

State of New Mexico
Energy, Minerals and Natural Resources Department

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Deputy Secretary

Adrienne Sandoval, Director
Oil Conservation Division



DATE: July 27, 2020

TO: Ms. Adrienne Sandoval, Director, Oil Conservation Division

FROM: Phillip Goetze, Engineering Bureau

RE: INITIAL SUMMARY REPORT REGARDING RECENT SEISMIC EVENTS OCCURRING SOUTH OF LOVINGTON, NEW MEXICO IN TOWNSHIP 18 SOUTH, RANGE 35 EAST, NMPM

Director Sandoval:

The Oil Conservation Division (OCD) of the New Mexico Energy, Mineral and Natural Resources Department (EMNRD) is providing this report which complies the effort to investigate a recent group of seismic events, or earthquakes, approximately 11 miles south of Lovington New Mexico. Beginning on June 27, 2020, and continuing through June 30, 2020, a series of 21 earthquakes were observed concentrated in this area.

Description of Seismic Events

The initial record of a seismic event occurred on June 27th at approximately 10:23 PM (MDT) and was subsequently flowed by individual events until approximately 5:06 PM (MDT) on June 30, 2020. Since June 30th, there have been not additional seismic events with a magnitude of 2.5 or greater. Table 2 provides a summary of the individual events along with specific locations and magnitudes.

The locations of the events are concentrated within Township 18 South, Range 35 East, NMPM in Lea County, New Mexico. Figure 1 shows the general area of the events while Figure 2 presents the plots from the United States Geological Survey (USGS) Earthquake Hazards Program.

The magnitude of the individual events ranged from a maximum 3.3, the first event, to the detection limit of 2.5. Of the 21 events, only four events had magnitudes of 3.0 or greater. Typically, seismic events of this magnitude are not typically felt by individuals and does not cause damage to structures.

The quality of the raw data used to determine magnitude and location of the seismic events is limited at this time. This is due to a lack of active seismic monitoring stations in this portion of the

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Delaware Basin. Both industry and government experts have stated that existing monitoring systems are deployed to assess activity farther south where the current oil and gas drilling activity is focused.

General Geology and Prior Seismic Activities

The location of the seismic events is in a transition of geologic features from the Delaware Basin to the Northwestern Shelf. This transition represents a general change from basin facies which are the targets of current hydrocarbon development in the Bone Spring and Wolfcamp formations to shallower facies that were developed during prior decades.

This area south of Lovington is marked by several older fields which includes the South Vacuum Devonian field. This field is an anticline modified by a fault system that is primarily oriented along a southeast to northwest trend. This geologic feature provided a natural trap for the accumulation of hydrocarbons in the Devonian formations which was developed over the decades for production. Figure 3 provides a map showing the anticlinal structure and associated fault system.

As part of the evaluation of these events, OCD researched the prior incidents of seismic activity in this portion of the shelf. Review of two earthquake catalogs found no prior record of seismic events at this location or adjoining shelf area. This does not eliminate the possibility for prior activity since a permanent array of seismic stations were not installed until required by the Department of Energy's Waste Isolation Pilot Project.

Review of UIC Class II Injection History in the Area

As part of the initial investigation, the OCD identified the need for further study of possible impacts from Underground Injection Control (UIC) Class II well activities in the area around the seismic events in Lea County. The results of the study are provided in Table 1 and Figure 2.

OCD used a model from similar locations in other states that injection into deep formations which had potential to communicate with the Precambrian basement rocks have a high probability to induce seismic events. Disposal wells with injection intervals that are close to the Precambrian basement rock are a primary concern. The use of the South Vacuum Devonian field as a disposal interval along with the proximity to an extensive fault system present a likely candidate as a possible source for the recent events.

Recently obtained information on well completion further supports this model for disposal well activity as a source for the seismic events. Figure 3 shows a disposal well with an open-hole completion that appears to penetrate the lower coning layer of formations used to prevent migration of injection fluids to the Precambrian basement rocks. Similar well construction was identified as a means for communication of disposal fluid with the Precambrian rocks in the Dagger Draw area that resulted in periodic swarms of earthquakes during the early 2000s.

Summary of OCD Response and Efforts for Investigation

During the period of OCD Director initiated the following actions:

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1. OCD field inspectors from the Hobbs Office were mobilized to inspect all wells in the township and provide a record of status. This includes disposal wells and reconnaissance for any completion/fracking activities that might be seismic sources. No sources associated with fracking operations were detected and there was no indications of property damage or risk to public safety.
2. The Engineering Bureau compiled information on geology and disposal activities in the township to develop models to identify the source of seismic activities.
3. OCD requested the state semiologist to deploy a temporary seismic array in the township for a more accurate earthquake catalog.
4. OCD requested operators to provide information on disposal operations in the area and notify operators of the ongoing investigation which may have directives for modification of their disposal operations.
5. OCD was to develop a process for assessing the compiled data and initiate corrective actions either through voluntary action or an emergency order and hearing.

