

Trends in Seismicity, Fluid Injection and Pressure in Kansas

by

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Dave Newell

Julio Gonzales

John Intfen

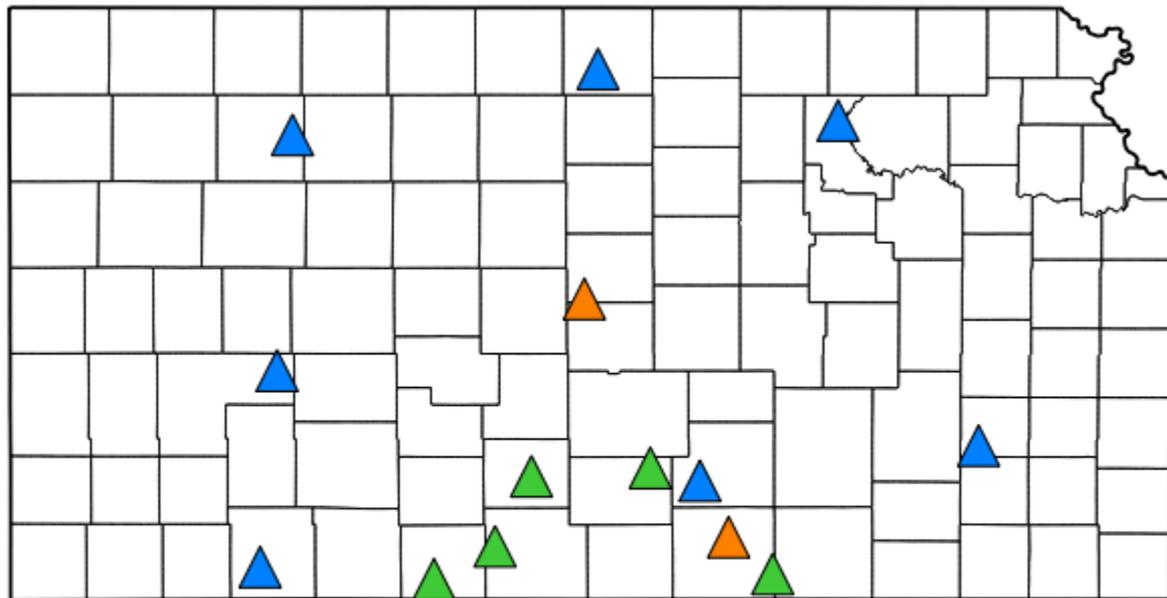
Kansas Geological Survey

Open-File Report 2017–8



Seismic Network Update and Recent Earthquake Trends

Currently Operating Stations



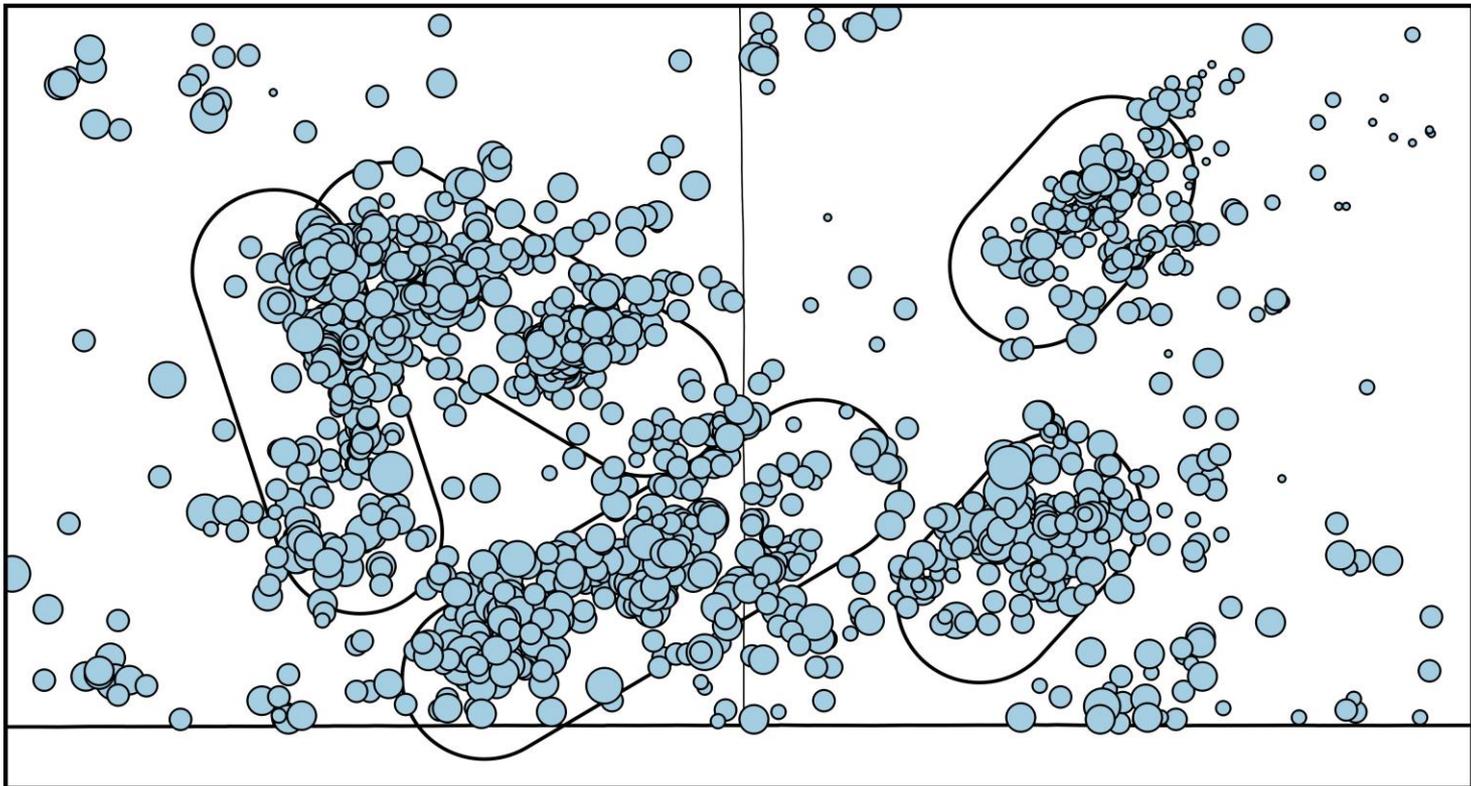
- ▲ KGS Temporary
- ▲ Other KGS temporary
- ▲ KGS Permanent *spring/summer 2016*

"Areas of Seismic Concern"

Total = 1195

M 2+ = 439

Jan-Jun 2015

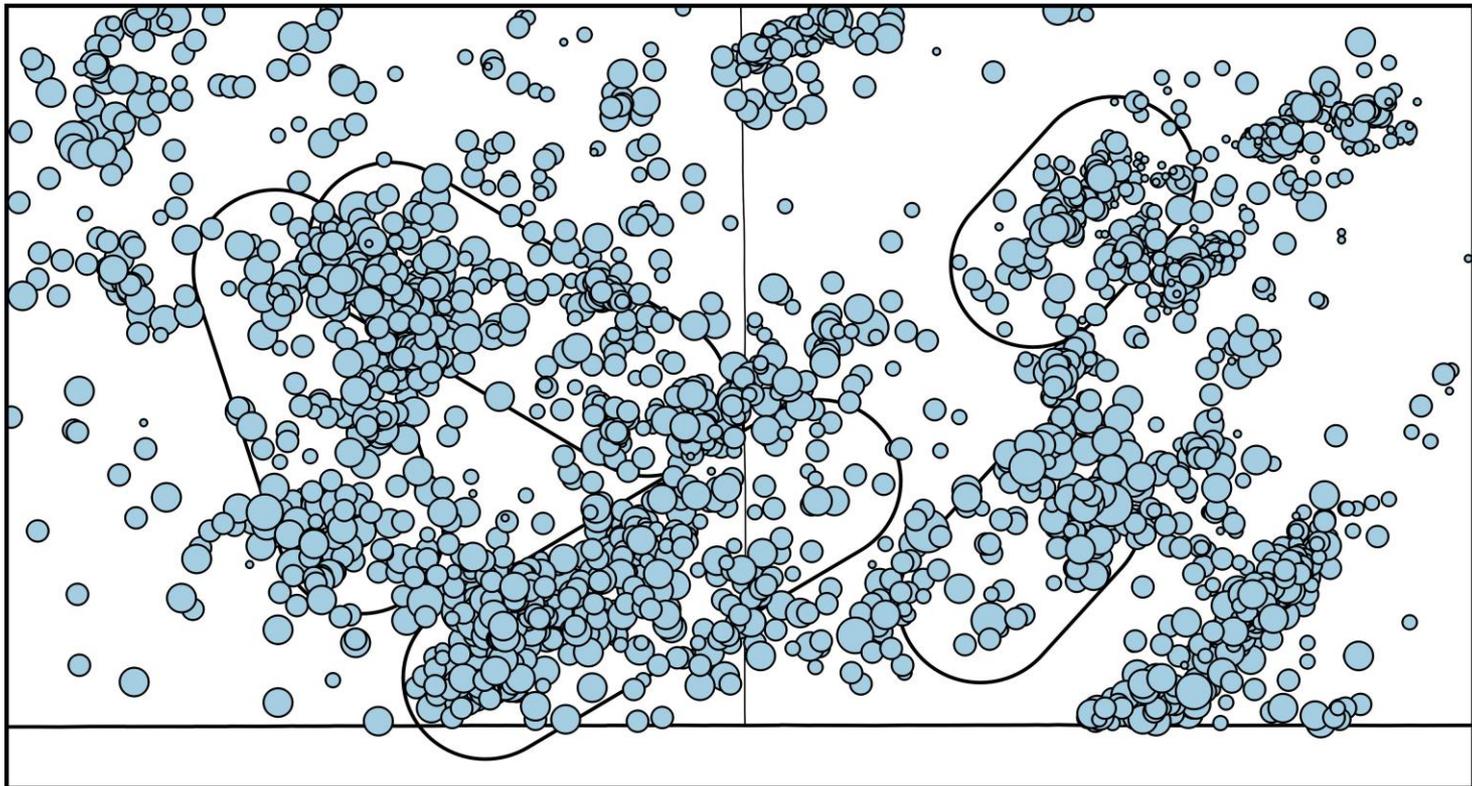


"Areas of Seismic Concern"

Total = 1169

M 2+ = 338

Jul-Dec 2015

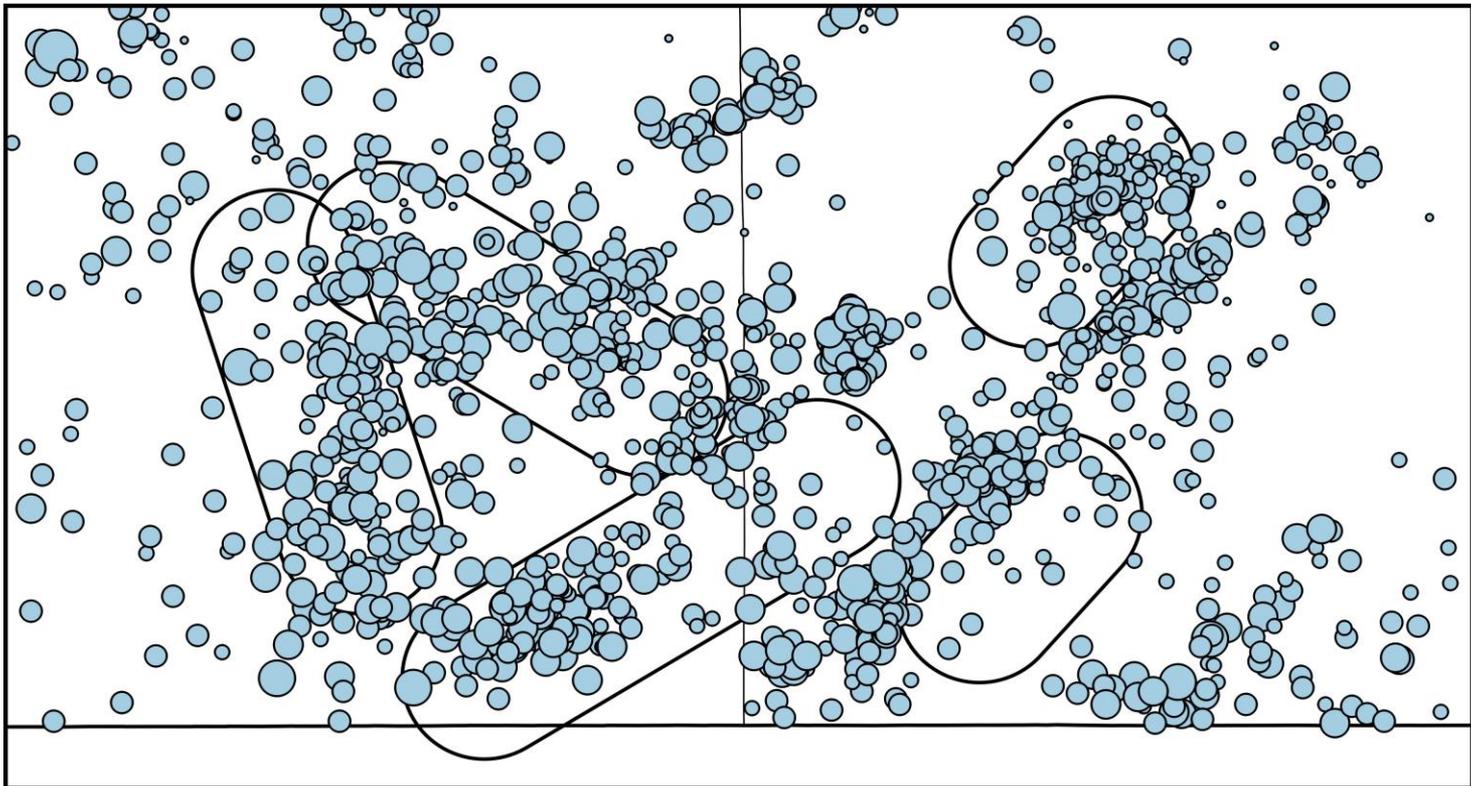


"Areas of Seismic Concern"

Total = 628

M 2+ = 157

Jan-Jun 2016

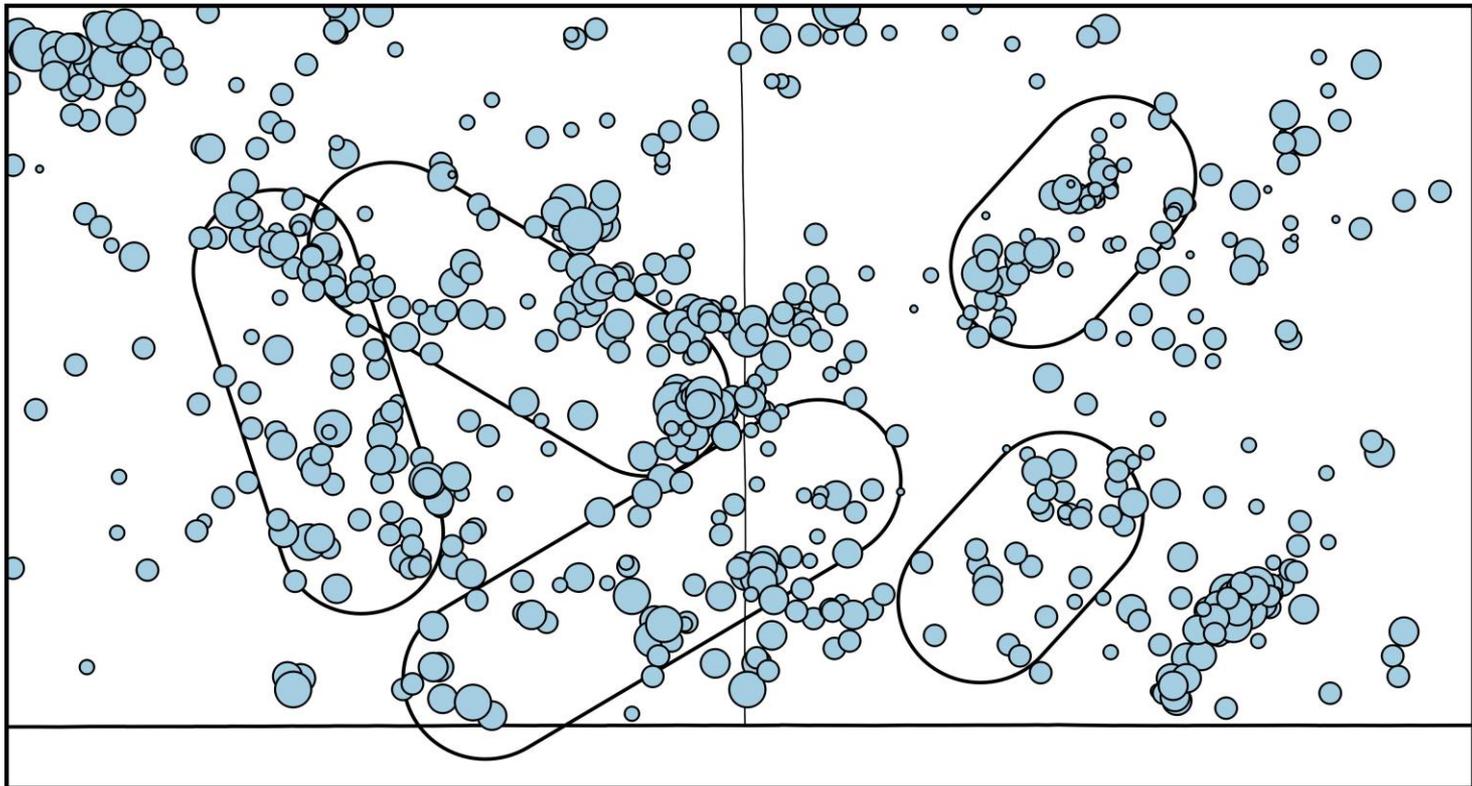


"Areas of Seismic Concern"

