Salinity in the Northern Segment of the Brazos River Alluvium Aquifer: A Hydro-Forensic Approach

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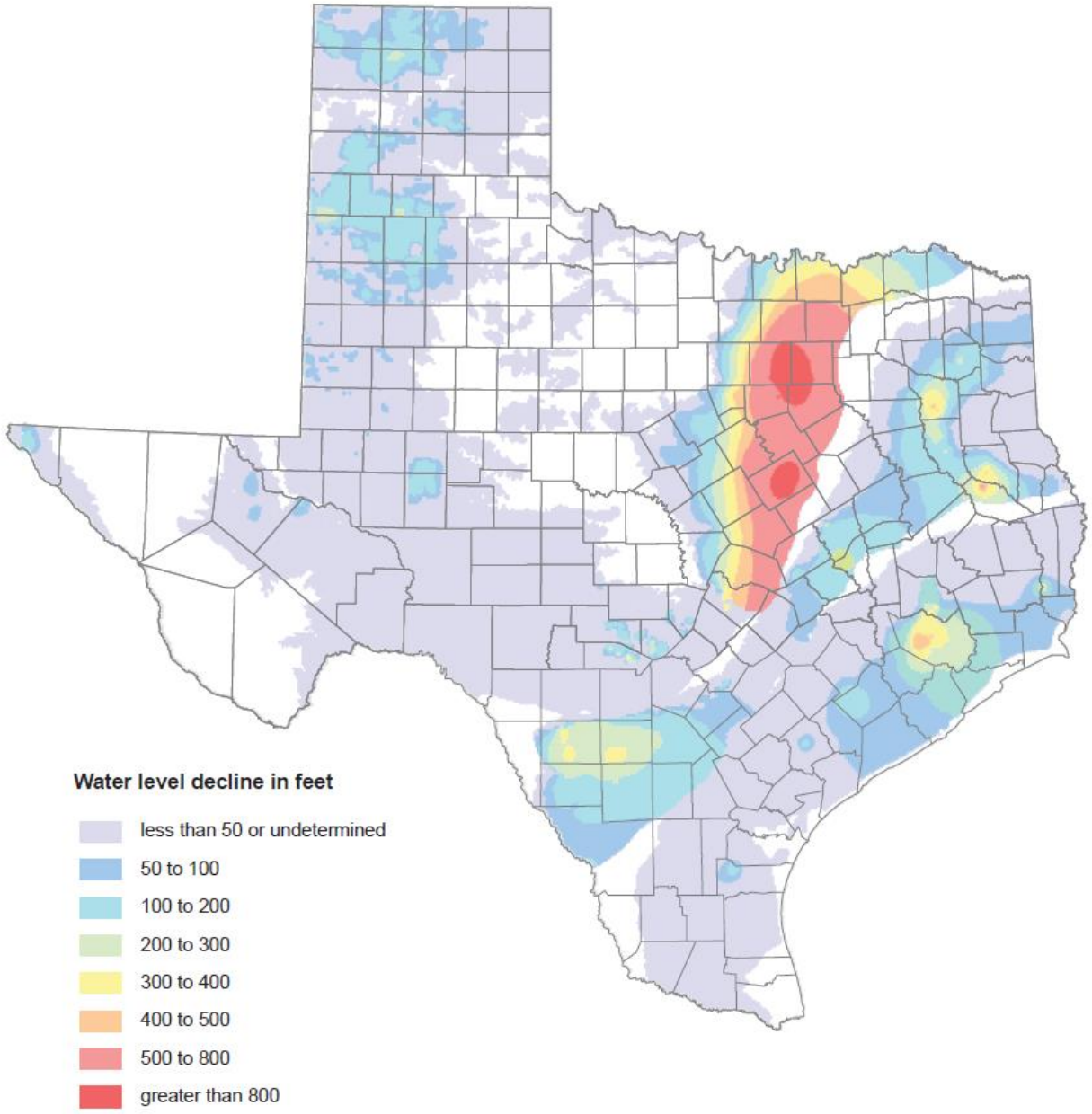
Introduction

- Growth along I-35 corridor has strained regions water resources
- Brazos River Alluvium aquifer (BRAA) is an underutilized minor aquifer
- Salinity varies throughout BRAA
- Effective aquifer management requires a better understanding of salinity sources and variability



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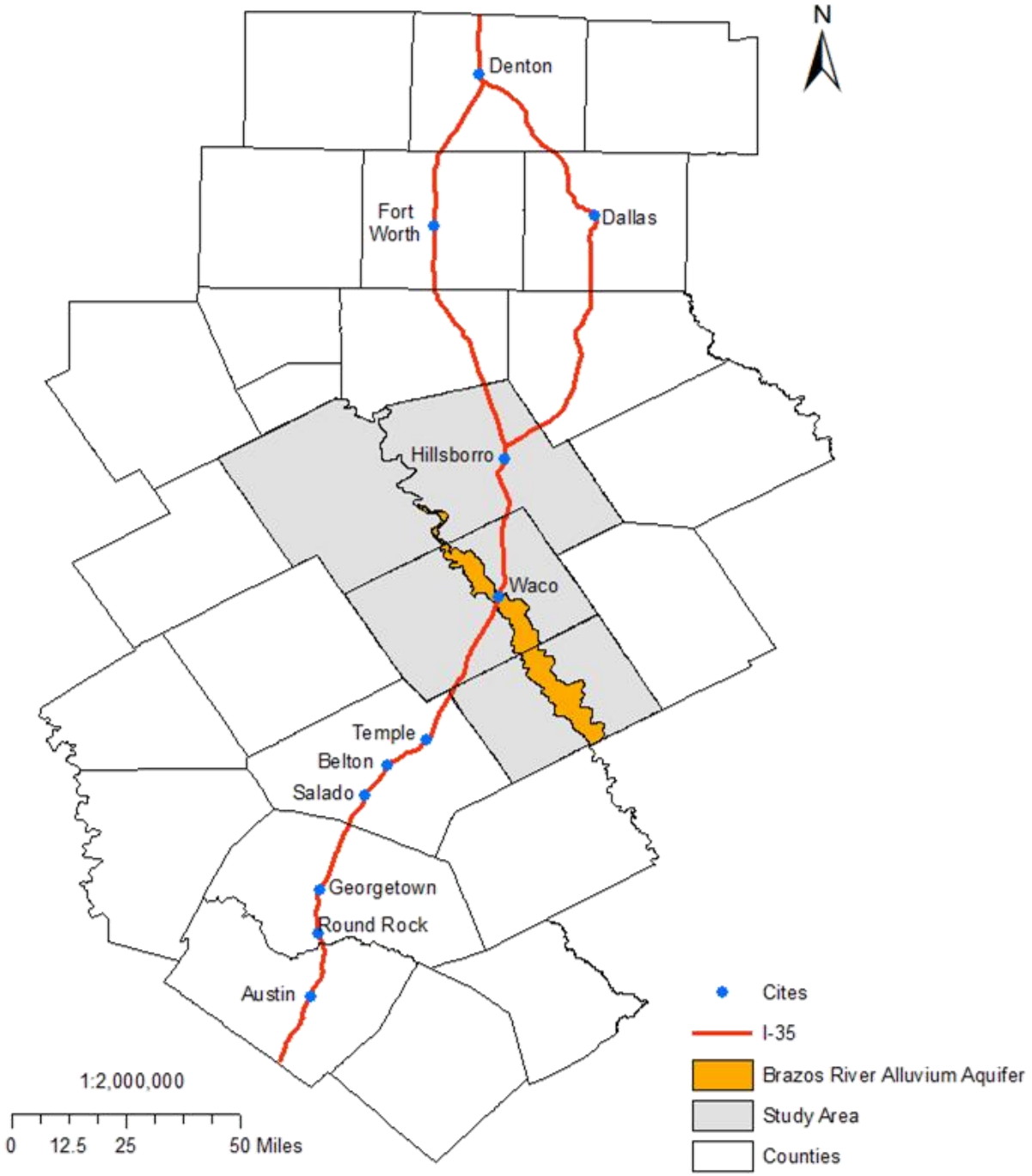
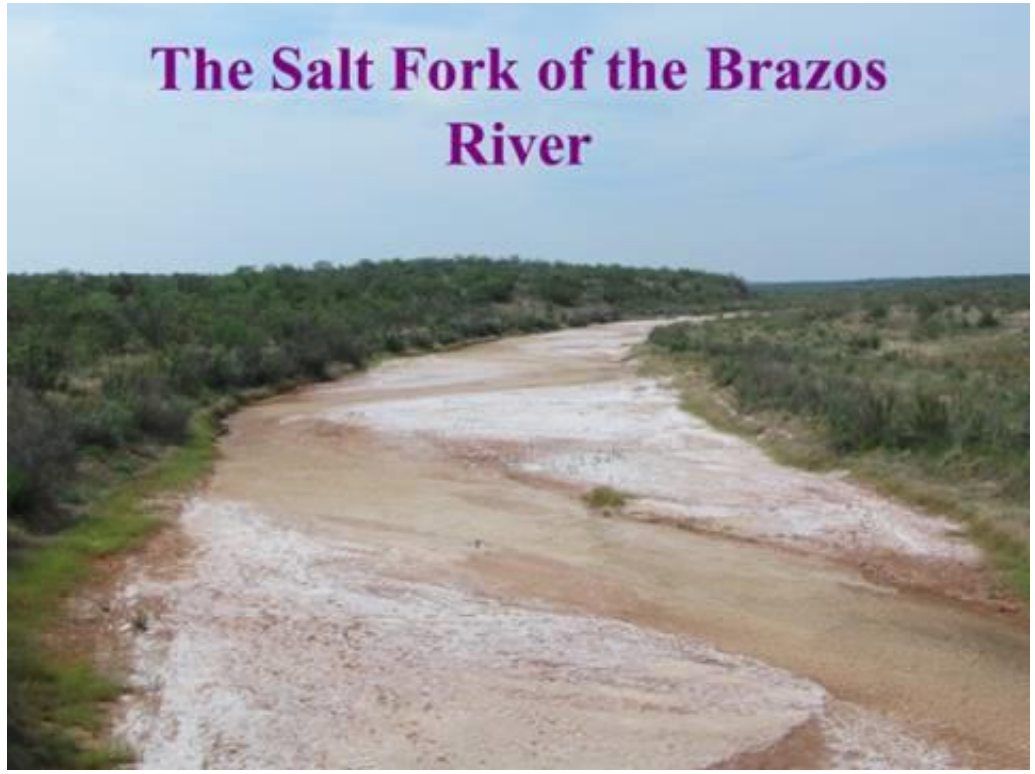