The OCD continues with the effort to assess the information provided by three operators along with files of the Division's database. Additionally, the OCD has been assisted by organizations outside of EMNRD:

1. The oil and gas industry with operations within the Delaware Basin:
Two stakeholders, XTO and Cimarex, have provided both raw data and geophysical expertise in assessing the seismic events. Currently, these same parties are processing raw data from private arrays in an effort to see patterns of activities below the 2.5-magnitude threshold.
2. The New Mexico Bureau of Geology and Mineral Resources (New Mexico Tech):
The state semiologist has provided a list of sites for deployment of temporary seismic stations. The deployment is to occur within the next month once access is approved by the State Land Office.
3. The United States Environmental Protection Agency (EPA):
Region 6 staff contacted the OCD and will provide assistance in scientific interpretation along with recommendations for possible mitigation that have proven successful in Oklahoma and Arkansas.
4. USGS:
The USGS is beginning a program for temporary installation of seismic monitoring stations within the Delaware Basin to better assess the growing activity. This effort is being coordinated with the New Mexico Tech deployment and the information being compiled by the private stakeholders.

Recommendations

The OCD will continue with the effort to identify potential sources for the seismic activity with the intent to provide guidance and final corrective actions based on the new seismic information gathered

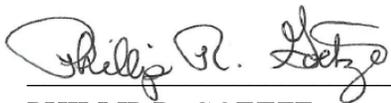
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with the focused arrays. The recommendations of the UIC group include:

1. Continued monitoring of the disposal operations in the township and actively deny any new applications for disposal in the South Vacuum area pending the results of the investigation of the seismic events.
2. Re-evaluation of the area stratigraphy and compare with the permitted disposal intervals of the disposal wells identified in Table 1. If the assessment determines that the permitted intervals are not consistent with the actual injection intervals reported for the wells, OCD will prepare plans for corrective actions including plugging back of the wells.
3. Complete review of other injection sources within the area but are not within proximity of a known fault system and determine if they are contributing factors to the seismic activity.
4. Continued consultations with industry representatives, state seismologist, and EPA Region 6 experts as new information are assembled. Currently, industry experts are compiling and evaluating raw seismic data with magnitudes below 2.5 to identify patterns of seismicity that predate the reported seismic events.
5. Provide a proposed plan of action for the Director if seismic activities expand in frequency or increase in magnitude. This plan would include the preparation of an emergency order that will require mandatory changes in operation such as reductions of injection rates.

The content of this response was prepared by Phillip Goetze of the Engineering Bureau along with staff of the UIC Group within the Bureau. Please contact Mr. Goetze with any questions regarding the content of this document.

Submitted by:



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Acting UIC Manager
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REFERENCES:

Broadhead, R., Mansell, M., and Jones, G., 2009, *Structure on Precambrian Surface; Carbon Dioxide in New Mexico: Geologic Distribution of Natural Occurrences*; Open-file Report 514; New Mexico Bureau of Geology and Mineral Resources; plate 1.

Lund Snee, J. and Zoback, M., 2018, *State of stress in the Permian Basin, Texas and New Mexico: Implications for induced seismicity*; The Leading Edge (Society of Exploration Geophysicists), Special Section: Injection-induced seismicity; p. 127-134.

Pursley, J., Bilek, S., 2013, Earthquake catalogs for New Mexico and bordering areas: 2005–2009; *New Mexico Geology*; v. 35, no. 1; p. 3-12.

Sanford, A., *et. al.*, 2006, Earthquake catalogs for New Mexico and bordering areas II: 1999–2004;

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Upp, G. E., 1960, *South Vacuum Devonian Field* in The Oil and Gas Fields of Southeastern New Mexico (1960 Supplement); Roswell Geological Society; p. 212-213.