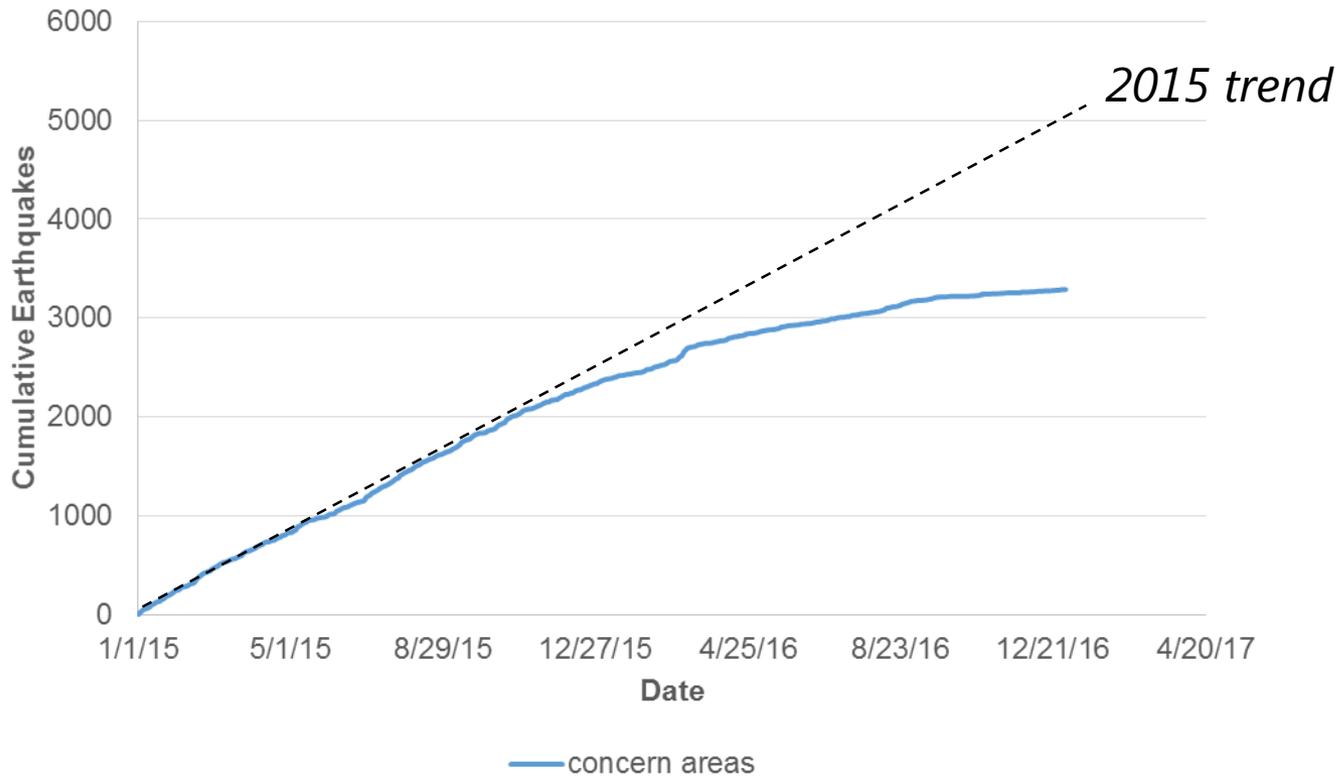
Total = 298

M 2+ = 99

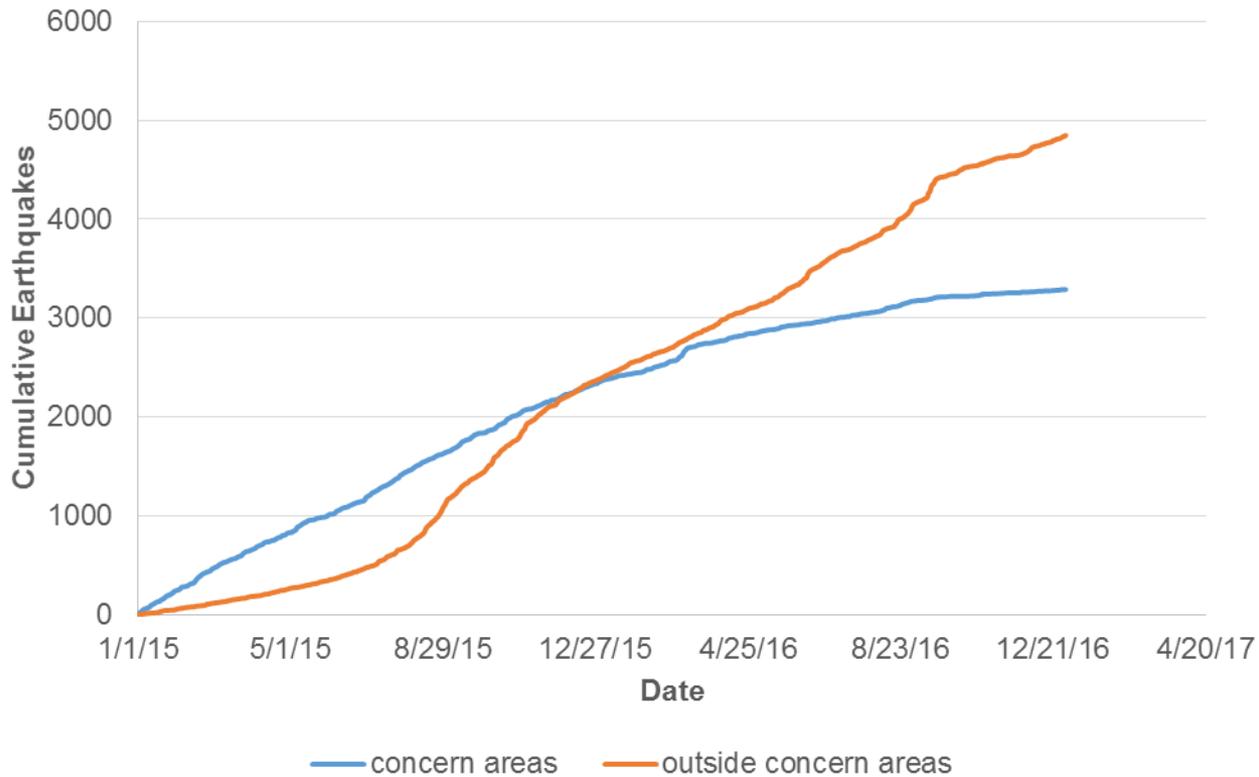
Jul-Dec 2016



Cumulative Number of Earthquakes

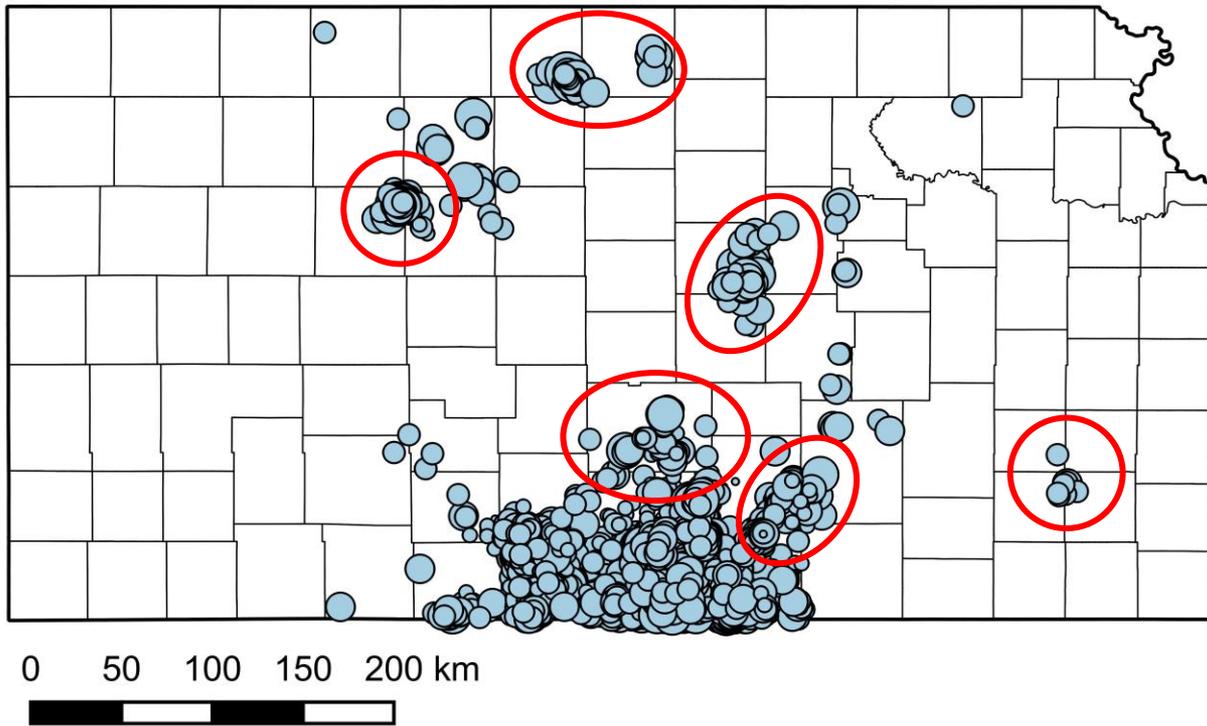


Cumulative Number of Earthquakes

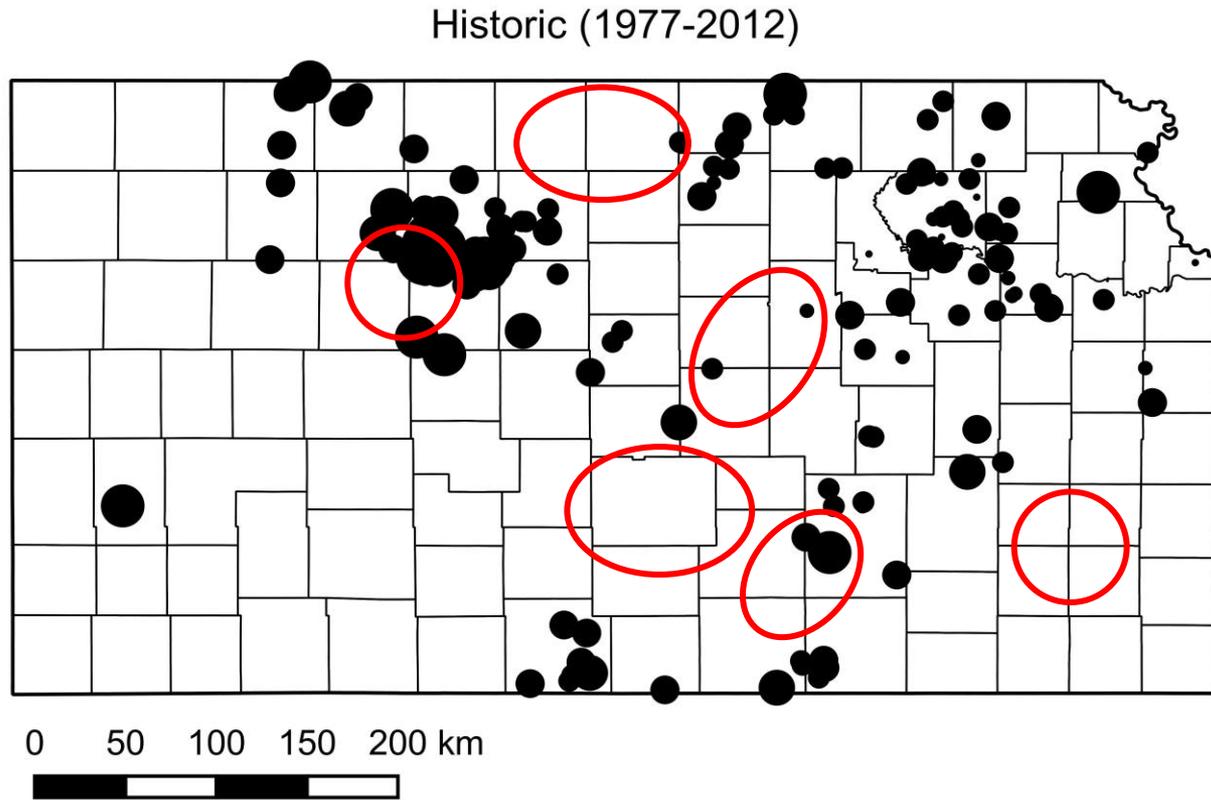


Statewide Earthquakes

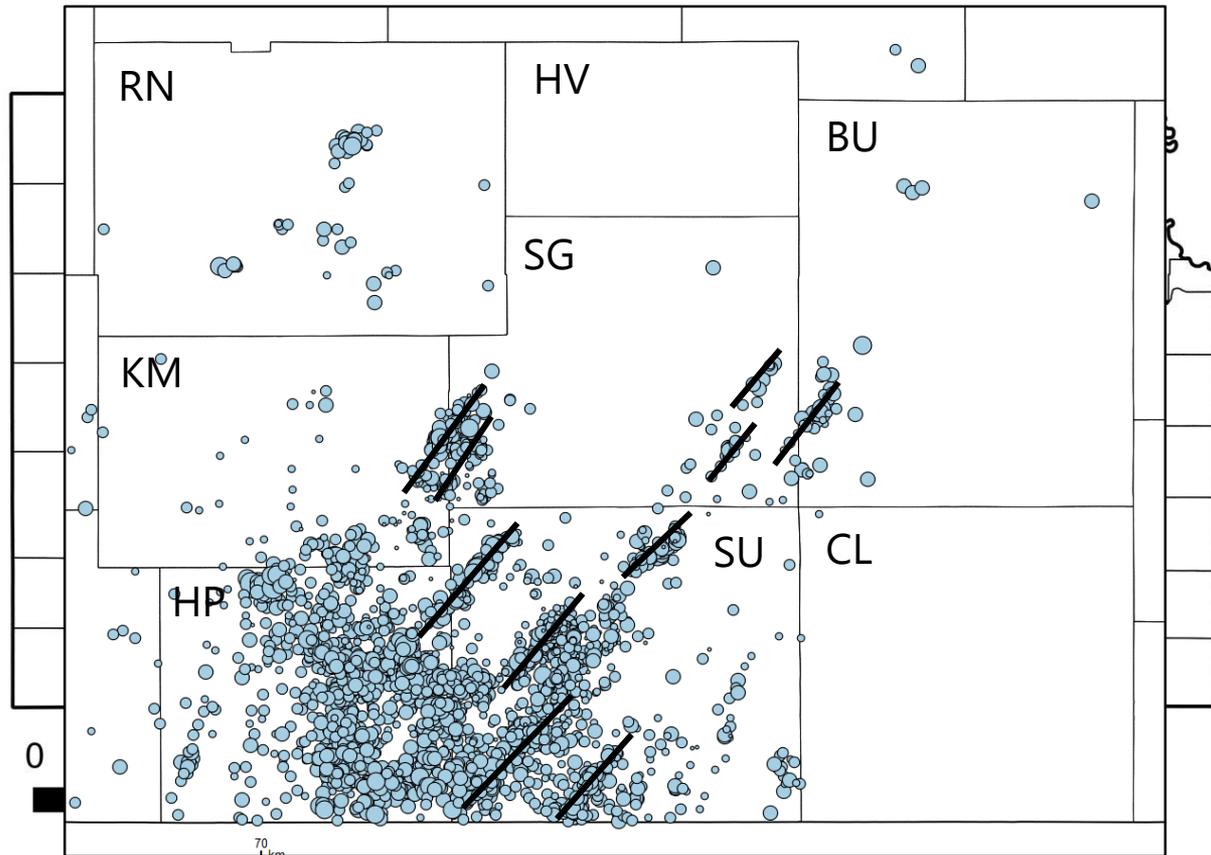
2015-2016

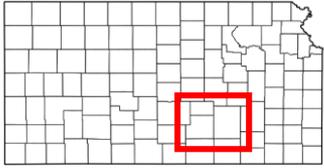


Statewide Earthquakes



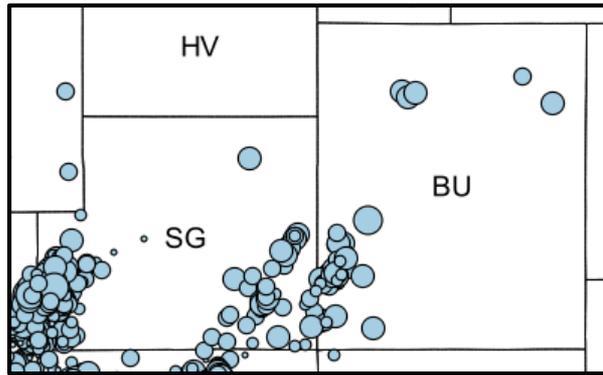
Earthquakes Along Structures



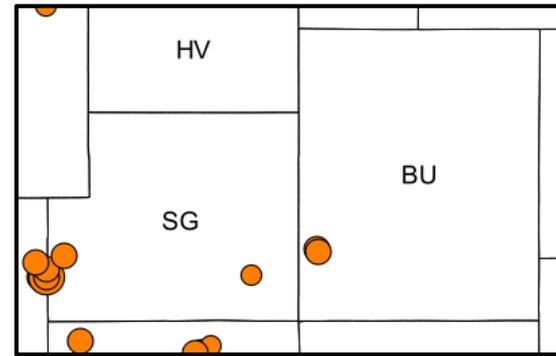


Sedgwick and Butler Counties

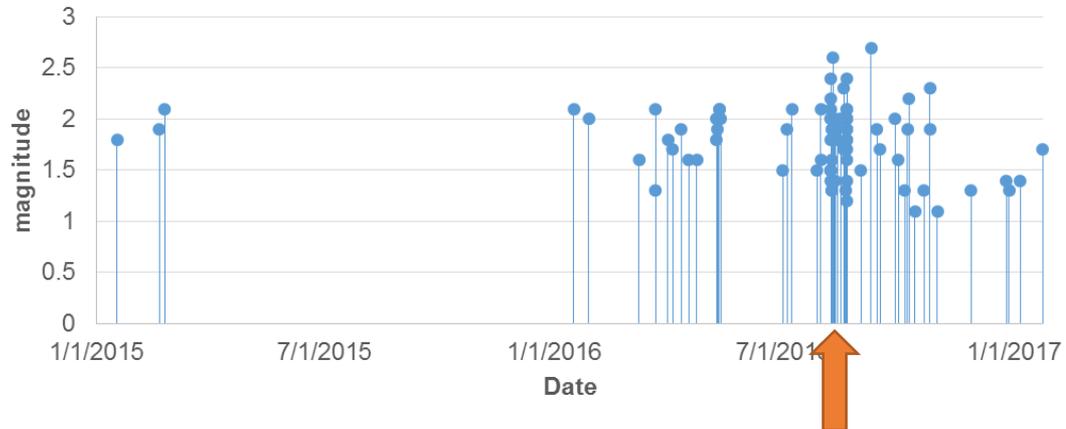
KGS (89)

