

# **Produced Water Disposal in the Southern San Joaquin Basin: A Direct Analog for Brine Leakage in Response to Carbon Storage\***

**Preston Jordan<sup>1</sup> and Janice Gillespie<sup>2</sup>**

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<sup>1</sup>Lawrence Berkeley National Lab, Berkeley, CA

<sup>2</sup>California State University, Bakersfield, CA ([jgillespie@csub.edu](mailto:jgillespie@csub.edu))

## **Abstract**

Injection of CO<sub>2</sub> during geologic carbon storage pressurizes reservoir fluid, which can cause its migration. Migration of saline water from the reservoir into underground sources of drinking water (USDW) via pathways such as permeable wells and faults is one concern. As of 2010, 2 billion cubic meters (MMMm<sup>3</sup>) of oil, 10 MMMm<sup>3</sup> of water, and 400 MMMm<sup>3</sup> of gas had been produced in the southern San Joaquin Valley. A considerable portion of the gas and a majority of the water were injected into production zones for pressure support, water flooding, or as steam for thermal recovery. However a portion of the produced water was disposed of by injection into zones without economic quantities of hydrocarbons, termed saline aquifers in the geologic carbon storage community. These zones often lay above the producing zone and, in the absence of hydrocarbon production, were at their original pressures. The subset of such zones at CO<sub>2</sub> storage depths received disposed water volumes equivalent to tens of megatons (MT) of CO<sub>2</sub> injected at overpressures of many MPa. For instance, in the Fruitvale Field, a water volume equivalent to over 20 metric tons (MT) of CO<sub>2</sub> was injected at a depth of 900 m and an average wellhead pressure of 6 MPa. The Fruitvale Field lies only one half mile east of downtown Bakersfield and many domestic water supply wells produce from the aquifer overlying the disposal zone in the area. Consequently the produced water disposal injection in the Fruitvale Field provides an analog for assessing the occurrence of water leakage impacts due to reservoir pressurization.

Almost 230 articles regarding groundwater contamination published from 2000 to 2013 by The Bakersfield Californian, the main newspaper in the area, were assessed. These were written by 71 authors including 38 staff writers. The articles covered 53 different types of facilities or activities that either contaminated groundwater or for which there was such a concern, and discussed 85 different geographic locations. They described groundwater contamination at hundreds of wells during and previous to the publication period. Contamination due to upward leakage caused by produced water disposal injection was not mentioned. This suggests the lack of reporting of groundwater impacts from leakage due to produced water disposal injection indicates no significant public impact, such as closure of numerous public supply wells, occurred during the article time period or for some years previous. This research continues with analysis of historic groundwater constituent data available from the California State Water Resources Control Board's Geotracker Groundwater Ambient Monitoring and Assessment database. This database contains TDS and other constituent results for 149 wells within or in the immediate vicinity of the Fruitvale Oil Field.

### **References Cited**

Hluza, A.G., 1965, Main area of Fruitvale oil field: California Div. Oil and Gas, California Oil Fields - Summary of Operations, p. 31-39.

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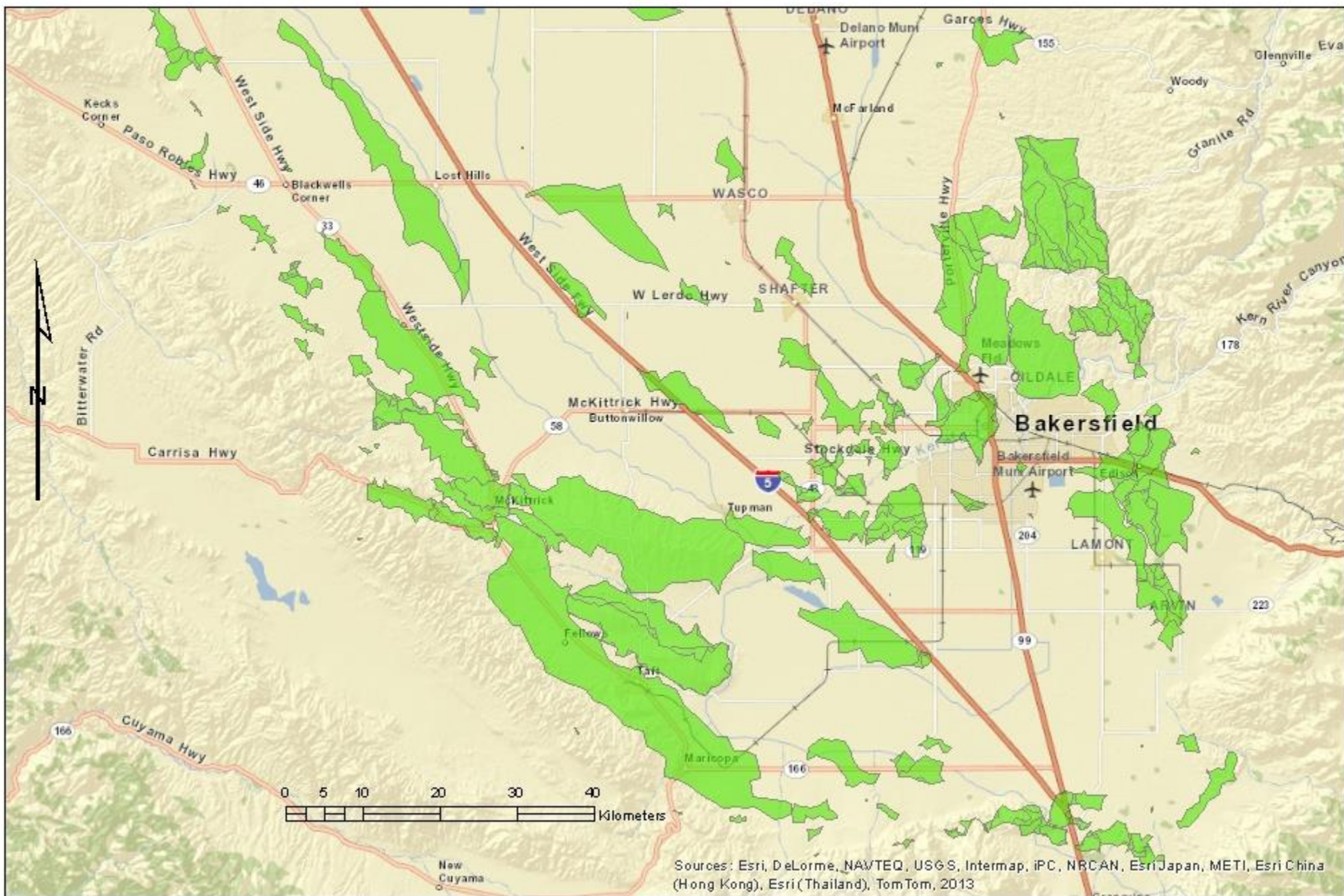
**California State University Bakersfield**



