



## TEP Rocky Mountains LLC

### Geoscience Review of the Potential for Seismic Events Associated with water Injection, Section 32 of T7S R96W, Grand Valley Field, Garfield County, Colorado

TEP Rocky Mountains LLC [TEP] proposes to recomplete a salt water disposal well into the Williams Fork and Iles formations of the Mesaverde Group. If approved, SG 922-32D (API 05-045-22654) will commence water injection in the Williams Fork Formation and Rollins Member of the Iles Formation in addition to the previously completed Cozzette and Corcoran Members. The proposed injection well, operated by TEP, is located (surface and bottom hole) in the South Grand Valley Field, Sec. 32, T7S R96W, Garfield County, Colorado.

TEP has carefully reviewed the surface and subsurface geology in the immediate area around the proposed wells to determine if there is any known seismic risk associated with these wells and has prepared Figures highlighting the geologic and geophysical review.

Figure 1 is a reference map of the Piceance Basin that shows: 1) the Basin margin (Mesaverde outcrop) in green, 2) the location of the proposed injection conversion well with blue injection symbol and 3) all known seismic events from 1973 through 2017 collected from the USGS Earthquake Database and plotted with orange circles with the magnitude of the seismic event above the location.

A review of seismic events in the Piceance Basin shows only four seismic events greater than 3.0 have been recorded in the Piceance Basin since 1969. Two of the events were the result of the Department of Energy's Nuclear Test Program that detonated nuclear devices with the intent of inducing fractures to improve natural gas production in the Williams Fork Formation. The 1<sup>st</sup> test was Project Rulison, Sec. 25, T7S, R95W, Garfield County in 1969 and resulted in a 5.5 seismic event. The 2<sup>nd</sup> test was Project Rio Blanco, Sec. 14, T3S, R98W, Rio Blanco County in 1973 and resulted in a 5.4 seismic event. The 3<sup>rd</sup>, located in Sec. 22, T1N, R97W, Rio Blanco County occurred in 1994 and measured a 3.4 seismic event. A review of the geologic literature shows this seismic event was located approximately 1 mile north-northeast from the axis of the Red Wash Syncline and 1.5 miles from a surface mapped normal fault (Hail and Smith, 1994). The 4<sup>th</sup> located in Sec. 15, T6S, R91W, Garfield County, is a recent event, January 2017, which measured a magnitude of 3.3.

Figure 2 is a map showing the location of the proposed SG 922-32D injection well in relation to the Grand Valley 3D seismic survey and identified Cretaceous and Precambrian faults. This map also shows the location of the Figure 4 cross section which ties to adjacent operated wells disposing in the Williams Fork.

Figure 3 is a seismic line extracted from the 3D seismic survey covering the South Grand Valley field. The seismic line shows the structural characteristic of the layers from the surface down to the Precambrian basement rock. This seismic line runs west to east, intersecting the proposed injection well. Due to the proprietary nature of the licensed seismic data, distribution of the trace data is not possible.

Figure 4 is a stratigraphic cross section including the SG 922-32D and highlighting the zone of interest from 800'-1,800' below the top of Mesaverde. See Table 1 for list of log curves displayed in which log tracks.

The existing perforations are shown in pink tick marks and the proposed perforations are in black tick marks to the left of the GR log. Injection intervals are highlighted in blue between the logs.

Figure 4A is a stratigraphic cross section including the SG 922-32D and highlighting the zone of interest from 4'-110' below the top of the Rollins. See Table 1 for list of log curves displayed in which log tracks. The existing perforations are shown in pink tick marks and the proposed perforations are in black tick marks to the left of the GR log. Injection intervals are highlighted in blue between the logs.

Given the numerous permitted and operating injection wells throughout the Piceance Basin, the lack of observed seismic activity directly correlated to injection in the Piceance Basin, and our review of the available well logs and 3D geophysical data in the immediate area of the proposed injection wells, TEP believes that the risk of induced seismic events from the proposed injection well is very low.