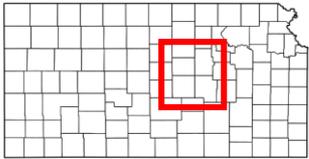


NEIC (3)



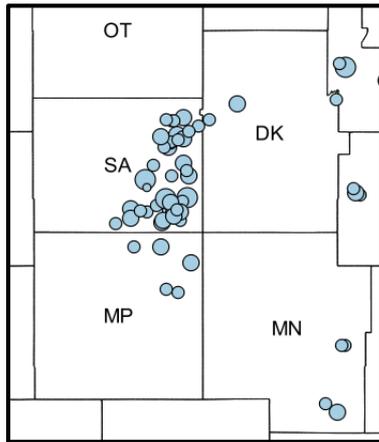
31 $M \geq 2$





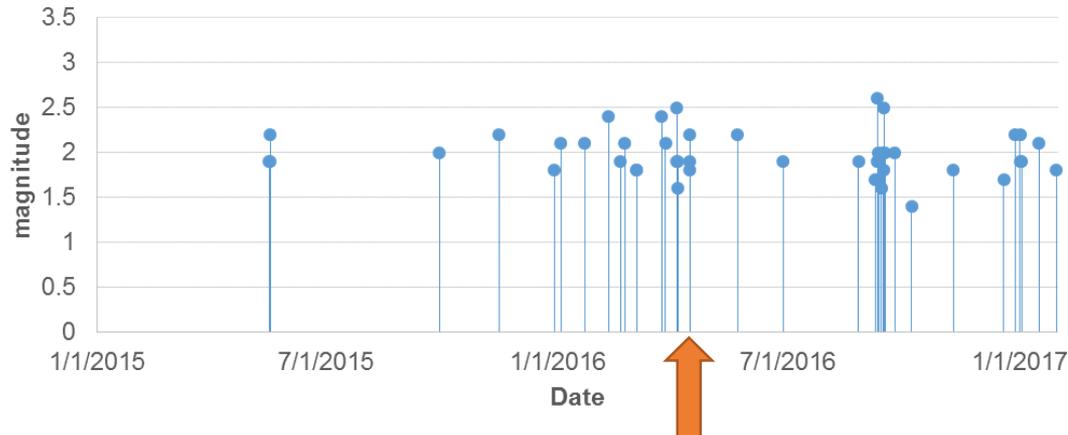
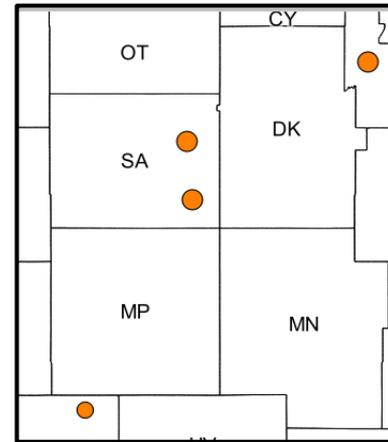
Saline and McPherson Counties

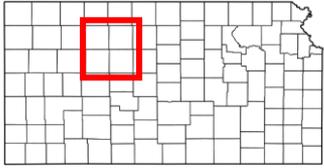
KGS (46)



21 $M \geq 2$

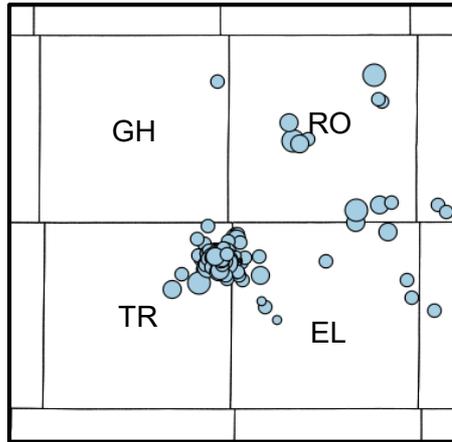
NEIC (3)



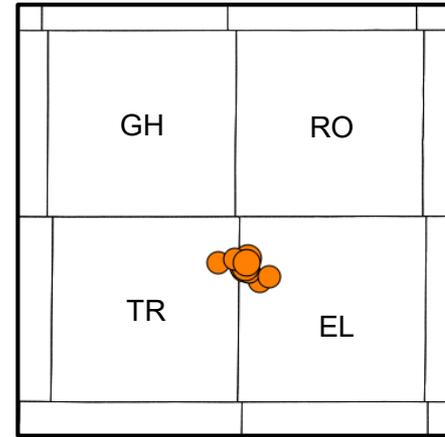


Trego County

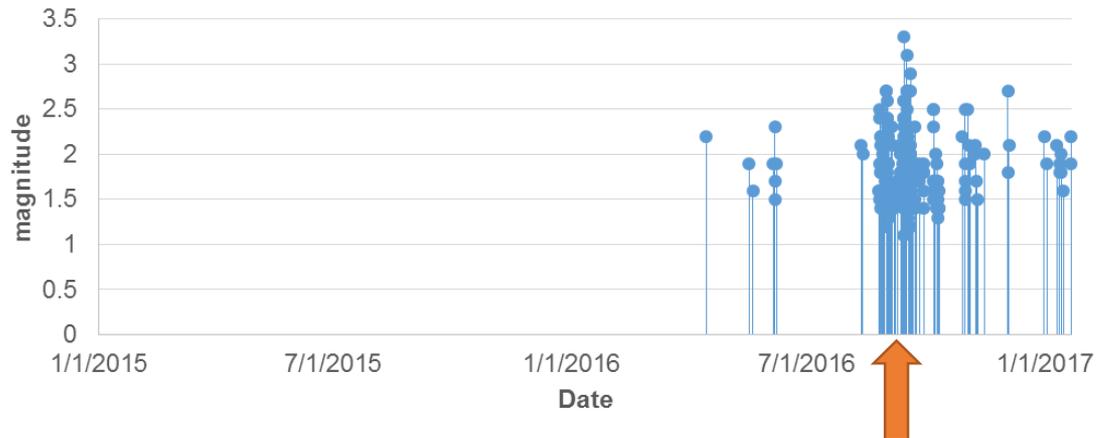
KGS (286)

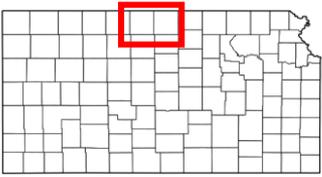


NEIC (10)



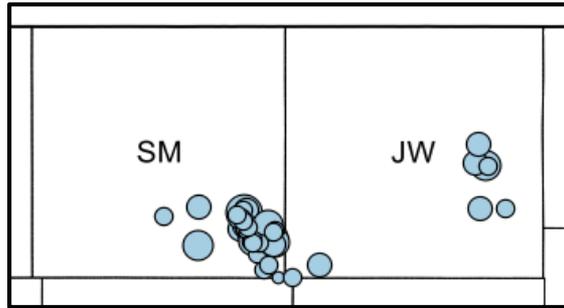
92 $M \geq 2$





Smith & Jewell Counties

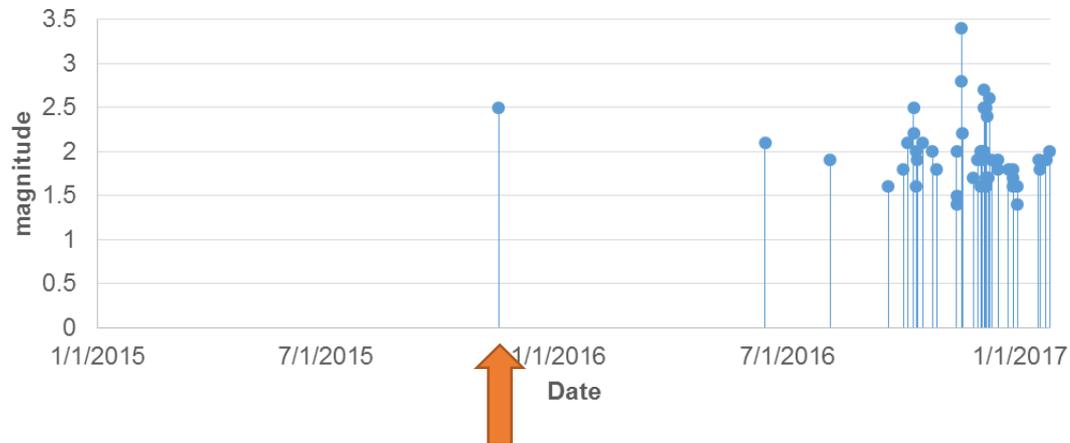
KGS (49)

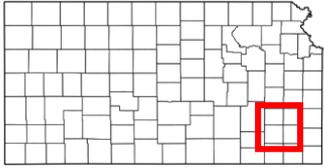


NEIC (0)



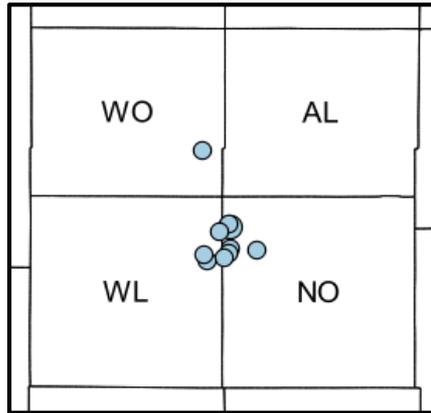
21 $M \geq 2$



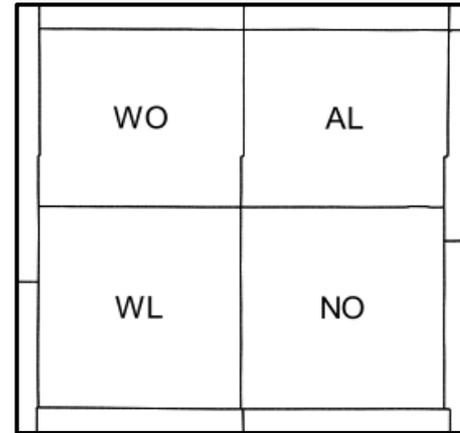


Wilson & Neosho Counties

KGS (10)



NEIC (0)

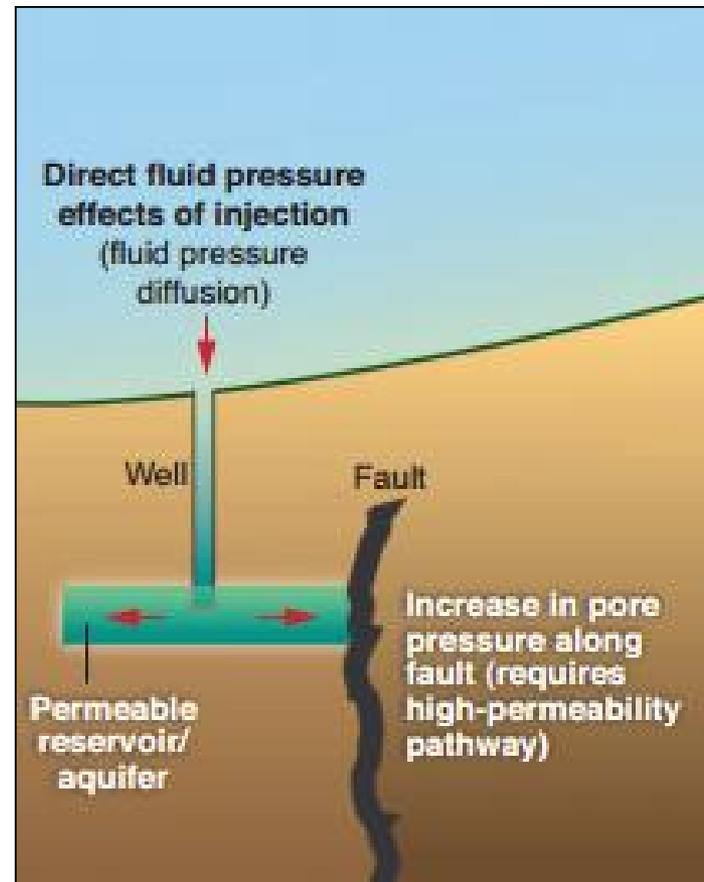


0 $M \geq 2$



Pressure Trends

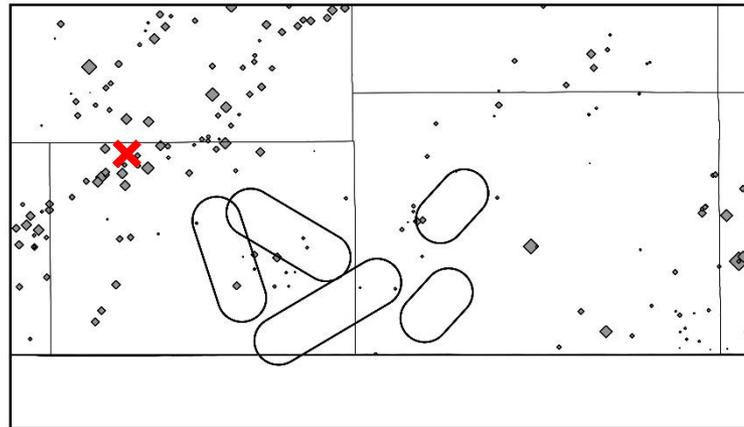
Importance of Pressure



From Ellsworth (2013)

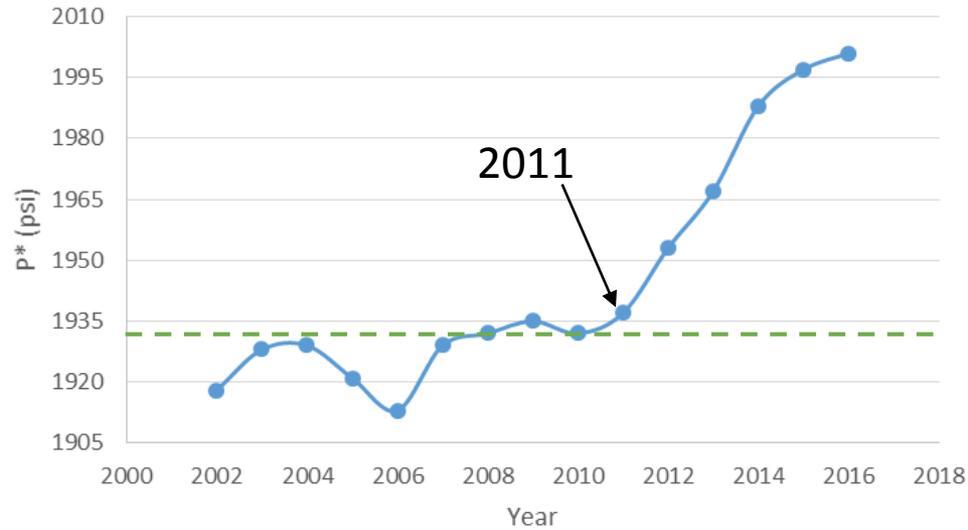
- ✕ Pioneer Class I
- ◆ class II
- Earthquakes NEIC