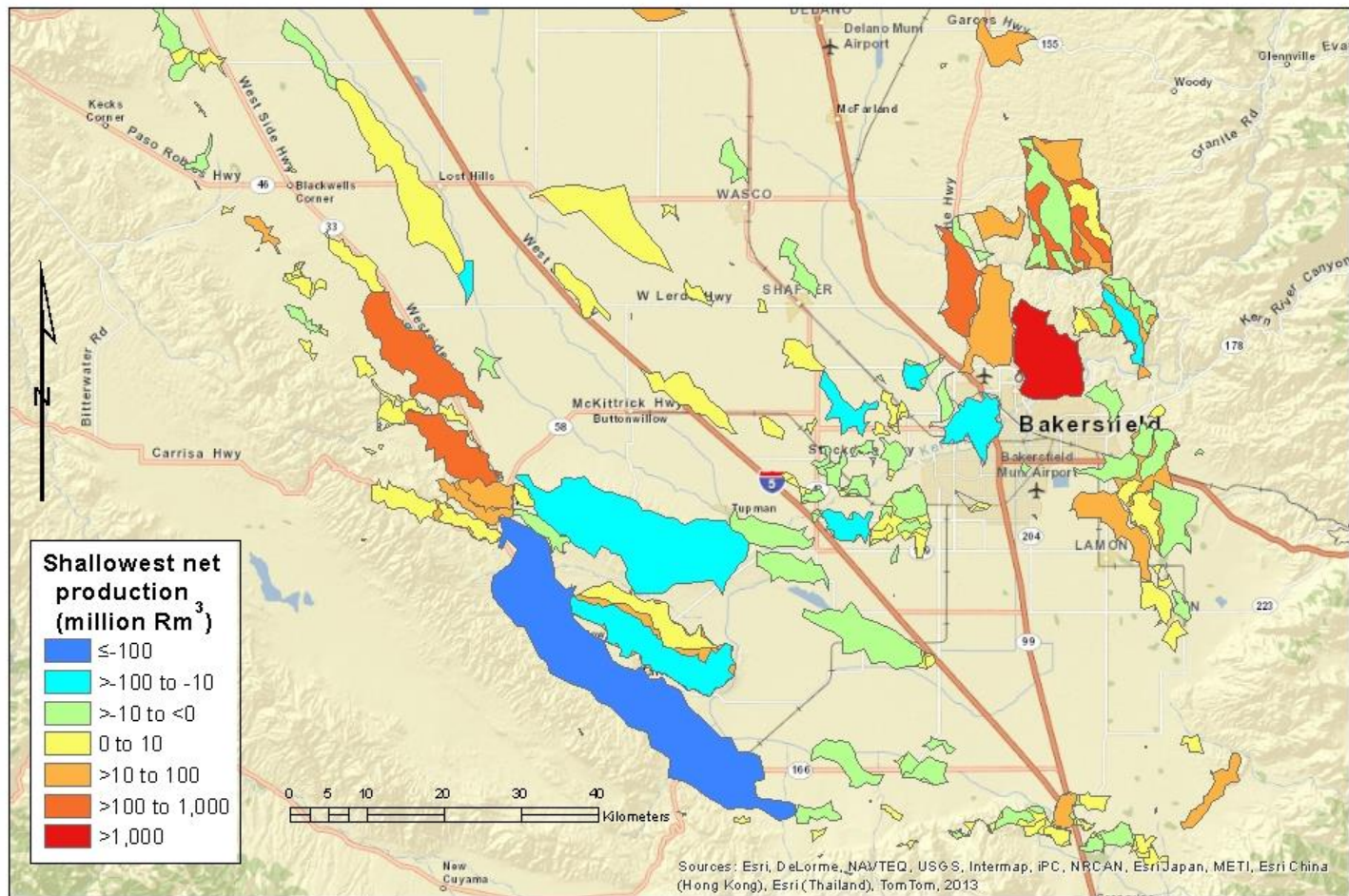
# Question

- **What is the likelihood of CO<sub>2</sub> and subsurface brine leakage into overlying aquifers due to injection in shallow zones?**
- **Can we use water injection (mainly produced water disposal) as a proxy for CO<sub>2</sub> injection**

# Kern County Oil Fields



# Shallowest Net Cumulative Production



Blue and Green colored fields/areas have large amounts of net injection in shallow zones and would indicate places most likely to leak brine into overlying fresh aquifers

# Net Injection Pools - Brine Leakage Analogs

Field	Area	Strata	Depth (m)	Cumulative million m <sup>3</sup>	(mega tons CO <sub>2</sub> at 600 kg/m <sup>3</sup> )	Average Wellhead Pressure (Mpa)	Average Total Dissolved Solids	Wells as of 25 June 2013
Ten Section	Main	Etchegoin	1,400	14	8	3.7	29,300	238
Fruitvale	Main	Etchegoin	900	37	22	6.3	2,300	966
Rosedale Ranch	Any/Main	Etchegoin	1,100	15	9	6.1	12,100	184
Greeley	Any	Etchegoin	1,100	14	8	5.4		199
Canfield Ranch	Gosford, East	Etchegoin	900	7	4	7.9	33,000	291
Tejon	Western	Chanac	600	9	5	6.9		541
total					57			2,419

1. No production overlying the shallow injection zones so no overlying pressure sink (thief zone) between disposal zone and fresh water aquifer

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1. No overlying production (no pressure sink)
2. Near minimum storage depth for CO<sub>2</sub> so could be considered a candidate for carbon storage

