ENSOLUM

Depth to Groundwater Measurement

Client: XTO Energy, Inc.

Project Name: Remuda Basin 19 Fed #2 SWD

Project Location: Eddy County, New Mexico

Project Manager: Tacoma Morrissey

GROUNDWATER MEASURMENT FORM

ENSOLUM

SAMPLING INFORMATION

Soil Boring / Monitor Well Number: 321742103552601

Project #: 03C1558239

Date Completed: 6/11/2024

Type of Water Quality Meter: NA

Total Depth of Monitor Well: 100'

Date Calibrated: NA

Screen Interval: NA

Other Notes: Groundwater monitoring well measured to confirm depth to groundwater

Sample Tubing Intake Depth: NA

Geologist: Connor Whitman

Monitor Well Detail

Tubing Placement | GW Depth (static) | After Purge

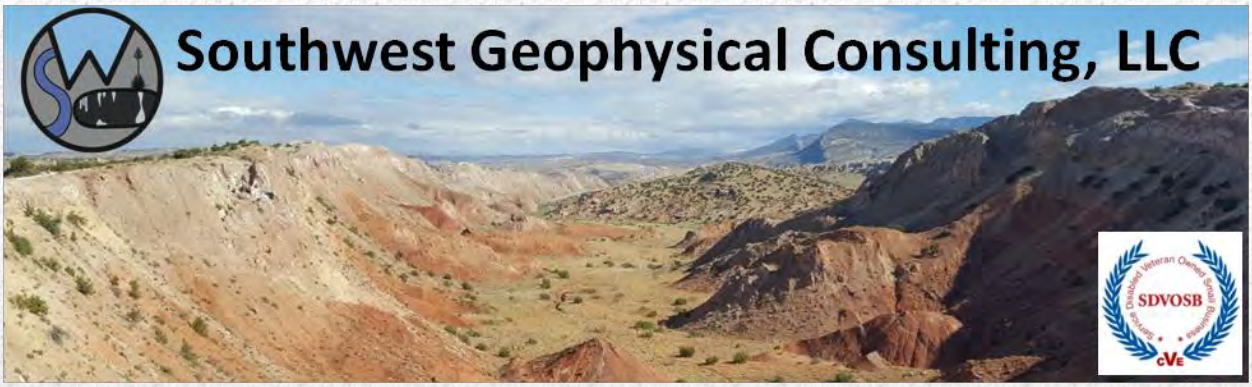
Time (minutes)	Purge Rate (L/min)	Temp. (ºC)	pH (unitless)	DO (mg/L)	ORP (mV)	Cond. (mS/cm)	GW Depth (feet)
0844	NR	NR	NR	NR	NR	NR	66.45'

Comments:

NA = Not Available
NR = Not Recorded

ENSOLUM

Karst Survey



Cave and Karst Resource Inventory Report
Remuda Basin Central Tank Battery
Eddy County, New Mexico

Prepared for:

LT Environmental, Inc.
3300 North A Street Building 1, Unit 222
Midland, TX 79705

☐ **Positive – HKOZ remediation process required**

☑ **Negative – MKOZ remediation process may be approved by the Oil Conservation Division**

February 10, 2019

LTE-003-20200121

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1.0 INTRODUCTION

This report was commissioned by LT Environmental, Inc. (hereinafter referred to as "the client") on January 21, 2020 for the purpose of determining what, if any, karst-related surface features are present near the Remuda Basin Central Tank Battery (hereinafter termed “Remuda”, **Figure 1**) and to provide guidance on the level of remediation required. This study does not include subsurface features, which would require a geophysical survey. The study area that this report covers is in a **HIGH** karst occurrence zone and entirely located within New Mexico State Land Office managed lands (**Figure 2**).

