[redacted]

UIC CLASS VI GEOLOGIC STORAGE OF CO_2 PERMIT APPLICATION

Dusek CCS #2 Well

[redacted]

Upton County, Texas

Section 1: Site Characterization & Narrative

[40 CFR §146.82, §146.83]

Prepared for:

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Glossary of Acronyms, Abbreviations and Terms for All Permit Sections: 1-12	
Acronym / Abbreviation / Term	**Definition / Meaning**
1-D	one-dimensional
2-D	two-dimensional
3-D	three-dimensional
4-D	four-dimensional
ACS	American Community Survey
AES	atomic emission spectrometry
AMA	active monitoring area
AMPP	Association for Materials Protection and Performance
AMS	accelerator mass spectrometry
AoR	area of review
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
AVO	amplitude variation with offset
AZMI	above-zone monitoring interval
bbl(s)	barrel(s)
Bcf	billion cubic feet – standard unit of measurement for natural gas
BEG	Bureau of Economic Geology
BET	Brunauer-Emmett-Teller analysis
BHA	bottomhole assembly
BHP	bottomhole pressure
BHIP	bottomhole injection pressure
BHT	borehole temperature
BNI	BNI Coal, Inc.
BOP	blowout preventer
BOPE	blowout preventer equipment
bpm	barrels per minute
BTC	buttress-thread and coupled
CBL	cement bond log
CBP	Central Basin Platform
CCP	corrosion control program
CCS	carbon capture and storage
CCUS	carbon capture utilization and storage
CFR	Code of Federal Regulations
cm	centimeter
CMG	Computer Modelling Group Ltd.
CO_2	carbon dioxide
CRA	corrosion resistant alloys
DAS	distributed acoustic sensing
DIC	dissolved inorganic carbon
DOT	U.S. Department of Transportation
°	degree symbol/glyph used to represent degrees of an arc (i.e., geographic coordinate systems), and degrees of temperature
DST	drill stem test
DTS	distributed temperature sensing
EC	electric conductivity
EJ	environmental justice
EM	electromagnetic
EOR	enhanced oil recovery
EOS	equation of state
EPA	U.S. Environmental Protection Agency
ERCOT	Electric Reliability Council of Texas
ERR	emergency or remedial response
ERRP	emergency and remedial response plan
ESD	Emergency Shutdown
°F	degree Fahrenheit
F/ft	Fahrenheit per foot

Glossary of Acronyms, Abbreviations and Terms for All Permit Sections: 1-12	
Acronym / Abbreviation / Term	**Definition / Meaning**
FADP	financial assurance demonstration plan
FM	farm-to-market
FMI	formation microimaging
FOC	fiber optic cable
FS	field superintendent
FSP	fault slippage potential
ft	foot
GAU	Groundwater Advisory Unit
GC	gas chromatography
g/cm^3	gram per cubic centimeter
GEM	generalized equation-of-state model
GFCI	ground fault circuit interrupter
GHG	greenhouse gas
GHGRP	Greenhouse Gas Reporting Program
GR	gamma ray
GSDT	Geologic Sequestration Data Tool – EPA's centralized, web-based system
h	hour
H_2S	hydrogen sulfide
HI	health index
HSE	health and safety and the environment
ICP	inductively coupled plasma
ID	inside diameter
in.	inch
Injection Unit	[redacted]
Injection Interval	[redacted]
km	kilometer
KNN	k-nearest neighbor algorithm (also known as k-NN)
Kv	vertical permeability
L	liter
lb	pound
LUST	leaking underground storage tank
M	magnitude
m	meter
m	cementation exponent
MASP	maximum anticipated surface pressure
Mcf	unit of volume equal to one thousand cubic feet
MICP	mercury injection capillary pressure
mD	millidarcy
MD	measured depth
MES	Milestone Environmental Services, LLC
mg	milligram
mg/L	milligram per liter
MICP	mercury injection capillary pressure
Midstream companies	operate the pipeline and gathering or transmission facilities that move the gas from the well (upstream) to our homes and businesses (downstream).
Milestone	Milestone Carbon Midland CCS Hub, LLC
mi	mile(s)
MIT	mechanical integrity test
mm	millimeter
MMscf/d	million standard cubic foot per day
MMt	million metric tonne
MMta	million metric tonne per annum (year)
MMT/yr	million tonne per year
mol%	mole percent
MPa	megapascal

Glossary of Acronyms, Abbreviations and Terms for All Permit Sections: 1-12	
Acronym / Abbreviation / Term	**Definition / Meaning**
MPSI	million pounds per square inch
MRV	monitoring, reporting, and verification
MS	mass spectrometry
MSIP	maximum surface injection pressure
MVA	monitoring, verification, and accounting
MWD	measurement while drilling
Mya	millions of years ago
n	exponent in the relation to water saturation
nD	nanodarcy
nm	nanometer
NMR	nuclear magnetic resonance
NPL	EPA's Superfund NPL: National Priorities List of sites of national priority among the known releases or threatened releases of hazardous substances, pollutants, or contaminants throughout the United States and its territories
NU	nipple up
NW	northwest
O_2	oxygen
P&A	plug and abandon
PBR	polished borehole receptacle
PEF	photoelectric factor
PISC	post-injection site care
PNL	pulsed neutron log
POD	points of diversion
ppb	parts per billion
ppf	pound per foot
ppg	pound per gallon
ppm	part per million
ppmv	part per million volume
PSD	prevention of significant deterioration
psi	pound per square inch
Psi/ft.	pound per square inch per foot
P/T	pressure/temperature
QA	quality assurance
QASP	quality assurance and surveillance plan
QC	quality control
QCSP	quality control and surveillance plan
RCRA	Resource Conservation and Recovery Act
RST	reservoir saturation tool
RRC	Railroad Commission of Texas
RU	rig up
R_w	resistivity of water
RWP	rated working pressure
§	typographical character for referencing individually numbered sections
sc-CO_2	supercritical CO_2
SAU	storage assessment unit, a USGS term related to CO_2 storage resources
SCADA	supervisory control and data acquisition
sDAS	seismic distributed acoustic sensing
SDRDB	Submitted Drillers Reports Database (a TWDB database on water wells)
SGS	sequential gaussian simulation
SIS	sequential indicator simulation
SMEs	subject matter experts
[redacted]	[redacted]
SP	spontaneous potential
Sq. mi	square mile
SWC	sidewall coring
TCEQ	Texas Commission on Environmental Quality
TCEQ Central Registry	provides a centralized location for core information about those TCEQ regulates, such as company names, addresses, and telephone numbers

Glossary of Acronyms, Abbreviations and Terms for All Permit Sections: 1-12	
Acronym / Abbreviation / Term	**Definition / Meaning**
TD	total depth
TDS	total dissolved solids
TEC	tubing encapsulated conductor
TF	task force
TIC	total inorganic carbon
TIH	trip in hole
TOC	total organic carbon
Top Seal	[redacted] interchangeable with Upper Confining Layer
TRI	toxic release inventory
TSDF	treatment, storage, and disposal facility
TVD	true vertical depth
TVDSS	true vertical depth subsea
TWDB	Texas Water Development Board
uD	microdarcy
UIC	underground injection control
ug/m^3	micrograms per meters cubed
Upper Confining Layer	[redacted] interchangeable with Top Seal or Upper Confining Unit or Upper Confining Zone
UCL	Upper Confining Layer
Upper Confining Unit	[redacted]
USD	U.S. Dollar
USDW	underground source of drinking water
USGS	U.S. Geological Survey
USIT	ultrasonic imaging tool
UST	underground storage tank
VCP	vertical proportion concentration
VSP	vertical seismic profile
VTI	vertically transverse isotropy
XRD	x-ray diffraction

1.0 SITE CHARACTERIZATION [40 CFR 146.82 (a);] [40 CFR 144.31(e)(1-6)]

1.1 Facility Information [40 CFR 146.82 (a)(1)]

Facility Name:	[redacted] Dusek CCS #2 Well
Facility Contact:	[redacted]
Well Location:	[redacted] Upton County, Texas [redacted] TRCC District 7C
Facility Address: (Injection Well)	Milestone Environmental Services – [redacted]
Owner and Operator Information:	Milestone Carbon Midland CCS Hub, LLC 15721 Park Row Suite 200, Houston, Texas 77084 Front Desk Phone: 832-739-6700 Privately Held Delaware Limited Liability Corporation
SIC Codes:	4953 – Refuse Systems 8999 – Environmental Consulting

For the purposes of this permit application, the following terms and their relationship to the proposed Class VI well application are as follows:

- Milestone Carbon Midland CCS Hub, LLC (Milestone) – The Operator and "Operational Area" (including the Facility and the Well)
- [redacted] – The "Facility"
- Dusek CCS #2 – The Injection "Well"
- Dusek AZM #2 – The Above Zone "Monitoring Well"
- Dusek USDW #2 – Underground Source of Drinking Water "(USDW) Monitoring Well"
- Injection Interval – [redacted] (**Section 1.5**)
- Injection Unit – [redacted]

1.2 Project Introduction [40 CFR 146.82 (a)(1)]

Milestone Carbon Midland CCS Hub, LLC (Milestone) is submitting this application to authorize the construction and operation of a Class VI Underground Injection Control (UIC) well in Upton County, Texas. [redacted]

Milestone has extensive experience with slurry injection and landfill operations associated with energy waste in Upton County, Texas. Accordingly, Milestone understands both the technical and regulatory obligations associated with responsibly managing project operations in this area. This Application demonstrates how Milestone will meet all applicable regulatory and monitoring requirements associated with the proposed Class VI Well in order to protect underground sources of drinking water (USDW) during pre-construction, pre-injection, operation, and post-injection periods.

Objectives and Benefits of the Well include:

1. Climate Change Mitigation: Natural gas combustion accounts for 22% of the world's greenhouse gas (GHG) emissions. Sequestering the carbon dioxide (CO_2) related to these emissions will help mitigate GHG effects on climate change. The Permian Basin, as one of the largest oil and gas producing provinces in the United States, emits approximately 60 million metric tonnes (MMta) of CO_2 annually (IEA, 2020 Report).

