

Application

Part III



**Seismic Risk Assessment**

**Overflow Energy**

**Rita SWD No. 1**

**Section 27, Township 22 South, Range 27 East**

**Eddy County, New Mexico**

**Cory Walk**

*Cory Walk*

**B.S., M.S.**

**Geologist**

**Permits West Inc.**

**April 2, 2019**



## GENERAL INFORMATION

Rita SWD #1 is located in the NW 1/4, section 27, T22S, R27E, about 4 miles southeast of Carlsbad, NM in the Permian Basin. Overflow Energy proposes the injection zone to be within the Devonian formation through an open hole from 12,900'-14,000' below ground surface. This report assesses any potential concerns relating to induced seismicity along deep penetrating Precambrian faults or the connection between the injection zone and known underground potable water sources.

## SEISMIC RISK ASSESSMENT

### *Historical Seismicity*

Searching the USGS earthquake catalog resulted in one (1) earthquakes above a magnitude 2.5 within 6 miles (9.7 km) of the proposed deep disposal site since 1970 (Fig 1). This earthquake occurred in 1974 about 4.5 miles (~7 km) southeast of the proposed Rita SWD site and had a magnitude of 3.9.

### *Basement Faults and Subsurface Conditions*

A structure contour map (Fig. 1) of the Precambrian basement shows the Rita SWD #1 is approximately 9 and 12 miles from two basement-penetrating faults inferred by Ewing et al (1990). Based on GIS data from Ruppel et al. (2009), basic information about these faults are calculated and listed in Table 1. These datasets don't include fault dip angles. Therefore, following Snee and Zoback (2018), we assume that within the generally extensional environment of the Permian Basin, all active faults will dip in the range of 50° to 90°.

Snee and Zoback (2018) state, "In the western part of Eddy County, New Mexico,  $S_{Hmax}$  is ~north-south (consistent with the state of stress in the Rio Grande Rift; Zoback and Zoback, 1980) but rotates to ~east-northeast-west-southwest in southern Lea County, New Mexico and the northernmost parts of Culberson and Reeves counties, Texas." Around the Rita SWD site, Snee and Zoback indicate a  $S_{Hmax}$  direction of N035°E and an  $A_p$  of 0.52, indicating an extensional (normal) stress regime.

Induced seismicity is a growing concern of deep SWD wells. Relatively new software developed by the Stanford Center for Induced and Triggered Seismicity allows for the probabilistic screening of deeply penetrating faults near the proposed injection zone (Walsh et al., 2016; Walsh et al., 2017). This software uses parameters such as stress orientations, fault strike/dip, injection rates, fault friction coefficients, etc. to estimate the potential for fault slip. Using the best available data as input parameters (Table 2), the Fault Slip Potential (FSP) models suggest an eighteen (0.18) percent chance of slip on a nearby fault, inferred by Frenzel et al (1988) and Ewing et al. (1990), through the year 2040 (Fig 2; Table 1). This model also suggests a pore pressure increase of 2.5 psi on the nearest fault (Fault 3; Fig. 3; Table 1) by the year 2040. Geomechanical modeling shows that the primary fault of concern (fault 2) would need a pressure increase of 2000 psi in order to reach a 100% probability of slip on the fault. Even a 50% probability requires an increase of 326 psi which is far greater than the modeled increase of 2.5 psi.



## **GROUNDWATER SOURCES**

Quaternary Alluvium acts as the principal aquifer used for potable ground water near the Rita SWD #1 location (Hendrickson and Jones, 1952). Nicholson and Clebsch (1961) state, "Potable ground water is not available below the Permian and Triassic unconformity but, because this boundary is not easily defined, the top of the Rustler anhydrite formation is regarded as the effective lower limit of 'potable' ground water." Around the Rita SWD #1, the top of a thick anhydrite unit interpreted to represent the Rustler Formation lies at a depth of ~350 feet bgs.