As indicated in section ***1.3 Affected Environment***, the bedrock and overlying soil at the survey site are susceptible to sinkhole development and karst features may be hidden beneath the existing soil stratum. Risk associated with sinkhole formation can be minimized during development with proper foundation design and construction, and the control of site hydrology. The Owner/Developer must recognize, however, that a risk of sinkhole-induced damage to infrastructure does exist. The Owner/Developer must evaluate the risks and attendant costs of performing a geophysical survey prior to development, versus no geophysical survey, and must be willing to accept these risks if it is decided that a surface karst survey is sufficient. Southwest Geophysical Consulting, LLC can provide a geophysical survey. If the decision is made to conduct a geophysical survey, a cost estimate and timeline will be provided upon request.

1.1 Goals of this Study

To provide the client with the location, description, photos, and boundaries of any surface karst-related features within a 200-meter boundary surrounding the pad on the Remuda project site as provided by the client via e-mail on January 21, 2020.

1.2 Summary of Findings

No surface karst features were located within the pedestrian survey area. However, unknown hidden features may still exist beneath the surface. Caution should be exercised during any remediation efforts.

Figure 1: Karst occurrence overview. Red transparent area is a high karst occurrence zone; blue transparent area is a medium karst occurrence zone. Study area is the red outlined area in the lower-right portion of the image. Background image credit: Google Earth. Image date: November 02, 2017. Datum: WGS-84.

1.3 Affected Environment

The Remuda project site is located in evaporite karst terrain, a landform that is characterized by underground drainage through solutionally enlarged conduits. Evaporite karst terrain may contain sinkholes, sinking streams, caves, and springs. Sinkholes leading to underground drainages and voids are common. These karst features, as well as occasional fissures and discontinuities in the bedrock, provide the primary sources for rapid recharge of the groundwater aquifers of the region.

The Bureau of Land Management (BLM) categorizes all areas within the Carlsbad Field Office (CFO) zone of responsibility as having either low, medium, or high cave potential based on geology, occurrence of known caves, density of karst features, and potential impacts to freshwater aquifers. This project occurs within a **HIGH** karst occurrence zone[1] (HKOZ, **Figure 1**). A high karst occurrence zone is defined as areas in known soluble rock types that contain a high frequency of significant caves and karst features such as sinkholes, bedrock fractures that provide rapid recharge of karst aquifers, and springs that provide riparian habitat[2].

An on-site inspection revealed that there are no surface karst features within the pedestrian survey area. However, unknown buried features may exist; therefore, this action is subject to mitigation measures designed to adequately protect known and potential cave/karst resources.

2.0 LOCATION AND DESCRIPTION OF STUDY AREA

2.1 Description of Site

The Remuda project site is located in Eddy County, New Mexico, 31 kilometers (19 miles) southeast of Carlsbad, New Mexico; 6 kilometers (3.7 miles) south of the junction of NM128 (Jal Highway) with Rawhide Road, and 6 kilometers (3.7 miles) to the east of Nash Draw (**Figure 1** and **Figure 2**). The site is located within section 19 of NM T23S R30E. This area is within the Chihuahuan Desert Thornscrub defined by the Southwestern Regional ReGAP Vegetation map[5] and the vegetation consists mostly of areas of grass, sparse creosote, and sparse yucca with very good visibility in most locations. See section ***2.3 Local Geology*** for the geology of the area. The pad and surrounding survey boundary are entirely within a high karst occurrence zone (**Figure 1**) and are located entirely within New Mexico State Land Office managed lands (**Figure 2**).