2. Energy Security: The Facility will help to ensure energy security by enabling the continued use of fossil fuels while reducing GHG. The Texas electricity market has one of the narrowest supply vs demand ranges in the USA. Therefore, disruptions in energy can have catastrophic effects on property and life in the state (Electric Reliability Council of Texas (ERCOT) Website, 2023).

3. Economic Development: The Facility will support economic development by creating new jobs in the area related to construction, including injection well, monitoring well, pipeline, and capture facility construction. Additional oil and gas service industry jobs related to monitoring such as seismic acquisition and well logging will be created/retained.

4. Technological Advancement: [redacted] Novel techniques and process efficiencies are likely to be discovered during injection and monitoring operations.

Milestone proposes to inject 1 million metric tonnes of CO_2 per year (1MMta) at the Well, at a rate of [redacted]. There is a total of 4.6 MMta of emissions within a radius of 30 miles (Emissions Source: Enverus, 2023). A summary of operational parameters can be found in **Table 1**.

Milestone will be the owner and operator of the Well and Facility. It is anticipated that collaborators (i.e., sourcing companies) will include Midstream companies who are capable of developing, constructing, and maintaining sub-surface pipelines to the Facility. At the time of this submittal, the pool of emitters and pipeline companies is not finalized.

An Aquifer exemption will not be required. The Railroad Commission of Texas (RRC) Groundwater Advisory Unit (GAU) provides Groundwater Protection Determinations for surface casing, underground injection and other underground activities. [redacted] Additional information on local aquifers, salinity, and water chemistry is detailed subsequently in **Sections 1.4, 1.9** and **1.11**.

The project is not located on, or near, Indian lands or Indian reservations. The nearest Indian reservation is the Mescalero Apache reservation, located in New Mexico. The reservation is located over 220 mi northwest (NW) from the calculated area of review (AoR).

Milestone holds no known prior Resource Conservation and Recovery Act (RCRA), Federal UIC, National Pollution Discharge Elimination System (NPDES) or Prevention of Significant Deterioration (PSD) permits.

A list of applicable federal, state and local contacts within the AoR can be found in **Table 2** [40 CFR 146.82(a)(20)]. A list of non-UIC federal, state and local permits can be found in **Table 3** [40 Code of Federal Regulation (CFR) 146.82 (a) (1)]

[redacted]

Proposed Property	Comment
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

Table 2: Contact Information for Key Local, State and Other Authorities [40 CFR 146.82(a)(20)]

Agency	Phone Number
Upton County Sheriff's Office	432-693-2422
Texas State Police	512- 424-2000 (HQ, Austin) 432-498-2140, Midland
Texas Dept. of Public Safety 24-hour non-Emergency	800-525-5555
Texas Dept. of Transportation	800-558-9368
Texas Division of Emergency Management agency:	512-424-2208
Texas Commission of Environmental Quality / Water Division:	512-239-6696
Texas Commission of Environmental Quality UIC Program Office:	512-239-6466
The Railroad Commission of Texas 24-Hour Emergency reporting line	844-773-0305 (toll free) or 512-463-6788
The Railroad Commission of Texas UIC Program Office	512-463-6792
The Railroad Commission of Texas Ground Water Advisory Unit	512-463-6882

Table 3: Additional Federal, State and Local Permits Required for Project Completion [40 CFR 146.82(a)(1)]

Agency	Permit
Environmental Protection Agency (EPA)	Monitoring, Reporting and Verification Plan (MRV)
	Spill Prevention Control and Countermeasure Plan (SPCC)
	Environmental Management Plan
Texas Railroad Commission (RRC)	Operator Permit (P-5 and P-5A)
	Geologic Storage Facility Permit
	Permit to Drill (Form W-1)
	Notice of Completion (Form W-2 and G-1)
	Permit to Operate
Texas Commission on Environmental Quality (TCEQ)	Construction General Permit
Upton County	Permit for Installation of County Right of Way, Pipeline and Utility Crossings

1.3 Overview Maps of AoR [40 CFR 146.82(a)(2)]

Figures 1-5 show the proposed Well location, along with all pertinent items listed in 40 CFR 146.82(a)(2). Below, this information is broken out into various maps for ease of reference and discussion. An omnibus map encompassing every element in this section is found in **Section 1.3.5**.

1.3.1 Major Roads Nearby Injection Site

[redacted]

[redacted]

[redacted]

[redacted]

1.3.2 Mines, Superfund Sites, Quarries, Other Hazardous Sites

No RCRA, Mines, Toxic Release Inventory (TRI), leaking underground storage tanks (LUST) or Superfund sites exist within the AoR of the proposed Well location. One quarry is present within the AoR near the northern end of the site. Additionally, there are no cleanup sites within the AoR. [redacted] The quarry maintained an active aggregate production operation permit for limestone as well as active air compliance and stormwater permits.

[redacted]

See **Figure 2** for locations of active and inactive hazardous sites, Superfund sites, and mines in the region with respect to the injection well and AoR. Sites are noted by their type in the legend.

[redacted]

[redacted]

1.3.3 Map of Rivers, Springs, Wells, Other Water Features

Climate in Upton County is a *hot semi-arid* based on the Koppen climate classification (Beck, et al. 2018). There are limited natural water sources in the vicinity of the AoR. [redacted]

Wells are colored by data source and the shape is by proposed use. [redacted] Sample records are included in **Appendix H** (Section 12). Labels are TCEQ or TWBD Well ID and Owner Name.

[redacted]

[redacted]

1.3.4 Map of Oil and Gas and Injection Wells in the Area of Review (AoR)

[redacted] These include oil and gas wells, stratigraphic test wells, shut-in wells, inactive wells, plugged and abandoned wells, injection wells, and other wells within the AoR. [redacted]. The map is high resolution, zoom in for clarity and detail. Extensive additional information on wells is in **Section 3.4.** Wells are labeled by the last 6 digits of the American Petroleum Institute (API) # identifier. [redacted]

[redacted]

[redacted]

1.3.5 Omnibus Map [40 CFR 146.82(a)(2)]

The information contained in **Sections 1.3.1** through **1.3.4** is contained in the map in **Figure 5.** Deep penetrations are labeled at the surface location by the last 6 numbers of the API number identifier. [redacted] Methodology for AoR delineation is covered in detail in **Section 3.1** through **3.2.**

[redacted] No subsurface cleanup, Superfund, RCRA, USTs or other listed hazardous sites of any type are present within the AoR. No known faults are present within the AoR. No state, tribal or territory boundaries are present within the AoR. No mines or springs are present within the AoR.

[redacted]

[redacted]

1.4 Regional USDW Characterization and Hydrogeology [40 CFR 146.82(a)(3)(vi), 146.82(a)(5)]

This section describes the general vertical and lateral limits of all Underground Sources of Drinking Water (USDW), water wells and springs within the AoR, their positions relative to the injection zone, and the direction of water movement, where known.

[redacted]. See **Section 4** for a full description of casing sizes, depths and cement. [redacted]

The 2011 Aquifers of Texas report by the TWDB identified two potential aquifers in the vicinity of the proposed Well: The Dockum Aquifer and the Edwards-Trinity (Plateau) Aquifer (George, Mace and Petrossian, 2011). In Upton County, the principal source of drinking water is Cretaceous Edwards-Trinity aquifer, which is a shallow freshwater aquifer located at depths of 175-300 feet below the surface. This aquifer is recharged by rainfall and is used for domestic, agricultural, and industrial purposes in the county. The Edwards Trinity aquifer is part of the High Plains aquifer system which contains significant groundwater resources. [redacted]

The High Plains Aquifer System in Texas consists of the southern and northern portions of the major Ogallala Aquifer and the minor Rita Blanca, Edwards-Trinity (High Plains), and Dockum Aquifers. Only the Edwards Trinity and Dockum are present in Upton County. [redacted].

The Fredericksburg, Washita and quaternary deposits exist above the Trinity but have not been known to yield sufficient quantities of water to be considered an aquifer (**Table 4**). According to the TWDB, Upton County does not fall within any current Underground Water Conservation Districts (UWCDs).

1.4.1 Dockum Group

[redacted]

The water quality in the aquifer is generally poor and very hard (**Fig. 7**). Naturally occurring radioactivity from uranium present within the aquifer has resulted in gross alpha radiation in excess of the State's primary drinking water standard in about 25 percent of Dockum Aquifer wells. Radium-226 and -228 also occur in amounts above acceptable standards. Nitrate is present at concentrations exceeding primary drinking water standards in about 10 percent of the wells, mostly in the outcrop areas, where it is associated with agricultural operations. Dockum Aquifer groundwater exceeds secondary drinking water standards for chloride, fluoride, iron, sulfate, and total dissolved solids in about one-third of the wells tested, primarily as the result of the evaporite minerals present in the Dockum Group and underlying formations of the Permian Basin.

The Dockum Group is composed of sandstones, conglomerates, mudstones, and siltstones. The Dockum Aquifer is overlain by the Ogallala Aquifer except in the outcrop areas along the Canadian and Colorado Rivers where the Ogallala has been eroded away. Permian System Ochoan series red-bed shales underlie the Dockum Aquifer, forming a no-flow lower boundary.

