitoring data used in conjunction with the project's computational model. The report will detail how the non-endangerment demonstration evaluation uses site-specific conditions to confirm and demonstrate non-endangerment. The report will include all relevant monitoring data and interpretations upon which the non-endangerment demonstration is based, model documentation and all supporting data, and any other information necessary for the UIC Program Director to review the analysis. The report will include the following sections:

Introduction and Overview

A summary of relevant background information will be provided, including the operational history of the injection project, the date of the non-endangerment demonstration relative to the post-injection period outlined in this PISC and Site Closure Plan, and a general overview of how monitoring and modeling results will be used together to support a demonstration of USDW non-endangerment.

Summary of Existing Monitoring Data

A summary of all previous monitoring data collected at the site, pursuant to the Testing and Monitoring Plan (Attachment C of this permit) and this PISC and Site Closure Plan, including data collected during the injection and post-injection phases of the project, will be submitted to help demonstrate non-endangerment. Data submittals will be in a format acceptable to the UIC Program Director [40 CFR 146.91(e)], and will include a narrative explanation of monitoring activities, including the dates of all monitoring events, changes to the monitoring program over time, and an

explanation of all monitoring infrastructure that has existed at the site. Data will be compared with baseline data collected during site characterization [40 CFR 146.82(a)(6) and 146.87(d)(3)].

Summary of Computational Modeling History

The results of computational modeling used for AoR delineation and for demonstration of an alternative PISC timeframe will be compared to the monitoring data collected during the injection and PISC phases of the project. The monitoring data used to update and calibrate the computational modeling and to demonstrate non-endangerment of USDWs will include:

- Temperature, pressure, and acoustic monitoring data from the Mt. Simon Sandstone, Ironton-Galesville Sandstone, and the St. Peter Sandstone, the deepest USDW
- Groundwater quality analyses
- Seismic data
- Pulsed neutron logs that characterize CO_2 saturations and vertical plume development along the well bores
- Time-lapse 2D surface seismic data

Data generated during the PISC period will be used to help show that the computational model accurately represents the storage site and can be used as a proxy to determine the CO_2 and pressure plume's properties and size. One Earth Energy LLC will demonstrate this degree of accuracy by comparing the monitoring data obtained during the PISC period against the model's predicted properties such as plume location, rate of movement, and pressure decay. The validation of the computational model with the large volume of available data will be a significant element to support the non-endangerment demonstration. Statistical methods will be employed to correlate the data and confirm the model's ability to accurately represent the storage site. The validation of the computational modeling results over the areas and zones where monitoring data have been collected will help to ensure confidence in those areas of the model.

Evaluation of Reservoir Pressure

One of the primary forces driving CO_2 or brine migration out of the storage formation is pressure increases in the storage formation above threshold pressure. Dynamic simulation indicates that after cessation of injection the pressure in the Mt. Simon Sandstone will decrease to below threshold pressure within about seven years, and that formation pressures will continue to steadily decrease toward the pre-injection static pressure. Figure 1 illustrates the simulated decrease in pressure in the Mt. Simon Sandstone once the injection phase of the project ends. Pressure decline toward pre-injection levels is a significant indicator of USDW non-endangerment. Additional discussion is provided in the Narrative and in the AoR and Corrective Action Plan.

During the PISC period the operator will collect formation pressure data that will be used to evaluate pressure decline and resulting non-endangerment to USDWs. The operator will monitor the downhole reservoir pressure at various locations and intervals using a combination of surface and downhole pressure gauges. The measured pressure at a specific depth interval will be compared against the pressure predicted by the numerical simulation. Comparison of actual and

the predicted values will help validate the accuracy of the model and demonstration of non-endangerment.

Evaluation of Carbon Dioxide Plume

The site modeling shows that the CO_2 plume will expand slightly during the PISC period. The CO_2 plume radius increases to 3.2 miles (5.1 kilometers) at the end of injection. The plume migrated in all directions after injection but stopped migrating to the west and south 5 years post injection and to the east and the north 20 years post injection. At 50 years post injection, the plume had migrated to 3.1 miles (4.9 kilometers) west, 2.0 miles (3.2 kilometers) east, 4.7 miles (7.6 kilometers) north, and 2.0 miles (3.2 kilometers) south of IZM #1. See Figure 7. Additional discussion is provided in the Narrative and in the AoR and Corrective Action Plan.

