Injection Induced Seismicity in Kansas: An Update

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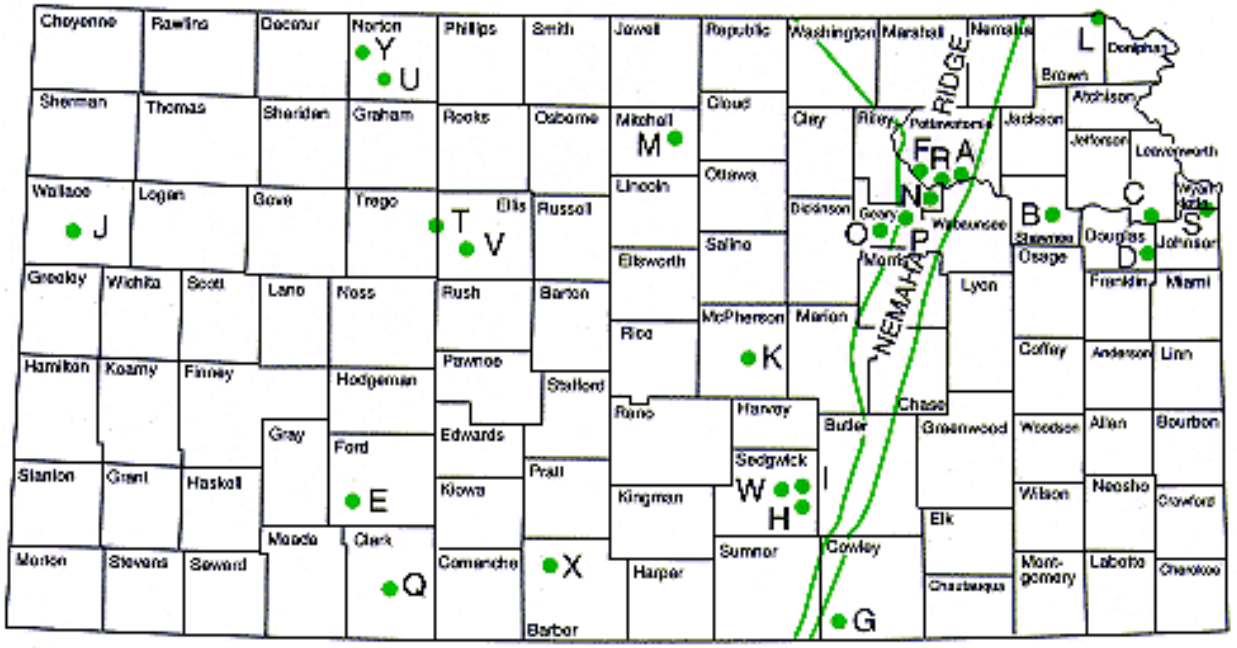
Historic Kansas Earthquakes



A.	1867	VII	F.	1906	VII	K.	1927	V	P.	1929	V	U.	1933	V
B.	1875	V	G.	1907	IV	L.	1927	VI	Q.	1929	V	V.	1942	IV
C.	1881	III	H.	1919	IV	M.	1928	IV	R.	1929	V	W.	1948	IV
D.	1902	II	I.	1919	IV	N.	1929	V	S.	1931	VI	X.	1956	VI
E.	1904	IV	J.	1926	?	O.	1929	V	T.	1932	V	Y.	1961	V

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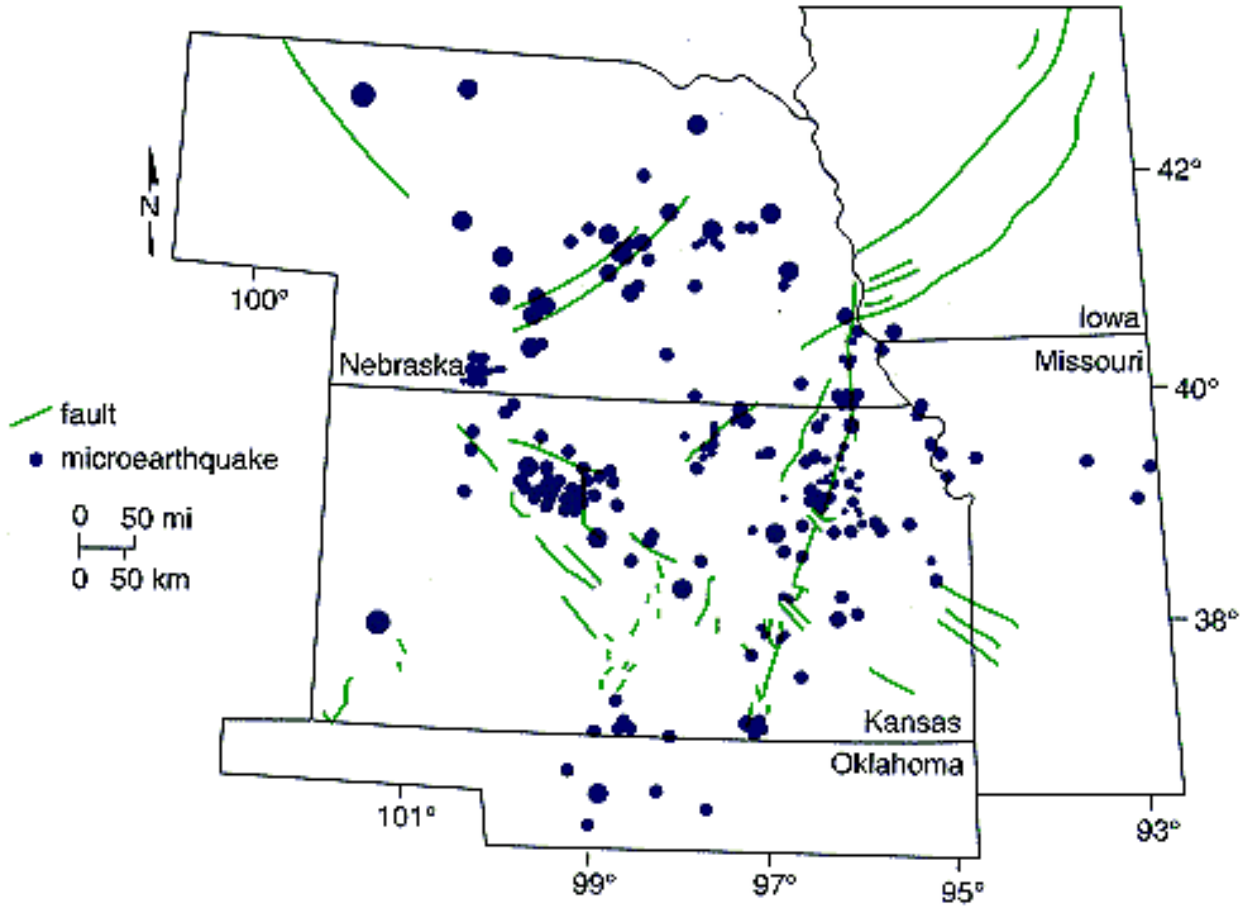
Midcontinent Micro-earthquakes, 1977-1989