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3. Largest volume injected up to 2010

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6. All wells pass through shallow disposal zone and are potential conduits

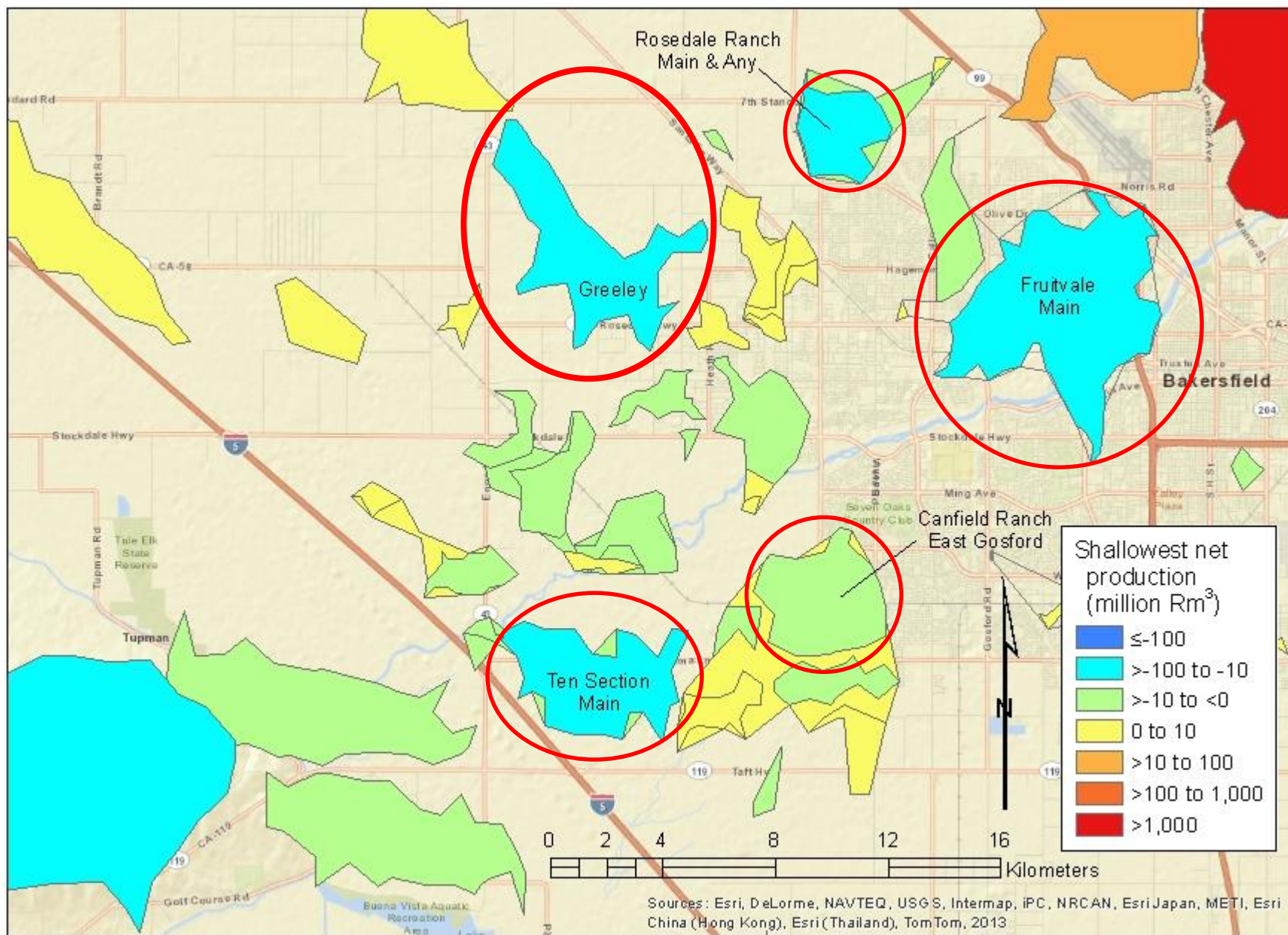
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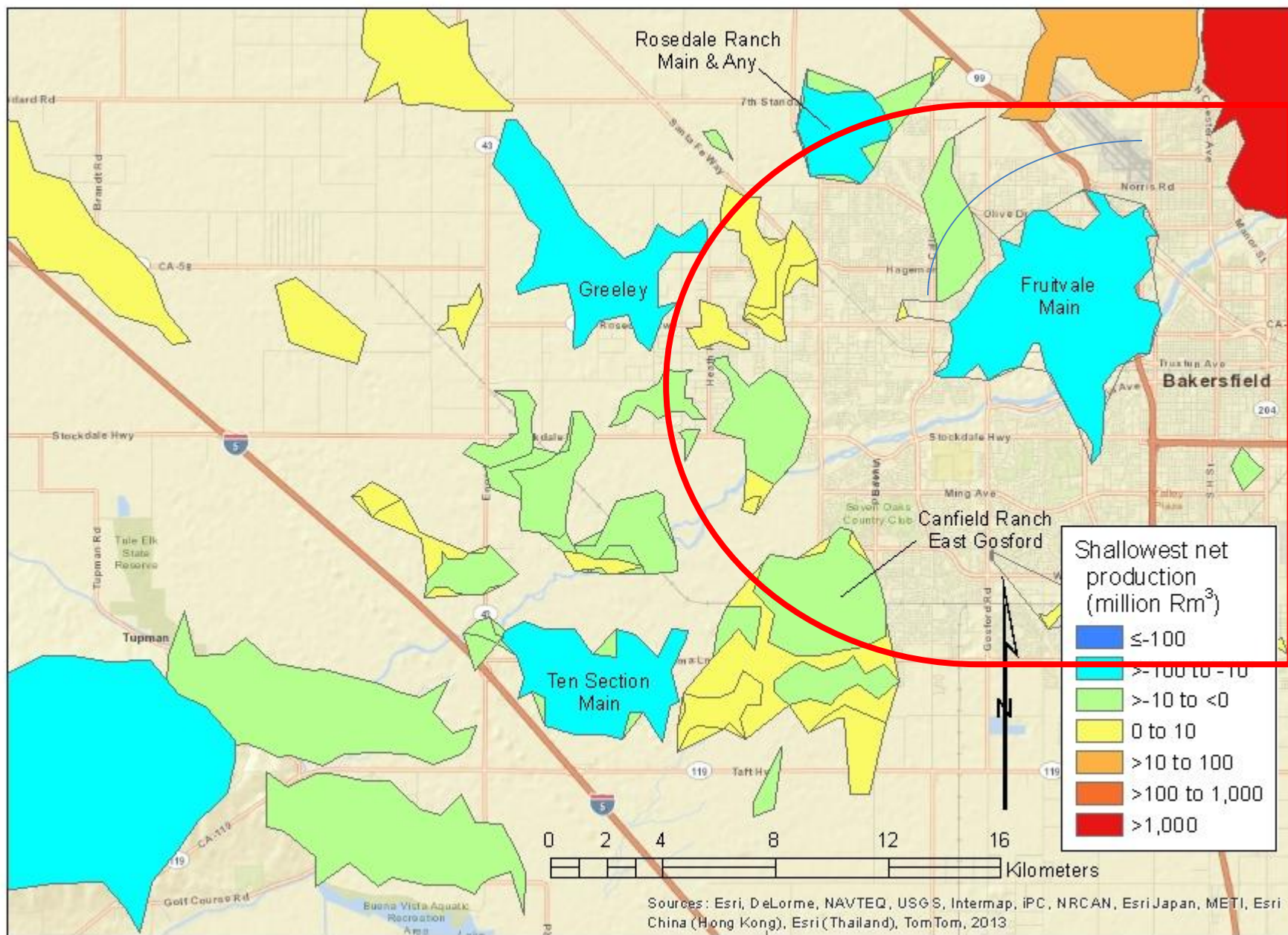
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# Analog Locations



