



# Using Seismic Monitoring to Increase Permitted SWD Injection Rates in Texas

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**Prepared by:** Nate Alleman, Reed Davis, Tom Tomastik, Mark Kidder, Fernando DeLeon, Ben Bockelmann (ALL Consulting)

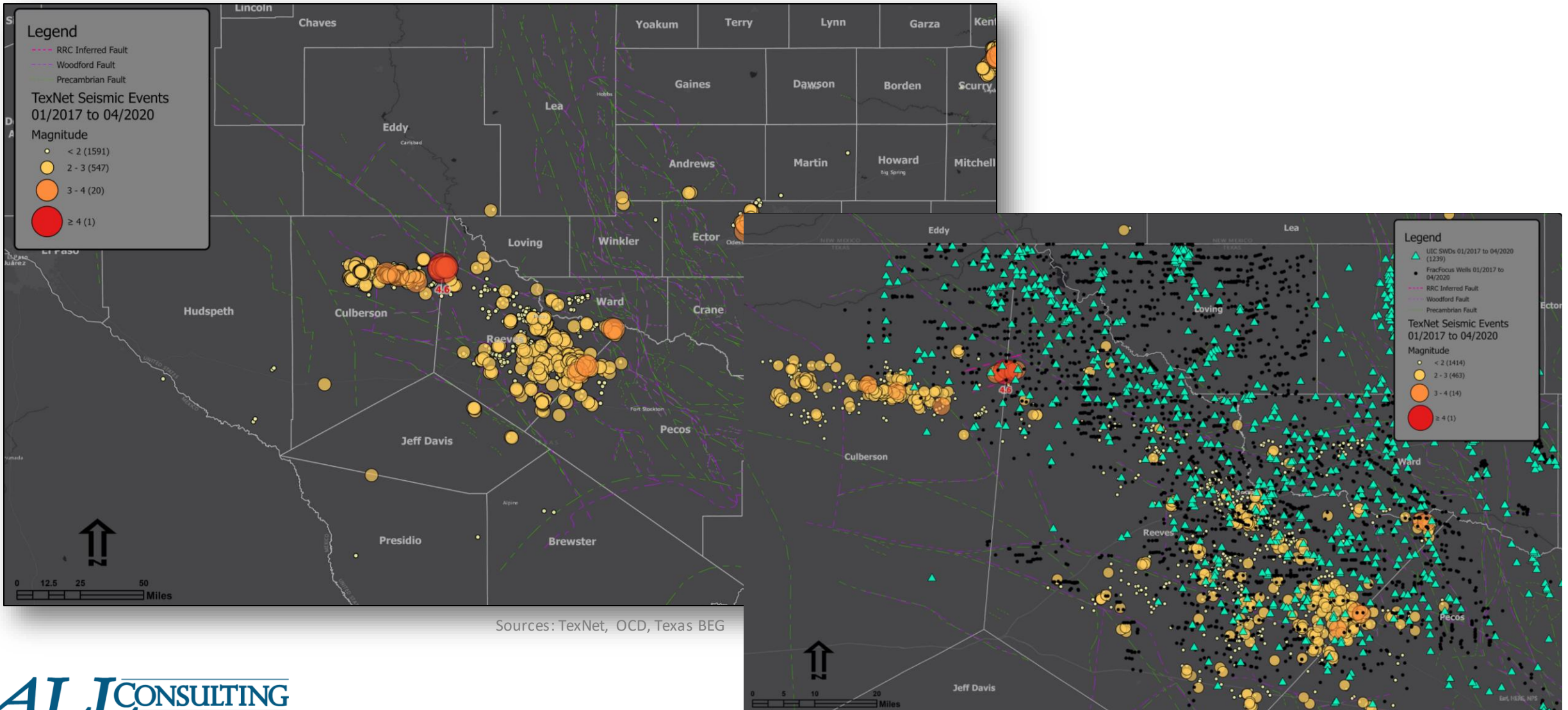
**Presented at:** GWPC Virtual Annual Forum  
Crockett

September 30, 2020

# Overview

- West Texas Seismicity
- Seismicity vs Saltwater Disposal
  - Deep vs Shallow SWDs
- Seismicity vs Hydraulic Fracturing
- RRC Response to Seismicity
- Seismic Monitoring to Increase Injection Rate

# West Texas Seismic Activity 2017- 2020



Sources: TexNet, OCD, Texas BEG

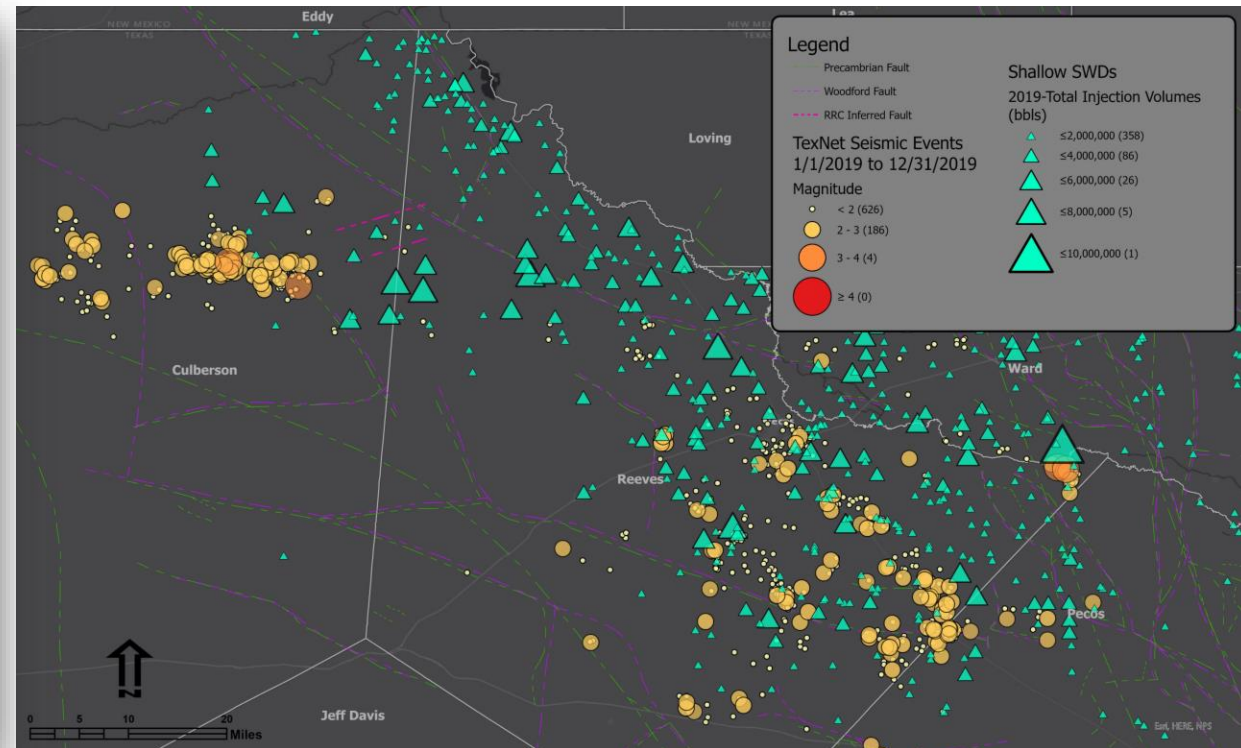
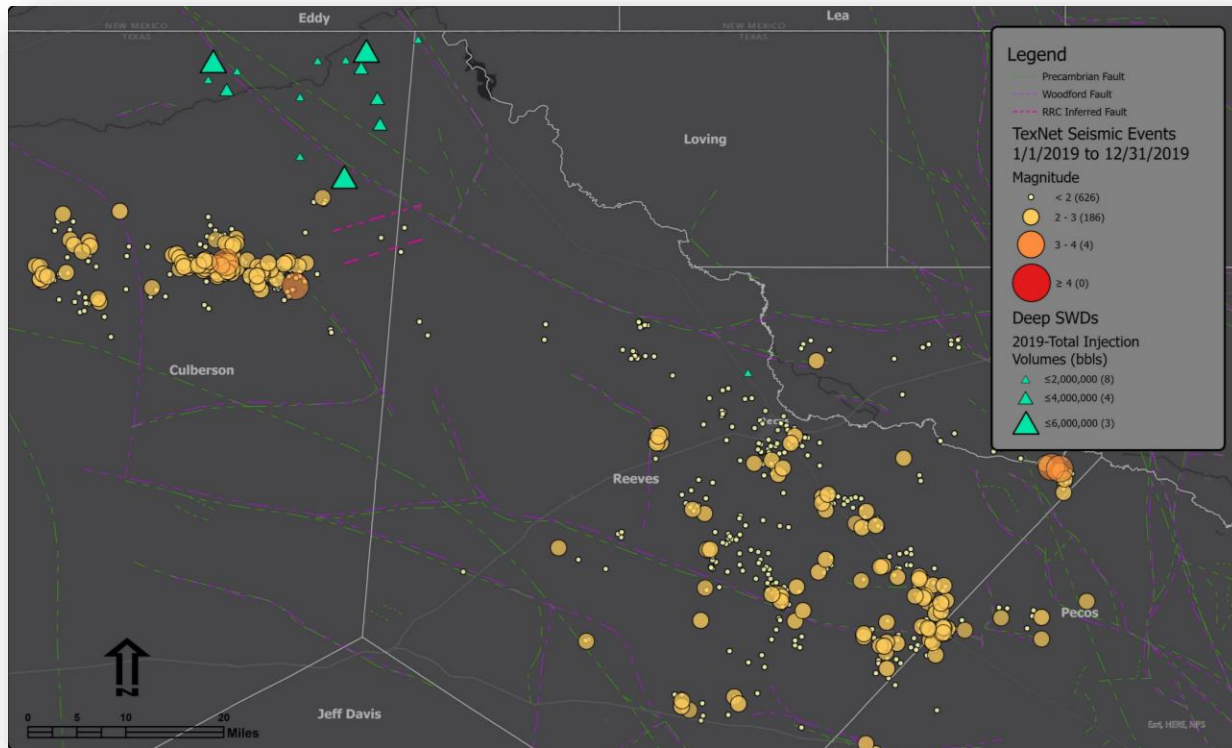
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# Deep vs Shallow SWD Volumes vs Seismicity (2019)