Induced or Triggered Seismicity

- Defined: Earthquake activity related to human activity; associated with deep wastewater injection, geothermal energy, large reservoirs

- Potential examples in midcontinent include Arkansas, Colorado, Ohio, Oklahoma, Texas

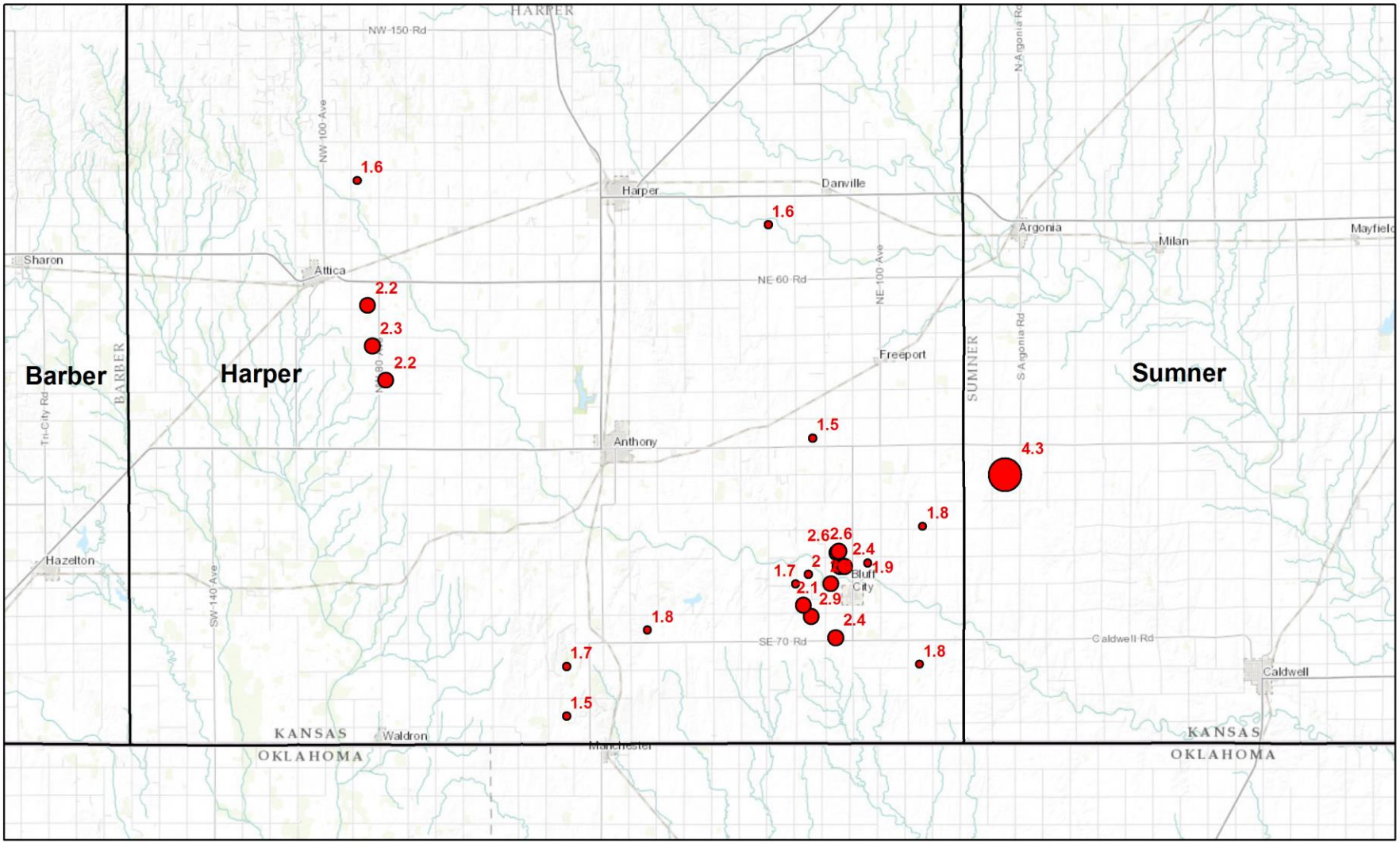
Induced Seismicity – Oil and Gas

- **Production and EOR (CO_2 & Waterfloods)**
  - Rare cases – water floods and production associated subsidence
  - In-situ stress balanced by withdrawal & injection
- **Hydraulic fracturing**
  - Very rare - near basement structure and/or critically stressed fault
  - Inherent microseismic events, very rarely felt at surface
- **Fluid Disposal** (UIC Class II)
  - Regulated by Federal/State Underground Injection Control Program
  - Rare – less than a dozen of over 30,000 UIC Class II disposal wells
  - Disposal near basement structure and/or a critically stressed fault