Objective

- Characterize the variability of salinity in the northern segment of the BRAA and evaluate potential sources of salinity

Hypotheses

1. Groundwater – surface water interactions between aquifer and Brazos River
2. Irrigation and evapotranspiration
3. Brine contamination from historic oil and gas fields



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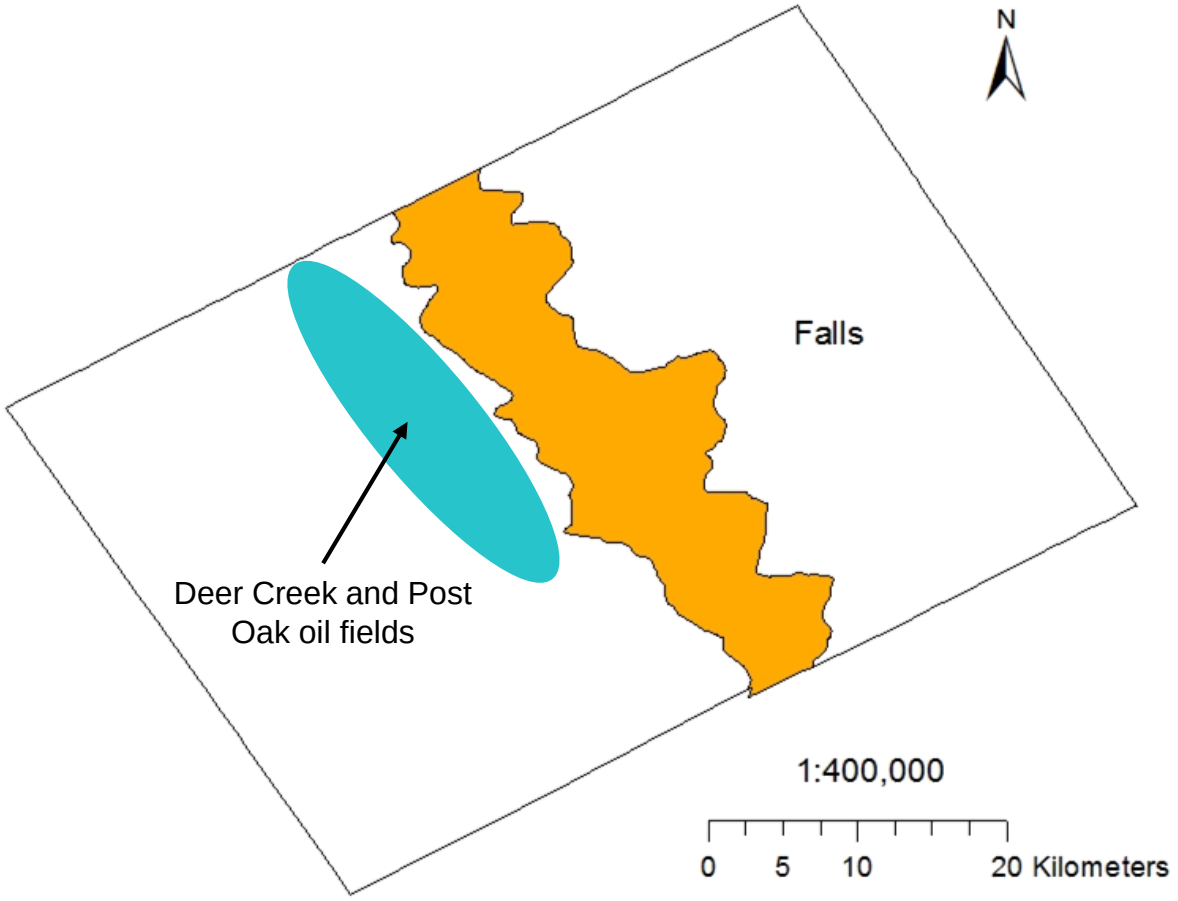
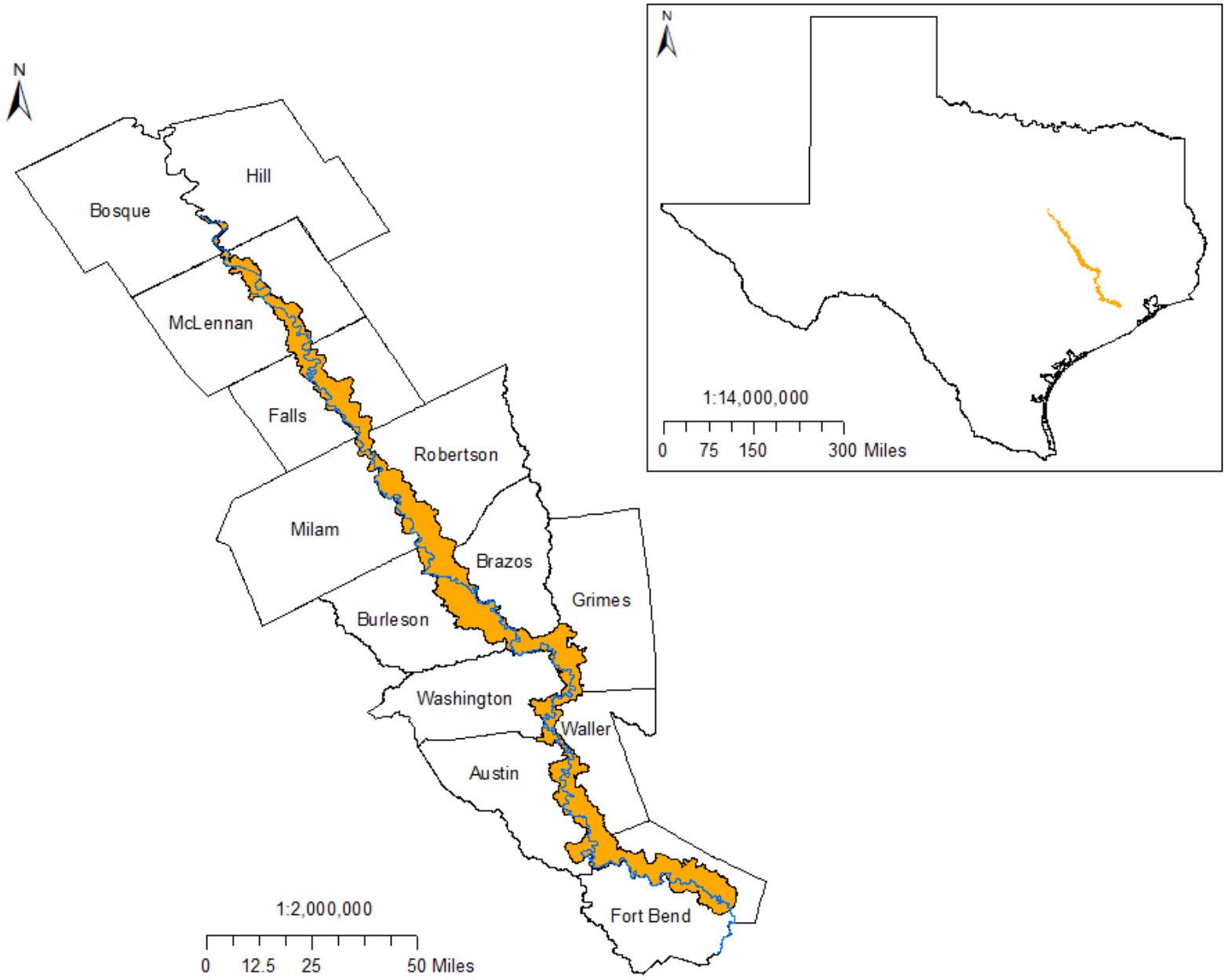