## Deep SWDs

## Shallow SWDs

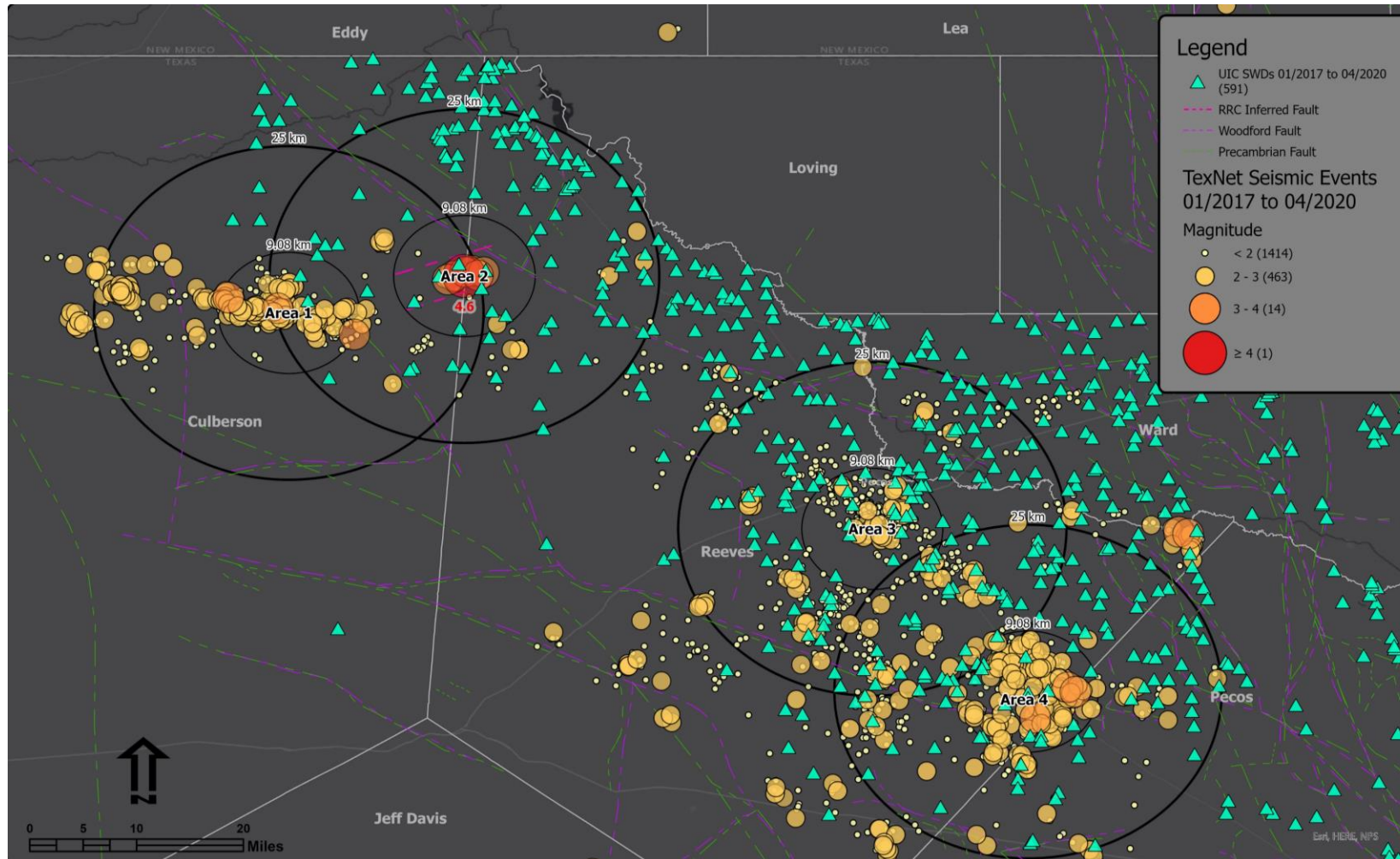


Sources: TexNet, OCD, Texas BEG

# Seismicity Comparison

Saltwater Disposal Area of Interest Timelines

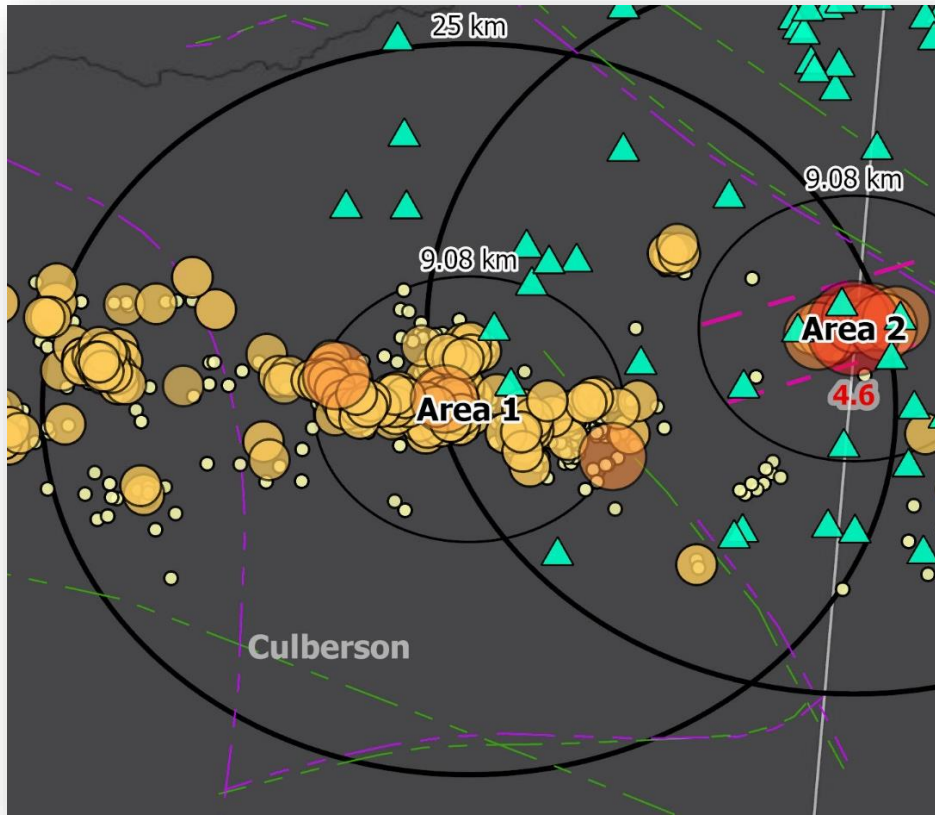
# West Texas Seismicity - Areas of Interest