Induced seismicity can be managed with operations monitoring and modulation of injection pressures and rates

Earthquake Activity - 2013

PRELIMINARY

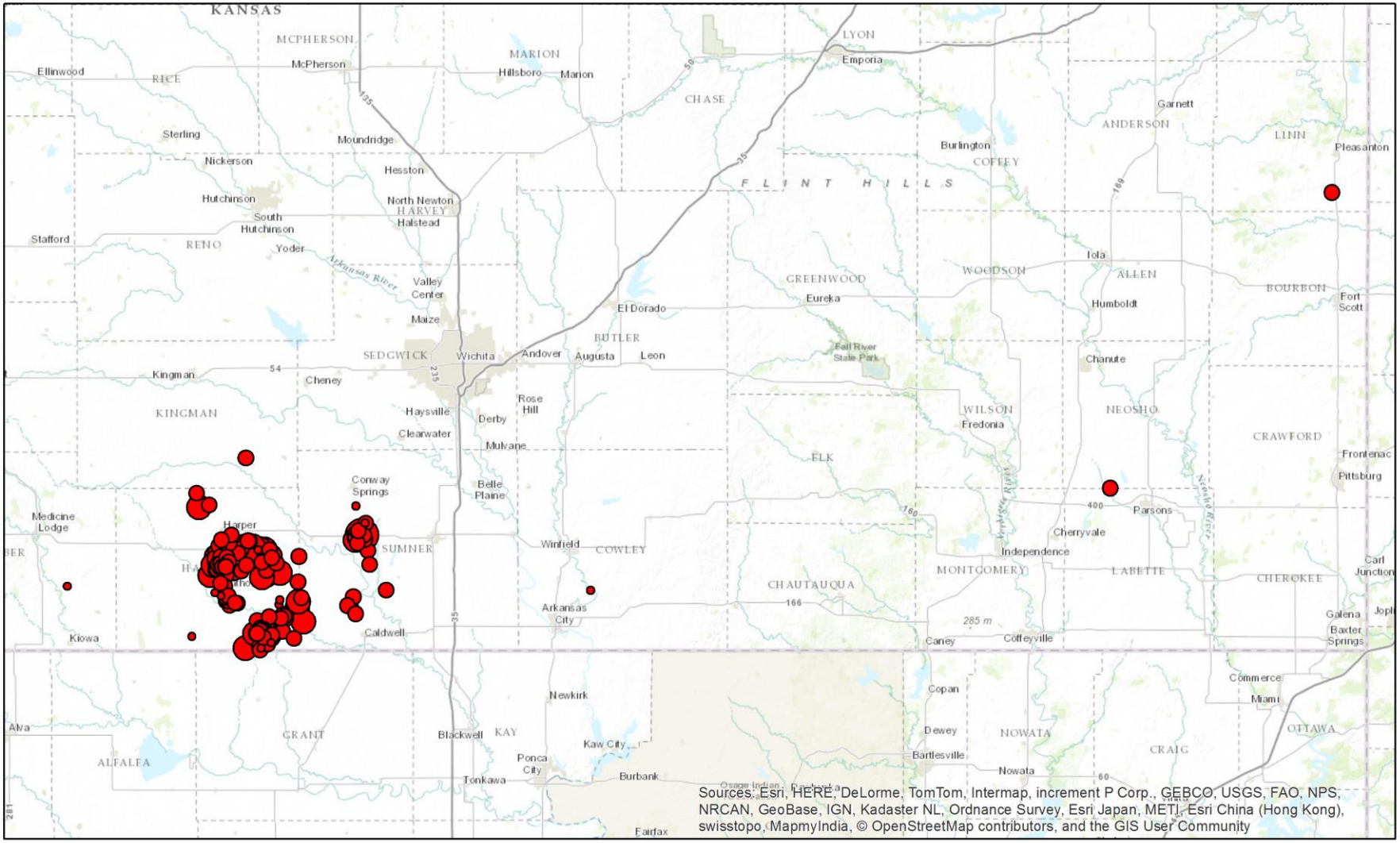


Kansas Geological Survey
Data from Oklahoma Geological Survey, USGS
18 March 2014