2011



- annual volume (MBBL)**
- ◇ 0.35
 - ◇ 1.0
 - ◇ 3.5
 - ◇ 8.0

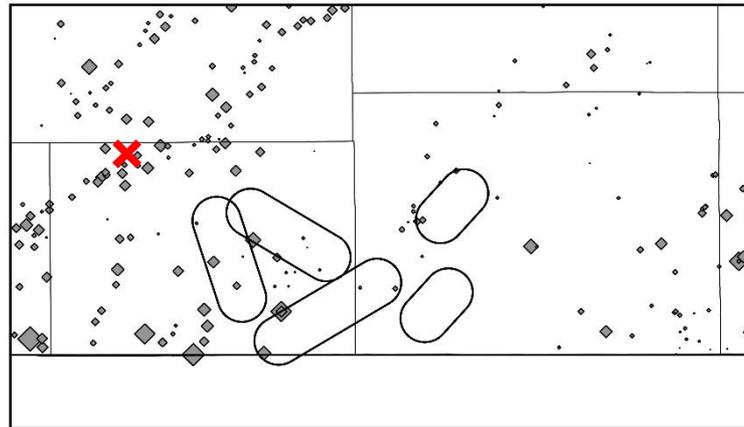
Pioneer WDDW#1



baseline/historic

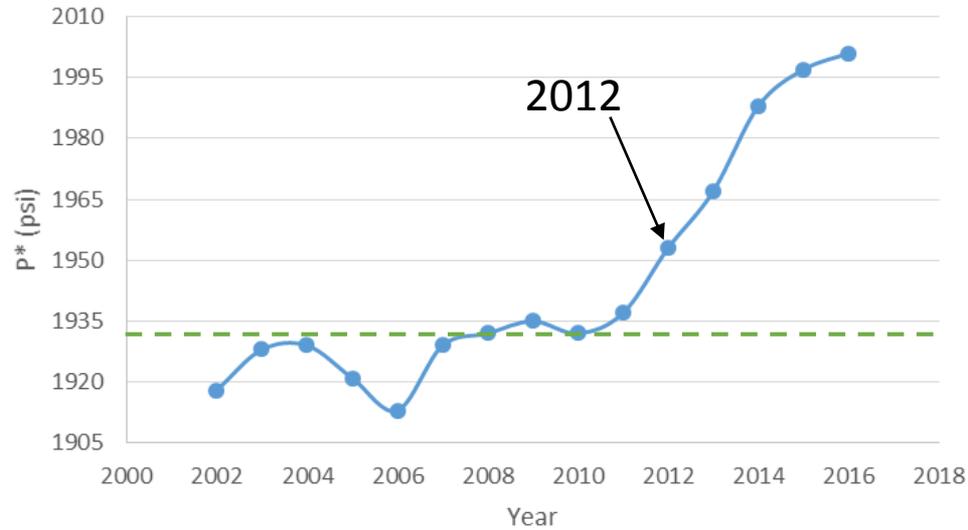
- ✕ Pioneer Class I
- ◆ class II
- Earthquakes NEIC

2012

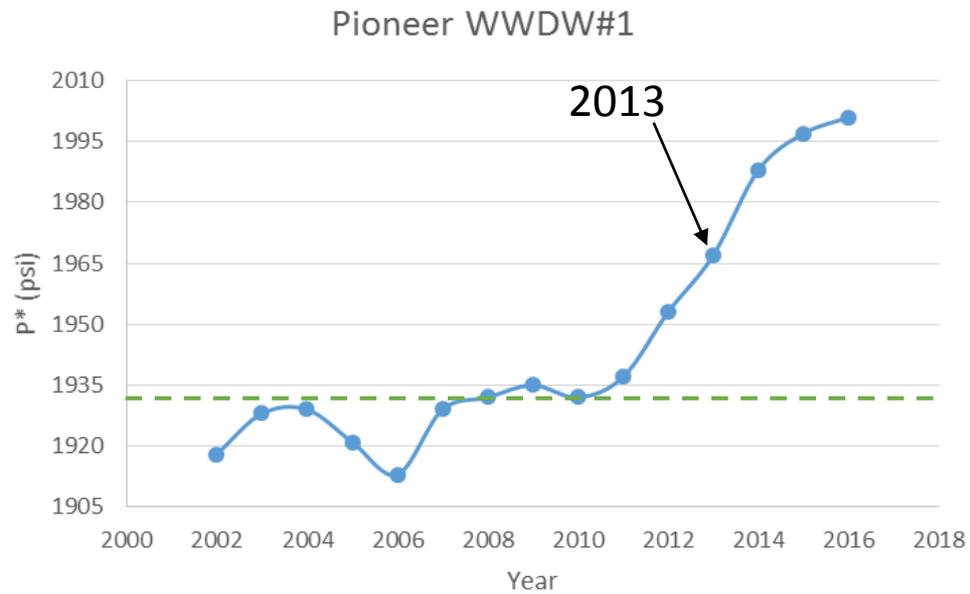
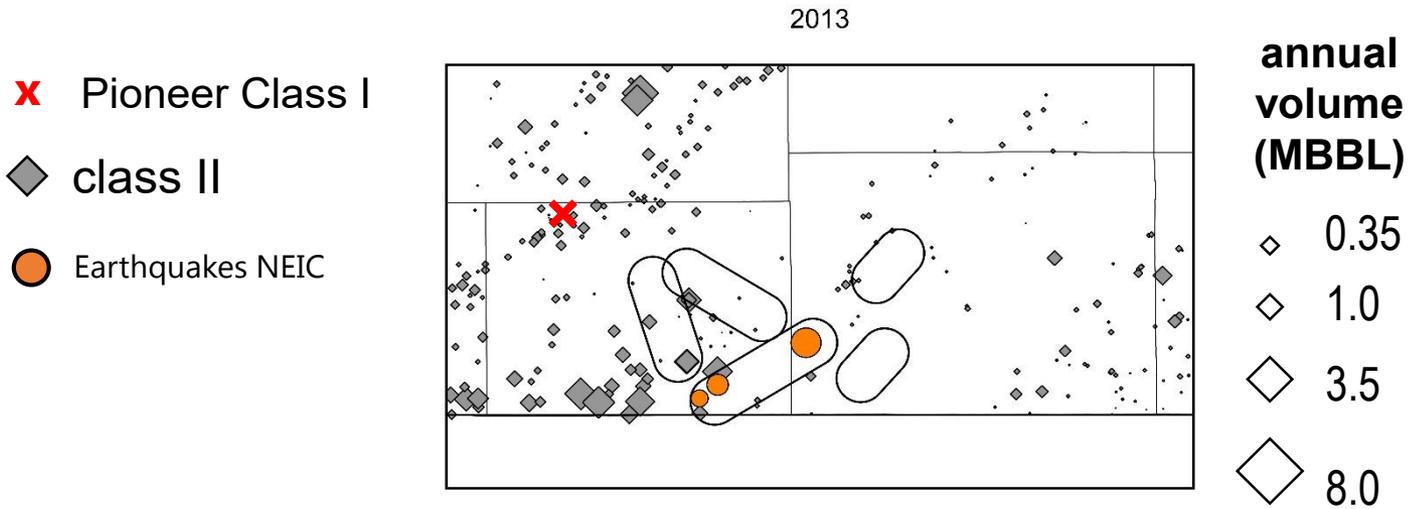


- annual volume (MBBL)**
- ◇ 0.35
 - ◇ 1.0
 - ◇ 3.5
 - ◇ 8.0

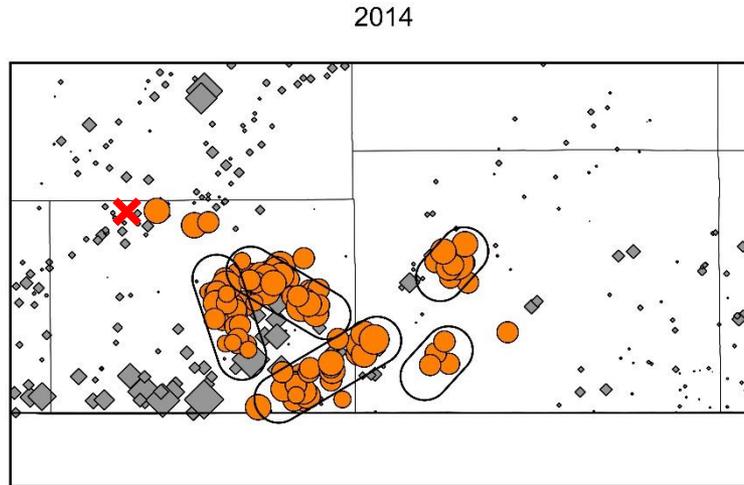
Pioneer WDDW#1



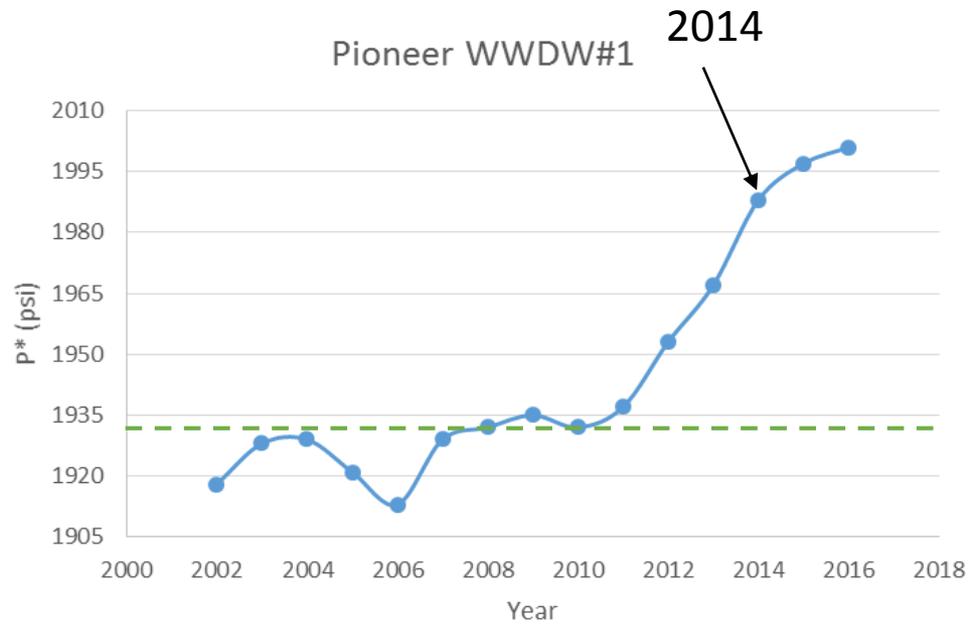
baseline/historic



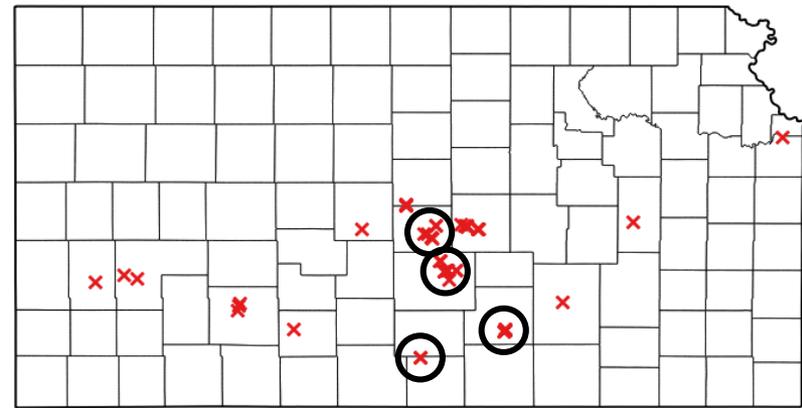
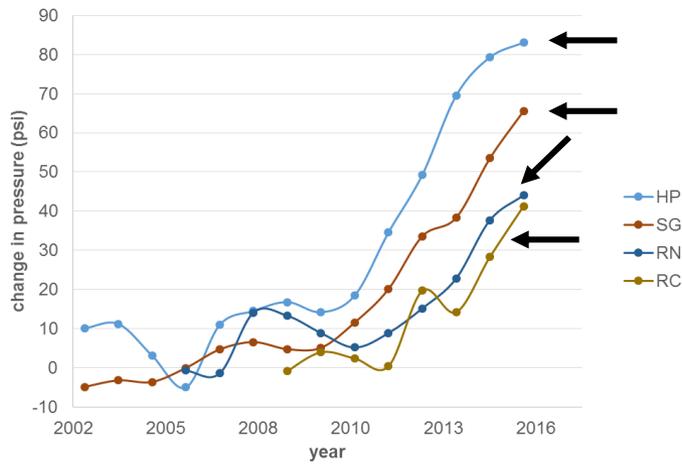
- X Pioneer Class I
- ◆ class II
- Earthquakes NEIC



- annual volume (MBBL)**
- ◆ 0.35
 - ◆ 1.0
 - ◆ 3.5
 - ◆ 8.0

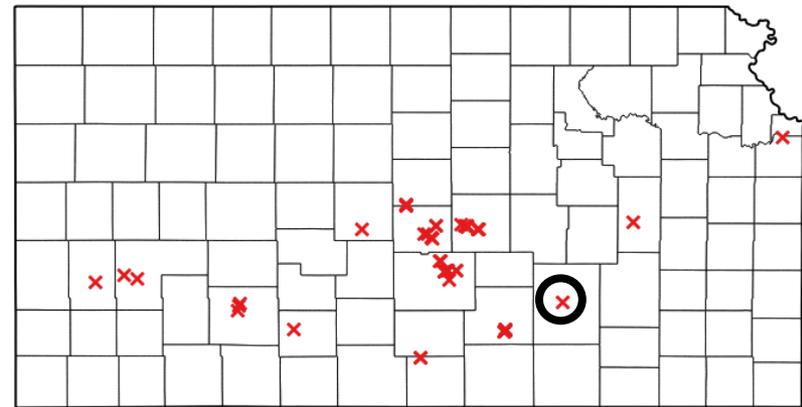
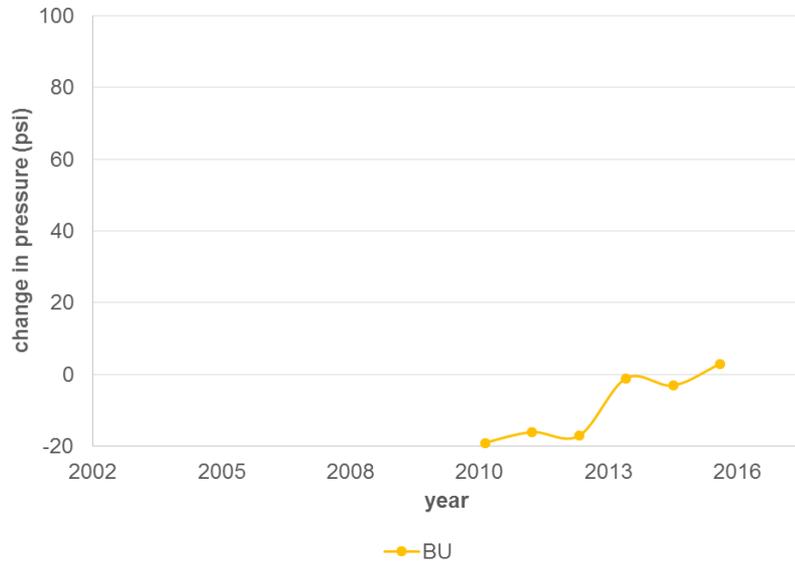


Pressure Change Measured in Class I Wells



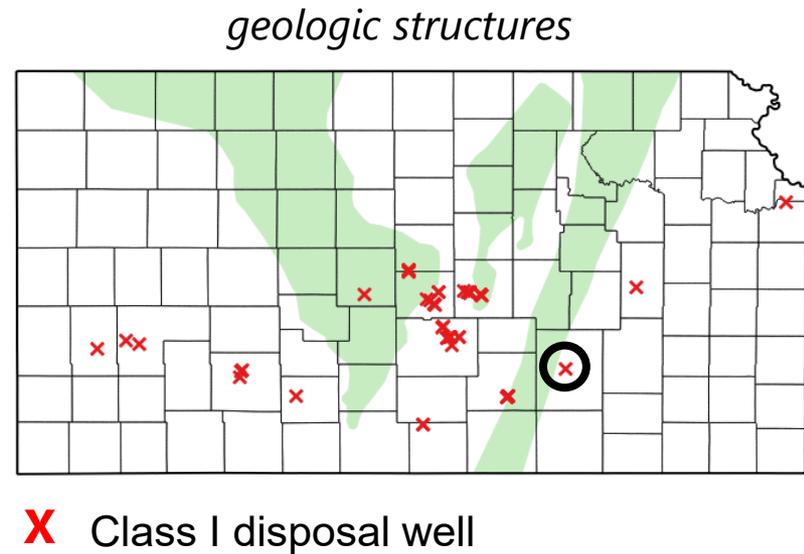
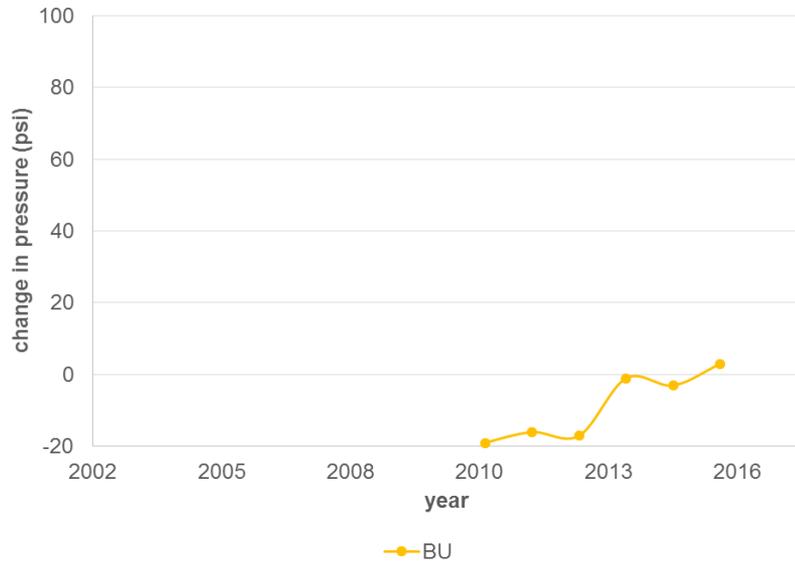
X Class I disposal well