Other than the project wells, there are no identified potential conduits for fluid movement or leakage pathways within the AoR. The nearest well that penetrates the Eau Claire shale is associated with the Manlove Gas Storage field and is approximately 10.3 miles (16.6 kilometers) SSE of the IZM#1 well. The well is recorded as R.S. Hinton #1; drilled in 1959 and serves as a Mt. Simon observation well. Based on the computational model, and forecast migration (Figure 8), the plume will not reach this location. Based on this information, the potential for fluid movement through artificial penetrations of the seal formation does not present a risk of endangerment to any USDWs.

One Earth Sequestration, LLC will use a combination of time-lapse pulsed neutron logs and time lapse 2D seismic methods to locate and track the extent of the CO_2 plume. Pulsed neutron logging will be used to monitor the distribution and saturation of CO_2 adjacent to the injection well and IZM monitoring wells. A good correlation between pulsed neutron data sets and modeled plume thicknesses will help provide strong evidence in validating the model's ability to represent the storage system.

The time-lapse 2D surface seismic data will be acquired at longer time intervals and track the development of the CO_2 plume over a larger spatial extent. The data will be compared against the model using statistical methods to validate the model's ability to accurately represent the storage site.

Both the pulsed neutron logs and seismic data will be used to verify the computational model's ability to predict the CO_2 behavior in the PISC phase of the project and support a demonstration of non-endangerment of USDWs at the end of the project.

Evaluation of Emergencies or Other Events

During the injection operations and post-injection phases of the project, measurement of water quality parameters from the ACZ monitoring wells will be used to demonstrate that the storage formation fluids have not migrated above the confining formations. Assuming there is no such detectable movement of injection zone fluids, they are not anticipated to pose a risk to USDWs. To demonstrate non-endangerment, the project will compare the results of the fluid sampling from the Ironton-Galesville Sandstone and St. Peter Sandstone USDW from the injection and PISC phases to the pre-injection baseline samples. This comparison will demonstrate whether significant

changes in the fluid properties of the overlying formations have occurred and whether mobilized storage formation fluids have moved through the confining layer.

During injection operations, the site will be monitored with DAS to assess induced seismic events, if they occur. This monitoring will continue in the post injection project phase. However, the monitoring capabilities from the injection wells will be eliminated once these wells are plugged and abandoned.

Artificial penetrations include wells associated with the project. The injection wells will be plugged and abandoned with the permit P&A plan. The ACZ and IZM monitoring wells will be plugged and abandoned in accordance with the procedures outlined below. No other wells penetrate the confining zone within the AoR.

Site Closure Plan

One Earth Sequestration, LLC will conduct site closure activities to meet the requirements of 40 CFR 146.93(e) as described below. One Earth Sequestration, LLC will submit a final Site Closure Plan and notify the permitting agency at least 120 days prior of its intent to close the site. Once the permitting agency has approved closure of the site, One Earth Sequestration, LLC will plug the monitoring wells and submit a site closure report to EPA. The activities, as described below, represent the planned activities based on information provided to EPA. The actual site closure plan may employ different methods and procedures. A final Site Closure Plan will be submitted to the UIC Program Director for approval with the notification of the intent to close the site.

Plugging Monitoring Wells

The IZM and ACZ monitoring wells will be flushed with a kill weight brine fluid. A minimum of three tubing volumes will be injected without exceeding fracture pressure. A final external MIT will be conducted to ensure mechanical integrity. A summary of plugging procedures is provided below; detailed procedures for the deep monitoring wells will be the same as for the injection well (See Injection Well Plugging Plan). All casing in the wells will be cemented to surface and will not be retrievable at abandonment. After injection ceases and after the appropriate post-injection monitoring period is finished, the completion equipment will be removed from the well.