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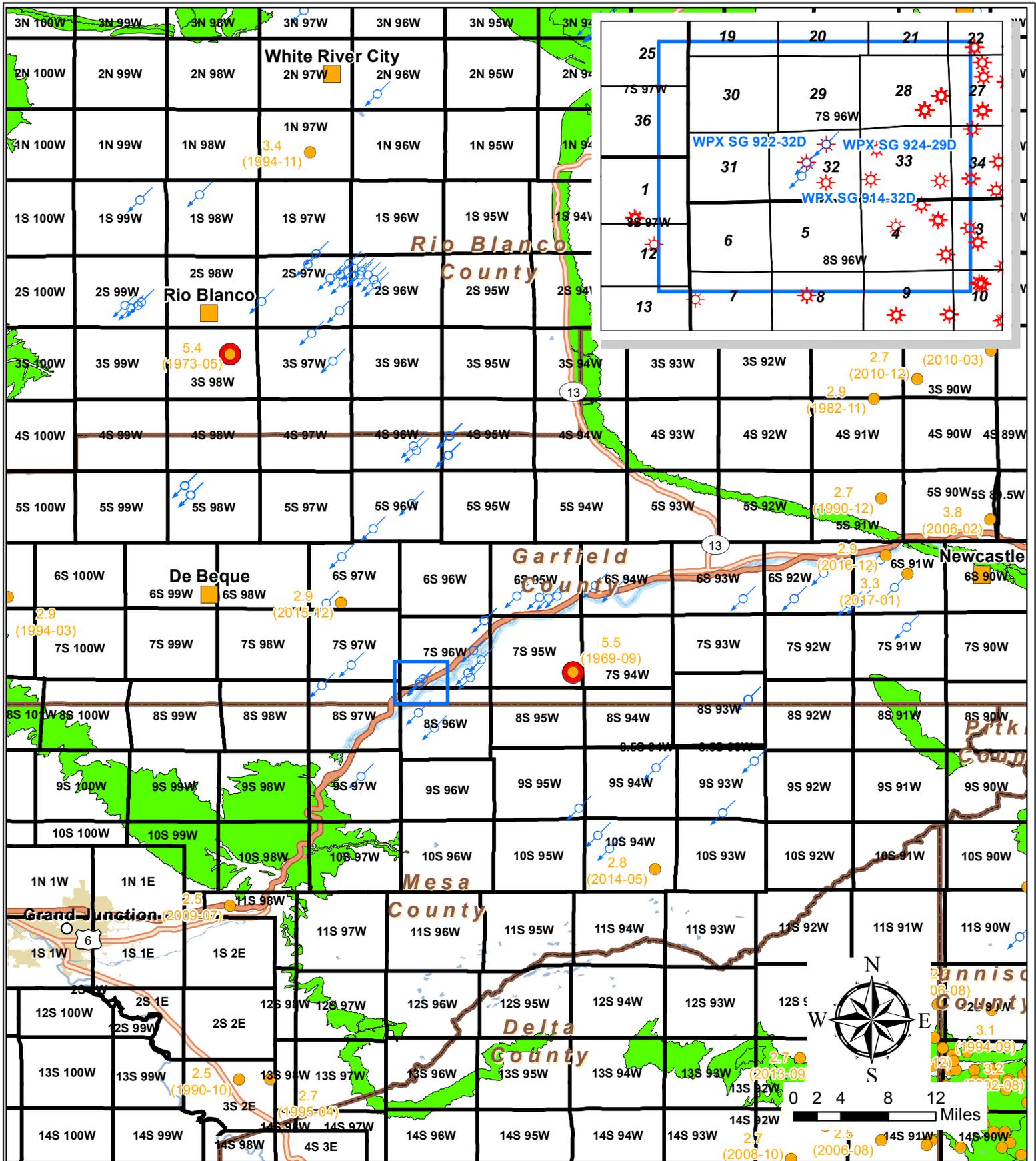
March 1, 2017

Table 1. List of Log Curves by Track Number from Left to Right on Exhibit 4

Track #	Log Curve Present	Log Curve Display	Log Curve Scale
Track 1	Caliper	Thin black line	5 to 16 inches
Track 2	Gamma Ray	Color shaded, sands yellow, shales gray	0 to 150 API
Track 2	SP	Thin blue dashed line	-160 to 40
Track 3	Deep Resistivity	Solid black line shaded with red if > 20 ohm-m blue shaded if < 20 ohm-m	2 to 200 ohm-m logarithmic
Track 3	Shallow Resistivity	Thin dotted black line	2 to 200 ohm-m logarithmic
Track 4	Density Porosity	Thin black line shaded red > 8 PU	0.2 to 0 PU

References Cited:

Hall, W.J., and Smith, M.C., 1994, Geologic map of the northern part of the Piceance Basin, northwestern Colorado: US Geological Survey, Miscellaneous Investigations Series, MAP I-2400.