Pressure Change Measured in Class I Wells

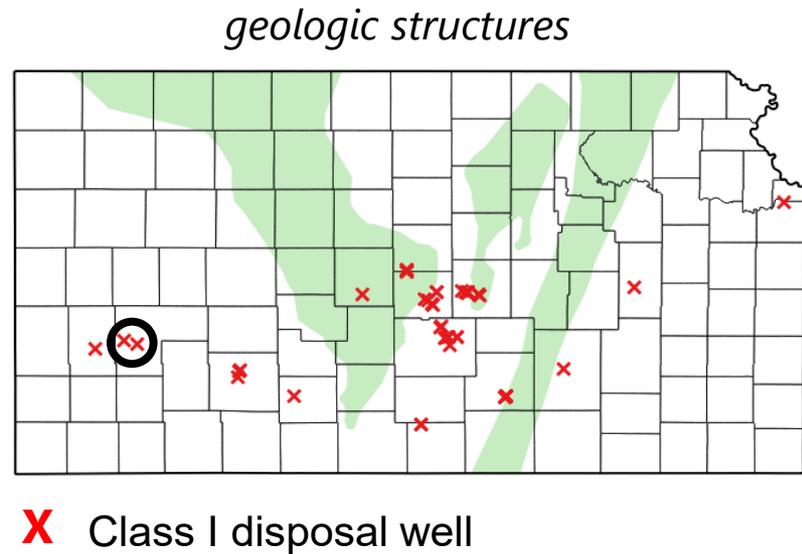
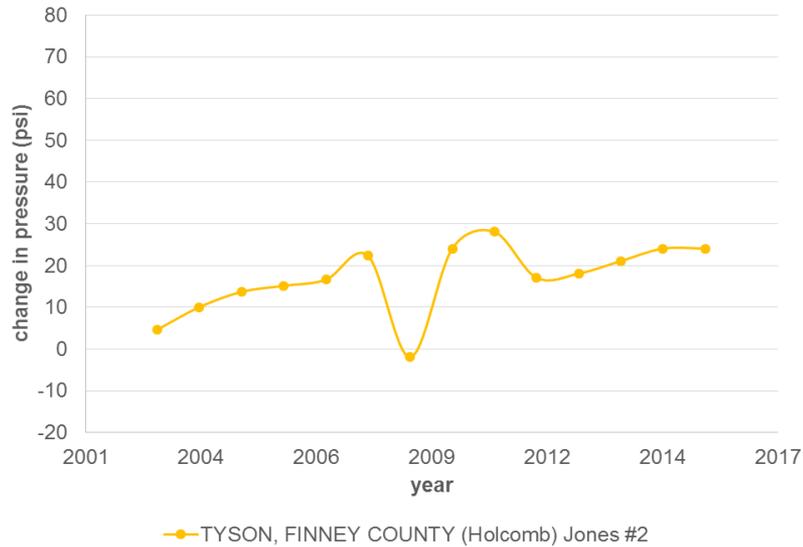


X Class I disposal well

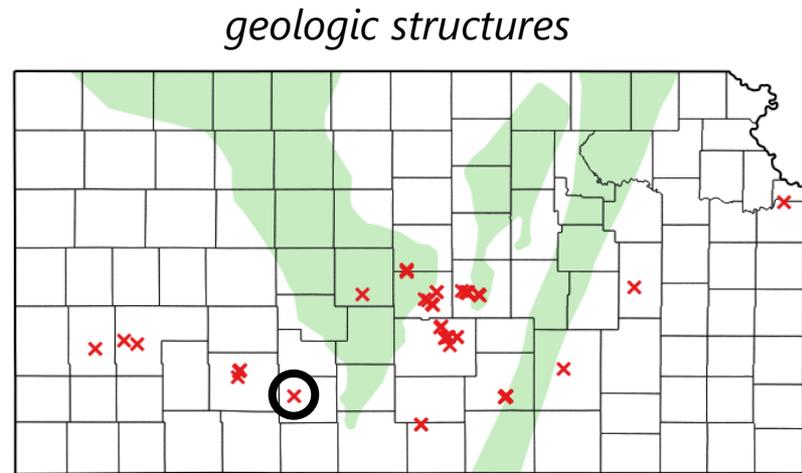
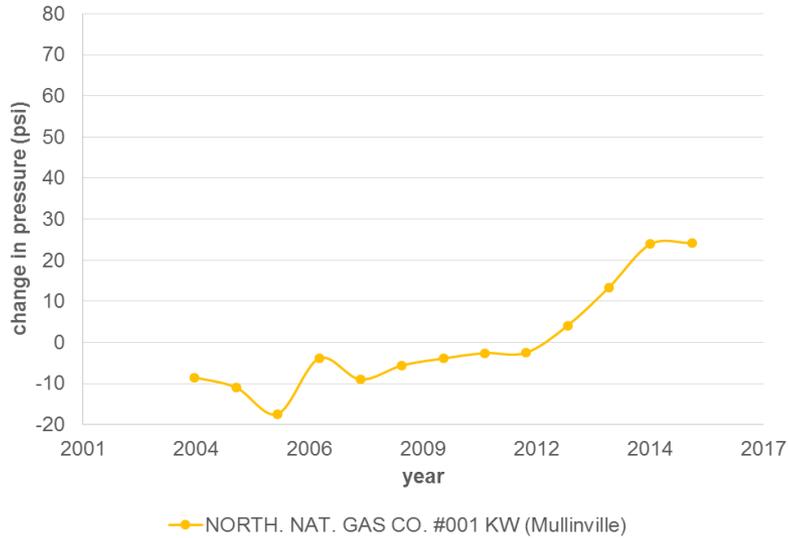
Pressure Change Measured in Class I Wells



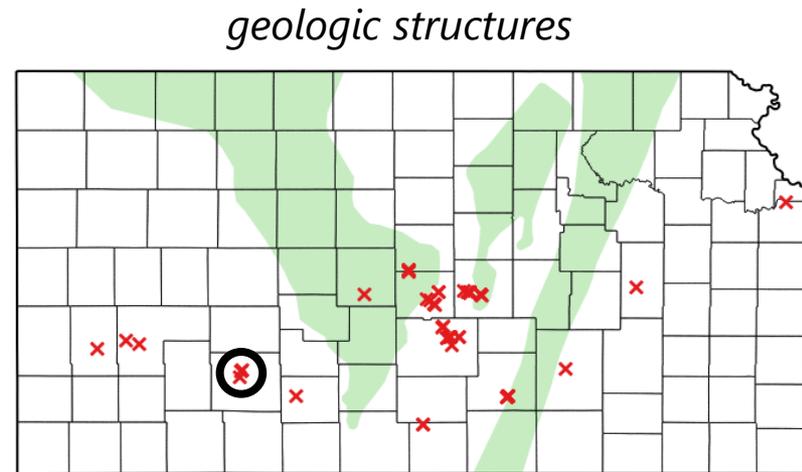
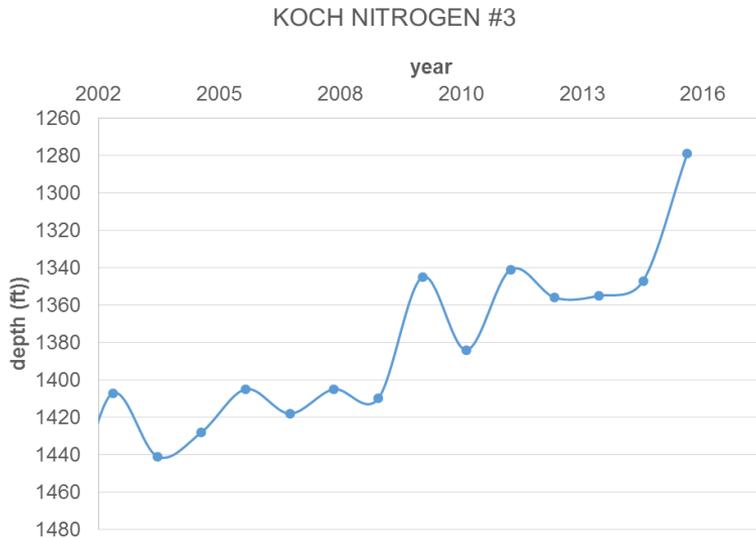
Pressure Change Measured in Class I Wells



Pressure Change Measured in Class I Wells

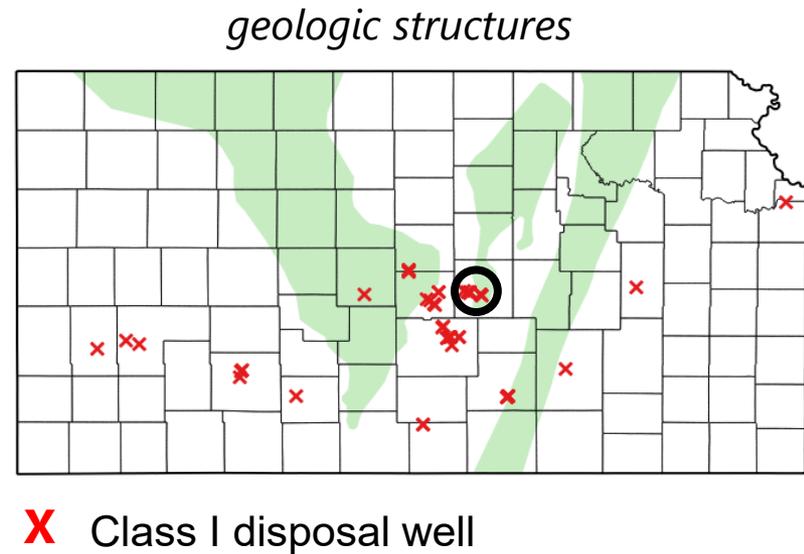
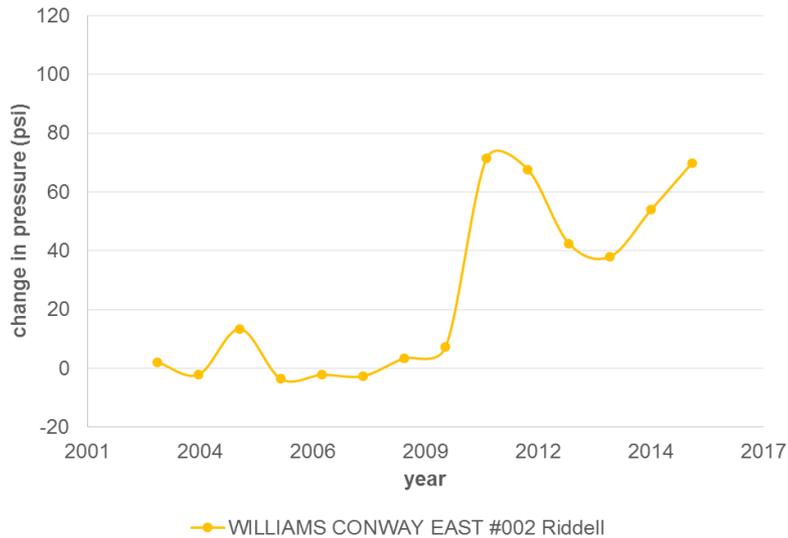


Static Fluid Level in Class I Wells



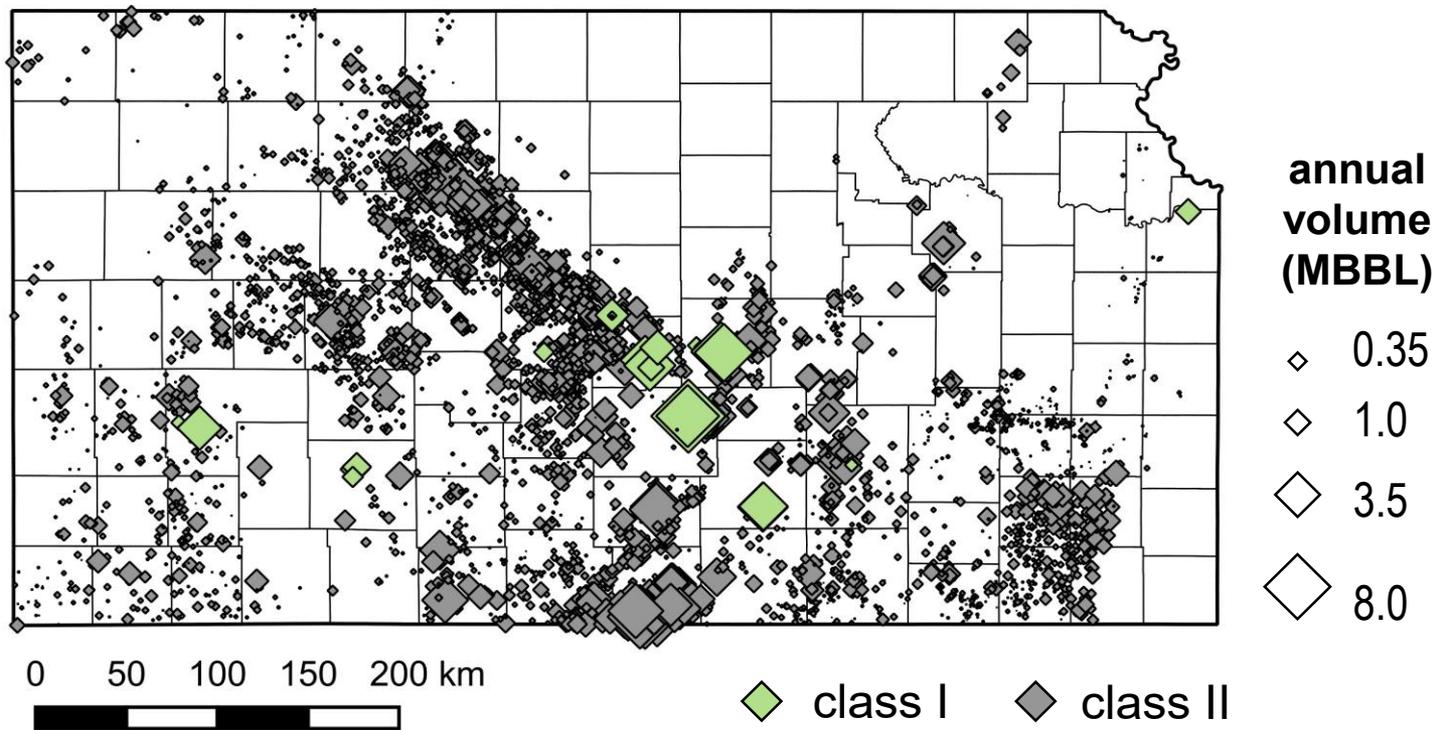
- No pressure data
- Static fluid level related to pressure
- Increase fluid level → increased pressure

Pressure Change Measured in Class I Wells

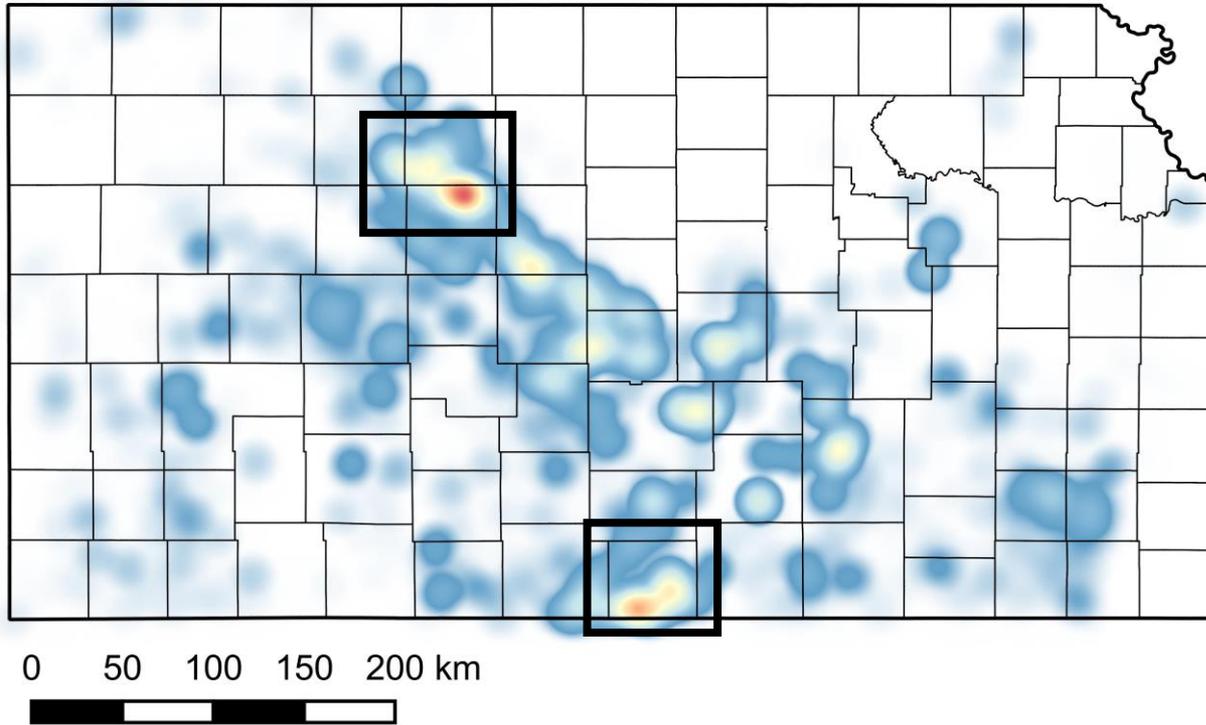


Injection Trends

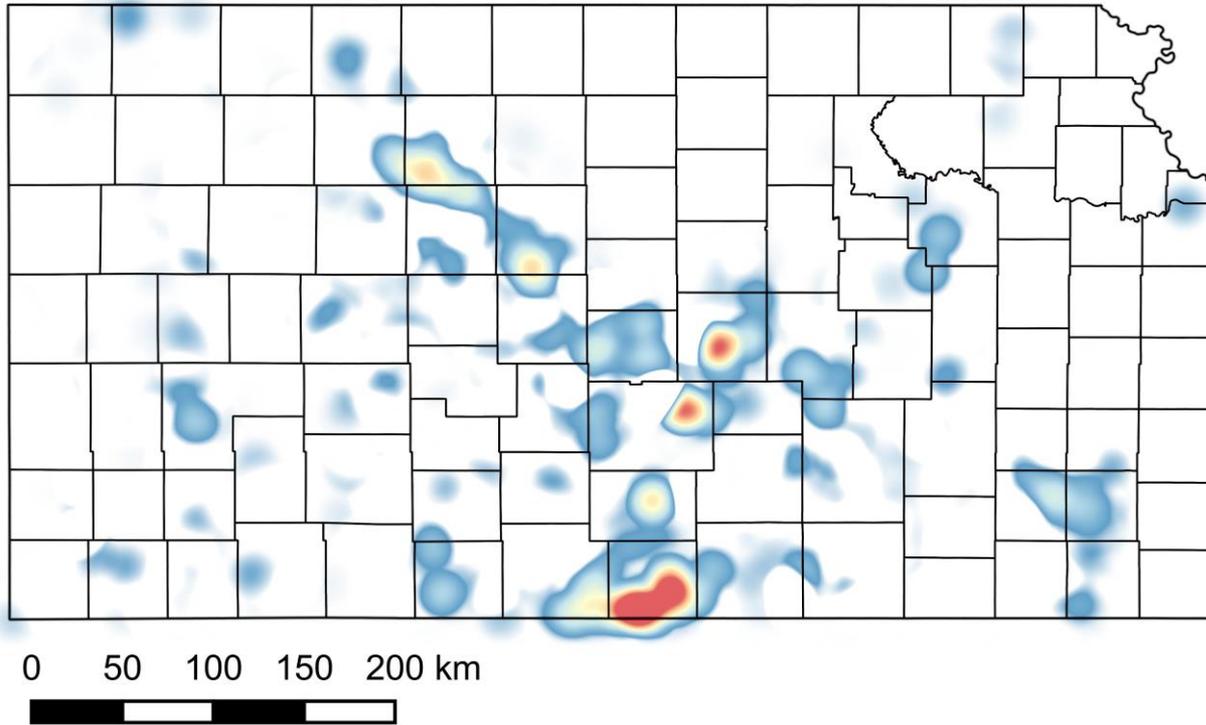
Kansas Class I and II Disposal Wells (2015)



