Class VI Injection Well Application

Attachment 01: Class VI Permit Application Narrative
40 CFR 146.82(A)

Compass Project

Carle Springs, DeWitt County, Illinois

17 May 2023

Project Information

Project Name: Compass

Project Operator: Heartland Greenway Carbon Storage, LLC

Project Contact: Tyler Durham, SVP and Chief Development Officer
13333 California St., Suite 202, Omaha, NE 68154
Phone: 402-520-7089
Email: tdurham@navco2.com

Project Location: Carle Springs, DeWitt County, IL

CO_2 Injection Well #1 (NC_INJ1) Location
Latitude: 40.281983°
Longitude: -89.005617°

CO_2 Injection Well #2 (NC_INJ2) Location
Latitude: 40.281981°
Longitude: -88.991517°

Confidential Business Information

Several figures contained within this document, "Attachment 01: Narrative with CBI", contains confidential business information (CBI) that is privileged and exempt from public disclosure. These images will be delivered to the United States (US) Environmental Protection Agency (EPA) in a separate document, "Attachment 01: Narrative with CBI". The attachment, figures, and tables listed below contain CBI and, as such, are redacted from the public disclosure version of this document:

CBI Attachments, Figures, and Tables

CBI: Attachment 03: Financial Assurance, 2023

Figure 21: CBI: West – east 2D seismic line 305 from the Compass Project Site
Figure 22: CBI: North – south 2D seismic line 306 from the Compass Project Site
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Table 5: CBI: Summary of average Young's Modulus, Poisson's Ratio, and Bulk Compressibility values calculated from ADM CCS1 well logs.
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This document is one of fourteen attachments being submitted to the US EPA for approval for a Class VI well for the Compass Project. In its entirety, "Attachment 03: Financial Assurance Plan" is considered CBI and will be delivered to EPA separately from the other thirteen attachments on the following list.

Full list of attachments:
Attachment 01: Class VI Permit Application Narrative
Attachment 02: Area of Review and Corrective Action Plan
Attachment 03: **CBI**: Class VI Permit Application Financial Assurance Plan
Attachment 04A: NC_INJ1 Well Construction Plan
Attachment 04B: NC_INJ2 Well Construction Plan
Attachment 05: Pre-operational Formation Testing Program
Attachment 06A: NC_INJ1 Well Operations Plan
Attachment 06B: NC_INJ2 Well Operations Plan
Attachment 07: Testing and Monitoring Plan
Attachment 08A: NC_INJ1 Injection Well Plugging Plan
Attachment 08B: NC_INJ2 Injection Well Plugging Plan
Attachment 09: Post-injection Site Care and Site Closure Plan
Attachment 10: Emergency and Remedial Response Plan
Attachment 11: Quality Assurance and Surveillance Plan
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List of Acronyms

2D	two-dimensional
3D	three-dimensional
AMSL	Above Mean Sea Level
ACZ	Above Confining Zone
ADM	Archer Daniels Midland Company
AoR	Area of Review
ARRA	American Recovery and Reinvestment Act
BHFP	bottomhole flowing pressure
CAA	Clean Air Act
CARB	California Air Resources Board
CBI	Confidential Business Information
CCS	carbon capture and sequestration
CCUS	carbon capture, utilization, and sequestration
CO_2	carbon dioxide
CWA	Clean Water Act
DENS	density
DNR	Department of Natural Resources
DOW	Division of Water
DPHI	Density Porosity Log
DST	Drill Stem Test
EGRP	Eastern Granite-Rhyolite Province
EMA	Emergency Management Agency
EPA	Environmental Protection Agency
ERRP	Emergency and Remedial Response Plan
FEMA	Federal Emergency Management Agency
fbgl	feet below ground level
fbsl	feet below sea level
GSDT	Geologic Sequestration Data Tool
GR	Gamma Ray
h	thickness
HGCS	Heartland Greenway Carbon Storage, LLC
IBDP	Illinois Basin–Decatur Project
IDNR	Illinois Division of Natural Resources
IEMA	Illinois Emergency Management Agency
IL-ICCS	Illinois Industrial Carbon Capture and Storage Project
ILD	Induction Log Deep
ILM	Induction Log Medium
ISGS	Illinois State Geological Survey
JV	Joint Venture
k	permeability
kt	kilotonnes
LAS	Log Ascii Standard
lbs	pounds
LCZ	Lost Circulation Zone
Ma	mega annum

mD	millidarcy
MICP	mercury injection capillary pressure
MMscf	million standard cubic feet
MNSM	Mt. Simon Sandstone Formation
MSL	Mean Sea Level
Mtpa	million tonnes per annum
NA	not applicable
NCV	Navigator CO_2 Ventures
NC_ACZ1	Compass Above Confining Zone Monitoring Well #1
NC_ACZ2	Compass Above Confining Zone Monitoring Well #2
NC_INJ1	Compass Injection Well #1
NC_INJ2	Compass Injection Well #2
NC_MA1	Mahomet Aquifer Monitoring Well #1
NC_MA2	Mahomet Aquifer Monitoring Well #2
NC_OBS1	Compass Deep Observation Well
NESHAPS	National Emission Standards for Hazardous Pollutants
NPHI	Neutron Porosity Log
O&G	oil and gas
PE	photoelectric log
PISC	Post Injection Site Care
PPMV	parts per million by volume
PSD	Prevention of Significant Deterioration
RA	risk assessment
RCRA	Resource Conservation and Recovery Act
RESD	deep resistivity
RESM	medium resistivity
RMP	Risk Management Plan
SDWA	Safe Drinking Water Act
SGR	Shale Gouge Ratios
TBD	to be determined
TCS	Total Closure Stress
TD	total depth
TDS	total dissolved solids
UIC	Underground Injection Control
US	United States
USGS	United States Geological Survey
USDW	Underground Source of Drinking Water

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1. Project Background and Contact Information [40 CFR 146.82(a)(1)]

1.1 Project Contact Information

Project Name: Compass

Project Operator: Heartland Greenway Carbon Storage, LLC

Project Contact: Tyler Durham, SVP and Chief Development Officer
13333 California St., Suite 202, Omaha, NE 68154
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CO_2 Injection Well #2 (NC_INJ2) Location
Latitude: 40.281981°
Longitude: -88.991517°

1.2 Project Background

The Compass Project is part of the Heartland Greenway proposed carbon capture, utilization, and sequestration (CCUS) system. The system is planned to connect industrial customers in Illinois, Iowa, Minnesota, Nebraska, and South Dakota through a 1,300-mile pipeline network and permanently sequester up to 15 million tonnes per annum (Mtpa) of carbon dioxide (CO_2) into sequestration sites in central Illinois. The Heartland Greenway system is proposed by Navigator CO_2 Ventures (NCV) and will be operated by Heartland Greenway Carbon Storage, LLC (HGCS), a subsidiary of NCV. Operations will be phased with an expected start date in 2025.

The Compass Project is one of several sites in Central Illinois that is being developed by NCV for long-term sequestration into the Mt. Simon Sandstone. The project seeks to transport 2.5 Mtpa to a location in the northwest portion of DeWitt County, Illinois. Well construction is expected to commence in Q2 2024. Injection will commence following completion and approval of all UIC Class VI permit requirements.

HGCS will be the owner, operator, and permit holder for the two injection wells, NC_INJ1 and NC_INJ2.

Neither an injection depth waiver nor aquifer exemption expansion is being requested for this project.

Within the Area of Review (AoR) there are no major surface water bodies, deep stratigraphic boreholes, State or EPA approved subsurface clean-up sites, mines, quarries, nor federally recognized Native American tribal lands or territories.

Figure 1 and Figure 2 display the project location and the location of the two CO_2 injection wells, one deep observation well, two above zone monitoring wells, and two shallow groundwater monitoring wells. Table 1 provides the coordinates and depth for the primary wells associated with the Compass Project.

Information on Oil and Gas (O&G) wells and water wells within the AoR can be found in Section 4.1 of the AoR and Corrective Action Plan (Attachment 2: AoR and Corrective Action Plan, 2023).

This document is one of the fourteen (14) attachments that are being submitted to the United States (US) Environmental Protection Agency (EPA) for approval for a Class VI well for the Project. Note that Attachment 03: Financial Insurance contains Confidential Business Information (CBI) that is privileged and is exempt from public disclosure. This Financial Assurance attachment will be delivered to the EPA separately from the other thirteen (13) attachments.

Full list of attachments:
Attachment 01: Narrative, 2023,
Attachment 02: AoR and Corrective Action Plan, 2023,
CBI: Attachment 03: Financial Assurance Plan, 2023,
Attachment 04A: NC_INJ1 Injection Well Construction Plan, 2023,
Attachment 04B: NC_INJ2 Injection Well Construction Plan, 2023,
Attachment 05: Pre-operational Formation Testing Program, 2023,
Attachment 06A: NC_INJ1 Well Operations, 2023,
Attachment 06B: NC_INJ2 Well Operations, 2023,
Attachment 07: Testing and Monitoring, 2023,
Attachment 08A: NC_INJ1 Injection Well Plugging Plan, 2023,
Attachment 08B: NC_INJ2 Injection Well Plugging Plan, 2023,
Attachment 09: PISC, 2023,
Attachment 10: ERRP, 2023,
Attachment 11: QASP, 2023).
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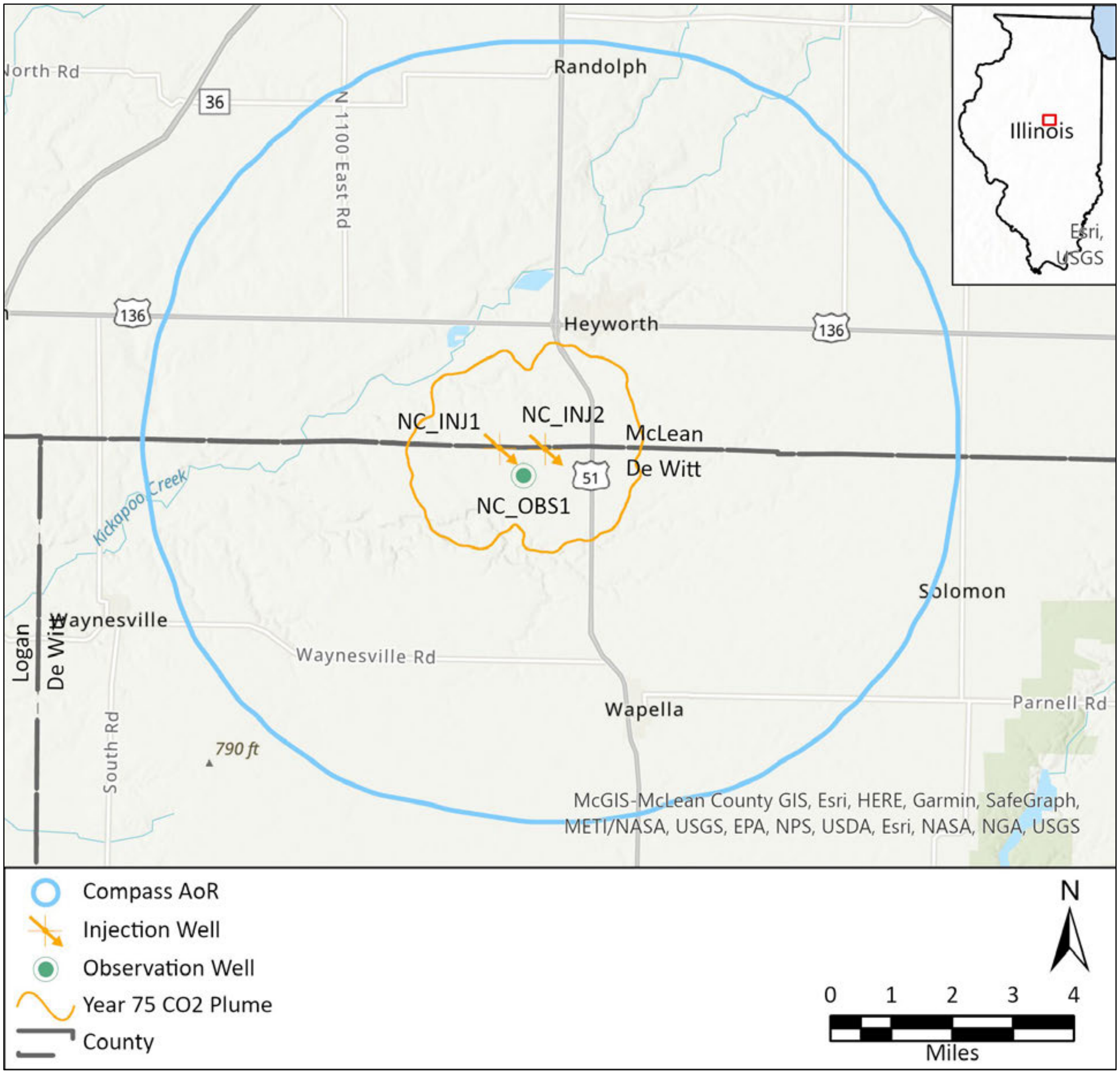

Figure 1: Map of Compass Project location, proposed locations for the injection and deep observation wells, simulated extent of the CO_2 plume 50 years post-injection, and the pressure based AoR.

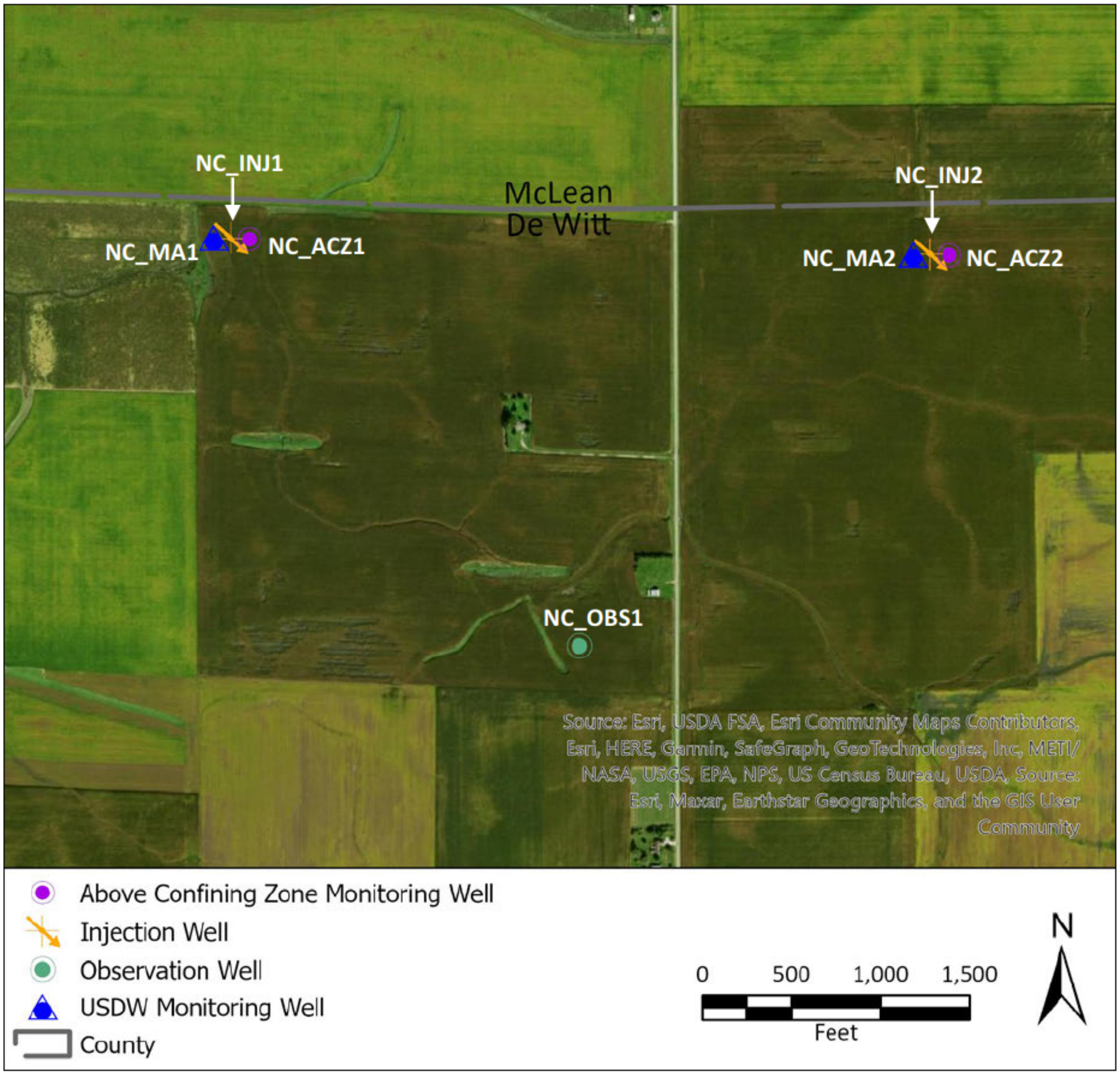

Figure 2: Proposed locations of injectors (NC_INJ1, NC_INJ2), deep observation (NC_OBS1), above confining zone monitoring (NC_ACZ1, NC_ACZ2), and Mahomet Aquifer monitoring (NC_MA1, NC_MA2) wells.

Table 1: Proposed Compass Project wells, location coordinates in NAD83 UTM Zone 16N ft (EPSG 26916)

Well Long Name	Well Name	X, feet	Y, feet	Ground Level (feet)	Measured Depth (feet)	Purpose
Injection Well 1	NC_INJ1	1081042	14635777	713	6817	CO_2 Injector
Injection Well 2	NC_INJ2	1084975	14635687	730	6824	CO_2 Injector
Deep Observation Well 1	NC_OBS1	1082998	14633481	729	6860	Injection Zone Observation Between the Injector Wells
Above Confining Zone Monitoring Well 1	NC_ACZ1	1081141	14635771	711	4486	Above Confining Zone Monitor Near NC_INJ1
Above Confining Zone Monitoring Well 2	NC_ACZ2	1085075	14635682	728	4509	Above Confining Zone Monitor Near NC_INJ2
Mahomet Aquifer Monitoring Well 1	NC_MA1	1080941	14635774	710	350	Mahomet Aquifer Monitor near NC_INJ1
Mahomet Aquifer Monitoring Well 2	NC_MA2	1084875	14635686	727	350	Mahomet Aquifer Monitor near NC_INJ2

1.3 Local, State, and Federal Emergency Contacts [40 CFR 146.82(a)(20)]

Table 2: Local, State, and Federal Emergency Contacts

Agency	Phone Number
DeWitt County Sheriff's Office	309-888-5034
DeWitt County Sheriff's Office 24 HR Dispatcher	217-935-9507 217-935-3196 (Dispatcher)
DeWitt County EMS	217-570-0176
Illinois State Police Troop 5 Serving DeWitt and McLean Counties	815-844-1500
DeWitt County Emergency Management Agency (EMA)	309-888-5020
Illinois Emergency Management Agency (IEMA)	217-782-2700 217-782-7860 (24-hour Response)
Federal Emergency Management Agency (FEMA)	800-621-3362 (FEMA Helpline) 312-408-5500 (FEMA Region 5 General)
Environmental Services Contractor to be determined (TBD)	TBD
Underground Injection Control (UIC) Program Director (Region 5)	312-353-7648
EPA Region 5 UIC Class VI Wells/Carbon Sequestration	312-353-3944
EPA National Response Center (24 hours)	800-424-8802
Illinois Department of Natural Resources (DNR) Oil & Gas Resource Management	217-782-6302

1.4 Summary of Other Permits Required

Table 3 provides a summary of permits required for the Compass Project.

Table 3: Permits Required for the Compass Project

Agency	Program	Permit(s) Required	Regulation Reference	Note
U.S. Environmental Protection Agency (US EPA), Resource Conservation and Recovery Act (RCRA)	Hazardous Waste Management program under RCRA	Not Required	40 CFR 144.31 (e)(1) 40 CFR 144.31 (e)(6)(i)	NA, non-hazardous waste.
U.S. Environmental Protection Agency (US EPA), Safe Drinking Water Act (SDWA)	UIC program under SDWA	Class VI Underground Injection Permit	40 CFR 144.31 (c) 40 CFR 144.31 (e)(1) 40 CFR 144.31 (e)(6)(II)	Applied for. No injection depth waiver or aquifer exemption expansion needed for project.
National Pollutant Discharge Elimination System (NPDES)	NPDES program under CWA	Stormwater Pollution Prevention Plan (SWPPP) or Stormwater Management Plan (SWMP)	40 CFR 144.31 (e)(1) 40 CFR 144.31 (e)(6)(iii)	Will apply for prior to construction.
Prevention of Significant Deterioration (PSD) Clean Air Act (CAA)	PSD program under CAA	Not Required	40 CFR 144.31 (e)(1) 40 CFR 144.31 (e)(6)(iv)	NA, not a major source.
U.S. Environmental Protection Agency (US EPA) Clean Air Act (CAA)	Nonattainment program under CAA	Not Required	40 CFR 144.31 (e)(6)(v)	NA, DeWitt County, IL is in attainment for all criteria pollutants.
National Emission Standards for Hazardous Air Pollutants (NESHAPS) Clean Air Act (CAA)	NESHAPS preconstruction approval under the CAA	Not Required	40 CFR 144.31 (e)(6)(vi)	NA, non-hazardous.
Marine Protection Research and Sanctuaries Act	Ocean dumping permits under Marine Protection Research and Sanctuaries Act	Not Required	40 CFR 144.31 (e)(6)(vii)	NA, onshore project.
Army Corp. of Engineers	Section 404 of CWA	Not Required	40 CFR 144.31 (e)(6)(viii)	NA. No disturbance to waters of US planned nor anticipated.
State or Other	**Other relevant environmental permits, including state permits**		**40 CFR 144.31 (e)(6)(ix)**	
Illinois Division of Natural Resources (IDNR)	Oil & Gas Resource Management	Drilling Permit	Illinois Oil and Gas Act (225 ILCS 725)	Will apply for prior to drilling monitor well(s)

2. Site Characterization [49 CFR 126.82(a)(2), (3), (5) and (6)]

Unless otherwise stated, all depths are in reference to feet below ground level (fbgl).

2.1 Regional Geology, Hydrogeology, and Local Structural Geology [40 CFR 146.82(a)(3)(vi)]

The Compass Project, located in DeWitt County of central Illinois, is within the intracratonic Illinois Basin that extends beneath much of Illinois, western Indiana, and western Kentucky (Figure 3). The Illinois Basin is comprised of Cambrian to Permian strata that reach a maximum thickness of nearly 23,000 feet in its southern portion (Collinson et al., 1988).

The Illinois Basin has been the focus of extensive research into geological carbon sequestration for over two decades through the Midwest Regional Carbon Sequestration Partnership's (MRCSP) Illinois Basin–Decatur Project (IBDP) (Wickstrom, 2005; Greenberg, 2021) and the CarbonSAFE program (Leetaru, 2019; Whittaker, 2019; Korose, 2022; Whittaker and Carman, 2022) funded by the United States (US) Department of Energy (DOE).

In addition, the American Recovery and Reinvestment Act (ARRA) funded Illinois Industrial Carbon Capture and Storage Project (IL-ICCS) is an active carbon commercial sequestration project taking place at the Archer Daniels Midland (ADM) ethanol facility at Decatur, IL, approximately 28 miles south of the proposed location for the Compass Project (Figure 3).

The IL-ICCS project storage complex uses the Cambrian Mt. Simon Sandstone as the injection zone and the overlying Eau Claire Formation as the confining zone (Gollakota and McDonald, 2014, Figure 4). These same formations are being proposed as the storage complex for the Compass Project.

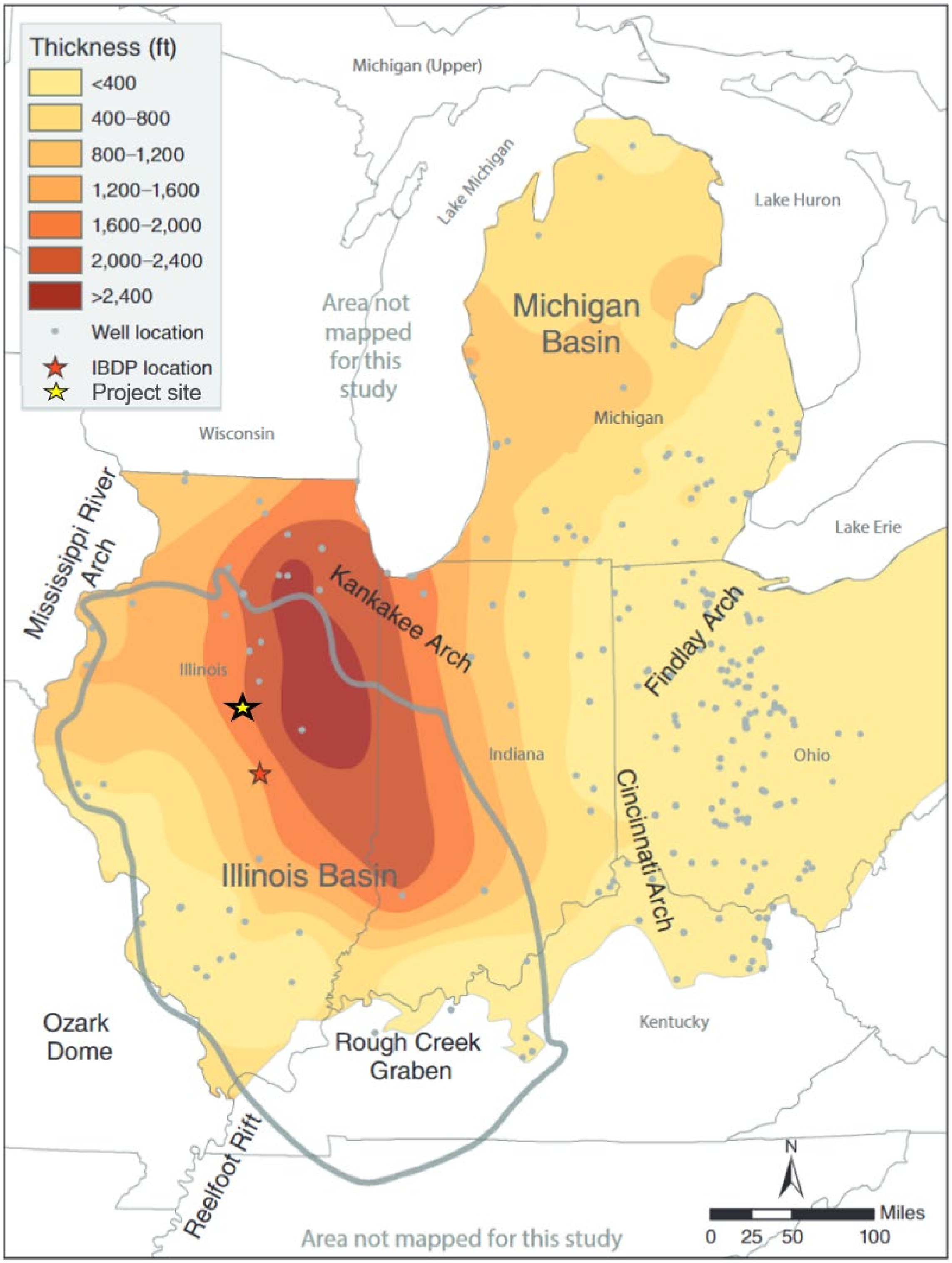

Figure 3: Mt. Simon Sandstone isopach map (feet) with the Illinois Basin extent, major structural features, the Compass Project site (yellow star), the IBDP and IL-ICCS Project sites (red star). Modified from Medina and Rupp (2012).

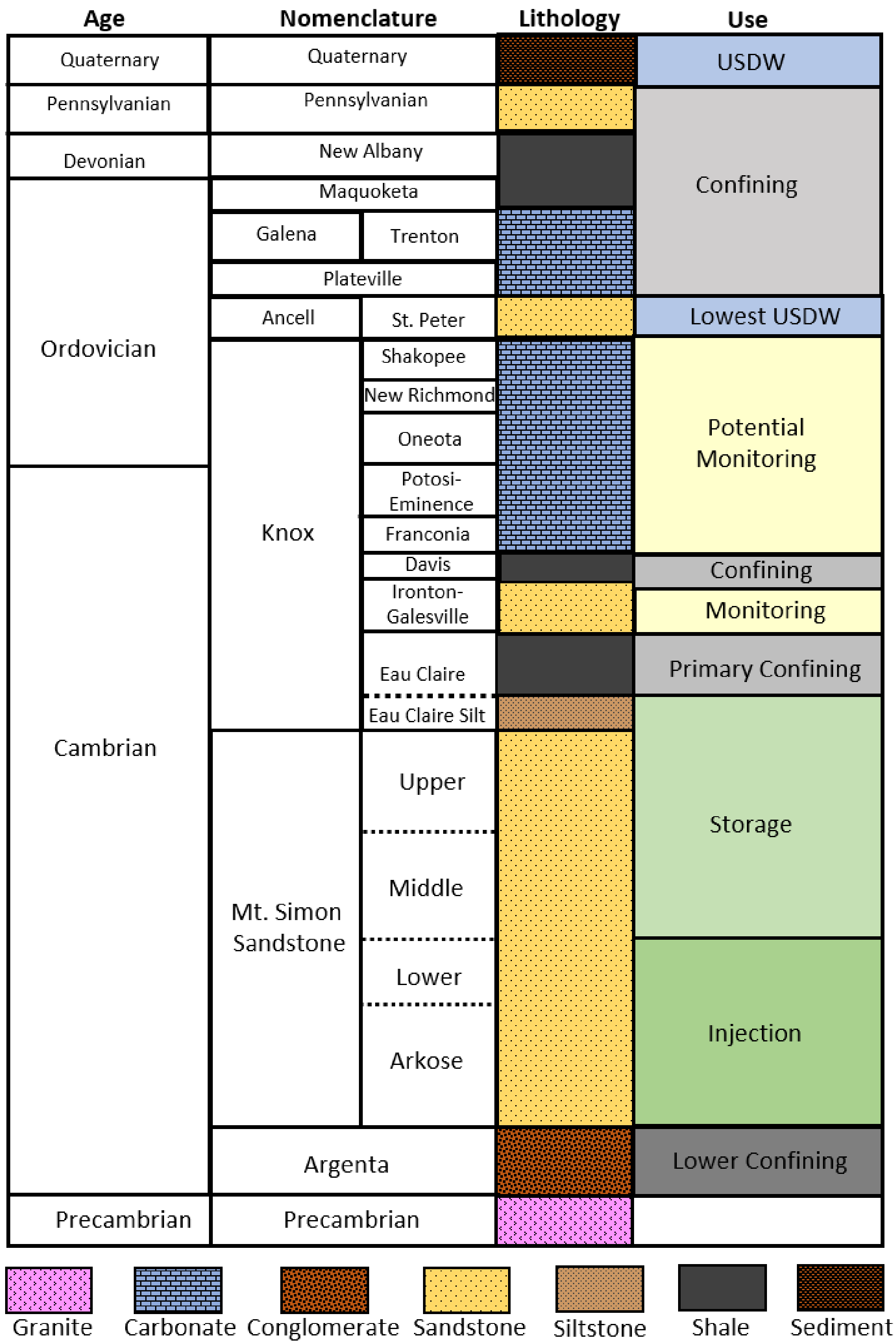

Figure 4: Compass Project site-specific stratigraphic column with age, nomenclature, generalized lithology, and zone of use.

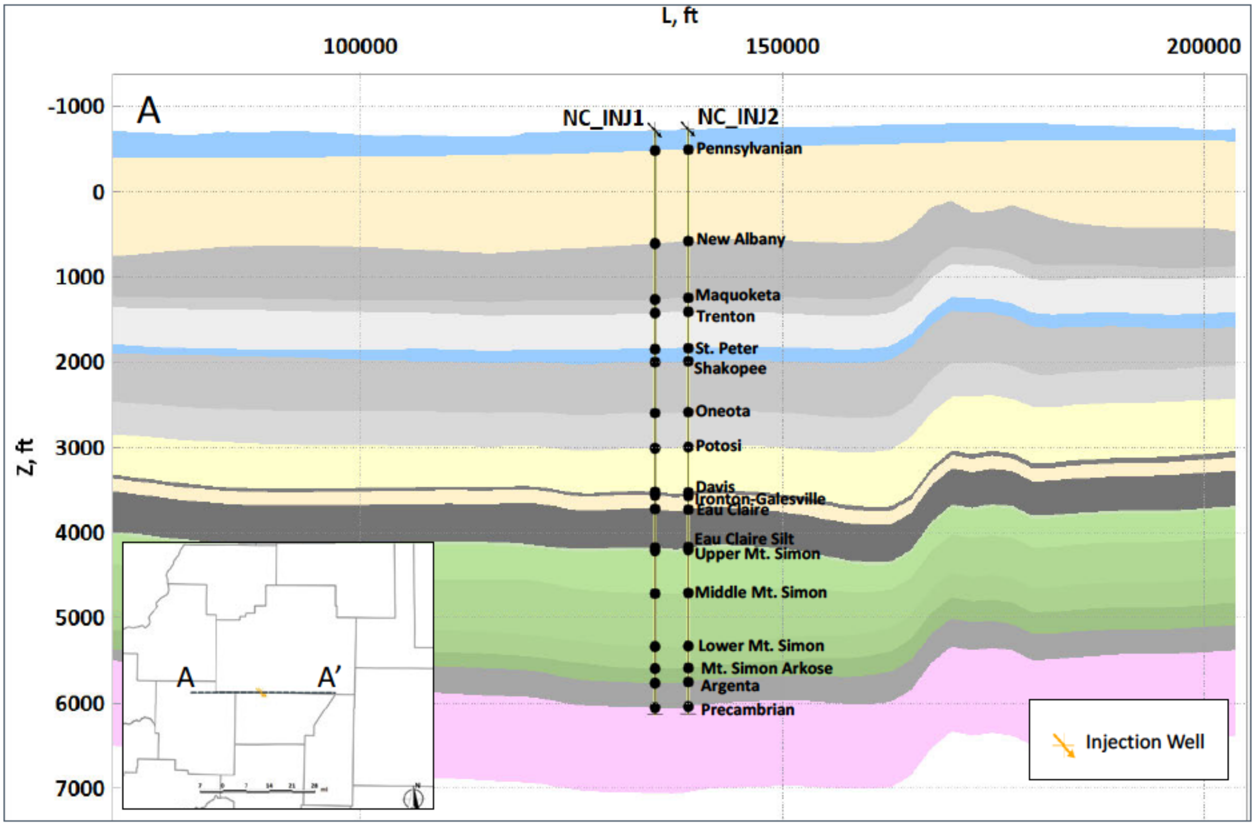

Figure 5: West to east regional cross section A-A' through the project site (see inset map).