Table 4: Upton County Aquifers

Description of the known aquifers in Upton County and surrounding formations. Texas Water Development Board, Report 78, 1968

ERA	SYSTEM	SERIES	GROUP	STRATIGRAPHIC UNIT	APPROXIMATE MAXIMUM THICKNESS (FT)	CHARACTER OF ROCKS	WATER-BEARING CHARACTERISTICS
Cenozoic	Quaternary	Recent to Pleistocene		Alluvial and eolian deposits	200	Caliche, clay, sand and gravel. Locally mantled with windblown silt and sand.	Yields small quantities of fresh to slightly saline water to live-stock and domestic wells along stream courses in the southern and western parts of the county.
Mesozoic	Cretaceous	Comanche	Washita		250	Massive to thin-bedded lime-stone and calcareous clay and marl.	Not an aquifer in Upton County.
			Fredericksburg	Kiamichi Formation Edwards Limestone Comanche Peak Limestone	270	Calcareous clay, marl, and pale gray to yellowish-brown mas-sive, nodular, fossiliferous limestone. Yellowish-brown argillaceous limestone at base.	All strata are above the water-table except near the south-eastern edge of Upton County where the lower beds yield small quantities of fresh water from joints and fractures to a few wells.
			Trinity	Trinity Sand	275	Buff to gray, fine- to medium-grained sand and sandstone interbedded with subordinate amounts of red, gray, and pur-ple shale. Fine gravel at base in some areas.	The principal aquifer in Upton County. Yields small to moderate quantities of fresh to slightly saline water to several hundred wells.
	Triassic		Dockum	Chinle Formation equivalent	570	Brick-red to maroon and purple shale; thin discontinuous beds of red or gray sandstone and siltstone.	Yields small quantities of fresh to moderately saline water to wells in the western and south-western parts of the county.
				Santa Rosa Sandstone	560	Reddish-brown to gray, medium-to coarse-grained, micaceous, conglomeratic sandstone inter-bedded with shale.	Yields small quantities of slightly to moderately saline water to shallow wells in the southwestern part of the county. Small to moderate quantities of moderately to very saline water have been pumped from deep wells in the northern part of the county.
				Tecovas Formation	270	Red shale, siltstone, and fine-grained sandstone.	Not known to yield water to wells in Upton County.

ERA	SYSTEM	SERIES	GROUP	STRATIGRAPHIC UNIT	APPROXIMATE MAXIMUM THICKNESS (FT)	CHARACTER OF ROCKS	WATER-BEARING CHARACTERISTICS
Paleozoic	Permian	Ochoa		Dewey Lake Redbeds	230	Thin-bedded siltstone and gypsum.	Not known to yield water to wells in Upton County. Probably capable of yielding small amounts of moderately saline water in the southwestern part of the county.
				Rustler Formation	150	Anhydrite, dolomite, and lime-stone interbedded with sand and shale.	Not known to yield water to wells in Upton County. Probably capable of yielding small amounts of moderately saline to very saline water.
				Salado Formation	850	Salt (halite), anhydrite, sylvite and polyhalite.	Not known to yield water to wells in Upton County.
		Guadalupe	Artesia	Tansill Formation Yates Sandstone Seven Rivers Formation Queen Formation	2,050	Dolomite, anhydrite, sand-stone, shale, and some salt.	Not known to yield water to wells in Upton County. Probably capable of yielding small amounts of very saline or brine water.
				Grayburg Formation	270	Tan to brown dolomite. Fine- to medium-grained sandstone with subordinate amounts of bentonite and anhydrite.	Yields small quantities of moderate to very saline sulfur water in conjunction with oil.
		Guadalupe and Leonard		San Andres Limestone	1,100	Limestone and gray dolomite with sandstone and inter-bedded black shale.	Yields moderate quantities of a sulfurous brine to wells for waterflood operation in the northern part of the county.

1.4.2 Trinity Aquifer

[redacted]

In Upton County, the Trinity Sand outcrops in a narrow band at the base of the irregular but generally continuous escarpment that marks the dissected perimeter of the Edwards Plateau. The formation is exposed near the base of several isolated mesas and buttes in the southwestern part of the county.

The Trinity Sand consists of buff-to-gray, fine-to-medium-grained, cross-bedded quartz sand and sandstone interbedded with lesser amounts of red, gray, and purple shale. A fine gravel occurs locally at the base of the formation. In some places, the sand is tightly cemented; in other places it is loose or poorly cemented and commonly is referred to as "pack sand" by local drillers.

The Trinity Sand dips southeasterly at an average rate of about 10 feet per mi. In most of the northeastern half of the county, the top of the formation ranges from 60 to 150 feet below the land surface; however, in the southern and southwestern parts of the county, where the topography is very irregular, the top is as much as 450 to 500 feet below the summits of the highest mesas and ridges.

Figure 6 shows the subsurface and outcrop extents of the Edwards-Trinity (Plateau) freshwater aquifer. The fresh saturated thickness of the aquifer is ~100 feet to the north and increases to over 800 feet AS down-dip to the south is followed (Bruun et al, 2016).

[redacted] ater in the unconfined Trinity Group is generally fresh but salinity increases to the west where upper confinement is present within the overlying Edwards Group (Bruun et al, 2016).

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

1.4.3 RRC GAU and TWDB Data

[redacted] The depths in this paragraph come from a review of the GAU determinations in RRC records for nearby oil and gas wells.

Milestone submitted an additional request to the GAU for a determination of base of USDW; [redacted] (GAU Determination letter, **Appendix I**).

Given the lack of continuous measurements in the AoR, there is no data on the direction of water movement. [redacted]

[redacted] A map of the total depth (TD) of all water wells in the AoR are shown in **Figure 9**.

[redacted]

1.5 Regional Geology [40 CFR 146.82(a)(3)(vi)]

[redacted]

[redacted] Upper Pennsylvanian and Permian Formations in the area are heavily penetrated with oil and gas activity and therefore unsuitable for carbon capture and underground storage (CCUS) injection.

Note: A more detailed treatise on Permian geology and regional background information is located in **Appendix F**. Please consult for detailed depositional, lithologic and structural information on all formations within the injection zone and top seals. This section of the permit is intended to briefly summarize the extensive volume of work that has been published on the Permian and [redacted] Basins over the past 120 years. However, the brevity in this section of the permit application, intended for ease of reading, should **not** be construed as a lack of material or extensive research.

[redacted]

Permian Basin

[redacted]

1.5.1 Stratigraphy

[redacted] Omitted from this column (since it is regional) are quaternary sands at surface then Cretaceous Trinity aquifer which is described in **Section 1.4** and is included in the USDW resources in the area (**Table 4**). [redacted]

The Dockum is the lowest known underground source of freshwater but the Trinity is the primary aquifer for Upton County. Below the aquifer zones, and forming a no flow boundary, are the Ochoan aged Permian Sands such as the Rustler and Dewey Lake. [redacted] Below the Permian sands the Permian and Guadalupian aged Artesia group is found. The Artesia Group is from Tansill-Grayburg Formations.

Next is the San Andres Formation, a prodigious waste-water injection zone that has been used continuously in the region since at least 1978, followed by the Leonardian aged Spraberry and Dean Formations.

Below the Dean is the Wolfcamp Formation. [redacted]

Below the Wolfcamp starts the Pennsylvanian section of rock. The Pennsylvanian aged Cisco and Canyon form a sequence of argillaceous shales and the Strawn and Atoka are predominantly carbonate benches. Following this, the Upper Mississippian Barnett Shale is present, which is equivalent to the Barnett Shale in the Fort Worth Basin. This is underlain by the organic Woodford Shale (**Fig. 11**). [redacted]

Finally, at the base of the section right above basement, is the Cambrian Bliss sand.

[redacted] Details of the injection schedule can be found in **Section 2** and **Section 4.**

Stratigraphic charts found in **Figures 11-12** with injection units, full injection interval and upper confining layers noted on each. A type log showing the formations from surface to basement can be found in **Figure 23** and a type log focused on only the seals and injection units can be found in **Figure 49**.

[redacted]

[redacted]

[redacted]

1.5.2 [redacted]

[redacted]

1.5.2.1 [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

1.5.3 [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

1.5.6 Major Geologic Features and Description on Tectonic History

The Permian Basin is composed of several sub-basins, each with its own unique characteristics (**Fig. 10**). The Delaware Basin is located in the western part of the Permian Basin and is known for its thick organic-rich source rocks and stacked reservoirs, making it a significant oil and gas producing region. The Midland Basin is located in the eastern part of the Permian Basin and is characterized by relatively few faults and fractures.

The Central Basin Platform is a relatively flat area that separates the Delaware and Midland Basins and contains several oil and gas fields, including the famous Yates Feld. The Northwest Shelf is the northernmost portion of the Permian Basin and is primarily a gas-producing area, while the Eastern Shelf is located in the southeastern part of the basin and contains a mix of oil and gas fields. Overall, the Permian Basin is a complex and diverse petroleum province with a long history of hydrocarbon production and several crustal blocks with different tectonic histories.

Hills (1970) used subsurface data to suggest the possibility of extensive lateral displacement along pre-Permian faults in the Permian Basin. Hills' primary objective was to determine the direction of tectonic forces responsible for regional deformation. Hills interpreted two tectonic systems. The first consists of folds and faults possessing orientations of N35W (folds) and N55-80E (right lateral faults), and N50-65 W (left lateral faults). The age of this deformation is thought to be early Late Mississippian to late Middle Pennsylvanian. There also are a series of NNW-trending faults that appear to be right lateral systems with larger displacement that formed synchronous with the other faults. It is this system of conjugate faults that has been interpreted to control the jagged geometry of the Central Basin Platform, especially along its eastern margin (**Fig. 17**) (T. Hoak et al. 1998).

A second, later deformation phase as interpreted by Hills (1970), is marked by the relaxation of stress and normal fault motion reactivation of older fault systems. The timing of this deformation is interpreted to be middle-to-late Permian in age and fault displacements relatively minor.
Finally, during the Tertiary, the western margin of the Permian Basin was uplifted, and Basin-and-Range tectonism commenced in this area. This deformation has apparently been restricted to the western Delaware Basin and the basin margin (T. Hoak et al. 1998).

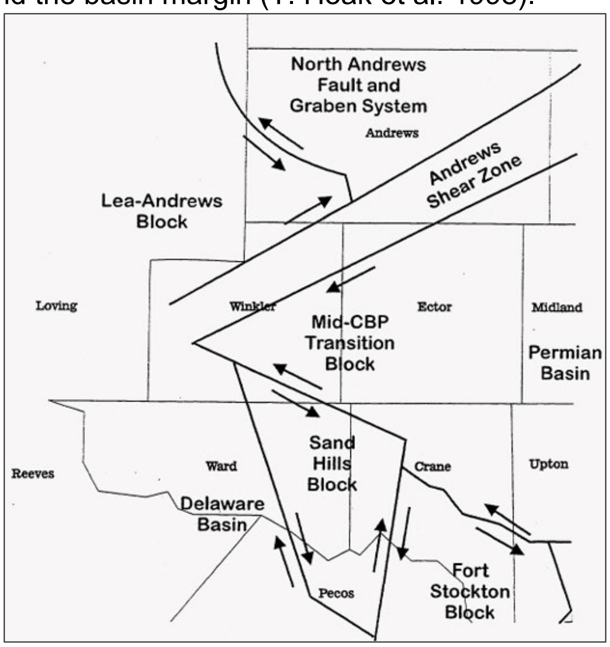


Figure 17: Interpreted crustal blocks
Interpreted crustal blocks from Gardiner (1990). After (T. Hoak et al. 1998). [redacted]

Hills (1985) describes the eastern boundary of the Midland Basin as possessing little evidence of tectonism. Instead, the Eastern Shelf is largely a stratigraphically controlled boundary with rocks of the Pennsylvanian-Permian-age carbonate shelf dipping gently westward into the basin.