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**Did we see any consequences of the  
produced water injection in  
aquifers overlying the Fruitvale oilfield?**

# **Consequence Survey: *Bakersfield Californian***

## **Justification: 1991 to 2005 Well Blowout Study**



PHOTO COURTESY OF KERN CHARTER SERVICE INC.

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## Justification: 1991 to 2005 Well Blowout Study

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- 7 are described in *Bakersfield Californian* articles, including 2 that required evacuation
- ***Bakersfield Californian* has coverage of highest consequence blowouts and is as good or better than government sources**

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- from 22 types of sources

These source  
types are  
covered in  
more than 5  
articles each

petroleum refinery  
underground storage tank  
arsenic  
power plant  
produced water - surface disposal  
pesticide and/or fumigant plant  
gas station spill  
waste disposal  
agriculture

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- resulting in at least 100 well closures

Single articles report on the closure of as few as 1 public supply well and several domestic wells

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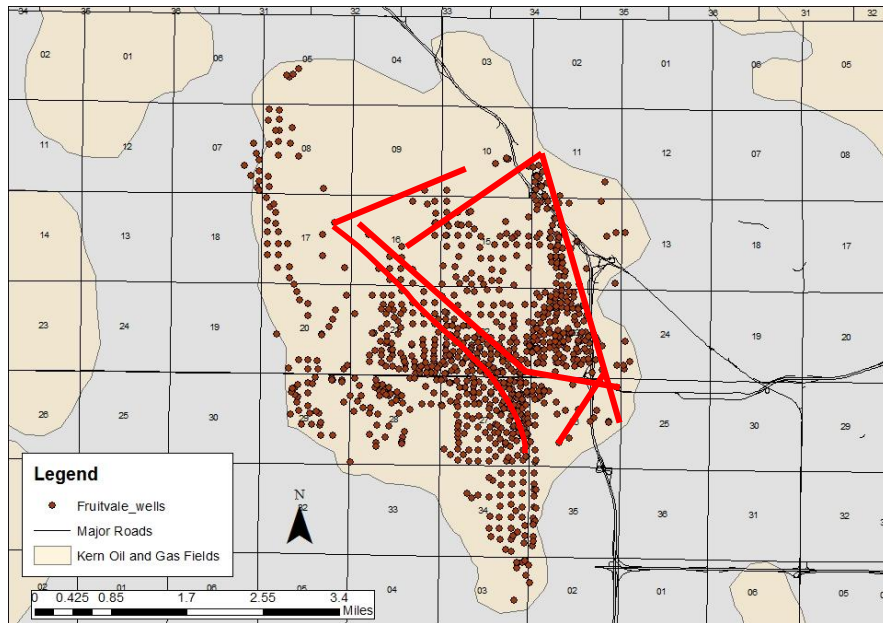
**High Consequence Saline Water Leakage Unlikely**

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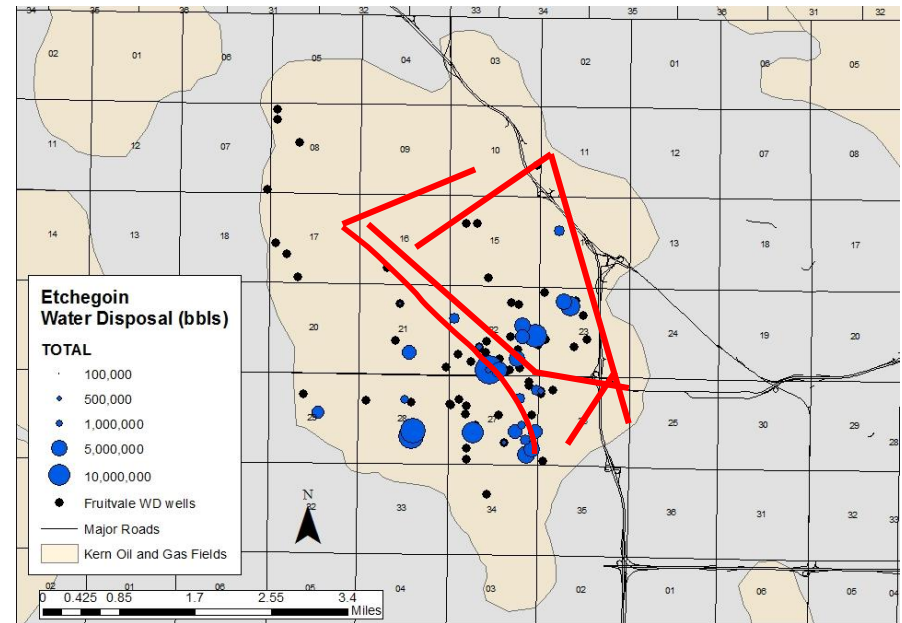
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# Fruitvale Main Oil & Gas Wells