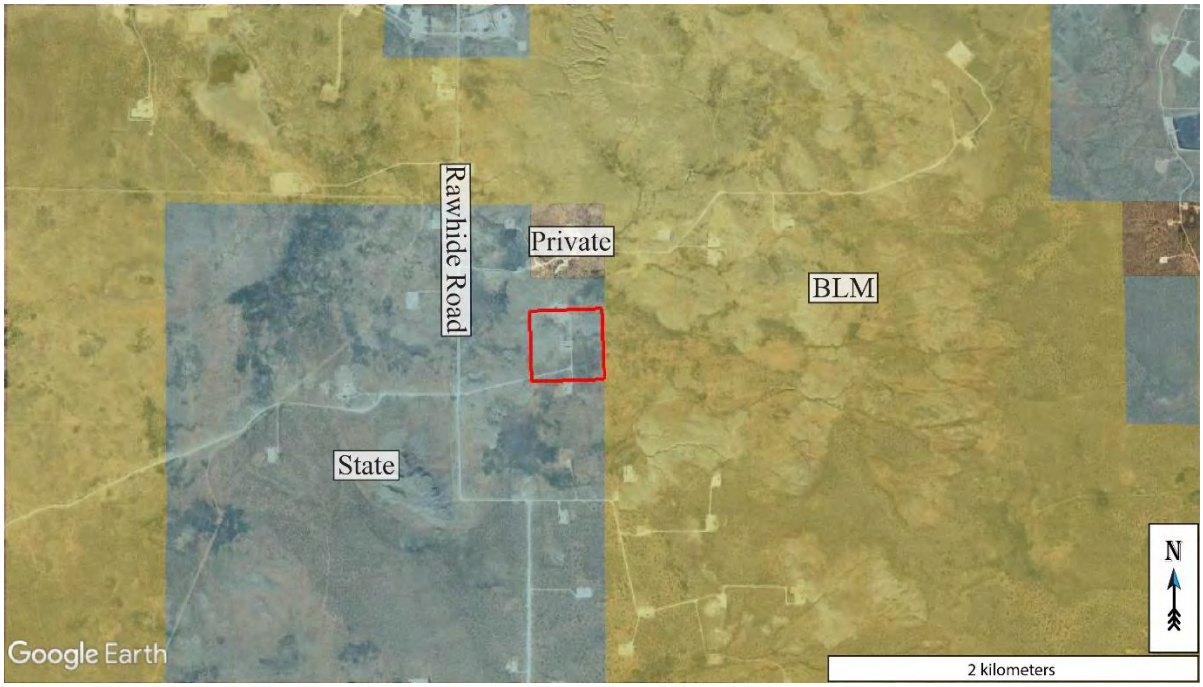

Figure 2: Land ownership overview. Yellow transparent area: BLM-CFO managed land. Blue transparent area: New Mexico State Land Office managed land. No color: Private land. Background image credit: Google Earth. Image date: November 02, 2017. Datum: WGS-84.

2.2 Description of Survey

For this survey 10 lines were walked in a raster pattern at 50-meter (165 feet) intervals in the designated area, providing 90 to 100% coverage for features greater than 50 centimeters (20 inches) in diameter (**Table 1**).

The survey was completed by Garrett Jorgensen on January 30, 2020. The total distance walked was 4.5 kilometers (2.8 miles) and the total area covered was 0.2 square kilometers (39.5 acres).

Table 1: Survey Track Data Files.

File Name	Surveyor	Date	Length (km/miles)	Area (km^2/Ac)
RMDSRV_D1S1.kmz	Jorgensen	01/30/2020	4.51/2.80	0.16/39.5

Figure 3: Survey overview. Light blue wavy lines are the actual survey lines walked. Yellow polygon is the pad site. Red polygon is the 200-meter buffer study area. Background image credit: Google Earth. Image date: November 02, 2017. Datum: WGS-84.