FIGURES

FIGURE 1: Location Map of Recent Seismic Events South of Lovington, NM

FIGURE 2: UIC Class II Disposal Wells in Proximity to Seismic Events [T18S, R35E, NMPM]

FIGURE 3: UIC Class II Disposal Wells in Devonian Interval of the South Vacuum Field [T18S, R35E, NMPM]

FIGURE 4: General Geology of the Lovington Area

TABLES

TABLE 1. Summary of UIC Class II Disposal Wells in Proximity of Seismic Events with Devonian of Deeper Injection Intervals

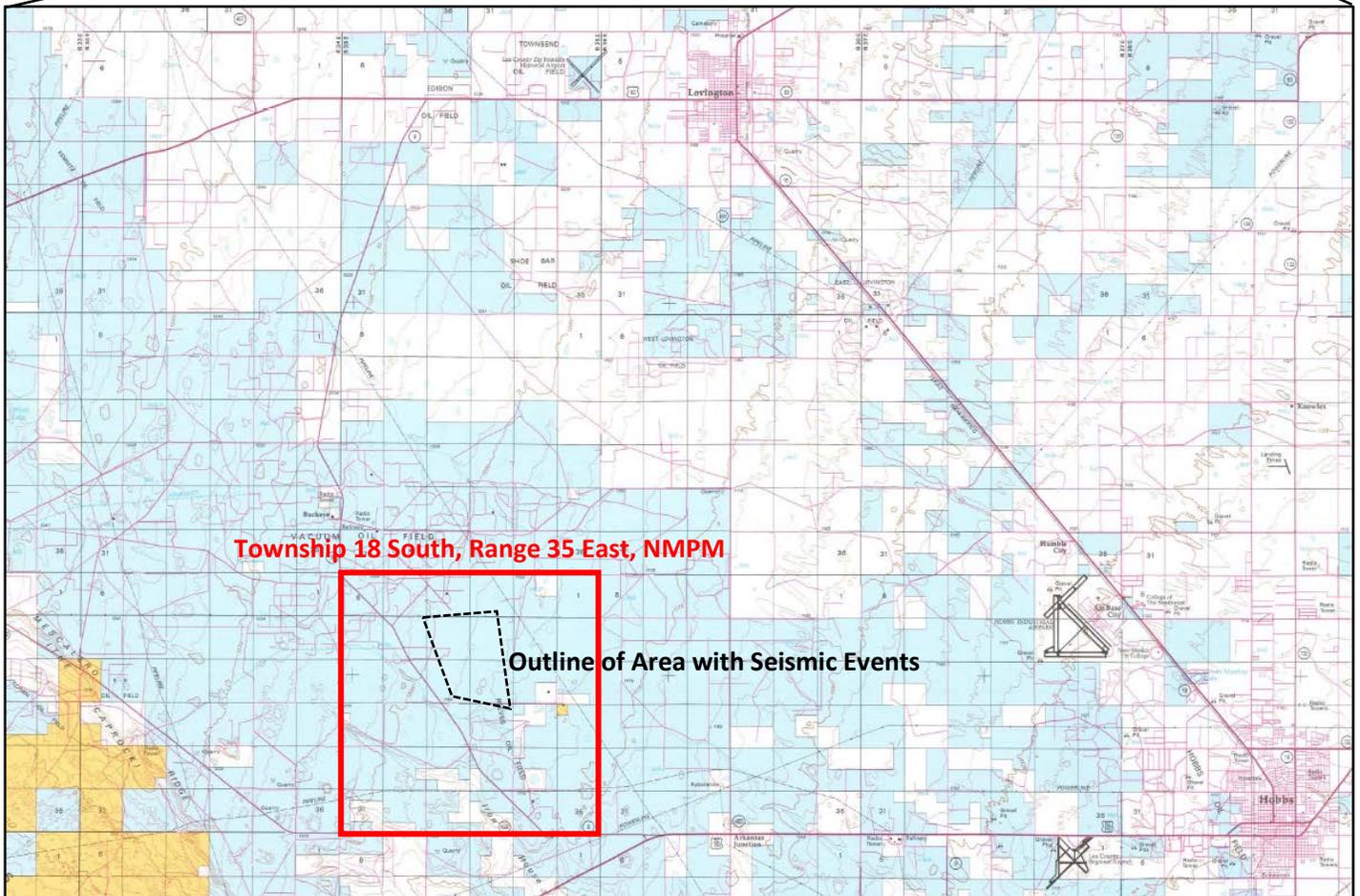
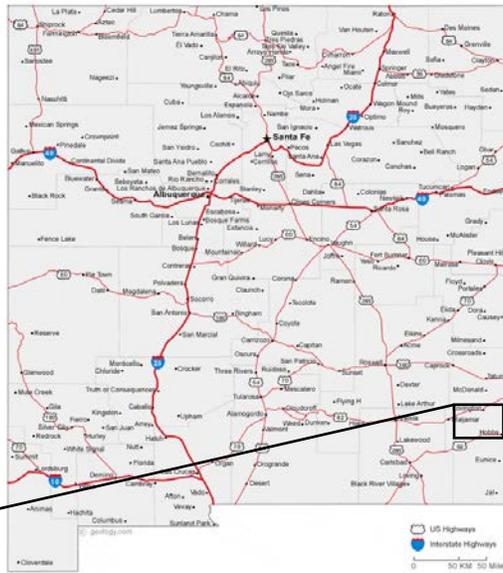
TABLE 2. Summary of Seismic Events Identified by the USGS Earthquake Hazards Program