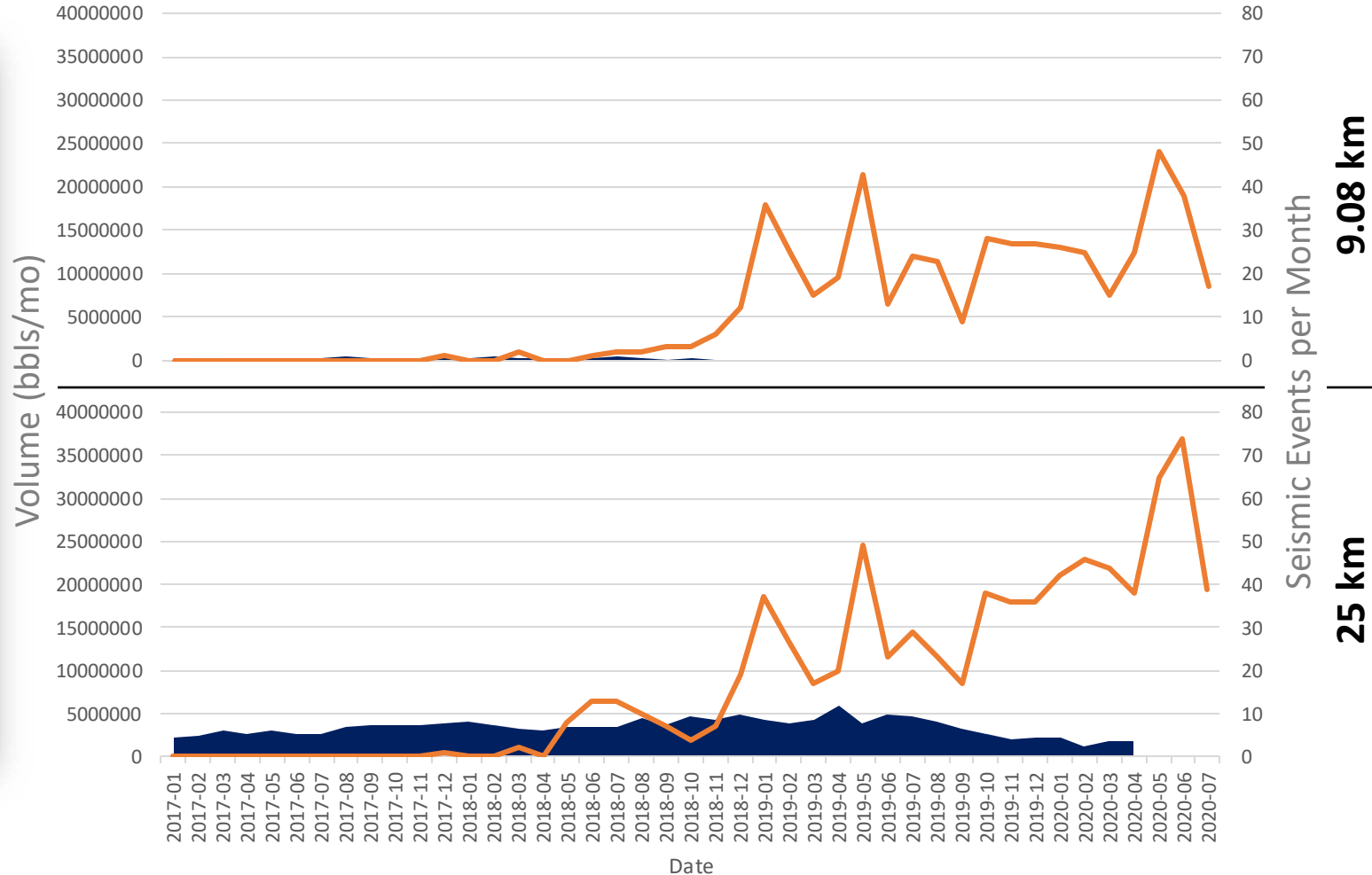
Sources: TexNet, OCD, Texas BEG



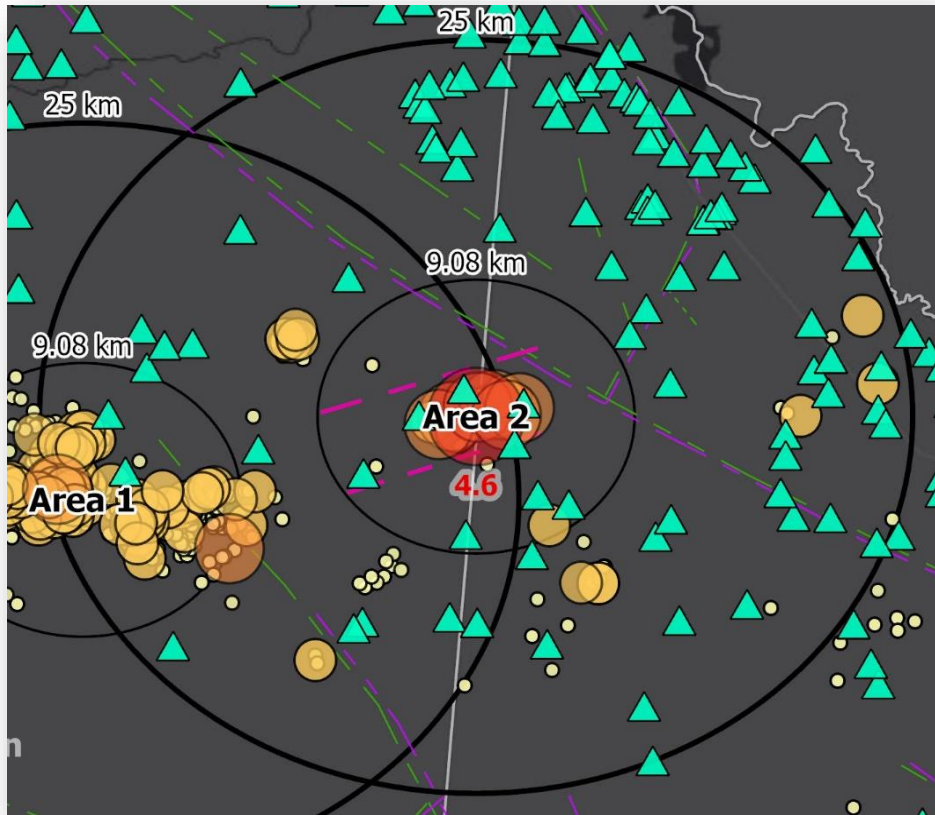
# Total Disposal Volume vs Seismicity - Area 1