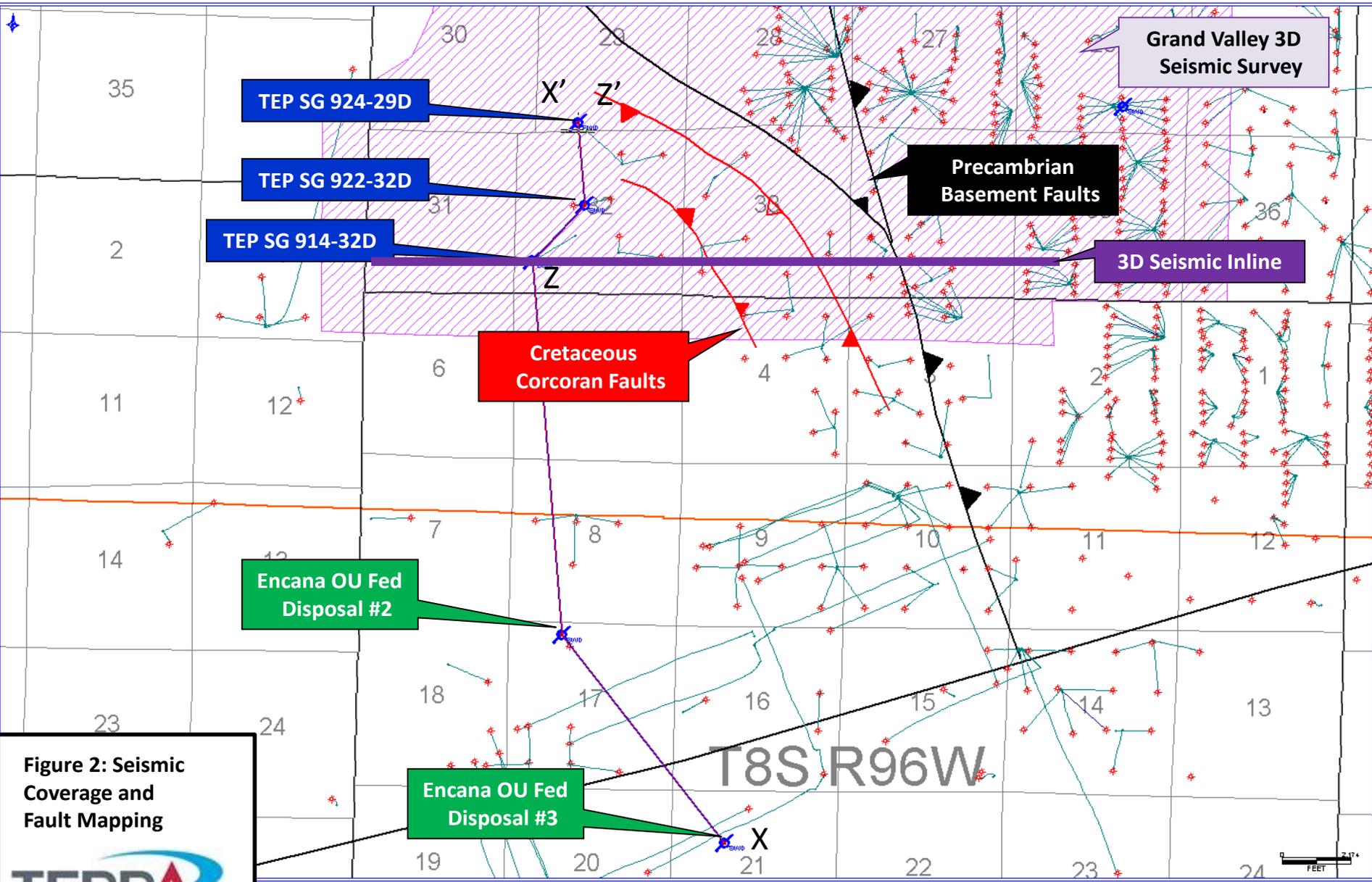


- Legend**
- Earthquake
  - Blast Site
  - Seismic Station
  - River
  - Injection Well (per COGCC)
  - Mesaverde Outcrop
  - ⊕ P&A
  - ⊕ Temporarily Abandoned
  - ★ Production Gas Well