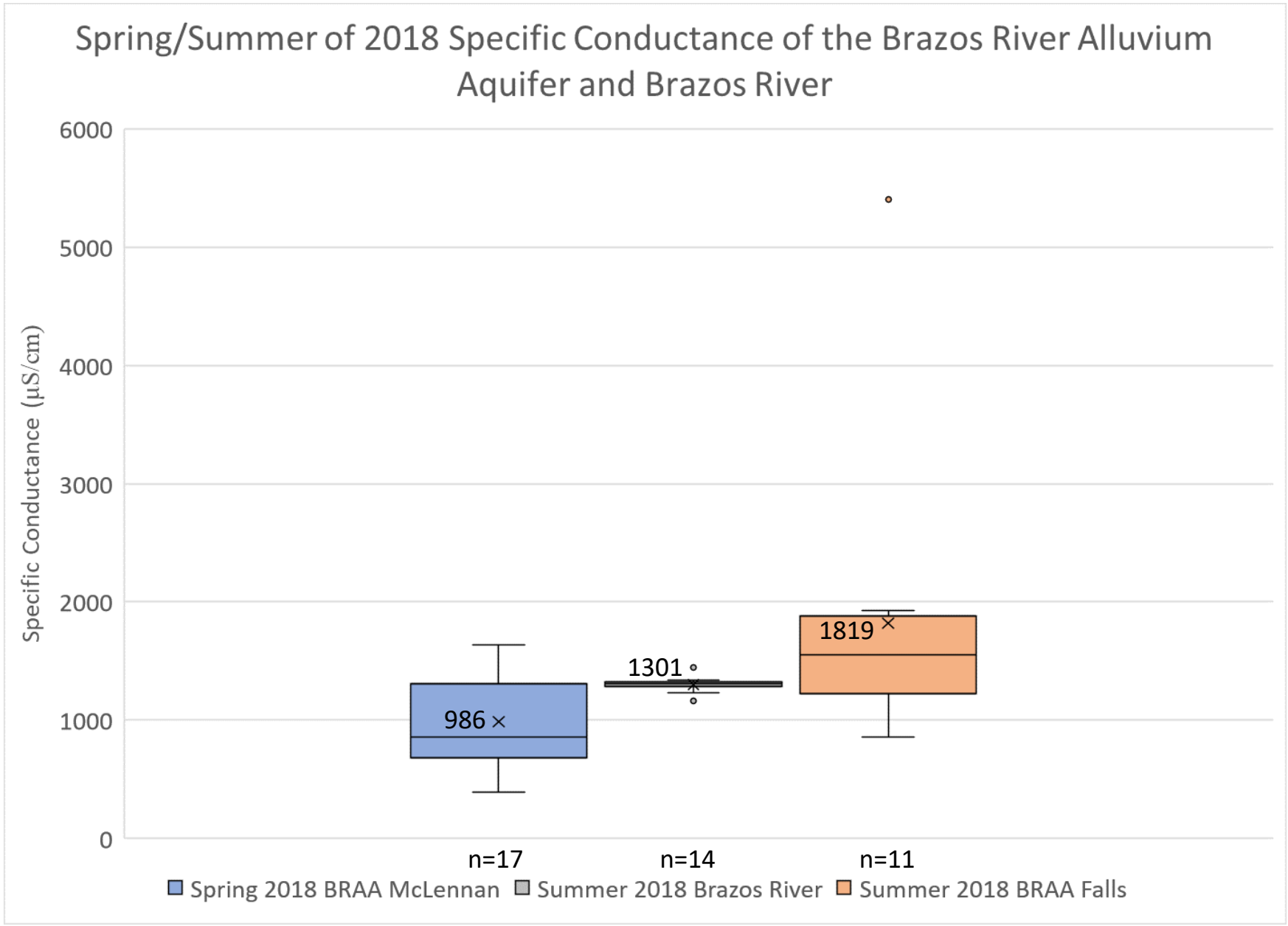
Hydrogeologic Setting

- Primarily used for irrigation
- Heterogeneous but typically exhibits fining upward sequence
- Recharged by precipitation and discharges at Brazos River
- Elevated salinity levels documented as early as 1967 by Cronin and Wilson



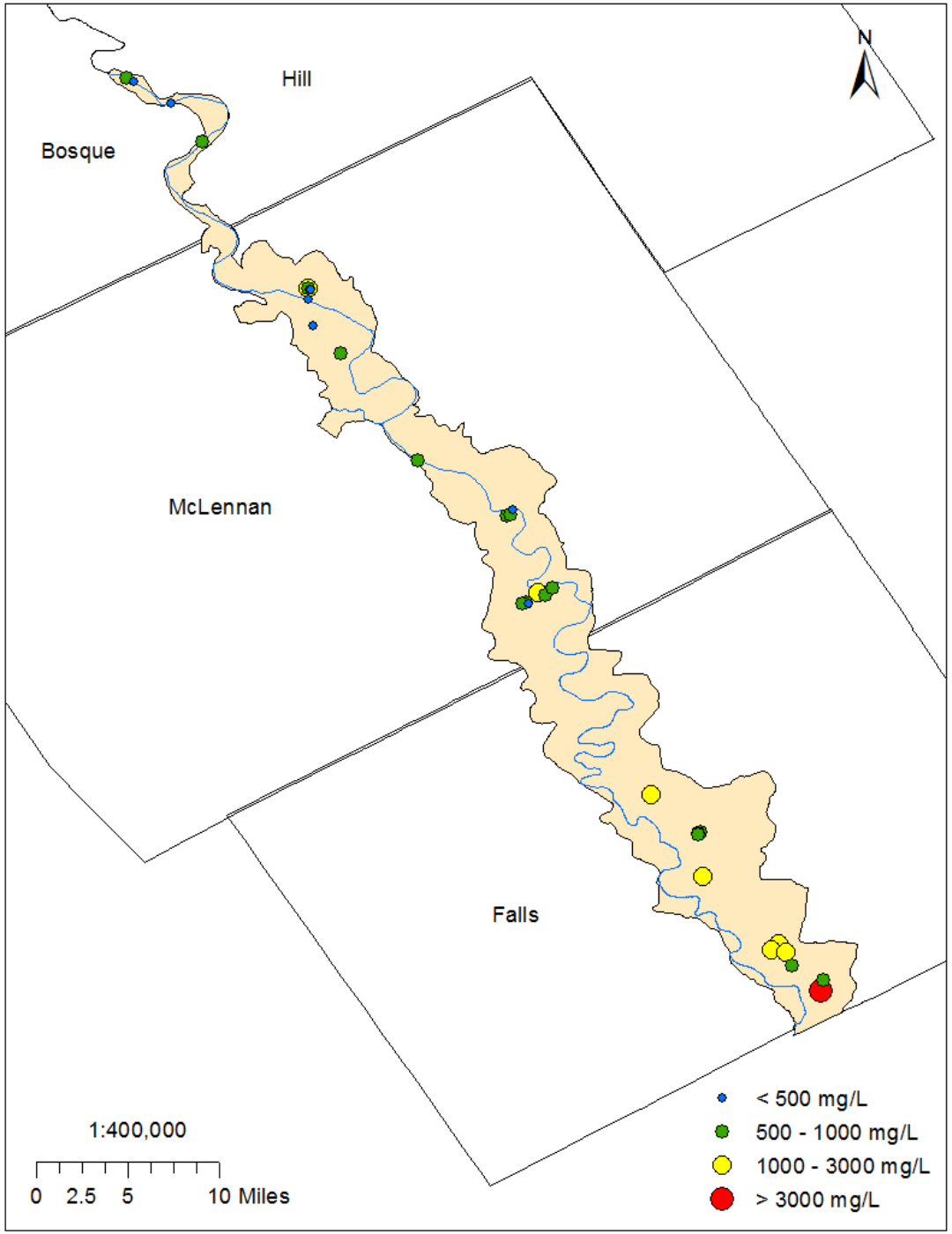
Methods

1. Analysis of historical BRAA and Brazos River chemistry data
2. BRAA and Brazos River water sampling: Specific conductance, temperature, major cations and anions, and ratios of hydrogen and oxygen isotopes
3. Coring and in-situ water sampling at three sites
4. Installation of data loggers to monitor changes in water level over time


Spring/Summer of 2018 Specific Conductance of the Brazos River Alluvium Aquifer and Brazos River
Specific Conductance (µS/cm)
6000
5000
4000
3000
2000
1000
0
986
1301
1819
n=17
n=14
n=11
Spring 2018 BRAA McLennan
Summer 2018 Brazos River
Summer 2018 BRAA Falls

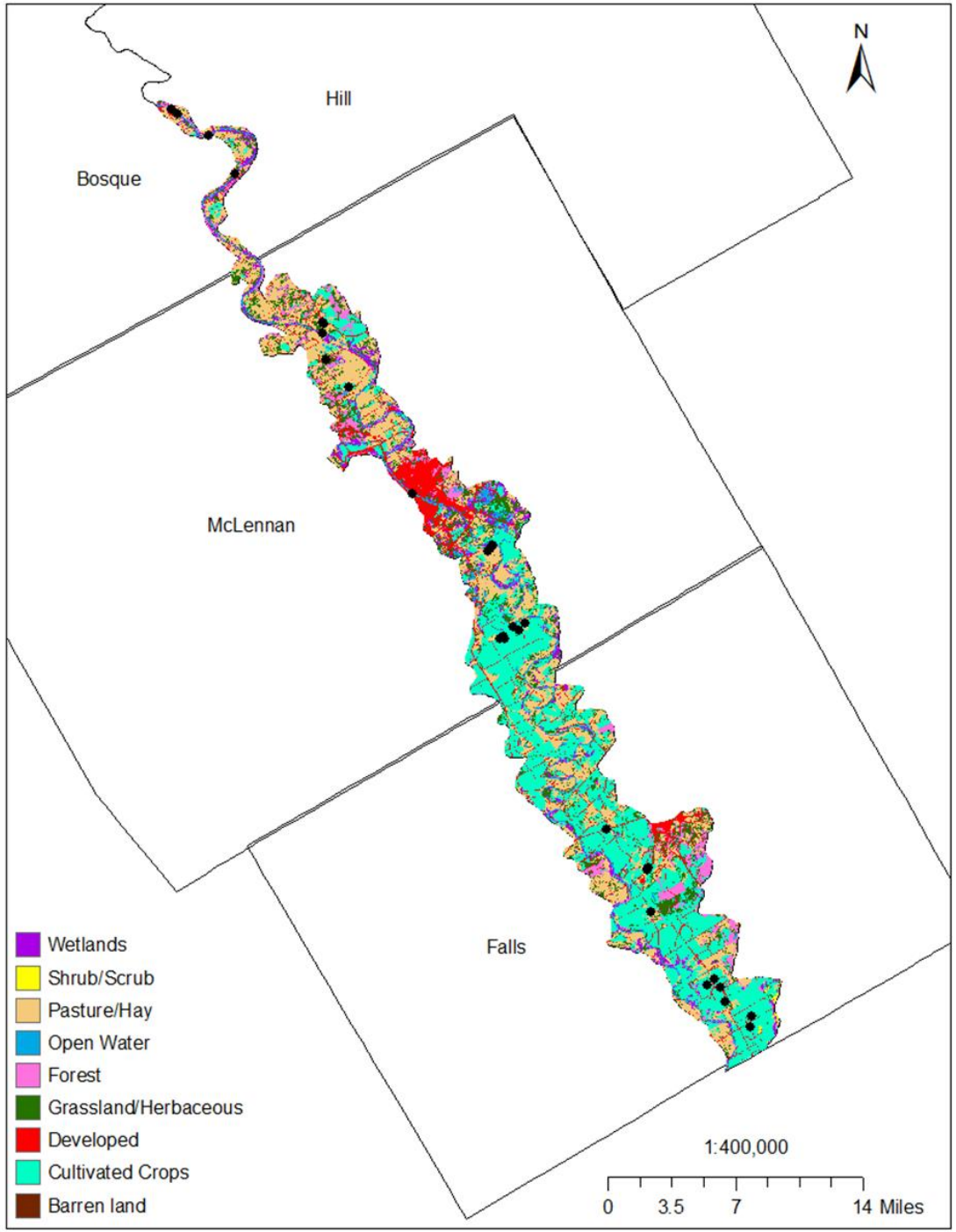
TDS of the Brazos River Alluvium Aquifer