cc: UIC Class II Program Imaging File



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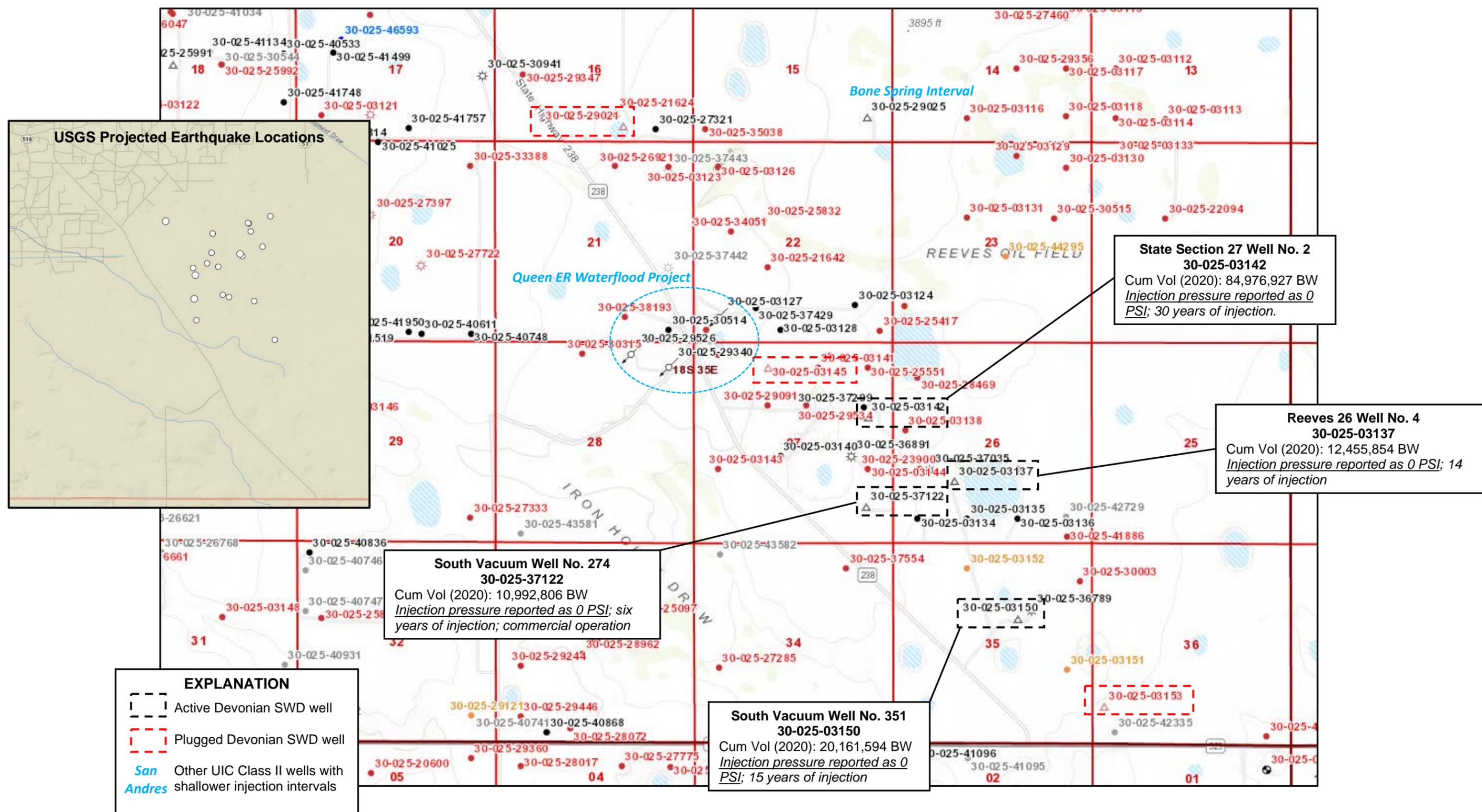
FIGURE 1: Location Map of Recent Seismic Events South of Lovington, NM