The Illinois Basin began to form during the late Precambrian to early Cambrian Period during the breakup of the supercontinent Rodinia (Braile et al., 1986; Kolata and Nelson, 1990, 1990, 1997). The Illinois Basin is bounded to the northwest by the Mississippi River Arch, to the north-northeast by the Kankakee Arch and to the east by the Cincinnati Arch (Figure 3).

The Reelfoot Rift and Rough Creek Graben are significant features within the southern portion of the basin related to processes linked to basin subsidence, and where the thickest accumulation of sediments exist in the basin (Kolata, 2010). It is noteworthy, however, that the depocenter for Cambrian sediments was more northerly (at present) as shown by the greatest thickness of the Mt. Simon Sandstone in Figure 3. Paleozoic sedimentary strata of the basin unconformably overlie the Precambrian basement, which is broadly composed of felsic intrusives and volcanics of the Eastern Granite-Rhyolite Province (EGRP) (Figure 5; Bradbury and Atherton, 1965; Bickford et al., 1986; Atekwana, 1996; Lidiak, 1996; Green, 2018).

The Cambrian Mt. Simon Sandstone and Cambrian Eau Claire Formation are among the oldest and deepest strata in the Illinois Basin (Figure 4 and Figure 5) and will serve as the injection/sequestration and confining zones, respectively, for the Compass Project. The clastic sediments of the Mt. Simon Sandstone are interpreted to have been deposited in the failed rift basin that ultimately provided up to 2,600 feet of accommodation space for Mt. Simon sediments to accumulate (Figure 3). The Mt. Simon Sandstone is underlain by the Argenta Formation that is variably present in the basin and that was, until recently, considered part of the Mt. Simon Sandstone. An erosional unconformity exists between the Argenta Formation/Mt. Simon Sandstone and the underlying Precambrian basement.

By late Cambrian, the tectonic regime evolved from a rift to a broad embayment, and the Illinois Basin was a slowly subsiding cratonic basin for the remainder of the Paleozoic (McBride and Kolata, 1999). Eustatic sea level fluctuations coupled with tectonics allowed for the accumulation of both marine and terrestrial sediments in the basin. Uplift during the Pennsylvanian to Late Cretaceous isolated the basin and created the present geometry (Figure 3; Kolata and Nelson, 1990, 1997; McBride and Kolata, 1999)

Much of the Illinois Basin was covered by a sea during the early Ordovician; this was followed by a marine regression that exposed newly deposited marine sediments to erosion and created the Middle Ordovician Knox Group unconformity. A series of transgressions and regressions and periods of both uplift and subsidence dominated the remainder of Ordovician time (Freeman, 1953).

By early to mid-Silurian time, deposition in the evolving Illinois Basin was close to wave-base and the surrounding sedimentary basins to the west, north, and east received large quantities of sediment (Janssens, 1968). Sea-level regressed and uplift occurred during the Devonian, causing extensive erosion. A sea level transgression during the Devonian-Mississippian deposited marine shales across the region including the regionally extensive New Albany Shale (Mikulic et al., 2010) that forms a barrier to vertical fluid movement. Subsidence and uplift continued to the end of the Paleozoic Era, and erosion and/or nondeposition prevailed throughout the Mesozoic and Cenozoic. During the Pleistocene Epoch, the region was covered by continental ice sheets that deposited hundreds of feet of glacial sediment in the region, some of which now serve as shallow groundwater aquifers.

2.2 Regional Stratigraphy

Figure 4 is a stratigraphic chart specific for the Compass Project and will be referred to throughout this narrative.

The regional continuity of the Paleozoic strata in the vicinity of the project site [40 CFR 146.82(a)(3)(i)] is demonstrated through cross-sections of the site model (Figure 5) and geophysical logs of regional wells (Figure 7). Quaternary glacial sediments overlie the bedrock (Figure 4) and are discussed in *Section 2.7 Hydrologic and Hydrogeologic Information*.

To develop a comprehensive understanding of the site-specific geology for this project, a database of publicly available geophysical well logs from Illinois, Indiana, Kentucky, and Ohio was compiled. The well logs were interpreted and used to develop a static model for the project site.

Within 50 miles of the Compass Project Site, eight wells penetrate the Precambrian Basement and over 100 wells are documented to penetrate the Upper Mt. Simon Sandstone, all of which were used to assess the site-specific geology. Additional wells penetrate the Mt. Simon Sandstone outside of the 50-mile radius (Figure 6). The closest wells that penetrate into the Mt.

Simon Sandstone and have well log data are located within the Hudson gas storage field, approximately 17 miles north of the project site (Figure 6). This field, along with the Lake Bloomington, Lexington, and Manlove gas storage fields, utilize the Upper Mt. Simon Sandstone as a gas storage reservoir. Most wells do not penetrate to the Lower Mt. Simon Sandstone. Most of the wells in these fields were drilled in the 1970s and remain active. The closest well that penetrates through the entire Mt. Simon Sandstone into the Precambrian basement is 28 miles south of the project site at the ADM site in Decatur, IL.

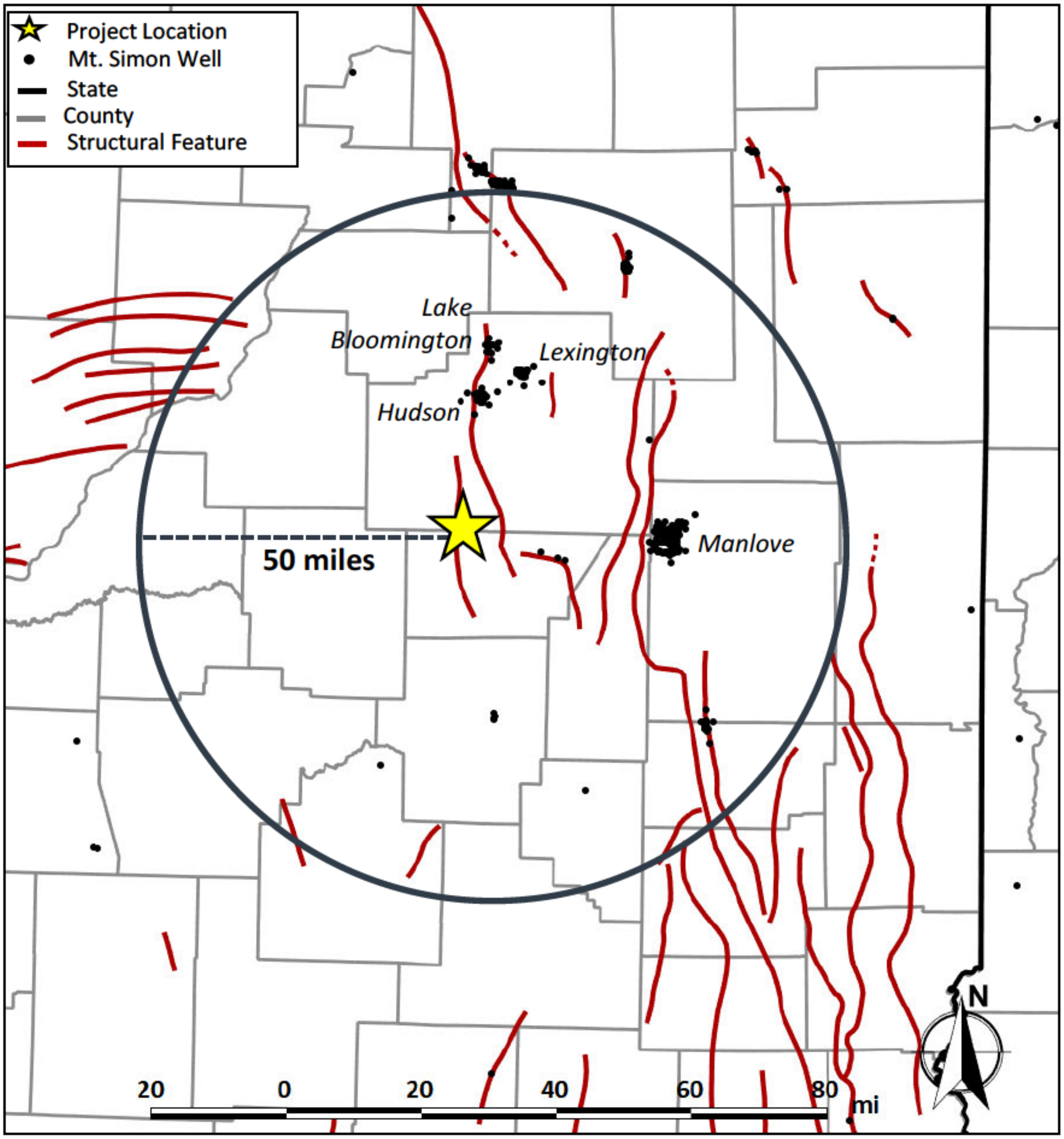

Figure 6: Map depicting Mt. Simon Sandstone wells (black dots) within a 50-mile radius (black circle) of the project site (yellow star). The gas storage fields are also highlighted. Structural features in red are from (Nelson, 1995).

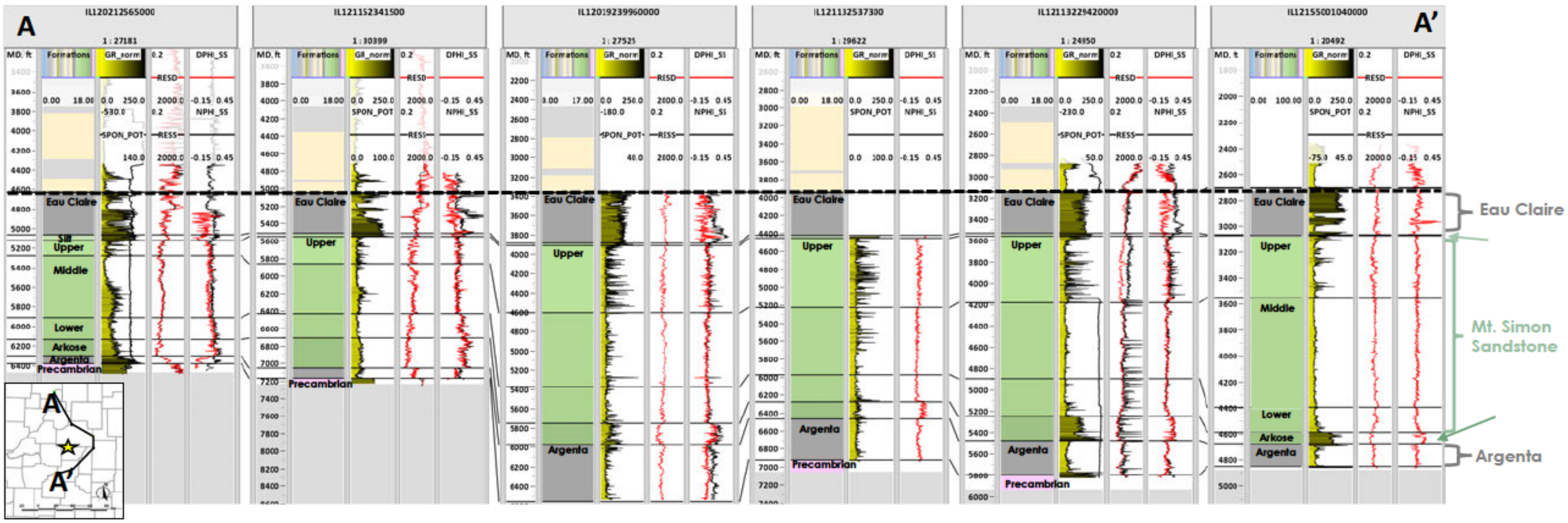

Figure 7: West to east regional cross section A-A' through the project site (see inset map) that demonstrates the regional continuity of the Eau Claire Formation, Mt. Simon Sandstone, and Argenta Formation. Gamma Ray Logs (GR_norm) are color-filled, deep resistivity (RESD) is red, shallow resistivity (RESS) is black, sandstone density porosity (DPHI_SS) is dark red, and sandstone neutron porosity (NPHI_SS) is dark gray. Well locations are shown on the inset map. Project location shown as well as yellow star. The cross section is flattened on the Eau Claire Formation top.

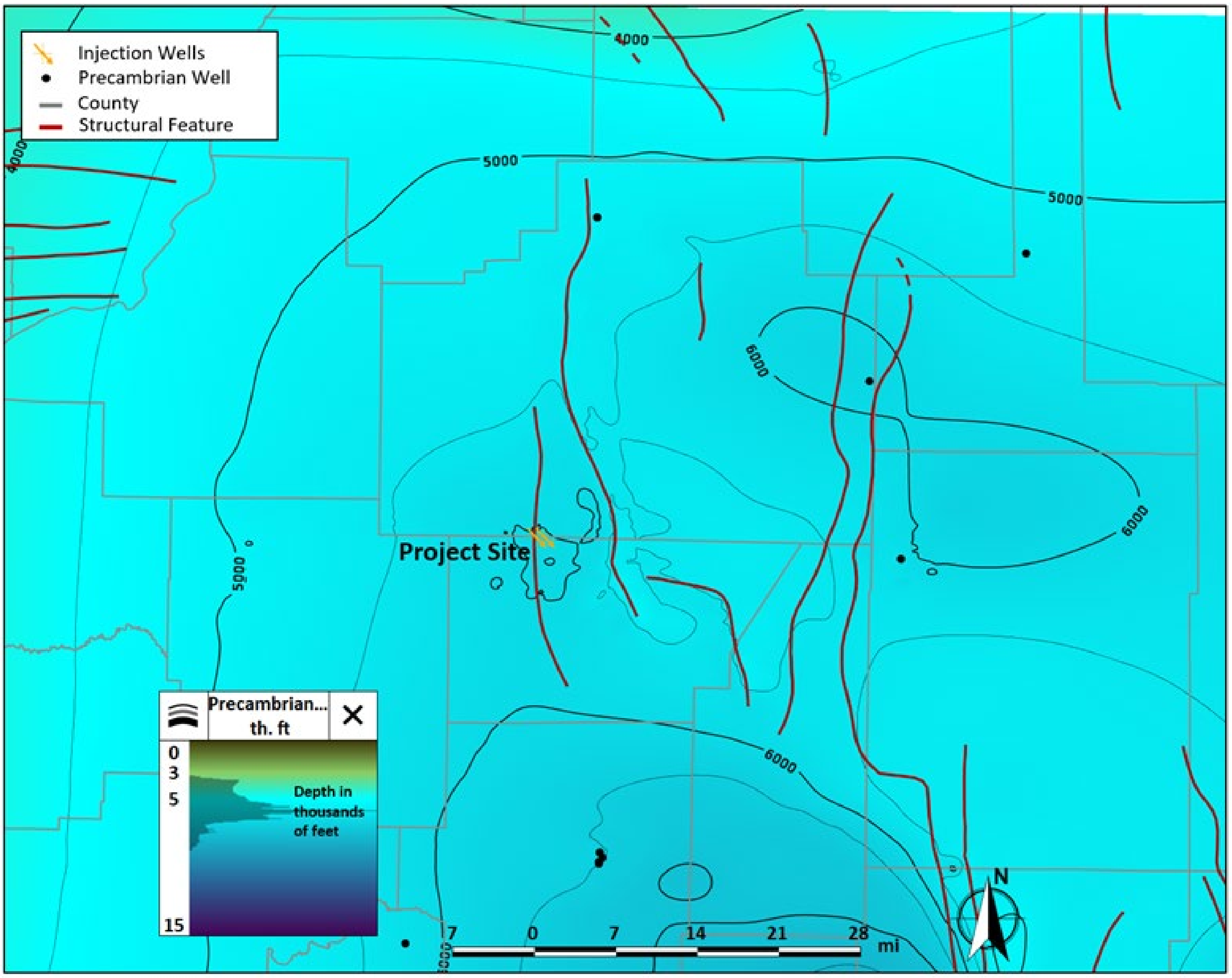

Figure 8: Elevation map in feet below sea level (fbsl) of the Precambrian Basement with structural features shown in red (Nelson, 1995). Black circles indicate wells that penetrate the Precambrian Basement top. The injector wells (NC_INJ1 and NC_INJ2) are shown and labeled "Project Site". Precambrian Basement Complex.

The strata of the project site overlie granite, rhyolite, trachyte, and quartzite of the EGRP of the Precambrian basement(Denison et al., 1984). These basement rocks are of extensional tectonic origin and contribute to the source of Early Cambrian siliciclastic strata in the Illinois Basin (Bickford et al., 1986).

Figure 8 shows the Precambrian Basement deepens from approximately 4,000 feet below sea level (fbsl) in the west and north of the map area to more than 7,000 fbsl in the southeast where basin structure becomes more complex.

2.3 Argenta Formation/Lower Confining Zone (Cambrian)

The Precambrian surface represents a 900-million-year depositional hiatus before Cambrian sediments of the Argenta Formation were deposited forming an unconformable contact. The Argenta strata are of variable thickness (e.g., Figure 7), in part due to Precambrian topography, and locally the Argenta Formation onlaps against the Precambrian Basement as observed in Figure 5. The Argenta Formation is also in unconformable contact with the overlying Mt. Simon Sandstone (Leetaru, 2015).

Until recently, the Argenta was considered to be part of the Lower Mt. Simon Sandstone but work by the Illinois State Geological Survey (Freiburg, 2015) suggests it is a pre-Mt. Simon sedimentary unit. The Argenta Formation is composed of shallow-marine, shoreface to fan-delta sandstone and conglomerate with some interbedded mudstone. Conglomerates are dominantly clast supported and exhibit inverse and normal graded bedding, as well as planar and cross-beds. Bioturbation is abundant in some sandstone intervals, suggesting a Lower to Middle Cambrian age for this formation, and it was likely deposited during a marine transgression associated with thermal subsidence.

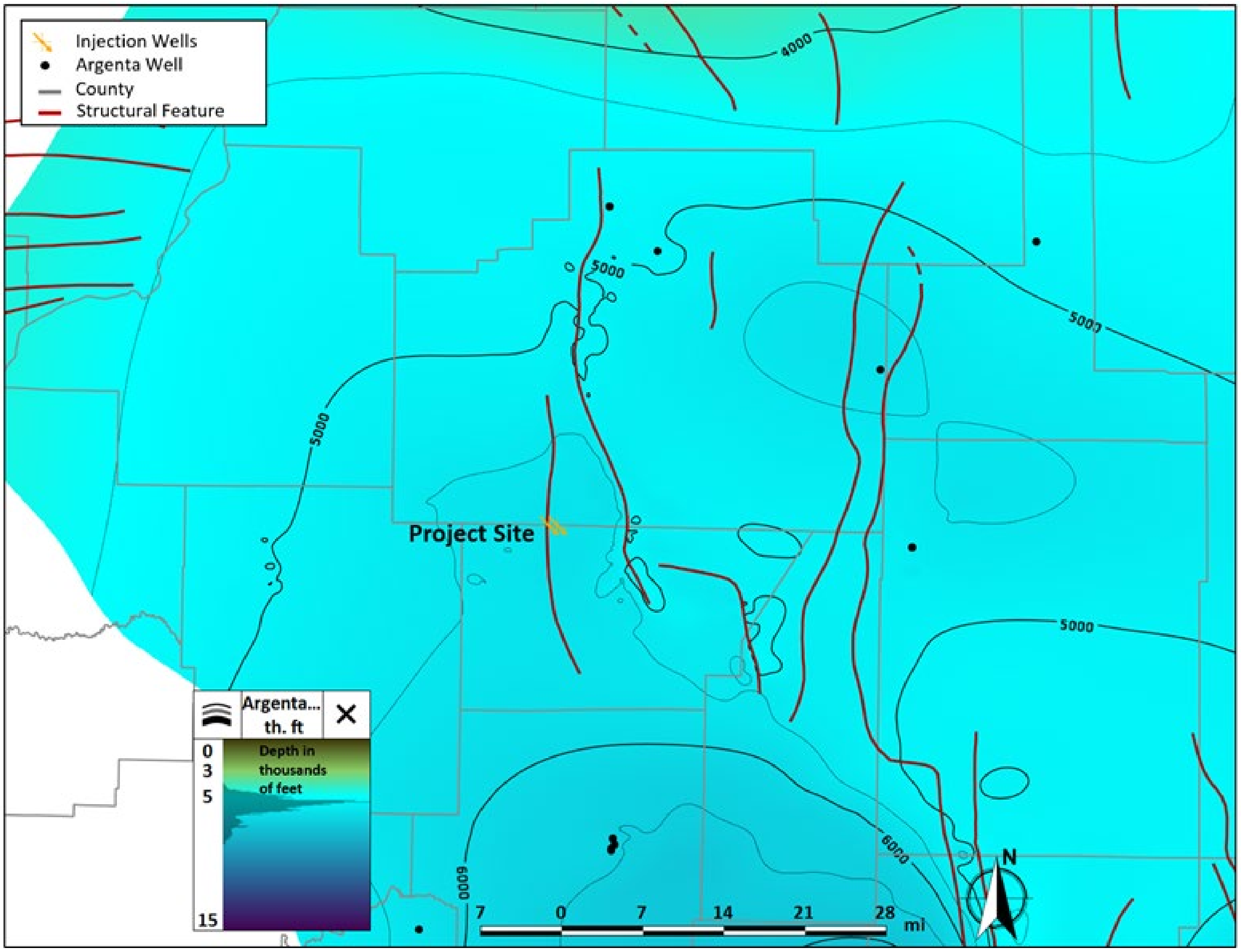

Figure 9: Elevation map in fbsl of the Argenta Formation. Structural features are in red (Nelson, 1995), and black circles are wells that penetrate the Argenta Formation.

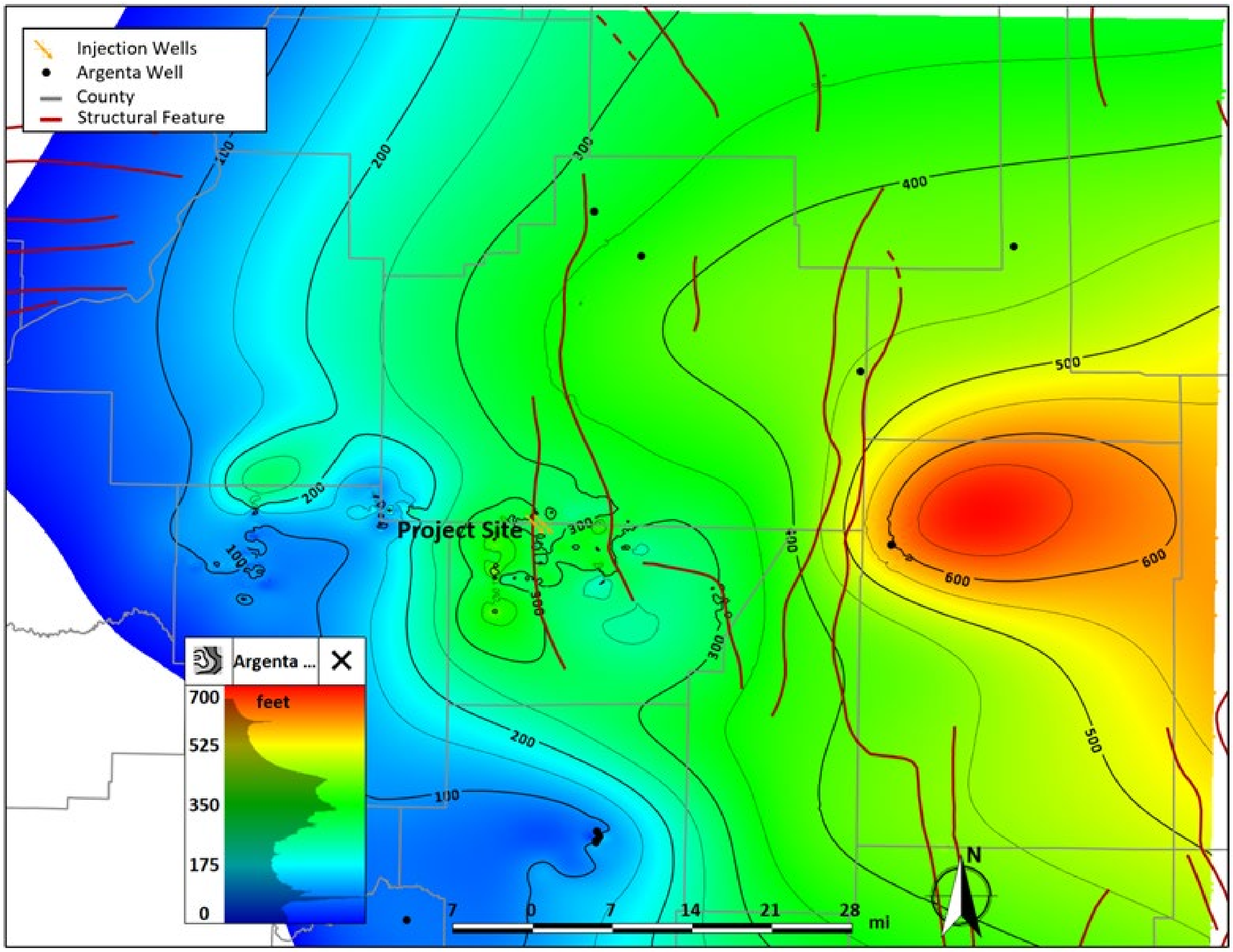

Figure 10: Thickness map of the Argenta Formation in feet with structural features annotated in red (Nelson, 1995). Black dots depict wells that penetrate the formation. The Argenta Formation is generally not present due to non-deposition in the western part of the mapped area beyond the limits of the Compass Project.

2.4 Mt. Simon Sandstone/Injection Zone (Cambrian)

The Cambro-Ordovician Sauk sequence unconformably overlies the Argenta Formation and includes the Mt. Simon Sandstone, the Eau Claire Formation, and the Knox Group (Figure 4, Figure 5, and Figure 7). Specific to this project, the Mt. Simon Sandstone is being considered for the injection and sequestration zone, and the Eau Claire Formation as the confining zone.

The Mt. Simon Sandstone is a transgressive terrestrial to shallow marine sequence that is a laterally extensive deposit in the Illinois Basin and throughout the Midwest (Kolata and Nelson, 1990). It is thickest in northeastern and east-central Illinois (Figure 3; Leetaru and McBride, 2009). Mt. Simon sedimentology was impacted by a wide range of depositional environments including shallow marine, deltaic, fluvial, eolian, and coastal (Baranoski, 2007; Saeed and Evans, 2012; Freiburg et al., 2016; Janssens). Fine to coarse-grained, poorly sorted, arkosic and quartz sandstone primarily compose the Mt. Simon Sandstone. Typically, the Mt. Simon Sandstone is subdivided into Lower, Middle, and Upper intervals, with the Lower Mt. Simon

Sandstone containing a basal arkosic zone. In this report, the arkosic zone will be referred to as the Mt. Simon Arkose and will be differentiated from the overlying Lower Mt. Simon Sandstone (Figure 4).

The Mt. Simon Sandstone has been the focus of considerable research into carbon sequestration in the Illinois Basin through a number of US DOE funded projects including the Regional Carbon Sequestration Partnerships' IBDP CCS1 well (Greenberg, 2021) and the CarbonSAFE program (Leetaru, 2019; Korose, 2022; Whittaker and Carman, 2022).The Mt. Simon Sandstone has also been demonstrated as an effective sequestration formation through the IL-ICCS, an active carbon sequestration project at the ADM facility in Decatur, IL (UIC Class VI Permit IL-115-6A-0001).

The Lower Mt. Simon Sandstone and Mt. Simon Arkose together are the target injection zone for the Compass Project. These beds are dominantly medium- to fine-grained cross-bedded to ripple-laminated subarkose arenite (Freiberg et al., 2014). They also contain planar-bedded sandstone and conglomerate composed of subarkosic to arkosic arenite, arkosic wacke and mudstone. Grading upwards the Mt. Simon Sandstone contains mixed eolian and fluvial deposits to marine tidal deposits in its upper portions. Porosity in the Mt. Simon Arkose and to a lesser degree in the Lower Mt. Simon is largely a result of diagenesis including dissolution of feldspars and clay (illite) coating of grains that restrict formation of porosity occluding cements. The dominant diagenetic cement is quartz, and the presence of authigenic quartz is less in the Arkose and Lower Mt. Simon units than in the Middle and Upper intervals (Freiberg et al., 2016). The Upper Mt. Simon Sandstone also exhibits good reservoir characteristics and is used for natural gas storage in several locations in the Illinois Basin including the sites shown in Figure 6.

The elevation map of the Lower Mt. Simon Sandstone, which represents the top of the planned injection zone, is shown in Figure 11, which shows the continuity of the unit across a wide region and its deepening southward toward the basin center. Figure 12 shows the thickness of the injection zone comprising both the Lower Mt. Simon unit and the Mt. Simon Arkose. The elevation map of the top of the Mt. Simon Sandstone is presented in Figure 13.

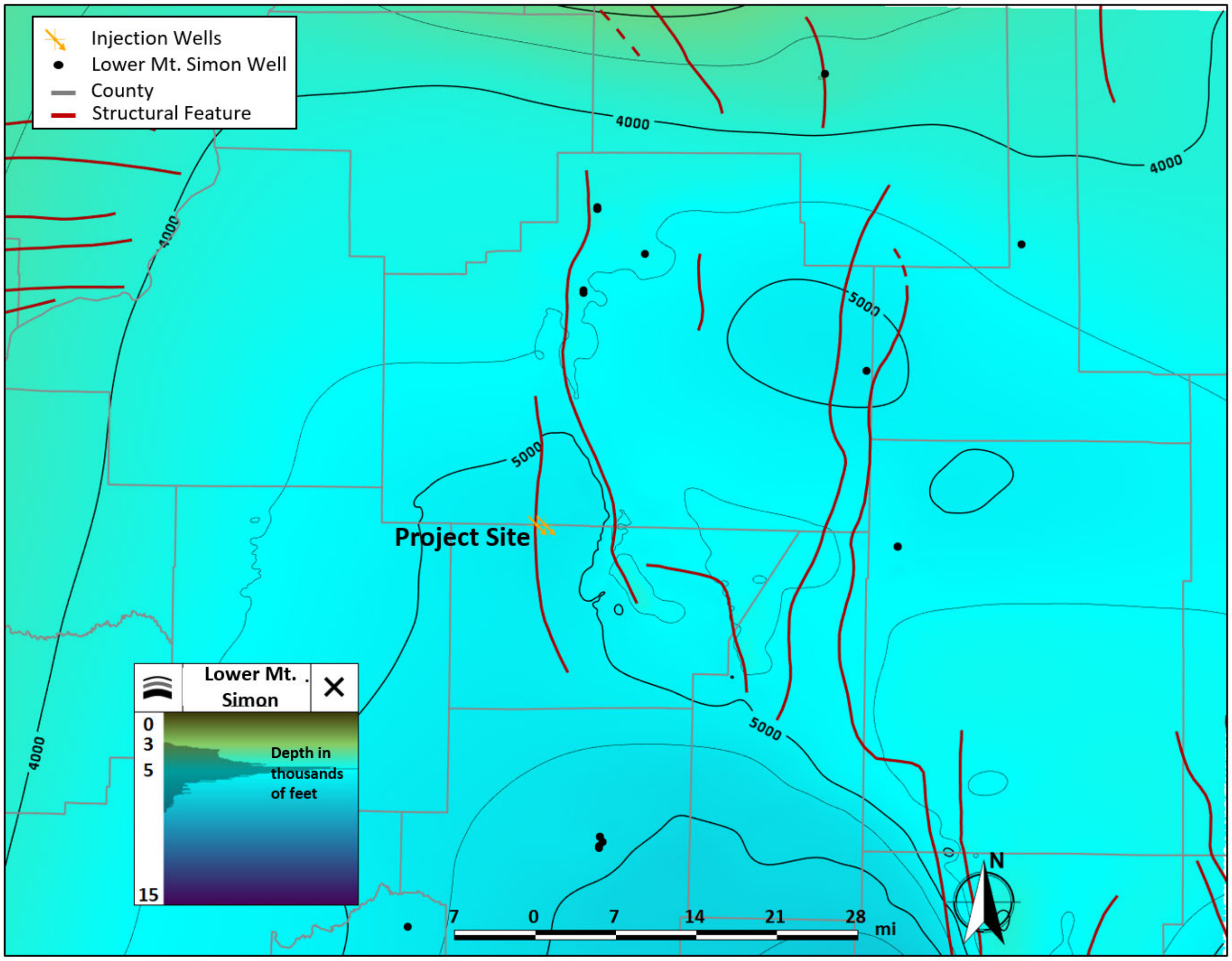

Figure 11: Elevation map (fbsl) of the Lower Mt. Simon Sandstone. Structural features annotated in red (Nelson, 1995). Black circles indicate wells that penetrate the Lower Mt. Simon Sandstone top. The injector wells (NC_INJ1 and NC_INJ2) are shown and labeled "Project Site".