2.3 Local Geology

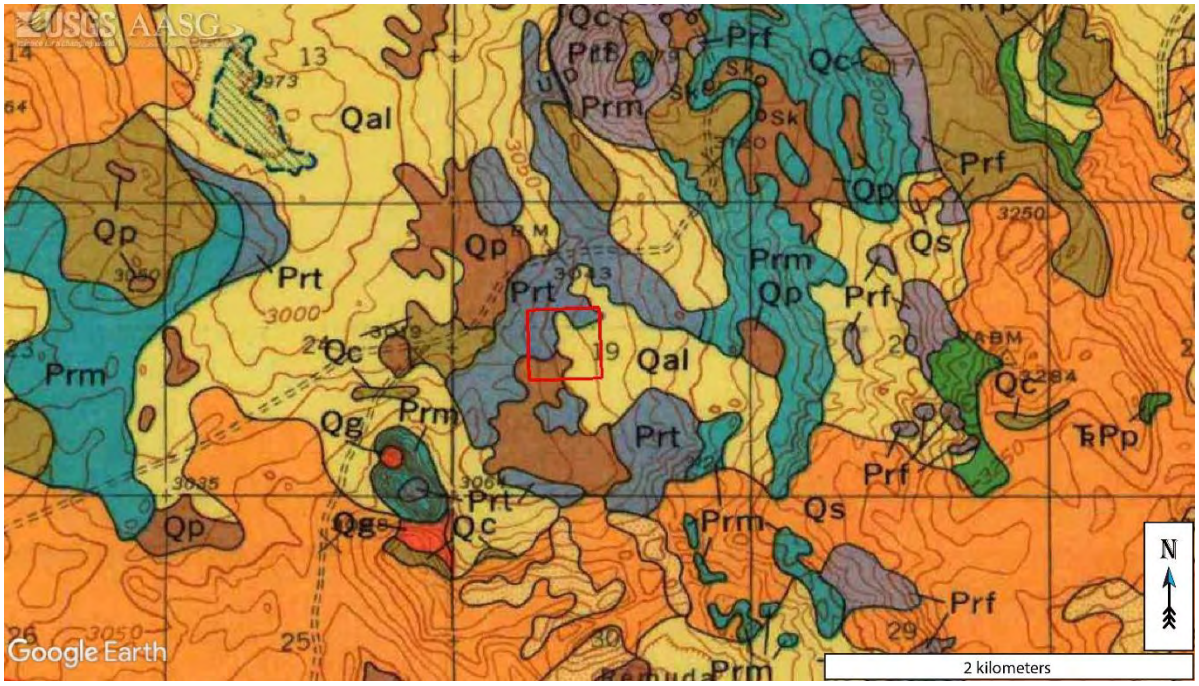

Figure 4: Geology overview. Red polygon highlights the survey area. Geologic Members of the Permian Rustler Formation: Prc - Culebra Dolomite Member, Prt - Tamarisk Member, Prm - Magenta Member, Prf - Forty-Niner Member. TRPp: Dewey Lake Formation (referred to by the name "Pierce Canyon Formation" in the geologic map and associated report. Please note the Pierce Canyon Formation has since been combined with the Dewey Lake Formation and classified as a single unit under the latter name). Qg: Quaternary Gatuna Formation. Qc: Quaternary caliche. Qal: Quaternary alluvium. Qp: Quaternary lacustrine and playa lake deposits. Qs: Quaternary sand. Qsd: Quaternary sand dune deposits. Map credit: Surface geology of the Nash Draw Quadrangle, Eddy County, New Mexico, scale: 1:62,500 (1963), and Google Earth. Image date: November 02, 2017. Datum: WGS-84.

The area surveyed for the Remuda project is located 6 kilometers west of a large, partially closed karst depression known as Nash Draw[6] at an elevation of 930 meters (3,050 feet), plus or minus 4 meters (12 feet), within an area underlain by the Permian Rustler Formation. The area is mantled by thin gypsiferous and calcareous soils (Qc) and quaternary alluvial sands (Qs and Qsd) between 0 and 5 meters in depth which, in turn, overlie the Quaternary Gatuna Formation (Qg), Dewey Lake Formation (TRPp), and then the Rustler Formation[6] (**Figure 4**). The Rustler Formation is an evaporite facies and is composed mainly of thin siltstones and sandstones interbedded with claystones, dolomite, and gypsum[4], and contains both karst-forming strata (the Forty-niner and Tamarisk members) and two shallow aquifers (the Magenta and Culebra Dolomite members). The Rustler overlies the Permian Salado Formation (Psl, not shown), a layer of extremely soluble halite, which can easily be dissolved to create caves, sinkholes, and other karst features[3]. The Rustler may be subject to collapse if a void has developed beneath it in the Salado Formation[4]. The two geologic maps that cover the survey area are the Geologic Atlas of Texas - Hobbs Sheet

(1976) at 1:250,000 scale, and the Surface Geology of Nash Draw Quadrangle, Eddy County, New Mexico (1963) at 1:62,500 scale.