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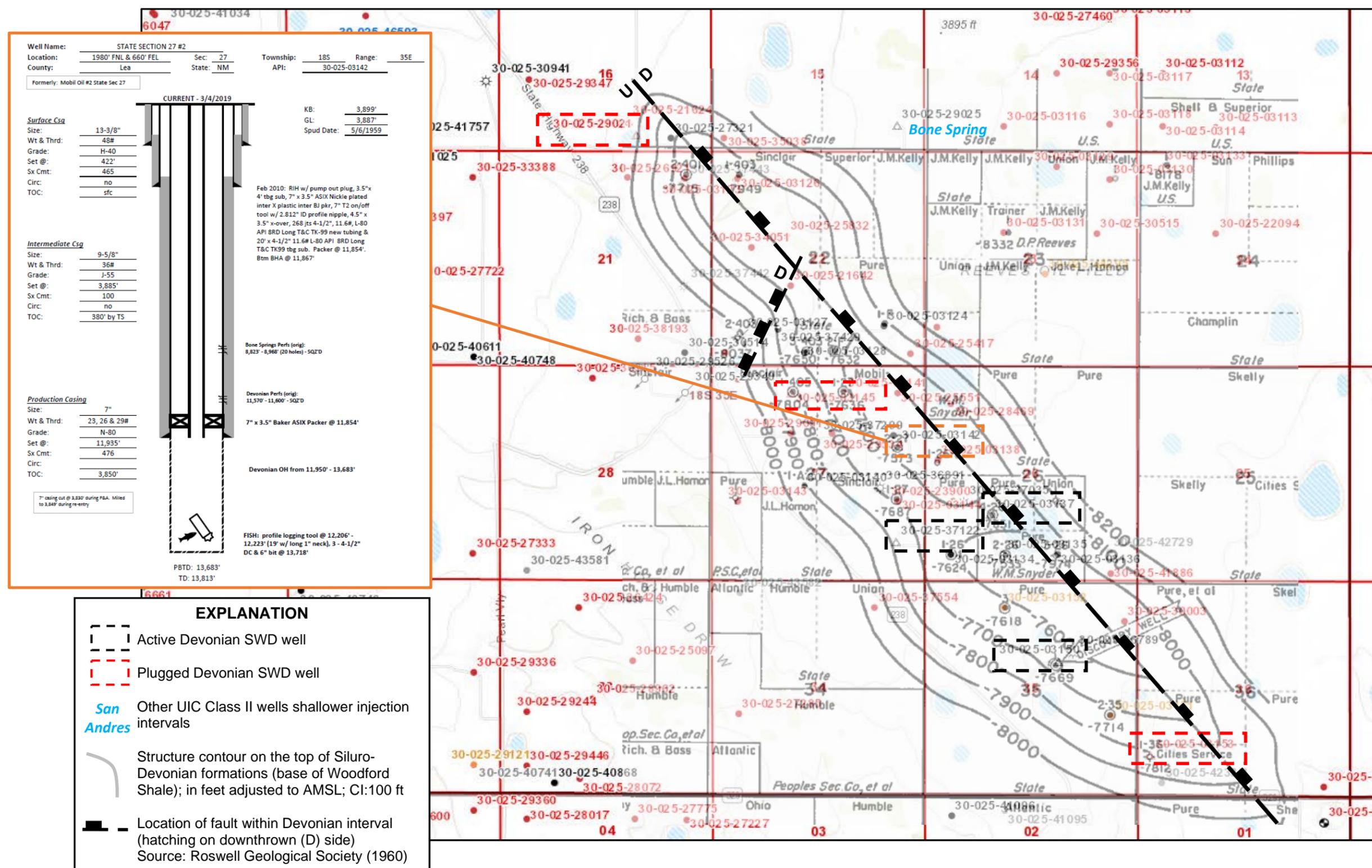
FIGURE 2: UIC Class II Deep Disposal Wells in Proximity to Seismic Events [T18S, R35E, NMPM]





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FIGURE 3: UIC Class II Disposal Wells in Devonian Interval of the South Vacuum Field [T18S, R35E, NMPM]





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FIGURE 4: General Geology of the Lovington Area