0 2.5 5 10 Miles

2014 Earthquakes

PRELIMINARY

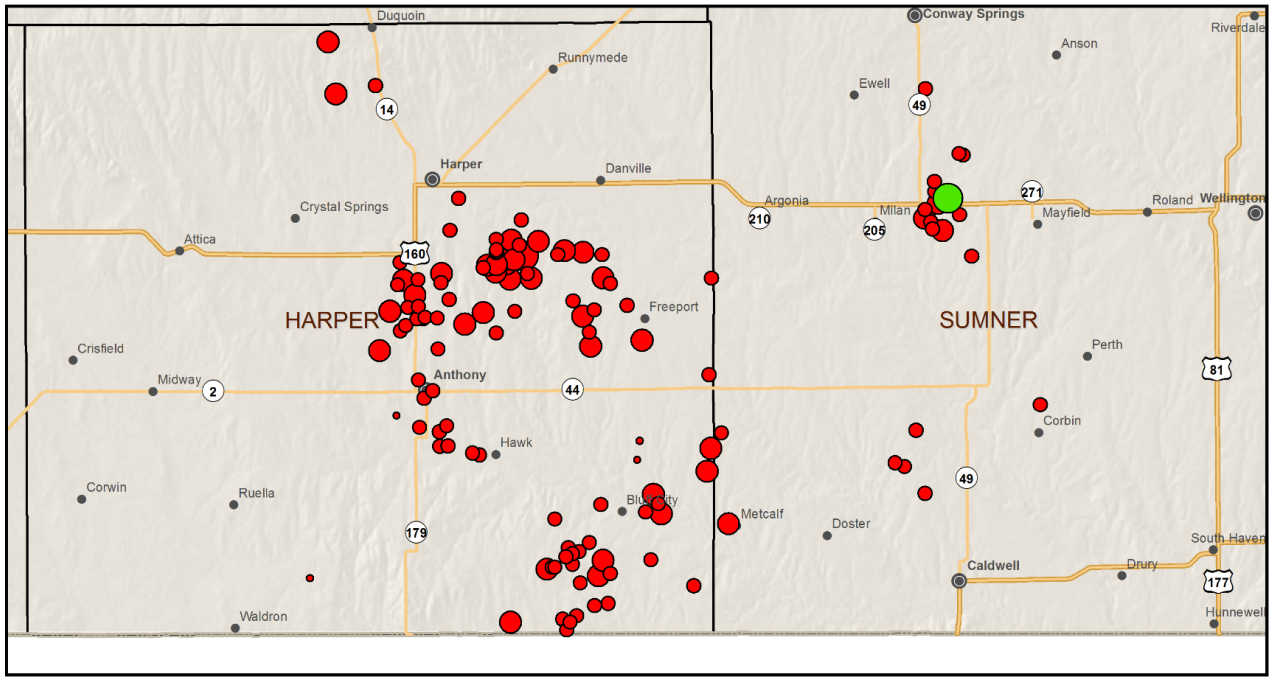


Kansas Geological Survey
Earthquake Data from Oklahoma Geological Survey, USGS
22 January 2015

0 10 20 40 Miles

2014 Earthquakes: Harper and Sumner Counties

Preliminary



Kansas Geological Survey
Data from Oklahoma Geological Survey, USGS
3 August 2015

Magnitude

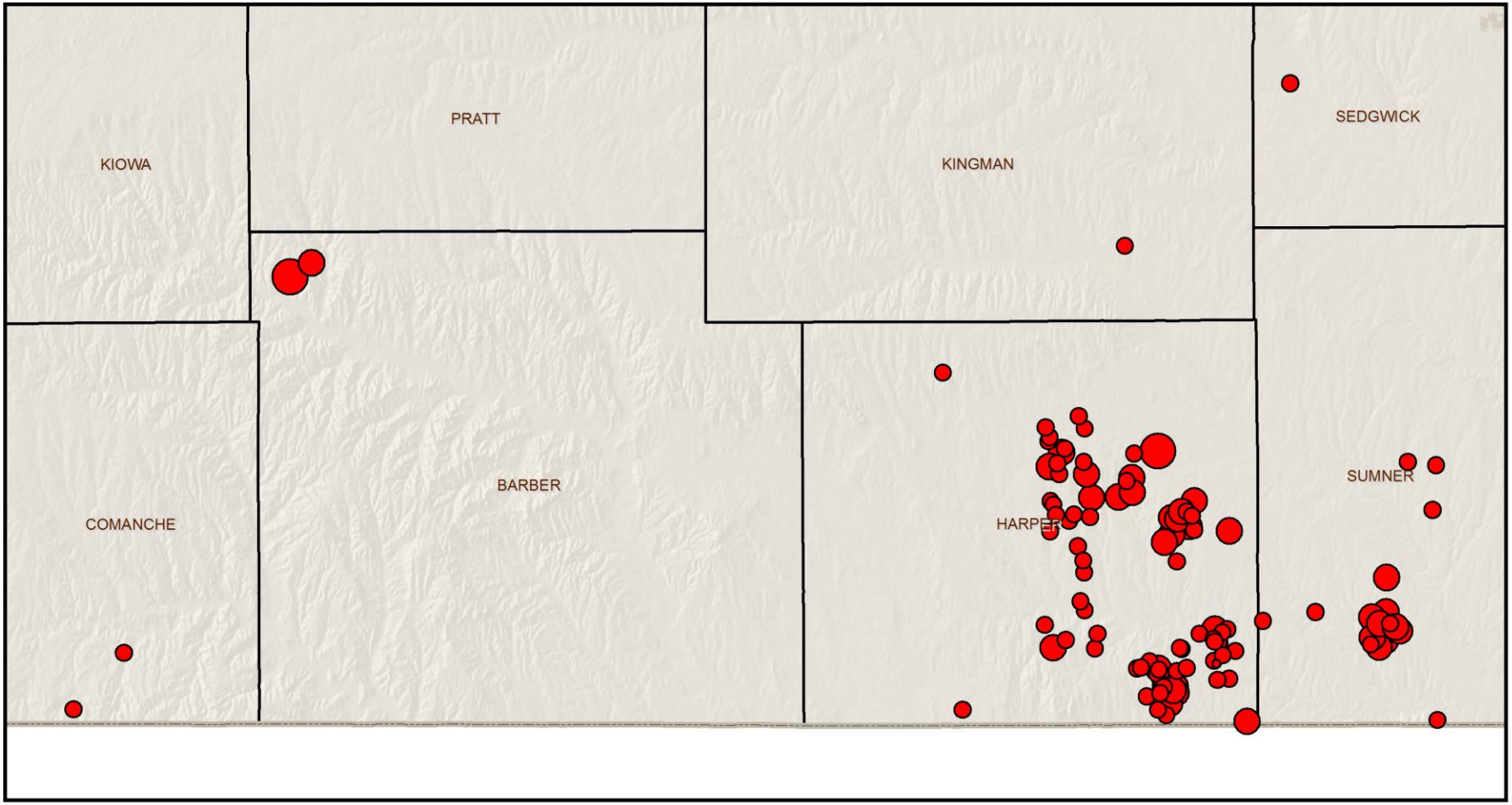
- 1.0 - 1.9
- 2.0 - 2.9
- 3.0 - 3.9
- 4.0 - 4.9