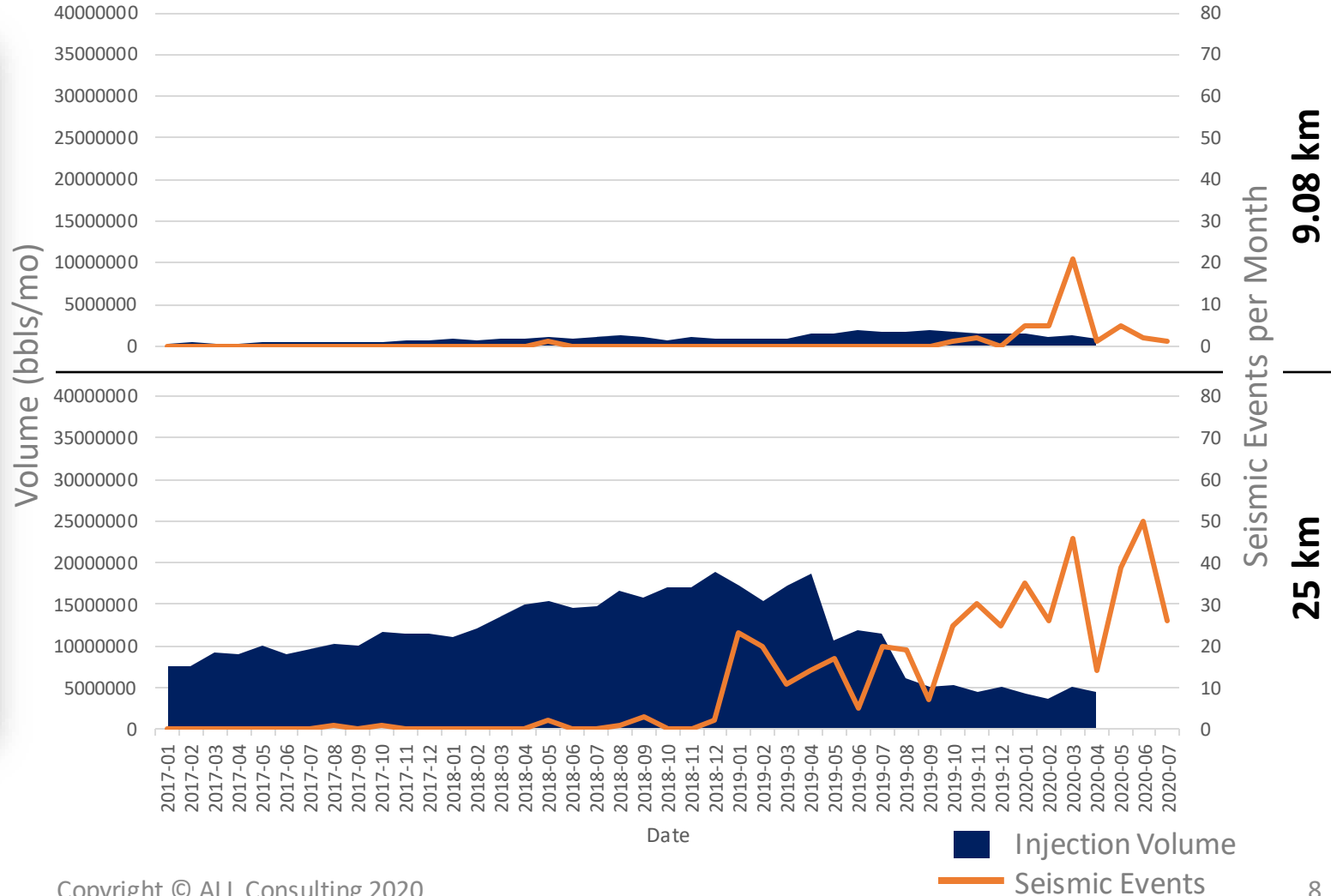
Sources: TexNet, OCD, Texas BEG



# Total Disposal Volume vs Seismicity - Area 2

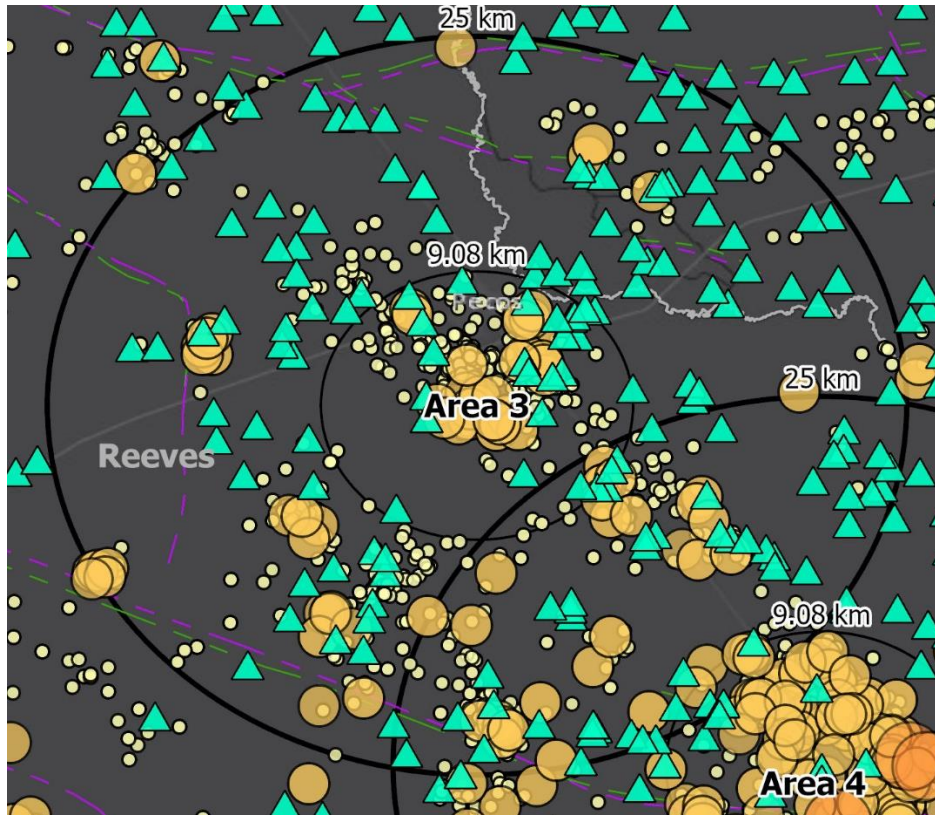


Sources: TexNet, OCD, Texas BEG

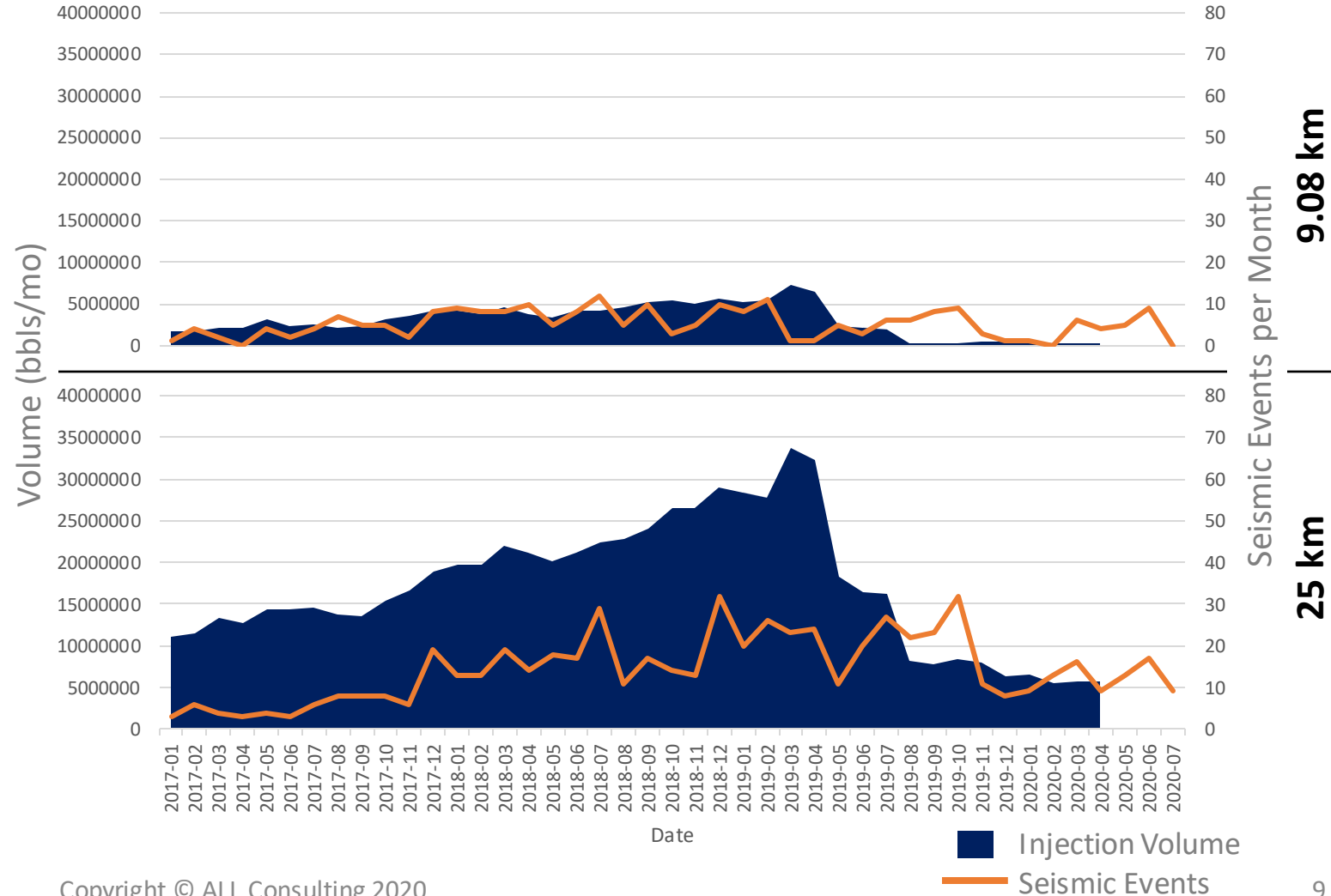




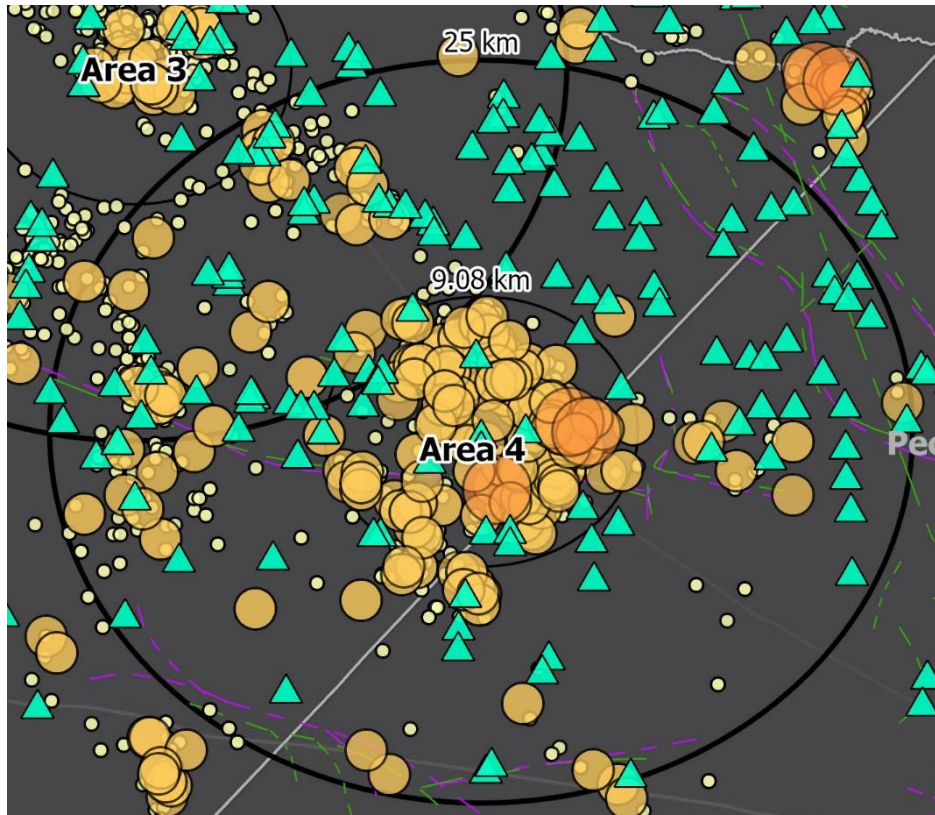
# Total Disposal Volume vs Seismicity - Area 3