- 32 total samples
- High degree of variability in salinity
- TDS can double over the course of a few hundred yards
- Brine contamination from oil fields not likely cause of high TDS in Falls County



Land Cover

- 2011 USGS land cover map
- Falls County has a significantly higher proportion of land used for cultivated crops than McLennan County
- McLennan County has a much higher population than Falls County
- Cultivated crops can be either irrigated or non-irrigated
- Historically, Falls County has significantly more irrigation than McLennan County



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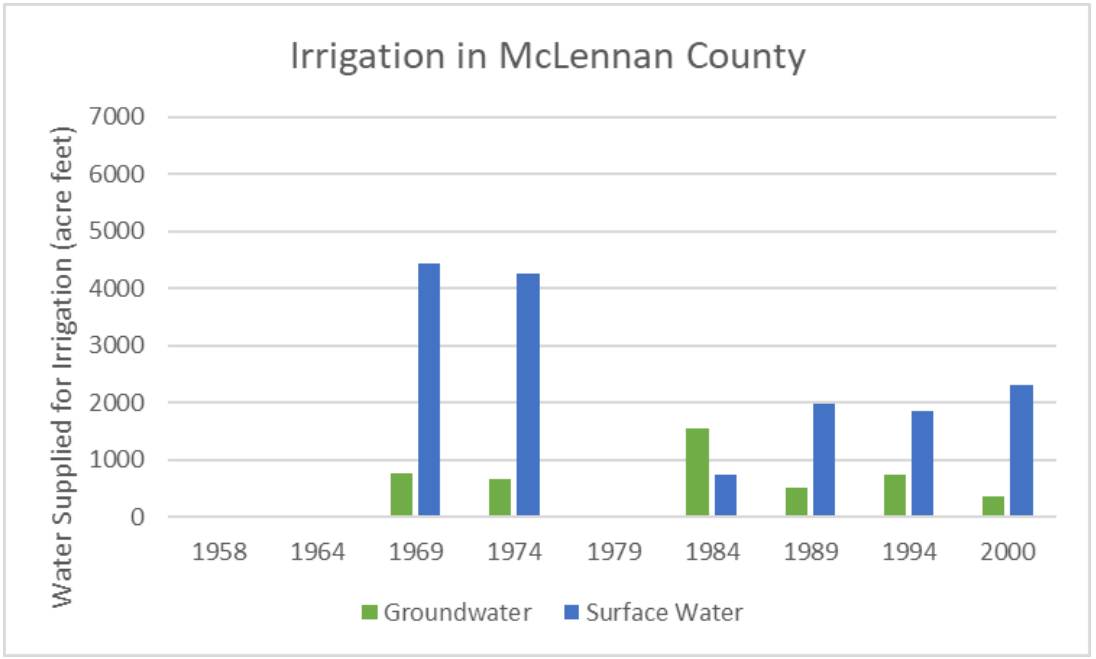
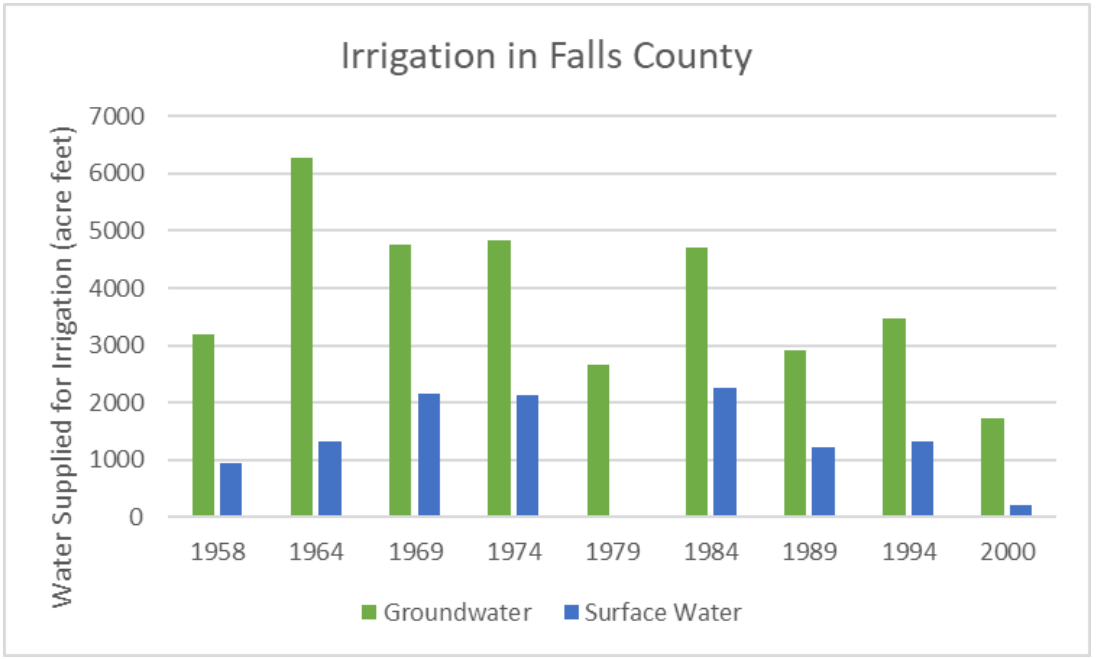
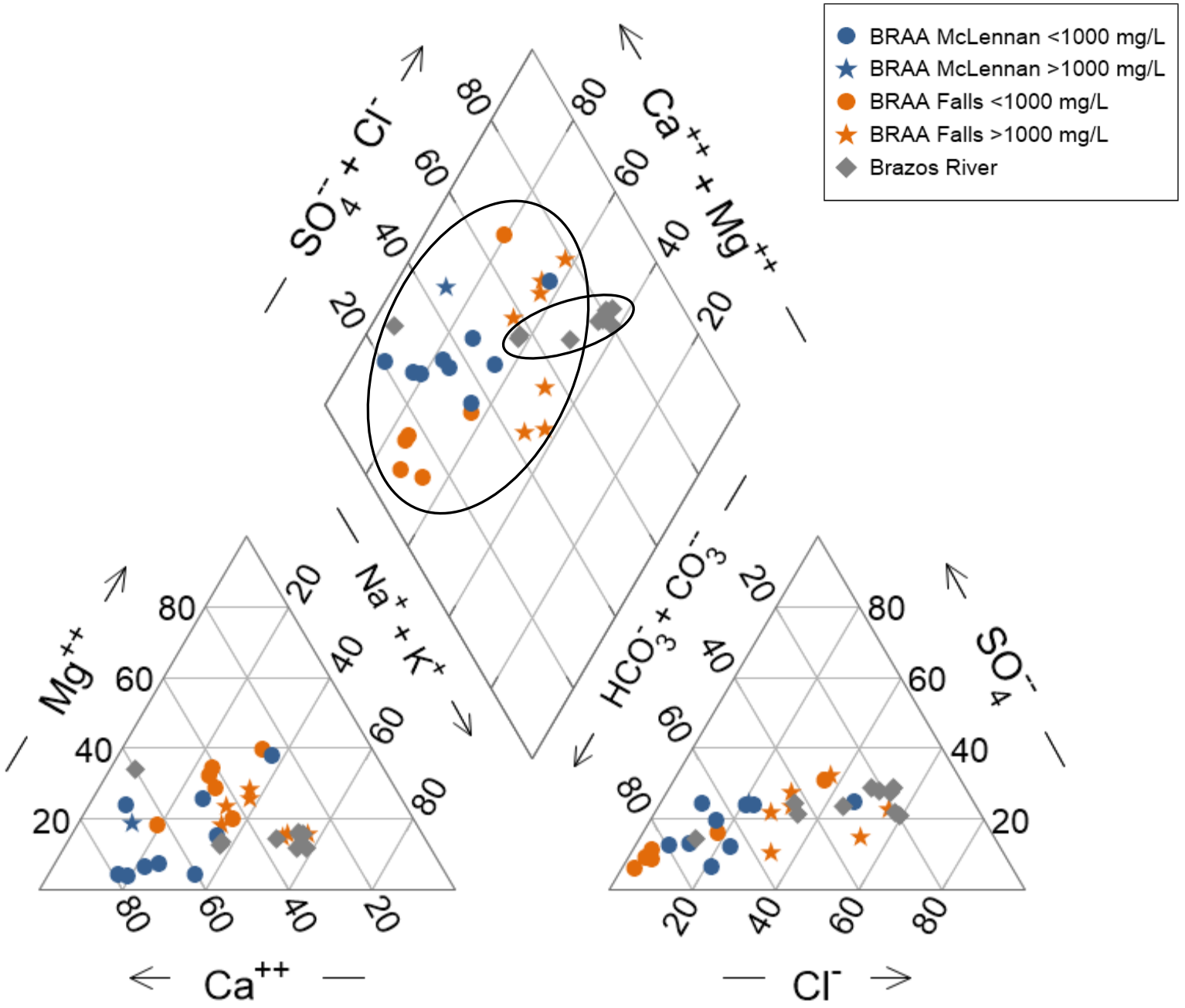
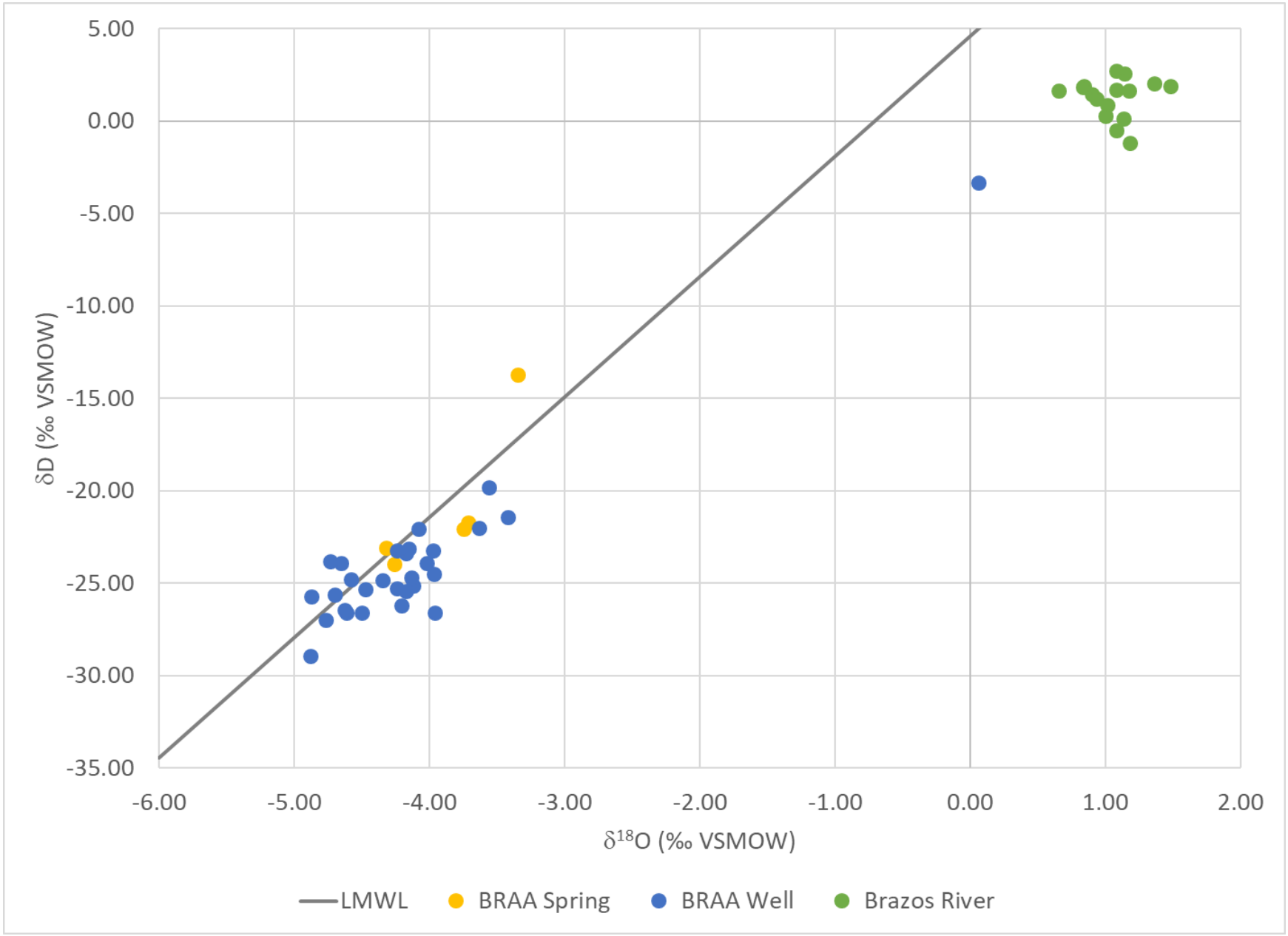