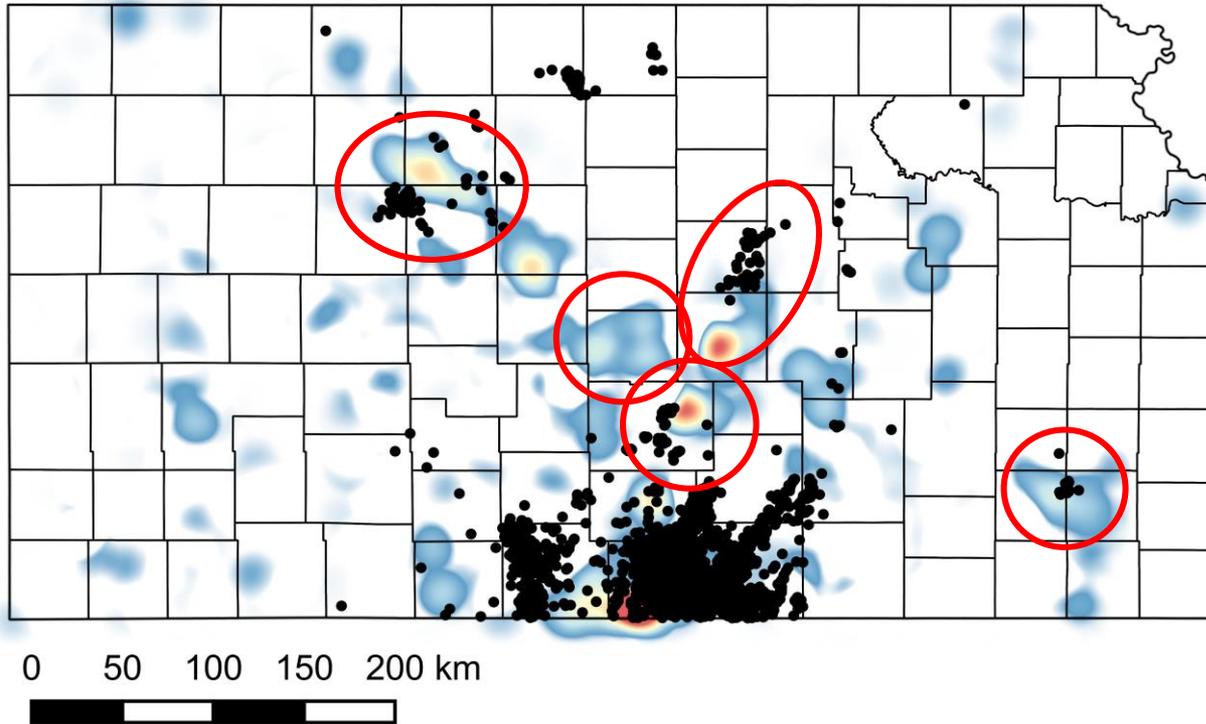
2015 Injection Volume (Class I & II)



Change in Injection Volume (relative to 2000)

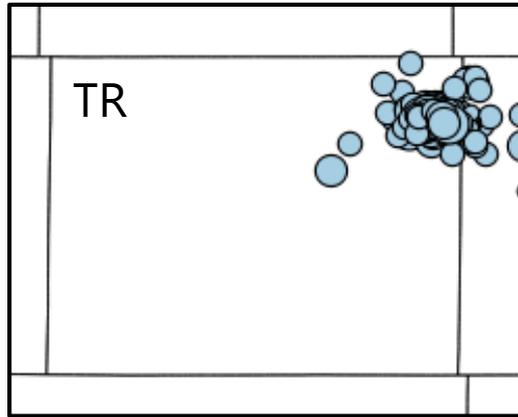


Change in Injection Volume (relative to 2000)

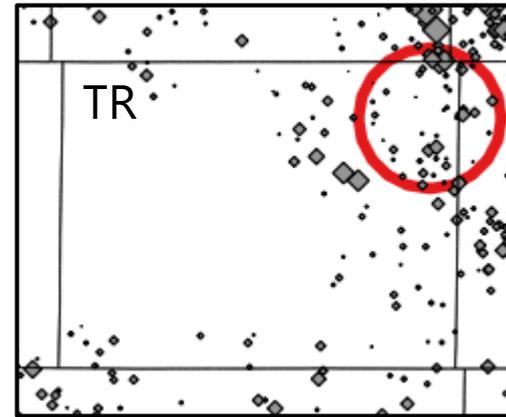


Injection Near Trego Swarm

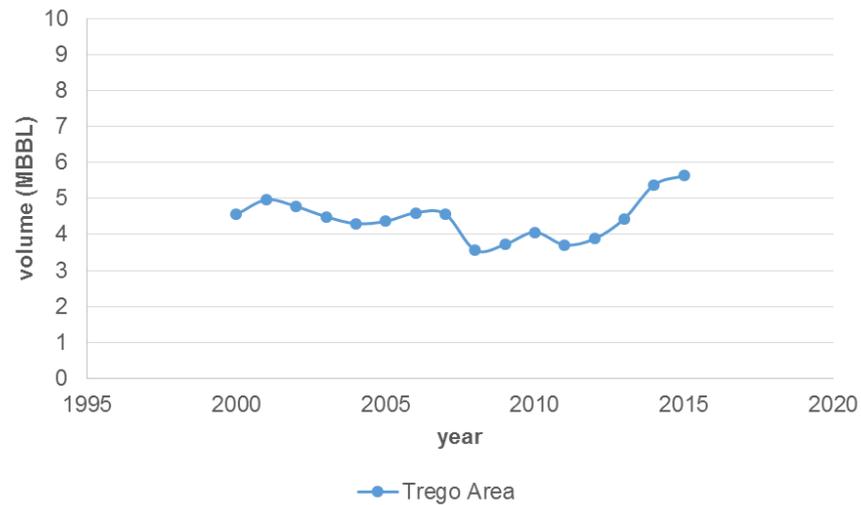
2016 earthquakes



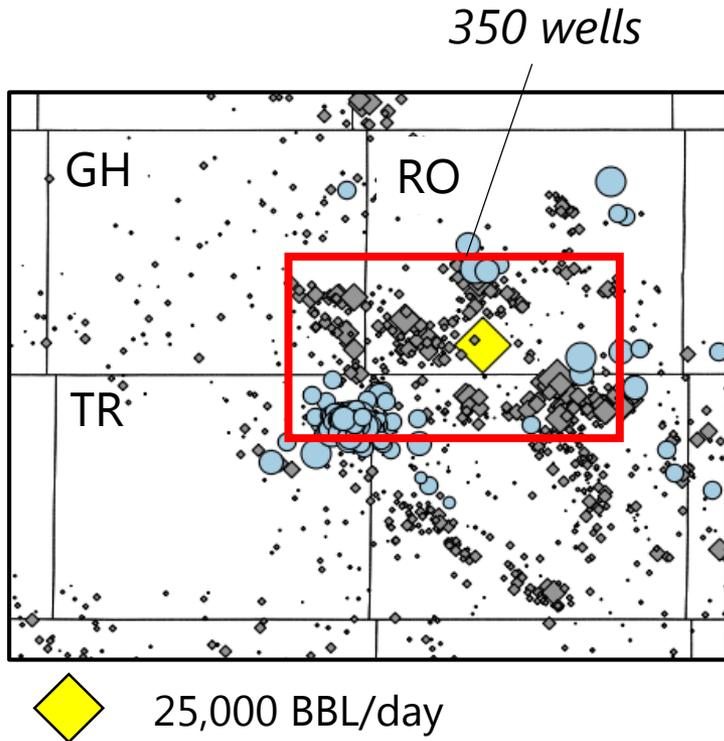
disposal wells



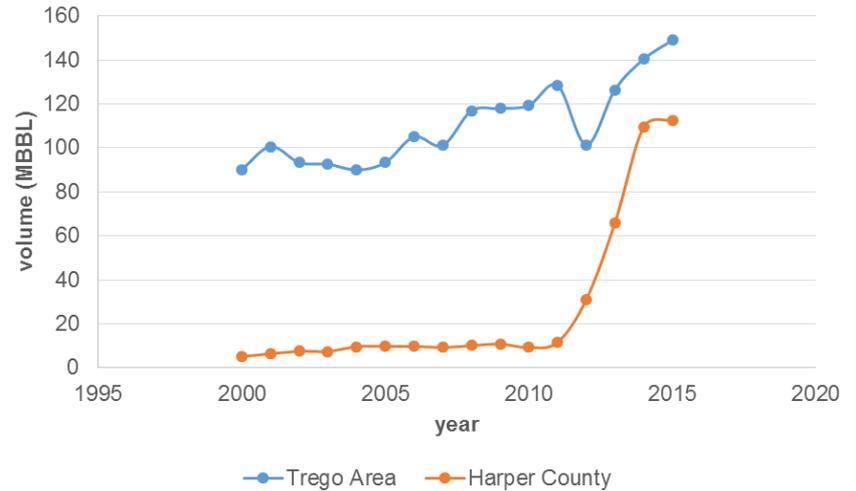
6 mi radius



Injection Near Trego Swarm

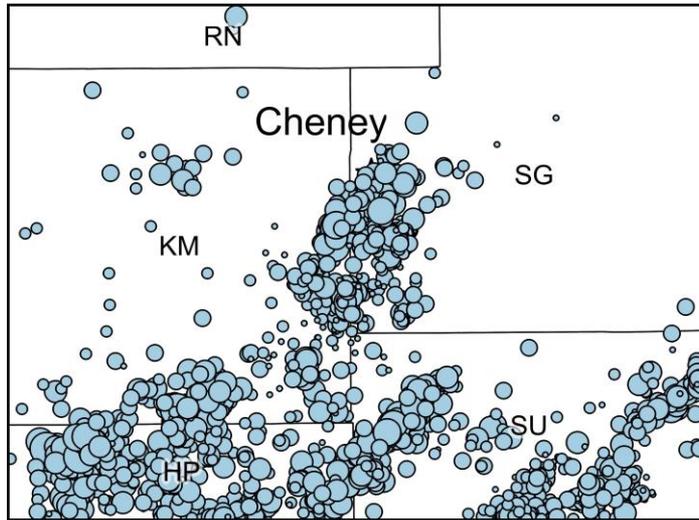


Annual Disposal Volume

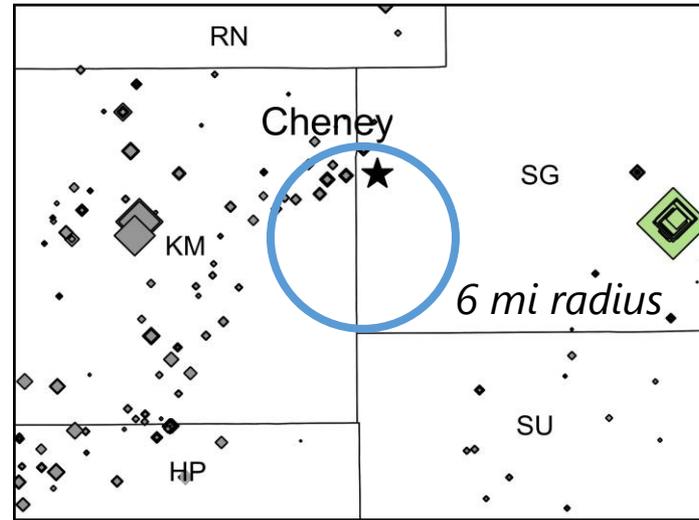


Cheney Area

2016 earthquakes



disposal wells



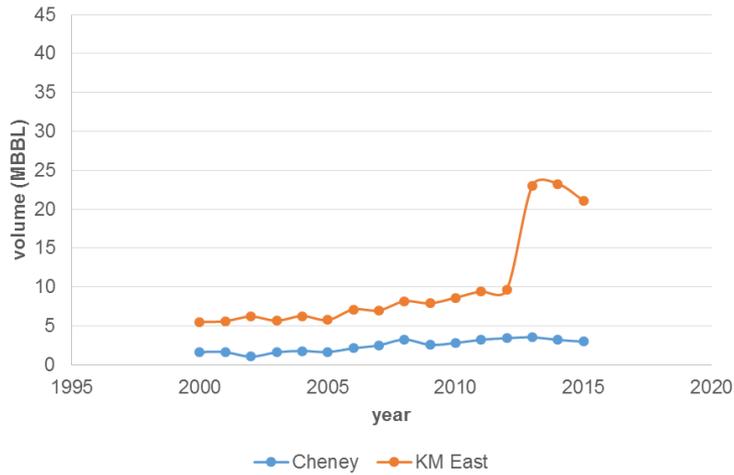
◆ class I ◆ class II

**annual
volume
(MBBL)**

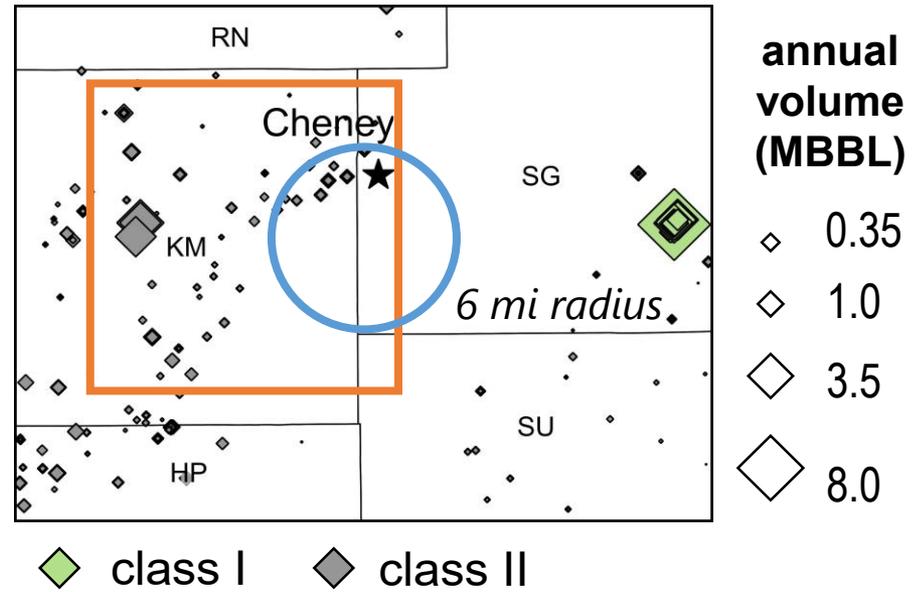
- ◆ 0.35
- ◆ 1.0
- ◆ 3.5
- ◆ 8.0

Cheney Area

Annual Disposal Volume

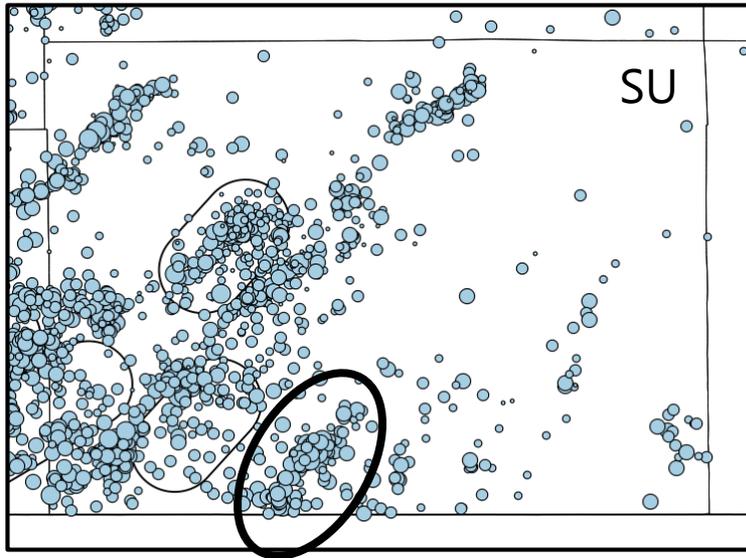


disposal wells

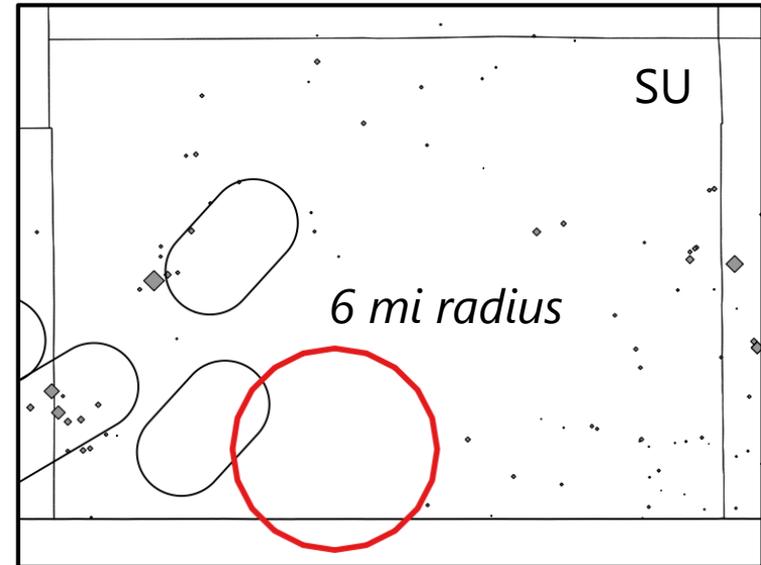


"Caldwell East"