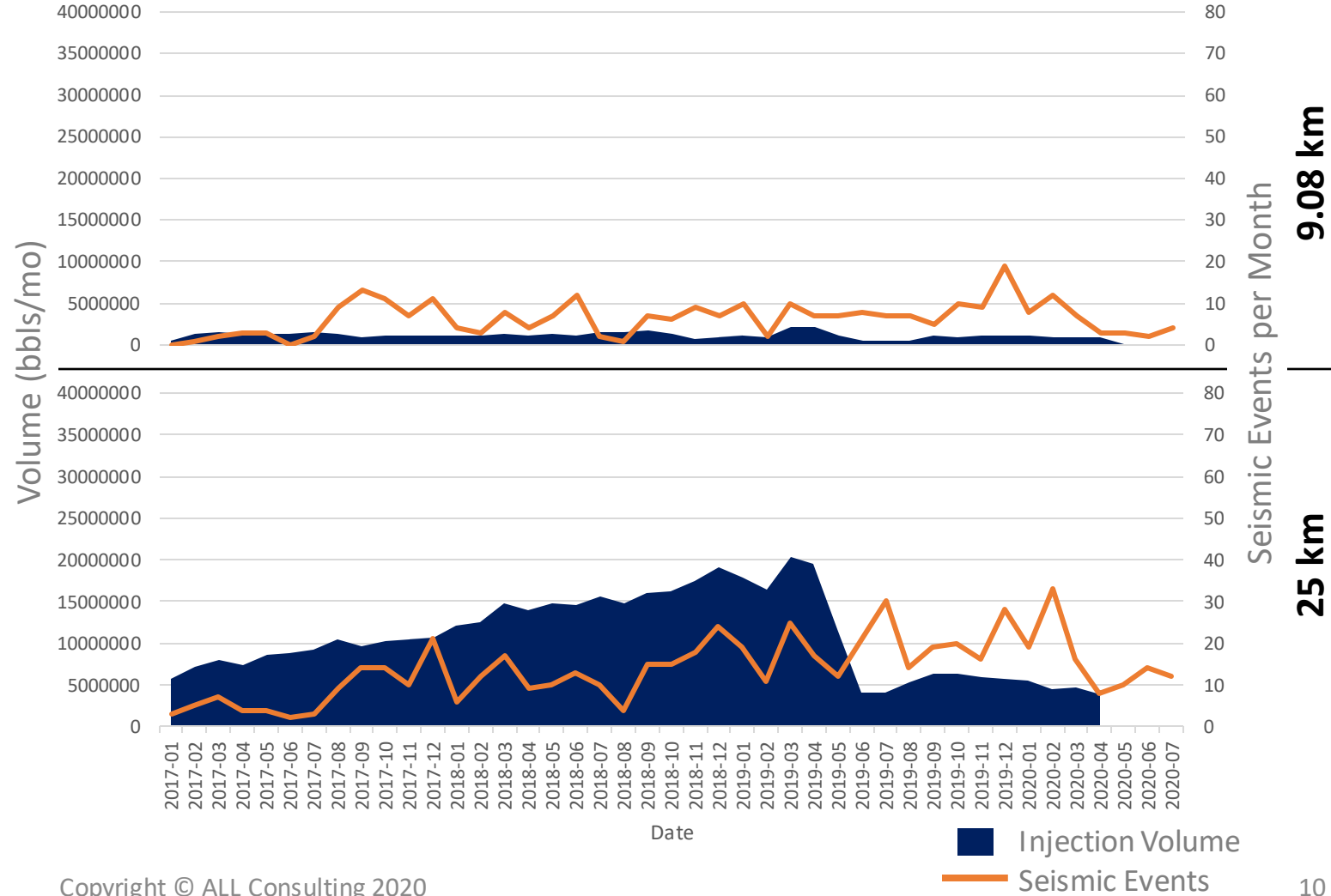
Sources: TexNet, OCD, Texas BEG



# Total Disposal Volume vs Seismicity - Area 4



Sources: TexNet, OCD, Texas BEG

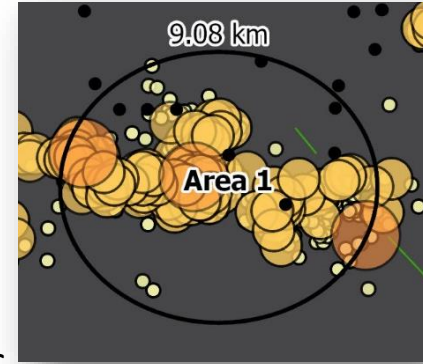


# Seismicity Comparison

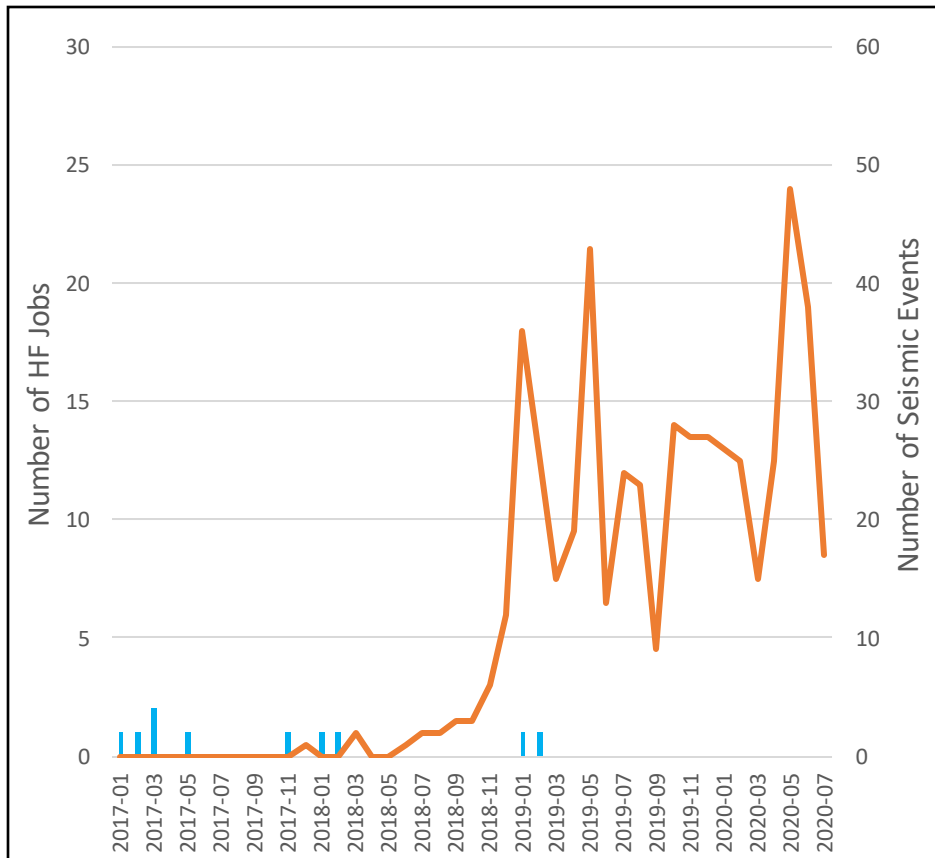
Hydraulic Fracturing



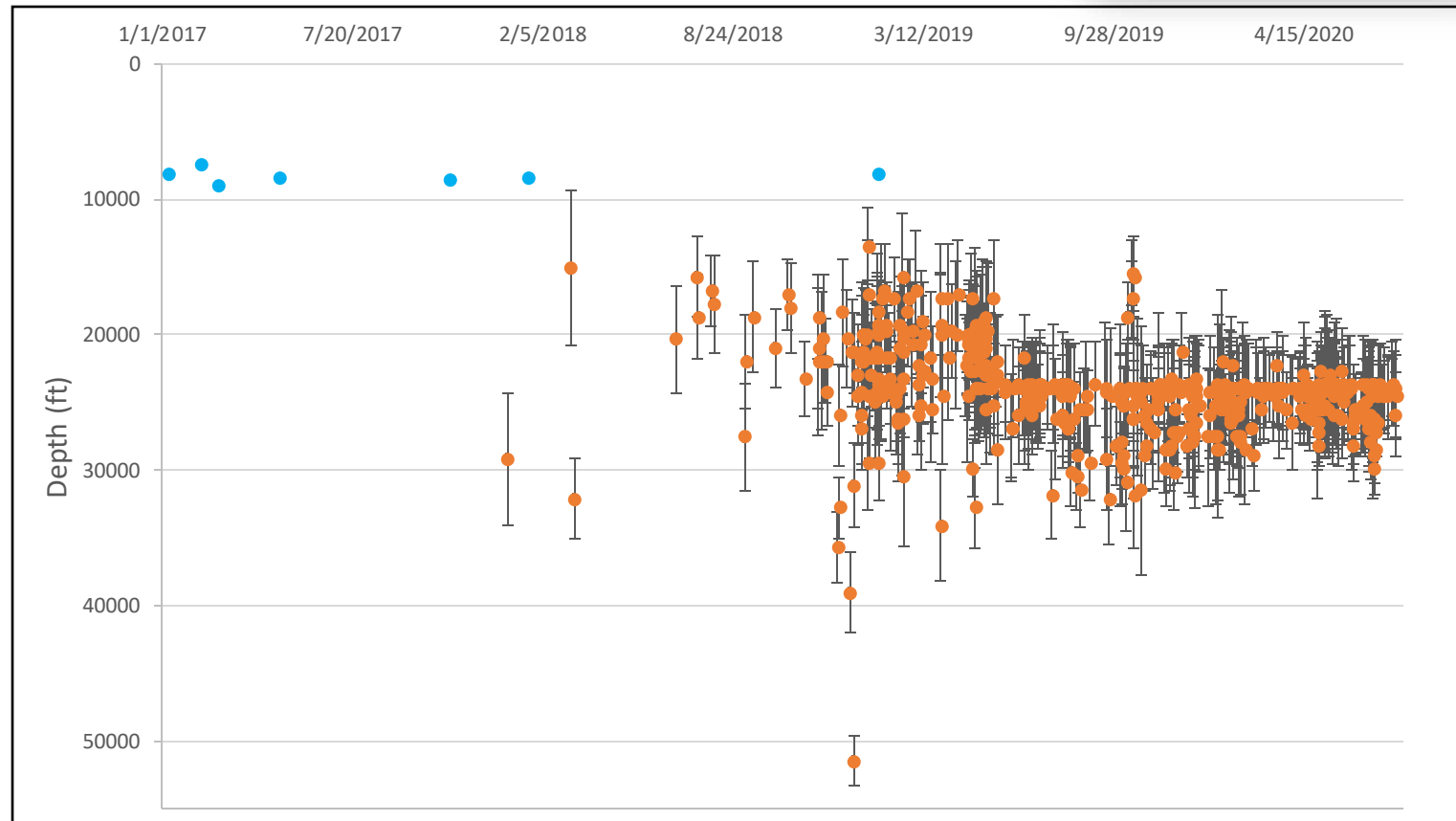
# Hydraulic Fracturing vs Seismicity - Area 1