Piper Diagram

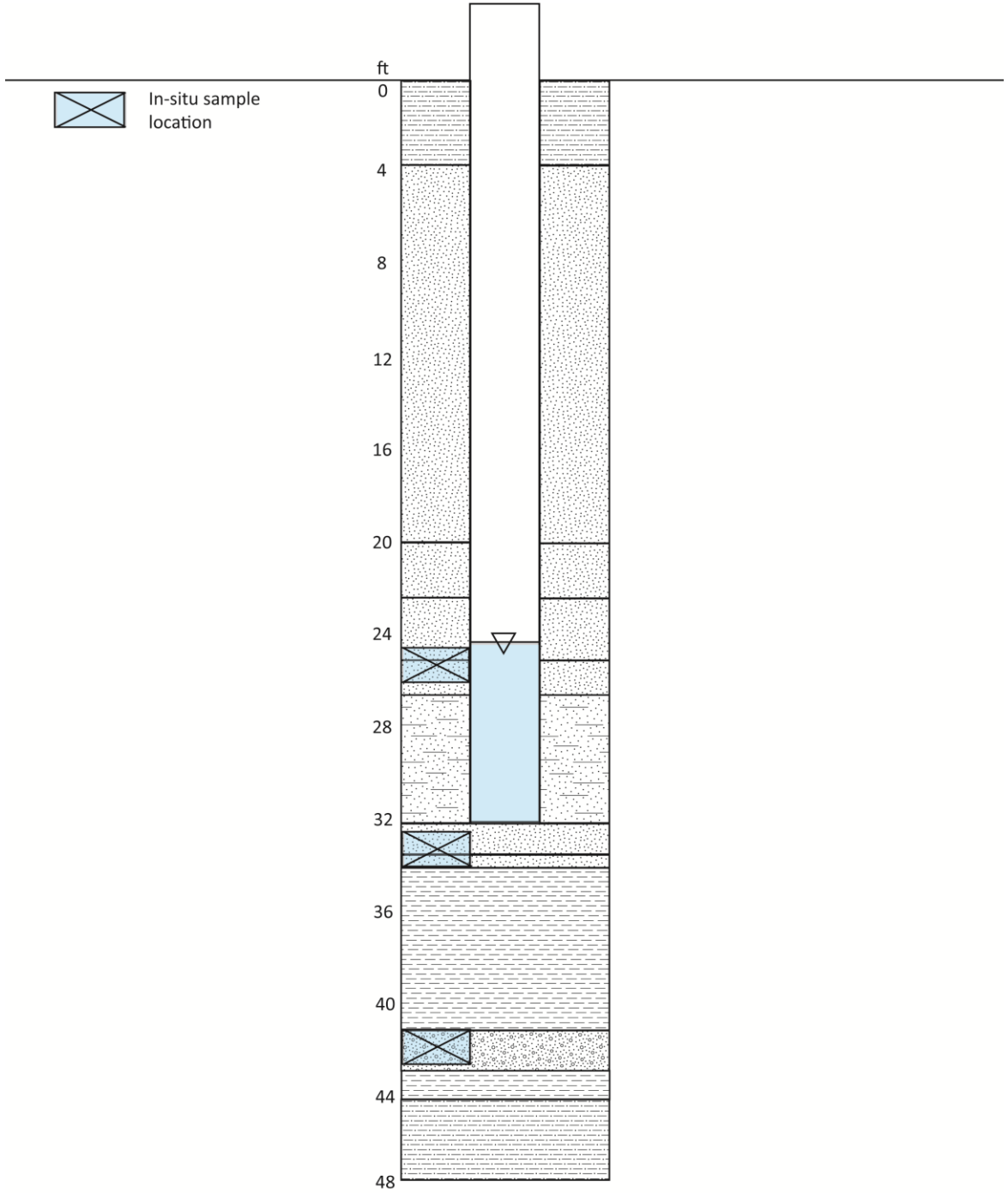
- Brazos River: Sodium chloride type water
- BRAA McLennan County: Calcium bicarbonate type water
- BRAA Falls County: Mixed bicarbonate to mixed cation and anion type water
- Aquifer and river tend to have distinct chemistries




5.00
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
-30.00
-35.00
δD (‰ VSMOW)
-6.00
-5.00
-4.00
-3.00
-2.00
-1.00
0.00
1.00
2.00
δ18O (‰ VSMOW)
LMWL
BRAA Spring
BRAA Well
Brazos River