## **STRATIGRAPHY**

Thick permeability barriers exist above (Woodford shale; 100 ft thick) and below (Simpson Group; 135 ft thick) the targeted Devonian injection zone (Plate 2, Comer et al., 1991; Fig. 8, Frenzel et al., 1988). Well data indicates ~12,550 ft of rock separating the top of the Devonian from the previously stated lower limit of potable water at the top of the Rustler anhydrite formation.

## **CONCLUDING STATEMENT**

Geologic data evaluated around the Rita SWD #1 well show no potential structural or stratigraphic connection between the Devonian injection zone and any subsurface potable water sources. Based on Fault Slip Potential modeling there is an 18% probability (0.18) of inducing seismic activity along nearby deeply penetrating Precambrian faults.



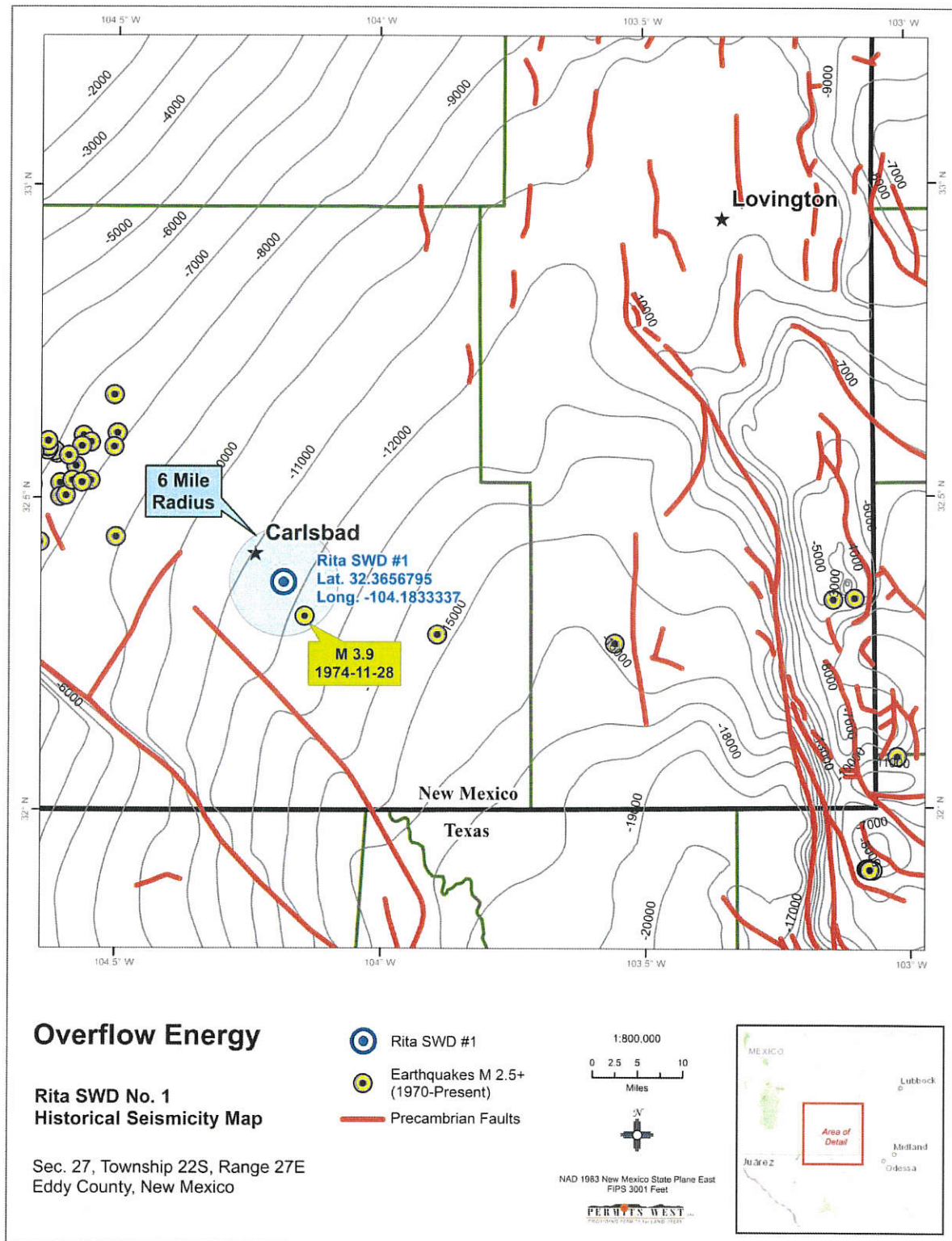


Figure 1. Structural contour map of the Precambrian basement in feet below sea level. Red lines represent the locations of Precambrian basement-penetrating faults (Ewing et al., 1990). The Rita SWD #1 well lies ~9 miles NE of the closest deeply penetrating fault and 4 miles from the closest historic earthquake.