The Midland Basin area is a large area (>-6,000 square miles) that is dominated by small NE and NW-trending faults and related folds. All structures are similar in style but smaller in size to those seen in the Mid-CBP Transition Zone. The majority of uplift occurred prior to the Mississippian with isolated fault block movement during Barnett-Strawn time. Since that time, the region has experienced regional subsidence.

Gardiner (1990) outlined the boundaries of six "crustal" blocks that are roughly 40 mi on their longest dimension (**Fig. 17**). The boundaries of these blocks represent major discontinuities that separate zones of distinct or different structural orientations and /or structural styles.

The Mid-CBP Transition Block is an area of ~ 600 square mi dominated by NW-trending reverse faults in the northern area (including Gandu Unit) and NW-trending reverse faults in the southern area. Both areas contain less dominant NE-trending normal faults. There is a NE-trending sag corresponding to the center of the area.

[redacted]

1.6 Local Geology Introduction

The following **Sections 1.7** through **1.12** discuss the local geology around the proposed Well.

- Section 1.7 – Structural Geology - Thickness, Lithology
- Section 1.8 – Faults and Fractures – Faults and Fractures, Seismic History, Regional Stress
- Section 1.9 – Petrophysical Characterization – Porosity, Permeability, Salinity, Cap Pressure
- Section 1.10 – Geomechanics – Stress Magnitude, Orientation, Strength, Ductility, Pressure
- Section 1.11 – Geochemistry – Brine-CO_2 Interactions, Mineral-CO_2 interactions
- Section 1.12 – Mineral Resources – [redacted]

[redacted]

Fifty-six (56) wells that penetrate deeper than the [redacted] were used to calculate these maps. The [redacted] Therefore, many wells hit 'total depth' in the [redacted] causing deep logs to be relatively sparse in an area with many penetrations. [redacted]

Faults are sourced from a variety of academic sources including Hoak et al. (1998) who interpolated seismic, gravity and magnetic data.

The Well location is noted on each map and cross section for reference, typically as a "red star."

1.7 Structural Geology [40 CFR 146.82 (a)(3)(iii)]

[redacted]

[redacted]

[redacted]

[redacted]

All of the formations below the [redacted] are regionally extensive, conformable and cover both Upton and Midland Counties. [redacted]. Some thinning of the [redacted] is observed across the area (**Figures 19-22**) but all three formations are present in all wells that penetrate deep enough to be observed. [redacted]

[redacted]

Interpolated depths at the proposed Facility are displayed in **Table 5**. These depths were interpolated from offset log data and will be updated as more information such as seismic becomes available.

Figures 19 – 22 illustrate the subsea depth of the [redacted] mapped due to the scarcity of penetrations; [redacted]

[redacted]

[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	

[redacted]

[redacted]

[redacted]

[redacted]

[redacted] *erval.*

[redacted] Oil and gas operators have been safely disposing of brine wastewater into the San Andres Formation at ~4,500 feet since at least 1978 (Lemons, C. et al, 2019).

[redacted] **Figure 23** shows a log from surface to basement with formations noted. [redacted]

1.7.1 Thickness

1.7.1.1 [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

1.7.1.2 [redacted]

[redacted]

[redacted].

1.7.2 Cross sections

Two cross sections were prepared: **Figures 28** and **29**. The first cross section, (**Fig. 28**), is from west-to-east across Upton County. The second cross section, (**Fig. 29**), is from north to south across Midland County and Upton County.

A base map showing the paths of each cross section is shown in (**Fig. 30**). The distance between wells is generally 6 mi or greater. [redacted]

In the west-to-east cross section A-A' in **Figure 28**, there are several observations worth noting. [redacted]

[redacted]

[redacted].

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted].

[redacted]

In reference to the north-south cross section B-B' in **Figure 29**, there are several observations worth noting in this cross section. [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

1.7.3 Lithology

[redacted] Facies were discretized using well logs with Photoelectric factor (PEF) curves and referenced to available core data described in literature. [redacted] **See Section 1.5** and **Appendix F** for additional lithologic information and geologic background.

[redacted]

Relative proportions of each facies comprising each zone within the AoR are summarized in **Figure 31.** [redacted]

[redacted]

[redacted]

1.8 Faults and Fractures [40 CFR 146,82 (a)(3)(ii)]

This section addresses data regarding faults and fractures in the seals and injection units as well as the seismic history of area. [redacted]

1.8.1 Known Faults and Fractures

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

There is little pattern or orientation to the fracture systems. No preferred orientation has been observed. This is likely due to the chaotic nature of karst collapse features with the additional overprint of some tectonic fracturing in the ancient Tobosa Basin.

Shales form an upper boundary to the fracturing and natural fractures are not expected to penetrate the [redacted]

[redacted]

[redacted]

The most prominent unknowns regarding the fractures are the quantity and depth range of fracturing at the proposed wellsite. [redacted]

[redacted]

A workflow has been developed for [redacted]ocks using 3-D seismic that has been proven effective in the Fort Worth Basin[redacted]was able to show that [redacted] correlated to [redacted] that were identifiable on 3-D seismic (**Figures 35** and **36**).

Horizons were mapped only where the reflection was distinct and continuous [redacted] Intervening low-amplitude, chaotic reflections are assumed to be [redacted]

These areas correlated strongly with observed image log data in the Fort Worth Basin (**Fig. 36**). [redacted]

[redacted] This testing scheme detailed in **Section 4.9** through **4.10** should address any unknowns related to the fracture system at the injection location. This information will further be used to refine the static and dynamic simulation model to attempt to determine if the fractures cause any unusual geometries in the plume.

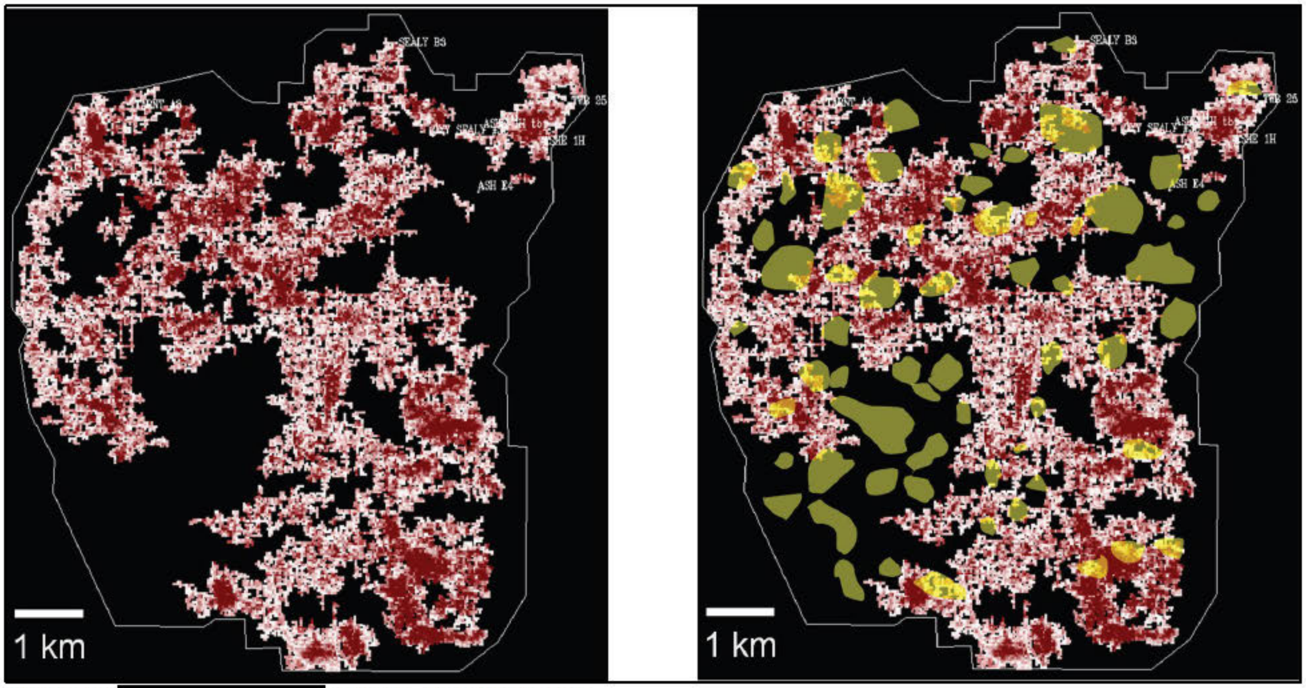


Figure 35: [redacted] **Horizon Amplitude Map**
From [redacted] *amplitude map extracted from an* [redacted] *horizon. The horizon was mapped only where the reflection was distinct and continuous* [redacted] *(Left) Intervening low-amplitude, chaotic reflections are assumed to be* [redacted]

1.8.2 Seismic History [146.82 (a) (3) (v)]

An important consideration in the design and development of all new injection well projects is the determination for the potential of injection activities to induce a seismic event. As shown in more detail below, there is a low probability that seismic activity will interfere with or adversely affect the proposed CCS project.

Studies completed by the United States Geological Survey (USGS) indicate there is a low probability of earthquake events occurring in the Midland Basin of west Texas that would cause damage to infrastructure with only 2-4 damaging earthquake events predicted to occur over a 10,000-year time period (**Fig. 37**) (Geological Survey, 2019).