Number of HF Jobs vs Seismic Events

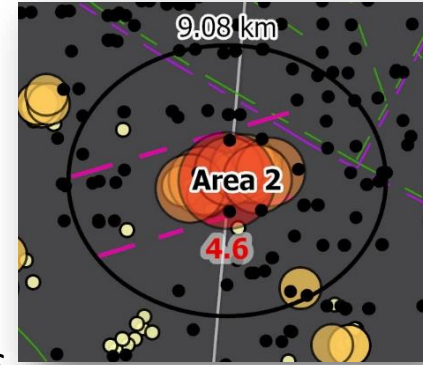


Depth of HF Jobs vs Seismic Events

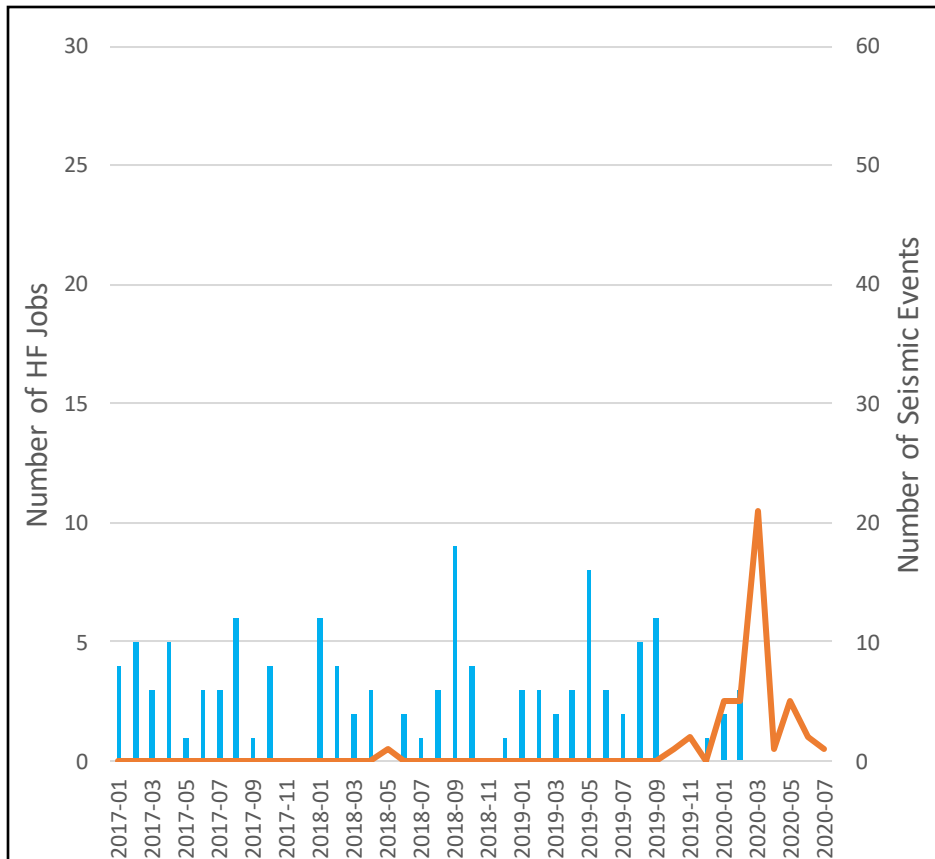


Sources: TexNet, OCD, FracFocus

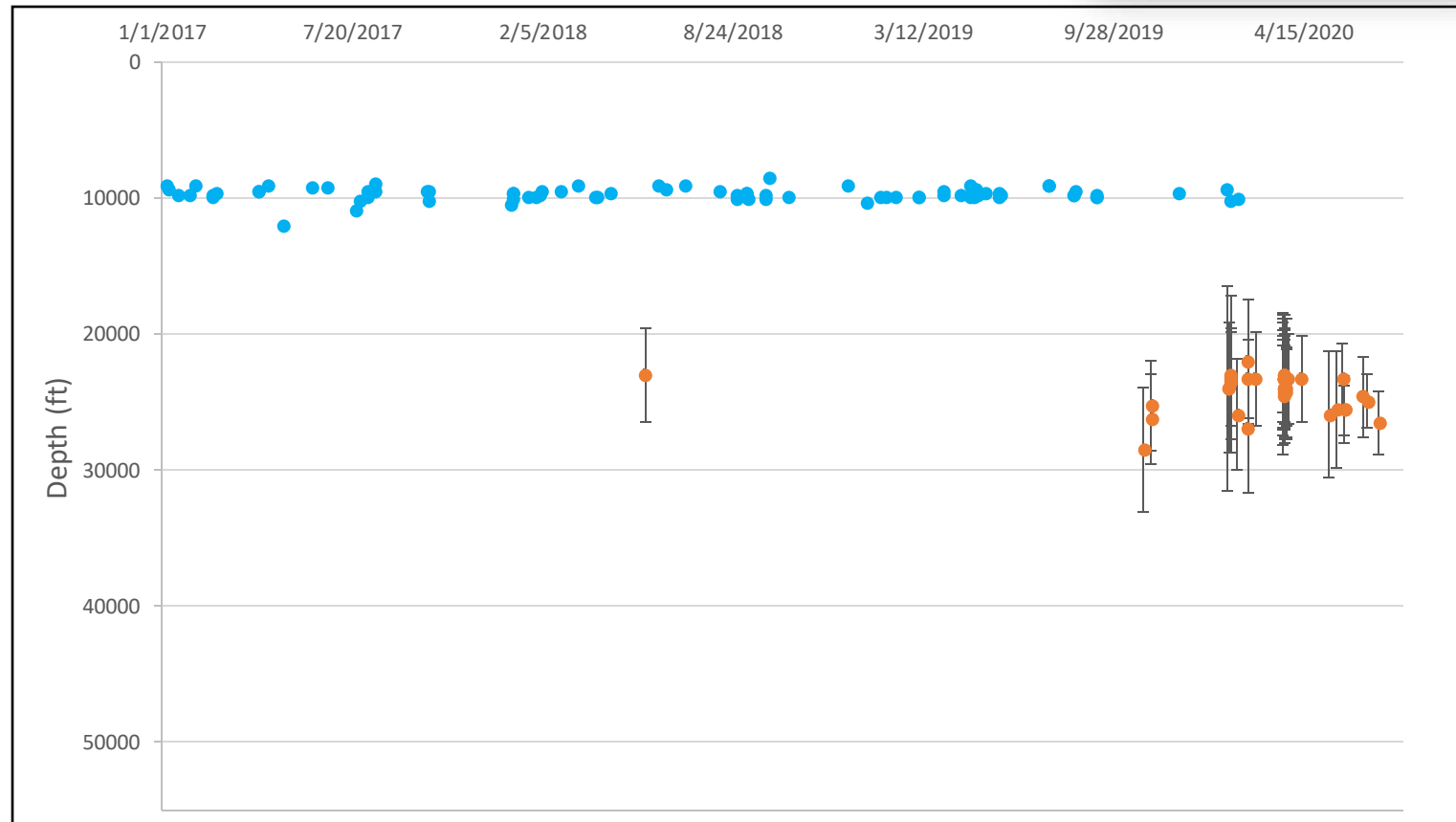
# Hydraulic Fracturing vs Seismicity - Area 2



Number of HF Jobs vs Seismic Events

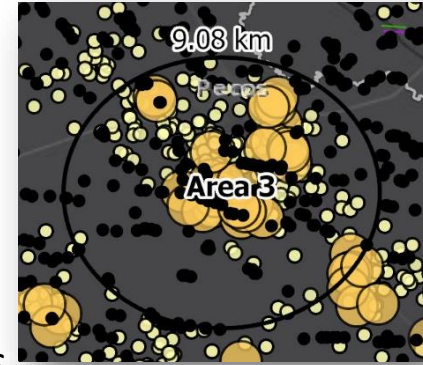


Depth of HF Jobs vs Seismic Events

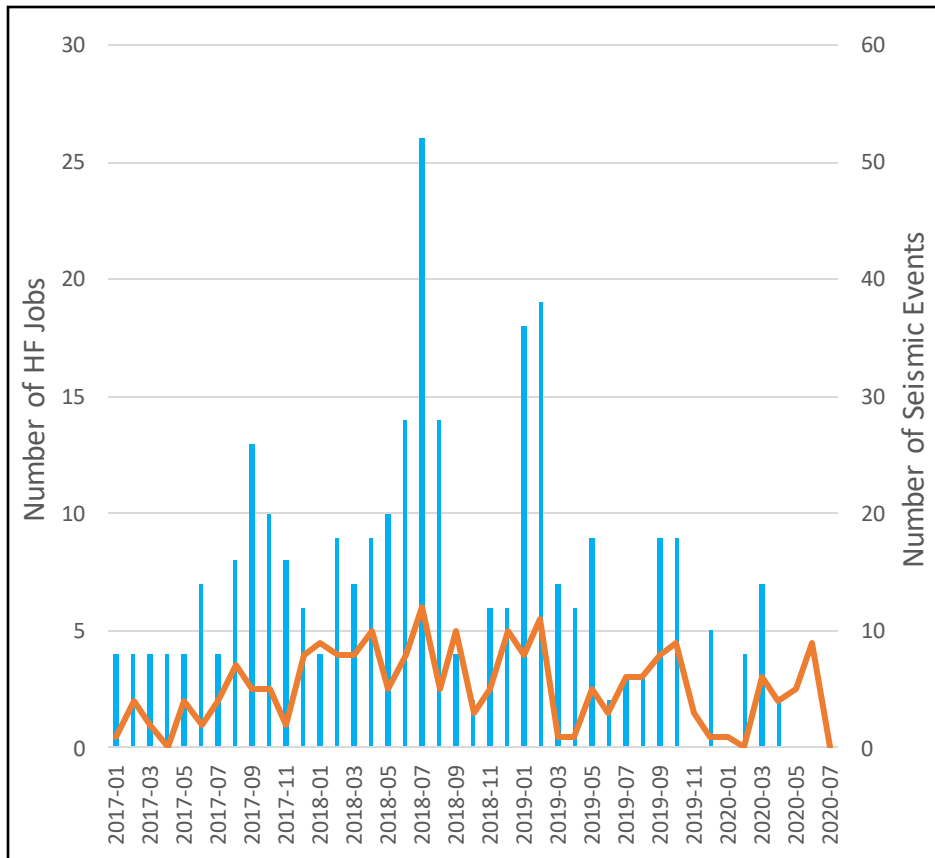


Sources: TexNet, OCD, FracFocus

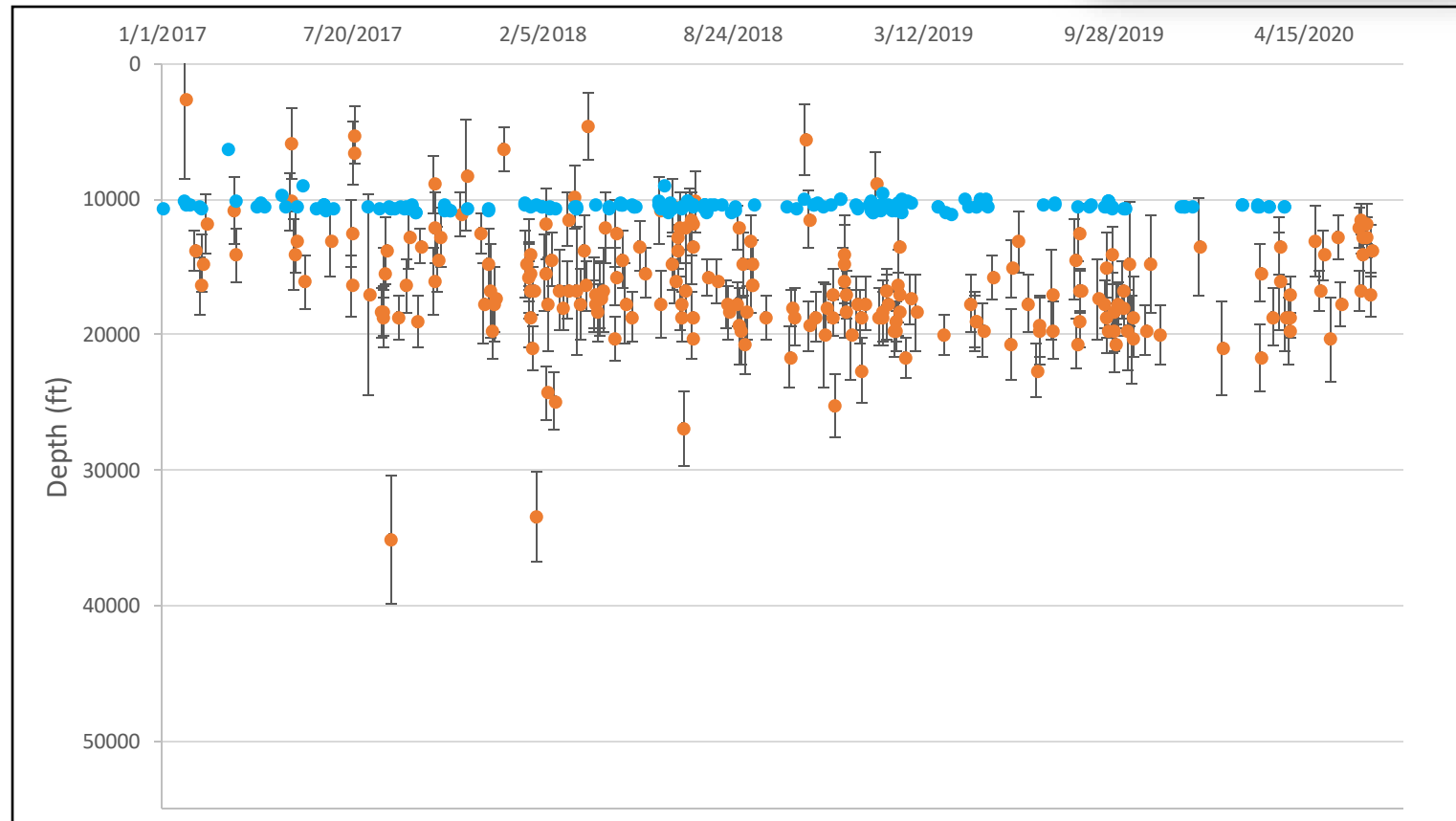
# Hydraulic Fracturing vs Seismicity - Area 3