## All Wells

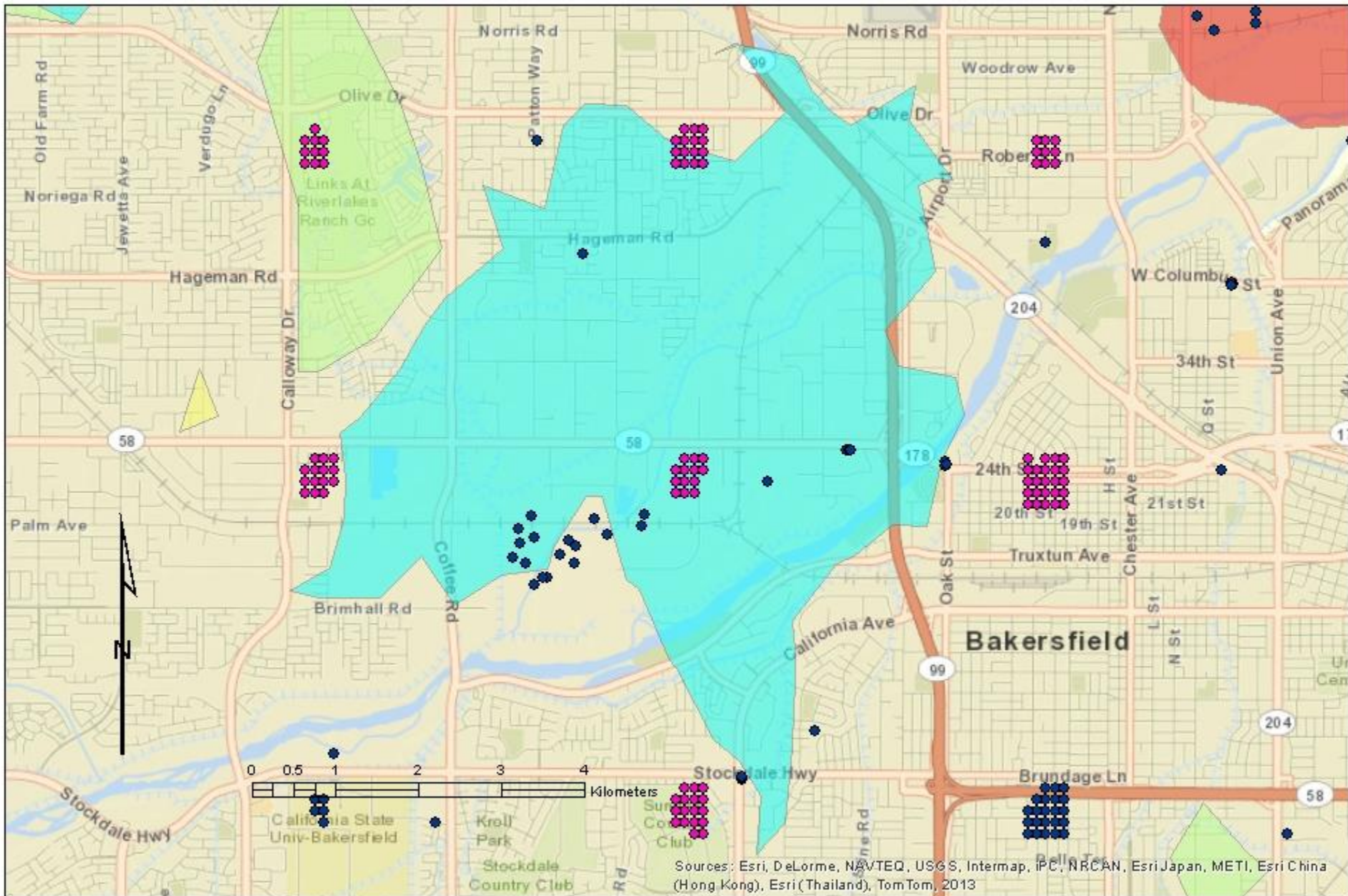


## Water Disposal Wells

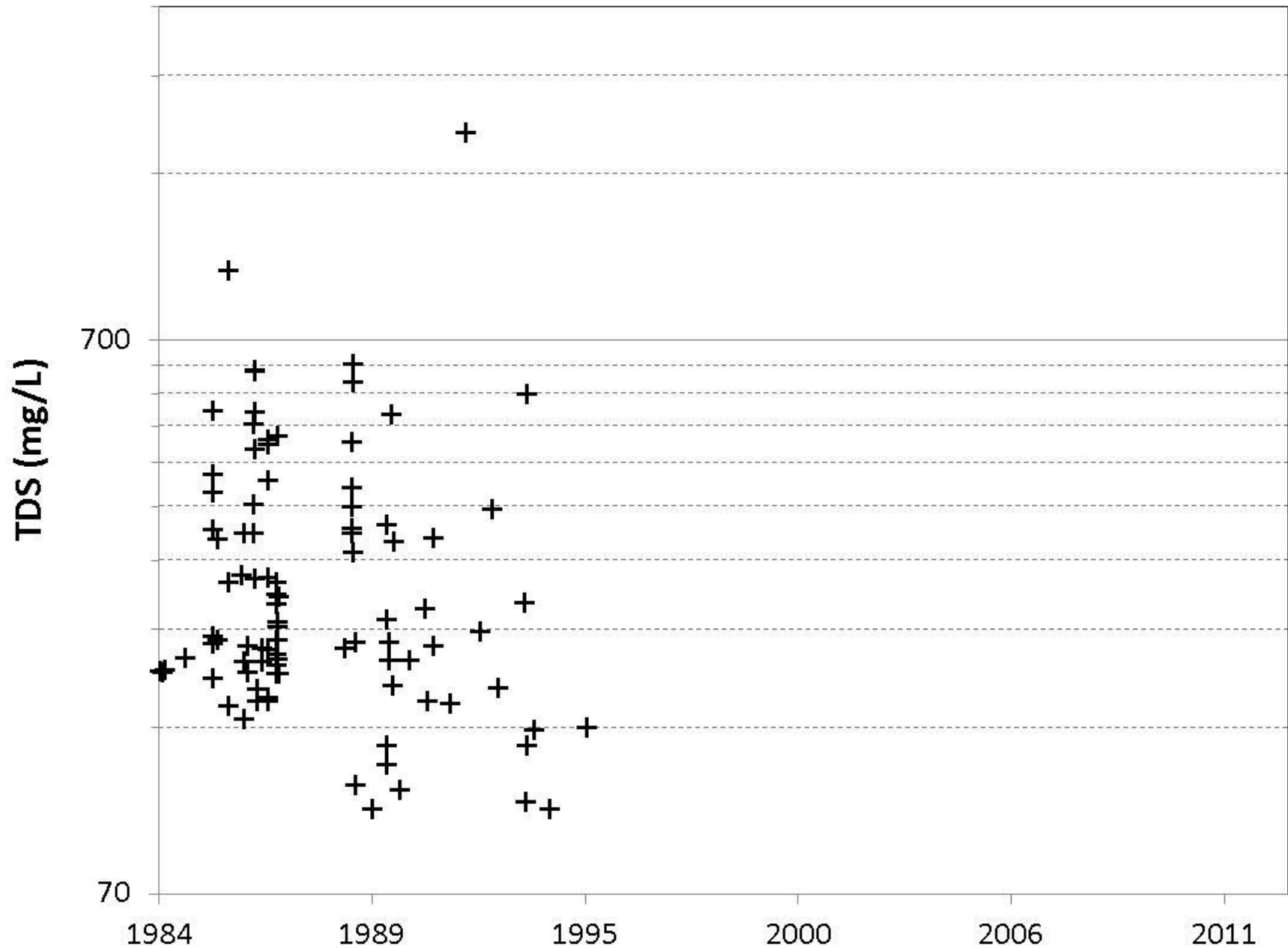