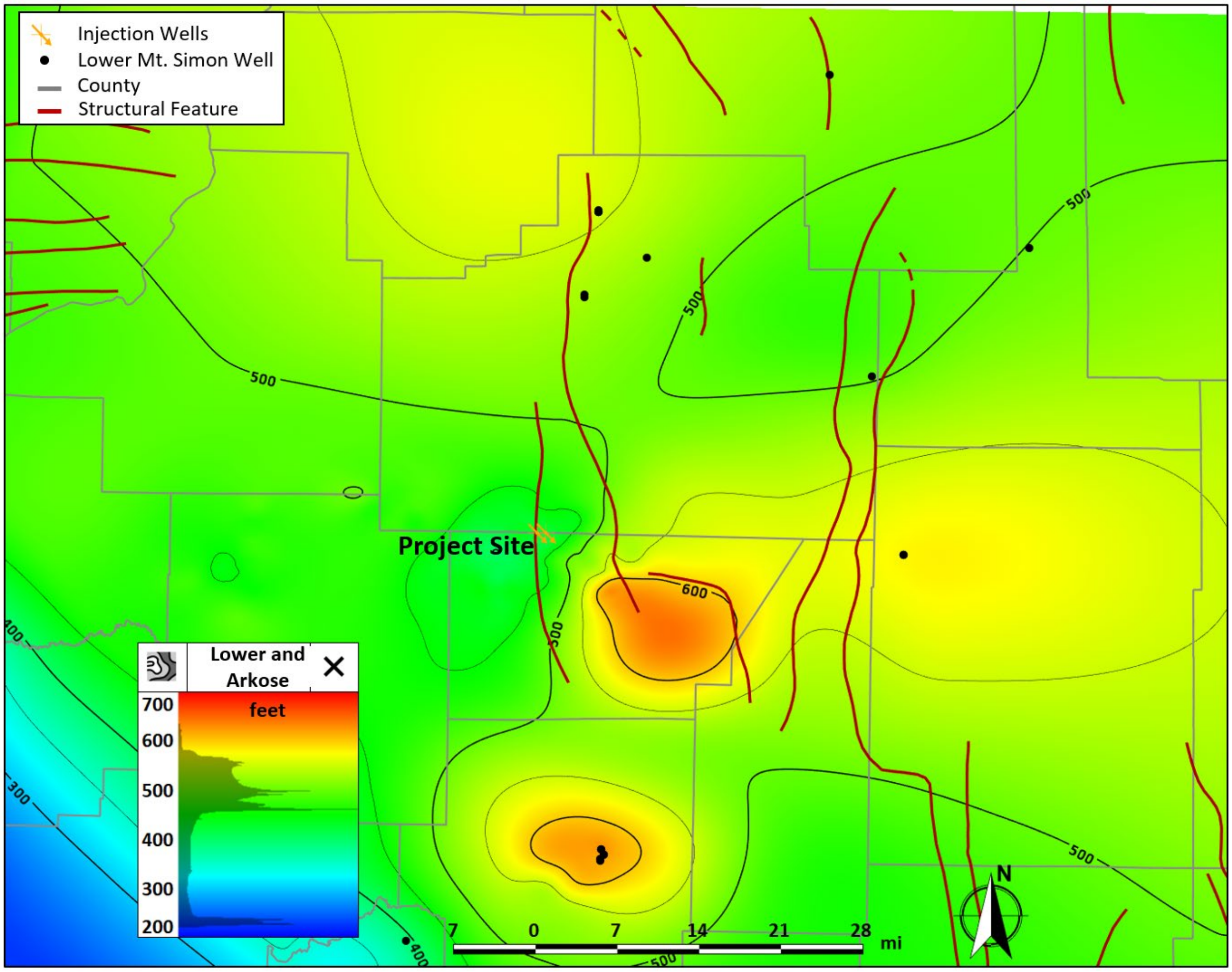

Figure 12: Thickness map (in feet) of the injection zone comprised of the Lower Mt. Simon and Mt. Simon Arkose with structural features annotated in red (Nelson, 1995). Black circles indicate wells that penetrate the Lower Mt. Simon Sandstone top. The injector wells (NC_INJ1 and NC_INJ2) are shown and labeled "Project Site".

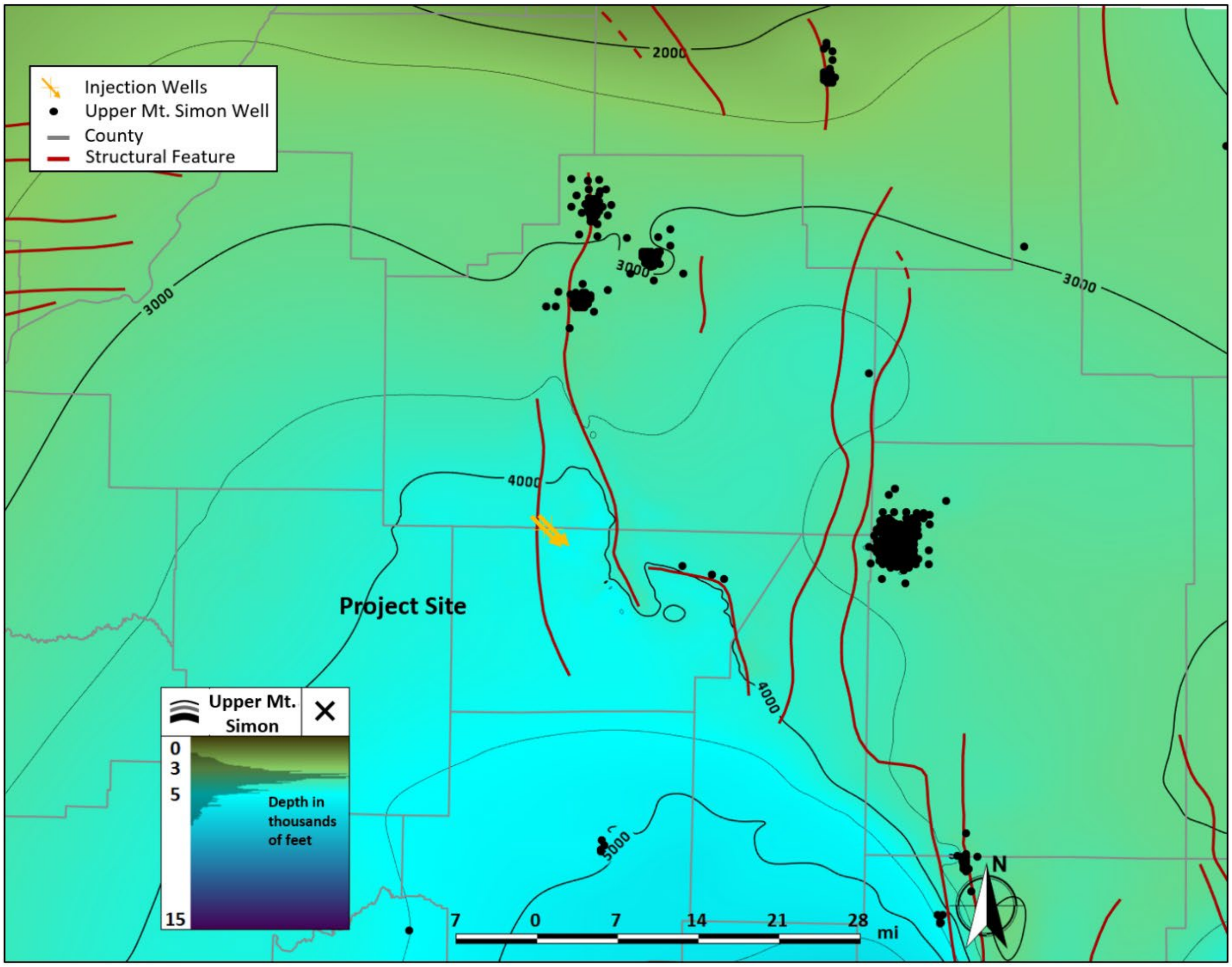

Figure 13: Elevation map (fbsl) of the Upper Mt. Simon Sandstone. Structural features in red (Nelson, 1995). Black circles indicate wells that penetrate the Upper Mt. Simon Sandstone top. The clusters of wells northeast and east of the project site are natural gas storage fields in the Upper Mt. Simon Sandstone.

2.5 Eau Claire Formation/Primary Confining Zone (Cambrian)

The Eau Claire Formation is the primary confining unit at the Compass Project Site (Figure 4, Figure 5, and Figure 7). The Eau Claire Formation directly overlies the Mt. Simon Sandstone and is the basal unit of the Knox Group (Kolata, 2010). Regionally, the Eau Claire Formation is a thick succession of fine-grained strata that is present across much of the Illinois Basin and surrounding area (Figure 14). The regional thickness of the Eau Claire Formation is shown in Figure 15.

The Eau Claire Formation exhibits a range of mineralogical and textural features across the Illinois Basin, and (Neufelder et al., 2012)) report five lithofacies in seven Illinois Basin cores: 1) sandstone, 2) clean siltstone, 3) muddy siltstone, 4) silty mudstone, and 5) shale. Lahann et al., (2014) additionally evaluated the sealing properties of the Eau Claire Formation and determined the finer-grained facies, such as mudstones and shale would restrict vertical entry of CO_2 into the rocks. Figure 16 shows Eau Claire Formation core and well log porosity and permeability data from four Illinois Basin wells, and these data were divided into the five lithofacies listed above. In general, the coarser grained lithofacies have higher porosities and associated permeabilities, and the finer grained, clay-rich lithofacies have lower values, though there is considerable scatter in this data. The base of the Eau Claire Formation can be siltstone to very fine-grained sandstone that forms a gradational contact with the underlying Mt. Simon Sandstone and is sometimes referred to as the Elmhurst Member (Willman et al., 1975). However, in this document it is called the Eau Claire Silt and is considered part of the sequestration zone.

At ADM CCS1 drilled as part of the IBDP (Greenberg, 2021) approximately 28 miles south of the Compass Project Site (Figure 3), the Eau Claire Formation is about 500 feet thick and grades from highly laminated shale to silty shale in the bottom portion to clayey limestone in the top half of the formation. The shale and muddy siltstone layers isolate the clayey limestone from the injection zone (Leetaru and Freiburg, 2014). The characteristics of the Eau Claire Formation around the Compass Project Site are described in more detail in Section 2.24 *Injection and Confining Zone Details*.

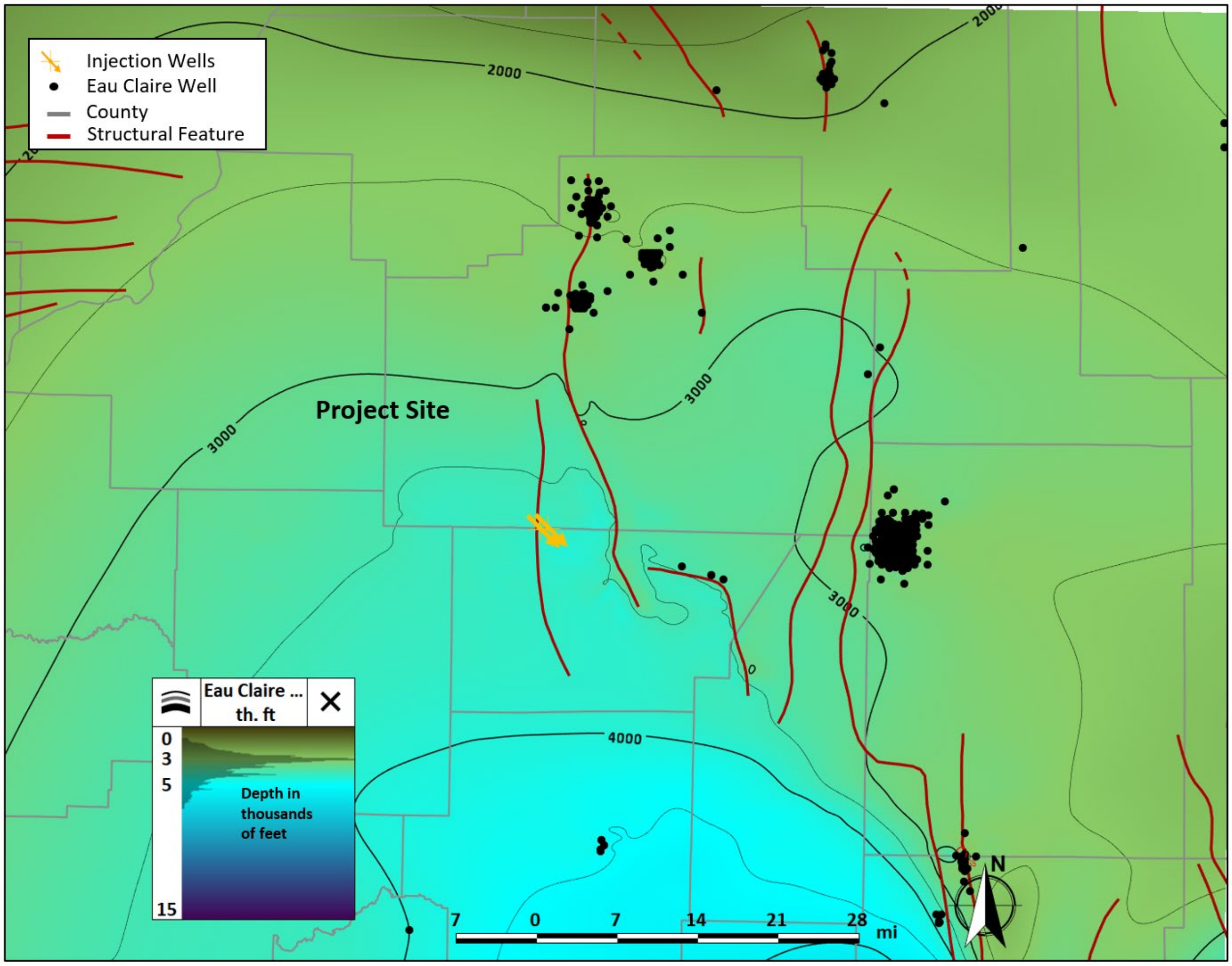

Figure 14: Elevation map (fbsl) of the Eau Claire Formation. Structural features annotated in red (Nelson, 1995). Black circles indicate wells that penetrate the Eau Claire Formation top.

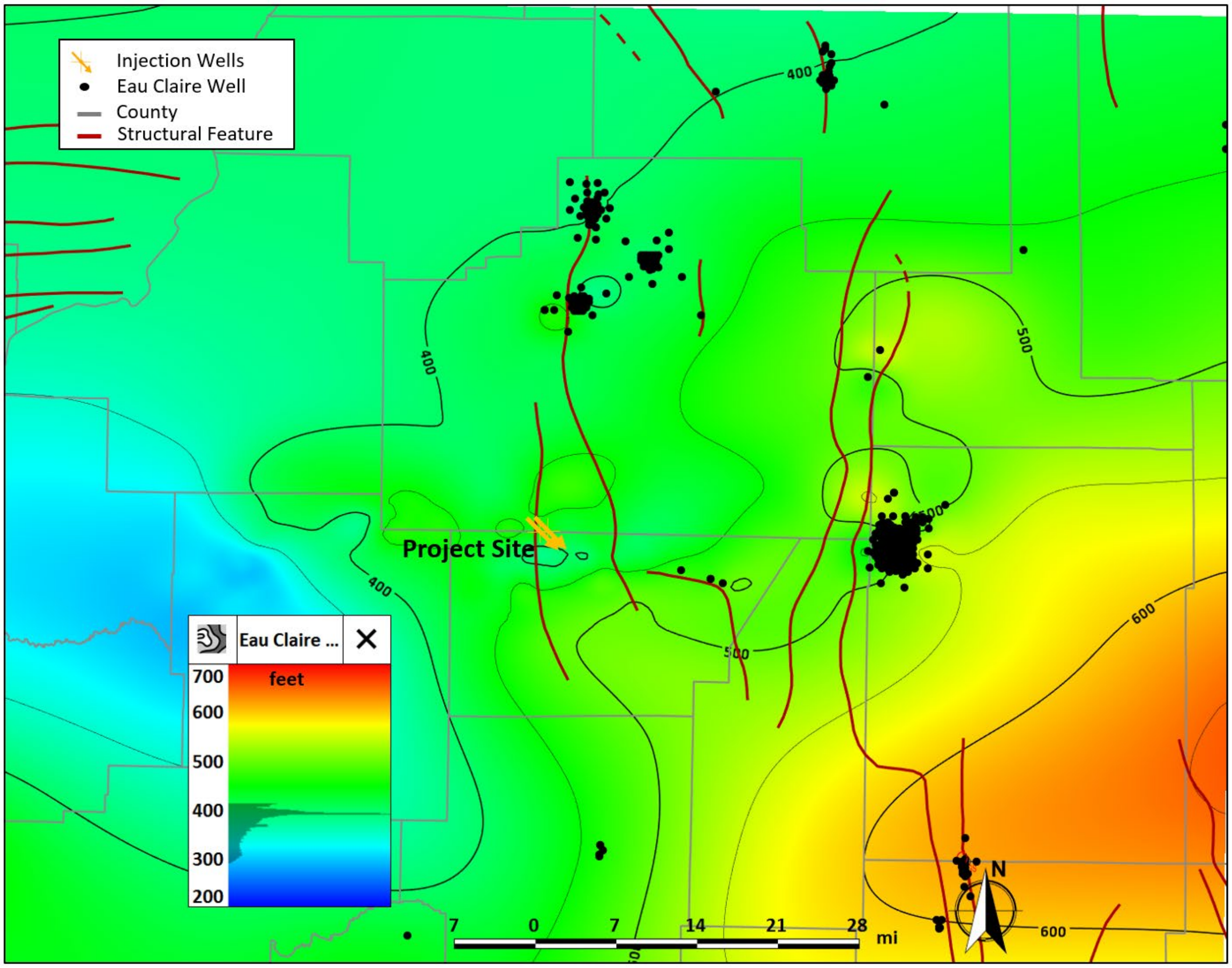

Figure 15: Thickness map (feet) of the Eau Claire Formation with structural features annotated in red (Nelson, 1995). Black circles indicate wells that penetrate the Eau Claire Formation top.

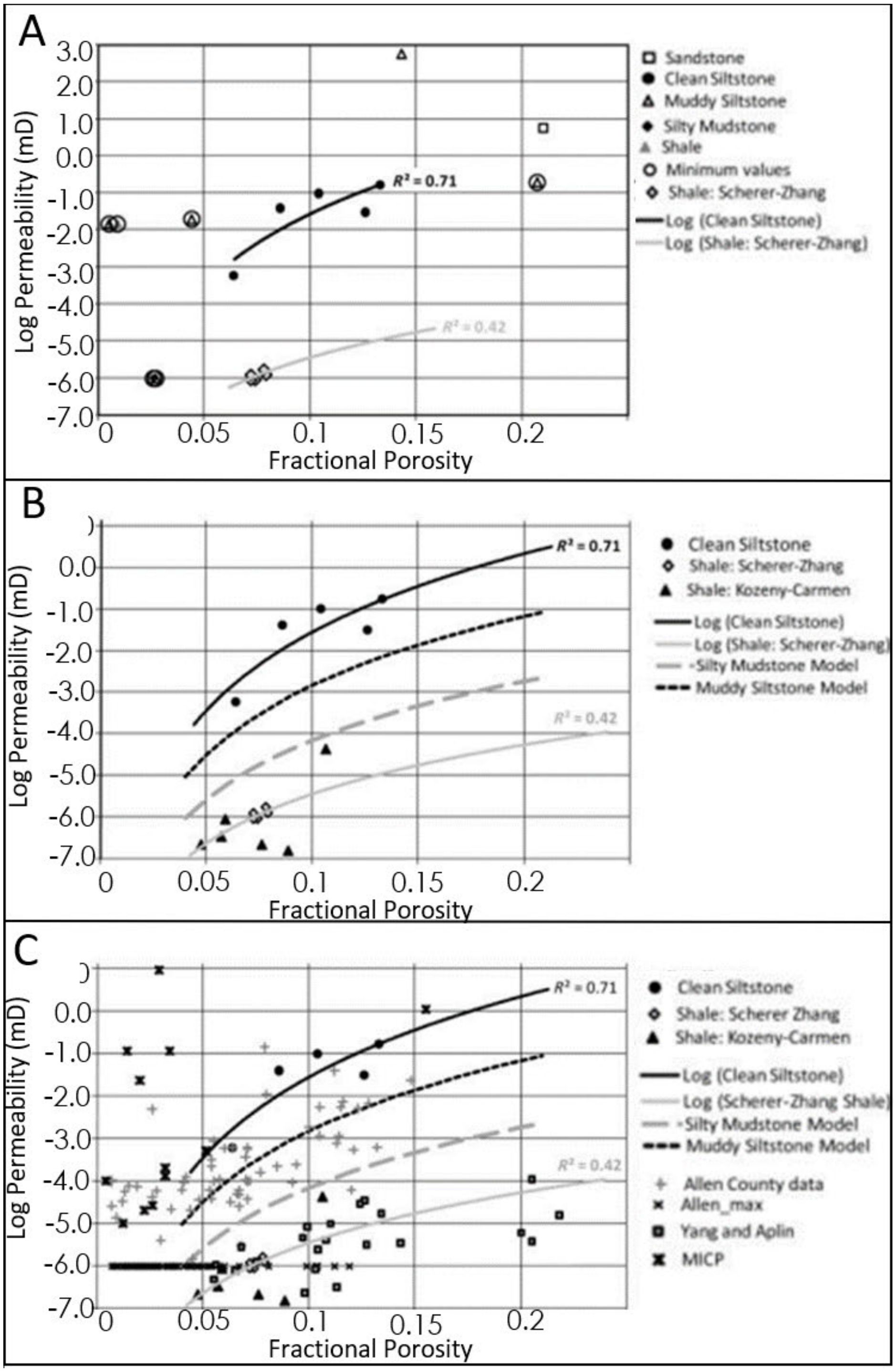

Figure 16: Porosity-permeability models for the Eau Claire Formation lithofacies modified from (Neufelder et al., 2012). (A) Cross plot of conventionally derived core porosity and permeability with regression lines for the clean silt lithofacies. (B) Cross plot of traditional core porosity and Kozeny-Carmen calculated permeability with regression lines for the clean silt, muddy siltstone, and silty mudstone lithofacies. (C) Cross plot of traditional core porosity and Kozeny-Carmen calculated permeability for clean silt, muddy silt, and shale lithofacies.

2.6 Ironton-Galesville Sandstones (Cambrian)

The Eau Claire Formation is overlain by the Ironton-Galesville Sandstones, which are also part of the Knox Group and will serve as the Above Confining Zone (ACZ) monitoring interval for the Compass Project (Figure 4). These sandstones were derived from pre-existing sedimentary rocks, sourced from the northern Michigan Highlands (Emrich, 1966). The sediments were deposited on a broad, shallow shelf with clastic deposition in the north and carbonate deposition in the south. The Ironton Formation is a fine to coarse grained, poorly sorted silty sandstone. The underlying Galesville Formation is fine to medium grained, well sorted sandstone and, in the lower part, fossiliferous (Emrich, 1966). Due to the gradational nature of the Ironton and Galesville Formations, it is difficult to distinguish between these formations in well data and they are typically considered together.

2.7 Davis Member/Secondary Confining Zone (Cambrian)

The Davis Member of the Knox Group overlies the Ironton-Galesville Sandstones and is composed of a number of carbonate and clastic lithologies, including: 1) brownish gray, silty, glauconitic dolomite with oolites, 2) yellowish gray, feldspathic siltstone with dolomite and glauconite, 3) dark gray, calcareous shale, and 4) gray limestone with interbedded shale, siltstone, and sandstone (Figure 4). They are interpreted to have been deposited in a shallow marine environment (Willman et al., 1975). In the project area the Davis Member is expected to be composed of impure dolomite, dolomitic sandstone, and siltstone or silty shale. Dolomitic sandstones are likely to be found mainly in the lower part of the unit. Shale layers at the top and base of the Davis can be distinctive on gamma-ray, neutron, and density logs.

2.8 Franconia Formation (Derby-Doerun Dolomite) /Secondary Confining Zone (Cambrian)

The Davis Member is the lower member of the Franconia Formation and is in conformable contact with the overlying Franconia strata (Figure 4), which consists of glauconitic, argillaceous sandstone and dolomite that underlies the relatively clean Potosi Dolomite. In extreme northern Illinois, the Franconia Formation primarily consists of gray to pink, fossiliferous, glauconitic, silty, argillaceous, fine-grained, dolomitic sandstone with some interbedded red and green shale (Willman and Templeton, 1951). It becomes increasingly shaly to the south, and the uppermost part grades to silty and sandy dolomite. In north-central Illinois, these two units are separated by a wedge of fine-grained, glauconitic, dolomitic sandstone, which is absent in central and southern Illinois where the silty, shaly sandstone of the Davis is directly overlain by relatively pure dolomite. Because of its diminishing amounts of sand, shale, and glauconite, the upper part of the Franconia Formation is difficult to differentiate from the overlying Potosi Dolomite (Willman et al., 1975). For this project, the Potosi and Franconia Formations will not be differentiated.

2.9 Potosi and Eminence Formations/Secondary Confining Zone (Cambrian)

The Potosi Formation overlies the Franconia Formation and consists of crystalline, clean to slightly argillaceous, brown to pinkish-gray dolomite (Figure 4). It is sandy at the base and glauconite content increases upward. Drusy quartz sometimes covers the surfaces of small to large cavities within the rock, which is a defining characteristic in both outcrops and well samples, and portions of this formation have relatively high permeability (Willman et al., 1975). Intervals within the Potosi Formation exhibit karst dissolution features (e.g., large vugs) and can be zones of lost circulation during drilling throughout the Illinois Basin.

2.10 Oneota Formation/Secondary Confining Zone (Ordovician)

The Oneota Formation consists of crystalline, light gray to brownish gray, cherty dolomite with minor amounts of sand and thin shaly beds at the base (Figure 4). The rock is generally white, light, or pinkish gray with some sandy and oolite layers. The chert occurs in layers, lenses, isolated nodules, and irregularly shaped bodies that have a distinctive branching habit (Willman et al., 1975).

2.11 New Richmond Sandstone (Ordovician)

The New Richmond Sandstone overlies the Oneota Dolomite and is locally unconformable. The New Richmond Sandstone grades upwards and laterally into the Shakopee Formation (Willman et al., 1975). The sandstone is gray, fine to medium grained, subrounded to rounded, friable, moderately-well sorted, with cross beds, ripple marks, and interbedded sandy dolomite with oolitic chert. The characteristics of the sandy dolomite intervals are similar to those of the overlying Shakopee Formation (Willman and Payne, 1943).

2.12 Shakopee Formation/Secondary Confining Zone (Ordovician)

The Shakopee Formation consists of argillaceous to pure, crystalline dolomite with some thin beds of medium-grained, cross-bedded sandstone, medium-grained dolomite, green to light gray shale, and buff siltstone. It contains oolitic, partly sandy chert in discontinuous bands and isolated nodules, conglomerate beds, ripple marks, and mud cracks (Willman et al., 1975). Bentonite layers are present in a quarry in northern Illinois (Willman and Templeton, 1951; Figure 4).

2.13 St. Peter Sandstone/Lowermost USDW (Ordovician)

The Knox Group is overlain by the St. Peter Sandstone (Figure 4), which consists of fine to medium, well sorted, rounded, frosted quartz sand grains that are friable or weakly cemented. The St. Peter Sandstone is an exceptionally pure quartz sandstone and was deposited in a near-shore environment (Lamar, 1928; Willman and Payne, 1943; Buschbach, 1964). Bedding is primarily horizontal with some low-angle cross bed. It has three members: 1) the Kress Member at the base (chert, sand, clay, and shale), 2) the Tonti Sandstone Member, and 3) the Starved Rock Sandstone Member (Willman et al., 1975). The St. Peter Sandstone is one of the major aquifers in Illinois and is the lowermost USDW zone in the project area.

2.14 Joachim Dolomite/Glenwood (Ordovician)

The St. Peter Sandstone is overlain by the Joachim Dolomite (Figure 4), which can be differentiated into six members regionally within the basin. This rock is generally light gray, argillaceous, silty, or sandy dolomite, and also contains beds of relatively pure dolomite, sandstone, limestone, shale, and chert. Dolomitic algal domes are also found within the Joachim Dolomite. Layers of anhydrite exist in the subsurface but are dissolved where the Joachim Dolomite crops out. The general absence of marine fossils and existence of algal domes suggests that the Joachim was deposited in a shallow, closed basin, and mud cracks and ripples occur in some beds. The Joachim contains more clastic material than the overlying Platteville Group (Willman et al., 1975).

2.15 Platteville Group (Ordovician)

The blue-gray, mottled limestone of the laterally continuous Platteville Group overlies the Joachim Dolomite. A diastem divides the Platteville Group into the lower Pecatonica Formation, which is a persistent dolomite, and the overlying Plattin Subgroup limestone (Willman et al., 1975).

2.16 Galena Group/Trenton Limestone (Ordovician)

Overlying the Platteville Group is the Trenton Limestone of the Galena Group (Figure 4). The Galena Group has three major facies:1) fine-grained limestone in northwestern Illinois, 2) dolomite, and 3) a calcarenite in southern Illinois. In most of northern Illinois, the group is entirely dolomite and the lower part grades into a limestone to the south. Still farther south, the limestone interval is truncated so that the group is entirely calcarenite and calcarenitic limestone (Willman et al., 1975).

2.17 Maquoketa Group/Potential Confining Zone (Ordovician)

The shale and carbonate of the Maquoketa Group exists in most of Illinois, unconformably overlies the Galena Group, and truncates the portions of the upper half of the Galena Group in southern Illinois (Figure 4). Silurian strata locally truncate the upper half of the Maquoketa. Throughout most of Illinois, the Maquoketa Group consists of a lower shale unit (Scales Shale), a middle limestone (Fort Atkinson Limestone), and an upper shale (Brainard Shale) (DuBois, 1945; Gutstadt, 1958; Templeton and Willman, 1963; Buschbach, 1964). The Maquoketa Group will serve as a significant confining zone for this project.

2.18 Silurian System

The Silurian System unconformably overlies the Maquoketa Group. During this period, a shallow sea transgressed across the Illinois Basin and surrounding area, depositing carbonate sediments. This, in conjunction with the subsidence of the Illinois and surrounding basins, allowed prominent shelf-edge carbonate banks to develop. At the end of the Silurian, eustatic fluctuations, cratonic uplift, and local tectonic events caused sea level to regress. This ended sedimentation, exposing and eroding the Silurian strata for millions of years (Mikulic et al., 2010).

2.19 New Albany Shale Group/Potential Confining Zone (Devonian)

The New Albany Shale of Middle to Upper Devonian age unconformably overlies Silurian strata and is widely distributed across the Illinois Basin and surrounding areas. Its cumulative thickness of the organic-rich black shales is greatest near the center of the basin and thins toward the basin edge. Organic-poor, greenish-gray shales predominate in the basin center and are thickest in western and west-central Illinois. A broad transitional zone, where these organic-rich and organic-poor facies interfinger and grade laterally into one another, trends northeast-southwest across central Illinois (Cluff and Dickerson, 1982).

Sea level regressed during the Mississippian, and the Illinois Basin contained a river system that flowed southwestward across a swampy lowland, carrying mud and sand from the highlands located to the northeast. This river system formed thin, widespread deltas that prograded into the shallow sea that covered much of present-day Illinois. Because the lowland stood only slightly above sea level, slight changes in relative sea level caused great shifts in the position of the shoreline (Siever, 1951). The Mississippian strata (i.e., St. Genevieve, St. Louis, Keokuk) are more than 3,000 feet thick in some parts of Illinois (Willman et al., 1975) but are expected to be thin to absent at the project site.

2.20 Pennsylvanian System

The Illinois Basin continued to subside throughout the Pennsylvanian, leading to accumulation and preservation of about 3,000 feet of sediments in the basin. The previously described Mississippian river system persisted to flow across a swampy lowland, carrying mud and sand from bordering highlands. These rivers formed thin but widespread deltas that coalesced into a vast coastal plain, and sediments continued to prograde into a shallow sea (Siever, 1951). During the late Pennsylvanian, a eustatic sea level regression coupled with the Alleghenian Orogeny tectonics, resulted in erosion of much Pennsylvanian and pre-Pennsylvanian strata.

2.21 Regional Structure

The Illinois Basin (Figure 3) has been affected by three major tectonic episodes during the Phanerozoic Eon, including Rodinia-related rifting; widespread compressional (reverse) faulting during the assembly of the supercontinent Pangea in the late Paleozoic; and extensional (normal) faulting during the Mesozoic related to Pangea’s breakup (Denny et al., 2017, 2020).

The most prominent structural feature in the central basin area is the La Salle Anticlinorium (Nelson, 1995), which is a large upward fold belt comprised of smaller domes, anticlines, monoclines (step-like folds), and intervening synclines; it trends N-S to NE-SW and is about 200 miles (320 km) long by 80 miles (130 km) wide. Major uplift of the La Salle Anticlinorium began during the Late Mississippian and lasted throughout most of Pennsylvanian time (Kolata and Nelson, 1990).

Approximately 43.6 miles of high density 2D seismic data acquired specifically for the Compass Project was collected to characterize the structural features identified in the region by Clegg (1972) and Nelson (1995) and is discussed in detail in section *2.23 Faults and Fractures*. Within the general vicinity of the Compass Project Site, the Downs Anticline forms the western-most element of the La Salle Anticlinorium (Nelson, 1995) and is about 7 miles east of the injection wells (Figure 17). The south-plunging Downs Anticline is evident on 2D seismic and is asymmetrical having a significantly steeper western flank. The Clinton Syncline is the closest mapped structural feature to the Compass Project Site (Clegg, 1972; Nelson, 1995); however, this feature, described as a broad shallow trough (Nelson, 1995), is not-discernable using 2D seismic at this location. The Wapella and Parnell domes also occur to the east of the project site along the Downs Anticline in DeWitt County. A series of east-plunging, asymmetrical individual folds (Bryant, Canton, Fairview, and Elmwood) compose the larger Peoria Fold Complex and are located more than 40 miles northwest of the project site (Nelson, 1995).

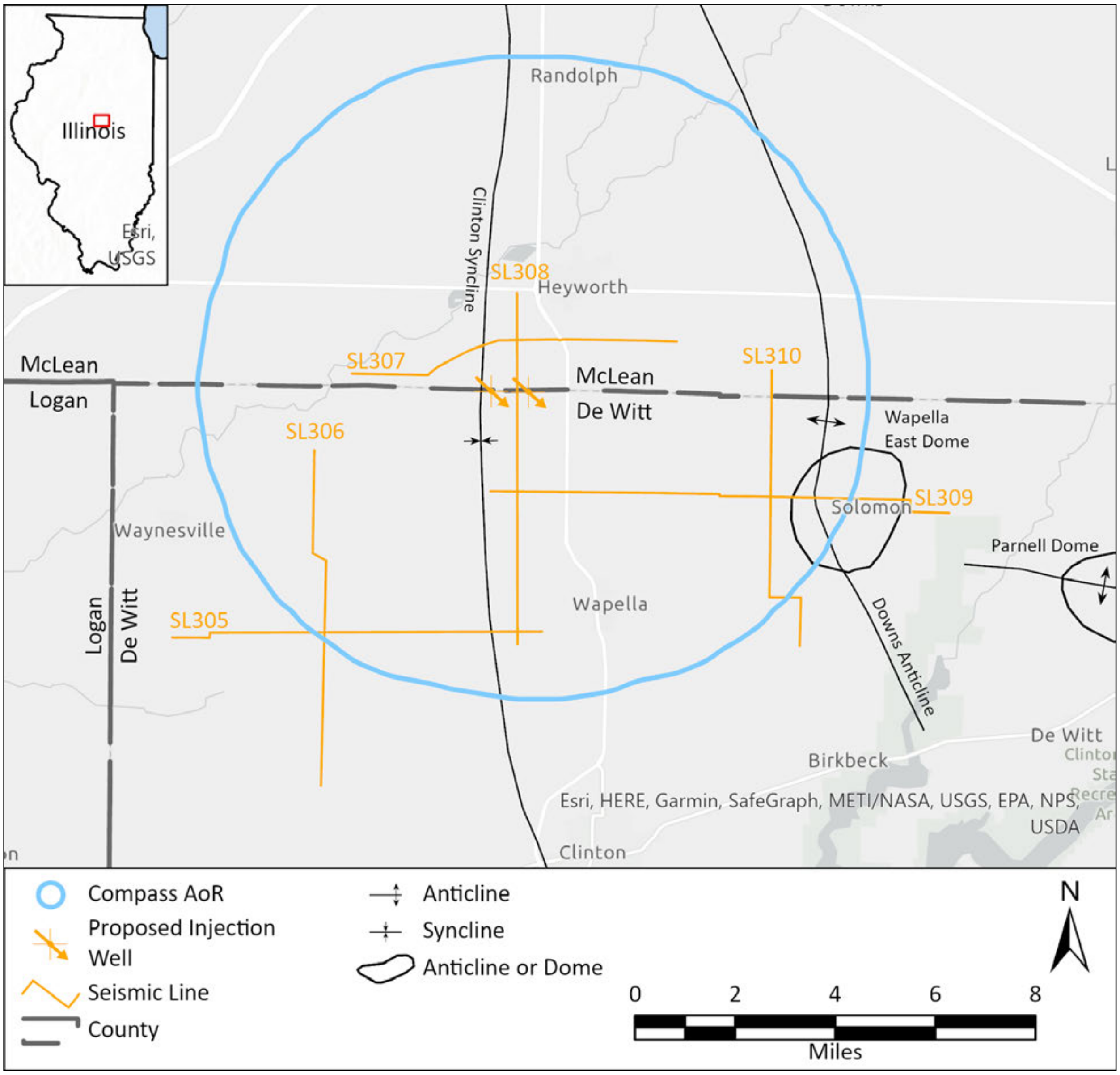

Figure 17: 2D seismic survey locations in relation to structural features in the vicinity of the AoR (modified from Nelson, 1995, p. 100). Inset map highlights the detailed mapped area.