0 2.5 5 10 Miles

UNITED
MIL

2015 Earthquakes

Preliminary



Kansas Geological Survey
Data from USGS
28 July 2015

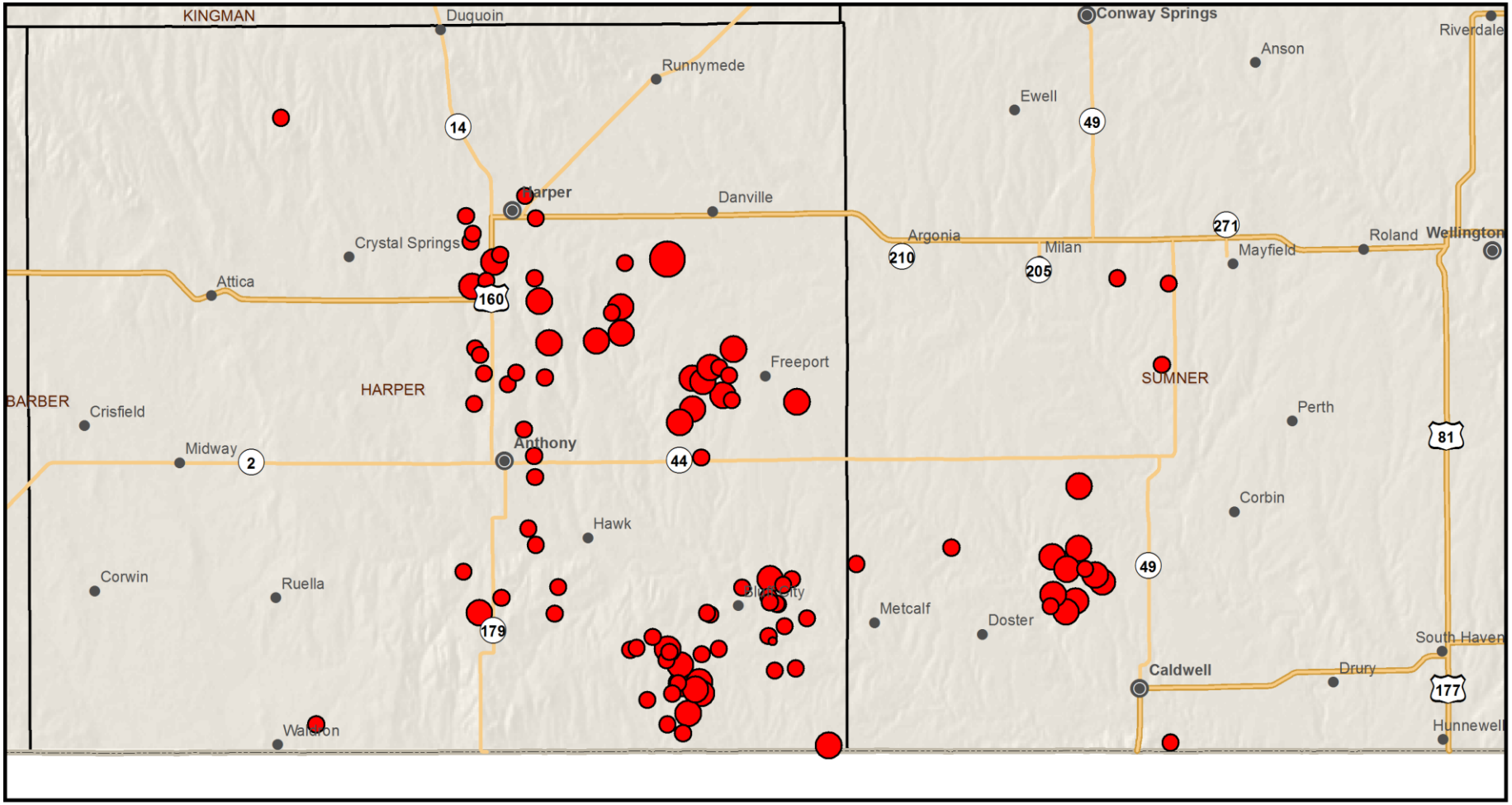
Magnitude

- 1.0 - 1.9
- 2.0 - 2.9
- 3.0 - 3.9
- 4.0 - 4.9

0 5 10 20 Miles

2015 Earthquakes: Harper and Sumner Counties

Preliminary



Kansas Geological Survey
Data from USGS
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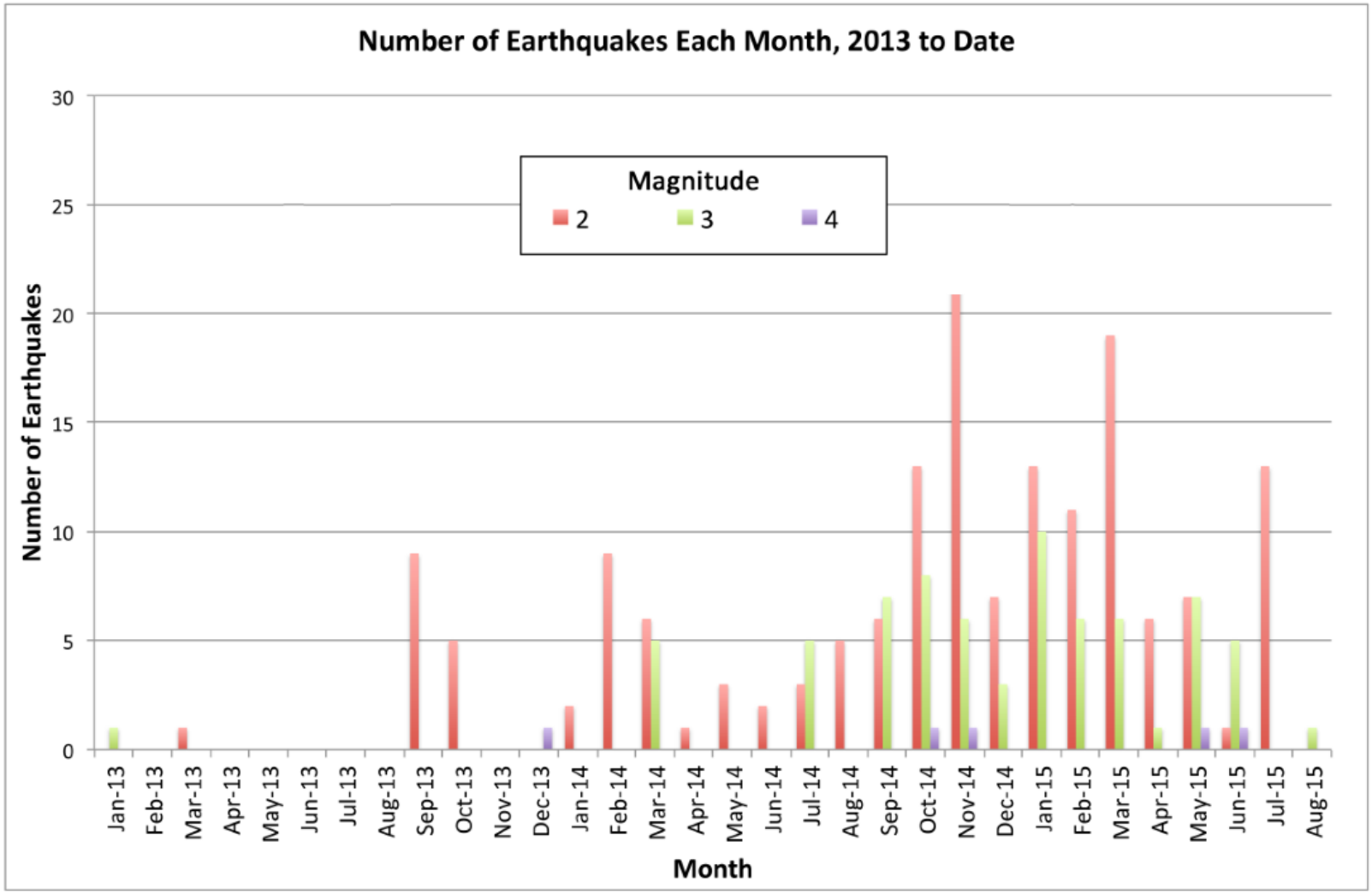