FIGURE 4A: General Stratigraphic Column

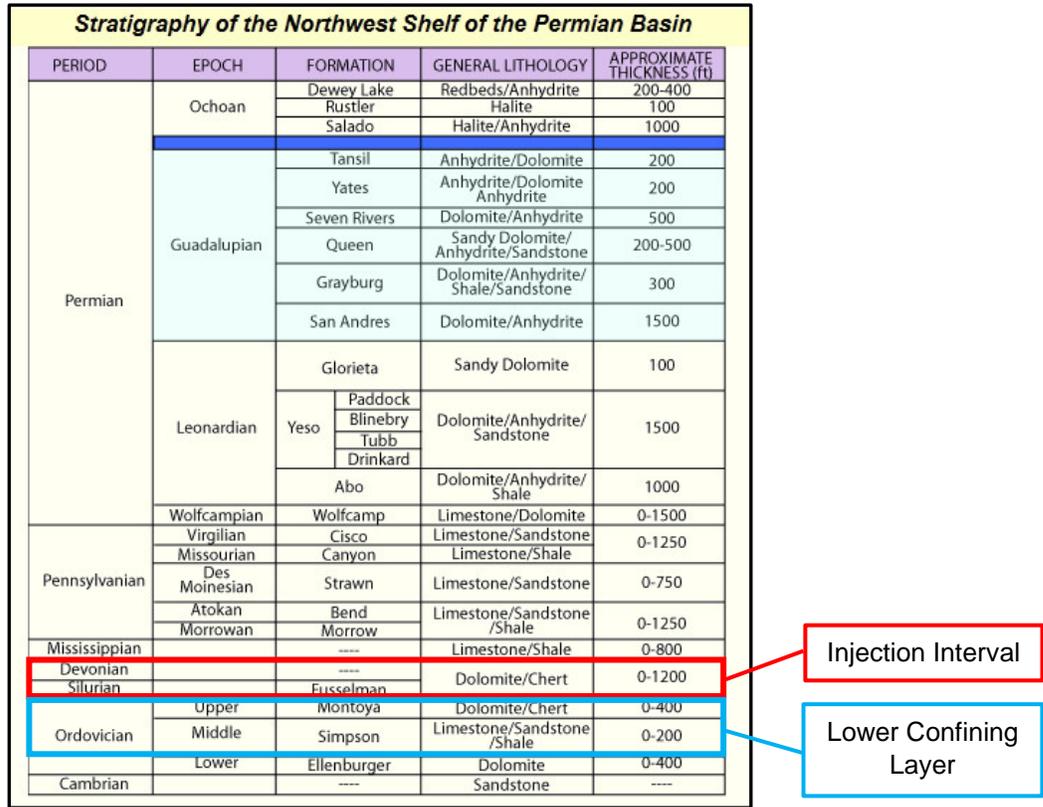


FIGURE 4B: Structure Contour Map on Top of Precambrian Basement (Broadhead, 2009)

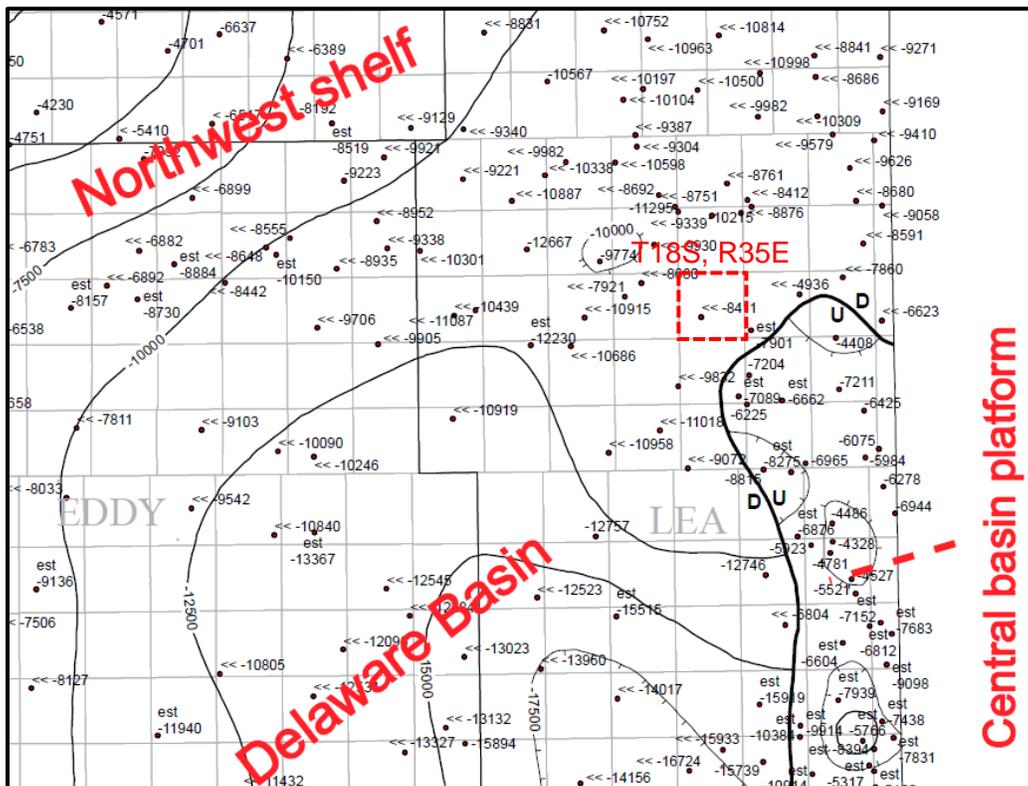


TABLE 1: Summary of UIC Class II Disposal Wells in Proximity of Seismic Events with Devonian or Deeper Injection Intervals