2.22 Maps and Cross Sections of the AoR [40 CFR 146.82(a)(2), 146.82(a)(3)(i)]

Figure 18 shows the AoR for the Compass Project, based on differential pressure front after 25 years of injection, and all the existing wells within the area. This is the maximum extent of AoR in the project timeframe. The method for delineation of the AoR is described in Attachment 02: AoR and Corrective Action Plan, 2023.

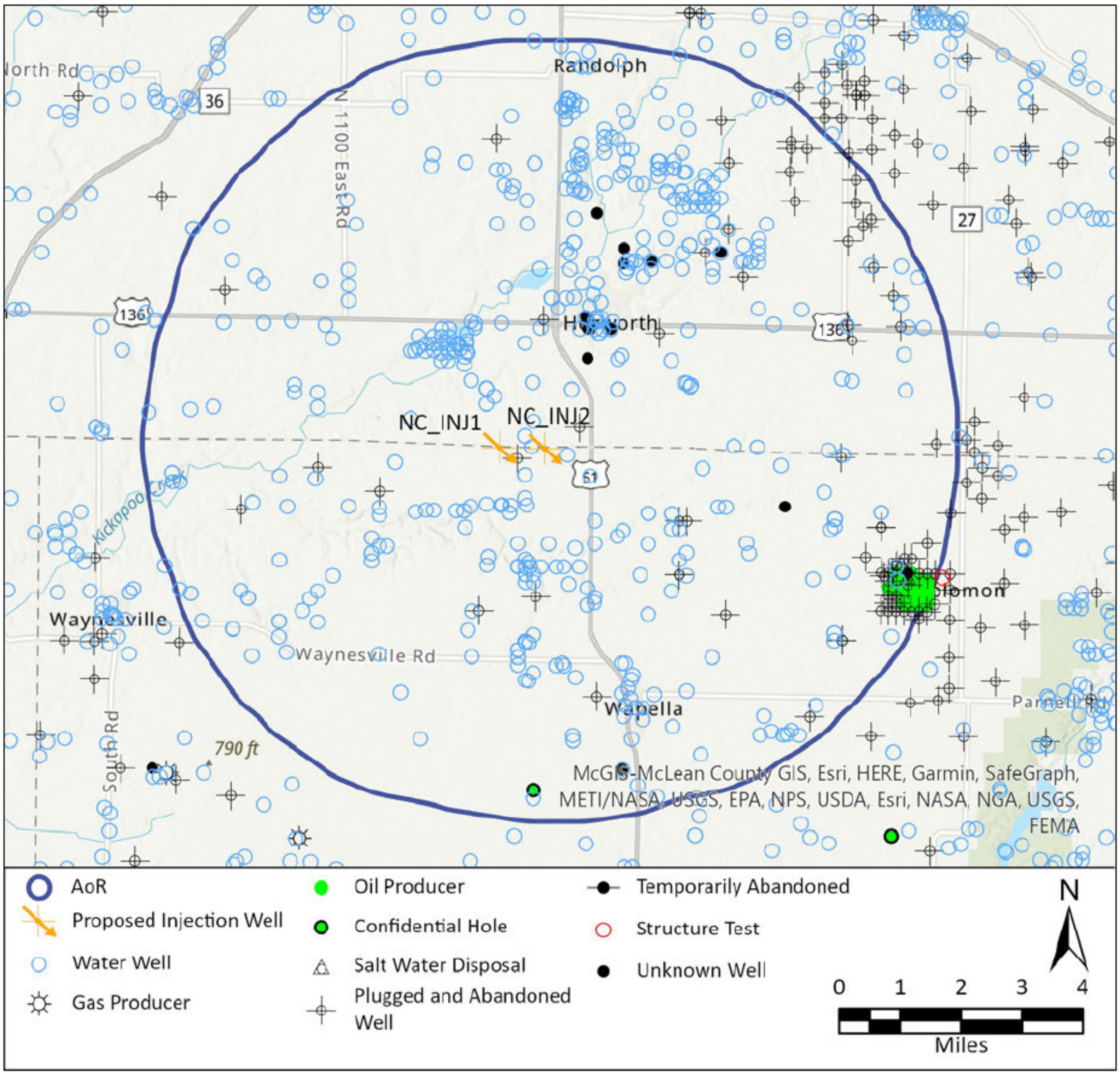

Figure 18: All oil/gas wells (105) and water wells (486) within the Compass AoR. Injector wells are also shown. Included in the oil/ gas well count are three saltwater disposal wells.

The Mt. Simon Arkose and Lower Mt. Simon Sandstone comprise the injection zone, the Eau Claire is the confining zone for the Compass Project, and all of these zones extend laterally beyond the AoR limits. This is demonstrated by the regional thickness maps (Figure 12 and Figure 15), the cross section shown in Figure 5 in Section 2.1 *Regional Geology* of this narrative, and 2D seismic data discussed below (Figure 19, Figure 20, Figure 21, Figure 22, Figure 23, Figure 24, Figure 25, and Figure 26).

Strata of the Mt. Simon Sandstone and Eau Claire Formation are of consistent thickness with no evidence of stratigraphic pinch-out throughout the AoR. Figure 27 shows the petrophysical analysis from the ADM CCS1 well, which demonstrates the thickness and shale content of the Eau Claire Formation. The thickness of the total storage interval (top of the Eau Claire Silt to the bottom of the Mt. Simon Arkose) is between 1,200-1,650 feet at the project site and thickens to the north (Figure 28). The Lower Mt. Simon Sandstone and Mt. Simon Arkose injection interval thickness is between 425-600 feet within the AoR (Figure 29). Thickness of Eau Claire Formation primary confining zone ranges between 400 to 475 feet at the project site (Figure 30).

More than 43 miles of 2D seismic data (Figure 21 and Figure 22) were acquired specifically for the Compass Project and are discussed in detail in *Section 2.23 Faults and Fractures* of this document. The 2D seismic data indicate the Mt. Simon Sandstone and Eau Claire strata are primarily flat lying and laterally continuous across the AoR. Several small basement faults that have limited offset and terminate within the Argenta or basal Mt. Simon Arkose zone have been identified and are not expected to have an impact on containment. At the eastern edge of the AoR, the strata rise along the western flank of the Downs Anticline; there are no faults identified within the core of the anticline and only small faults are observed that terminate within the Mt. Simon Sandstone. At the extreme southeast edge of the AoR, a fault is observed that transects the Eau Claire Formation into the Knox Group strata. The delta pressure front approaches the fault after 25 years of injection, which is the projected end of the injection period.

The continuity and thickness of the Eau Claire Formation and lack of structural features within the AoR indicate the confining zone has excellent characteristics for sequestration of CO_2 at the Compass Project Site. No potential conduits for CO_2 to migrate out of the Mt. Simon storage zone were identified within the AoR of the Compass Project.

The St. Peter Sandstone is the lowermost USDW present within the AoR based on regional data (Figure 47) and is predicted to occur at a depth of approximately 2,570 feet and with its base more than 1,700 feet above the top of the Eau Claire confining zone at the Compass Project Site (*Section 2.27.3 Determination of Lowermost USDW)*. There are no structural features or faults observed to intersect the St. Peter Formation in the AoR. As described in *Section 2.1 Regional Geology* there are several secondary confining zones within the Knox Group between the Eau Claire Formation and the St. Peter Sandstone in the AoR.

There are 105 oil and gas and 486 water wells found within the Compass AoR (Figure 18) that were collected from the Illinois Water and Related Wells website and the Illinois Oil and Gas Resources website. The resultant table detailing the identifying information, location, depth, and status of these wells and borings was uploaded to the GSDT tool.

Groundwater wells are the most common well type with a total of 486 wells located within the Compass AoR (Figure 18; ILWater). The shallow groundwater water wells have an average depth of 142 feet, with depths ranging from less than 100 feet to 398 feet. One groundwater well was drilled to a depth of 1195 feet and has subsequently been plugged.

No existing well penetrates the confining strata of the Eau Claire Formation in the AoR at the Compass Project Site.

2.23 Faults and Fractures [40 CFR 146.82(A)(3)(ii)]

A high density 2D seismic program conducted in November/December 2022 acquired six 2D seismic lines totaling approximately 43.6 miles in DeWitt and McLean counties for the Compass Project to provide information regarding subsurface structure and stratigraphy (Figure 19). The seismic data were acquired using a vibrator truck operating on county roads with a 2-120 Hz broad band sweep of 20 second duration and a source and receiver spacing of 32 feet. High density processing was performed to identify both shallow and deep subsurface features.

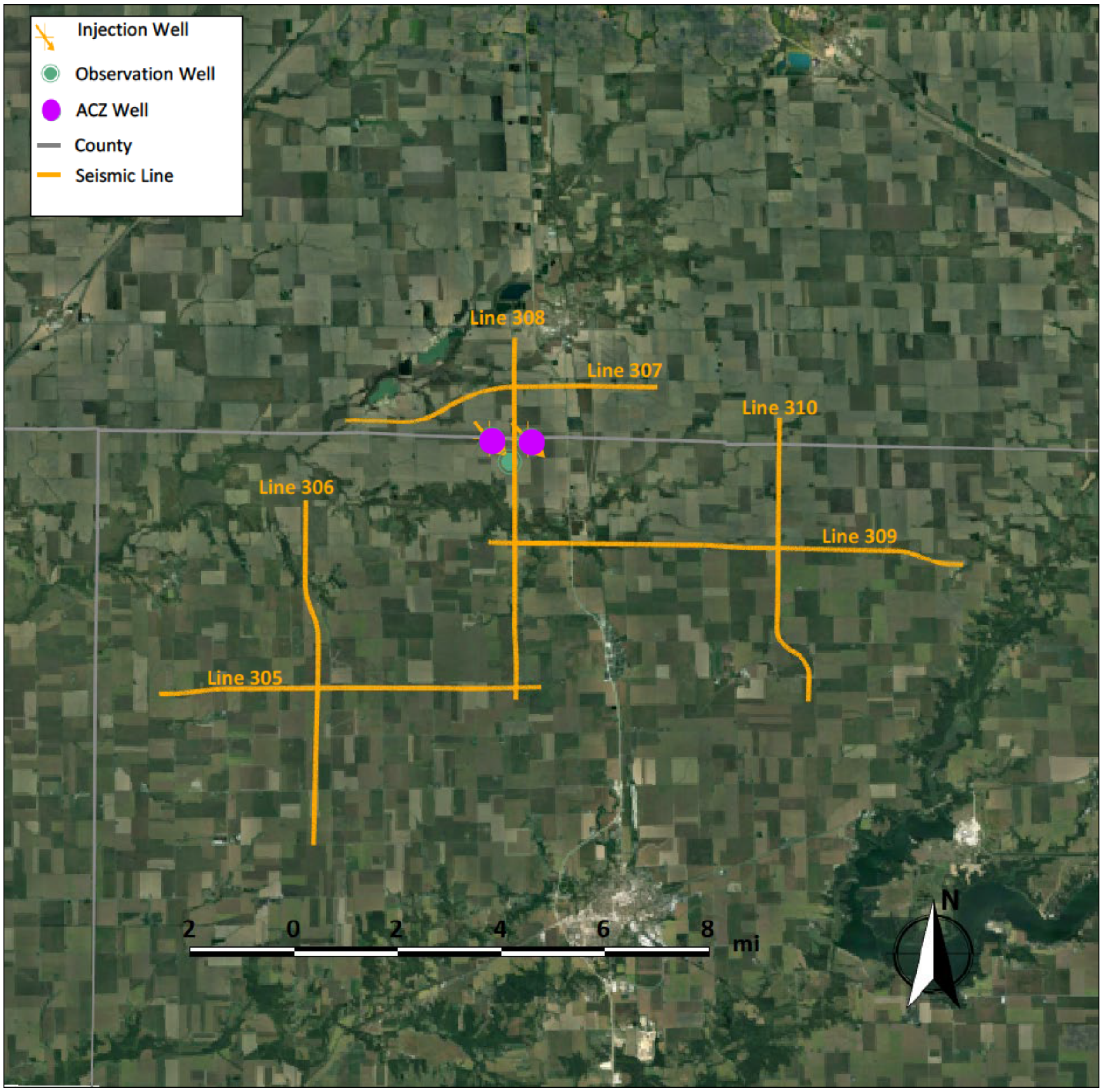

Figure 19: Map of 2D seismic lines 305, 306, 307, 308, 309, and 310 acquired for the project. Project well locations also shown.

No deep wells are in immediate proximity to the six 2D seismic lines acquired at the Compass Project Site that would allow a direct tie to the seismic surveys, so the ADM CCS1 well drilled for the IBDP about 28 miles south of the project area was used to correlate the stratigraphy to the seismic data. The ADM CCS1 well penetrates similar stratigraphy as is present at the Compass Project Site. Data from ADM CCS1 was used to generate a synthetic seismogram which was then used to help correlate the stratigraphy to the seismic lines (Figure 20). Although ADM CCS1 is located some distance from the seismic lines, which leads to more uncertainty in the seismic interpretation than a closer well, the stratigraphy and resulting seismic stratigraphy in the central part of the Illinois Basin are generally well understood. The uncertainty on the seismic interpretation is considered to be plus or minus one seismic cycle. The seismic data has been converted to depth and incorporated into the static model using velocities from the ADM CCS1 well (Attachment 02: AoR and Corrective Action Plan, 2023).

In the central Illinois Basin, the Maquoketa, Trenton, St. Peter, and Knox seismic horizons are generally associated with a zone of high amplitude continuous reflectors, representing the impedance contrasts between the high impedance Trenton and Knox dolomites and the low impedance Maquoketa Shale and St. Peter Sandstone. For the Precambrian pick on the seismic lines, a lower amplitude, high impedance reflector was chosen based on a combination of the ADM CCS1 synthetic seismogram as well as comparing the overall time-depth relationships of other Precambrian picks from other deep wells across central Illinois.

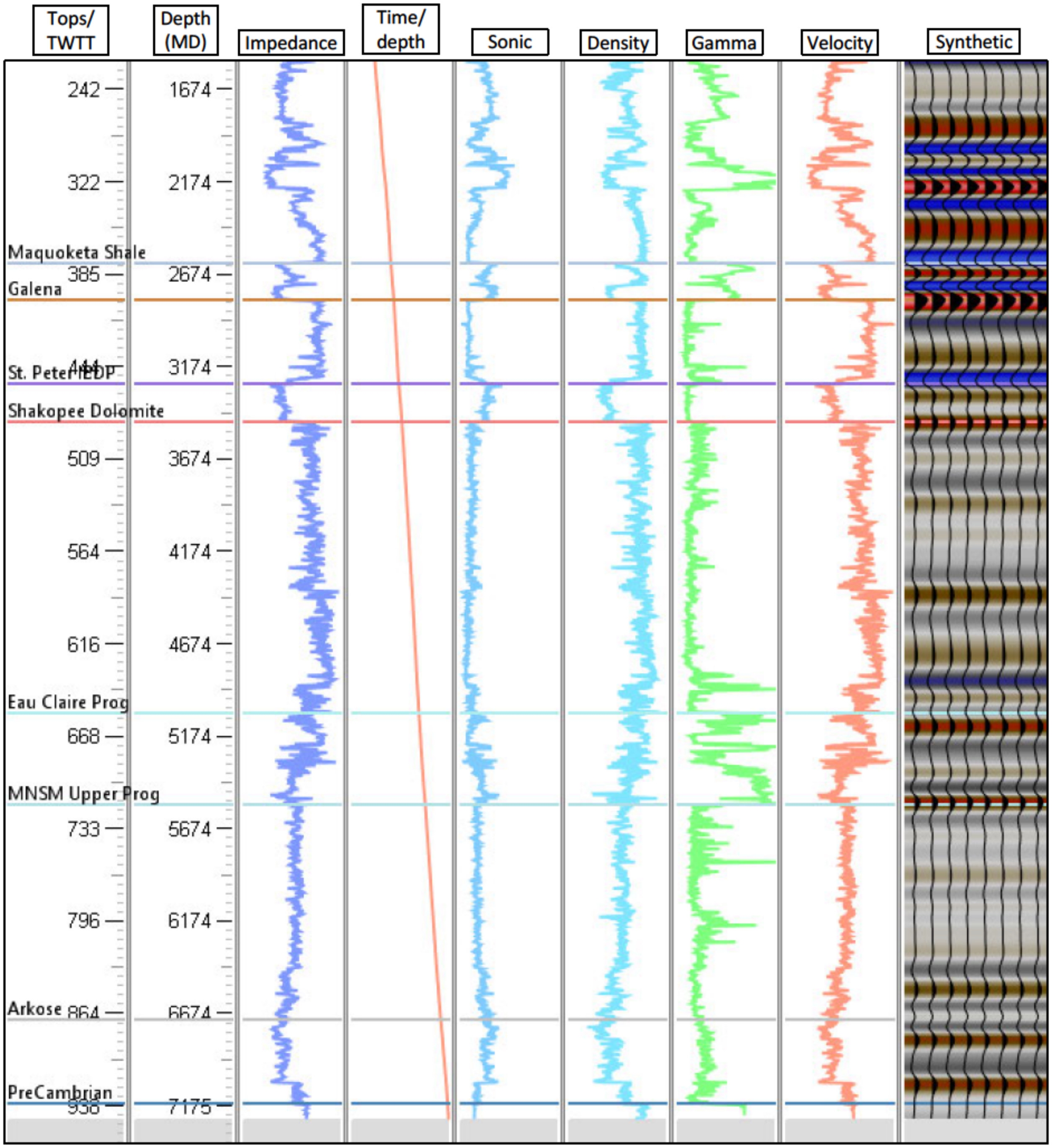

Figure 20: Well logs and synthetic seismogram from ADM CCS1 well. The stratigraphy at the ADM CCS 1 location is similar to the Compass Project Site and was used to tie the 2D seismic for seismic interpretation.

The locations of the 2D seismic lines are shown in Figure 19. Figures 21 to 24 show the seismic sections in time. Seismic sections 305 (Figure 21), 306 (Figure 22), 307 (Figure 23), and 308 (Figure 24) indicate the stratigraphy of the area to be generally flat lying, continuous, and without notable structural features. Seismic sections 305 (Figure 21) and 307 (Figure 23) each cross over the suggested location of the Clinton Syncline as described by Clegg (1972) and Nelson, (1995), but this feature is not easily discernable on these lines. The feature either does not extend this far south or is of very muted expression; as such it will not influence injection or containment.

Seismic lines 305 to 308 show continuous, flat-lying seismic stratigraphy with no notable structure (Figure 21 to Figure 24). Several small faults that originate in the basement and terminate in the Argenta or Mt. Simon Sandstone have been identified on the seismic lines; these faults have limited offset and are not expected to impact containment. On seismic line 305 (Figure 21), a fault originating in the basement and tipping out within the Mt. Simon Sandstone has been interpreted. Two small faults have been observed on east-west seismic line 307 (Figure 23) that originate in the basement and terminate in the Argenta and lower Mt. Simon Sandstone. No clear evidence of the Clinton Syncline can be observed on this line. Line 308 (Figure 24) also has flat lying stratigraphy with no observed structure.

Figure 21: CBI: West–east 2D seismic line 305 from the Compass Project site with annotated interpreted stratigraphy. The diagonal green line is a possible fault that originates in the Precambrian Basement and terminates in the Mt. Simon Sandstone.

Figure 22: CBI: North–south 2D seismic line 306 from the Compass Project site with annotated interpreted stratigraphy. No faults or structures are observed on this seismic line.

Figure 23: CBI: West – east 2D seismic line 307 from the Compass Project site with annotated interpreted stratigraphy. The diagonal dark lines are possible faults that originate in the Precambrian Basement and terminate in the Argenta or Lower Mt. Simon Sandstone.

Figure 24: CBI: North – south 2D seismic line 308 from the Compass Project site with annotated interpreted stratigraphy. No faults or structures are observed on this seismic line.

On the western side of seismic line 309, the strata are flat and continuous until the expression of the Downs Anticline becomes clearly evident at the eastern margin of the line (Figure 25). The Mt. Simon Sandstone and Eau Claire Formation are continuous and of constant thickness over this structure that began to form during the Late Mississippian and throughout most of Pennsylvanian time (Kolata and Nelson, 1990). No faults have been identified within the core of the anticline; although beyond the limits of the AoR, small faults are present that have little offset and that originate within the basement. These faults terminate in the Argenta and Mt. Simon Sandstone and would have no impact on containment.

Within the AoR, the seismic line 310 displays generally flat lying stratigraphy until near the southern end of the line. At the maximum extent of the AoR, a fault has been observed that transects from the Precambrian through to upper Knox strata (Figure 26). This feature has limited offset and has been interpreted as a flower structure that is likely related to tectonic stresses associated with the formation of the Downs Anticline and LaSalle Anticlinorium. A small reverse fault is also observed near the center of line 310 that terminates within the Lower Mt. Simon Sandstone.

Figure 25: CBI: West-east 2D seismic line 309 from the Compass Project site with annotated interpreted stratigraphy. The Downs Anticline is shown on the eastern edge of the line. Small faults shown as green lines.

Figure 26: CBI: North – south 2D seismic line 310 from the Compass Project site with annotated interpreted stratigraphy. A reverse fault is shown in the center of the line terminating in the Lower Mt. Simon Sandstone. The fault on the southern edge of line is located at the maximum extent of the AoR and extends into Knox strata.

2.23.1 Impact on Containment

Within the Compass Project AoR, no faults or fractures are observable within the Eau Claire Formation confining zone. In general, the Eau Claire Formation and Mt. Simon Sandstone as well as the overlying strata, are without notable structural features in the AoR with the exception of the western edge of the Downs Anticline at the eastern margin of the AoR. The Mt. Simon and Eau Claire strata are continuous across this feature and no faults are present within the confining zone.

The Clinton Syncline is another regional structural feature that was anticipated in this area but does not appear to be developed within the Compass AoR. On seismic line 305 (Figure 21), one possible fault was identified that originates from the Precambrian, cuts through the Arkose Zone, and tips out in the Upper Mt. Simon Sandstone. Because this fault terminates in the Mt. Simon Sandstone and does not reach the Eau Claire Formation, there is no risk to containment from this fault. Additionally on line 307, two small faults originate in the basement and terminate within the Argenta and lower Mt. Simon Sandstone and pose no impact to containment (Figure 23). Previously collected seismic data associated with CO_2 sequestration projects in the Illinois Basin (Greenberg, 2021) suggests that minor faults in the Precambrian and Argenta/Mt. Simon strata are not expected to act as conduits through the confining zone and that they present a negligible risk to endangerment of USDWs.

On seismic line 310, a small reverse fault has been observed that terminates within the lower Mt. Simon and poses no impact to containment. South of the AoR on line 310 a larger fault has been interpreted that extends from the basement through the Eau Claire Formation and into strata of the upper Knox Group. This fault shows limited offset (ca. 50 ft) and is interpreted to be a flower structure that may suggest polyphase movement including strike-slip displacement that was likely related to the formation of the Downs Anticline and LaSalle Anticlinorium during the Mississippian and Pennsylvanian periods (Kamp et al., 2016). The Illinois Basin has experienced variable tectonic stresses since the Precambrian, and polyphase faults have been seen elsewhere in the Illinois Basin. The fault is located to the southeast at the maximum extent of the AoR and about 4.8 miles from the greatest predicted extent of the CO_2 plume. The evaluation of this fault indicates it is sealing and non-transmissive to fluids and will not be an endangerment to USDWs. This is based on the ductile nature of the Eau Claire Formation and the small offset of the faults relative to Eau Claire thickness, typical clay content, and resulting high Shale Gouge Ratios (SGR) (Yielding, 2002).

Regionally the Eau Claire Formation exhibits a range of lithofacies (Neufelder et al., 2012; Lahann et al., 2014) that include variable amounts of clay minerals. In central Illinois, the Eau Claire Formation grades from laminated to silty shale upwards into clayey limestone with the main phyllosilicate minerals being illite, mixed layer illite-smectites and lesser amounts of kaolinite and chlorite (Leetaru and Freiburg, 2014). Yielding (2002) states that faulted rocks with around 40% phyllosilicates will form clay/shale smears that will effectively plug porosity within the fault zone, and much of the Eau Claire Formation meets this phyllosilicates threshold. Petrophysical analyses of the Eau Claire Formation using logs from ADM CCS1 at IBDP show Vshale values average 70% over the lower 200 ft reflecting the high clay content, and high Vshale values throughout the entire thickness of the Eau Claire (Figure 27). Because of the juxtaposition of shale against shale, clay smearing of phyllosilicates will be concentrated along the shear zone effectively clogging porosity (Freeman et al., 1998). Yielding (2002) indicates that SGRs above 15-20% are the threshold between sealing and non-sealing faults. The SGR is expected to be effectively 100% over these high clay intervals in the Eau Claire Formation. These analyses indicate that the portion of the fault within the Eau Claire Formation will be sealing and containment will not be impacted by the presence of this fault.

Figure 27: CBI: Petrophysical analyses of CCS#1 showing bulk volumes and Vshale values of the Eau Claire Formation that average 74% for its entire thickness. For the shaley basal interval from 5,220 to 5,509 MD Vshale averages over 90%.

Overall, the consistent thickness, ductile nature of the Eau Claire Formation, and few structural features within the AoR indicate the confining zone has excellent characteristics for sequestration of CO_2 at the Compass Project site. HGCS intends to acquire a baseline 3D surface seismic survey at the Compass Project site prior to injection to further confirm the quality of the Eau Claire Formation as a confining zone. This survey will evaluate injection and confining zone properties, map Precambrian basement topography as well as any subsurface structural features or faults that might be present in order to assess their potential impact to storage or containment.

The data gathered during the pre-operational phase of the project will be used for geomechanical modeling to evaluate the influence of regional stresses and injection on any faults identified in the surface seismic data (Attachment 05: Pre-operational Formation Testing Program, 2023). The geomechanical modeling will be used to assess the impact of the changing pressures and stresses on fault stability.

2.23.2 Tectonic Stability

Faults originating in the Precambrian basement and terminating in the basal units of the Argenta and Mt. Simon Sandstone have not been active since Cambrian time. Regionally, thickness changes in the Cambrian-aged Argenta, Arkose, and Lower Mt. Simon formations may be related to interpreted syn-depositional fault movement along the basement-involved faults, but at the Compass Project Site no changes in thickness of strata overlying the Mt. Simon Sandstone within the AoR can be attributed to these faults, which suggests there has been little active faulting since early Cambrian time.

Structural features such as the Downs Anticline to the east of the project area were likely active into late Mississippian and Pennsylvanian time (Nelson, 2010). These features are related to the LaSalle Anticlinorium, which is postulated to have formed in response to the Ancestral Rocky Mountains orogeny (McBride, 1998; McBride and Nelson, 1999). The fault observed on 2D seismic line 310 to the southeast of the project site transects to the mid- to upper-Knox strata likely formed in association with the regional structural events so it was potentially active as late as the Mississippian Period, or approximately 300 million years ago.

A future 3D seismic survey will be acquired at the Compass Project Site to evaluate injection and confining zone properties, map Precambrian basement topography, and characterize any identified basement faults. The 3D seismic survey will be designed to obtain full fold data over the predicted extent of the CO_2 plume after 25 years of injection and proposed 15-year PISC period (Attachment 07: Testing and Monitoring, 2023). The Pre-operational Formation Testing Program details the geophysical log and core data that will be acquired to evaluate the nature of any identifiable fractures and their impact on long-term integrity of the confining zone (Attachment 05: Pre-operational Formation Testing Program, 2023).

In Central Illinois, the area of the Compass Project, earthquakes above M 2.5 are rare.
See *Section 2.26 Seismic History.*

2.24 Injection and Confining Zone Details [40 CFR 146.82 (a)(3)(iii)]

2.24.1 Injection Zone and Confining Zone Extent and Thickness

The Mt. Simon Arkose and Lower Mt. Simon Sandstone units together represent the injection zone for the Compass Project. The entire storage interval is represented by the sedimentary succession bracketed by the base of the Mt. Simon Arkose and the top of the Eau Claire Silt (Figure 4). Within this package, the Middle Mt. Simon unit typically has relatively poor reservoir quality in the central Illinois Basin and serves as a baffle to upward fluid migration. Most of the injected CO_2, as simulated, remains in the Mt. Simon Arkose and Lower Mt. Simon Sandstone (Attachment 02: AoR and Corrective Action Plan, 2023). The Upper Mt. Simon Sandstone can also have good reservoir characteristics and is used for natural gas storage within the Illinois Basin region (Figure 6). The Eau Claire Formation above the Eau Claire Silt is the confining zone for the Compass Project (Figure 4). Characteristics of the injection and confining zones are also described in *Section 2.2 Regional Stratigraphy*.

Available public data were collected and integrated to develop site-specific subsurface maps, petrophysical relationships, and a static model of the Compass Project Site. Geophysical well logs were used to generate thickness maps for the Argenta Formation through Eau Claire Silt (the total storage interval; Figure 28), the combined Mt. Simon Arkose and Lower Mt. Simon Sandstone (injection zone; Figure 29), and the Eau Claire Formation (confining zone; Figure 30).

Within the Compass AoR there are only minor elevation variations and no significant thinning of either the injection zone (Lower Mt. Simon Sandstone and Mt. Simon Arkose) or confining zone (Eau Claire Formation). The thickness of the total storage interval is between 1,200 to 1,650 feet at the project site (Figure 28). The Lower Mt. Simon Sandstone and Mt. Simon Arkose injection interval thickness is between 425-600 feet (Figure 29). Thickness of the Eau Claire Formation primary confining zone ranges between 400-475 feet at the project site (Figure 30). Site specific 2D seismic data discussed in *Section 2.23 Faults and Fractures* confirms the lateral continuity and structural integrity of these strata across the AoR.

CO_2 plume development is expected to be controlled dominantly by sedimentological heterogeneities within the injection zone, as structural features will have minimal influence on plume development at this site. The Eau Claire Formation confining zone is predicted to be between 400 and 475 feet thick within the AoR and will provide a thick, laterally extensive barrier to prevent upward migration of injection zone fluids over time.

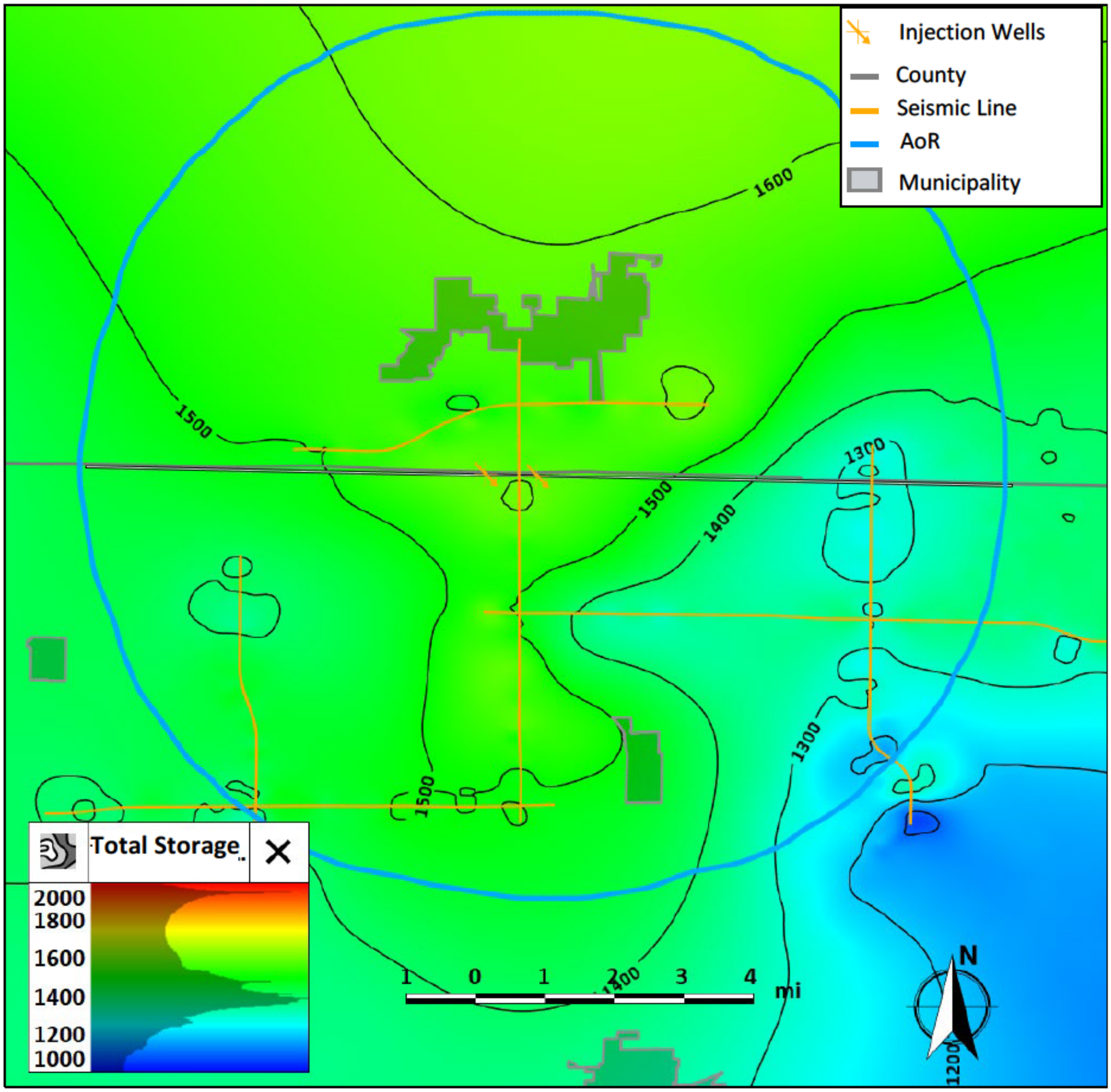

Figure 28: Thickness (feet) of the storage interval (Mt. Simon Arkose, Lower-Middle-Upper Mt. Simon Sandstone and Eau Claire Silt) in the AoR.