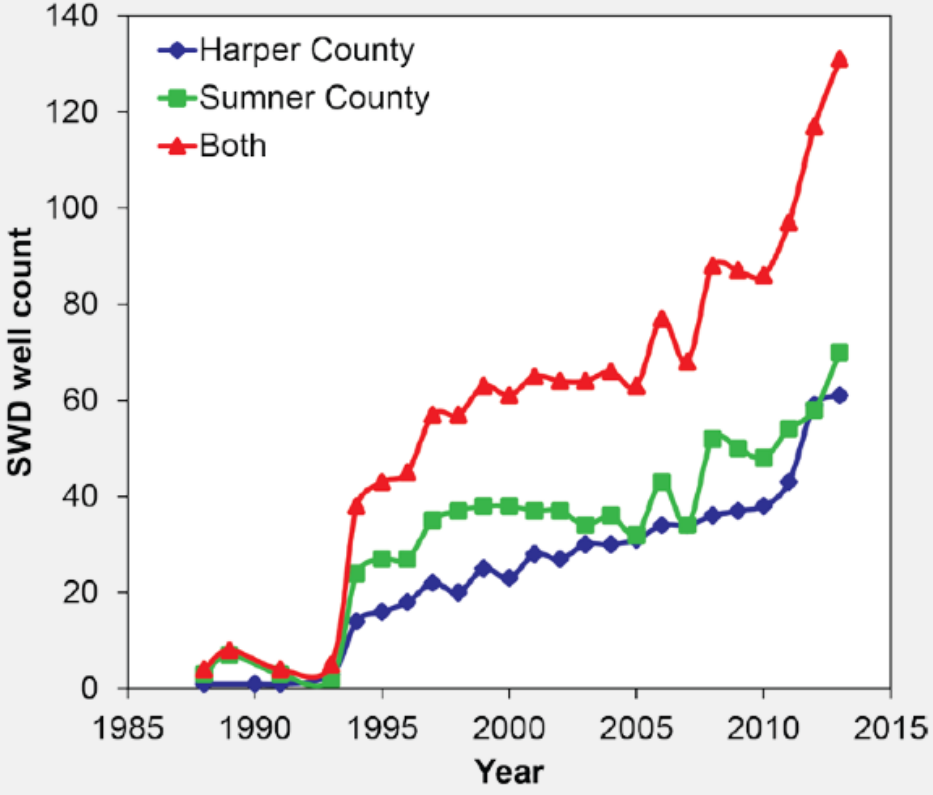
Kansas Geological Survey

Data from U.S. Geological Survey

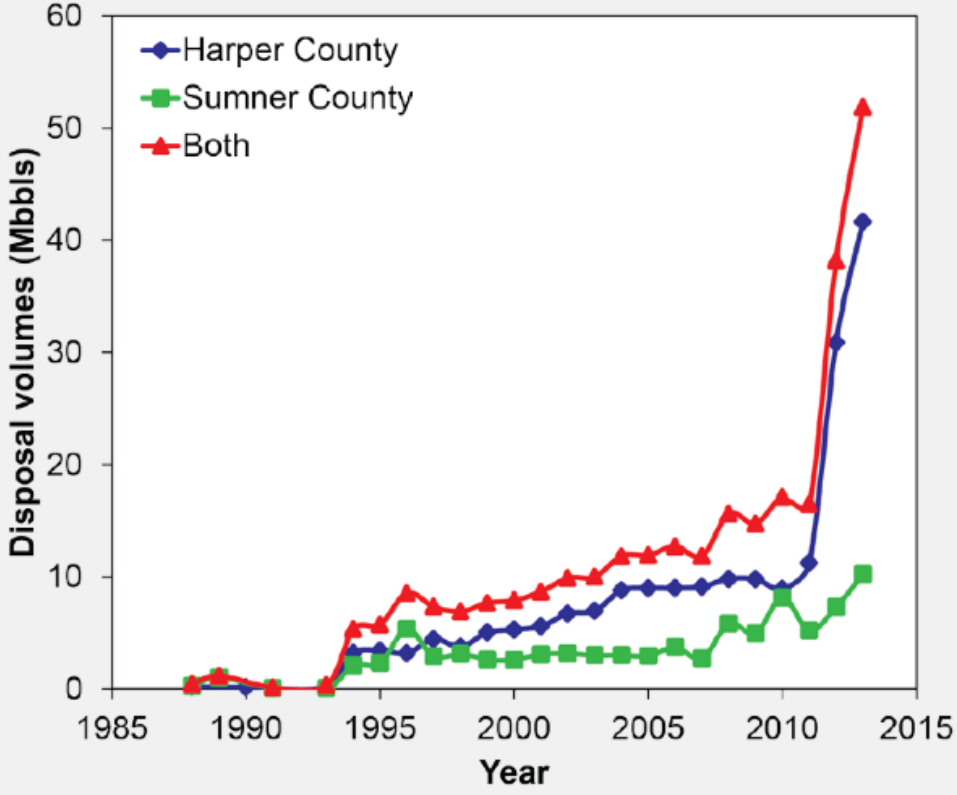
Aug. 8, 2015

Brine disposal trends

Well count



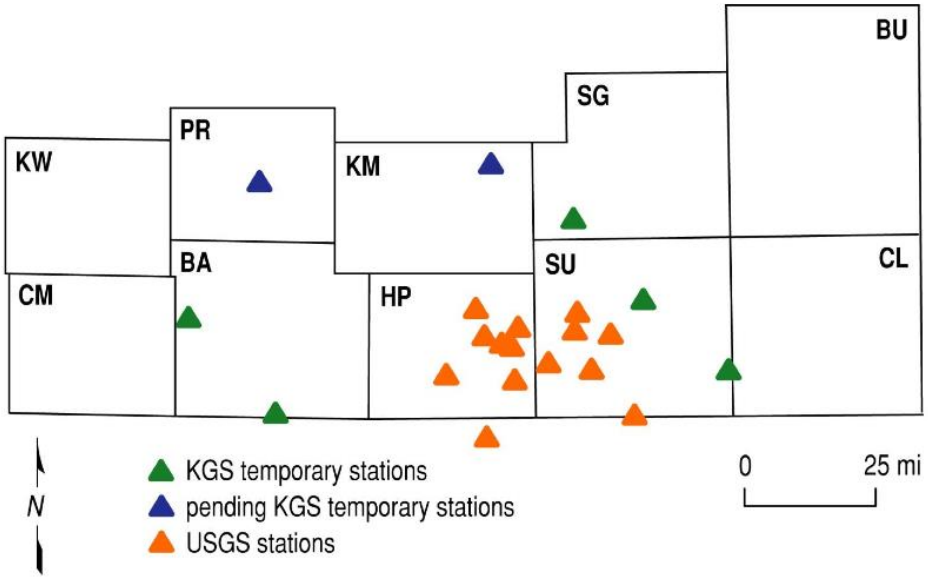