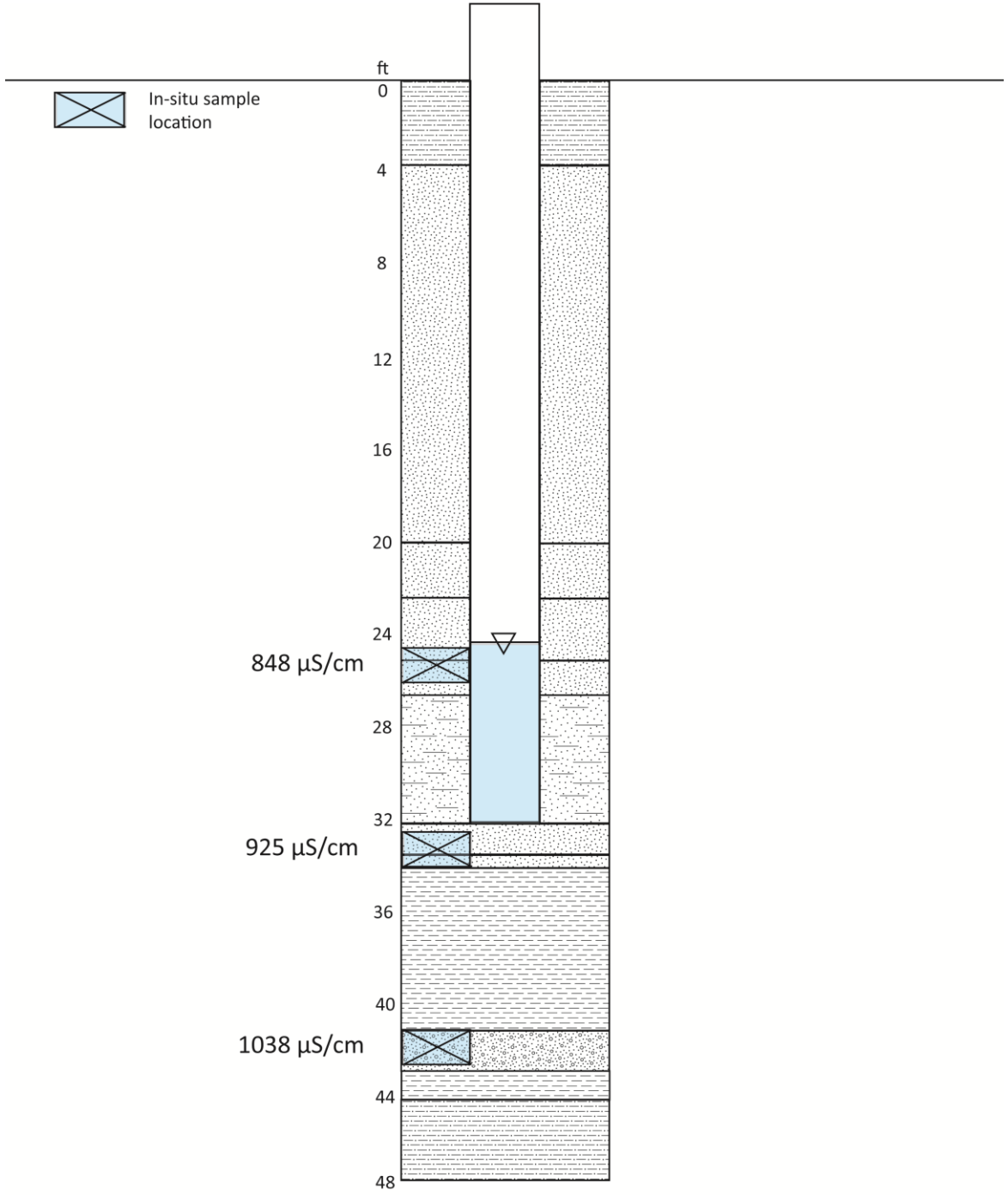
Coring and In-situ Water Sampling

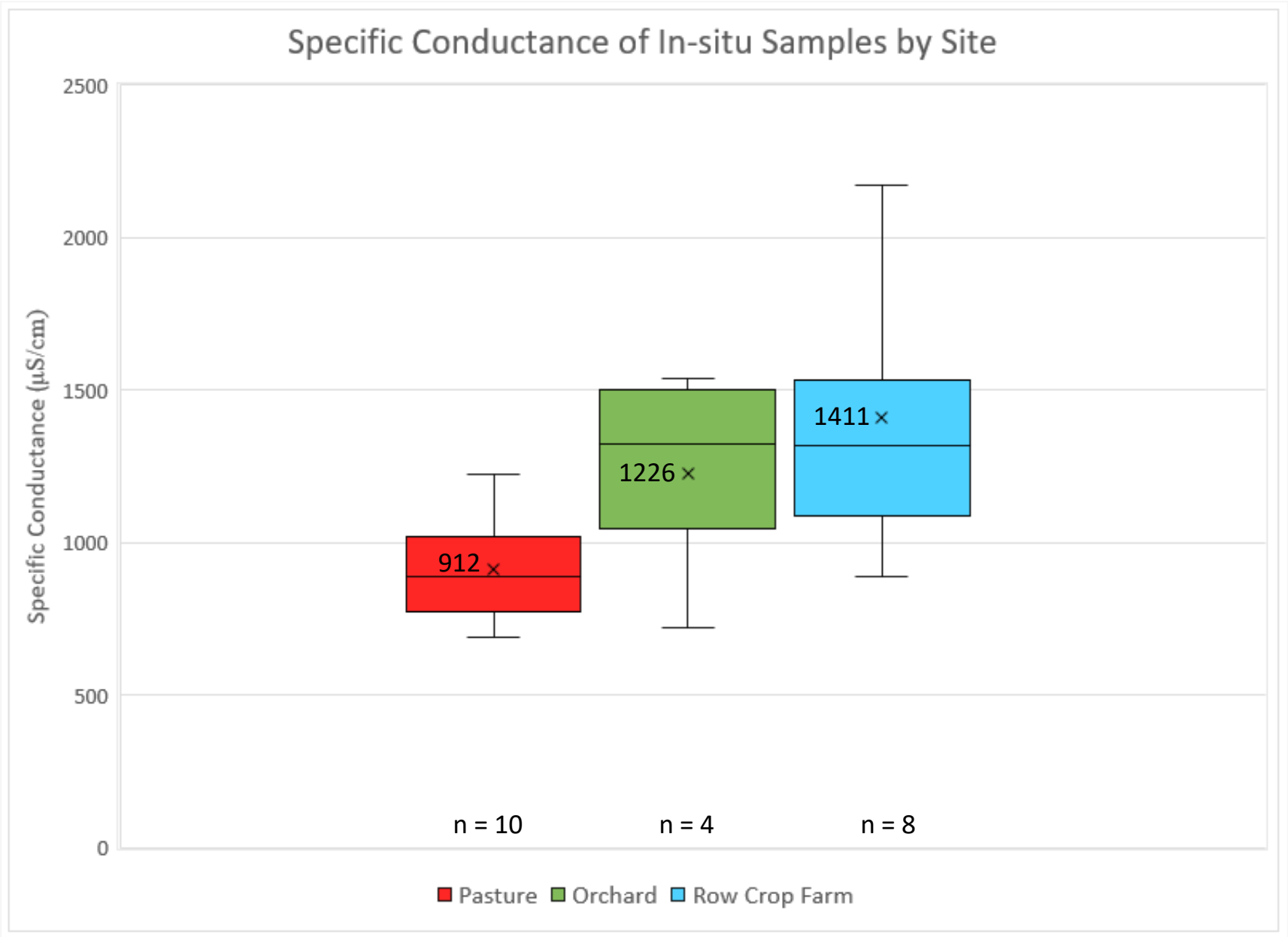
- Three sites: Non-irrigated pasture, irrigated orchard, and irrigated row-crop farm
- Core and in-situ water samples collected next to 3-4 wells at each site
- In-situ water samples collected using 1.5-foot screened interval
- Composite well sample also collected



Coring and In-situ Water Sampling

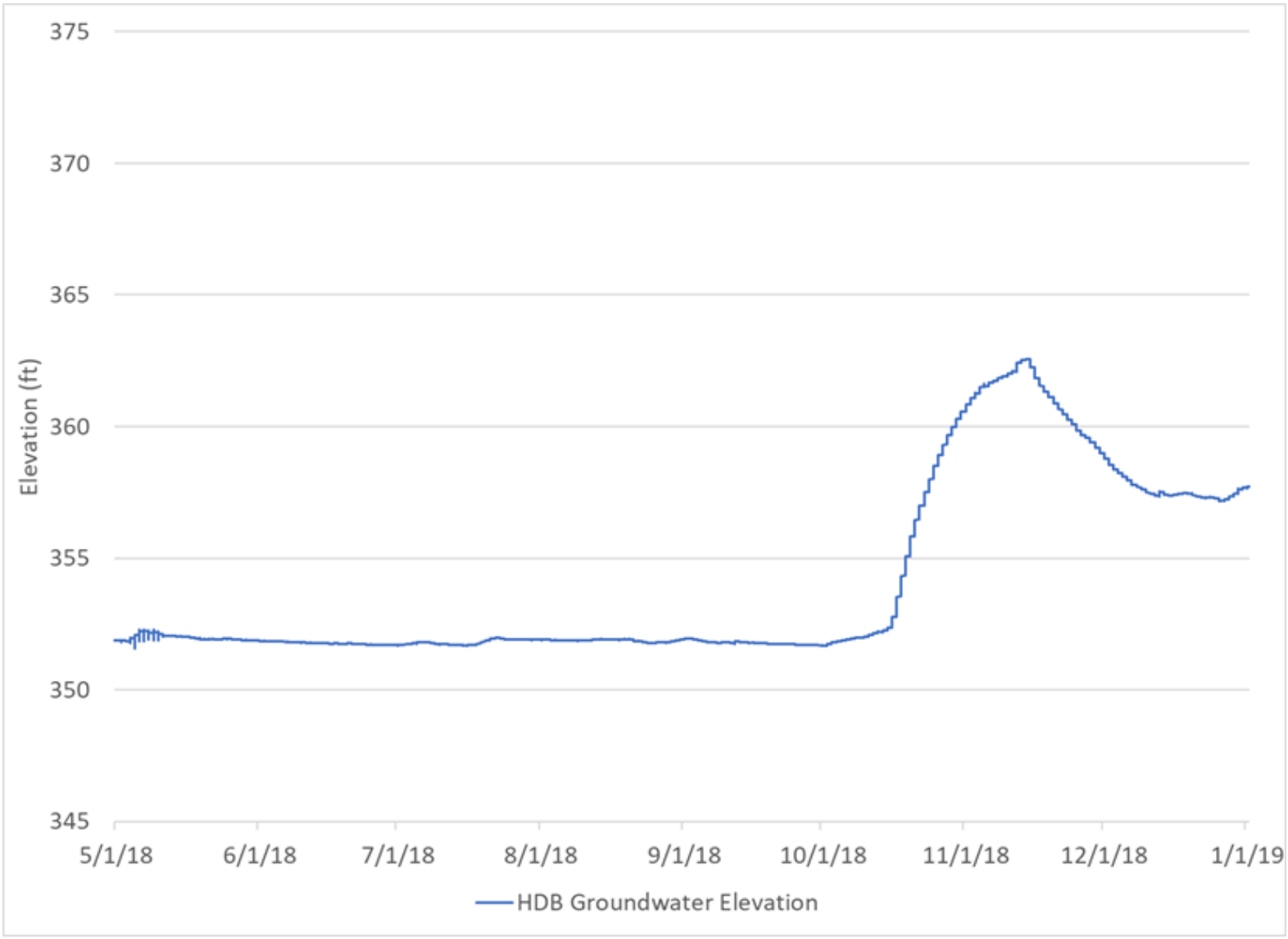
- In-situ water sampling showed some stratification present in aquifer
- However, specific conductance was found to both increase and decrease with depth, and is some cases was constant depending on the location




Specific Conductance of In-situ Samples by Site
Specific Conductance (µS/cm)
2500
2000
1500
1000
500
0
912
1226
1411
n = 10
n = 4
n = 8
Pasture
Orchard
Row Crop Farm

Groundwater / Surface Water Interactions between BRAA and Brazos River

- To create 10.78 foot rise in water level (assuming a porosity of 25%) would need 32.34 inches of recharge
- Area only received 15.24 inches of precipitation
- River stage rose 20.75 feet