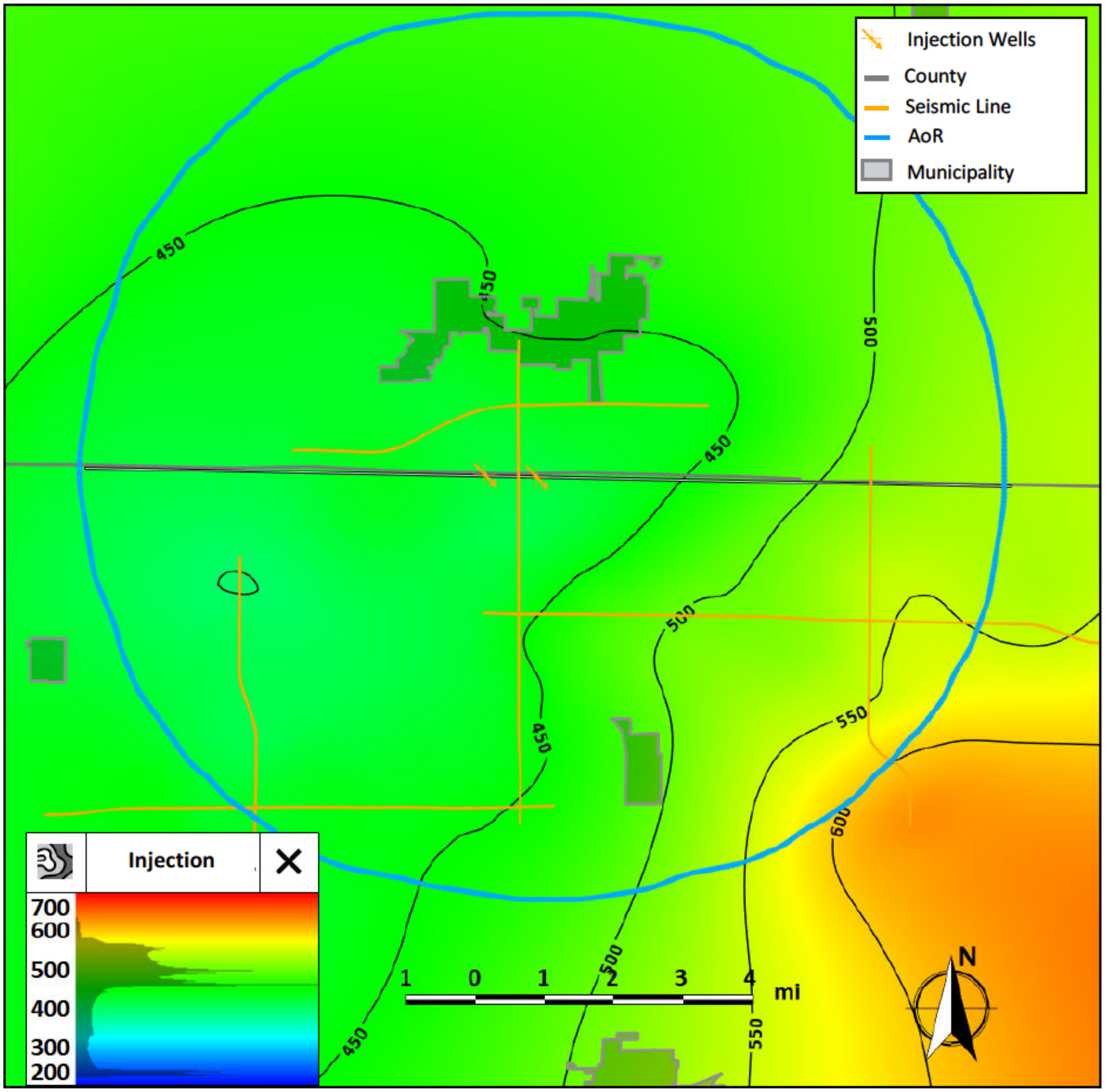

Figure 29: Thickness (feet) of injection zone (Mt. Simon Arkose and Lower Mt. Simon Sandstone) in the AoR.

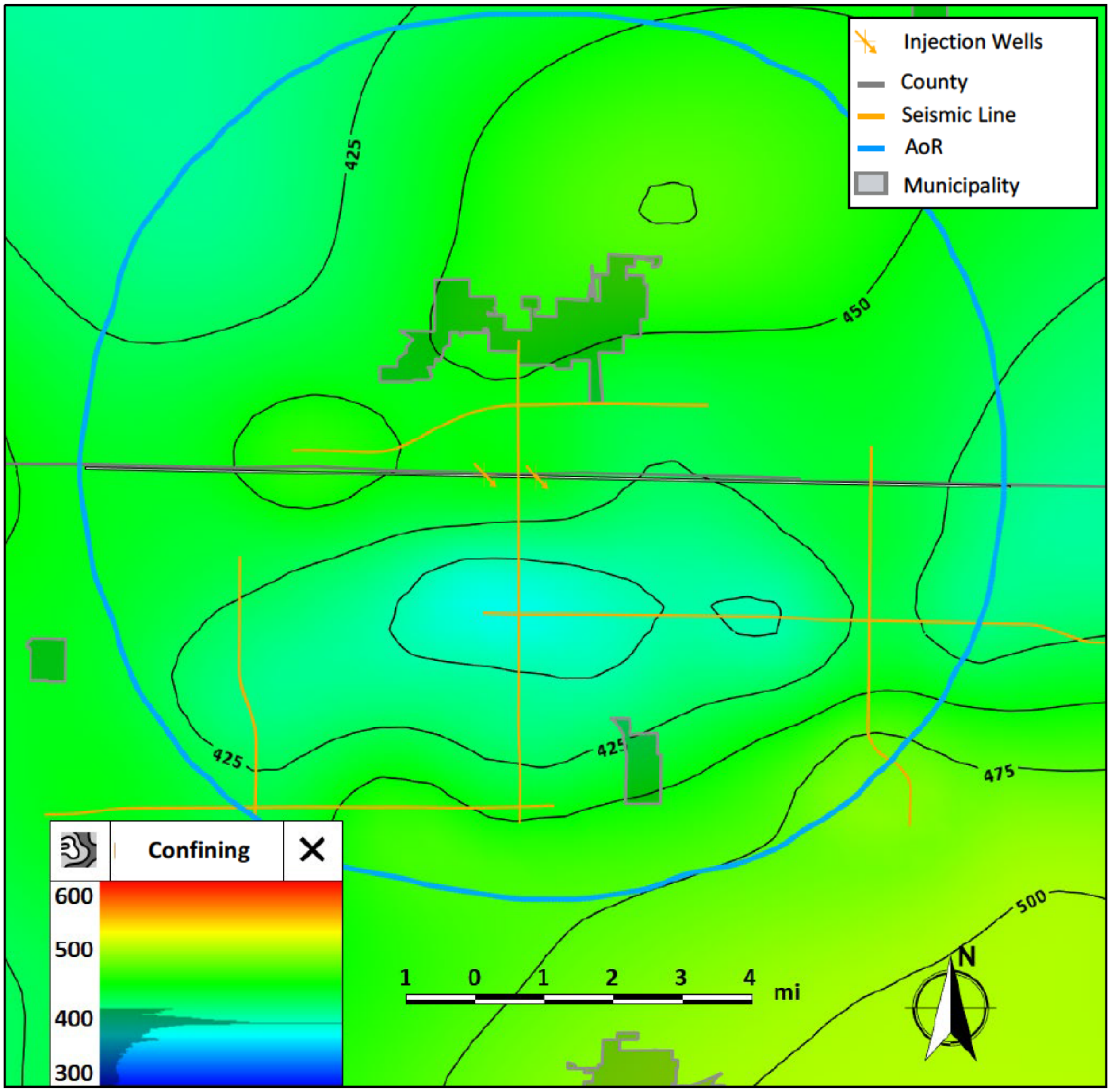

Figure 30: Thickness (feet) of the confining zone (Eau Claire Formation) in the AoR.

2.24.2 Porosity and Permeability

Public log and core information from five wells in Illinois provide significant data to characterize the injection, storage, and confining zones at the Compass Project Site. Available wells that penetrate the Mt. Simon Sandstone or deeper are from gas storage sites, UIC Class VI sites, and structure test wells that have well logs, core, and fluid injection data from the Mt. Simon Sandstone and Eau Claire Formation (Figure 31). The ADM CCS1 well is located 28 miles south of the project site and represents the closest analog for the injection and confining zones (Figure 31). Mt. Simon Sandstone average porosity and permeability values from the five offset wells in central Illinois are presented in Table 4.

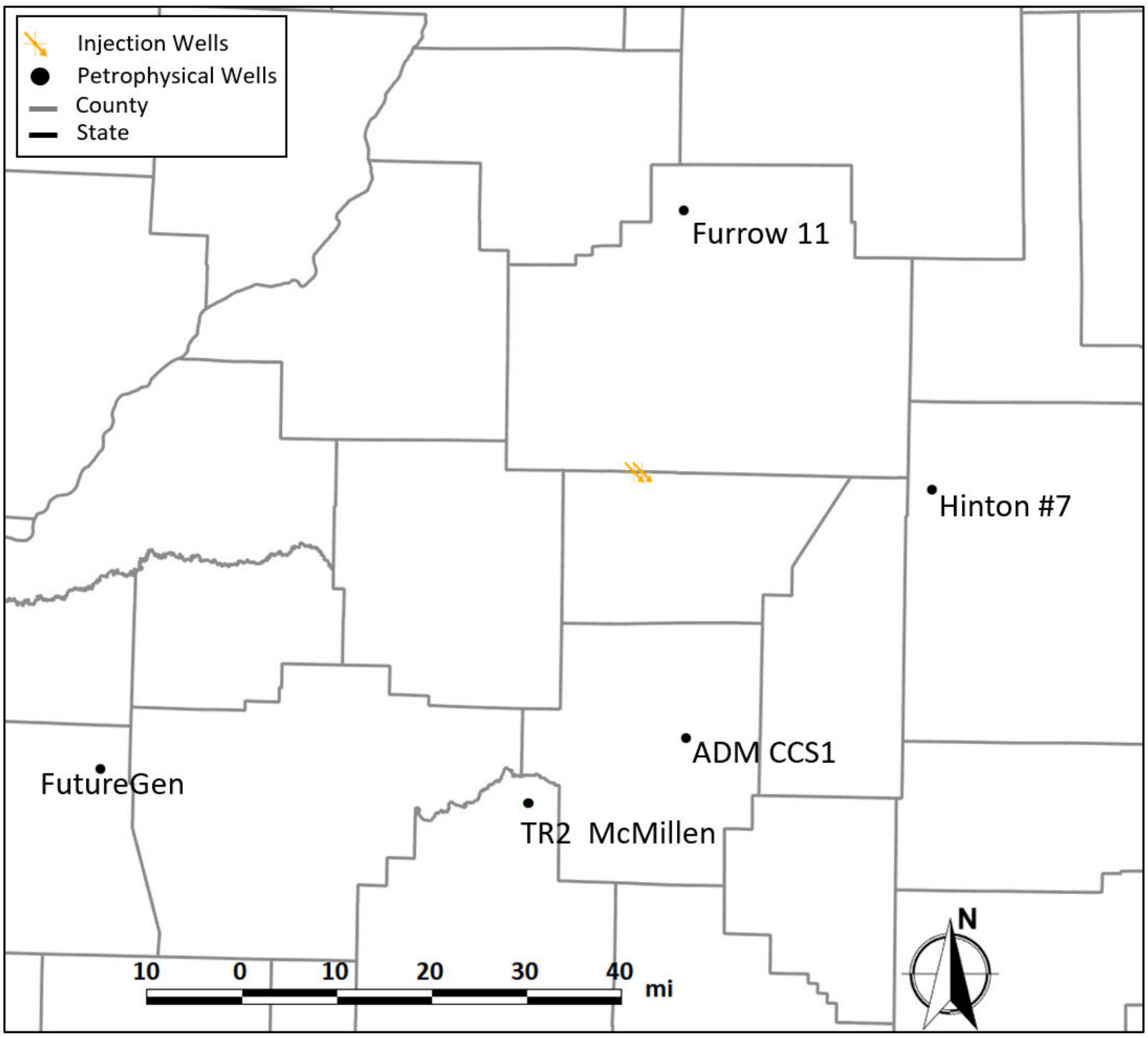

Figure 31: Wells used for petrophysical analysis of the Compass injection and confining zones. ADM CCS1 Mt. Simon Sandstone porosity and permeability values are reported in Table 4, and geomechanical properties are reported in Table 5.

2.24.3 Mt. Simon Sandstone

As described in *Section 2.2 Regional Stratigraphy,* the Mt. Simon Sandstone can be divided into Lower, Middle, and Upper intervals with a basal Arkose Sandstone unit (Figure 4) that often has enhanced reservoir quality through secondary porosity development resulting from dissolution of feldspar grains (Leetaru and McBride, 2009; Medina and Rupp, 2012; Freiburg et al., 2016; Leetaru, 2019). As shown in the cross-section of Figure 5, the sub-units of the Mt. Simon Sandstone are present across a wide expanse within the Illinois Basin, including the Arkose zone that can be correlated regionally. For example, at the Hinton #7 well approximately 30 miles east of the project site the Arkose zone is about 215 feet thick, at the TR McMillen #2 well about 36 miles southwest it is about 175 feet thick (Whittaker and Carman, 2022) and at the ADM CCS1 well 28 miles south it is 342 feet thick (Leetaru and Freiburg, 2014). Very good reservoir quality is found in the Arkose zone at each of these wells including porosity values generally over 20% and permeability values of 100's to 1,000's of mD (Whittaker and Carman, 2022).

The Middle Mt. Simon Sandstone generally has poorer reservoir properties than either the Lower or Upper Mt. Simon units (Leetaru and McBride, 2009; Medina and Rupp, 2012; Freiburg et al., 2016; Leetaru, 2019) (Leetaru and Freiberg, 2014; Whittaker and Carman, 2022). At ADM CCS1 and TR McMillen #2, the Middle Mt. Simon consists of planar parallel and low-angle to trough cross-stratified, medium- to coarse-grained pure quartz sandstone, interbedded with thin intervals of feldspar sandstone. The average porosity and permeability of the Middle Mt. Simon strata at ADM CCS1 (Table 4) is 8.7% and 10.2 mD, respectively, and impairs vertical movement of CO_2 out of the injection zone.

The Upper Mt. Simon Sandstone may exhibit good reservoir characteristics particularly in thin, tidal flat channel sands such as are utilized for natural gas storage in the basin (Morse and Leetaru, 2005). The Upper Mt. Simon Sandstone is heterogeneous with interbedded shale and has regional log-derived porosity and permeability averages of 8.5% and 5.4 mD, respectively, although more porous and permeable units are present (Leetaru, 2019).

At the ADM CCS1 well, the entire Lower Mt. Simon Sandstone interval (which integrates the Arkose zone) is reported to have a mean well log porosity of 16.6% and permeability values as high as 400 mD (Leetaru, 2019). The average effective porosities and intrinsic permeabilities for various depth intervals within the Mt. Simon Sandstone and Argenta Formation were reported by Patrick Engineering (2011), (Figure 32). These data are also shown on the ADM CCS 1 well log, were calculated by integrating geophysical logs/core/well test data, and then used to divide the Eau Claire, Mt. Simon Sandstone, and Argenta Formation into seven sub-intervals based on lithologic and porosity trends (Table 4 and Figure 32). The ADM CCS1 data show that the Lower Mt. Simon Sandstone and the Mt. Simon Arkose have the best reservoir quality, with the highest reported average porosity and permeability values (21.8%, 107 mD) found within the Mt. Simon Arkose (Table 4 and Figure 32). The Upper Mt. Simon Sandstone has relatively high average values (10.8%, 19.4 mD) compared to the underlying Middle Mt. Simon Sandstone interval (8.7%, 10.2 mD; Table 4; Figure 32).

Table 4: ADM CCS1 depth interval, formation, average effective porosity, and average intrinsic permeability for seven sub-intervals in the Mt. Simon Sandstone and Argenta Formation (Patrick Engineering, 2011). These data are also shown on the ADM CCS1 well log in Figure 32.

Measured Depth Interval (feet)	Formation	Average Effective Porosity (%)	Average Intrinsic Permeability (mD)
5,545-5,900	Upper -Middle Mt. Simon Sandstone	10.8	19.4
5,900-6,150	Middle Mt. Simon Sandstone	8.7	10.2
6,150-6,430	Middle Mt. Simon Sandstone	10.1	8.4
6,430-6,650	Lower Mt. Simon Sandstone	15.2	8.2
6,650-6,820	Lower Mt. Simon Sandstone-Mt. Simon Arkose	21.8	8.6
6,820-7,050	Mt. Simon Arkose	18.7	107
7,050-7,165	Argenta	9.8	4.4

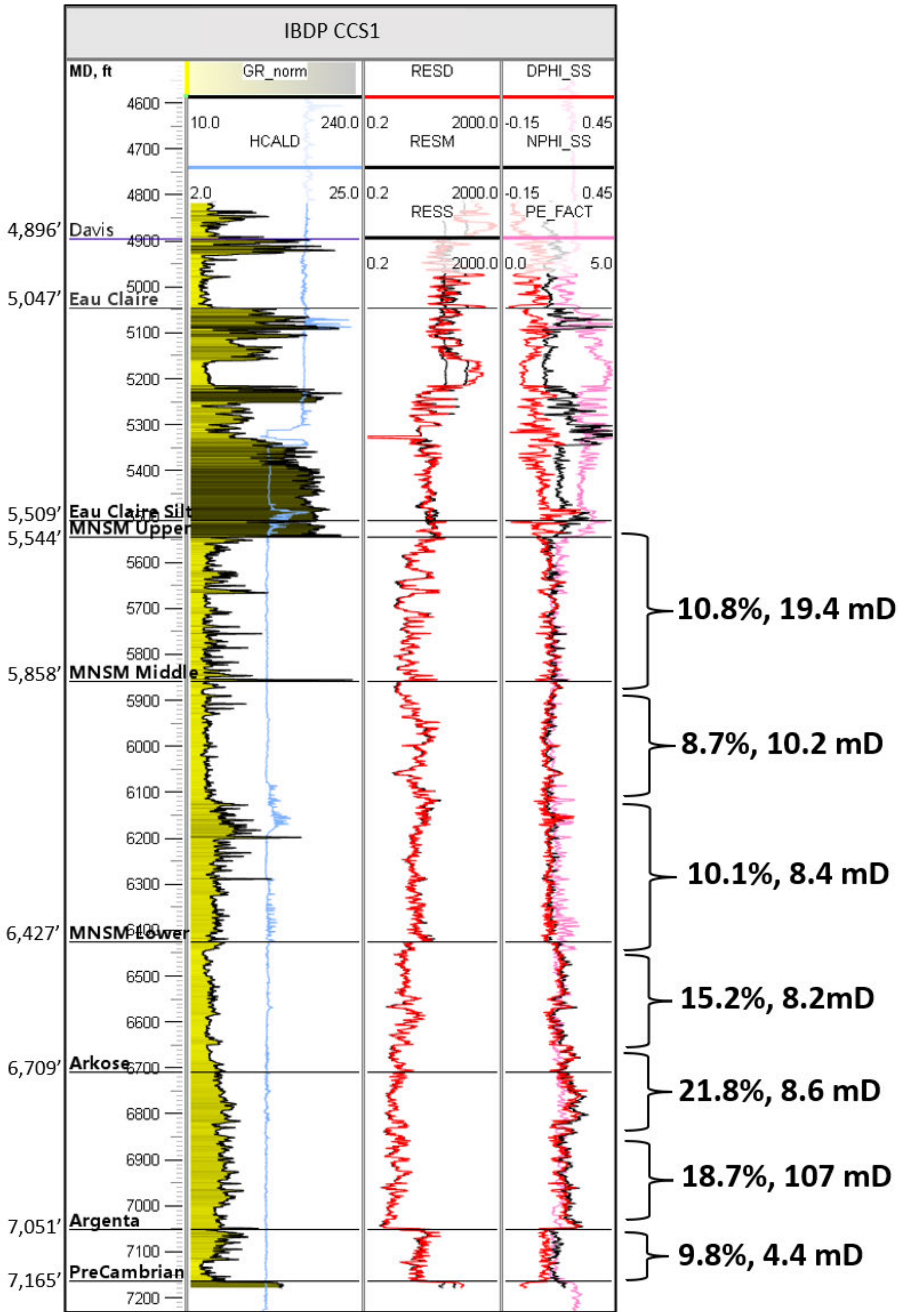

Figure 32: ADM CCS1 geophysical logs with measured depth (MD), formation tops, average effective porosity (%), and intrinsic permeability (mD) values. GR_norm=normalized gamma ray log; HCALD=caliper; RESD, RESM, and RESS = deep, medium, and shallow resistivity; DPHI_SS=density derived sandstone porosity; NPHI_SS=neutron-derived sandstone porosity; PE_FACT= photoelectic factor.

Site specific information from the injection zone will be acquired when the project wells are drilled through the pre-operational testing program and will include, but are not limited to, well logging, fluid sampling, core acquisition and analysis, and injectivity testing (Attachment 05: Pre-operational Formation Testing Program, 2023).

The baseline 3D surface seismic data will be calibrated to the well data and used for inversion analysis. This will allow the project to characterize variations in injection zone porosity and lithology away from the project wells over the imaging area of the 3D surface seismic data volume.

2.24.4 Eau Claire Formation

The low porosity, clay-rich mudstones of the Eau Claire Formation have extremely low permeabilities and serve as an effective seal for gas storage projects in the central Illinois Basin (Patrick Engineering, 2011). At ADM CCS1, the upper portion of Eau Claire Formation is composed of dense limestone with siltstone stringers, and the lower portion primarily consists of shale (60% clay minerals and 37% quartz and potassium feldspar) with a silt interval at the base of the formation.

Twelve sidewall cores were collected from the Eau Claire Formation in ADM CCS1, and the average horizontal permeability for these cores is 0.00034 mD. Average vertical permeability of the Eau Claire Formation is expected to be lower than horizontal permeability, and regional collection of Eau Claire Formation core from underground injection wells shows that the confining zone has median regional porosity and permeability values of 4.7% and 0.000026 mD, respectively (Patrick Engineering, 2011). (Neufelder et al., 2012) and Lahann et al., 2014 inferred that MICP values and higher permeabilities of the coarser grained Eau Claire Formation lithofacies may have entry pressures that could allow CO_2 to enter the formation and the finer grained, whereas clay-rich lithofacies have MICP values and lower permeability that would restrict CO_2 movement (Figure 16).

Experimental results and modeling by Roy et al., 2014 using samples of Eau Claire Formation from ADM CCS1 have shown that advective flow and ionic diffusion of CO_2 from the Mt. Simon Sandstone into the Eau Claire is expected to be insignificant.

Similar to the injection zone, well logs, core analyses, and seismic data collected as part of the pre-operational testing program will be used to further characterize the porosity and permeability of the confining zone (Attachment 05: Pre-operational Formation Testing Program, 2023). The capillary pressure of the confining zone is not yet known at the Compass Project Site; however, the permeability of the confining zone is expected to be very low and prevent vertical migration of CO_2. Capillary pressure and permeability will be measured as part of the Eau Claire Formation core analysis reported in the pre-operational testing program (Attachment 05: Pre-operational Formation Testing Program, 2023). As the Eau Claire Formation regionally exhibits effective seal characteristics, it is expected to be a competent seal for the underlying Mt. Simon Sandstone injection zone at the Compass Project Site.

2.24.5 Knox Group

The thick Knox Group carbonates above the Eau Claire Formation are considered a secondary confining zone and monitoring zone. These formations include the Potosi/Eminence, Oneota, and Shakopee Formations (Figure 4). The low-porosity Knox Group carbonates may function as locally effective seals for CO_2 injection (Leetaru, 2014), though the Potosi Formation may have permeable intervals (Willman et al., 1975). Below the Knox Group, porous members of the Ironton/Galesville formations will be used for above zone monitoring.

Well logs acquired as part of the pre-operational testing program will be used to further characterize the porosity and permeability of the Knox Group formations and verify that some of the formations will provide an effective secondary confining zone (Attachment 05: Pre-Op Testing Program, 2023). The baseline 3D surface seismic data will be calibrated to the well data and used for inversion analysis. This will allow the project to characterize variations in porosity and lithology away from the project wells for the Knox Group formations over the seismic imaging area.

2.24.6 Maquoketa Shale

The regional Maquoketa Shale generally exceeds 100 feet thickness within the Illinois Basin, and regionally serves as a seal for hydrocarbons in the underlying Trenton Limestone (Patrick Engineering, 2011). Young (1992) indicates the Maquoketa Shale is a low permeability groundwater-confining unit throughout the Midwest. Core from Kentucky reveals that the Maquoketa is a black, fissile shale dominated by clay minerals and has both sufficiently low permeability and high compressive strength to serve as caprock for an underlying CO_2 reservoir. In the Decatur area of the central Illinois Basin, the Maquoketa Shale contains higher fractions of quartz and carbonate minerals relative to clays and is thinly laminated with low effective porosity (<3%) and permeability (<9.86×10^{-12} cm^2 [1 mD] (Zaluski, 2014).

2.25 Geomechanical and Petrophysical Information [40 CFR 146.82 (a)(3)(iv)]

2.25.1 Geomechanics

A dual permeability, finite difference reservoir simulation model was constructed with a corresponding 3-D finite element geomechanical grid to evaluate the confining zone (Eau Claire Formation) integrity. The geomechanical model is a single well, radial model. The geomechanical model calculates the effective minimum stress of each gridblock as CO_2 is being injected and the pore pressure increases, using specific rock properties for each formation. Young's Modulus, Poisson's Ratio, and the bulk compressibility for the Ironton-Galesville Sandstones, Eau Claire, Mt. Simon Sandstone, and Argenta Formations were calculated from the well logs available from the Hinton #7 well on a 0.5 ft interval, and the averages for each zone are shown in Table 5. The log suite consisted of modern sonic, density, neutron, PE, GR, and resistivity logs. A caliper log was also available and was used to assist in quality control of the log data.

Average total closure stress (TCS), initial pore pressure, and the change in stress needed to open fractures are listed in Table 6. The average calculated TCS gradient in the Lower Mt. Simon zone is 0.730 psi/ft based on data from the Hinton #7 well. This value is consistent with the fracture gradient of 0.715 psi/ft from the ADM CCS1 well that was obtained from a step-rate test and was used to calculate the maximum bottomhole flowing pressure (BHFP). EPA requirements state that no fractures should be created and that no existing fractures should be propagated as a result of CO_2 injection (40 CFR 146.88(a)). The maximum BHFP was calculated by multiplying the depth of the top perf by the max BHFP gradient and then multiplying that value by a safety factor of 0.9. This assures that the operating BHFP will be much lower than the anticipated fracture pressure. The TCS values for each zone were used to define the initial effective stress in the model. The Barton-Brandis fracture model was included to simulate the opening of fractures if the effective minimum stress falls below the fracture opening stress. In this way, it is possible to determine if fractures will develop or open given a particular injection rate.

Two cases were run:

- Case 1 – Max BHFP < Fracture Pressure x 0.9 (Rate = 1.25 Mtpa)
- Case 2 – Max BHFP = Fracture Pressure (Rate = 5.8 Mtpa)

Case 1 is the base case, with operating conditions as proposed in this application, i.e., maximum BHFP is 90% of the fracture pressure, and the injection rate is limited to 1.25 Mtpa; this is mainly due to THP constraints (~1,700 psi). Case 2 is a theoretical case to test fracture behavior should the BHFP equal the fracture pressure assuming no THP constraints. It should be noted that THP constraints prevent the project from reaching the rates used in Case 2.

For Case 1, the results indicate that no fractures are created in any zone when a 0.9 safety factor is used. In Case 2, where max BHFP = fracture pressure, fractures are created in the Lower and Middle Mt. Simon Sandstone, but they do not extend into the Upper Mt. Simon or Arkose intervals. In the unlikely event that fractures were to occur in the Lower Mt. Simon Sandstone, the sudden decrease in THP would be noticed and corrective actions would be taken immediately. The results from the two cases demonstrate that even with a very large injection rate, no fractures are created that will propagate into and compromise the confining zone. In addition, the Middle and Upper Mt. Simon units provide a large buffer zone between the perforated interval and the Eau Claire Formation.

Table 5: CBI: Summary of average Young's Modulus, Poisson's Ratio, and Bulk Compressibility values calculated from the Hinton #7 well logs.

Table 6: CBI Summary of average TCS, Pore Pressure, and the reduction in stress needed to open fractures.

During the pre-operational phase of the project, a variety of site-specific data from the confining and injection zones will be acquired in the project wells to support further geomechanical modeling. Information on the core testing that will provide ductility information for the injection and confining zones are provided in of the Pre-Operational Testing Program (Attachment 05: Pre-operational Formation Testing Program, 2023). These data include:

- Caliper and image logs,
- Triaxial testing to establish geomechanical parameters such as rock strength, Young's Modulus, Poisson's Ratio, and fracture gradient,
- Step-rate testing.

2.25.2 Petrophysics

Petrophysical analysis of the Precambrian Basement, Mt. Simon Sandstone, and Eau Claire Formation was completed using data from five (5) wells in the general region of the Compass Project Site (Figure 31; Table 7). Log ascii standard (LAS) files and routine core data was acquired from the Illinois State Geological Survey's Illinois Oil and Gas Resources Map (ILOIL) and public data sources.

Table 7: Well logs used for petrophysical analysis. Log abbreviations can be found at the beginning of this document.

Well Name	Well UWI	Well Logs
FutureGen Industrial Alliance	IL121372213200	Gamma ray, medium/deep resistivity, sandstone porosity (density and neutron), limestone porosity (density and neutron), photoelectric factor, density, sonic
TR McMillen #2	IL120212565000	Caliper, gamma ray, medium/deep resistivity, sandstone porosity (density), photoelectric factor, limestone porosity (density)
ADM CCS1	IL121152341500 1	Gamma ray, medium/deep resistivity, sandstone porosity (density and neutron), limestone porosity (density and neutron), photoelectric factor, density, sonic
Hinton 7	IL12019239960000	Spontaneous potential, gamma ray, medium/deep resistivity, sandstone porosity (density and neutron), limestone porosity (density and neutron), density
Furrow 11	IL12113229420000	Spontaneous potential, gamma ray, medium/deep resistivity, sandstone porosity (density and neutron), photoelectric factor, limestone porosity (density and neutron), density

Core and log data were calibrated to well test data that was publicly available from the Illinois Basin–Decatur Project Dataset (2022), Sandia Technologies (2013), and the TR McMillen #2 well (Whittaker and Carman, 2022). Histograms and cross plots were made using this data which enabled better analysis of wells which did not have core data and improved the geologic model (Figure 33 and Figure 34).

Petrophysical analyses were completed to evaluate the characteristics of the confining and injection zones (Figure 33, Figure 34, and Figure 35). Geophysical well logs, core plugs and well test data were used to calibrate the petrophysical calculations to derive effective porosity and permeability (Figure 34 and Figure 35). These analyses will be re-visited once the project acquires site-specific well logs and core data in the project wells (Attachment 05: Pre-operational Formation Testing Program, 2023).

Pre-processing work on the raw log data, including depth shifting, unit conversion, and synthetic log generation, was performed prior to the petrophysical calculations. Gamma, neutron porosity, sonic, PE, and density logs were used to derive the petrophysical properties for the eight wells, which included:

- Effective Porosity
- Permeability
- Mineralogy (where data quality was reliable)
    - Volume Shale (VSH_V)
    - Volume Quartz (Quartz_V)
    - Volume Limestone (Limestone_V)
    - Volume Dolomite (Dolomite_V)
    - Volume Sphalerite (Sphalerite_V)
    - Precambrian (Basalt_V)
    - Bound Water (BVW_V)

Table 8 and Table 9 summarize petrophysical values determined from geophysical well logs and calibrated using data from core and reservoir testing for the Mt. Simon Sandstone and Eau Claire Formation, respectively. The petrophysical values are incorporated into the static model for the Compass Project Site (Attachment 02: AoR and Corrective Action Plan, 2023). Of the wells evaluated, ADM CCS1 has the highest Mt. Simon Sandstone average porosity and permeability values (13.7% and 56.4 mD) whereas Furrow #11 has the lowest values (10.5% and 13.9 mD).

The effective porosity/permeability cross plots (Figure 33), effective porosity histograms (Figure 34), and permeability histograms (Figure 35) indicate that the Upper, Lower and Arkose Mt. Simon Sandstone intervals have the highest porosity and permeability values. The Middle Mt. Simon has slightly poorer reservoir quality. The Argenta and Eau Claire Shale have the lowest porosity and permeability values. (Attachment 02: AoR and Corrective Action Plan, 2023).

The petrophysical and core data show that the Mt. Simon Sandstone is primarily composed of quartz sandstone with some interbedded shale layers, and that the Lower and Upper Mt. Simon Sandstone intervals generally have better reservoir quality. The Eau Claire Formation primary confining zone has significantly lower effective porosity and permeability values and higher shale content compared to the underlying Mt. Simon Sandstone and the carbonate content increases upward (Figure 34 and Figure 35).

Table 8: Summary of log-derived porosity and permeability values for the Mt. Simon Sandstone from wells in the region

(calculated using applied cut-offs: Phie>0.05 and Perm>=1 md, Argenta Formation properties included in values).

Well Name	API	Thickness (feet)	Porosity Avg. (%)	Permeability Avg. (mD)
Future Gen	121372213200	424.8	12.2	20.7
T.R. McMillen #2	120212565000	949.3	12.3	30.2
ADM CCS1	121152341500	1102.8	13.7	56.4
Hinton Bros. #7	120192399601	1904.0	11.3	19.6
Furrow #11	121132294201	1703.5	10.5	13.9

Table 9: Summary of porosity and permeability values for the Eau Claire Formation from wells in the region (no cut-off applied).