Type and Quantity of Plugging Materials, Depth Intervals

Commercially available well cementing software will be used to model the plugging and aid in the plug design. The cements used for plugging will be tested in the lab prior to plugplacement and both wet and dry samples will be collected during plugging for each plug to ensure quality of the plug.

The casing strings will be cut off at least 3 feet below the surface, below the plow line. A blanking plate with the required permit information will be welded to the top of the cutoff casing.

Volume Calculations

Volumes will be calculated for the specific abandonment wellbore environment based on desired plug diameter and length required. The methodology employed will be to:

1) Choose the following:

    a. Length of the cement plug desired.

    b. Desired setting depth of base of plug.

    c. Amount of spacer to be pumped ahead of the slurry.

2) Determine the following:

    a. Number of sacks of cement required.

    b. Volume of spacer to be pumped behind the slurry to balance the plug.

    c. Plug length before the pipe is withdrawn.

    d. Length of mud freefall in drill pipe.

    e. Displacement volume required to spot the plug.

<u>Plugging and Abandonment Procedure</u>

At the end of the serviceable life of the deep monitoring wells, they will be plugged and abandoned. In summary, the plugging procedure will consist of removing all components of the completion system and then placing cement plugs along the entire length of the well. Prior to placing the cement plugs, casing inspection and temperature logs will be run confirming externalmechanical integrity. If a loss of integrity is discovered, then a plan to repair using the cement squeeze method will be prepared and submitted to the agency for review and approval. At the surface, the well head will be removed; and the casing will be cut off 3 feet below surface.

<u>Planned Remedial/Site Restoration Activities</u>

To restore the site to its pre-injection condition following site closure, One Earth Sequestration, LLC will be guided by the state rules for plugging and abandonment of wells located on leased property under The Illinois Oil and Gas Act: Title 62: Mining Chapter I: Department of Natural Resources - Part 240, Section 240.1170 - Plugging Fluid Waste Disposal and Well Site Restoration.

The following steps will be taken:

1. The free liquid fraction of the plugging fluid waste, which may consist of produced water and/or crude oil, shall be removed from the pit and disposed of in accordance with state and federal regulations (e.g., injection or in above ground tanks or containers pending disposal) prior to restoration. The remaining plugging fluid wastes shall be disposed of byon-site burial.
2. All plugging pits shall be filled and leveled in a manner that allows the site to be returnedto original use with no subsidence or leakage of fluids, and where applicable, with sufficient compaction to support farm machinery.
3. All drilling and production equipment, machinery, and equipment debris shall be removed from the site.
4. Casing shall be cut off at least four (4) feet below the surface of the ground, and a

steel plate welded on the casing or a mushroomed cap of cement approximately one (1) foot in thickness shall be placed over the casing so that the top of the cap is at least three (3) feetbelow ground level.

5. Any drilling rat holes shall be filled with cement to no lower than four (4) feet and no higher than three (3) feet below ground level.
6. The well site and all excavations, holes and pits shall be filled, and the surface leveled.

Site Closure Report

A site closure report will be prepared and submitted within 90 days following site closure, documenting the following:

- Plugging of the verification and geophysical wells (and the injection well if it has not previously been plugged),
- Location of sealed injection well on a plat of survey that has been submitted to the local zoning authority,
- Notifications to state and local authorities as required at 40 CFR 146.93(f)(2),
- Records regarding the nature, composition, and volume of the injected CO_2, and
- Post-injection monitoring records.

One Earth Sequestration, LLC will record a notation to the property's deed on which the injection well was located that will indicate the following:

- That the property was used for carbon dioxide sequestration,
- The name of the local agency to which a plat of survey with injection well location was submitted,
- The volume of fluid injected,
- The formation into which the fluid was injected, and
- The period over which the injection occurred.

The site closure report will be submitted to the permitting agency and maintained by the owner or operator for a period of 10 years following site closure. Additionally, the owner or operator will maintain the records collected during the post-injection period for a period of 10 years after which these records will be delivered to the UIC Program Director.

Quality Assurance and Surveillance Plan (QASP)

The Quality Assurance and Surveillance Plan is presented in the Appendix of the Testing and Monitoring Plan.