A 1-year seismic forecast (including both induced and natural seismic events) released by USGS in 2016 determined west Texas has very low risk (less than 1% chance) of experiencing any natural or induced seismic events resulting in damage (USGS, 2016) (**Fig. 38**).

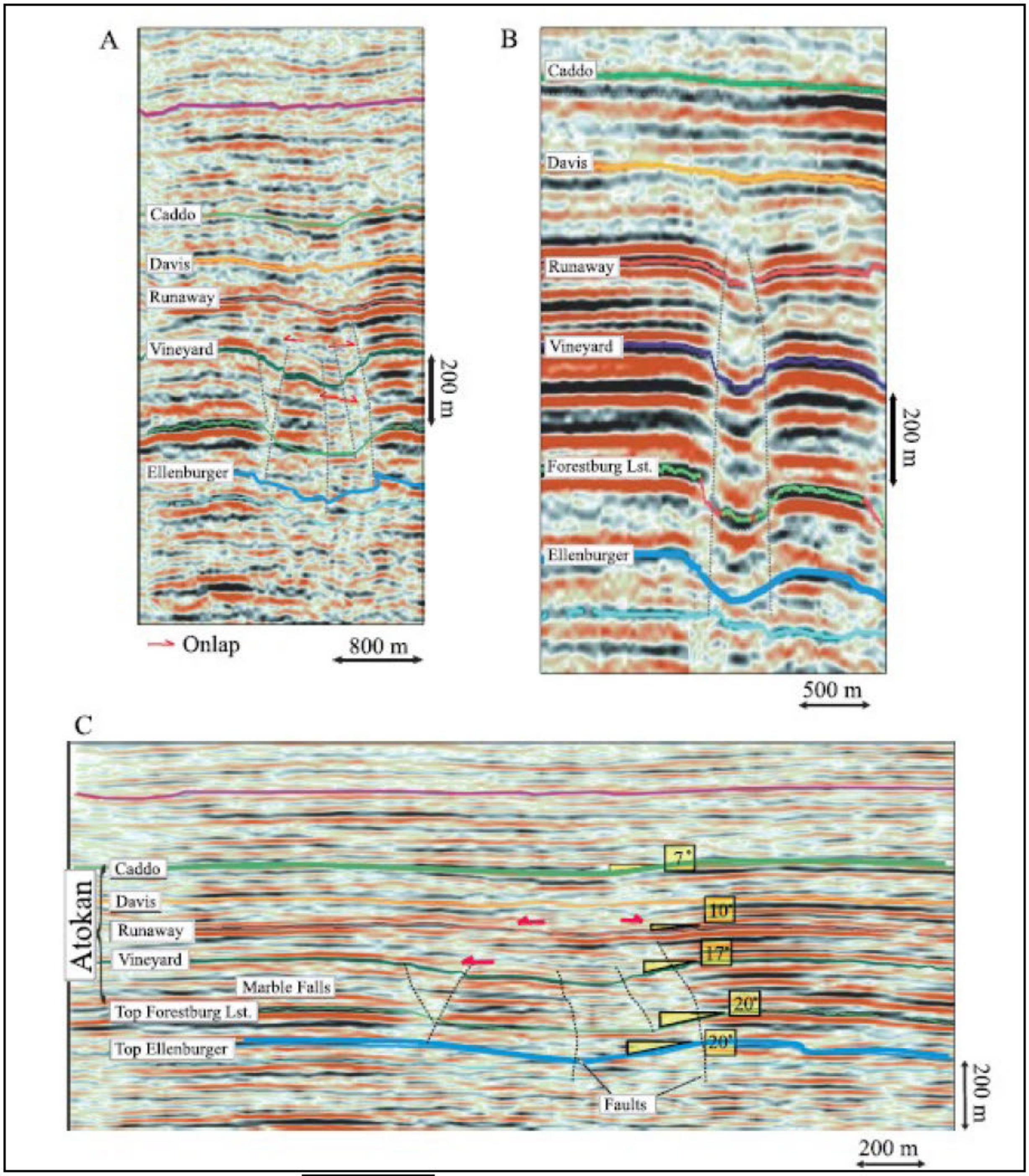


Figure 36: Seismic Cross Section / [redacted]

[redacted]

The Permian Basin is a tectonically stable region of the North American Craton. Most of the relatively larger earthquakes in Texas are associated with the major geological faults and uplifts (**Figure 39**). [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

1.8.3 Regional Stress

The stress regime and maximum horizontal stress orientation is well-studied and understood in west Texas area. **Figure 42** displays the regional stress map. [redacted]

1.8.4 Fault Slippage Potential Analysis

This section contains a fault slippage potential analysis to examine the potential of fault slippage caused by an increase in reservoir pressure due to CO_2 injection at the Well. [redacted]

1.8.4.1 [redacted]

[redacted] This model will be updated based on well testing results during the drilling and completion process of the Well.

[redacted] Smoothing may be due to lack of data in some areas. Ellenburger [redacted]

[redacted]

[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted] Refer to **Section 3.3** for additional details on changes in bottomhole pressure.

[redacted]

[redacted]

[redacted]

1.8.4.2 [redacted]

[redacted]

[redacted]

[redacted]

Table 7 shows the input parameters used in the [redacted]FSP model based on current understanding of the regional stress. This model will be updated based on well testing results during the drilling and completion process of the Well.

[redacted]

[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

1.8.5 Summary

[redacted]

This indicates stable geologic conditions in the region surrounding the potential injection site. [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

1.9 Petrophysical Characterization [40 CFR 146.82(a)(3)(iii)] [40 CFR 146.82(a)(3)(iv)]

This section includes a petrophysical characterization of the injection and confining zones and includes discussion on porosity, permeability, salinity, capillary pressure and related properties. [redacted]

1.9.1 Type Log

[redacted] This log was chosen due to a full suite of petrophysical curves including a photoelectric factor (PEF) curve. [redacted] Basement rock was not penetrated on this well.

From left to right:

- TRACK 1: Gamma ray and SP;
- TRACK 2: Depth;
- TRACK 3: Formation Tops;
- TRACK 4: Resistivity on log scale 0-2000, logarithmic scale;
- TRACK 5: Raw porosity curves such as neutron and bulk density, also photoelectric curve;
- TRACK 6: Caliper and density correction;
- TRACK 7: Calculated mineral volumes displayed in a cumulative basis:
- TRACK 8: Calculated true matrix porosity shaded by fluid type blue for free fluid, grey for bound fluid, red for hydrocarbons, the true porosity is scaled 20% on the left to 0% on the right;
- TRACK 9: Water saturation calculated from Indonesian equation scaled from 100%-0%, TRACK 10: Calculated matrix permeability on logarithmic scale, scaled from 0.01 mD to 10,000 mD.

[redacted] The kerogen curve is shaded brown in the mineralogy Track 7. Expected organic volumes are >10% in [redacted] This is consistent with regional data. Another item of interest is the change in mineralogy between the [redacted] is a mix of clastics, carbonate, illite and smectite, which is one reason it is has prevalent hole washouts on most logs in the region.

[redacted]

[redacted]

1.9.2 Porosity

[redacted] There are several reasons for this, the Paleozoic age of the rocks, the depth of the rocks and compaction plus the lack of overpressure.

[redacted].

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]	[redacted]				
	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

[redacted]

1.9.3 Permeability

[redacted]

[redacted] Thus, the lower limit is based on the unfractured matrix end member, but the upper limit of the system permeability is a function of [redacted]

[redacted]

A study by T. Sanchez et al. 2019, showed that the [redacted] could accept up to 100,000 bbls of brine disposal [redacted] (**Fig. 57**) (1MMta CO_2 ~ 17,000 Brine BBLs/D). This corresponds to the higher perm ranges of 100 mD reported by Loucks 2019 (**Fig. 56**). [redacted]

[redacted]

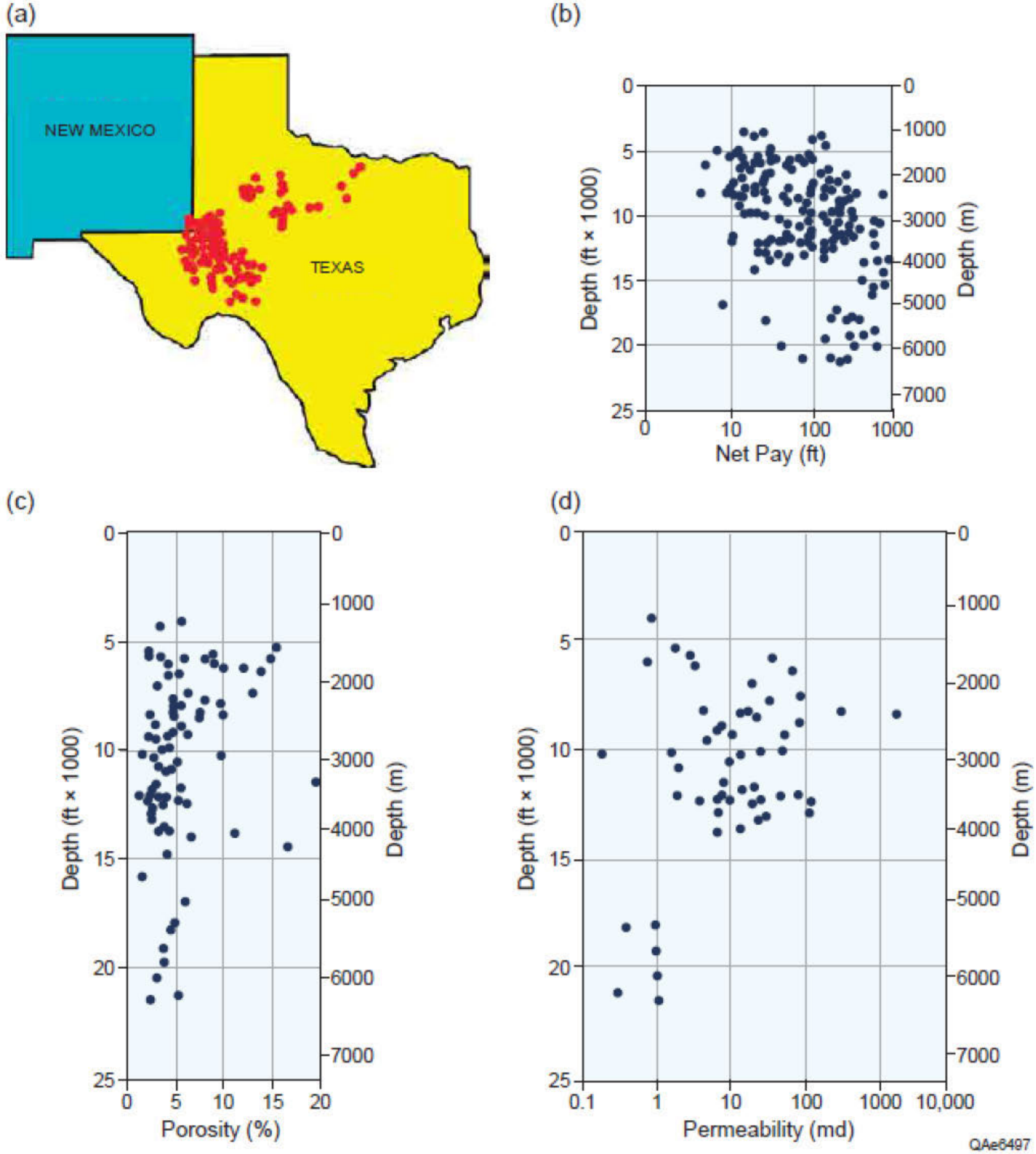


Figure 54: [redacted] Field Data

[redacted]