Well (API)	API	Thickness (feet)	Porosity Avg. (%)	Permeability Avg. (mD)
T.R. McMillen #2	120212565000	284.5	0.008	0.046
ADM CCS1	121152341500	494.0	0.006	0.002
Hinton Bros. #7	120192399601	551.0	0.010	0.009
Furrow #11	121132294201	430.0	0.008	0.026

Figure 33: CBI: Effective porosity (PHIE) and permeability cross plots with core plug values (grey squares). A) the Eau Claire Formation confining zone above Eau Claire Silt, B) the Upper Mt. Simon Sandstone and the Eau Claire Silt storage zone, C) the Middle Mt. Simon Sandstone, D) the Lower Mt. Simon Sandstone, E) the Mt. Simon Arkose, and F) the Argenta Formation.

Figure 34: CBI: Effective porosity (PHIE) histograms of the key petrophysical wells. The plots are divided into the various storage and confining intervals: A) the Eau Claire Formation confining zone above Eau Claire Silt, B) the Upper Mt. Simon Sandstone and the Eau Claire Silt, C) the Middle Mt. Simon Sandstone, D) the Lower Mt. Simon Sandstone, E) the Mt. Simon Arkose , and F) the Argenta Formation.

Figure 35: CBI: Permeability (mD) histograms of the key petrophysical wells. The plots are divided into the various storage and confining intervals: A) the Eau Claire Formation confining zone above Eau Claire Silt, B) the Upper Mt. Simon Sandstone and the Eau Claire Silt, C) the Middle Mt. Simon Sandstone, D) the Lower Mt. Simon Sandstone, E) the Mt. Simon Arkose, and F) the Argenta Formation.

Figure 36: CBI: ADM CCS1 (IL121152341500) geophysical logs and petrophysical results. Normalized gamma-ray API (Gamma), resistivity (Res), and porosity (PHI) logs are shown. Effective porosity (PHIE), permeability (Perm), mineralogy/rock type (Min, Limestone, Dolomite, Sphalerite, Quartz), and bound water (Water). Results from petrophysical analyses are also displayed. Core porosity and permeability data are represented by black circles.

Figure 37: CBI: T.R. McMillen #2 geophysical logs and petrophysical results. Normalized gamma-ray API (Gamma), resistivity (Res), porosity (PHI), and photoelectric (PE) logs are shown. Effective porosity (PHIE), permeability (Perm), mineralogy/rock type (Min, Limestone, Dolomite, Sphalerite, Quartz), and bound water (Water). Results from petrophysical analyses are also displayed. Core porosity and permeability data are represented by black circles.

2.26 Seismic History [40 CFR 146.82(a)(3)(v)]

Based on Federal Emergency Management Agency (FEMA) classification the Compass Project Site has a very small probability of experiencing damaging earthquake effects. The site is more than 230 miles north of the strongest shaking Zone E associated with the New Madrid Seismic Zone (Figure 38). All earthquakes since 1800 having magnitude of 2.5 or greater within a 100-mile radius of the project site are shown in Figure 39 and listed in Table 10 (USGS, 2022). The largest earthquake within this 100-mile radius occurred in 1909 approximately fifty miles west with a magnitude of 4.8 The most recent earthquake occurred on June 17, 2021, approximately 75 miles from the project site near the Indiana/Illinois border with a magnitude of 3.8. No earthquakes have been recorded that have an epicenter within the project AoR.

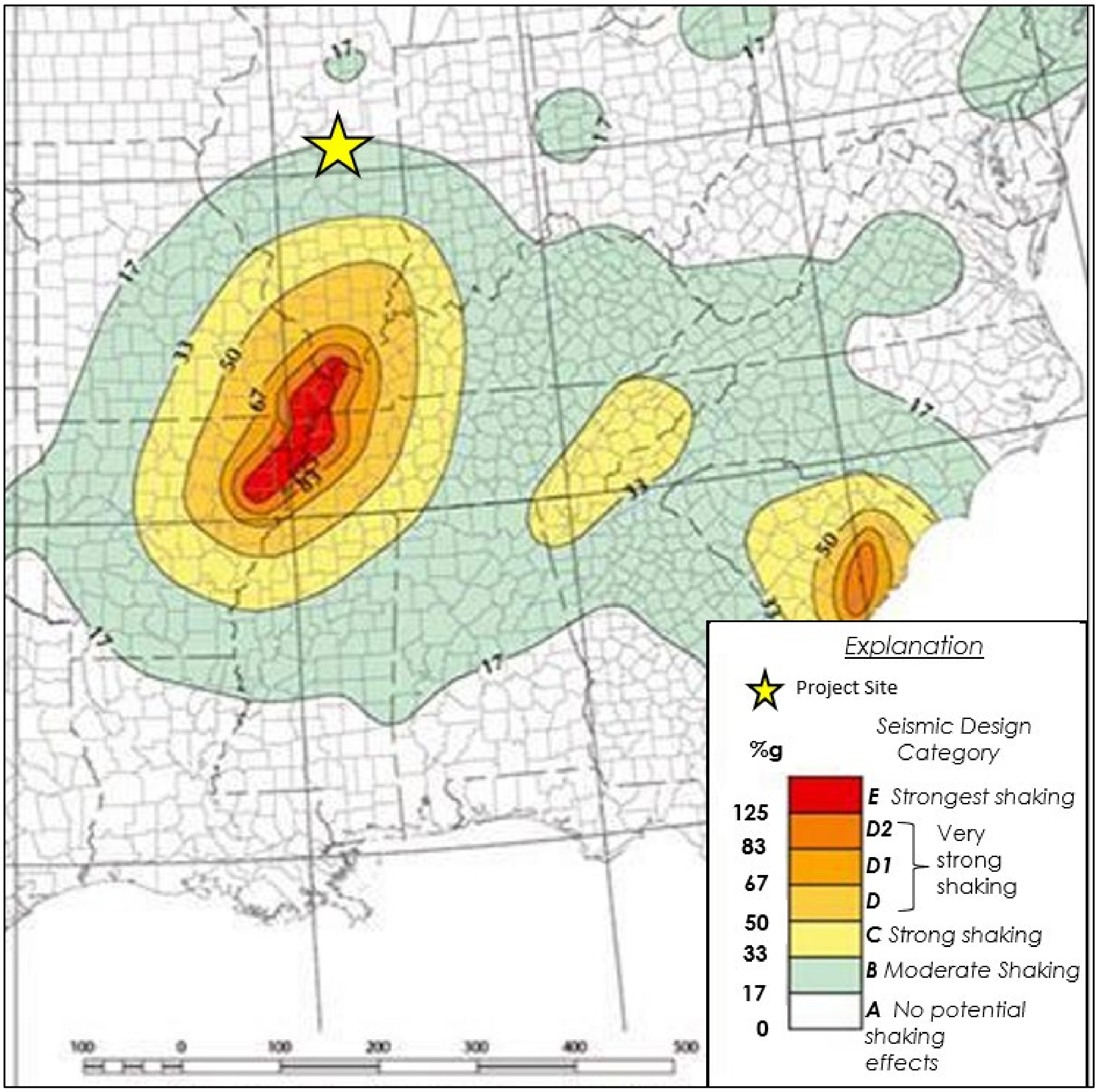

Figure 38: FEMA Earthquake Hazard Map shows that the project site (gray arrow) is located in the lowest earthquake hazard category A (FEMA).

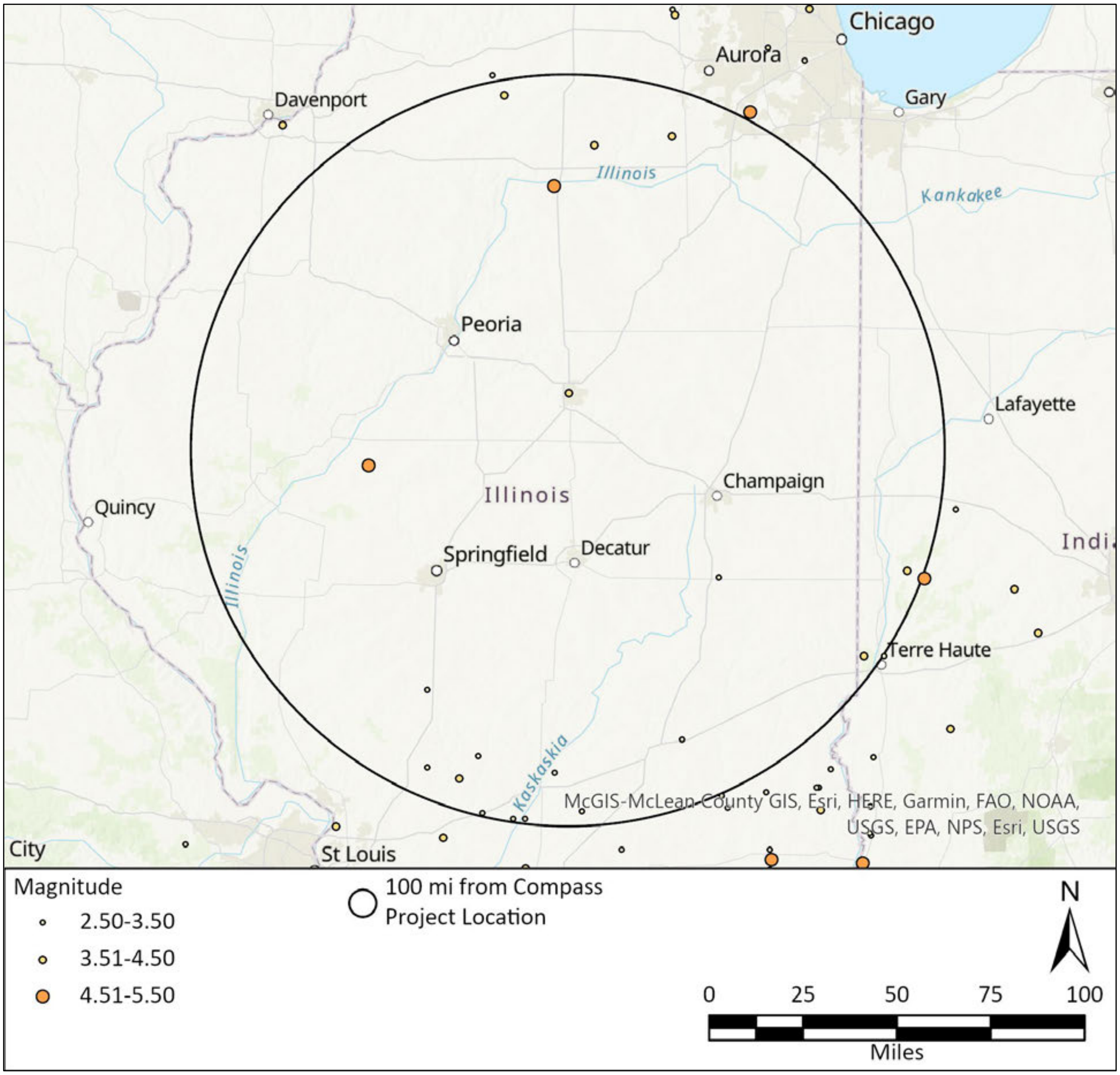

Figure 39: Map of earthquake epicenters with 2.5 or greater magnitude that occurred between 1 January 1800 to 11 April 2023 within 100 miles of the Compass AoR (USGS 2023). Table 10 provides further details.

Table 10: Earthquakes since 1800 with magnitude of 2.5 or greater within a 100-mile radius of the project site.

	Date	Latitude	Longitude	Depth	Magnitude	Location
1	06/17/2021	39.83	-87.29	6.3	3.8	Illinois-Indiana border region
2	07/01/2017	38.85	-89.23	16.8	3.1	9 km SSE of Mulberry Grove, Illinois
3	09/05/2004	38.89	-88.89	33.1	2.9	3 km WNW of Saint Peter, Illinois
4	06/28/2004	41.46	-88.90	10.0	4.2	12 km NW of Dayton, Illinois
5	01/29/1993	39.03	-89.03	5.0	3.2	7 km WNW of Brownstown, Illinois
6	03/02/1990	38.85	-89.17	0.1	3.4	9 km NW of Vernon, Illinois
7	03/13/1987	39.09	-89.41	1.1	3.2	1 km W of Coffeen, Illinois
8	03/28/1985	39.04	-89.66	5.0	2.5	4 km SW of Walshville, Illinois
9	07/01/1982	39.34	-89.67	5.0	2.6	4 km SSW of Waggoner, Illinois
10	04/08/1981	38.87	-89.38	1.1	3.5	3 km SE of Greenville, Illinois
11	02/16/1978	39.80	-88.23	5.0	2.7	4 km E of Tuscola, Illinois
12	02/28/1977	39.17	-88.40	5.0	2.9	1 km WNW of Montrose, Illinois
13	09/15/1972	41.65	-89.37	11.0	4.0	8 km SSW of Amboy, Illinois
14	03/14/1921	39.50	-87.50		4.4	3 km WSW of Saint Mary-of-the-Woods, Indiana
15	01/02/1912	41.50	-88.50		4.5	2 km NW of Lisbon, Illinois
16	07/19/1909	40.20	-90.00		4.8	5 km N of Kilbourne, Illinois
17	02/04/1883	40.50	-89.00		4.3	Near Bloomington, Illinois
18	10/15/1882	39.00	-89.50		4.0	Southern Illinois
19	10/15/1882	39.00	-89.50		3.4	Southern Illinois
20	10/15/1882	39.00	-89.50		4.0	Southern Illinois
21	09/27/1882	39.00	-89.50		4.4	Southern Illinois
22	05/27/1881	41.30	-89.10		4.6	Near La Salle, Illinois

2.27 Hydrologic and Hydrogeologic Information [40 CFR 146.82(a)(3)(vi), 146.82(a)(5)]

The following sections provide information regarding available drinking water resources and delineation of the lowermost Underground Source of Drinking Water (USDW), which is the St. Peter Sandstone, around the project site. Water well, monitoring well, and dry well records were collected for the project AoR from the Illinois State Geological Survey. A total of 485 shallow water/monitoring/dry wells are located within the AoR. The AoR and Corrective Action Plan includes a detailed discussion of the number and locations of the groundwater wells within the AoR (Attachment 02: AoR and Corrective Action Plan, 2023). A shallower USDW source, the Mahomet Aquifer (Figure 40), is located above the St. Peter Sandstone in both unconsolidated sediments and bedrock.

2.27.1 Near Surface Aquifers

The study site is located within the Sangamon River Basin, which is a major tributary to the Illinois River (Figure 40). These rivers primarily drain rural agricultural land between Peoria and Springfield, Illinois. The average ground elevation within the AoR is approximately 720 feet above mean sea level (MSL).

Illinois glacial deposits overlie bedrock and affect surface hydrology and aquifers in the region. During the Pleistocene Epoch, the Illinois Basin experienced several glacial intervals, and glacial processes and post-glacial streams deposited more than 500 feet of valley fill in certain areas of the state (Figure 41 and Figure 42). Specific to glacial geology, the AoR is located where the till and diamict of the Wisconsinan-aged Wedron Group were deposited (Figure 41; Hansel and Johnson, 1996). The Wedron Group is part of the larger Mahomet Aquifer system (Figure 40). Figure 42 shows that there is between 300 to 400 feet of glacial drift sediments overlying the above the Pennsylvanian Shelburn-Patoka Formation bedrock in the AoR (Figure 43).

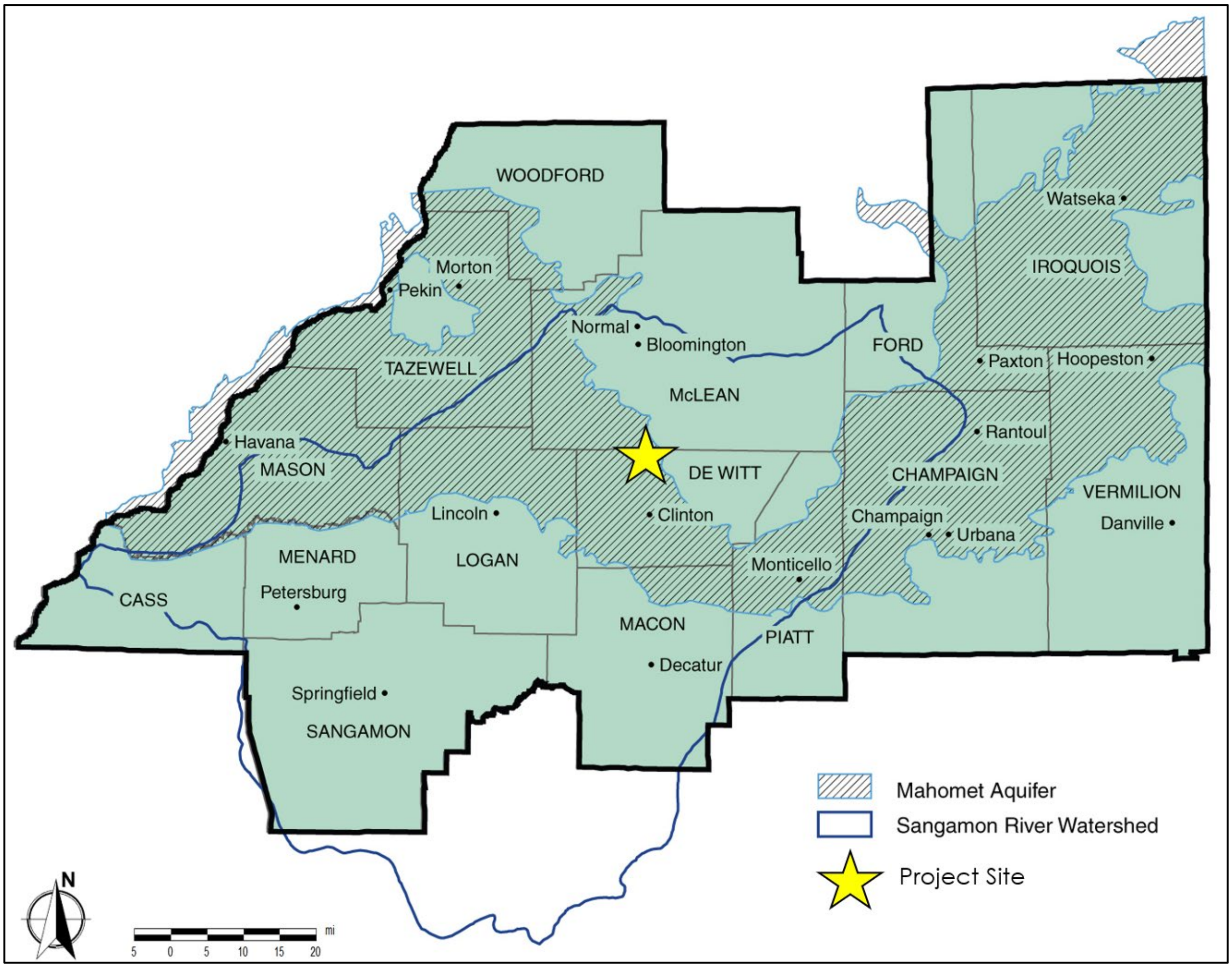

Figure 40: Map of the Mahomet Aquifer and the Sangamon River Watershed. County names and major municipalities are labeled. From Mahomet Aquifer Consortium (2022).

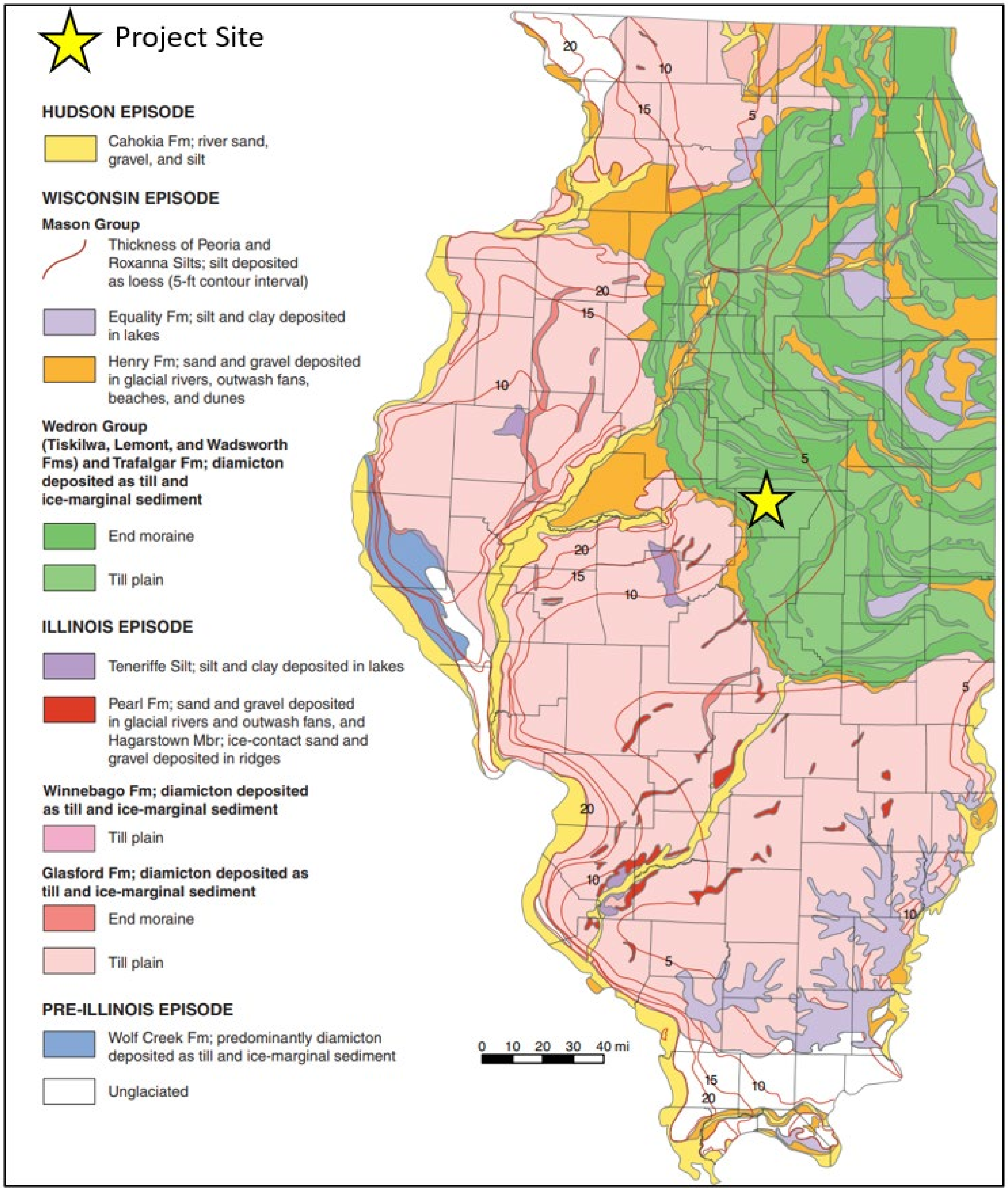

Figure 41: Quaternary deposits of Illinois map show the project site is located on the Wedron Group ice-margin, sediments, and till. ISGS, 2005, Quaternary deposits: Illinois State Geological Survey, ISGS 8.5 × 11 map series

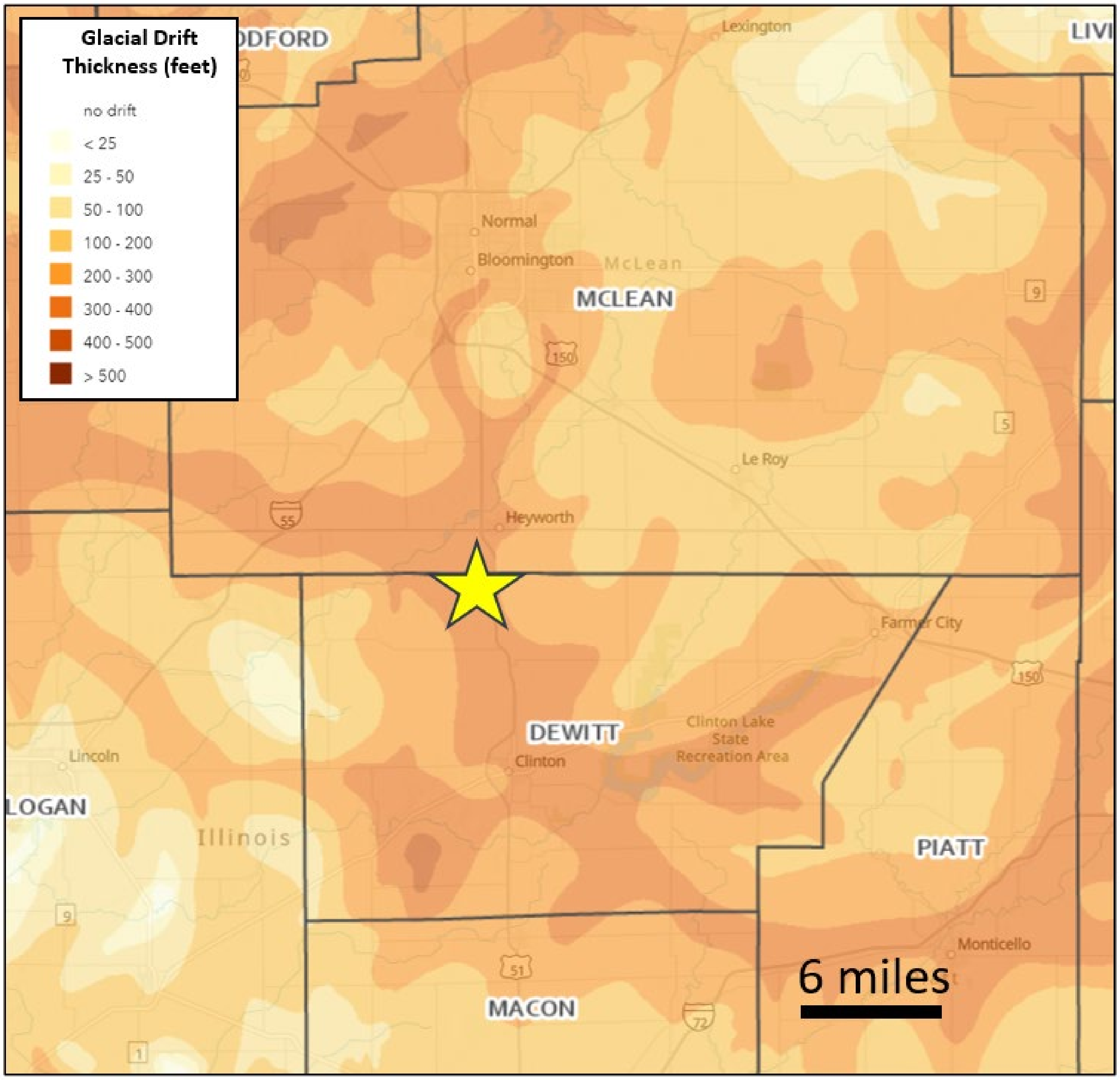

Figure 42: Map of glacial drift thickness in feet. At the project site, 300 to 400 feet of glacial drift are expected. Modified from IndianaMap.

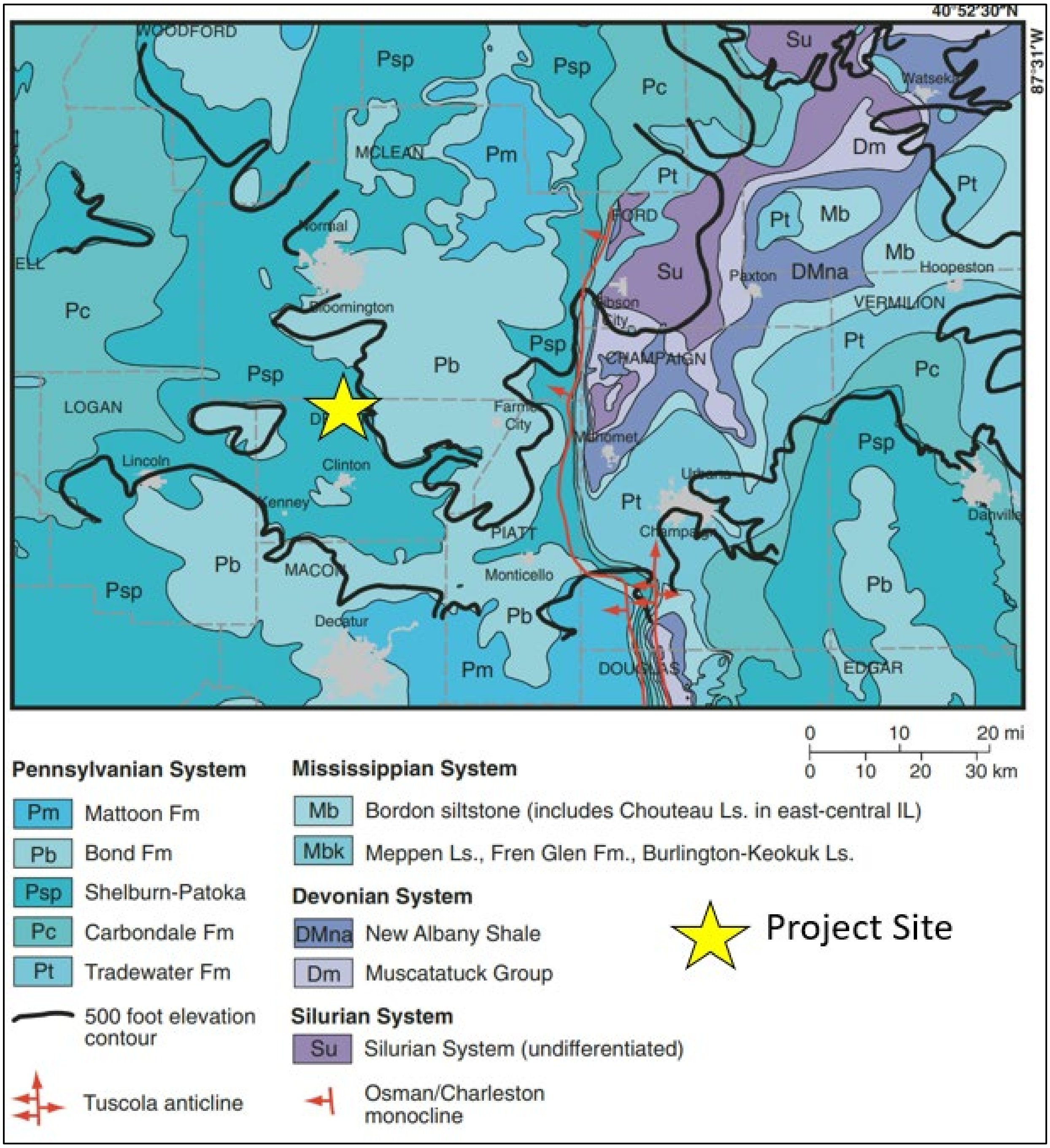

Figure 43: Bedrock geology underlying the Mahomet Aquifer. Modified from Kempton et al., 1991 & Kolata et al., 2005.

2.27.2 Mahomet Aquifer System

Unconsolidated aquifers provide much of the water supply to communities, agriculture, and industry in central Illinois, and the main source of groundwater at the project site is the unconsolidated Wedron Group of the Mahomet Aquifer System (Figure 41). The project site is underlain by 300 to 400 feet of glacial sediments that were deposited on the Pennsylvanian Shelburn-Patoka Formation (Figure 42 and Figure 43).

The Mahomet Aquifer occurs within an east–west trending buried bedrock valley in east-central Illinois, extends into western Indiana, and flows westward at the project site (Figure 44; Kempton et al., 1991; Roadcap et al., 2011). Glacially derived sand and gravel deposits compose the Mahomet Aquifer, which was subsequently buried by up to 300 feet of glacial till in some areas (Kempton et al., 1991). This aquifer is an extensive source of high-quality, fresh groundwater in central Illinois and provides an estimated 220 million gallons of water per day to communities, agriculture, industry, and rural wells (Ammons et al., 2018). The aquifer is recharged by natural processes in the surficial glacial deposits (Panno et al., 1994; Roadcap et al., 2011; Panno and Kelly, 2020). Within the project AoR, there are 485 shallow water wells, less than 400 feet depth, which were primarily drilled into the shallow glacial deposits (Figure 45).

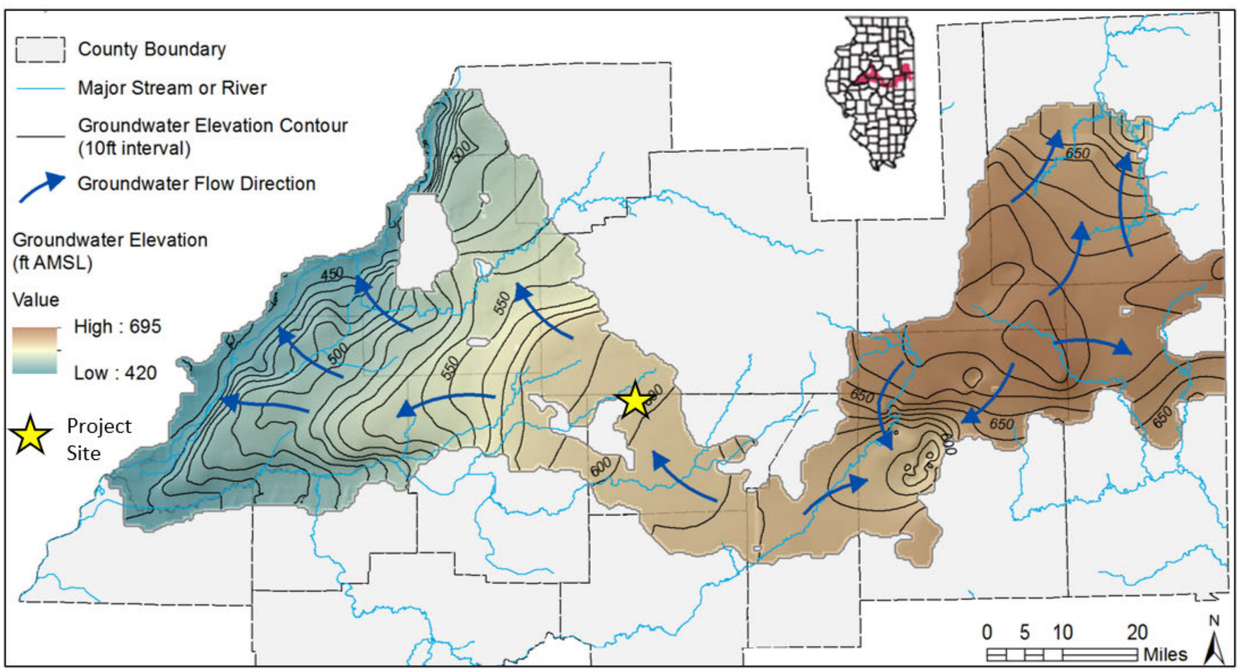

Figure 44: Map of the Mahomet Aquifer with groundwater elevation in feet above mean sea level (AMSL) contours and flow direction. Modified from Roadcap et al., (2011).