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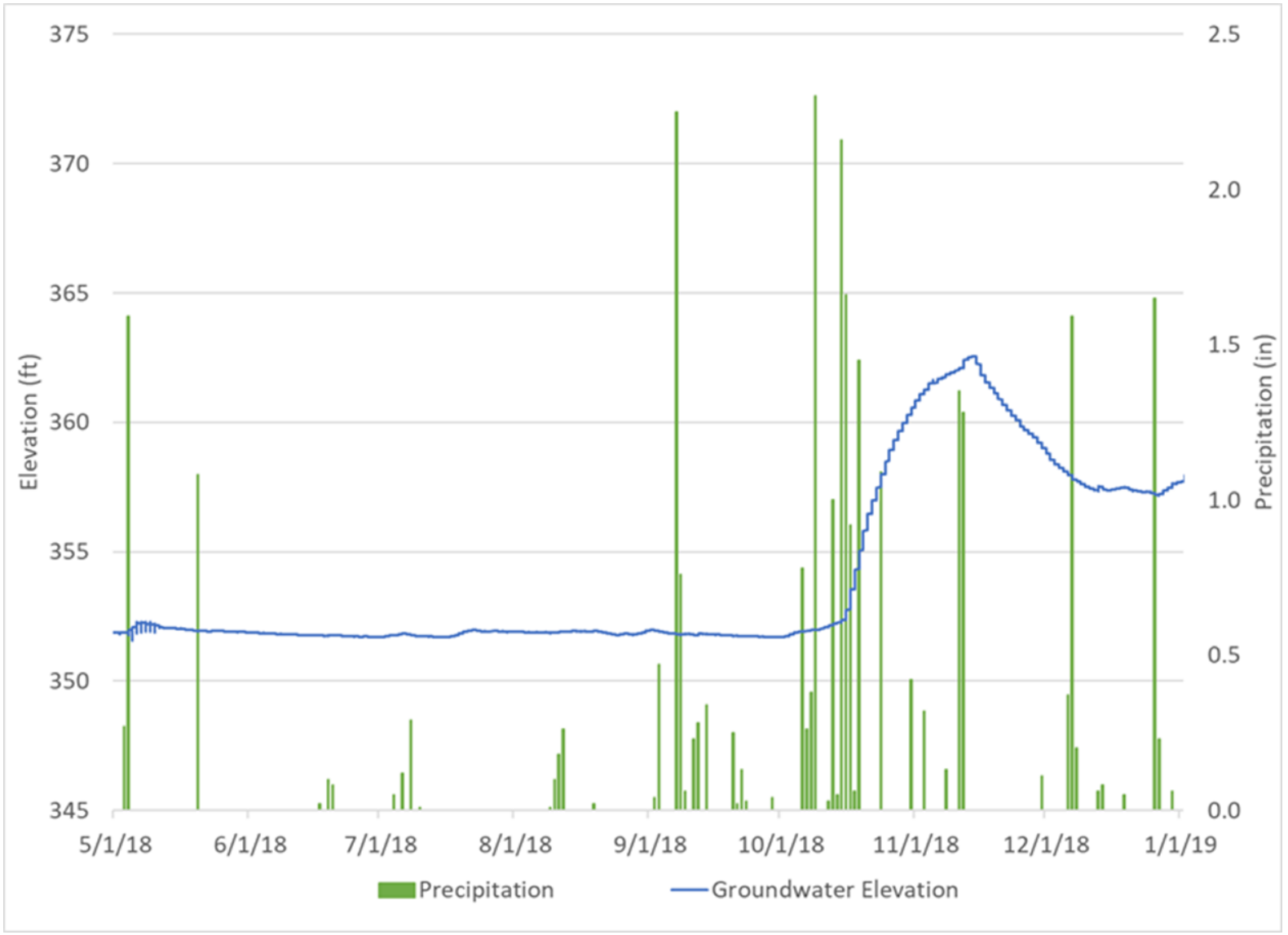