Brine disposal volumes



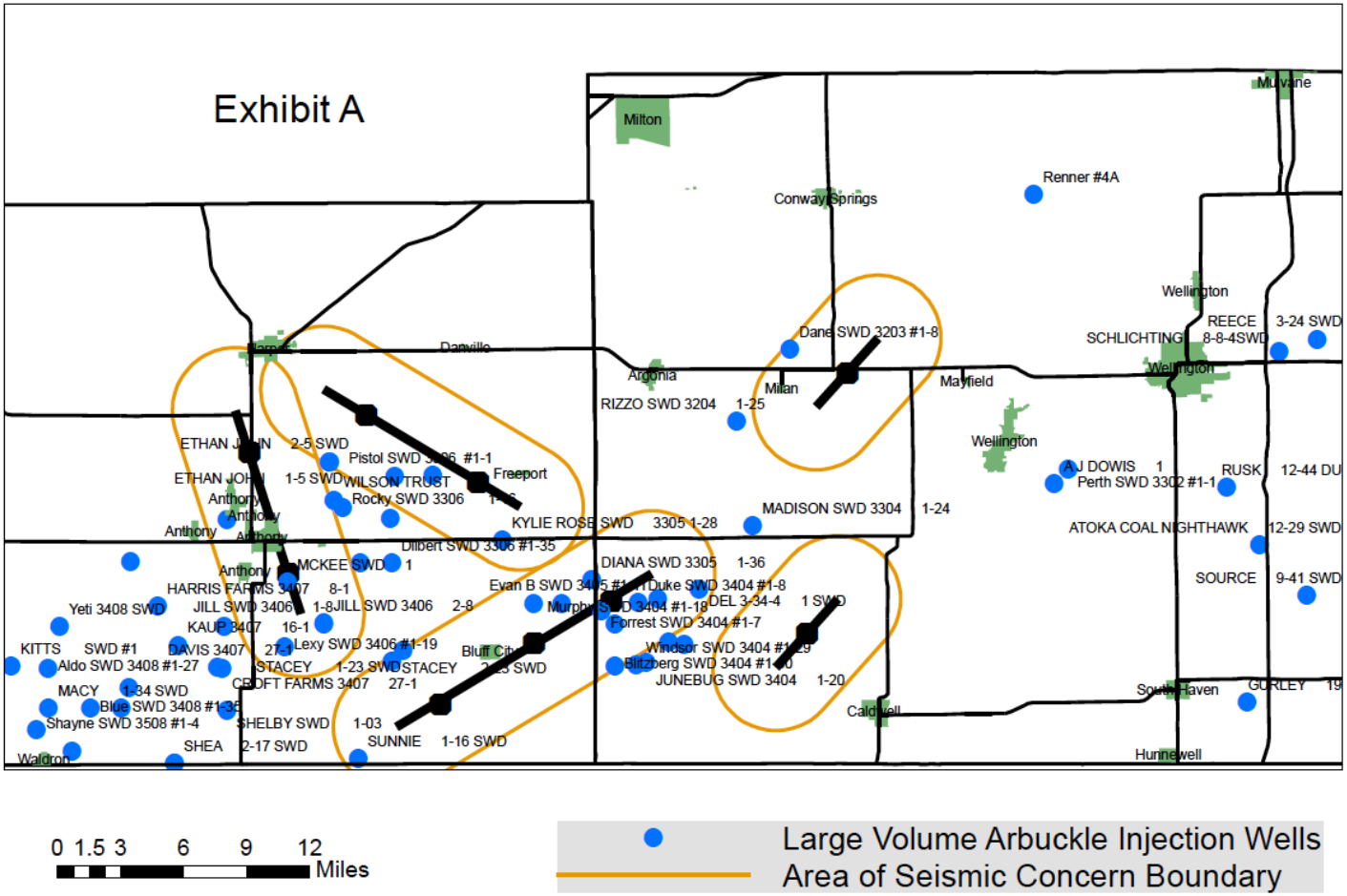
- Well count has doubled since 2005
- 6-fold increase in yearly disposal volumes since mid-1990s
- Yearly volumes have tripled since 2011