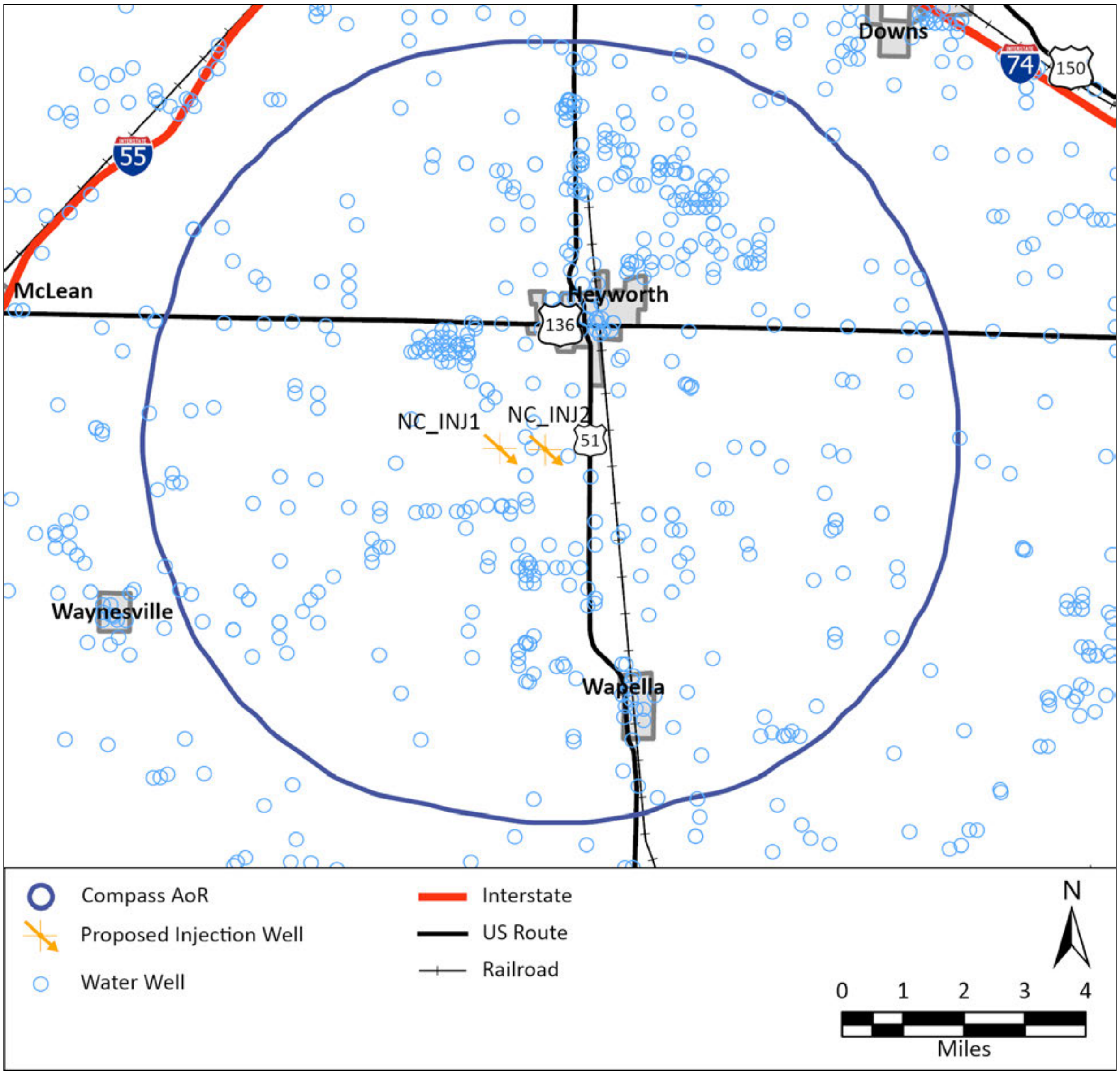

Figure 45: Map of groundwater wells within AoR.

2.27.3 Determination of Lowermost USDW

A USDW is defined by the EPA as an aquifer that (*40 CFR 146*):

- Supplies any public water system
- Contains a sufficient quantity of groundwater to supply a public water system; and
    - Currently supplies drinking water for human consumption, or
    - Contains fewer than 10,000 mg/l total dissolved solids (TDS),
- Which is not an exempted aquifer.

At the Compass Project Site, the Ordovician St. Peter Sandstone is the lowermost USDW based on data from the IBDP and IL-ICCS sites where TDS values range from 4,500 to 5,400 mg/l (Figure 46; Gollakota and McDonald, 2014; Attachment 02: AoR and Corrective Action Plan, 2023). The St. Peter Sandstone is a widespread, near-shore quartz arenite (Lamar, 1928; Willman and Payne, 1943; Buschbach, 1964) and is part of the larger St. Peter Sandstone-Prairie du Chien-Jordan regional aquifer system that is located across the Midwest United States (Young, 1992).

The geophysical logs from the ADM CCS1 well shows the top of St. Peter Sandstone USDW at approximately 3,269 feet and base at 3,477 feet (Figure 46). Figure 47 displays that the St. Peter Sandstone formation water is expected to have a TDS concentration around 4,500 mg/l at the Compass Project Site, which less than the EPA 10,000 mg/l TDS threshold (Young, 1992). The bottom of the St. Peter Sandstone is estimated to be more than 1,700 feet above the top of the Eau Claire Formation confining zone at the project site.

Based on regional data and mapping, the Mt. Simon Sandstone injection and storage zone formation water TDS is expected to range between 100,000 – 150,000 mg/L at the Compass Project Site (Figure 48). The Cambrian Ironton-Galesville Sandstones are an aquifer in northern Illinois, but the ADM CCS1 well indicates that it contains saline water in central Illinois (Patrick Engineering, 2011). In general, the Silurian through Pennsylvanian-aged rock in central Illinois are not USDW's, as they either have poor water quality and/or limited production potential.

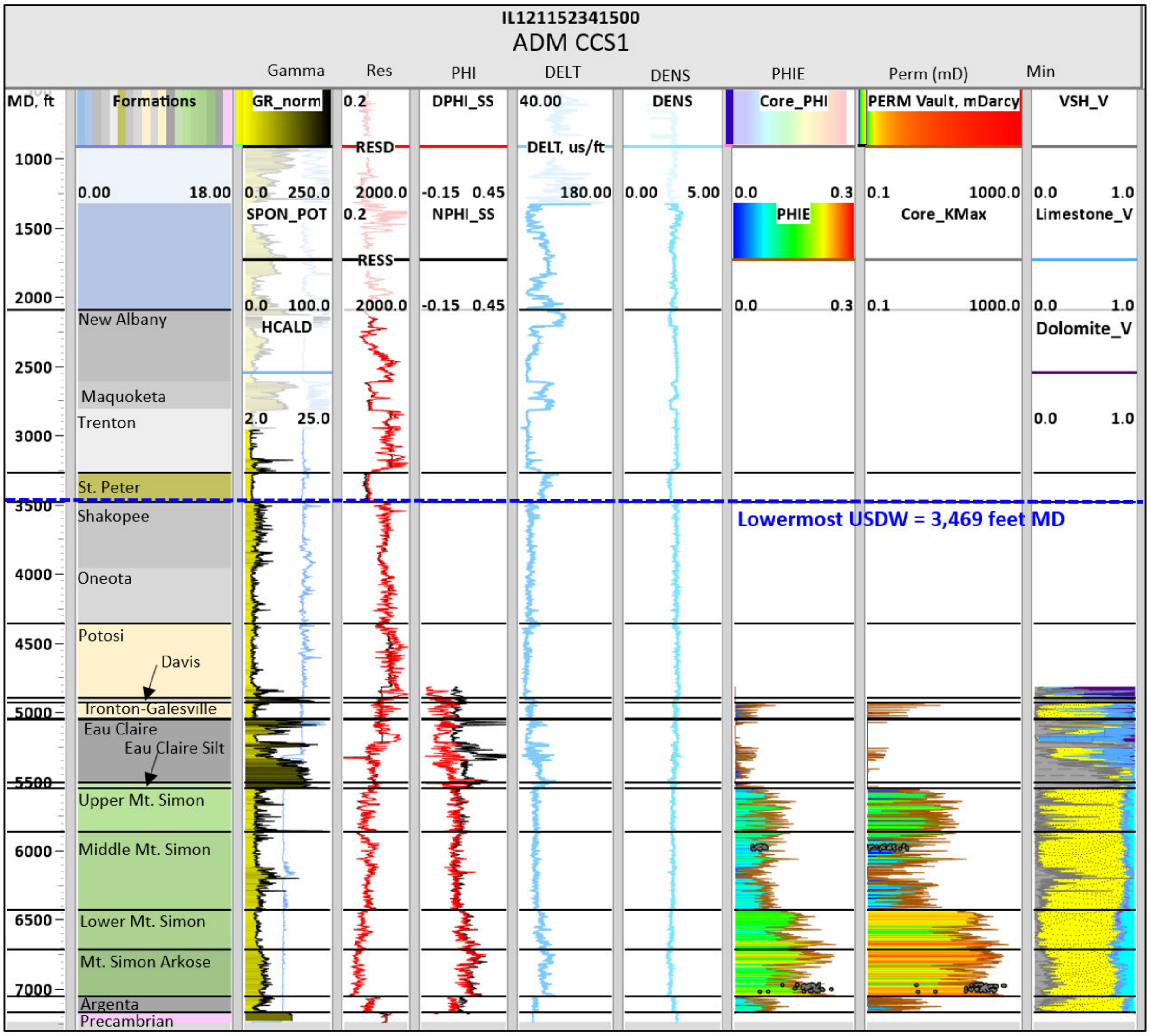

Figure 46: ADM CCS1 (IL121152341500) well logs that show that the lowermost USDW occurs in the St. Peter Sandstone at 3,469 feet measured depth. MD=measured depth in feet, TVDSS=subsea true vertical depth, Gamma=gamma ray, RES=deep resistivity, DPHI=density porosity, DELT=sonic, DENS=density, Zone=stratigraphic zone, PHIE=effective porosity (%), Perm=permeability (mD), and Min=mineralogy.

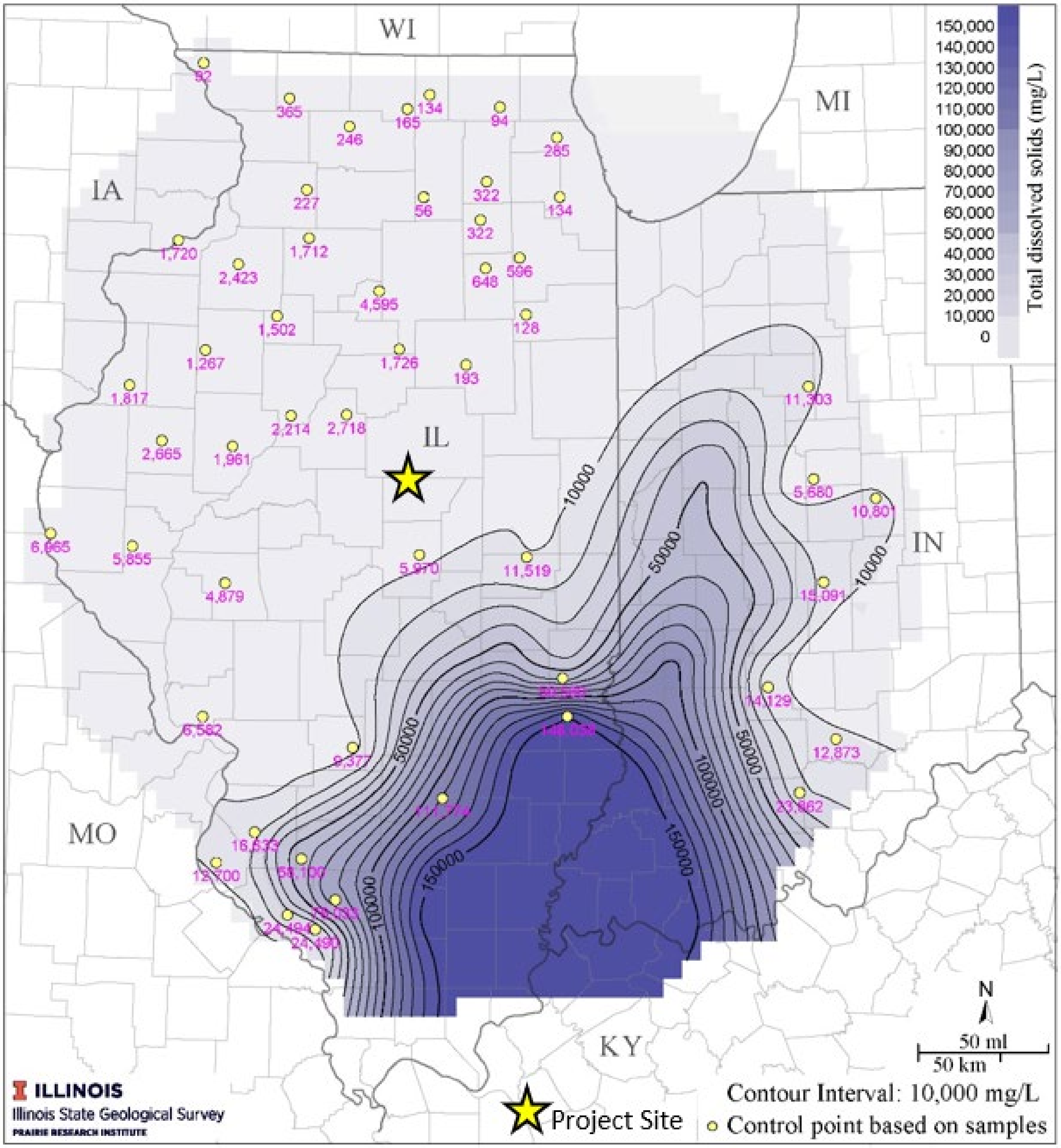

Figure 47: Map of the St. Peter Sandstone total dissolved solids. The project site is represented with a yellow star and sample locations are shown by yellow circles. This is unpublished work by the Illinois State Geological Survey (Whittaker, 2021).

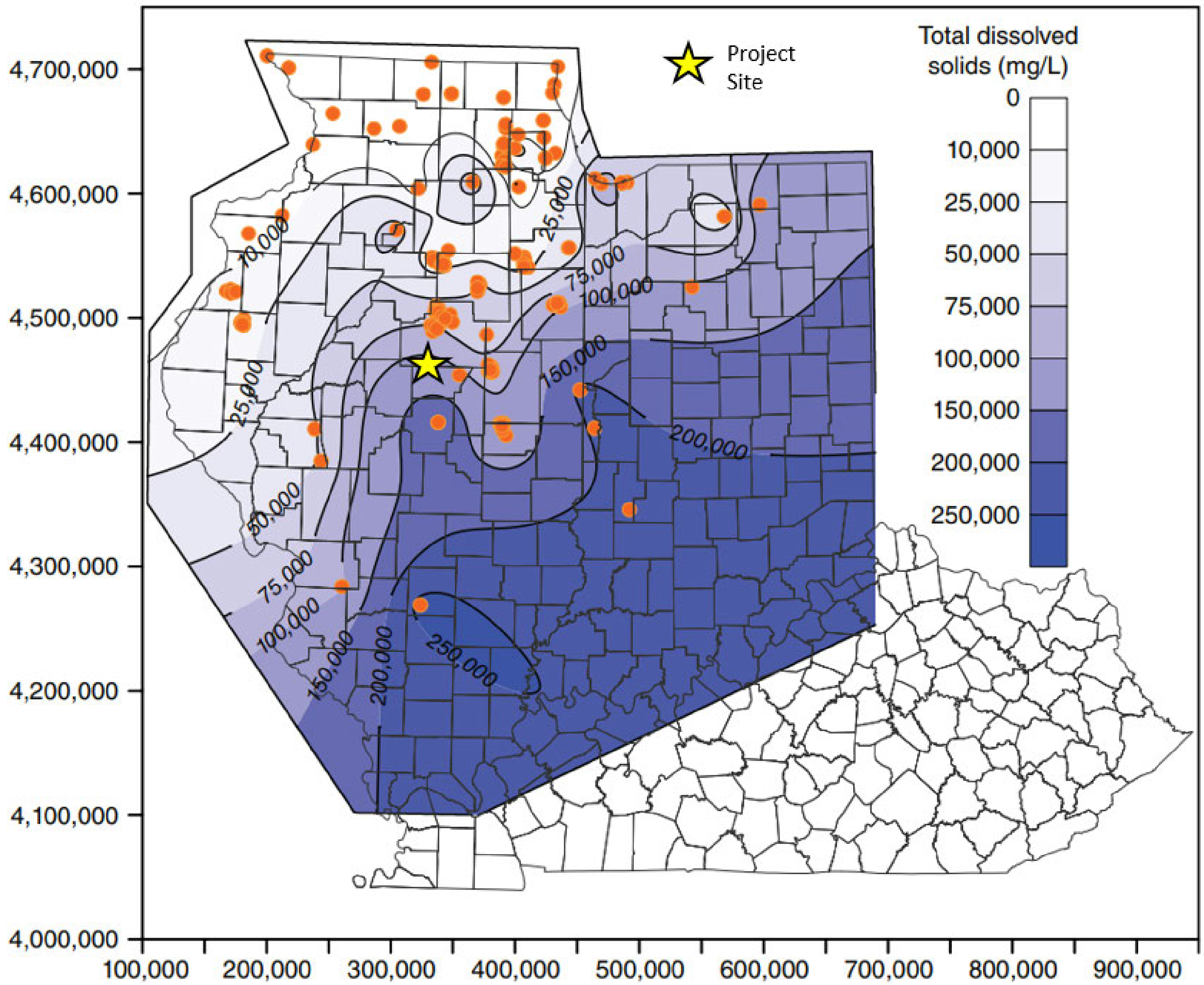

Figure 48: Map of total dissolved solids concentration contours in the Mt. Simon Sandstone formation water. The project site is represented with a yellow star and sample locations are shown by orange circles. (Modified from Mehnert and Weberling, 2014)

2.27.4 Topographic Description

The Compass Project is located in section 16 and 17, Township 21N, Range 2E, DeWitt County at an elevation of approximately 720 feet above sea level. It is part of the Till Plains Physiographic Province, which is characterized by generally flat or gently sloping topography with glacial deposits overlying bedrock (Figure 41). This is an area of minimal flood hazard as established by FEMA, and a Zone A flood hazard (1% chance of annual flooding) is located more than one mile to the northwest of the site along the Kickapoo Creek flood plain (Figure 49, FEMA Flood, 2022).

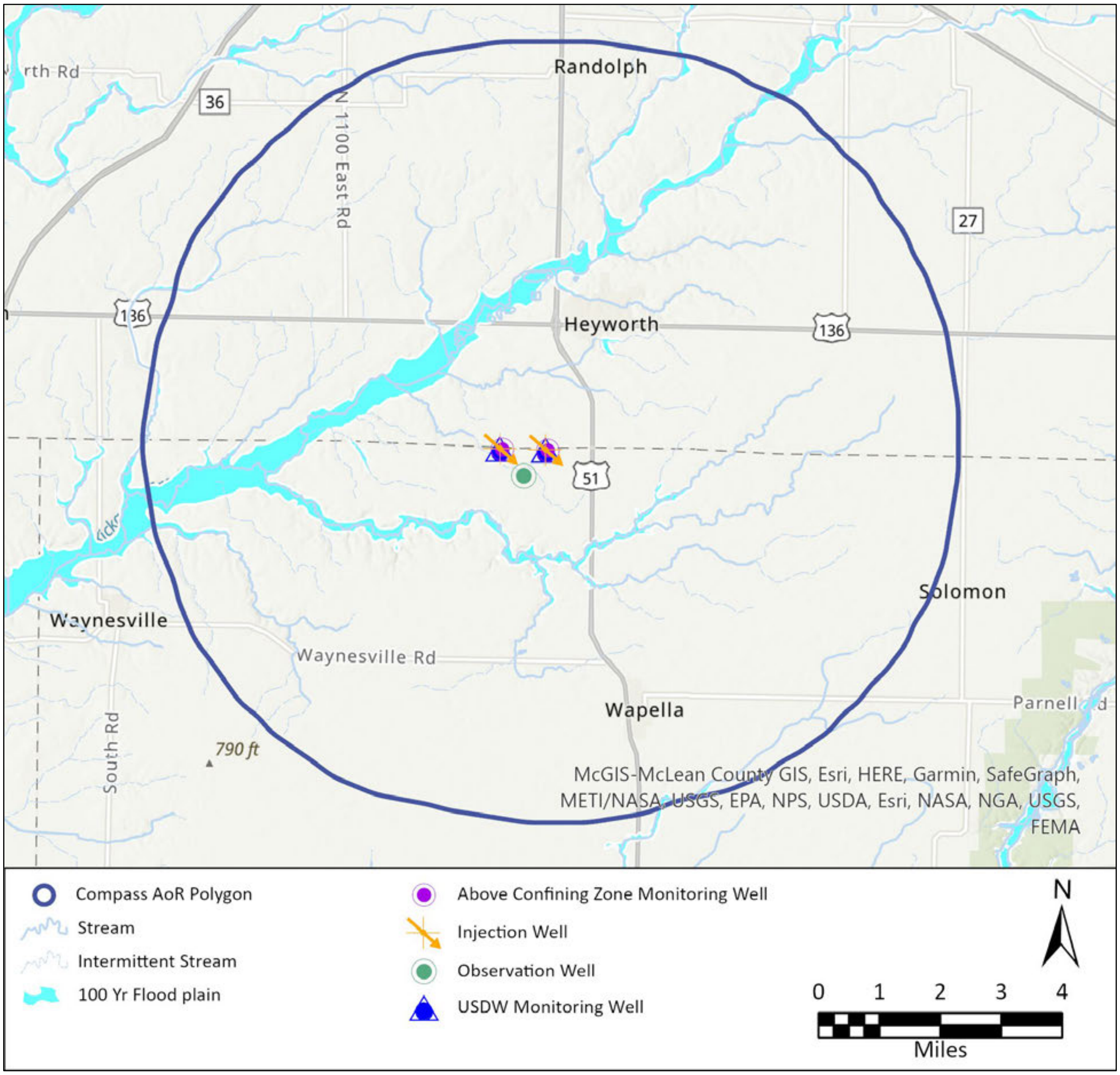

Figure 49: National Flood Hazard Layer from the FEMA website. The project wells are located on this map, and a 100-year flood plain along Kickapoo Creek is located within the AoR over a mile from the project site.

2.28 Geochemistry [40 CFR 146.82(a)(6)]

2.28.1 Data Sources, Analyses

There has been extensive research into the regional understanding of the geochemistry of fluids and lithology of most strata within the Illinois Basin from numerous studies by the Illinois State Geological Survey as well as detailed work at CCS projects in the vicinity of the Compass Project Site including the IBDP (Greenberg, 2021), IL-ICCS (Gollakota and McDonald, 2014), and CarbonSAFE Illinois – Macon County (Whittaker and Carman, 2022). Although local variations will exist, there is high confidence in the bulk lithology and mineralogy of rock and geochemistry of formation fluids in injection zone, confining zone, and USDW in the Compass AoR. Formation fluids, full-diameter rock core, and side-wall core samples have been collected and analyzed by the projects identified above.

The Pre-Operational Testing Program details the data that will be acquired in Deep Observation Well (NC_OBS1) and NC_INJ1 that may be used to support future geochemical evaluation (Attachment 05: Pre-operational Formation Testing Program, 2023). The mineralogy of the injection zone and confining zone will be determined through a combination of core analysis and well logging. Well log data will also be acquired through the lowermost USDW and ACZ monitoring zone to assist in establishing the mineralogy of these formations. Fluid samples will also be collected and analyzed from the St. Peter Sandstone (lowermost USDW), the Ironton-Galesville Sandstones (ACZ), and the Mt. Simon Sandstone (injection zone).

The Testing and Monitoring Plan details the parameters and analytes that will be used to establish baseline conditions for these formations as well as during the injection phase of the project (Attachment 07: Testing and Monitoring, 2023). The aqueous geochemistry data gathered during the pre-operational phase of the project will also be used to support future geochemical modeling work. Geochemical modeling will likely focus on reactions in the injection zone and any reactions in the confining zone that may impact long-term containment and endangerment of USDWs.

2.28.2 Fluid Geochemistry

Many fluid samples have been collected from the Mt. Simon Sandstone in the central Illinois Basin (Locke et al., 2013). To fulfil the requirements for Underground Injection Control (UIC) Class I or VI permits for the IBDP and IL-ICCS projects, the Illinois State Geological Survey has collected fluid samples since 2011 from both the Mt. Simon Sandstone and St. Peter Formation from these sites at Decatur, IL, about 28 miles south of the Compass Project Site. Mt. Simon fluids are of the Na-Ca-Cl type with Cl/Br ratios typically ranging 165±15 (Panno et al., 2013). The general range of total dissolved solids measured for fluids from Mt. Simon Sandstone at the Decatur, IL, sites is from 150,000 to 200,000 mg/L and the salinity at the Compass Project Site is expected to be slightly lower from around 100,000 to 150,000 mg/L Figure 48).

The St. Peter Sandstone is the lowermost USDW at the Decatur sites and fluid samples had TDS values around 4,500 to 5,400 mg/L. (Panno et al., 2018) indicates the salinity of St. Peter Formation trends lower as the formation becomes shallower to the north of Decatur so salinities at Compass are expected to be slightly less than about 4,500 mg/L.

2.28.3 Solid-Phase Geochemistry

The mineralogy of the Mt. Simon Sandstone has been regionally characterized by numerous studies (Carroll et al., 2013; Freiburg et al., 2014; Yoksoulian et al., 2014; Davila et al., 2020; Shao et al., 2020) that indicate that it is dominated by quartz (63-95%) with lesser amounts of feldspar (2 to 22%), authigenic clay, and detrital clay minerals (Freiburg et al., 2014). The clay-sized fraction of minerals usually present in the Mt. Simon Sandstone are a very small percentage (1 to 3% by volume). The comparison of the clay mineral components of the Mt. Simon Sandstone in central Illinois is consistent among wells and are predominantly illite, montmorillonite, fine mica, and minor kaolinite.

2.28.4 Geochemical Reactions and Modeling

Laboratory batch studies have been conducted using rock samples collected from Mt. Simon Sandstone and Eau Claire Formation at IBDP wells to investigate the geochemical interaction of rock, brine, and CO_2 (Carroll et al., 2013; Yoksoulian et al., 2014; Shao et al., 2020). The experiments were conducted under relevant reservoir conditions to identify the reaction mechanisms, kinetics, and solid-phase products that are likely to occur when rock and brine are exposed to injected CO_2. The results of batch studies were also used to constrain the conceptual geochemical model, calibrate mean parameter values, and quantify parameter uncertainty in reactive-transport simulations.

The batch reactor experiments with Mt. Simon Sandstone generally indicated that limited dissolution of rock minerals occurs (Carroll et al., 2013; Yoksoulian et al., 2014; Shao et al., 2020). A decrease of pH occurs quickly in these experiments after CO_2 is introduced because of its dissolution into the brine and dissociation of carbonic acid. Reaction of the Mt. Simon Sandstone can be characterized by an increase in dissolved Si and Al after reaction, suggesting the dissolution of aluminosilicate minerals, such as feldspar and clay minerals. The amount of mineral dissolution is limited, however, as the mass of Al that dissolved from the solid phase into aqueous phase accounted for less than 0.3% of total Al in the rock samples. The liquid to solid ratios in batch experiments were much higher than aquifer conditions suggesting that under aquifer conditions less than 0.002% of Al would be mobilized. Results from XRD analyses indicated the bulk mineral composition remained unchanged for all sandstone samples after reaction (1 to 4 months), indicating that the influence of rock-brine-CO_2 interaction on bulk rock composition was negligible.

Batch experiments introducing CO_2 to crushed Eau Claire shale indicated mineral dissolution from Eau Claire samples were more significant than Mt. Simon sandstone samples (Carroll et al., 2013; Shao et al., 2020). This is likely, in part, due to the processing of rock samples to small fragments that increased the reactive surface area, thus accelerating mineral dissolution of Eau Claire rock. The Eau Claire Formation, however, is a highly laminated, fissile shale to silty shale with the shaliest section near the base (above the Eau Claire Silt) and 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 (Carroll et al., 2013) 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 were not confirmed with available characterization techniques.

Potential geochemical reactions at the Compass Project site were also modeled using Computer Modelling Group (CMG) Generalized Equation Model (GEM). As modeling mineralization is computationally expensive, a 12-layer model was used to represent the Mt. Simon Sandstone with 3 layers used in each of the Arkose, Lower, Middle, and Upper Mt. Simon Sandstone zones. The four main expected mineral components and their percentages used in the model are based on Mt. Simon Sandstone core from VW#1 (Leetaru and Freiburg, 2014):

- Quartz (70 %),
- K-feldspar (20%),
- Illite (5%), and
- Smectite (5%).

The modeling results from the 12-layer model indicate that some precipitation of K-feldspar as well as some dissolution of smectite will occur over the 30-year injection period (Figure 50). There is little reaction with quartz or illite. A very small amount of mineralization is predicted to occur in this timeframe (0.01% of injected CO_2). Any change (reduction) in porosity is negligible during the injection period.

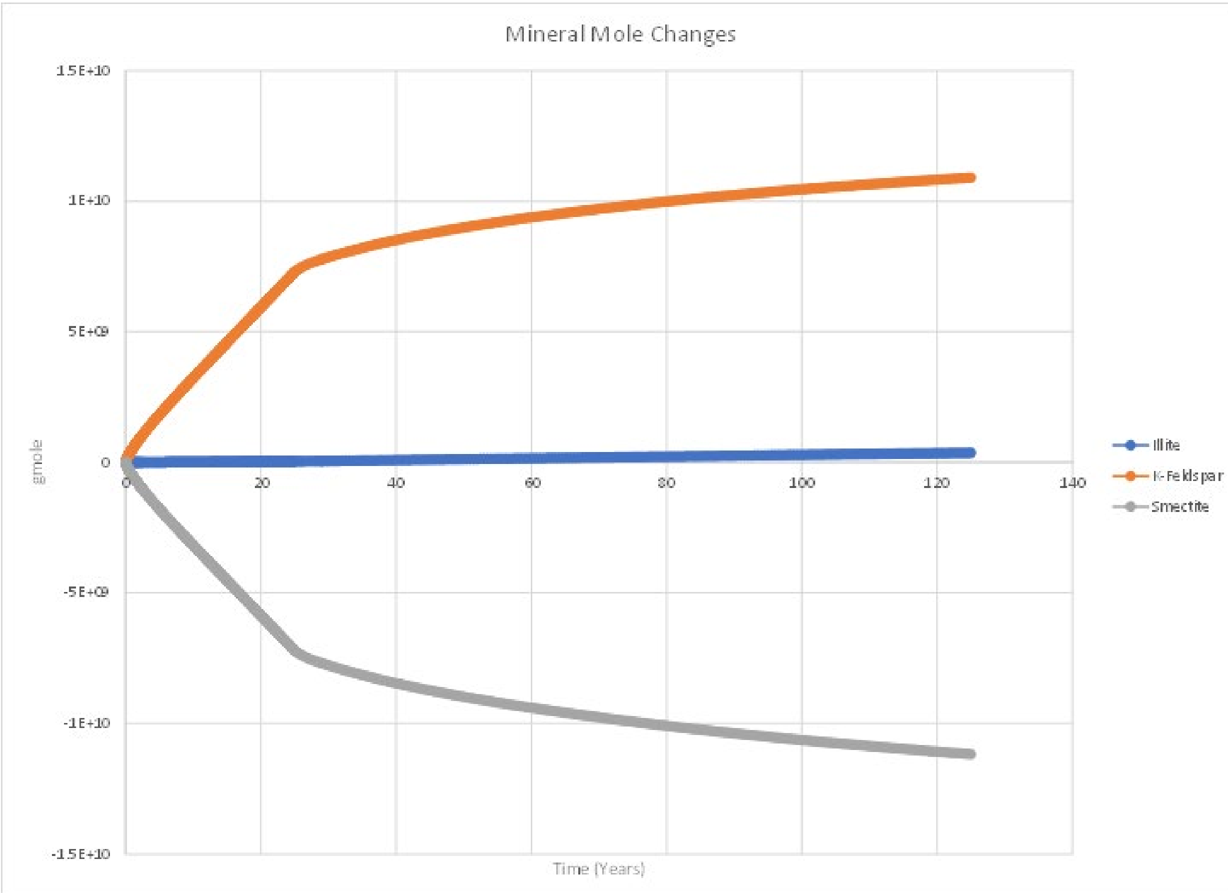

Figure 50: Modeled geochemical reaction products during the 25-year injection period and 50-year post injection period.

The geochemical modeling also predicted the main CO_2 trapping mechanisms. Figure 51 displays the evolution of the main trapping mechanisms during injection and PISC periods. Initially, a large percentage of the CO_2 is structurally trapped. As the fluids gravity segregate, the amount of residual (immobile) gas increases. Dissolution of CO_2 into brine also begins at a slow rate. Dissociation of dissolved CO_2 into aqueous ions also occurs but only accounts for a small percentage of the trapping. Mineralization is a slow process that generally takes hundreds or thousands of years to become a significant trapping mechanism. Table 11 indicates the evolution of trapping mechanisms and percentage of CO_2 trapped over time at the Compass Project site.