**Figure 1 - Water Injection and Seismic Activity Overview**

# SG 922-32D Figure 2: Seismic Coverage



**Figure 2: Seismic Coverage and Fault Mapping**

# SG 922-32D Figure 3: Seismic Inline Extracted from Grand Valley 3D Seismic Survey

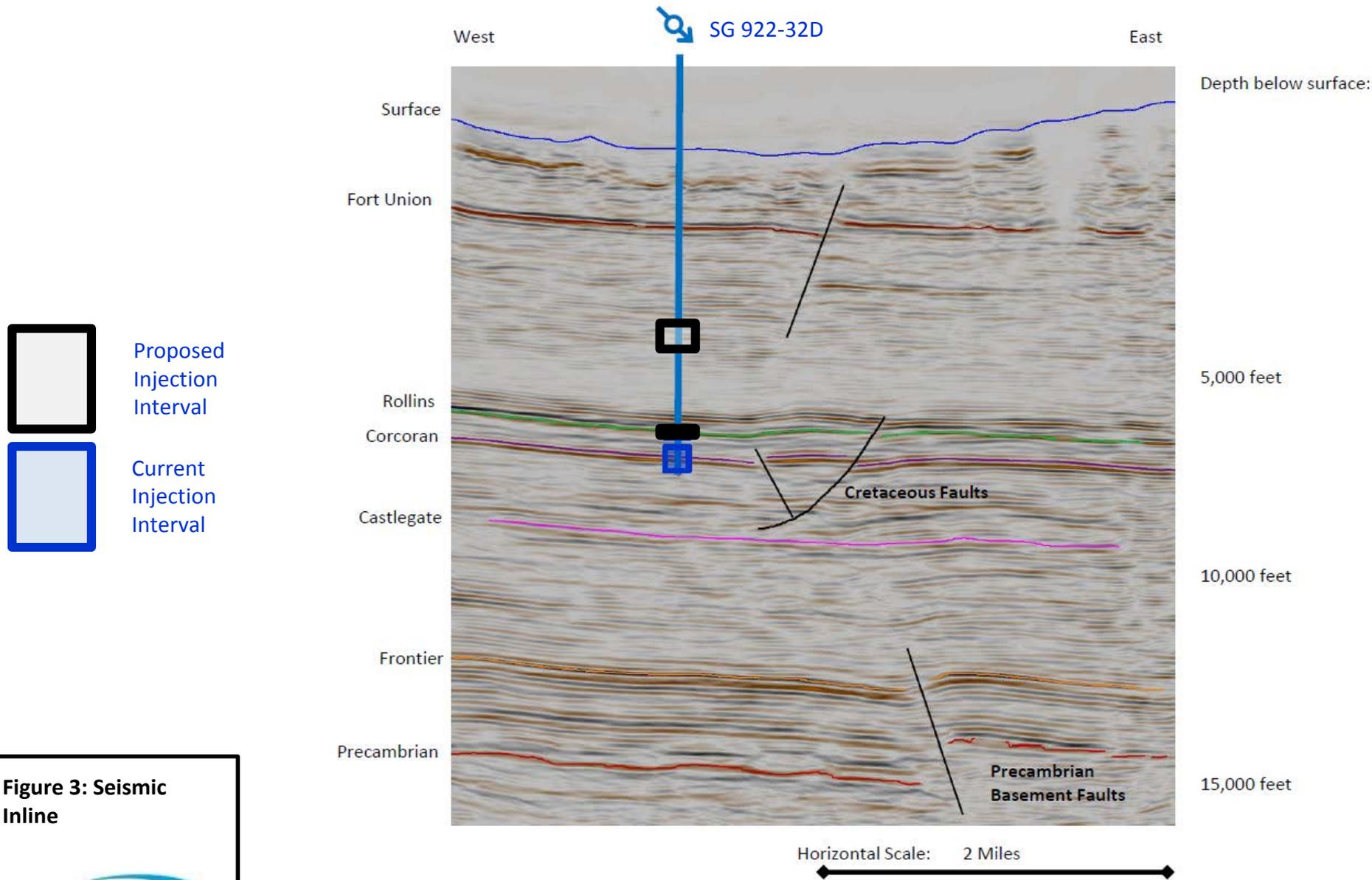
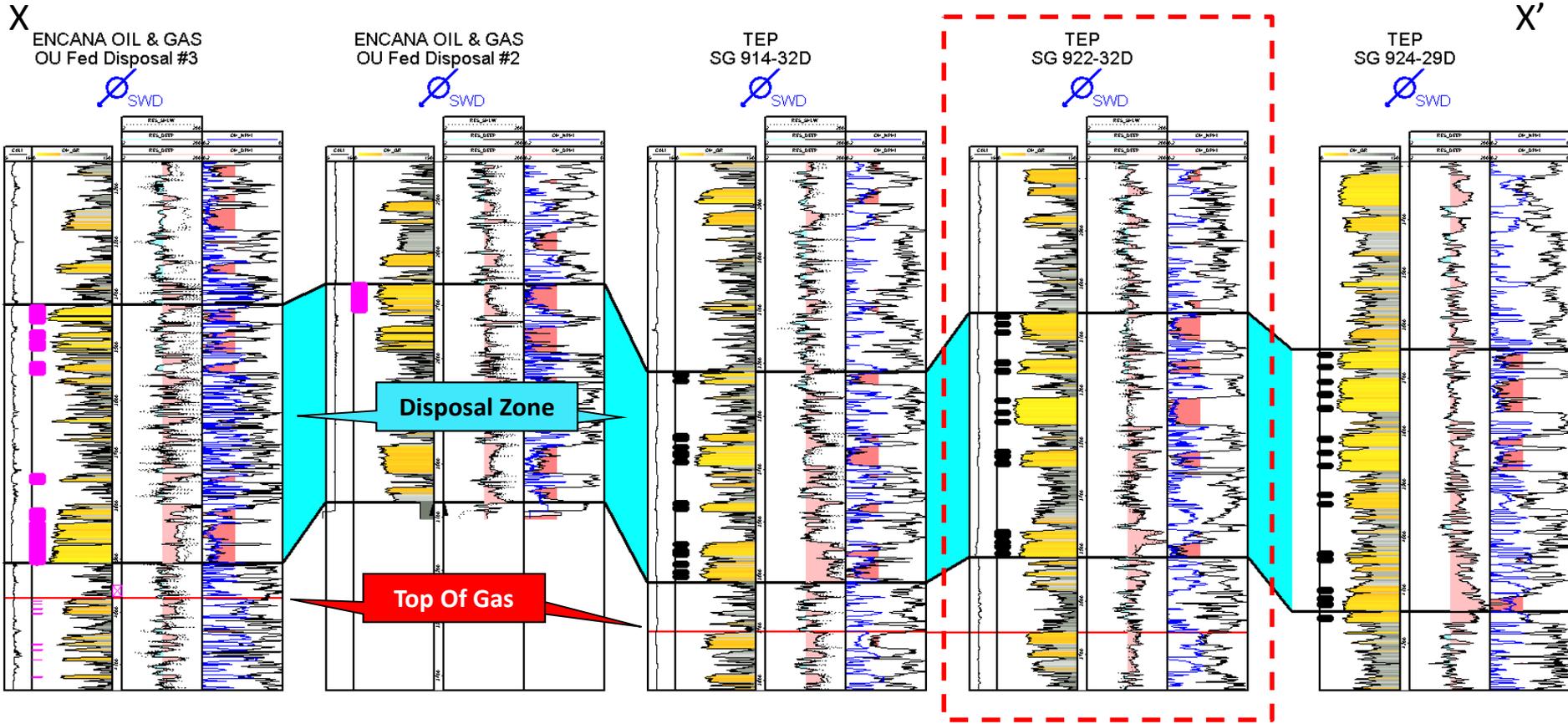