2.4 Description of Karst Features

No surface karst features were located within the 200-meter boundary of the pedestrian survey area for the Remuda project.

3.0 RECOMMENDATIONS

No surface karst features were located during this survey. Based on the above findings, allowing use of medium karst occurrence zone spill remediation procedures may be considered by the Oil Conservation Division within the 200-meter survey area. Confirmation to use a lower remediation level should be received from the Oil Conservation Division before proceeding.

Vigilance during remediation is paramount. If voids are encountered during trenching or digging contact the New Mexico State Oil Conservation Division if on State land, and the Bureau of Land Management – Carlsbad Field Office at (575) 234-5972 if on BLM land and request an onsite investigation from a karst expert. A karst consultant can generally be onsite in Eddy County within five hours.

4.0 REFERENCES

1. Rybacki, K., *Karst Potential Map.* CFO Basemap, 2019.
2. Scholle, P.A., *Geologic Map of New Mexico.* 2003. (1:500,000).
3. Johnson, K.S., *Evaporite Karst in the United States.* Carbonates and Evaporites, 1997. **12(1)**: p. 2-14.
4. Martinez, J.D., K.S. Johnson, and J.T. Neal, *Sinkholes in Evaporite Rocks.* American Scientist, 1998. **86(1-2)**: p. 38-51.
5. Whitehead, W. and C. Flynn, *Plant Utilization in Southeastern New Mexico: Botany, Ethnobotany, and Archaeology.* 2017, Carlsbad, NM: Bureau of Land Management, Carlsbad Field Office.
6. Vine, J.D., Surface *Geology of Nash Draw Quadrangle Eddy County New Mexico,* 1963.

5.0 GLOSSARY OF TERMS

BLM	Bureau of Land Management
CFO	Carlsbad Field Office
cave	A natural opening at the surface, large enough for a person to enter.
GPS	Global Positioning System
NMSLO	New Mexico State Land Office
playa lake	A natural depression on the surface that collects rainwater. Some contain swallets and/or caves, others do not.
pseudokarst	Karst-like terrain that forms through processes other than dissolution.
swallet	A natural opening in the surface, too small for a person, that drains water to an aquifer. Some are "open," meaning a void can be seen below; some are "closed," meaning they are full of sediment.
WGS	World Geodetic System