API	Well Name	Well Number	Mineral Owner	Status	Initial APD Approval Date	Unit Letter	Section	Township	Range	Footages	Spud Date	Elevation	Measured Depth	Order	Order Date	Approved Injection Interval	Depth of Approved Interval (ft, BGS)	Last Reported Monthly Volume	Last Reported MSIP (PSI)	Cum Injection Volume (U.S. Barrels)	Last MIT	Plugged On	Current Operator or Operator at Plugging
30-025-03137	REEVES 26	#004	Private	Active	2/5/1960	K	26	18S	35E	1654 FSL, 1654 FWL	2/10/1960	3861	11730	SWD-1092-A	9/2/2011	Wolfcamp and Devonian	9,883 to 10,002 (Perf) 11,515 to 11,696 (Perf) 11,730 to 12,230 (OH)	32,260	0	12,455,854	5/30/2019		[328449] Catena Resources Operating, LLC
30-025-03150	SOUTH VACUUM UNIT	#351	State	Active	9/9/1957	G	35	18S	35E	1980 FNL, 1980 FEL	9/8/1957	3869	12030	SWD-980	6/8/2005	Devonian	11,643 to 12,100 (Perf and OH)	21,252	0	20,161,594	11/25/2019		[328449] Catena Resources Operating, LLC
30-025-37122	SOUTH VACUUM	#274	State	Active	3/9/2005	P	27	18S	35E	960 FSL, 693 FEL	4/30/2005	3886	14230	SWD-1444	10/8/2013	Mississippian and Devonian	10,858 to 12,400 (Perf)	29,986	0	11,033,412	2/17/2020		[371101] Clearwater SWD, LLC
30-025-03142	STATE SECTION 27	#002	State	Active	2/1/1991	H	27	18S	35E	1980 FNL, 660 FEL	5/6/1959	3899	13813	R-8645	5/5/1988	Siluro-Devonian	11,950 to 13,708 (OH)	275,065	0	85,252,992	6/16/2020		[298299] Cross Timbers Energy, LLC
30-025-29021	ARCO STATE SWD	#002	State	Plugged, Site Released		O	16	18S	35E	405 FSL, 1850 FEL	11/30/1984	3920	12197	SWD-312	2/12/1987	Devonian	12,173 to 12,197 (OH)	575	0	3,014,441	5/25/2007		[173413] E G L Resources INC
30-025-03133	NIX 24	#001	Federal	Plugged, Site Released		D	24	18S	35E	330 FNL, 660 FWL	12/10/1959	3877	12232	R-3414	5/20/1968	Devonian	12,081 to 12,178 (Perf and OH)	NR	NR	NR	7/30/1987		[23710] Union Oil CO of California
30-025-29865	AIRPATH AEM STATE	#001	State	Active	2/23/1987	P	8	18S	36E	660 FSL, 660 FEL	3/13/1987	3838	13004	SWD-1572	8/26/2015	Devonian	12,850 to 13,004 (Perf and OH)	6,343	0	2,229,854	3/12/2019		[371003] Burns Express, LLC
30-025-42461	WILD COBRA 1 STATE SWD	#002	State	Active	3/2/2015	C	1	19S	34E	660 FNL, 1650 FWL	3/30/2015	3964	15900	SWD-1525	2/20/2015	Siluro-Devonian	14,400 to 16,100 (OH)	54,874	0	4,586,227	3/6/2019		[229137] COG Operating LLC

NR - not reported; records of injection volume predate current database BGS - below ground surface PSI - pounds per square inch ft - feet

TABLE 2: Summary of Seismic Events Identified by the USGS Earthquake Hazards Program