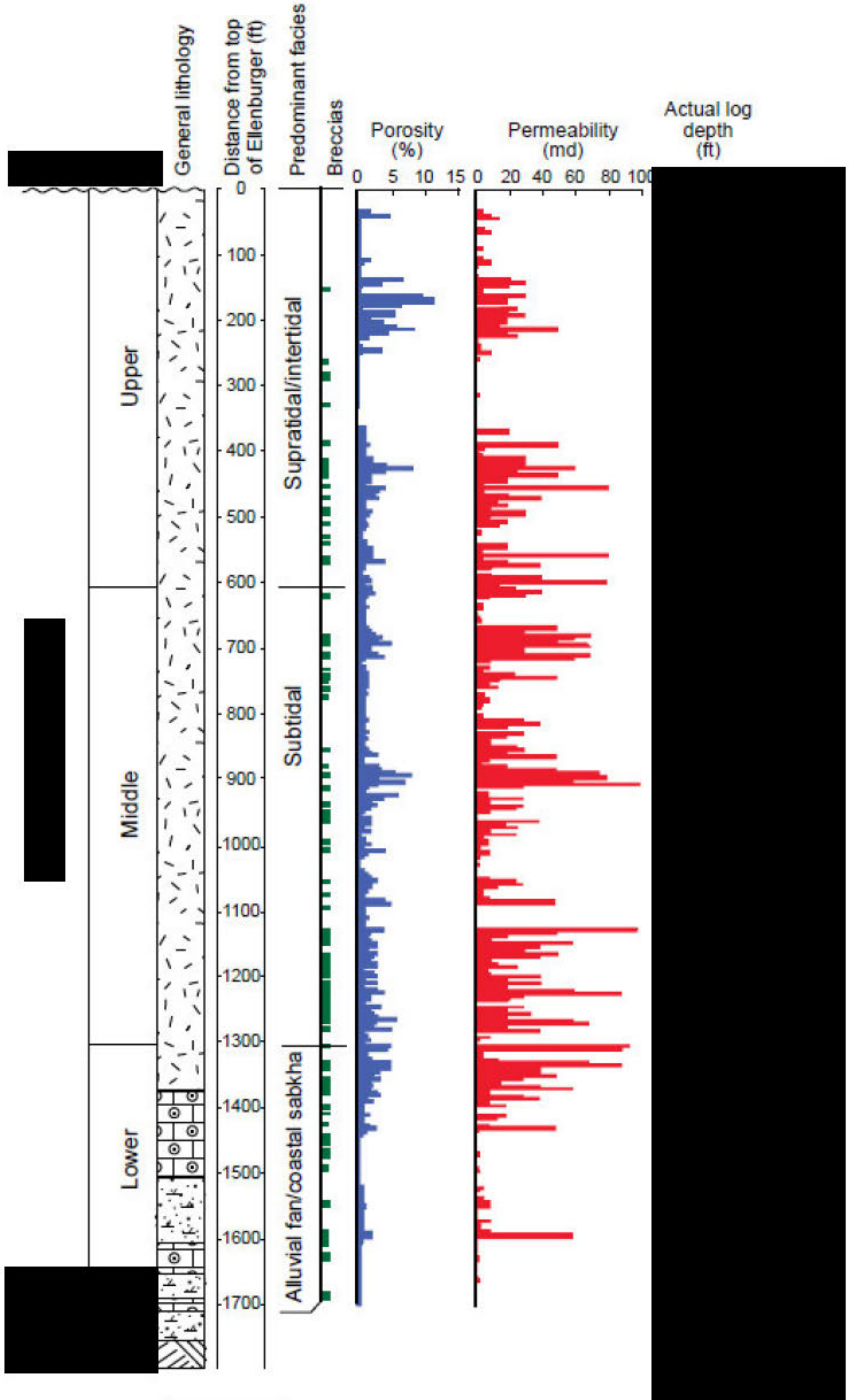
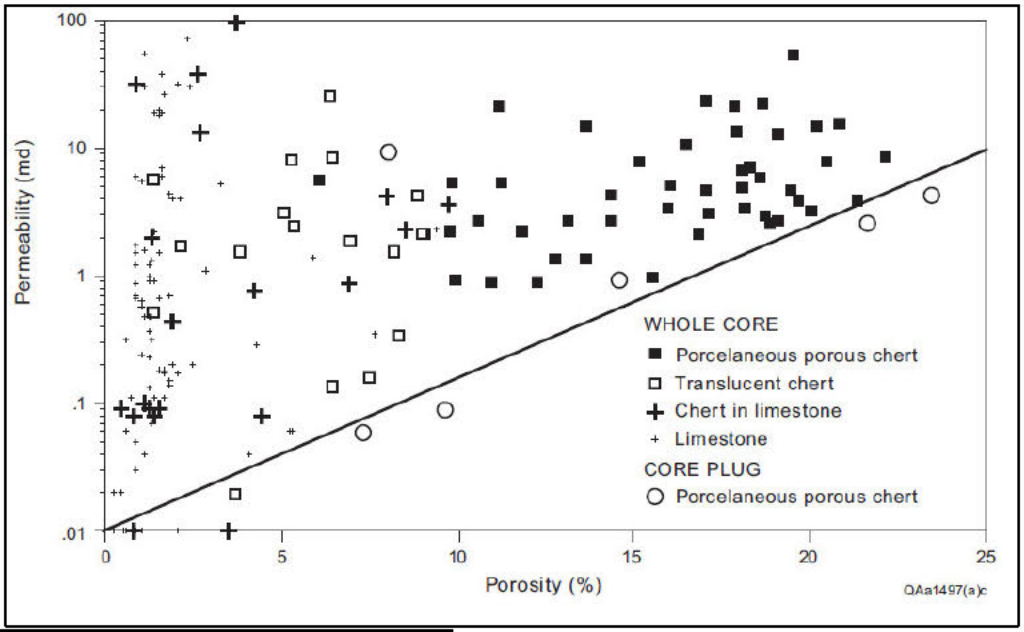


Figure 55: Permeability Ranges [redacted] **Formation**

[redacted]



[redacted]

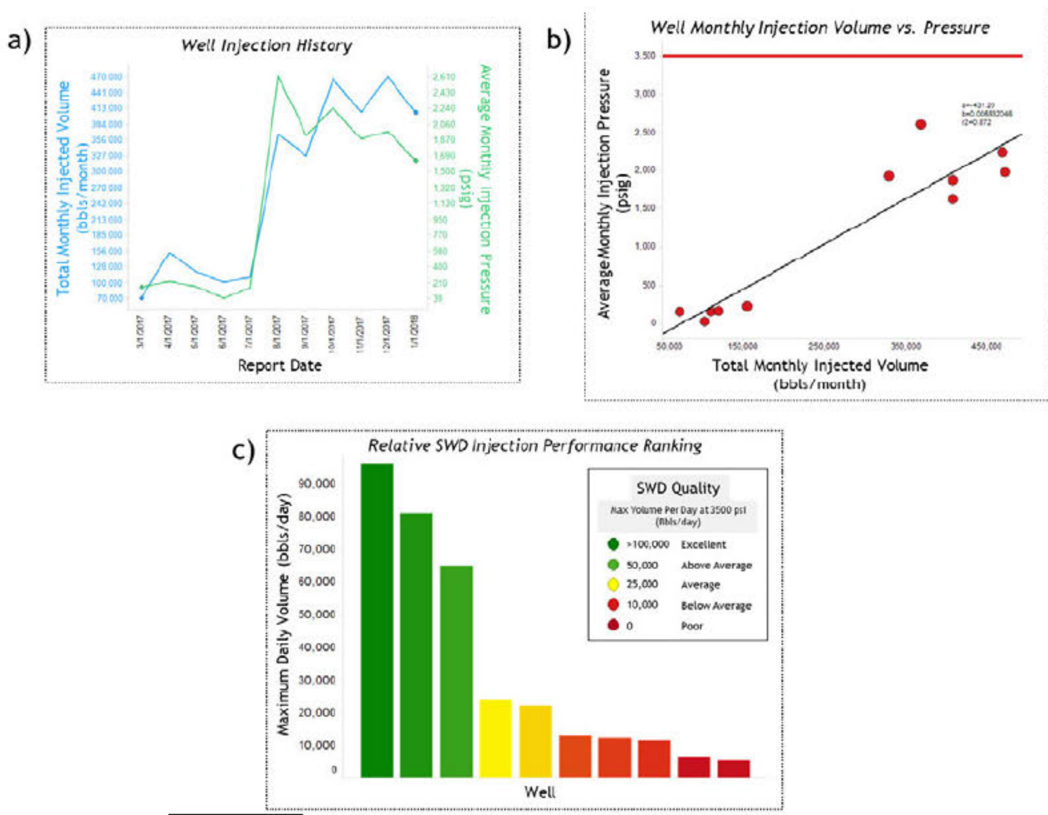


Figure 57: Injection Data [redacted] Wells

From Sanchez, 2019, proprietary injection data shows that fractured [redacted] wells can accept up to 100,000 bbls/month but unfractured rock is limited to less than 10,000 bbls/month. A) Example of Well injection history in [redacted] B) Plot of total monthly injection vs Injection pressure, C) Bar Chart of injection in bbls/d at 3500 psi injection