Figure 3: Seismic Inline



# SG 922-32D Figure 4: Stratigraphic Cross Section



## SG 922-32D:

Top of Cement: 2,226' MD

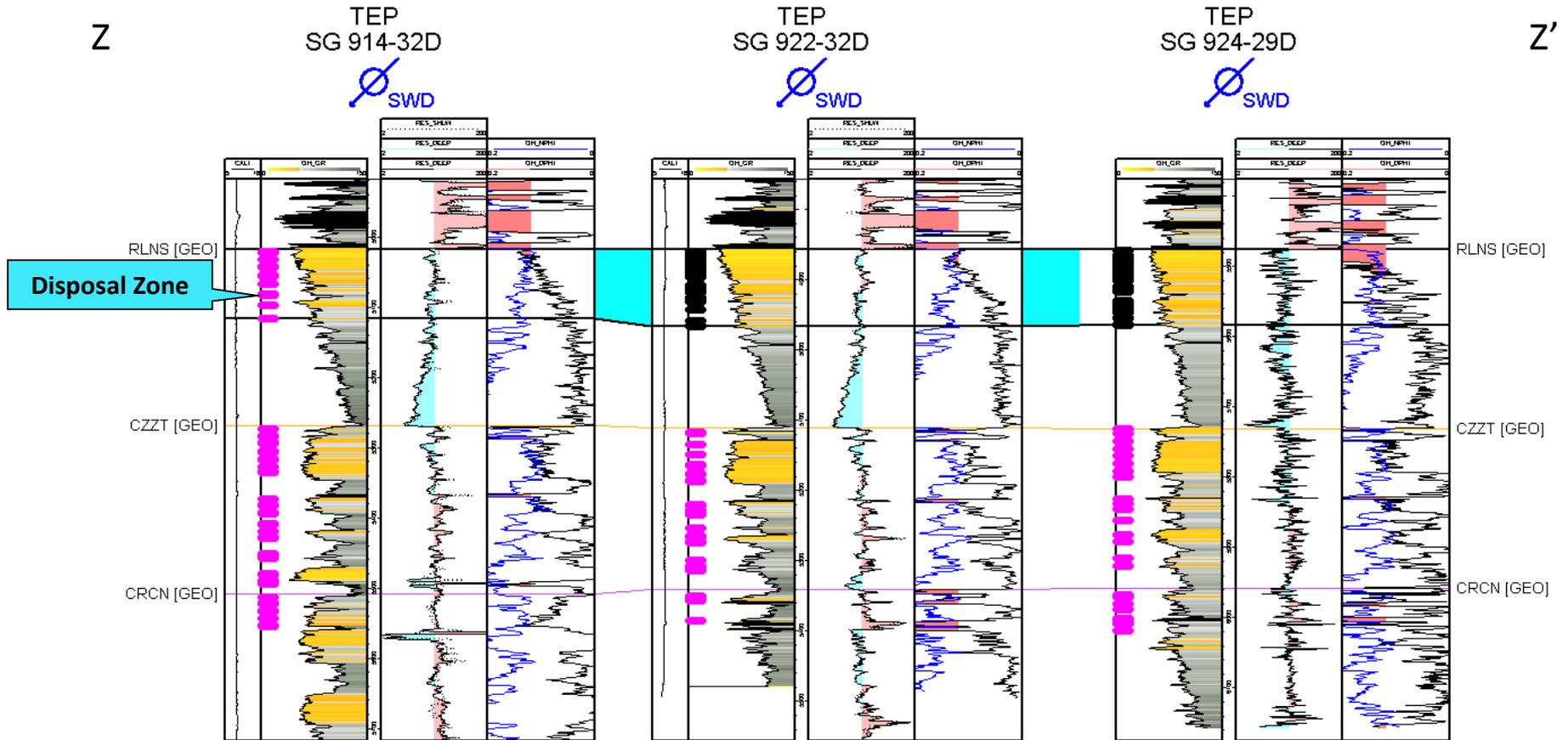
Top Proposed WFRK Injection: 3,061' MD

Base Proposed WFRK Injection: 3,510' MD

Figure 4:  
Stratigraphic  
Cross Section



# SG 922-32D Figure 4A: Stratigraphic Cross Section



## **SG 922-32D:**

Top of Cement: 2,226' MD

Top Rollins (Iles): 4,856' MD

Top Rollins Injection: 4,860' MD

Base Rollins Injection: 4,966' MD

**Figure 4:**  
Stratigraphic  
Cross Section