Event No.	Date and Time	Latitude	Longitude	Calculated Depth (km)	Magnitude	Updated	General Location	Horizontal Error (km)	Depth Error (km)	Mag Error	Mag Nst
21	2020-06-30 T23:06:21.348Z	32.7425	-103.4615	5	2.7	2020-07-07T02:35:42.040Z	22 km NW of Monument, New Mexico	0.9	2	0.072	50
20	2020-06-30 T02:14:37.970Z	32.7598	-103.4568	14.97	2.6	2020-06-30T23:51:52.040Z	22 km SSW of Lovington, New Mexico	1.8	8.3	0.097	14
19	2020-06-29 T19:57:11.102Z	32.7475	-103.4439	5	2.7	2020-06-30T20:15:22.040Z	23 km SSW of Lovington, New Mexico	1.7	1.8	0.089	33
18	2020-06-29 T18:01:34.420Z	32.7614	-103.4413	5	2.6	2020-06-30T20:13:51.040Z	22 km SSW of Lovington, New Mexico	1.6	1.9	0.117	19
17	2020-06-29 T15:19:37.282Z	32.7596	-103.4481	5	3.1	2020-06-29T17:25:29.040Z	22 km SSW of Lovington, New Mexico	1.4	1.9	0.091	16
16	2020-06-29 T10:04:51.462Z	32.7692	-103.4389	5	2.7	2020-06-29T18:07:19.008Z	21 km SSW of Lovington, New Mexico	0.9	1.9	0.09	32
15	2020-06-29 T09:07:57.593Z	32.7675	-103.4457	3.2	2.5	2020-06-30T08:32:24.040Z	21 km SSW of Lovington, New Mexico	1.8	4.9	0.084	37
14	2020-06-29 T08:37:17.590Z	32.768	-103.471	5	3	2020-06-30T13:21:38.040Z	22 km SSW of Lovington, New Mexico	2.3	1.9	0.148	12
13	2020-06-28 T17:09:25.550Z	32.7541	-103.4618	5	3.1	2020-06-28T20:57:59.833Z	23 km SSW of Lovington, New Mexico	1.5	1	0.097	14
12	2020-06-28 T14:05:39.988Z	32.759	-103.4475	5	2.5	2020-07-06T14:35:38.040Z	22 km SSW of Lovington, New Mexico	1.6	1.9	0.091	16
11	2020-06-28 T12:51:49.385Z	32.756	-103.4626	6.37	2.6	2020-07-16T07:17:16.040Z	23 km SSW of Lovington, New Mexico	1.6	6.5	0.07	55
10	2020-06-28 T11:13:14.286Z	32.7375	-103.4374	5	2.7	2020-07-16T07:05:46.040Z	20 km NW of Monument, New Mexico	2	2	0.068	74
9	2020-06-28 T10:20:21.917Z	32.7653	-103.4448	3.46	2.6	2020-07-16T06:53:31.040Z	21 km SSW of Lovington, New Mexico	1.8	6.7	0.082	61
8	2020-06-28 T10:10:41.007Z	32.7673	-103.4453	5	2.5	2020-07-16T06:38:41.040Z	21 km SSW of Lovington, New Mexico	2	2	0.08	57
7	2020-06-28 T09:30:33.109Z	32.7518	-103.4471	5	2.3	2020-07-15T09:17:39.040Z	22 km NW of Monument, New Mexico	1.9	2	0.098	42
6	2020-06-28 T08:19:06.410Z	32.7485	-103.4515	5	2.6	2020-06-28T08:48:56.040Z	23 km SSW of Lovington, New Mexico	0.8	2	0.073	68
5	2020-06-28 T08:14:44.778Z	32.7647	-103.4566	6.8	2.6	2020-06-28T11:27:12.040Z	22 km SSW of Lovington, New Mexico	1.5	3.9	0.082	57
4	2020-06-28 T07:26:43.160Z	32.7562	-103.4549	8.48	2.8	2020-06-28T07:37:03.040Z	23 km SSW of Lovington, New Mexico	1.4	5	0.059	100
3	2020-06-28 T06:09:34.060Z	32.7571	-103.4583	1.21	2.7	2020-06-28T06:31:12.040Z	23 km SSW of Lovington, New Mexico	1.5	2.3	0.068	76
2	2020-06-28 T04:33:52.712Z	32.749	-103.4534	5	2.9	2020-06-28T04:49:57.040Z	23 km SSW of Lovington, New Mexico	2	2	0.148	12
1	2020-06-28 T02:23:24.172Z	32.748	-103.4622	5	3.3	2020-06-28T04:48:20.040Z	24 km SSW of Lovington, New Mexico	1.5	2	0.148	14

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State of New Mexico
Energy, Minerals and Natural Resources
Oil Conservation Division
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CONDITIONS

Action 430895

CONDITIONS

Operator: CLEARWATER SWD, LLC P.O. Box 1476 Lovington, NM 88260	OGRID: 371101
	Action Number: 430895
	Action Type: [IM-SD] Admin Order Support Doc (ENG) (IM-AAO)

CONDITIONS

Created By	Condition	Condition Date
mgebremichael	None	2/11/2025