1.9.4 Salinity

[redacted] Offset data has a mean of 152,704 ppm (**Figure 59-60**), which is consistent with other [redacted] aged waters. (USGS Produced Waters Database) [redacted]

- [redacted]
- [redacted]
- [redacted]
- [redacted]

[redacted]

[redacted]

Figure 58: Pickett Plots

[redacted]

[redacted]

[redacted]

1.9.5 Capillary Pressure

Porosity and permeability data, but not full capillary pressure data, is available in the literature for [redacted]. After the initial test well, associated with the Well is drilled, more data will be collected. [redacted]

[redacted]

[redacted]

For the [redacted] Shale, published mercury injection capillary pressure (MICP) testing suggests that the threshold entry pressure is between 5-20 Kpsi. One complication of examining MICP data in organic shales is the pore structure is typically deformed before the mercury enters the pore system. This leads to a section of the MICP curve that is related to the bulk modulus of the shale and not actual intrusion [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

The importance of capillary pressure data cannot be understated. [redacted]

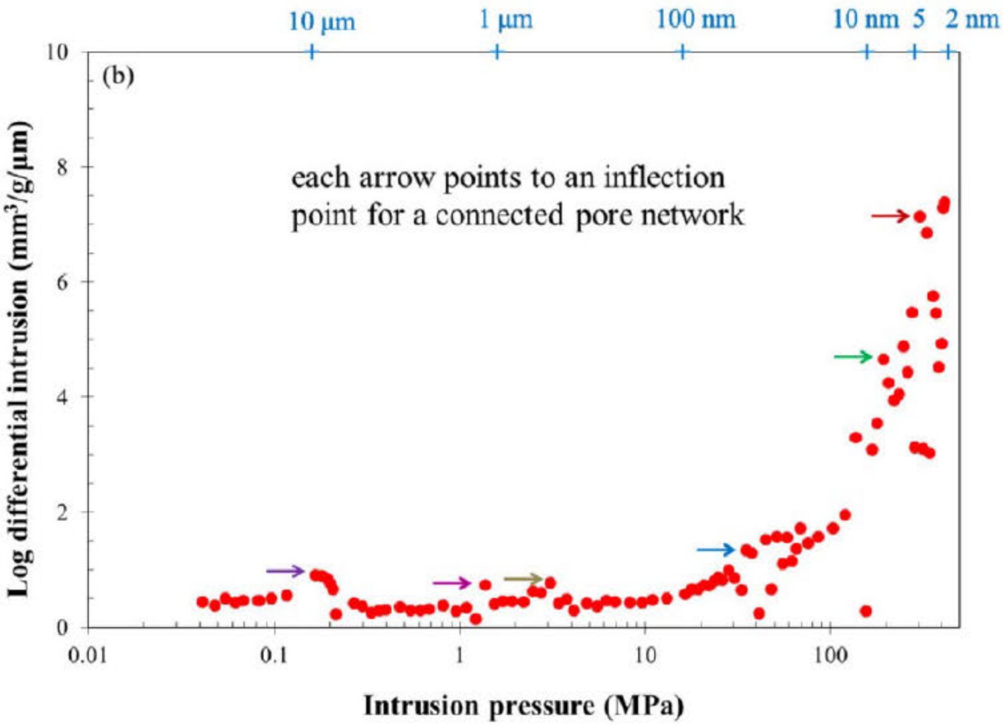


Figure 61: [redacted] **Capillary Pressure Test** [redacted]

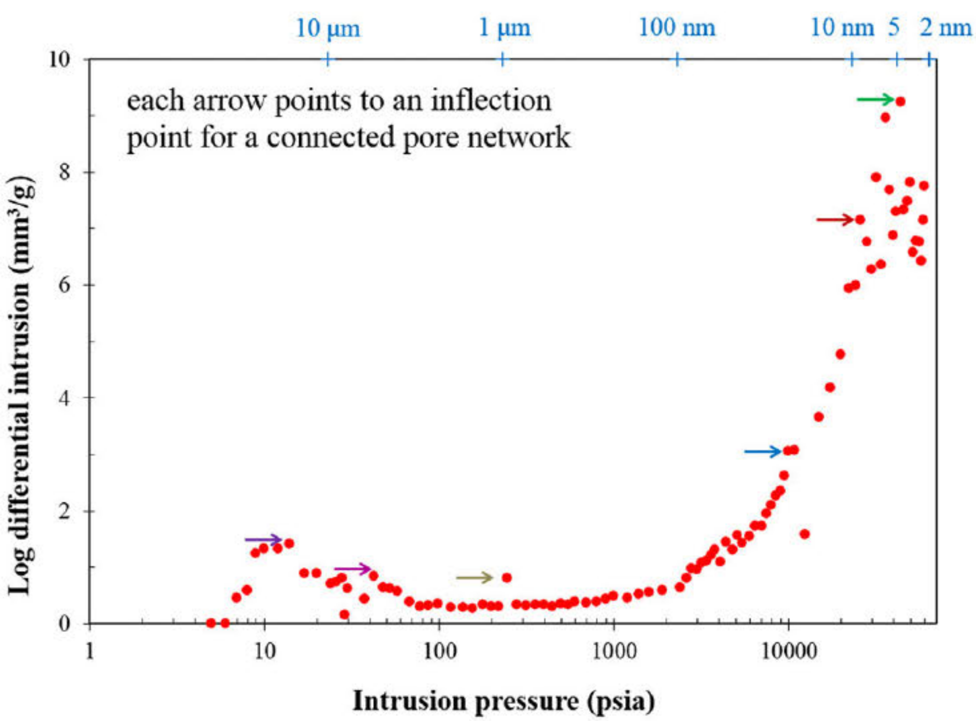


Figure 62: [redacted] **Capillary Pressure Test** [redacted]

1.10 Geomechanics [40 CFR 146.82(a)(3)(iv)]

[redacted]

1.10.1 Methods

Current geomechanical models for the project use offset dipole sonic data to calculate dynamic mechanical properties then published dynamic-static corrections to calculate the two Young's moduli (E_{11} and E_{33}) and three Poisson's ratio (v_{13}, v_{31} and v_{12}) at every foot of the wireline log. These dynamic properties can be used to determine stress magnitude, strength, and other properties. [redacted]

Modeling dynamic mechanical rock properties in a vertically transverse isotropy (VTI) medium requires characterization of five independent stiffness coefficients: C33, C44, C66, C11, and C13. Using the conventional Voigt notation, the 6×6 real symmetric definite positive stiffness tensor of a VTI medium with an axis of symmetry along the x3-axis is shown as follows: (Suarez-Rivera et al. 2009, Gu et al. 2016).

Matrix 1, VTI Symmetry

$$\begin{pmatrix} C_{11} & C_{12} & C_{13} & 0 & 0 & 0 \\ C_{12} & C_{11} & C_{13} & 0 & 0 & 0 \\ C_{13} & C_{13} & C_{33} & 0 & 0 & 0 \\ 0 & 0 & 0 & C_{44} & 0 & 0 \\ 0 & 0 & 0 & 0 & C_{44} & 0 \\ 0 & 0 & 0 & 0 & 0 & C_{66} \end{pmatrix}$$

with $C_{12} = C_{11} - 2C_{66}$.

$$C_{11} > 0; C_{33} > 0; C_{44} > 0; C_{66} > 0; C_{11} > |C_{12}| \text{ and } (C_{11} + C_{12})C_{33} > 2\,C_{13}^2 \quad (3)$$

Elastic properties are calculated as follows if the rock is isotropic or <10% calculated volume of clay (Gu et al. 2016)

$$E_{iso} = \frac{C_{44}(3\,C_{33} - 4\,C_{44})}{C_{33} - C_{44}};$$

$$\nu_{iso} = \frac{C_{33} - 2\,C_{44}}{2\,(C_{33} - C_{44})}. \quad (4)$$

If the rock is anisotropic, which is indicated by the volume of clay curve, then **(3)** and **(4)** are used in lieu of the isotropic versions. This is due to the change in Tensor matrix. The matrix shown in matrix 1, VT1 Symmetry, **(3)** assumes VTI symmetry (Gu et al. 2016). E_{vert} corresponds to E_{33}, E_{hor} corresponds to E_{11}, v_{vert} corresponds to v_{31}, v_{hor} corresponds to v_{12} and finally v_{hv} corresponds to v_{13}.

$$E_{vert} = \frac{C_{33}(C_{11}+C_{12})-2\,C_{13}^2}{C_{11}+C_{12}};$$

$$E_{hor} = \frac{(C_{11}-C_{12})(C_{33}(C_{11}+C_{12})-2\,C_{13}^2)}{C_{11}\,C_{33}-C_{13}^2};$$

$$v_{vert} = \frac{C_{13}}{C_{11}+C_{12}};\, v_{hor} = \frac{C_{33}\,C_{12}-C_{13}^2}{C_{33}C_{11}-C_{13}^2};$$

$$v_{hv} = \frac{E_{hor}}{E_{vert}}v_{vert}.$$

(5)

Once the elastic parameters are obtained minimum horizontal stress and strength are then calculated from the various Young's and Poisson's ratio. Stress is calculated using a modified Eaton equation using the notation from Theirciln and Plumb (1994).

$$\sigma_h - \alpha\, p_p = \frac{E_{hor}\, v_{vert}}{E_{vert}(1-v_{hor})}\left(\sigma_v - \alpha(1-\xi)\,p_p\right) + \frac{E_{hor}}{1-v_{hor}^2}\,\varepsilon_h + \frac{E_{vert}\,v_{hor}}{1-v_{hor}^2}\,\varepsilon_H$$

(6)

The difference between the isotropic and VTI case can be calculated from the following equation (Gu et al. 2016).

$$\frac{\sigma_h-\alpha\,p_p\,(\text{iso})}{\sigma_h-\alpha\,p_p\,(\text{VTI})} = \frac{C_{33}-2\,C_{44}}{C_{13}}.$$

(7)

Stress can also be calculated using an injection test to physically breakdown the rock. [redacted]

[redacted]

Shales – $UCS\ (MPA) = 7.22 * E(GPA)^{0.712}$ (Chang et. al. 2006)
Limestones – $UCS\ (MPA) = 13.8 * E(GPA)^{0.51}$ (Golubev and Rabinovich, 1976) (Chang et. al. 2006)
Dolomites – $UCS\ (MPA) = 25.1 * E(GPA)^{0.34}$ (Golubev and Rabinovich, 1976) (Chang et. al. 2006)

(8)

1.10.2 Pore Pressure

[redacted] The data shows that the pore pressure gradient below the [redacted] is <0.49 psi/ft and likely normally pressured at approximately 0.45 psi/ft as this is the P10 of the data. Mud-weights are generally higher than actual pore pressure.