2016 earthquakes



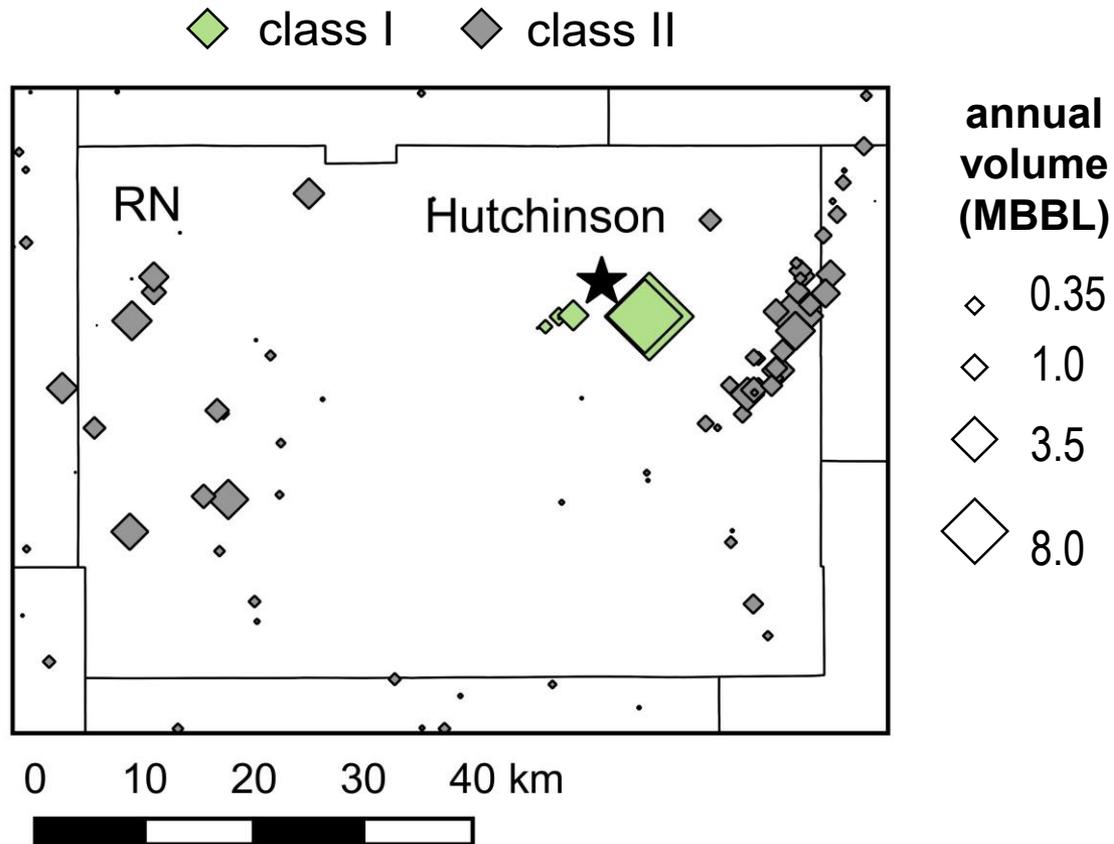
disposal wells



?? Oklahoma ??

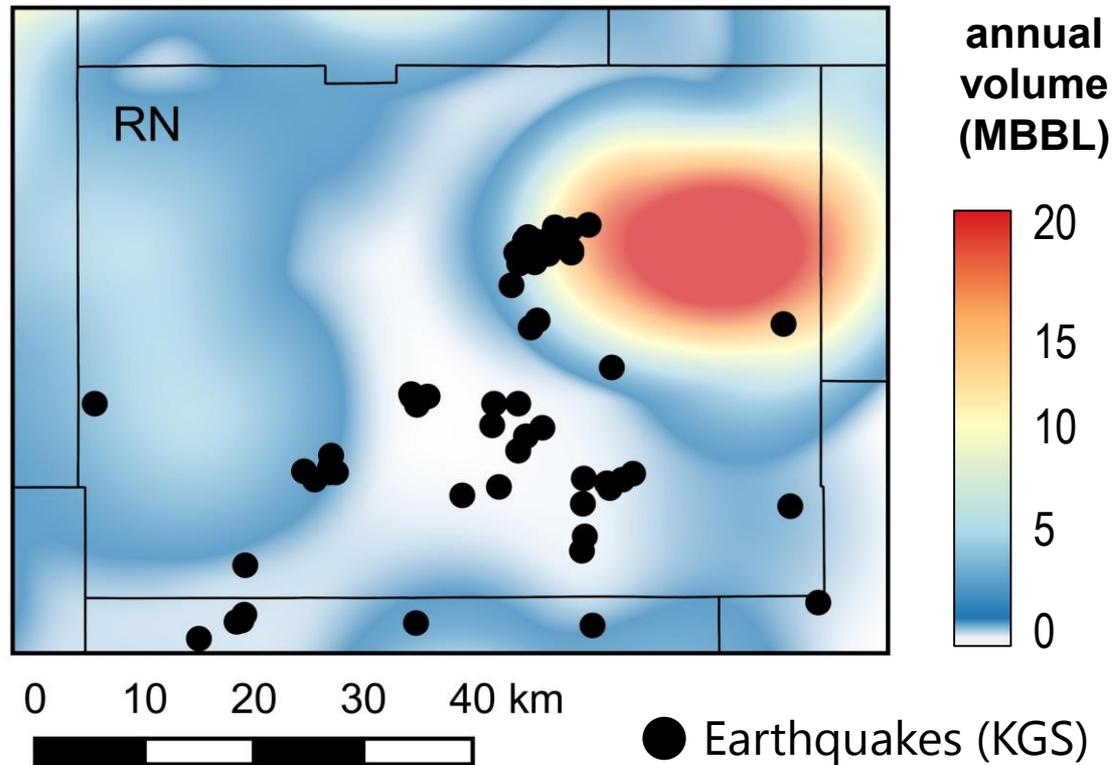
Reno County

Reno County Disposal Wells

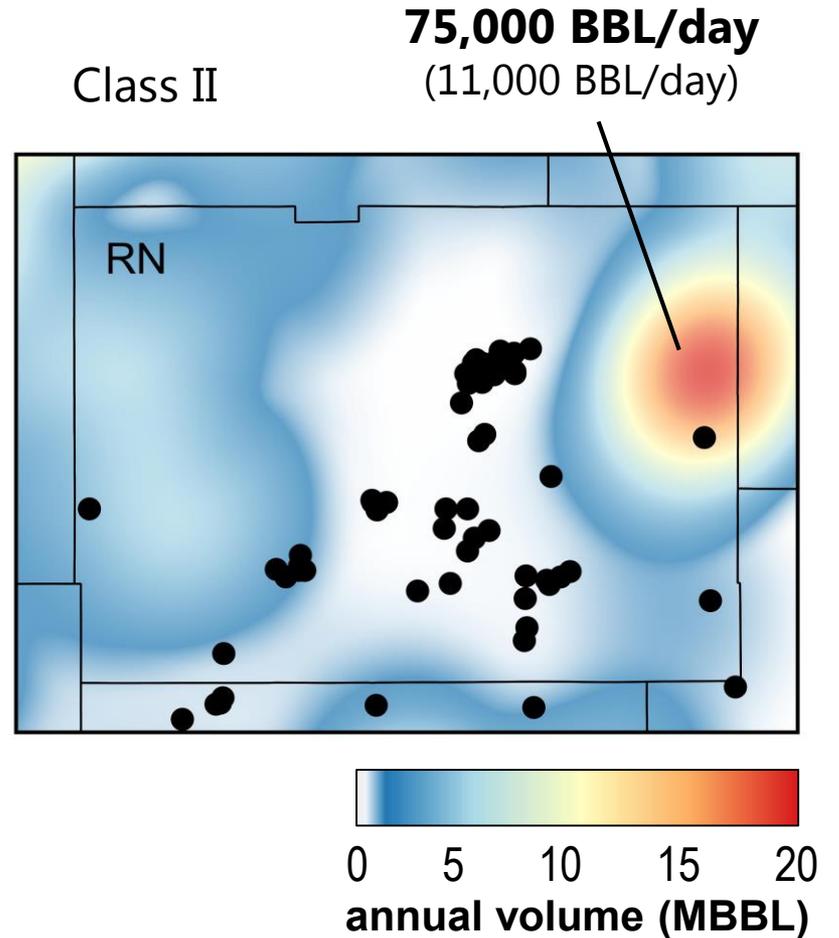
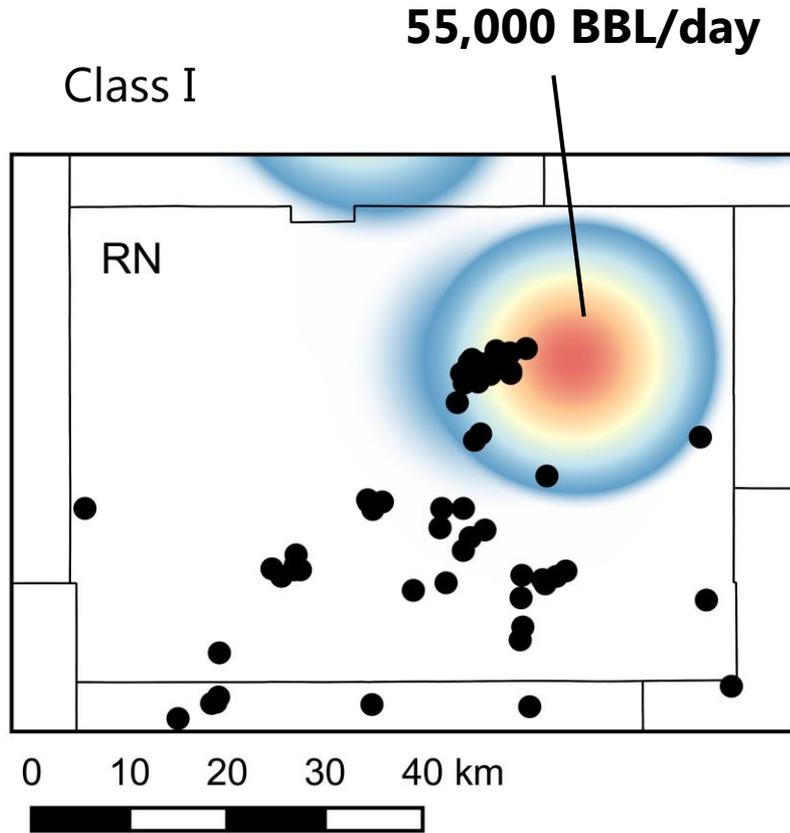