**Table 1: Nearby Basement Fault Information**

<b>ID</b>	<b>Distance from proposed Rita SWD (mi)</b>	<b>Strike (°)</b>	<b>Dip (°)</b>	<b>FSP</b>	<b>Pore Pressure change after 20 years (psi)</b>
Fault 3	9.0	137	50-90	0.00	2.5
Fault 2	12.0	33	50-90	0.18	0.7

**Table 2: Fault Slip Potential model input parameters**

<b>Faults</b>	<b>Value</b>	<b>Notes</b>
Friction Coefficient	0.58	Ikari et al. (2011)
Dip Angle (deg)	70	Snee and Zoback (2018)
<b>Stress</b>		
Vertical stress gradient (psi/ft)	1.1	Hurd and Zoback (2012)
Max Horizontal Stress Direction (deg)	35	Snee and Zoback (2018)
Depth for calculations (ft)	14000	Proposed injection zone
Initial Reservoir Pressure Gradient (psi/ft)	0.7	calculated from mud wt (ppg) used in drilling at these depths
A Phi Parameter	0.52	Snee and Zoback (2018)
Reference Friction Coefficient	0.58	Ikari et al. (2011)
<b>Hydrology</b>		
Aquifer thickness (ft)	1100	Proposed injection zone
Porosity (%)	6	
Permeability (mD)	150	
Injection Rate (bbl/day)	25000	Maximum proposed injection rate