A histogram of the data points in the area is shown in **Figure 63**. A map of the data points in the area is shown in **Figure 66**. [redacted] Pore pressure will be measured more accurately with a formation testing tool when data is collected after logging.

[redacted]

1.10.3 Stress Magnitude

The minimum horizontal stress magnitude, calculated from offset dipole sonic logs, and extrapolated to the proposed Well are detailed in **Table 10**. [redacted] Shale have been shown repeatedly in literature to be anisotropic with a VTI orientation to the anisotropic tensors. [redacted] This typically yields higher stress values consistent with testing due to the ratio of E_{vert} to E_{horz} at the beginning of the stress equation. [redacted]

Gradients are used since the depth is variable by location. [redacted]

[redacted]

[redacted]

The mechanical properties of the formation are constant with little variation seen within the [redacted] section. [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted].

[redacted]

1.10.4 Stress Orientation

[redacted] Most measurements put it at 80 from true N +/- 10 in a clockwise direction. World Stress Map data shown in **Figure 67** illustrates the consistent mostly E-W pattern of stress direction. This has been proven repeatedly by horizontal well development in the basin as well. [redacted] Moving farther west, on the Central Basin Platform, and in the Delaware, some rotation is observed to be related to the Guadalupe Mountains and past orogenic events. [redacted] There is high confidence based on repeated tests that the max stress orientation is oriented 80 +/- 10° from the north in the Midland Basin in northern Upton County.

1.10.5 Rock Strength

Average unconfined compressive rock strength of the injection and seal intervals is shown in **Table 11**. As noted in the methods section, these strength values are correlated from the static vertical Young's modulus. [redacted]

[redacted]

1.10.6 Ductility

[redacted] Dolomite and chert are expected to have very brittle behavior. An example of dolomite low ductility or brittle behavior is shown in **Figure 68** (D. Xu, et. al., 2020). Post-failure behavior has steep fall off indicating brittle behavior at lower confining pressures. At higher net confining pressures, this rock like most, takes on a more ductile behavior as confining stress increases. [redacted] Detail of net stress calculation found in **Table 12.** Result was generated from (9). Ductility and brittle behavior are expected to have minimal impact on the geomechanical model.

[redacted]

[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

[redacted]

[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]		
[redacted]	[redacted]		

$$Net\ Stress = \frac{\left((\sigma v - \alpha pp) + 2(\sigma h - \alpha pp)\right)}{3} \quad (9)$$

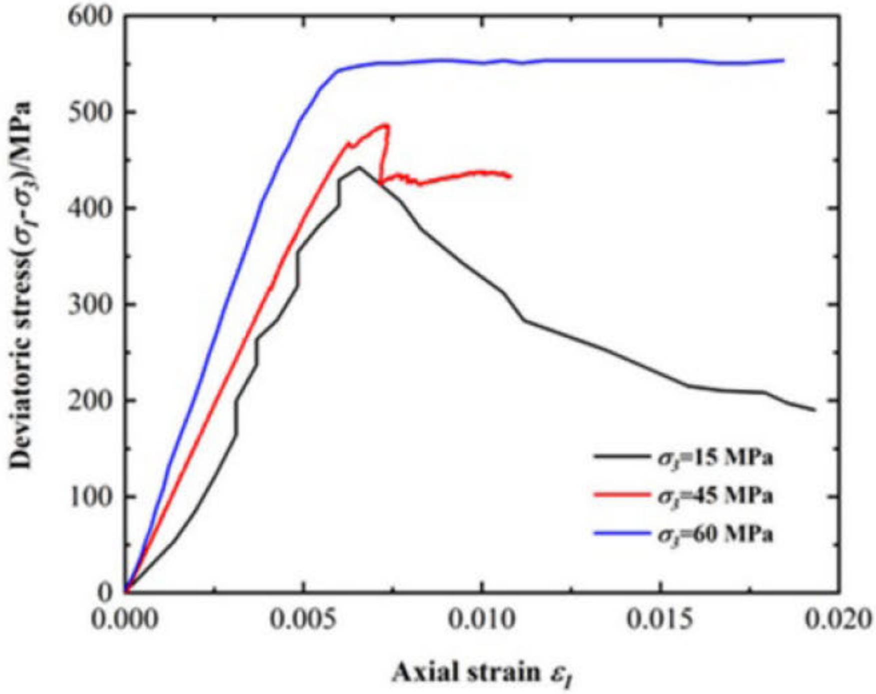


Figure 68: Dolomite Triaxial Test from Analogous Low Porosity Dolomite
Dolomite triaxial test from analogous low porosity dolomite found in China. Exhibits brittle behavior at low confining stress (σ3). [redacted]

1.10.7 Additional Testing

Extensive additional geomechanics testing will be performed once core material is obtained from a stratigraphic test well. [redacted]

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

[redacted]

1.11.1 Methods

[redacted] These simplifying assumptions align with the reality of the physical system in that continuous injection allows for abundant gas supply to the system.

1.11.2 Brine Geochemistry

[redacted] The composite values along with the depth and facies designation are shown in **Table 13**.

[redacted]

1.11.3 Mineral Geochemistry

Despite the well-understood nature of the stratigraphy in the vicinity of the subject site, published x-ray diffraction (XRD) data across the target formations are scarce. There is however good well-log control including numerous log suites with a PEF curve that enabled the creation of a multi-mineral petrophysical model. [redacted]

[redacted] This plot can be viewed in **Figure 71**.

[redacted]

An example of the mineralogical facies assemblages for a single well is shown in **Figure 72.** [redacted]

1.11.4 Models

[redacted] Sensitivity analysis during the creation of the models indicated that variations in pressure and temperature are not extreme enough to necessitate additional models until more specific mineralogic data can be secured during drilling. [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

1.11.5 Results

a) [redacted]

[redacted]

1.12 Mineral Resources

Milestone performed a review of all wells located within ten (10) mi of the proposed Well location in order to confirm there are no mineral or hydrocarbon resources located within or beneath the proposed CO_2 storage site.

[redacted]

[redacted]

[redacted]

The 10-mi search radius also identified several wells in the area that dispose of saltwater into the Devonian or Ellenburger Formations [redacted]

[redacted]

[redacted]

[redacted]

[redacted].

1.13 Site Suitability [40 CFR 146.83]

The proposed Well is sited in a geologically suitable area. Specifically, the injection zone is suitable because it is of sufficient areal extent, thickness, porosity, and permeability to receive the total anticipated volume of the carbon dioxide stream. [redacted]

[redacted]

1.13.1 Subsurface Distribution of Facies and Fractures – Implications for CO_2 plume migration

See **Section 1.7.3** for additional information on Lithology.

See **Section 2** for additional information on Plume modeling

[redacted]

1.13.2 Injectability

[redacted]

1.13.3 Carbon Dioxide Containment

[redacted]

- ✓ See **Section 1.8** for additional details
- [redacted]
  - ✓ See **Section 3.4** on AoR for additional details
- [redacted]
  - ✓ See **Section 1.9** on Petrophysics for additional details
- [redacted]
  - ✓ **See Section 1.7** on structural geology for additional details
- [redacted]
  - ✓ [redacted]
  - ✓ See **Section 1.4** on USDW for additional information
- [redacted]
  - ✓ See **Section 1.8.2** for additional information

1.13.4 [redacted]

[redacted]

Refer to **Section 1.5** and **1.7** for more information on stratigraphy in the region. [redacted]. See **Section 3** for more information on wells penetrating zones above the primary seal. [redacted]

1.13.5 Carbon Dioxide Interaction with Well Materials and Formation

The well head, tubulars and other components that CO_2 could potentially touch are all designed with rigorous corrosion resistant materials (Appendix A – **Metallurgical Analysis**). [redacted]

See **Section 1.11** for additional information on carbon dioxide – reservoir interactions. See **Section 4.2** and **Section 5.3** for additional information on well design and component corrosion resistance as well as corrosion testing. Finally, see **Appendix A** for a Metallurgical Analysis.

1.13.6 Total Storage Capacity

[redacted] Therefore, any estimation of total storage capacity must be constrained either by number of wells or surface acreage ownership. [redacted] Parameters for this result are located in **Table 14**. It should be noted that this method does not account for frac gradient pressure, or migration due to buoyancy and is simply a volumetric solution. [redacted]. See **Section 2** for additional information on storage and cellular model parameters.

(10), CO_2 is the storage in tonnes/acre or tonnes/square mi if 640 acres is used for A. Where A is the area, H is the reservoir height, Φ is total porosity, Sw_{Irr} is irreducible water saturation, ρ_{co2} is the mean CO_2 density, Eco2 is the injection efficiency, Bg_{Co2} is the formation volume factor (if surface density of CO_2 is used, otherwise set to 1).

$$CO2 = \frac{43560 * 62.42 * A * H * \emptyset_t * (1 - SW_{irr}) * \rho_{CO2} * E_{CO2}}{Bg_{CO2} * 2204.623} \quad (10)$$

[redacted]

		[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]