Reno County Fluid Injection

2015 Disposal (Class I & II)

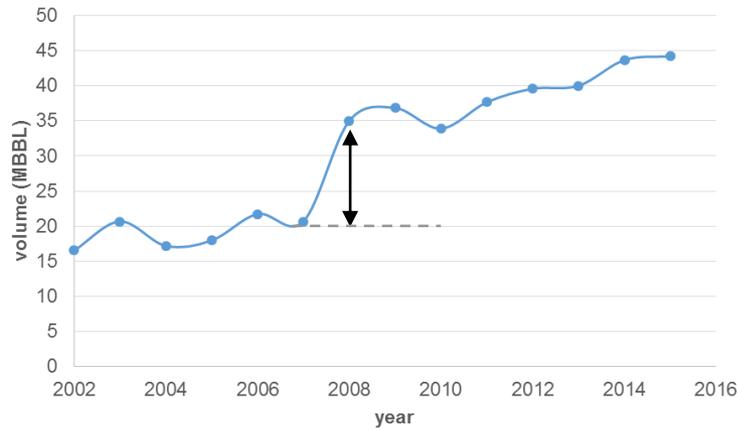


Reno County Fluid Injection

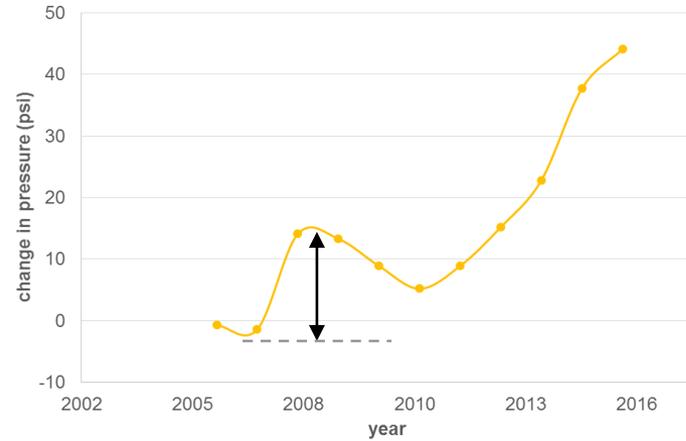


Reno County Injection & Pressure

annual injection volumes

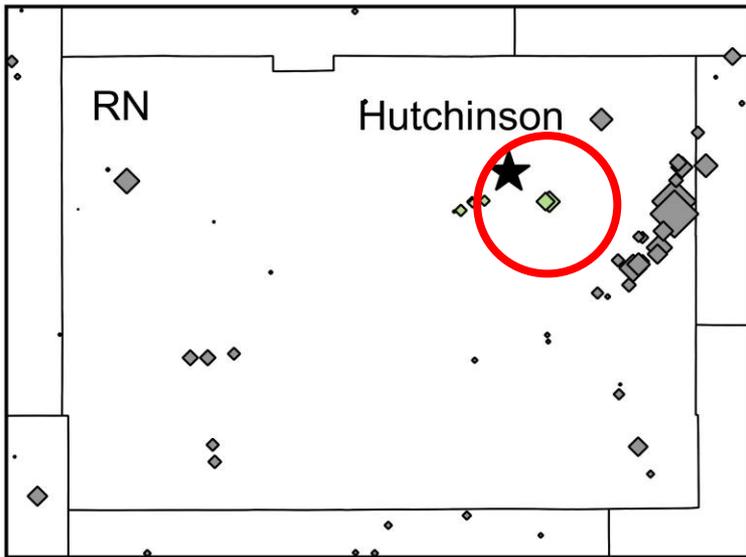


ΔP^*

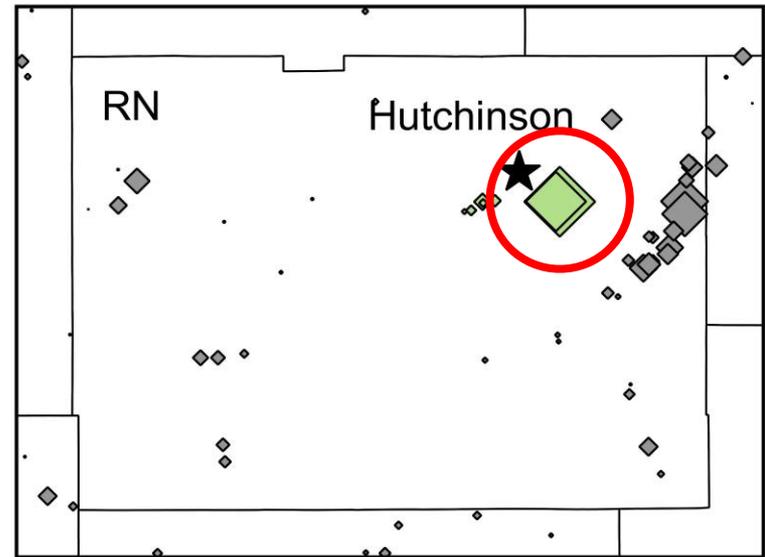


Injection Volumes

2007

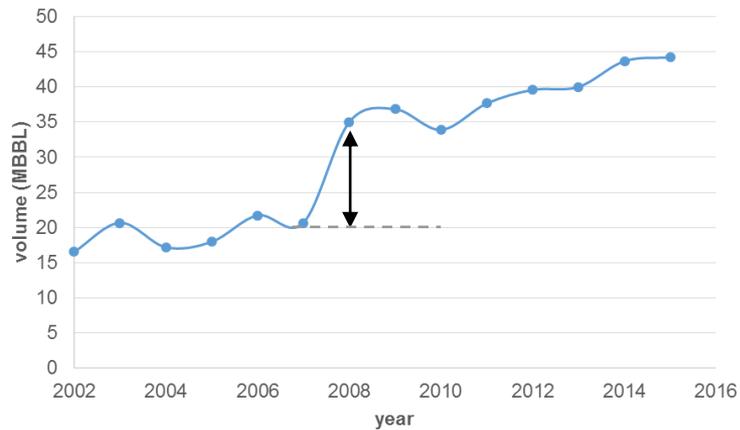


2008

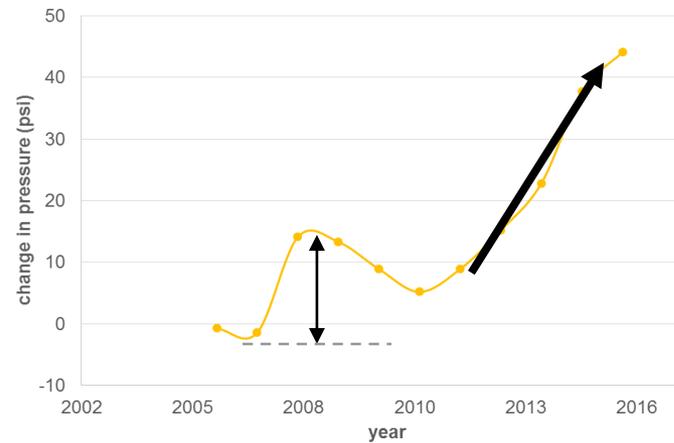


Reno County Injection & Pressure

annual injection volumes

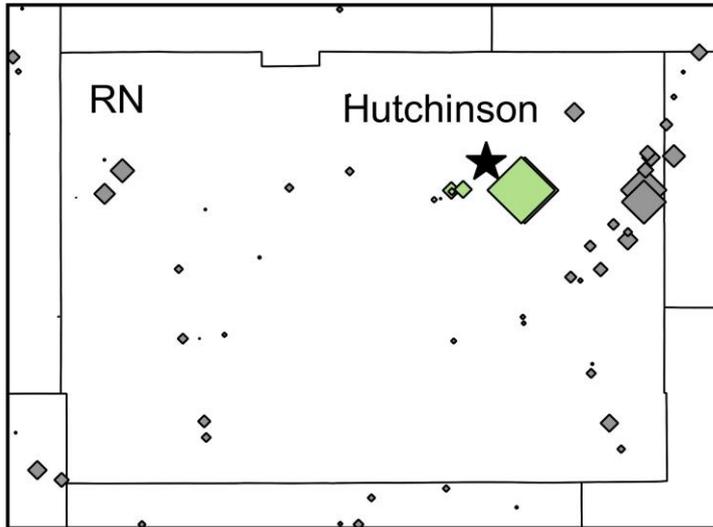


ΔP^*

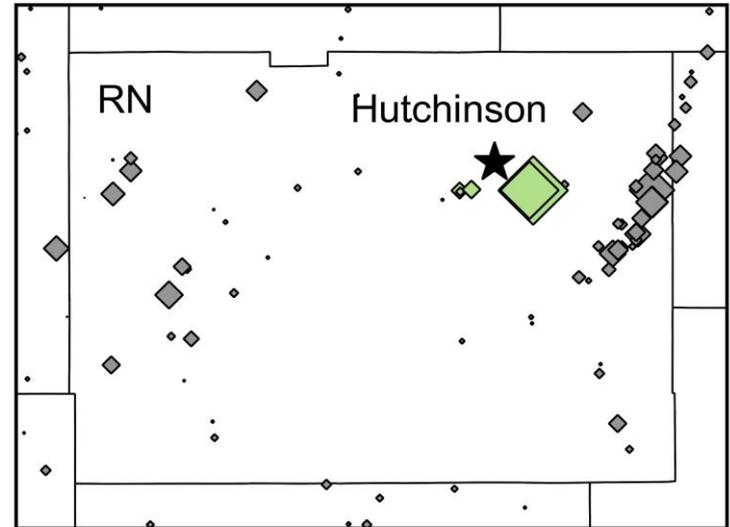


Injection Volumes

2010

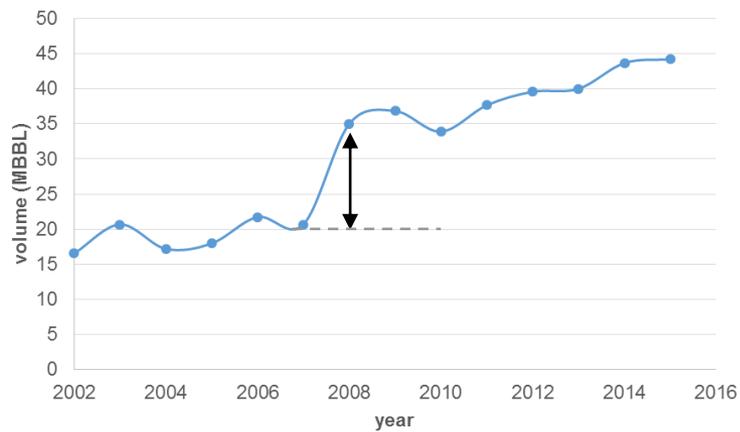


2013

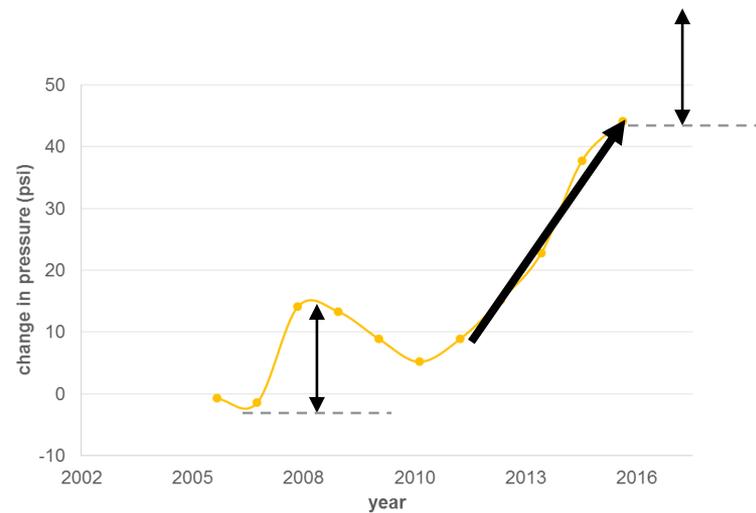


Reno County Injection & Pressure

annual injection volumes

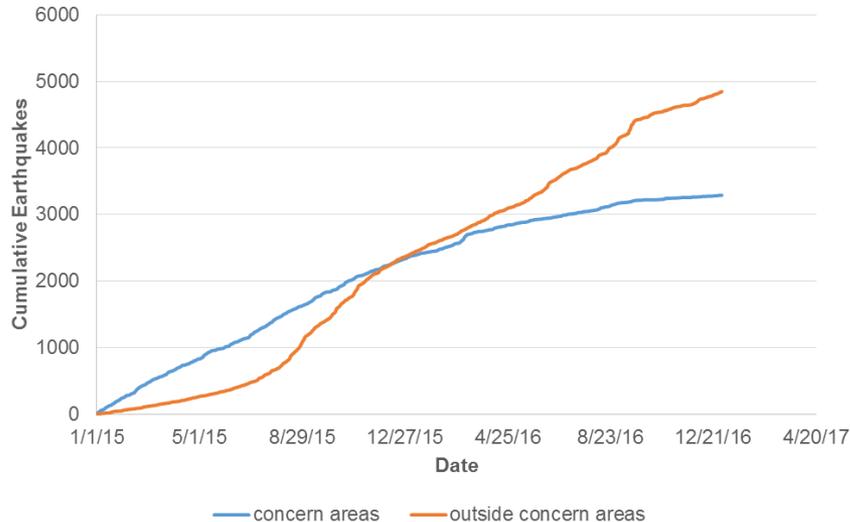


ΔP^*



Summary

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Increased number of earthquakes outside of Harper and Sumner Counties

Earthquakes trend along geologic structures

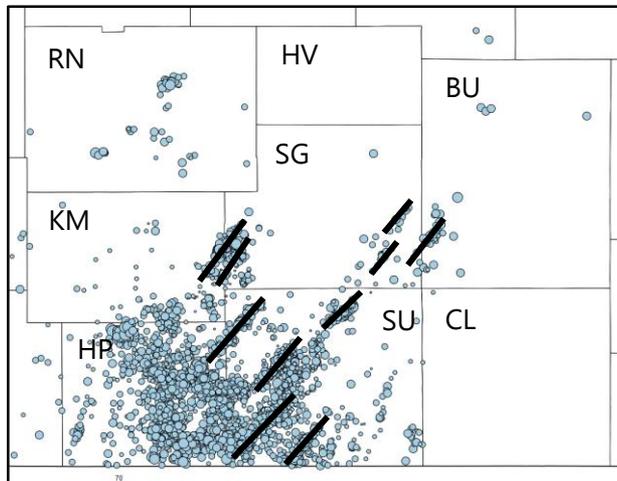
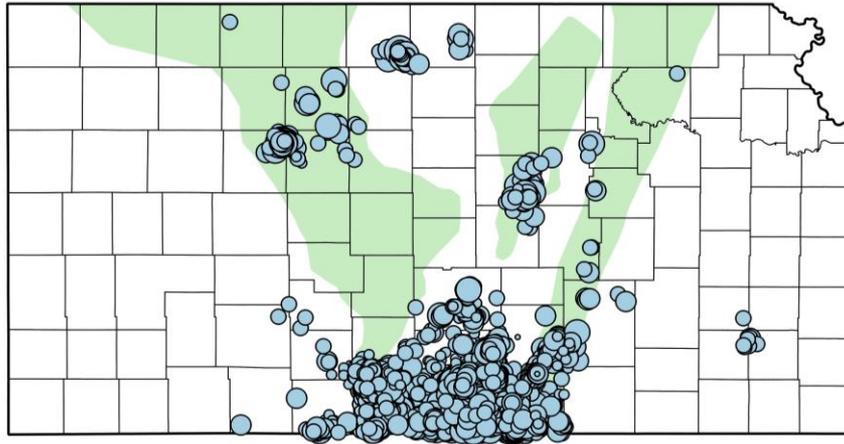
Pressure increasing to the north (pressure front)

Correlation between earthquakes and regional injection (>6 mi)

Seismicity influenced by both class I and class II

Previously tolerated change in pressure may result in seismic activity

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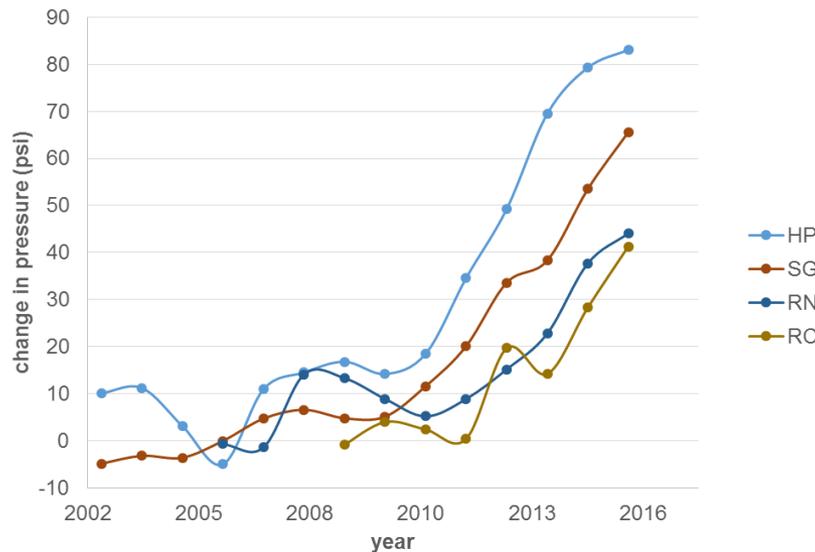
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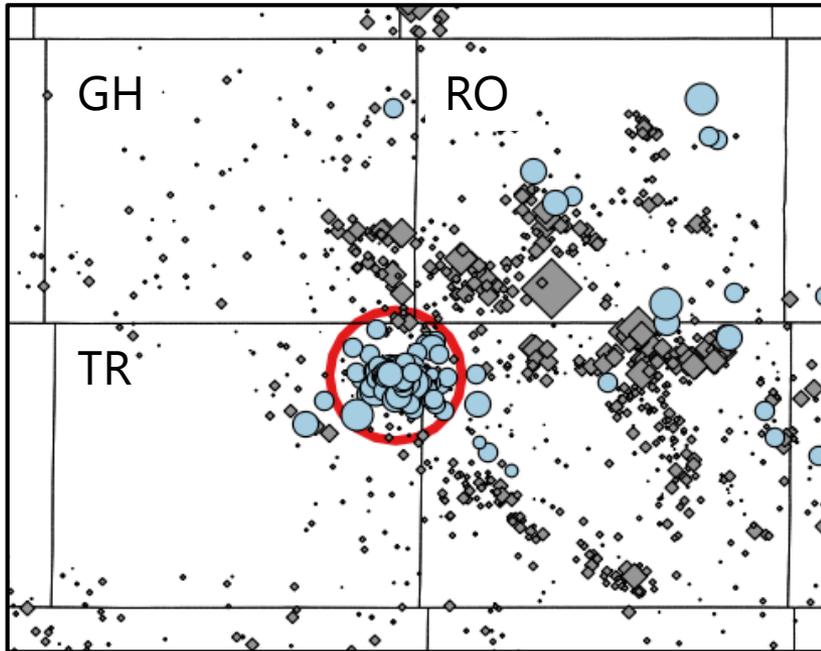
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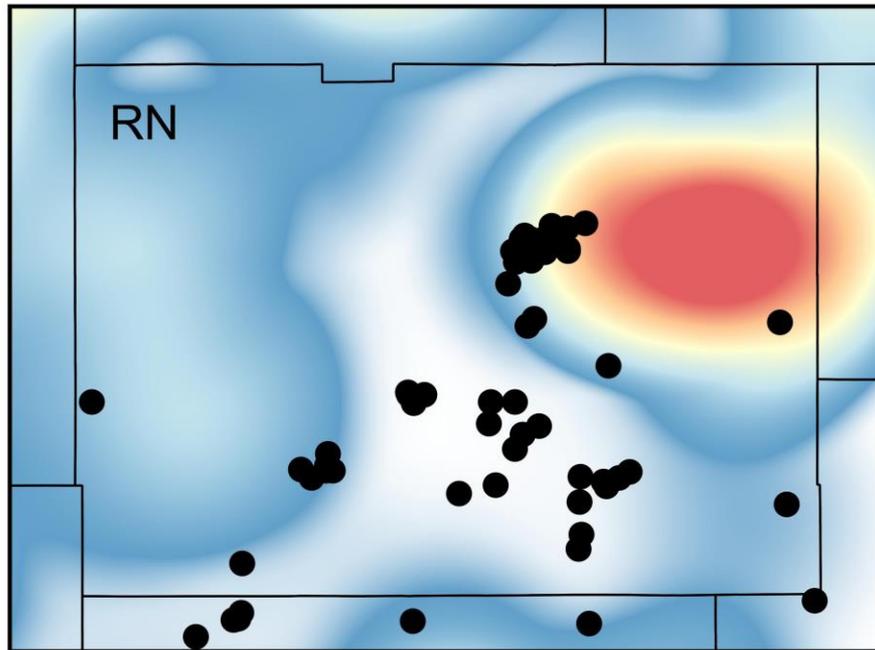
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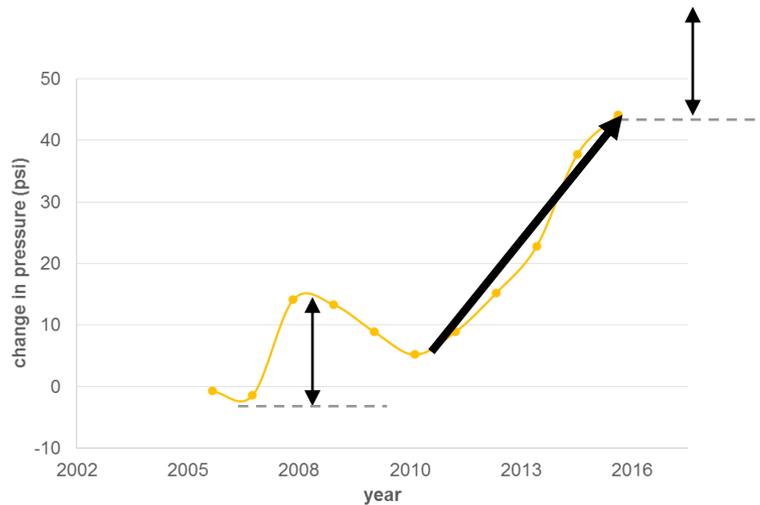
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Reno County Earthquakes