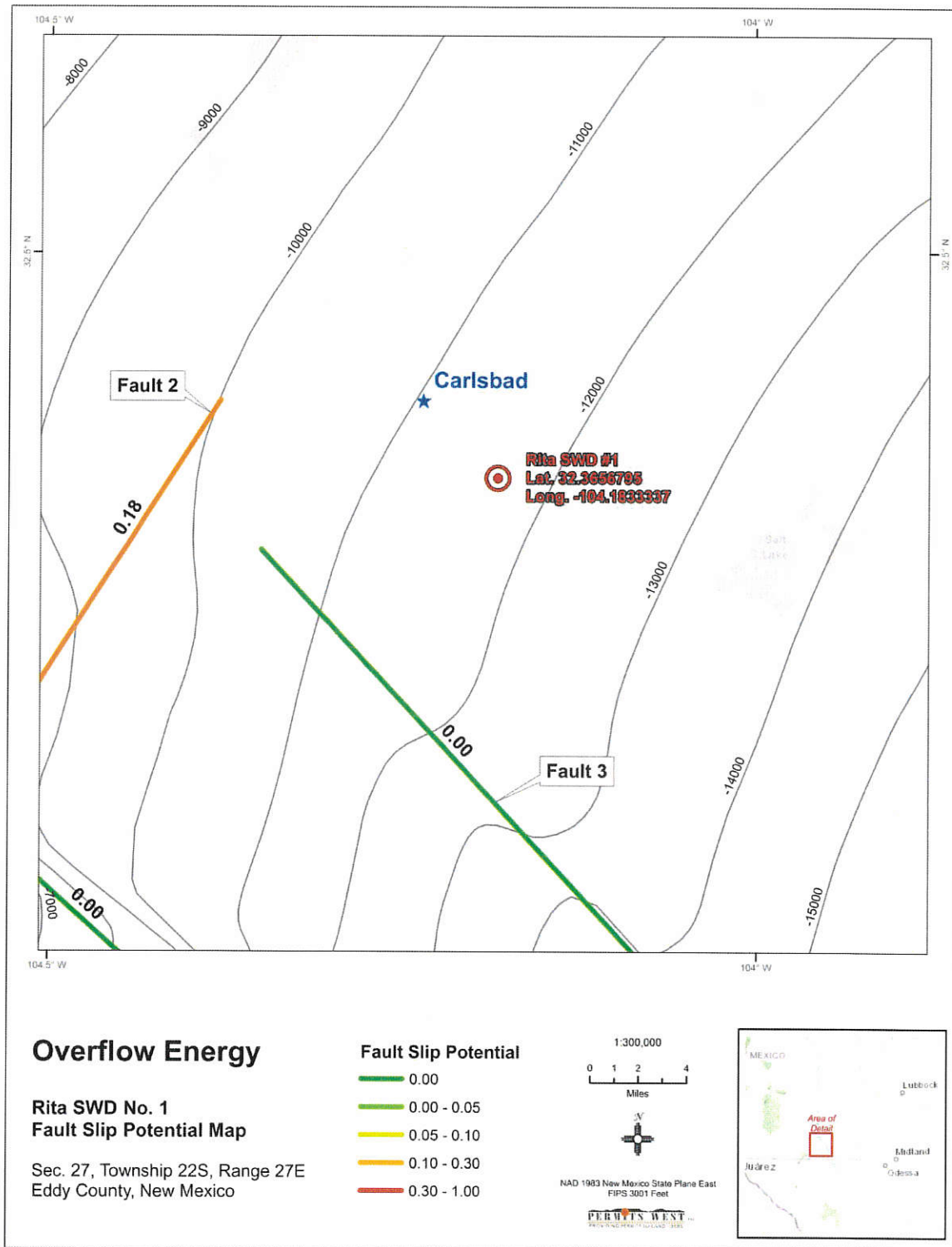


Figure 2. Precambrian fault map of southeastern New Mexico as mapped by Ewing et al. (1990). Faults are colored based on probability of fault slip as modeled using Fault Slip Potential software (Walsh and Zoback, 2016). Labeled values represent the calculated fault slip potential using the parameters indicated in Table 2. Contours show the top of the Precambrian basement in feet below sea level.