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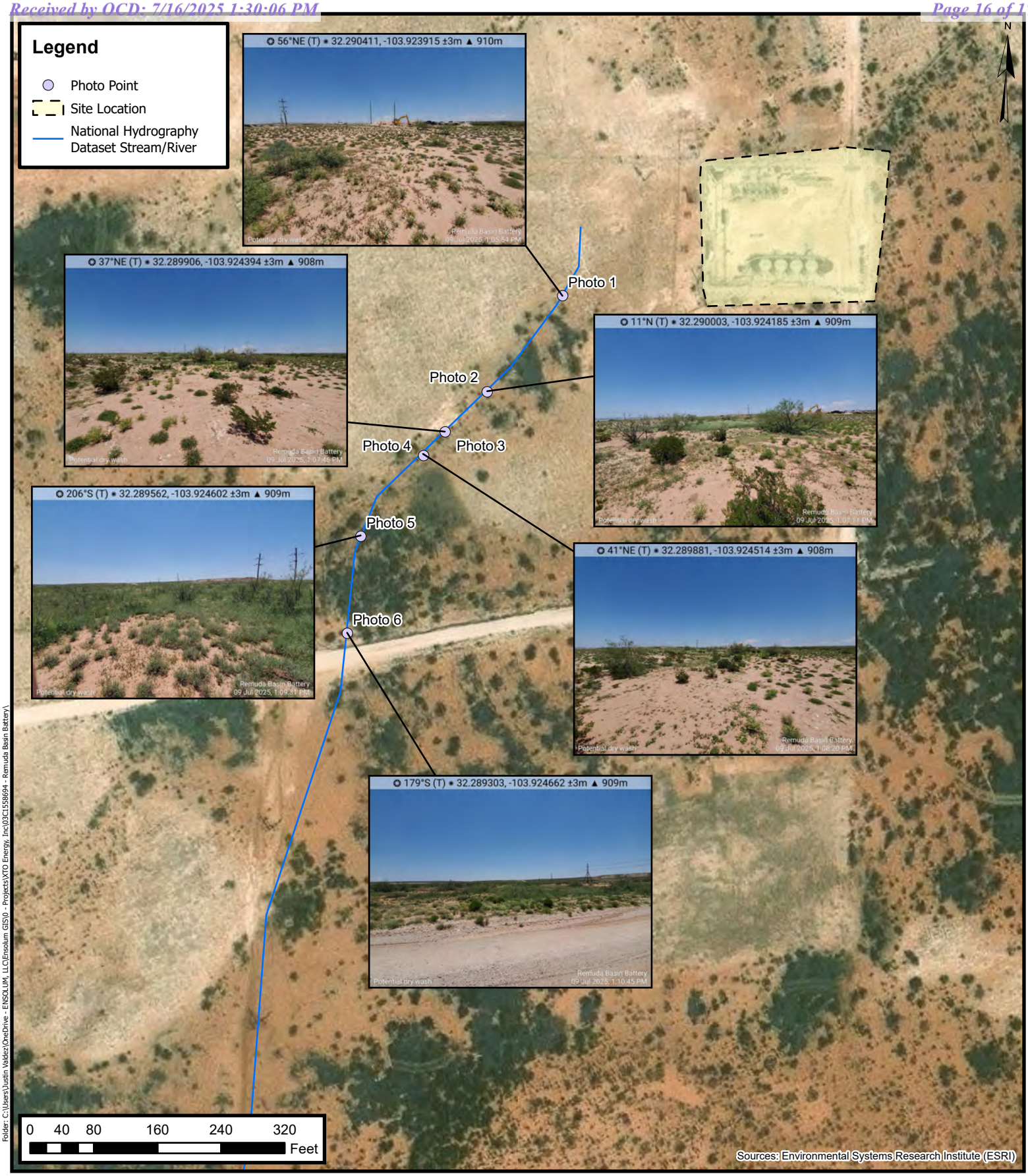
Watercourse Survey



Folder: C:\Users\Justin Valdez\OneDrive - ENSOLUM, LLC\Ensolum GIS\0 - Projects\XTO Energy, Inc\03C1558694 - Remuda Basin Battery\

ENSOLUM
Environmental, Engineering and Hydrogeologic Consultants

Watercourse Survey Map

XTO Energy, Inc
Remuda Basin Battery
Incident Numbers: NMAP1825437863 and NJMW1303140115
Unit F, Sec 19, T 23S, R 30E
Eddy County, New Mexico

FIGURE 1

Sante Fe Main Office
Phone: (505) 476-3441

General Information
Phone: (505) 629-6116

Online Phone Directory
https://www.emnrd.nm.gov/ocd/contact-us

State of New Mexico
Energy, Minerals and Natural Resources
Oil Conservation Division
1220 S. St Francis Dr.
Santa Fe, NM 87505

CONDITIONS

Action 485630

CONDITIONS

Operator: XTO ENERGY, INC 6401 Holiday Hill Road Midland, TX 79707	OGRID: 5380
	Action Number: 485630
	Action Type: [IM-SD] Incident File Support Doc (ENV) (IM-BNF)

CONDITIONS

Created By	Condition	Condition Date
nvelez	None	7/16/2025