 Faults in basal Etchegoin sands from Hluza (1965)

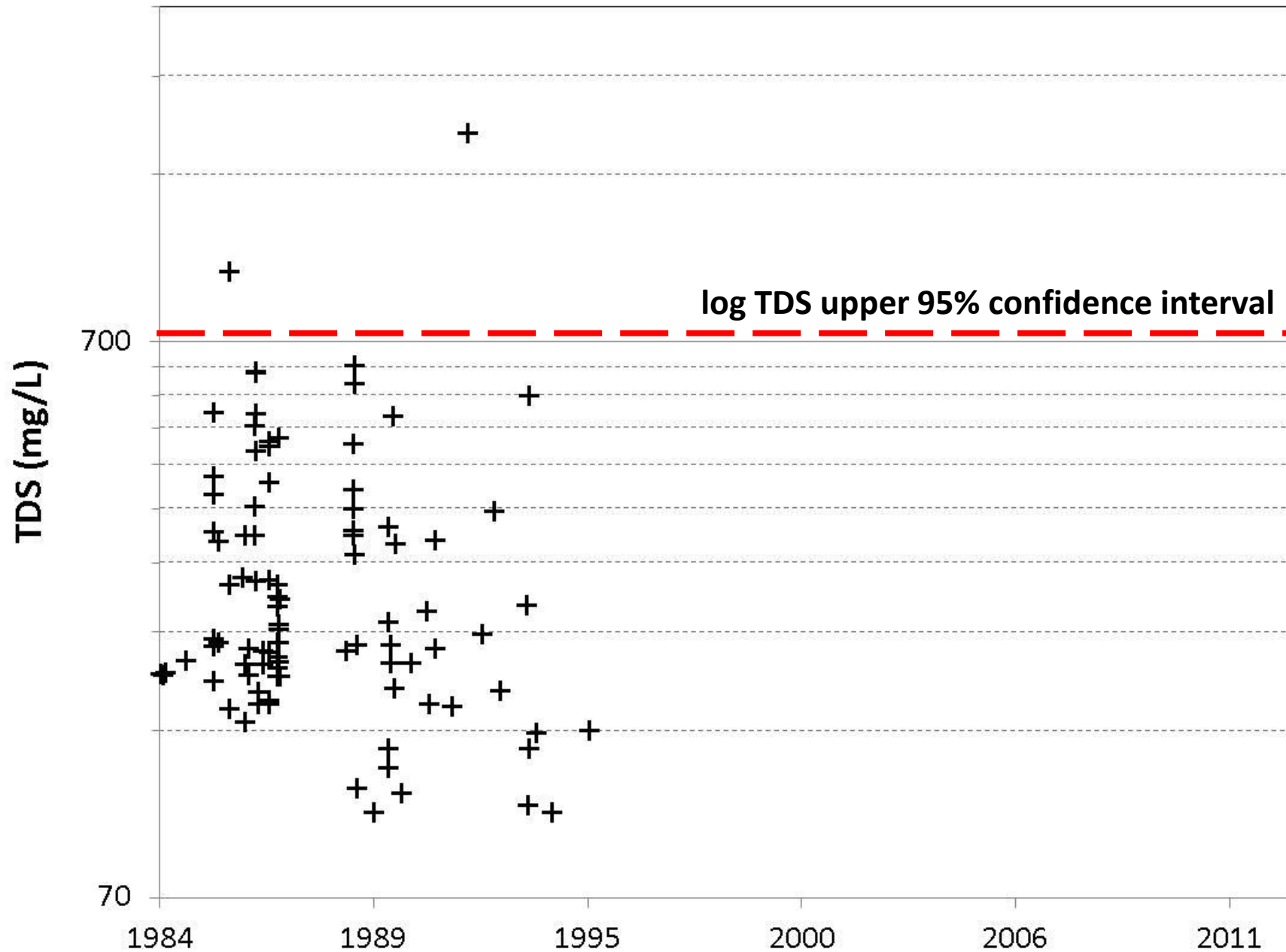
# Public Supply Wells With GAMA TDS Data