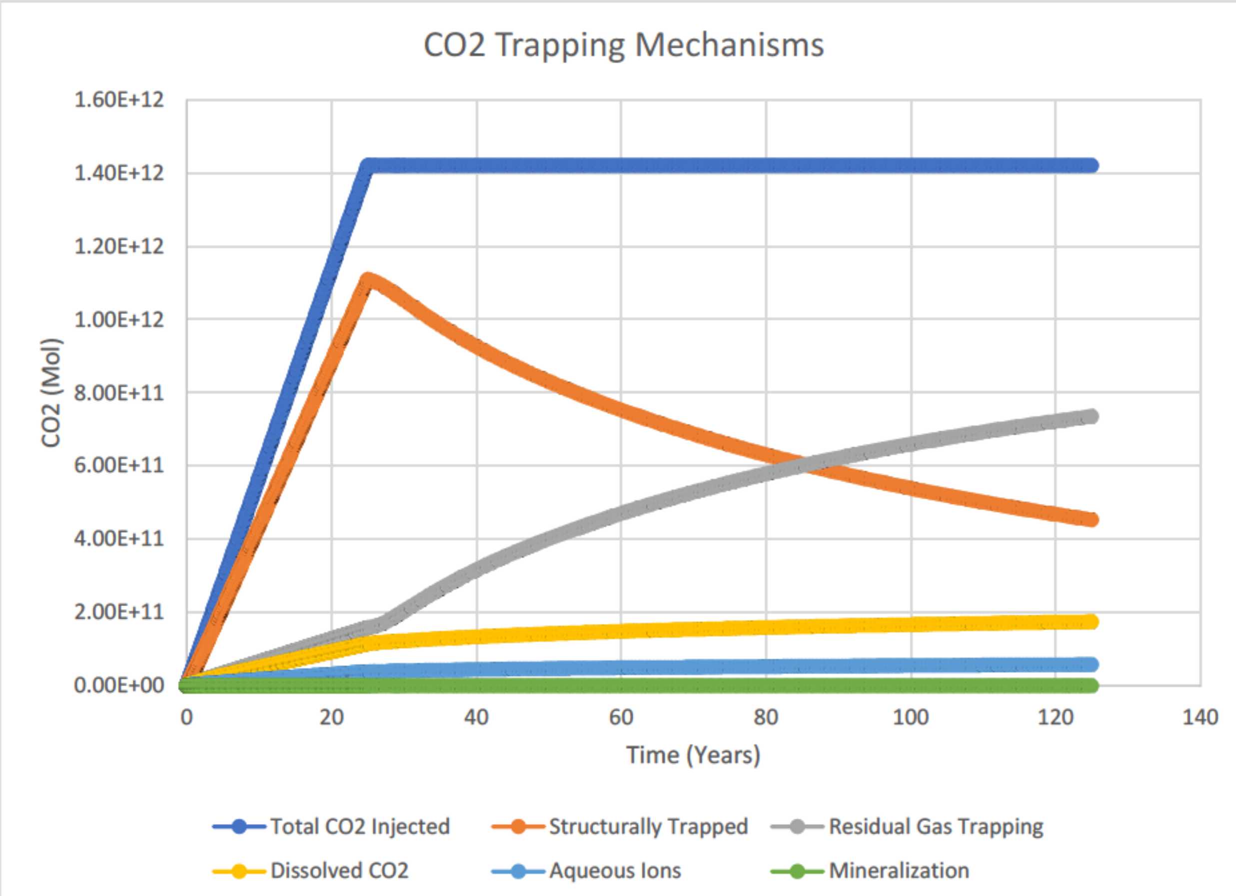

Figure 51: Graph of the relationships and evolution of CO_2 trapping mechanism during 30 years of CO_2 injection followed by a 50-year PISC period at the Compass Project site.

Table 11: CO_2 trapping mechanisms and percentages trapped after 30-years injection and 50-years post-injection.

Trapping Mechanism	% of CO_2 trapped after 30 years of injection	% of CO_2 trapped 50 years post-injection
Structural	78.10	31.89
Residual (immobile) Gas	11.16	51.76
Dissolved gas	8.08	12.29
Aqueous ions	2.66	4.06
Mineralization	0.009	0.01

2.28.5 Mineral trapping

Computational modeling for the Compass Project Site investigated the effect of mineralization on long-term trapping of CO_2 based on the potential reactions between brine-CO_2-rock matrix as part of the PISC Alternative Timeframe using the information currently available (Attachment 09: PISC, 2023). This modeling confirmed that mineralization is not expected to play a significant role in trapping for thousands of years.

2.29 Other Information (Including Surface Air and/or Soil Gas Data, if Applicable)

The Pre-Operational Testing Program presents the data that will be collected in order to determine and verify the depth, thickness, mineralogy, lithology, porosity, permeability, and geomechanical information of the injection zone, confining zone, and other relevant geologic formations via petrophysical logging and analysis, and core acquisition and testing (Attachment 05: Pre-operational Formation Testing Program, 2023). In addition, baseline 3D surface seismic data will be acquired during the pre-construction phase of the project to assist in characterizing injection zone and confining zone rock properties away from NC_INJ1, NC_INJ2, and NC_OBS1.

At this time, the project does not plan to acquire baseline atmospheric or soil gas data, nor are there plans to pursue atmospheric or soil gas monitoring during the injection phase of the project.

2.30 Site Suitability [40 CFR 146.83]

2.30.1 Summary

The Mt. Simon Sandstone at the Compass Project Site meets all requirements necessary to serve as a competent storage formation and can sequester an estimated 62.5 million tonnes of CO_2 over 25 years as evident through geologic evaluation, static modeling, and computational modeling results (Attachment 02: AoR and Corrective Action Plan, 2023). The Eau Claire Formation at the project site has sufficient thickness, continuity, and low porosity and permeability that support it to be an effective primary confining zone. The successful demonstration of CCS by the IBDP and ongoing commercial IL-ICCS project near Decatur, IL, have each provided significant data that supports the Mt. Simon – Eau Claire storage complex as being highly suitable for long-term carbon sequestration.

Specifically, the injection zone comprised of the Lower Mt. Simon Sandstone and Arkose intervals, as well as the Argenta Formation lower confining zone, have the following properties at the proposed project site:

- Depth to the top of the Lower Mt. Simon Sandstone/Arkose primary injection zone: approximately 5,336 fbsl,
- Thickness of the Lower Mt. Simon Sandstone/Arkose primary injection zone: approximately 430 feet,

- Thickness of the entire Eau Claire Silt/Mt. Simon Sandstone storage zone: approximately 1,580 feet,
- Lateral continuity of the Mt. Simon Sandstone over the region,
- Estimated average porosity of the Lower Mt. Simon Sandstone/Mt. Simon Arkose injection zone: 13%,
- Estimated average permeability of the Lower Mt. Simon Sandstone/Mt. Simon Arkose injection zone: 63 mD,
- Thickness of the Argenta Formation lower confining zone: approximately 287 feet.

CO_2 plume development will likely be controlled by heterogeneities within the injection zone, and these heterogeneities will be characterized using a combination of well log, core, and 3D surface seismic data (Attachment 05: Pre-operational Formation Testing Program, 2023). The AoR and Corrective Action Plan includes discussion of the capacity estimates for the injection zone (Attachment 02: AoR and Corrective Action Plan, 2023).

No deep wells penetrate the confining zone within the AoR. The closest well (API # IL120390041400) penetrating the Eau Claire Formation is approximately 12.5 miles to the east and outside of the AoR.

FEMA classifies the project site to have a very small probability of experiencing damaging earthquake effects and a low probability of experiencing annual flooding.

2.30.2 Primary Seal

The Eau Claire Formation above the Eau Claire Silt will be a competent confining zone. It is estimated to be 455 ft thick at the project site and is laterally continuous across the basin. Its dominant clay content indicates that it is ductile and not prone to brittle fracturing. Based on the petrophysical analysis of wells in the region, it is expected to have low porosity and permeability of 1% and less than 1 mD, respectively, at the proposed site (Attachment 02: AoR and Corrective Action Plan, 2023). Data gathered during the pre-operational phase of the project will be used to verify the Eau Claire Shale as a highly competent confining zone (Attachment 05: Pre-operational Formation Testing Program, 2023).

2.30.3 Lowermost USDW

The St. Peter Sandstone is the lowermost USDW at the project site and is expected to be more than 1,700 feet above the top of the Eau Claire Formation confining zone.

2.30.4 Secondary Confinement Strata

There are multiple secondary confining beds within the Knox Group to prevent fluids from reaching the lowermost USDW (St. Peter Sandstone) should they migrate past the primary confining zone. The Argenta Formation will act as a lower confining zone with an average permeability of 1.5 mD estimated for the project site.

2.30.5 Structural Integrity

The two-dimensional (2D) surface seismic data indicates that faults within the AoR that impact the confining zone are largely absent (*Section 2.23 Faults and Fractures*). A single fault identified at the extreme southeast edge of the AoR on 2D seismic line 310 does transect the Eau Claire Formation and the critical pressure front is modeled to encounter this fault in year 25, the final year of injection. This fault has limited offset and high shale gouge ratios (SGR) within the Eau Claire Formation that will prevent fluid movement along the fault zone.

2.30.6 Capacity and Storage

The AoR and Corrective Action Plan shows that the Mt. Simon Sandstone at the Compass Project Site storage location has the capacity and hydrogeologic characteristics necessary to store an estimated 62.5 million tonnes of CO_2. Computational modeling was used to simulate multiphase (brine and CO_2) flow in the subsurface and considered the reservoir geologic and hydrogeologic characteristics. The simulation includes two injection wells within the sequestration site and resulting AoR. Major CO_2 trapping mechanisms modeled include structural/stratigraphic trapping, residual trapping, solubility trapping, and mineral trapping. The model shows that in the post-injection phase and beyond, the pressure front dissipates rapidly, and the CO_2 plume is stable and confined to the injection reservoir.

2.30.7 Reservoir and Compatibility with the Injectate

Studies using laboratory experiments and reactive modeling of the Mt. Simon Sandstone from the Illinois Basin suggest that there is minimal reactivity of the rock with brine and CO_2 (Carroll et al., 2013; Yoksoulian et al., 2014; Shao et al., 2020). Experiments using Mt. Simon Sandstone core samples suggest minor dissolution of aluminosilicate minerals, such as feldspar and clay minerals may occur, but the bulk of the mineralogy (i.e., quartz) is effectively inert. Results from XRD analyses indicated the bulk mineral composition remained unchanged for all sandstone samples after reaction, indicating that the influence of rock-brine-CO_2 interaction on bulk rock composition was negligible. Computational modeling indicate that some carbonate minerals may precipitate as a result of feldspar dissolution, but it would take hundreds of years to see any impact of mineral trapping. These reactions will be monitored using fluid samples that will be taken from the injection zone in NC_OBS1 during the first three to five years of the injection phase of the project (Attachment 07: Testing and Monitoring, 2023).

The well casing, tubing, and cement used through the confining zone and injection zone will be CO_2 resistant (Attachment 04A: NC_INJ1 Injection Well Construction Plan, 2023; Attachment 04B: NC_INJ2 Injection Well Construction Plan, 2023).

3. AoR and Corrective Action

Computational modeling of the expected AoR for the Compass Project is shown in Figure 52 The AoR and Corrective Action module provides a detailed summary of the modeling parameters (Attachment 02: AoR and Corrective Action Plan, 2023). After a thorough review of all identified wells in the region, it has been determined that there are no wells within the AoR that penetrate the confining zone, and there is no requirement for corrective action.

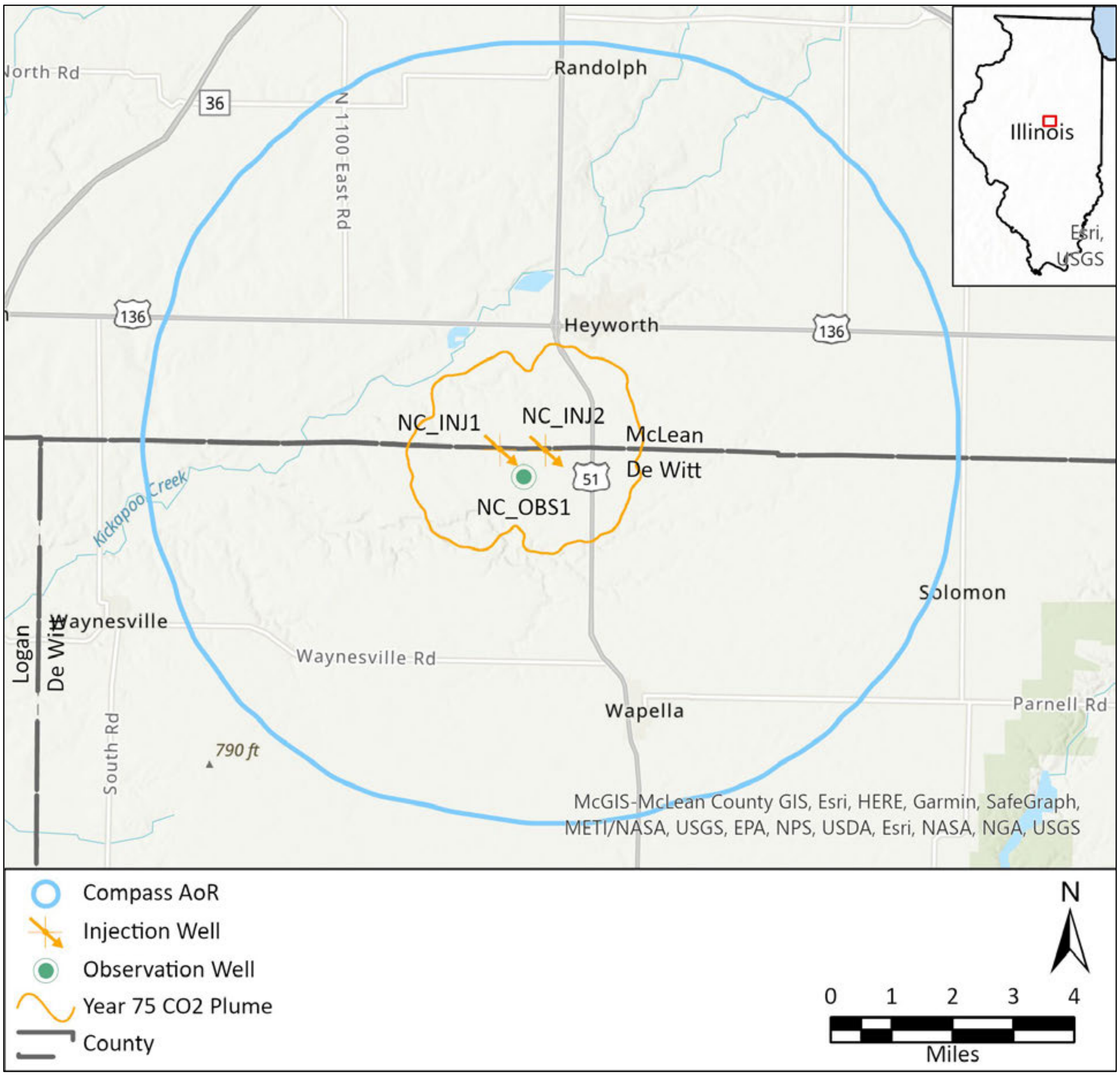

Figure 52: Map of Compass Project location, proposed location of the injection and deep observation wells, simulated extent of the CO_2 plume 50 years post injection, and the pressure based AoR.

AoR and Corrective Action GSDT Submissions
GSDT Module: AoR and Corrective Action ***Tab(s):*** All applicable tabs Please use the checkbox(es) to verify the following information was submitted to the GSDT: ☐ Tabulation of all wells within AoR that penetrate confining zone ***[40 CFR 146.82(a)(4)]*** ☐ AoR and Corrective Action Plan *[40 CFR 146.82(a)(13) and 146.84(b)]* ☐ Computational modeling details ***[40 CFR 146.84(c)]***

4. Financial Responsibility

The financial assurance estimation for the project was divided into four components: 1) Corrective Action, 2) Injection Well Plugging and Abandonment, 3) Post Injection Site Care and Closure, and 4) the Emergency and Remedial Response Plan (ERRP). Components 1-3 will be covered by a segregated Escrow Account and the ERRP component will be covered by Insurance.

Costs for the first three components were based on independent, third-party engineering data. All appropriate quotes that were obtained from vendors are provided with the submittal documentation. The cost estimate for the ERRP was developed in tandem with DNV. Their full report is provided with the submittal documentation.

Further detail is provided in (Attachment 03: Financial Assurance Plan, 2023) of this permit application, which is considered CBI and will be submitted separately to EPA. (Attachment 03: Financial Assurance Plan, 2023).

Financial Responsibility GSDT Submissions
GSDT Module: Financial Responsibility Demonstration ***Tab(s):*** Cost Estimate tab and all applicable financial instrument tabs Please use the checkbox(es) to verify the following information was submitted to the GSDT: ☐ Demonstration of financial responsibility ***[40 CFR 146.82(a)(14) and 146.85]***

5. Injection Well Construction

HGCS intends to use construction materials (casing, cement, etc.) that are verified by independent third-party sources as suitable for the worst-case corrosive load expected to occur during the life of the project. Verification of the suitability is provided as part of the supporting documents for Attachment 04A: NC_INJ1 Injection Well Construction Plan, 2023 and Attachment 04B: NC_INJ2 Injection Well Construction Plan, 2023.

The Compass injection wells are planned to have three (3) hole sections: 1) surface, from surface to approximately 330 feet (below base of Mahomet Aquifer); 2) intermediate, from approximately 330 feet to approximately 4,300 feet (below base of Davis formation and USDWs); and 3) long string, from approximately 4,300 feet to approximately 6,570 feet (total depth). The surface and intermediate casing cement systems will provide isolation of the deepest USDW.

Both injection wells along with the deep observation well (NC_OBS1) are planned to penetrate the top of the Precambrian Granite Basement (basement). Depending upon the drilling order one of these wells will be used to collect basement characterization data. Once the basement characterization data has been collected, whether in NC_INJ1, NC_INJ2, or NC_OBS1, the open basement section will be plugged back to the injection zone such that the CO2 will not be directly injected into the basement. This will be done prior to running and cementing the long string casing in place.

Should a substantial lost circulation zone (LCZ) be encountered during the drilling of the intermediate string section, well control and loss prevention measures will be implemented. The anticipated potential LCZ is the Knox Group.

Wellheads will be used with appropriately sized components and construction materials based on the build of the wellbore. Following installation of the long string casing and cement, perforations will be made into the casing to access the Lower Mt. Simon Sandstone and Arkose Sandstone for injection.

Schematics for the wellbore and wellhead are provided in the well construction plan attachments Attachment 04A: NC_INJ1 Injection Well Construction Plan, 2023 and Attachment 04B: NC_INJ2 Injection Well Construction Plan, 2023 of the permit application.

Downhole pressure and temperature gauges will be installed just above the packer. The downhole pressure gauge will be used to help ensure that the maximum allowable bottomhole pressure (BHP) does not exceed 90% of the fracture pressure. The downhole temperature gauge will be used to calculate the bottomhole density and volume of the injected fluid. The BHP gauges will be programed to take data at the intervals outlined in the testing and monitoring program section of this application (Attachment 07: Testing and Monitoring, 2023). The data collected from these measurement systems will be collected continuously and sent to a surface SCADA system. More information about these sensors is provided in the Well Operations and

Testing and Monitoring Plans (Attachment 06A: NC_INJ1 Well Operations, 2023; Attachment 06B: NC_INJ2 Well Operations, 2023; Attachment 07: Testing and Monitoring, 2023).

Further details on the proposed stimulation program, construction plans, and materials of construction are provided in this section and in the well construction attachments (Attachment 04A: NC_INJ1 Injection Well Construction Plan, 2023; Attachment 04B: NC_INJ2 Injection Well Construction Plan, 2023).

5.1 Proposed Stimulation Program [40 CFR 146.82(a)(9)]

Based on current analysis, it is unlikely that well stimulation will be necessary on either of the injection wells after initial completion, other than to clean out the perforations made in the long-string casing.

HGCS reserves the right to perform intermediate stimulation on the proposed injector wells, should the need arise. Some of the common remediation techniques that may be deployed in the future is listed below. Note that this is not an exhaustive list and additional technologies or treatments may be used. Further detail on methods, materials, and chemicals to be used during treatments is provided in (Attachment 04A: NC_INJ1 Injection Well Construction Plan, 2023) and (Attachment 04B: NC_INJ2 Injection Well Construction Plan, 2023).

- Matrix acid stimulation,
- Coil tubing chemical stimulation,
- Coil tubing mechanical stimulation,
- Perforations.

Stimulations will occur as necessitated by well conditions. These will be identified by evaluating well performance over time. The necessary notification will be provided to the Agency prior to any field mobilization. Within this notification, detail on the proposed procedure, equipment, and chemicals to be used will be provided.

5.2 Construction Procedures [40 CFR 146.82(a)(12)]

The injection wells will be drilled as new wells. Multiple strings of carbon steel and 13-Chrome casing will be installed and cemented in place to protect the USDWs and other strata overlying the injection formation. Fluids will be injected into the Lower Mt. Simon Sandstone and Arkose Sandstone using internally coated carbon steel tubing landed in a nickel coated packer. The Lower Mt. Simon Sandstone and Arkose Sandstone will be accessed through perforations in the long string casing.

A high-level construction procedure is provided below, and a more detailed schedule and procedure is provided in Attachment 04A: NC_INJ1 Injection Well Construction Plan, 2023 and (Attachment 04B: NC_INJ2 Injection Well Construction Plan, 2023).

1. Conductor casing will be driven into the ground.
2. Surface hole section will be drilled below the base of the Mahomet Aquifer.
3. Open hole logs will be run.
4. Casing will then be run and cemented in place.
5. After allowing sufficient time for the cement to harden, cased hole logs will be run, and the casing will be pressure tested.
6. Intermediate string hole section will be drilled to within the Davis Formation.
7. Open hole logs will be run.
8. Casing will then be run and cemented in place.
9. After allowing sufficient time for the cement to harden, cased hole logs will be run, and the casing will be pressure tested.
10. Long string hole section will be drilled into basement.
11. Fluid samples will be collected in the Mt. Simon Sandstone for analysis. Or if not run at this time, fluid samples will be collected during well completion operations.
12. Open hole logs will be run.
13. Casing will then be run and cemented in place.
14. After allowing sufficient time for the cement to harden, cased hole logs will be run, and the casing will be pressure tested.
15. Perforations will be made in the long string casing into the Lower Mt. Simon Sandstone and Arkose Sandstone.
16. The packer, tubing, and wellhead will then be installed.

Specifications on the casing, tubing, and cement are provided in more detail in Attachment 04A: NC_INJ1 Injection Well Construction Plan, 2023 and Attachment 04B: NC_INJ2 Injection Well Construction Plan, 2023. All materials of construction are designed to API standards.

5.2.1 Casing and Cementing

Table 12 and Table 13 display the safety factors and safety factor loads based on the proposed well design. It is noted that an 80% derating factor is applied prior to any analyses. This implies an additional 1.20 safety factor on top of those displayed in the table. Additionally, material and specification derating based on tensile loading is also considered. Finally, worst-case analyses (i.e., evacuated casing while pumping cement while also pulling up at the max tensile rating) were considered in casing evaluation. Anticipated loads are displayed first, followed by worst case loads. In addition to these analyses, cyclic and temperature loading analysis was performed. The results of this analysis are presented in Attachment 04A: NC_INJ1 Injection Well Construction Plan, 2023 and Attachment 04B: NC_INJ2 Injection Well Construction Plan, 2023.

Table 14 displays the setting depths and specifications of the casing to be used for the injection wells. All casing conforms with API specifications. Table 15 shows the design parameters of the casing, tubing, and packer to be used for the injection wells.

Details on the cement program are provided in Attachment 04A: NC_INJ1 Injection Well Construction Plan, 2023 and Attachment 04B: NC_INJ2 Injection Well Construction Plan, 2023. All cement used conforms with API standards. Corrosion resistant cement will be used from the bottom of the well to above the top of the Eau Claire Formation.

Mechanical integrity will be demonstrated as part of the initial completion, and routinely as discussed in Attachment 05: Pre-operational Formation Testing Program, 2023 and Attachment 07: Testing and Monitoring, 2023, respectively. All materials of construction are suitable for the anticipated loading and are not anticipated to decrease in suitability over time.

Table 12: Casing Safety Factors for Design.

Burst	Collapse	Tensile
1.2	1.2	1.5

Table 13:Casing Safety Factor Loads for Design.

String	Burst	Collapse	Tensile*
Surface	6.73	2.41	45.2
Intermediate	2.66	3.87	3.01
Long String	3.09	4.57	2.89
Injection Tubing	3.69	4.54	3.3

Table 14: Injection Wells Casing and Tubing details.

Casing String	Depth	Borehole Diameter	Wall Thickness	External Diameter	Casing Material	String Weight
Surface	330 feet	24 inches	0.438 inches	20 inches	94 lbs./foot, J55, BTC	31,020 lbs
Intermediate	4,284 feet (NC_INJ1) 4,309 feet (NC_INJ2)	17.5 inches	0.38 inches	13.375 inches	54.5 lbs./foot, L80, BTC	233,480 lbs 234,840 lbs
Long String	4,370 feet (NC_INJ1) 4,380 feet (NC_INJ2)	12.25 inches	0.395 inches	9.625 inches	47 lbs./foot, L80, LTC	205,390 lbs 205,860 lbs
Long String (Chrome)	4,370 feet to 6,570 feet (NC_INJ1) 4,380 feet to 6,570 feet (NC_INJ2)	12.25 inches	0.472 inches	9.625 inches	47 lbs./foot, 13Cr80, Special	103,400 lbs 102,930 lbs
Injection Tubing	6,030 feet (NC_INJ1) 6,040 feet (NC_INJ2)	8.835 inches	0.304 inches	5.5 inches	17 lbs./foot, L80, Special, Internally Coated	102,510 lbs 102,680 lbs

Table 15: Injection Wells Casing and Tubing Design Parameters.

Material	Setting Depth (feet)	Tensile Strength	80% of Tensile Strength	Burst Strength	80% of Burst Strength	Collapse Strength	80% of Collapse Strength	Material of Construction
Surface Casing	330	783,000	626,400	2,110	1,688	520	416	94 lbs./foot, J55, BTC
Intermediate Casing	4,284 (NC_INJ1) 4,309 (NC_INJ2)	514,000	411,200	3,980	3,184	1,140	912	54.5 lbs./foot, L80, BTC
Long String Casing	6,570	893,000	714,400	6,870	5,496	4,750	3,800	47 lbs./foot, L80/13Cr80, LTC/Special
Injection Tubing	6,030 (NC_INJ1) 6,040 (NC_INJ2)	348,000	278,400	7,740	6,192	6,290	5,032	17 lbs./foot, L80 lined, Special
Baker Signature F	6,020 (NC_INJ1) 6,030 (NC_INJ2)							Chrome/Nickel plated

5.2.2 Tubing and Packer

The tubing will be internally coated 5-1/2-inch L80 pipe and is anticipated to withstand the corrosive loading experienced during normal operations. The internal coating has been field-proven to be suitable for more extreme cases of Enhanced Oil Recovery (EOR) projects. Further detail on the suitability is provided in Attachment 04A: NC_INJ1 Injection Well Construction Plan, 2023 and Attachment 04B: NC_INJ2 Injection Well Construction Plan, 2023.

The packer to be used for the project is Baker Hughes Signature F Injection style packer. This packer will be externally coated with chrome and nickel to resist any corrosion. This packer and coated mechanism are typical for disposal purposes and designed to prevent corrosion or leakage. Further details on the packer are provided in Attachment 04A: NC_INJ1 Injection Well Construction Plan, 2023 and Attachment 04B: NC_INJ2 Injection Well Construction Plan, 2023.

6. Pre-Operational Logging and Testing

Details on the pre-operation testing plan are provided in the relevant section of this permit application (Attachment 05: Pre-operational Formation Testing Program, 2023).

Pre-Operational Logging and Testing GSDT Submissions
GSDT Module: Pre-Operational Testing ***Tab(s):*** Welcome tab Please use the checkbox(es) to verify the following information was submitted to the GSDT: ☐ Proposed pre-operational testing program ***[40 CFR 146.82(a)(8) and 146.87]***

7. Well Operation

The following provides a brief overview of the well operation conditions. Further details on the well operation program are provided in Attachment 06A: NC_INJ1 Well Operations, 2023 and Attachment 06B: NC_INJ2 Well Operations, 2023.

7.1 Operational Procedures [40 CFR 146.82(a)(10)]

Table 16 displays the operational parameters that will be used during injection operations. Details on the methods of calculations and inputs for these values are provided in Attachment 06A: NC_INJ1 Well Operations, 2023 and Attachment 06B: NC_INJ2 Well Operations, 2023. Values provided in this table are designed to stay below the critical fracture pressure, while also managing the pressure loading experienced during operations to protect equipment. It is not anticipated that significant deviation from these values will occur during the life of the project.

Table 16: Injection Wells Proposed operational procedures.

Parameters/Conditions	NC_INJ1 Limit or Permitted Value	NC_INJ2 Limit or Permitted Value	Unit
Maximum Injection Pressure			
Surface*	2,417	2,422	psi
Downhole	3,873	3,881	psi
Average Injection Pressure**			
Surface	1,809	1,794	psi
Downhole	3,455	3,437	psi
Maximum Injection Mass			
Annual	1.25	1.25	Mtpa
Daily	3.425	3.425	kt
25-year Project	31.25	31.25	Mt
Average Injection Rate*			
Mass Injection Rate	2,378	2,378	kg/min
Volumetric Injection Rate	1,007	1,007	gal/min
	34,509	34,509	barrels/day
Annulus Pressure			
Maximum	1,500	1,500	psi
Minimum	-5	-5	psi
Operational	100	100	psi
*Calculations made based on annual maximum injection volume, assuming the density provided in Attachment 06A and Attachment 06B (Section 4) **Based on the projected computational modeling results after stable injection operations have occurred.			

7.2 Proposed CO_2 Stream [40 CFR 146.82(a)(7)(iii) and (iv)]

The CO_2 injection stream will be sourced from biofuel and fertilizer plants located in Illinois, Iowa, Minnesota, Nebraska, and South Dakota and is anticipated to have the fluid composition as shown in Table 17. Once injection begins, HGCS will analyze the CO_2 stream during the injection phase of the project to provide data representative of its chemical characteristics and to meet the requirements of 40 CFR 146.90 (a). Details on the testing and monitoring of the CO_2 stream are provided in the testing and monitoring section of this permit (Attachment 07: Testing and Monitoring, 2023). Additional details on technical standards, QA/QC policy, sample collection and storage policies, and analytical methods are provided in the QASP (Attachment 11: QASP, 2023).

It is currently anticipated that quarterly sampling of the CO_2 injection stream will be sufficient to accurately track the composition of the stream. The regular samples will be taken on quarterly intervals, at the end of each quarter (March, June, September, and December).

Table 17: Anticipated CO_2 Injection Stream Composition.

Component	Specification	Unit
Minimum CO_2	98	mole %, dry basis
Water Content	</= 20	lb/MMscf
Impurities (dry basis):		
Total Hydrocarbons	</= 2	mol% dry basis
Inerts (N_2, Ar)	</= 2	mol% dry basis
Hydrogen	</= 1	mol% dry basis
Alcohols, aldehydes, esters	</= 500	ppmv
Hydrogen Sulfide	</= 100	ppmv
Total Sulfur	</= 100	ppmv
Oxygen	</= 800	ppmv
Carbon monoxide	</= 100	ppmv
Glycol	</= 1	ppmv

8. Testing and Monitoring

Testing and Monitoring GSDT Submissions

GSDT Module: Project Plan Submissions
Tab(s): Testing and Monitoring tab

Please use the checkbox(es) to verify the following information was submitted to the GSDT:
☐ Testing and Monitoring Plan [40 CFR 146.82(a)(15) and 146.90]

Details on the well operation program are provided in Attachment 07: Testing and Monitoring, 2023 that address 40 CFR 146.82(a)(15) and 146.90.

9. Injection Well Plugging

Following the conclusion of injection operations, the injection wells will be permanently plugged and abandoned. Details on the methods of these operations are provided in Attachment 08A: NC_INJ1 Injection Well Plugging Plan, 2023 and Attachment 08B: NC_INJ2 Injection Well Plugging Plan, 2023. The methods and procedures presented in the attachments are consistent with industry standards and the requirements detailed in 40 CFR 146.92. All materials to be used for the plugging and abandonment are suitable for the anticipated corrosive loading below the top of the Eau Claire Formation. Above the top of the Eau Claire Formation, the materials are standard construction materials, conforming to the API specifications.

Injection Well Plugging GSDT Submissions

GSDT Module: Project Plan Submissions
Tab(s): Injection Well Plugging tab

Please use the checkbox(es) to verify the following information was submitted to the GSDT:
☐ Injection Well Plugging Plan [40 CFR 146.82(a)(16) and 146.92(b)]

10. Post-Injection Site Care and Closure

The requested documents listed below have been included in the file submission (Attachment 09: PISC, 2023). These documents address the rule requirements for the above EPA citations. HGCS is requesting a 15-year alternative PISC timeframe for the Compass Project.

PISC and Site Closure GSDT Submissions
GSDT Module: Project Plan Submissions ***Tab(s):*** PISC and Site Closure tab Please use the checkbox(es) to verify the following information was submitted to the GSDT: ☐ PISC and Site Closure Plan [40 CFR 146.82(a)(17) and 146.93(a)]
GSDT Module: Alternative PISC Timeframe Demonstration ***Tab(s):*** All tabs (only if an alternative PISC timeframe is requested) Please use the checkbox(es) to verify the following information was submitted to the GSDT: ☒ Alternative PISC timeframe demonstration ***[40 CFR 146.82(a)(18) and 146.93(c)]***

11. Emergency and Remedial Response

The requested documents listed below have been included in the file submission (Attachment 10: ERRP, 2023). These documents address the rule requirements for the above EPA citations.

Emergency and Remedial Response GSDT Submissions
GSDT Module: Project Plan Submissions ***Tab(s):*** Emergency and Remedial Response tab Please use the checkbox(es) to verify the following information was submitted to the GSDT: ☐ Emergency and Remedial Response Plan *[40 CFR 146.82(a)(19) and 146.94(a)]*

12. Injection Depth Waiver and Aquifer Exemption Expansion

HGCS does not intend to apply for a Depth Waiver or Aquifer Exemption for the Compass Project. As such, no supplemental documents have been filed.

Injection Depth Waiver and Aquifer Exemption Expansion GSDT Submissions
GSDT Module: Injection Depth Waivers and Aquifer Exemption Expansions ***Tab(s):*** All applicable tabs Please use the checkbox(es) to verify the following information was submitted to the GSDT: ☐ Injection Depth Waiver supplemental report ***[40 CFR 146.82(d) and 146.95(a)]*** ☐ Aquifer exemption expansion request and data ***[40 CFR 146.4(d) and 144.7(d)]***

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Attachment 01: Narrative, 2023: Compass.

Attachment 02: AoR and Corrective Action Plan, 2023: Compass.

Attachment 03: Financial Assurance Plan, 2023: Compass.

Attachment 04A: NC_INJ1 Injection Well Construction Plan, 2023: Compass.

Attachment 04B: NC_INJ2 Injection Well Construction Plan, 2023: Compass.

Attachment 05: Pre-operational Formation Testing Program, 2023: Compass.

Attachment 06A: NC_INJ1 Well Operations, 2023: Compass.

Attachment 06B: NC_INJ2 Well Operations, 2023: Compass.

Attachment 07: Testing and Monitoring, 2023: Compass.

Attachment 08A: NC_INJ1 Injection Well Plugging Plan, 2023: Compass.

Attachment 08B: NC_INJ2 Injection Well Plugging Plan, 2023: Compass.

Attachment 09: PISC, 2023: Compass.

Attachment 10: ERRP, 2023: Compass.

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