Number of HF Jobs vs Seismic Events



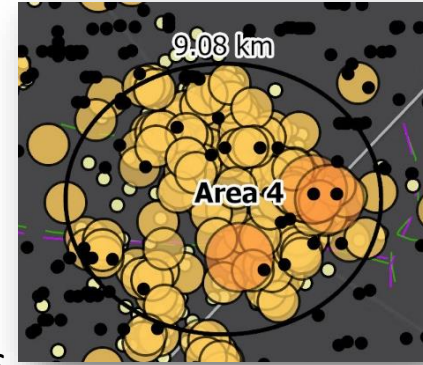
Depth of HF Jobs vs Seismic Events



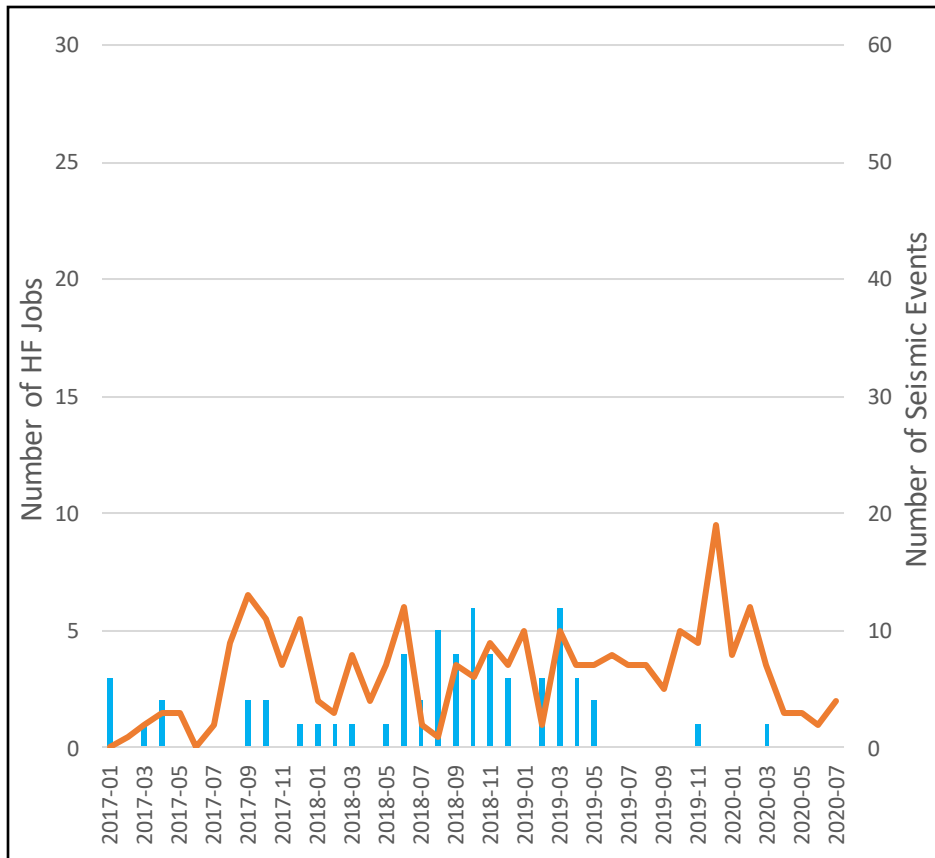
Sources: TexNet, OCD, FracFocus



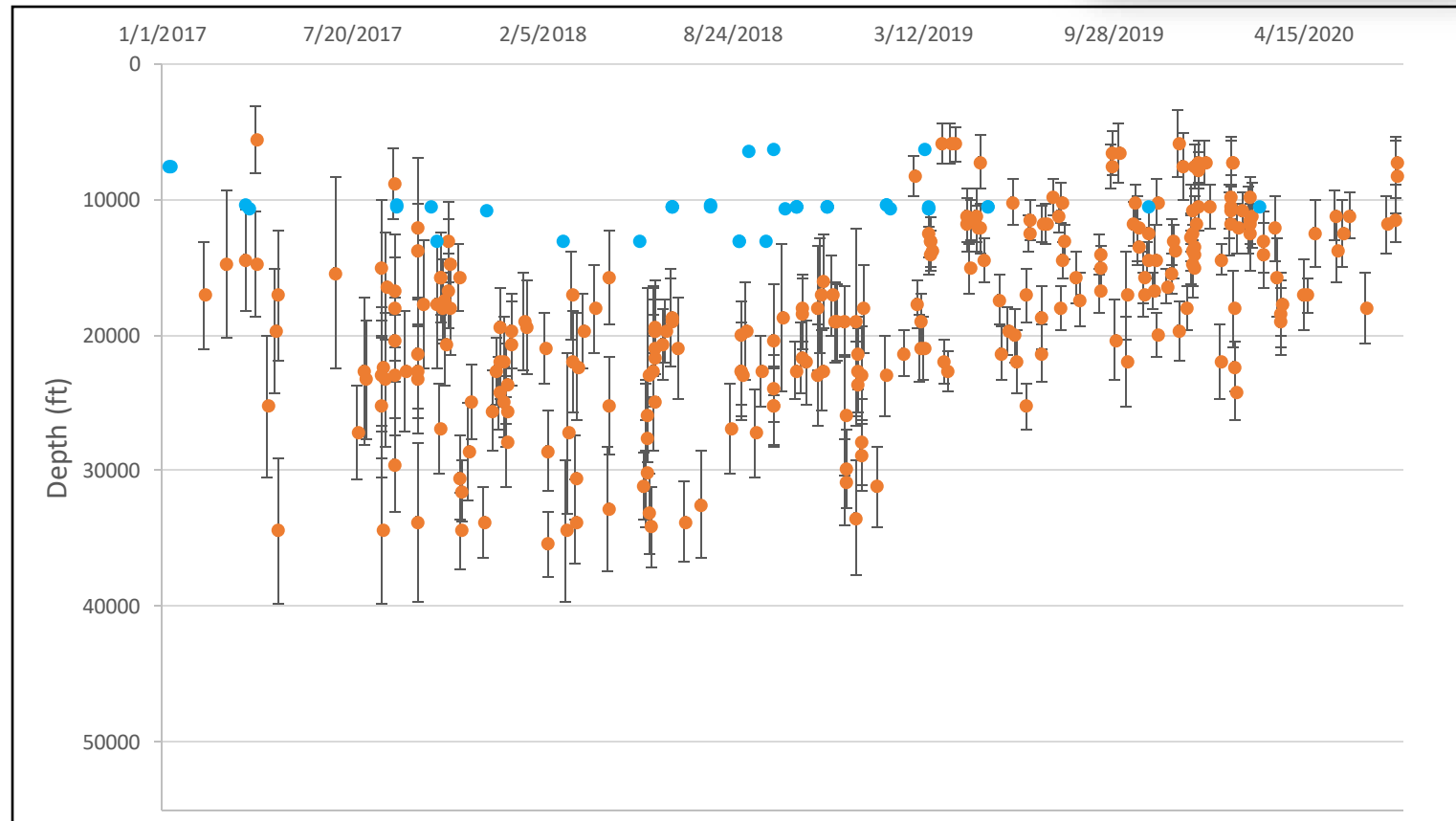
# Hydraulic Fracturing vs Seismicity - Area 4