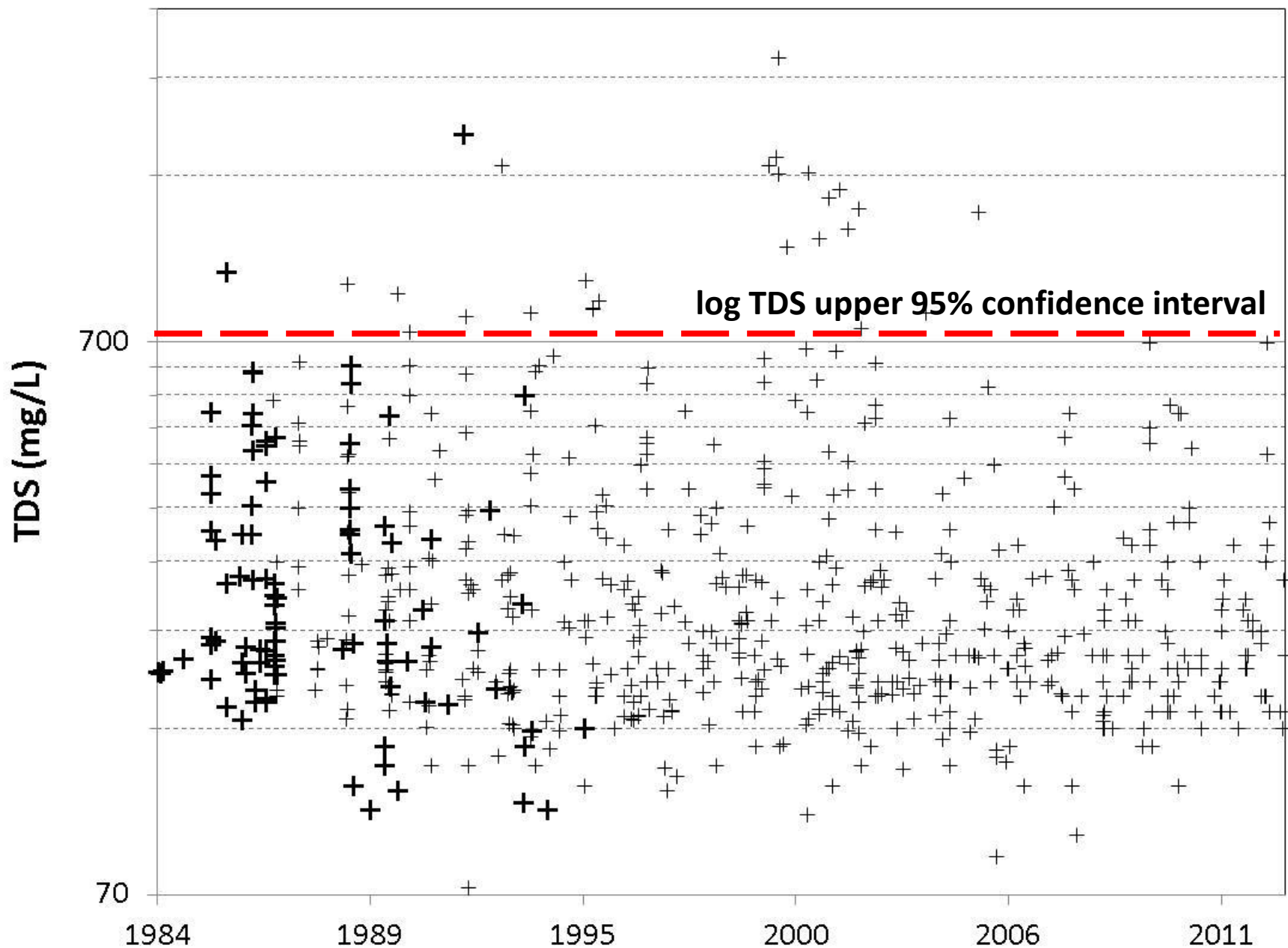
# First Result From Each Well



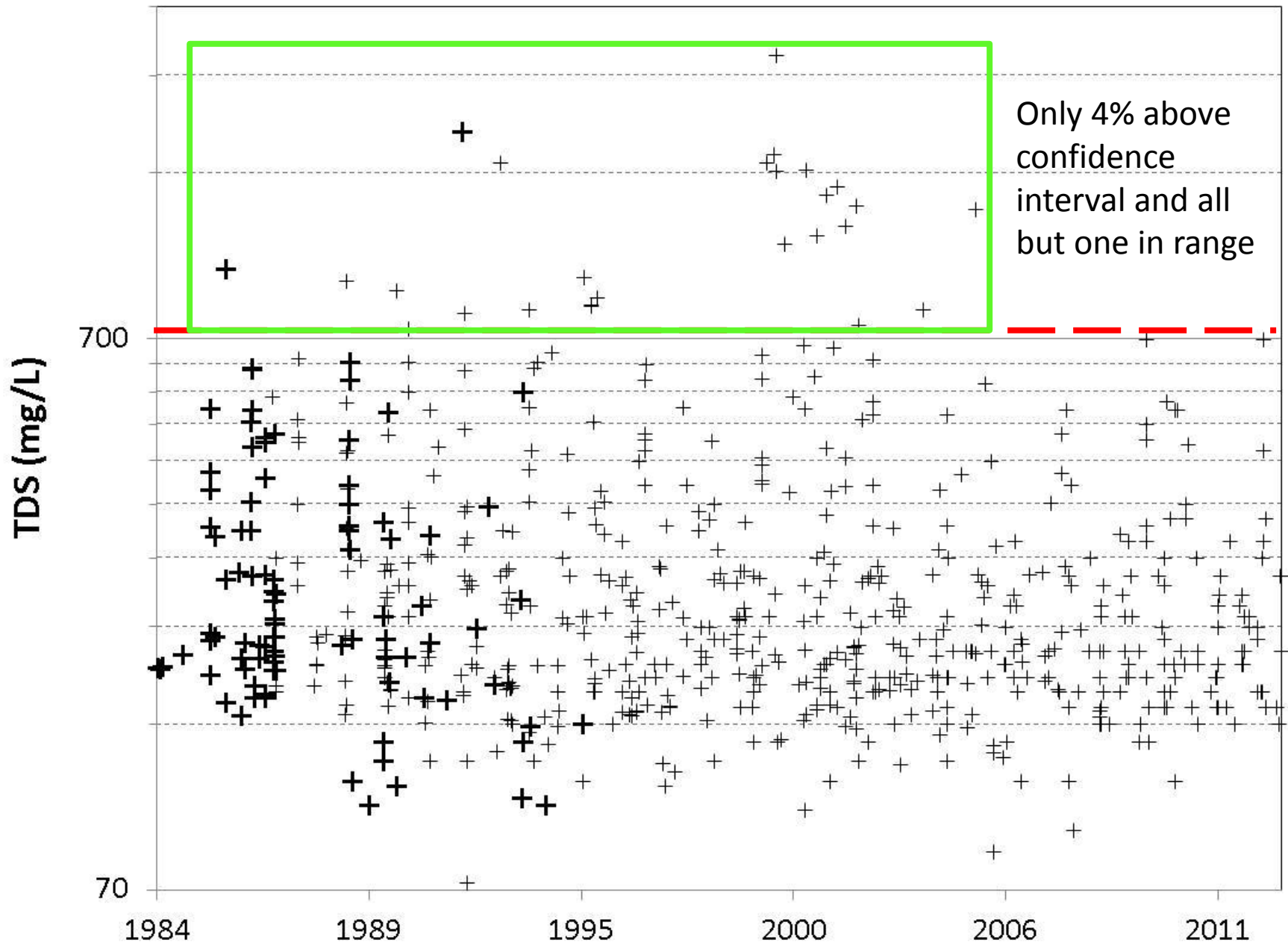
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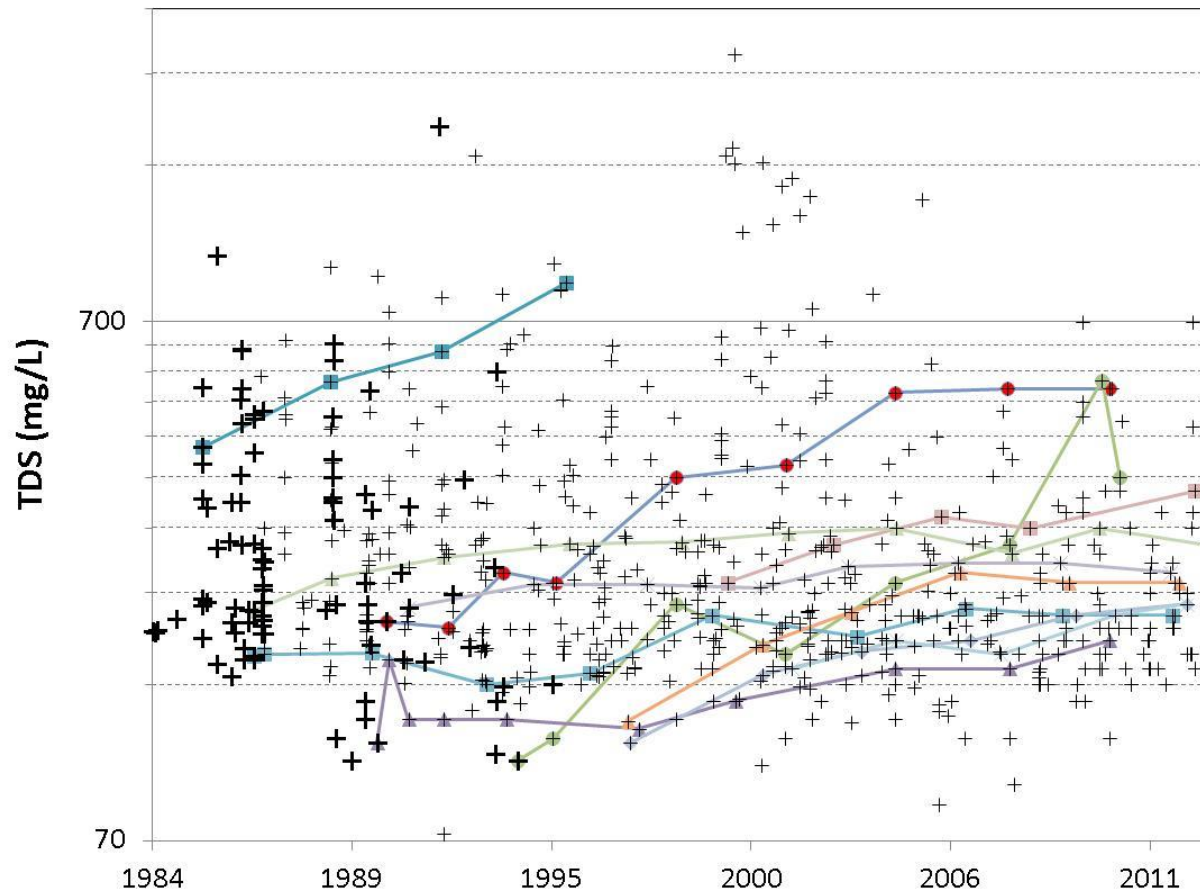
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# Increasing TDS By Mann-Kendall (95%)



- 11 out of 79 TDS series (14% of total wells) showed increasing TDS over time

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- $\text{NO}_3$  is substantially non detect for 2 of these 3, so they may or may not also be due to contamination from surface

# Conclusions

- Some produced water disposal operations in Kern County may be analogs for potential brine leakage due to carbon sequestration

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- No consequence of such leakage was noted in the Bakersfield Californian, despite extensive coverage of groundwater contamination
- No significant TDS increase was observed in water supply wells over the largest analog – Fruitvale Main

# Acknowledgments

The authors thank Simarjit Chehal, Gina Gonzales and John Wilson for assembling the annual production database and Michelle David for assembling injection data regarding Fruitvale Main. The California Energy Commission's Public Interest Energy Research Program (PIER) and the Department of Energy's National Risk Assessment Partnership (NRAP) and various internship programs kindly provided support for this work.