Data courtesy of the KCC

KGS and USGS Temporary Networks



Large Volume Arbuckle Injection Wells



Courtesy, Kansas Corporation Commission

States First Initiative

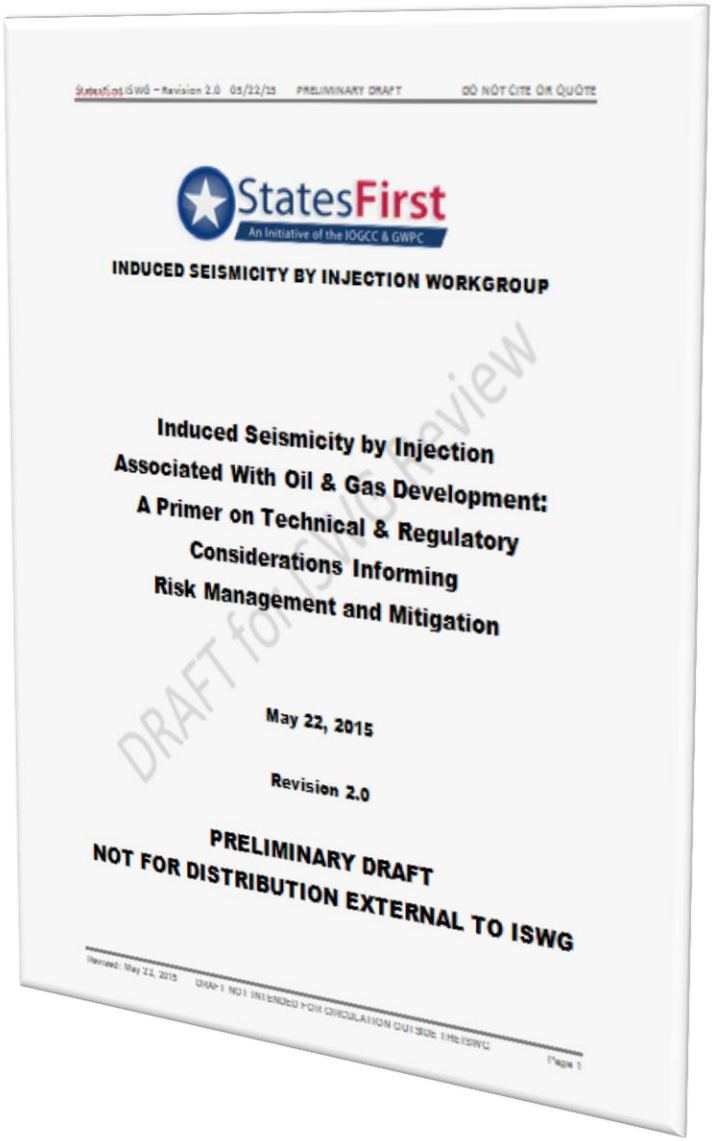
- States First: Collaborative partnership between Ground Water Protection Council and the Interstate Oil and Gas Compact Commission

- Increased Seismic Events: Public concern led to States need for quick actions

- The **Induced Seismicity Work Group** is a States First effort to address concerns associated with induced seismicity

Document Overview

- Primary emphasis on UIC Class II disposal wells
- Includes some discussion of well completions & hydraulic fracturing
- Informational document only and is not intended to offer recommended rules or regulations
- Guide for better understand and respond to seismicity events
- Options available for risk assessment and management approaches
- Considerations for public engagement and response



For More Information

- Kansas Seismic Action Plan: http://kcc.ks.gov/induced_seismicity/state_action_plan.htm
- KCC Order Concerning Class II Injection Wells in Harper and Sumner counties: http://estar.kcc.ks.gov/estar/ViewFile.aspx/15-770%20Order.pdf?Id=05630050-78a3-4800-a08b-85202375305a
- Kansas Geological Survey Resources on Induced Seismicity: http://www.kgs.ku.edu/PRS/Seismicity/index.html
- Association of American State Geologists Fact Sheet on Induced Seismicity: http://www.stategeologists.org/temp/AASG%20Induced%20Seismicity%20Statement%20Update%2002-25-15.pdf
- National Academy of Sciences, Division on Earth Sciences, Induced Seismicity Potential in Energy Technologies:http://dels.nas.edu/Materials/Report-In-Brief/4298-Induced-Seismicity
- U.S. Geological Survey, National Earthquake Information Center: http://earthquake.usgs.gov/contactus/golden/neic.php

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