Number of HF Jobs vs Seismic Events



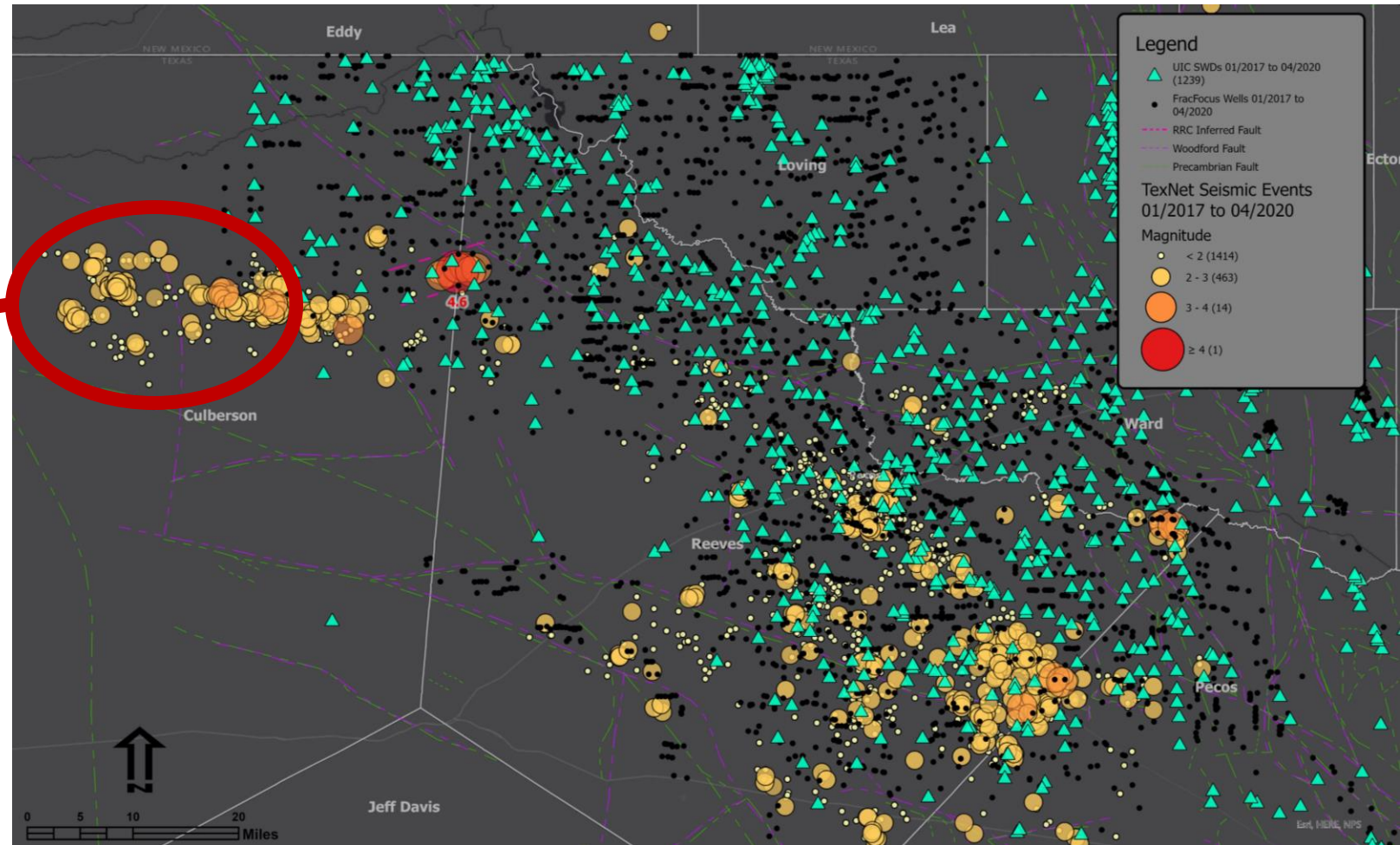
Depth of HF Jobs vs Seismic Events



Sources: TexNet, OCD, FracFocus

# Central Culberson County

What's going on here?



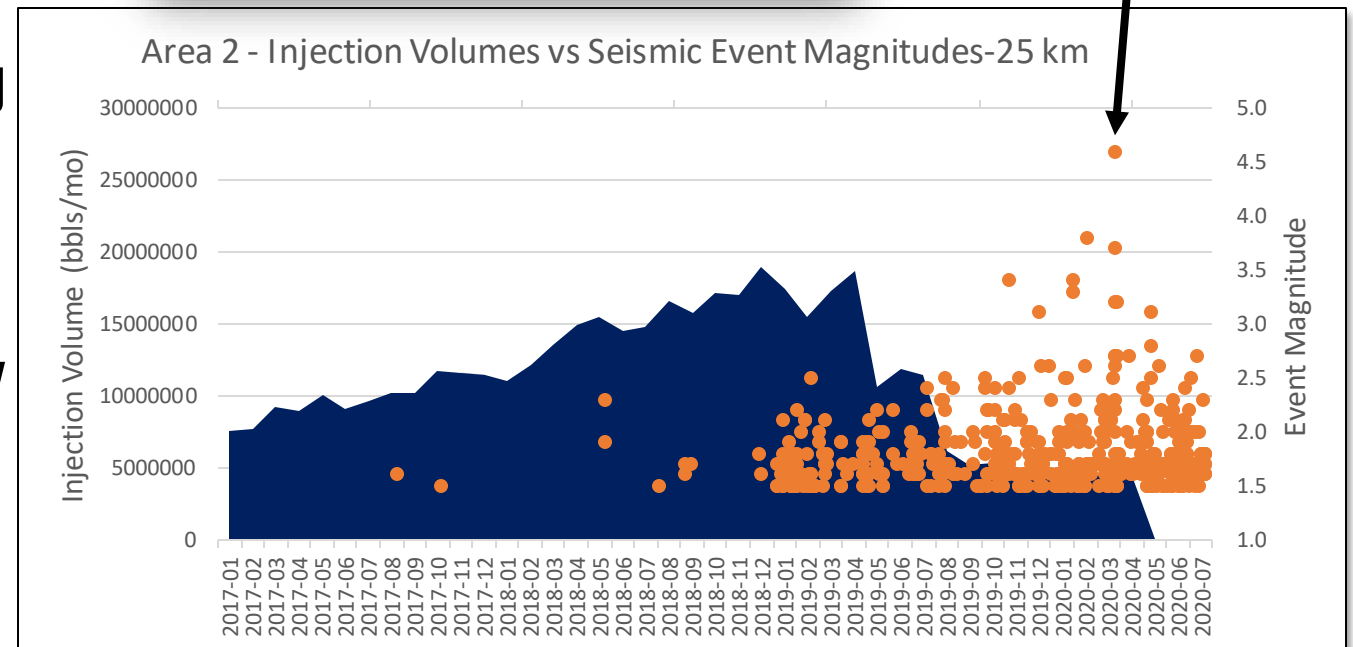
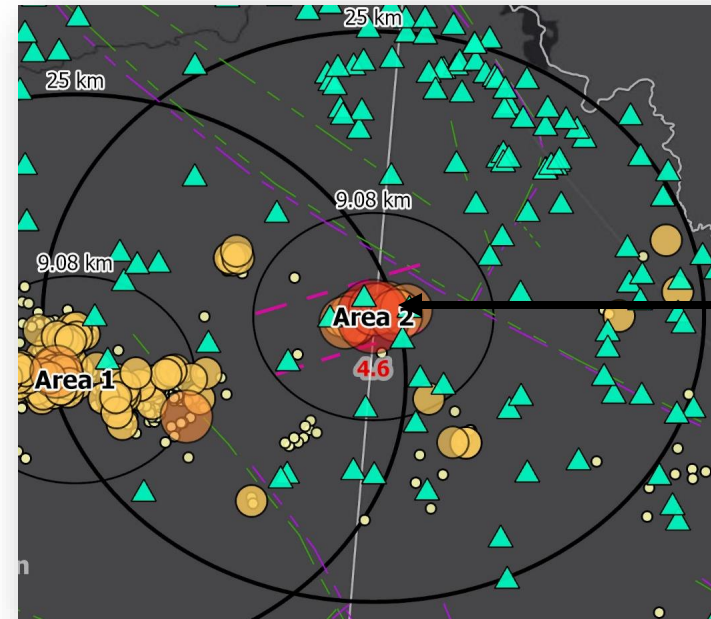
Sources: TexNet, OCD, Texas BEG

# RRC Regulatory Response



# M4.6 - RRC Response

- M4.6 Event Details
  - Date: March 26, 2020
  - Location: Reeves/Culberson County line
  - Depth: 23,293' ft (Precambrian basement)
- RRC placed temporary “hold” on pending SWD applications within 25 km.
- Denying Deep SWD applications.
- Restricting volumes on Deep and Shallow SWD Applications.
- Requested restrictions on existing SWDs.



# RRC Seismicity Screening

- Grading system triggered by seismic events within 100 square miles
- Receive score based on grading criteria
- Grading Criteria
  - Seismic event proximity and characteristics
  - Fault proximity and characteristics
  - Depth to the Precambrian basement
  - Injection formation rock types/characteristics
- Injection rate restrictions based on your score
  - Score A: 30,000 bpd maximum limit
  - Score B: 20,000 bpd maximum limit
  - Score C: 10,000 bpd maximum limit



Source: ALL Consulting, 2014

# Seismic Monitoring

- SWDs that score “B” or “C” may be authorized for additional 10,000 bpd by implementing Seismic Monitoring Plan and Seismic Response Plans.
  - Seismic Monitoring Plan
    - Installation of a seismic monitor meeting TexNet and RRC minimum requirements
    - Supply data to public seismic data networks
  - Seismic Response Plan:
    - Triggered by  $\geq M3.5$
    - Discussion with RRC on path forward



High-Frequency Seismometer (Source: IESE)



Seismic Recorder (Source: IESE)

# RAD Letters and Permit Conditions

- Step-Rate Test if applying for injection rate  $\geq 25,000$  BWPD
- Bottom Hole Pressure Test
- Geology Data
  - Structure Maps of top and bottom of disposal zone
  - Isopach Map of disposal zone
  - Two Structural Cross-Sections
- Fault Slip Potential (FSP) Modeling
  - Two model runs:
    - all permitted injection well volumes in AOI, plus proposed injection well(s) volume
    - Only proposed injection well volume
  - Include all faults and disposal volumes regardless of depth



# Key Takeaways

- Few Deep SWDs near seismically active areas in West Texas.
- Little correlation between injection volumes and seismic activity.
- Some correlation between HF and seismic activity in Areas 3 and 4 (eastern Reeves County).
- Seismic activity in central Culberson County without HF or SWD activity nearby. **What's going on?**
- Pro-actively evaluate potential SWD locations based on proximity to seismic events and optimally oriented faults, amongst other operational and environmental factors.
- Proactively prepare geology data (isopach map, structure maps, and cross-sections) and FSP analysis to reduce regulatory delays associated with RAD Letters.
- Seismic Monitoring can be conducted to increase maximum injection rates, in some instances.

# Question & Answer

## Contact Information:



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