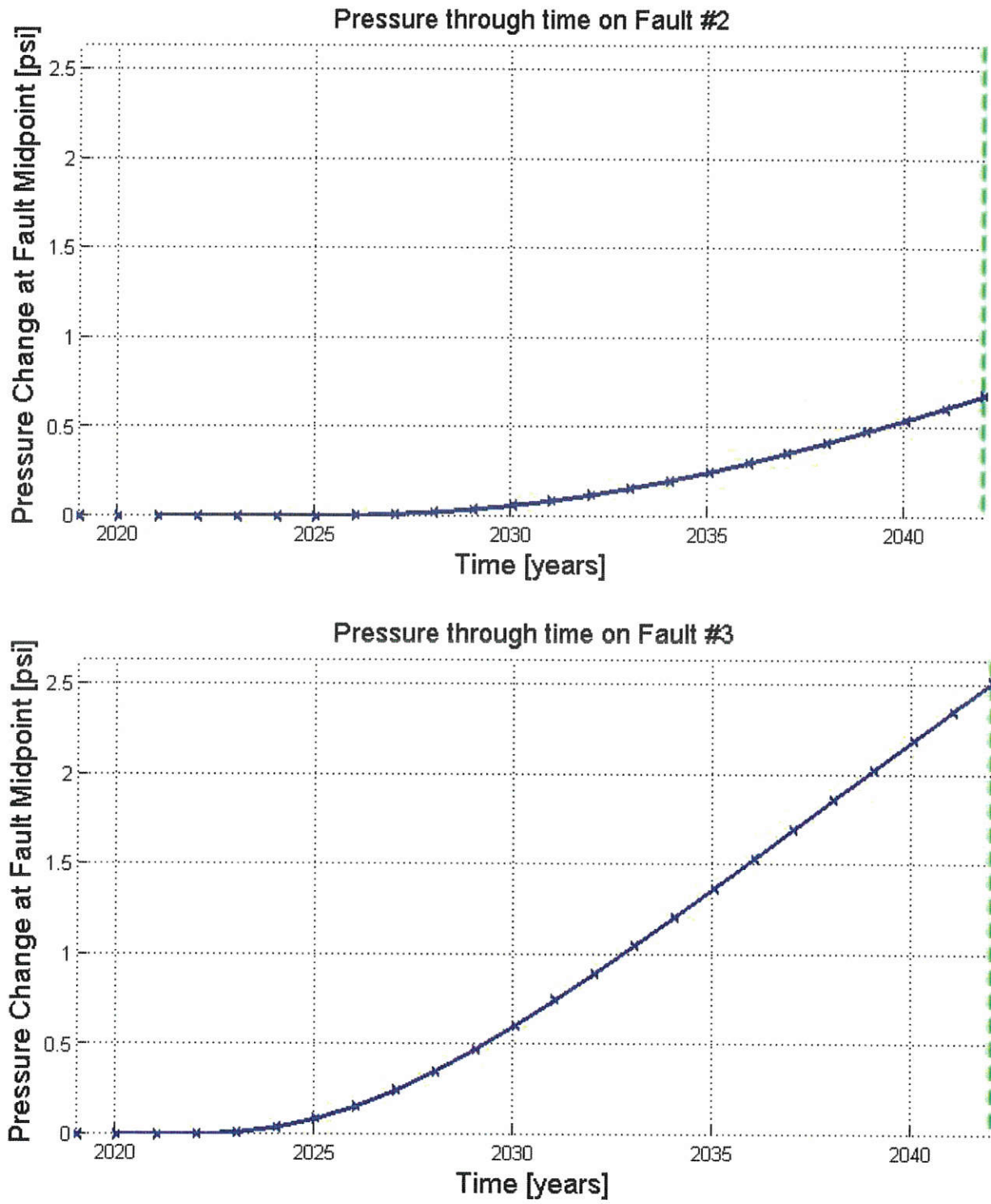


Figure 3. Scatter plots showing the modeled change of pore pressure on faults 2 and 3 through time as a response to the proposed SWD well.



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Rita SWD 1

32.36567, -104.18333

54 miles

Quaternary faults

EXHIBIT I



30 mi



**AFFIDAVIT OF PUBLICATION**

Ad No.  
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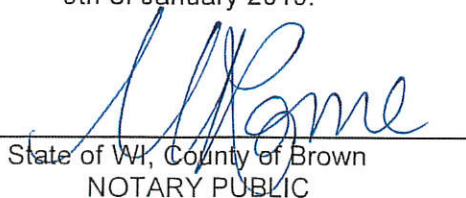
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37 VERANO LOOP  
SANTA FE NM 87508

I, a legal clerk of the **Carlsbad Current-Argus**, a newspaper published daily at the City of Carlsbad, in said county of Eddy, state of New Mexico and of general paid circulation in said county; that the same is a duly qualified newspaper under the laws of the State wherein legal notices and advertisements may be published; that the printed notice attached hereto was published in the regular and entire edition of said newspaper and not in supplement thereof on the date as follows, to wit:

01/09/19

  
Legal Clerk

Subscribed and sworn before me this  
9th of January 2019.

  
State of WI, County of Brown  
NOTARY PUBLIC

  
My Commission Expires

Overflow Energy, LLC will apply to drill the Rita SWD 1 as a salt-water disposal well. The well will dispose into the Devonian formation from 12,900' to 14,000'. It is 4 miles southeast of Carlsbad, NM at 1876' FNL & 807' FWL Sec. 27, T. 22 S., R. 27 E., Eddy County, NM. Maximum disposal rate will be 25,000 bwpd. Maximum injection pressure will be 2,580 psi. Interested parties must file objections or requests for hearing with the NM Oil Conservation Division, 1220 South Saint Francis Dr., Santa Fe, NM 87505 within 15 days. Additional information can be obtained by contacting: Brian Wood, Permits West, Inc., 37 Verano Loop, Santa Fe, NM 87508. Phone number is (505) 466-8120.

January 9, 2019