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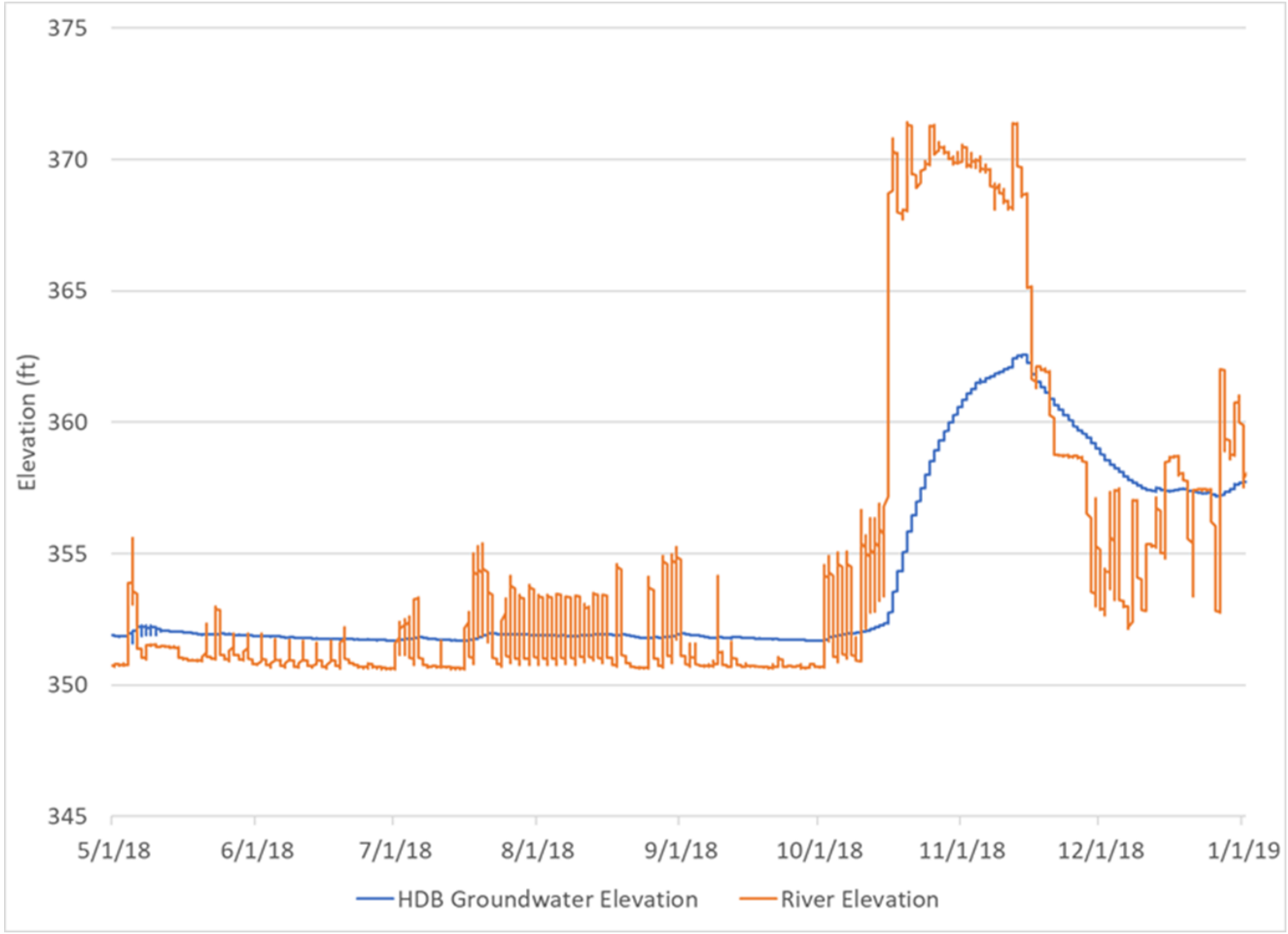
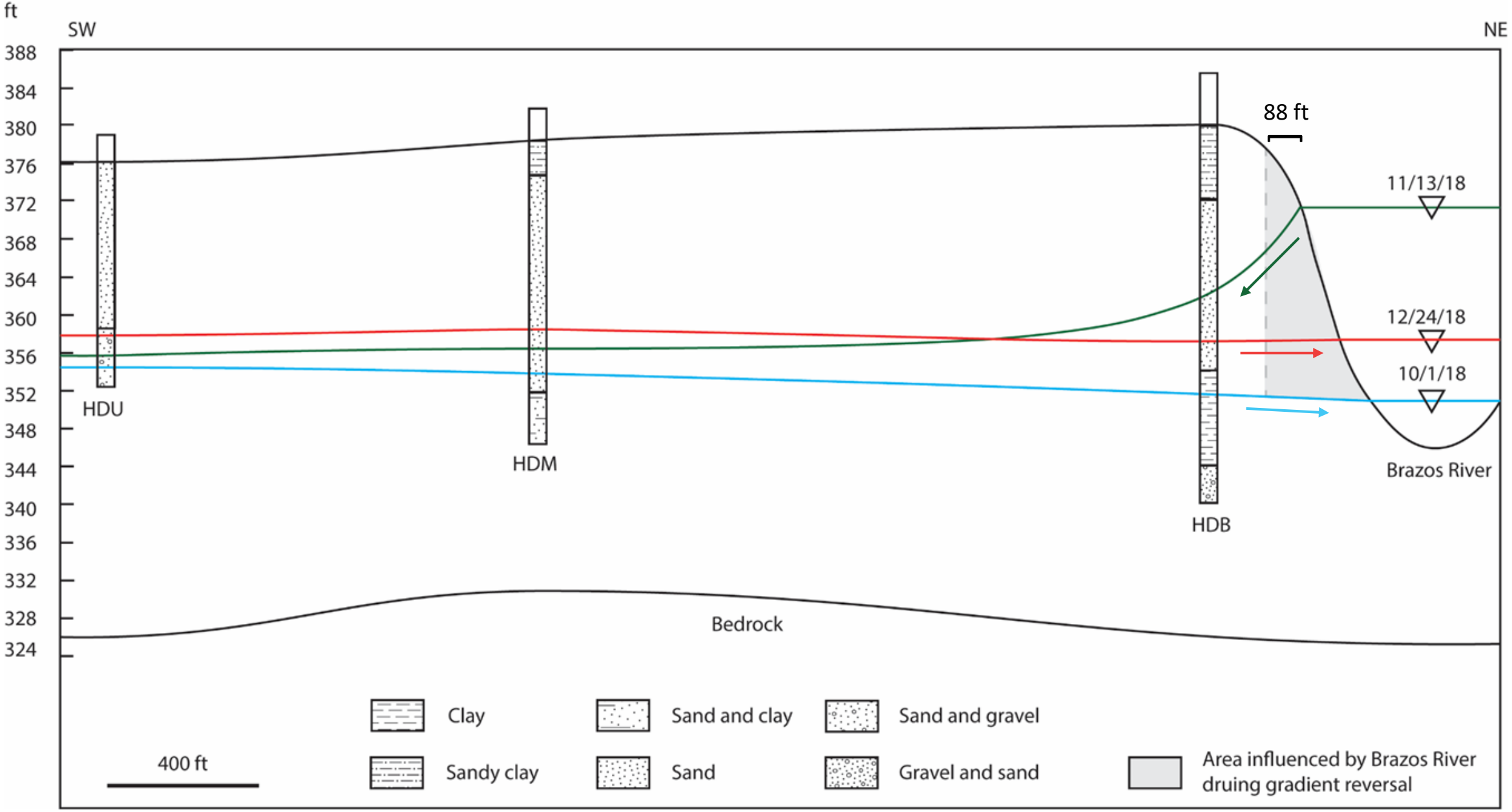
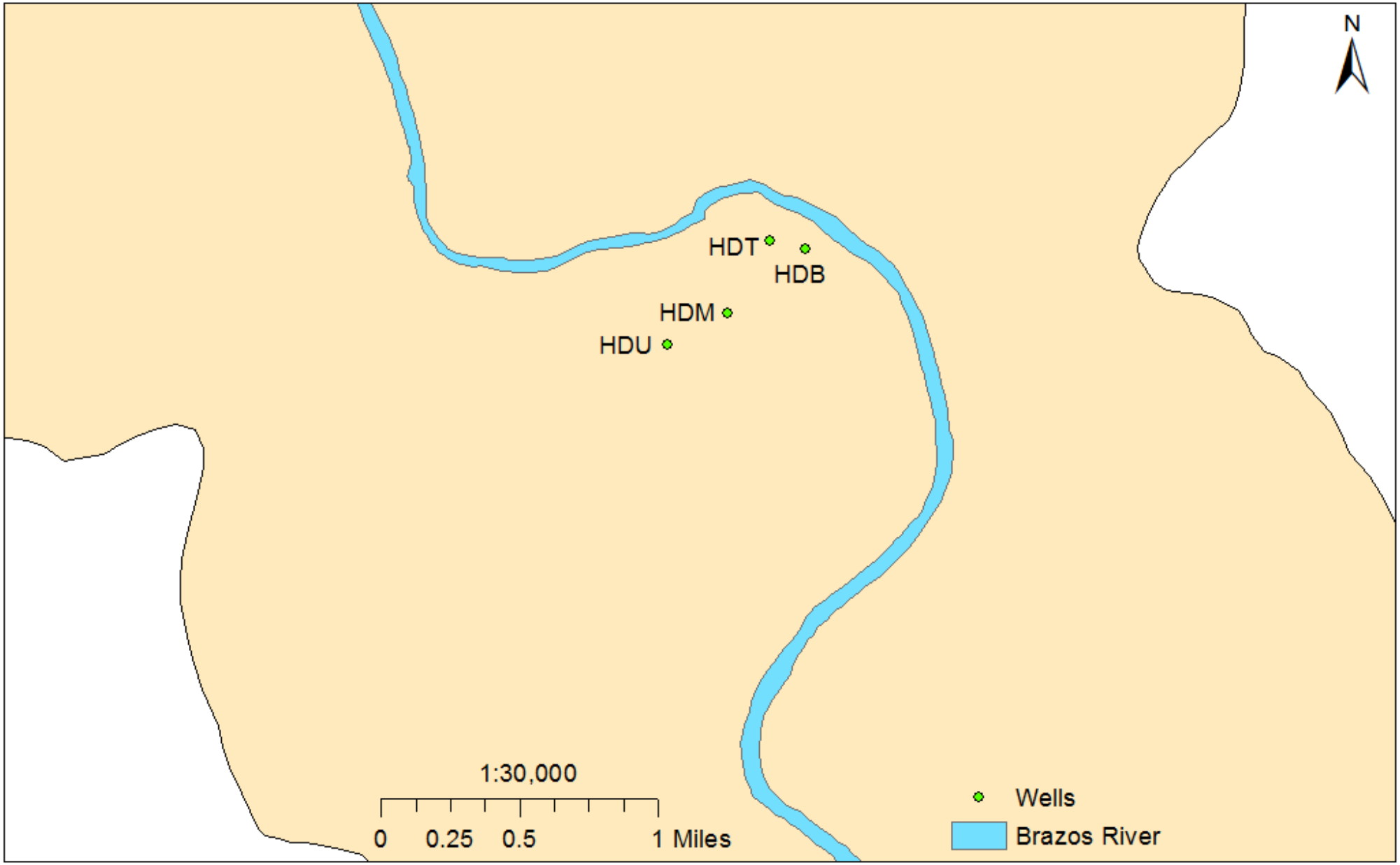
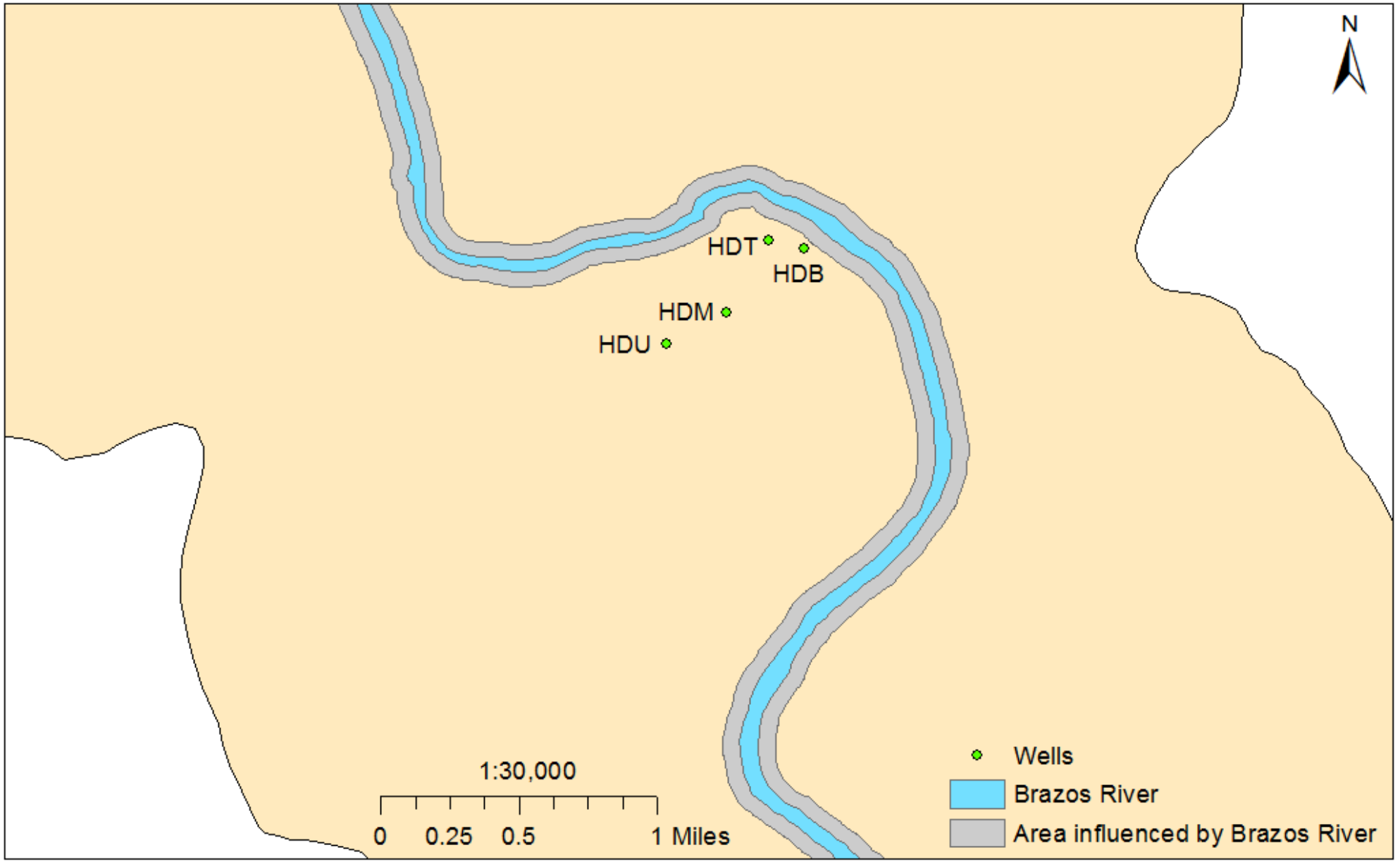



ft
SW
NE
388
384
380
376
372
368
364
360
356
352
348
344
340
336
332
328
324
88 ft
11/13/18
12/24/18
10/1/18
HDU
HDM
HDB
Brazos River
Bedrock
Clay
Sand and clay
Sand and gravel
Sandy clay
Sand
Gravel and sand
400 ft
Area influenced by Brazos River druing gradient reversal


N
HDT
HDB
HDM
HDU
1:30,000
0 0.25 0.5 1 Miles
Wells
Brazos River


N
HDT
HDB
HDM
HDU
1:30,000
0 0.25 0.5 1 Miles
Wells
Brazos River
Area influenced by Brazos River

Discussion and Conclusions

- Aquifer shows significant variability in salinity
- Aquifer specific conductance in Falls County is almost double that of McLennan County
- Little change in aquifer specific conductance due to seasonality or since 1960's
- In-situ sampling showed some salinity stratification, but stratification is not consistent
- River is not likely source of aquifer salinity
  - Aquifer and river tend to have different ionic chemistries
  - Aquifer and river are isotopically distinct
  - During 37-day gradient reversal, river water only traveled ~88 feet into aquifer
- Historic oil and gas fields do not appear to be salinity source
- In-situ sampling showed that irrigation could potentially impact aquifer salinity

Acknowledgements

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- All land owners who participated in this study

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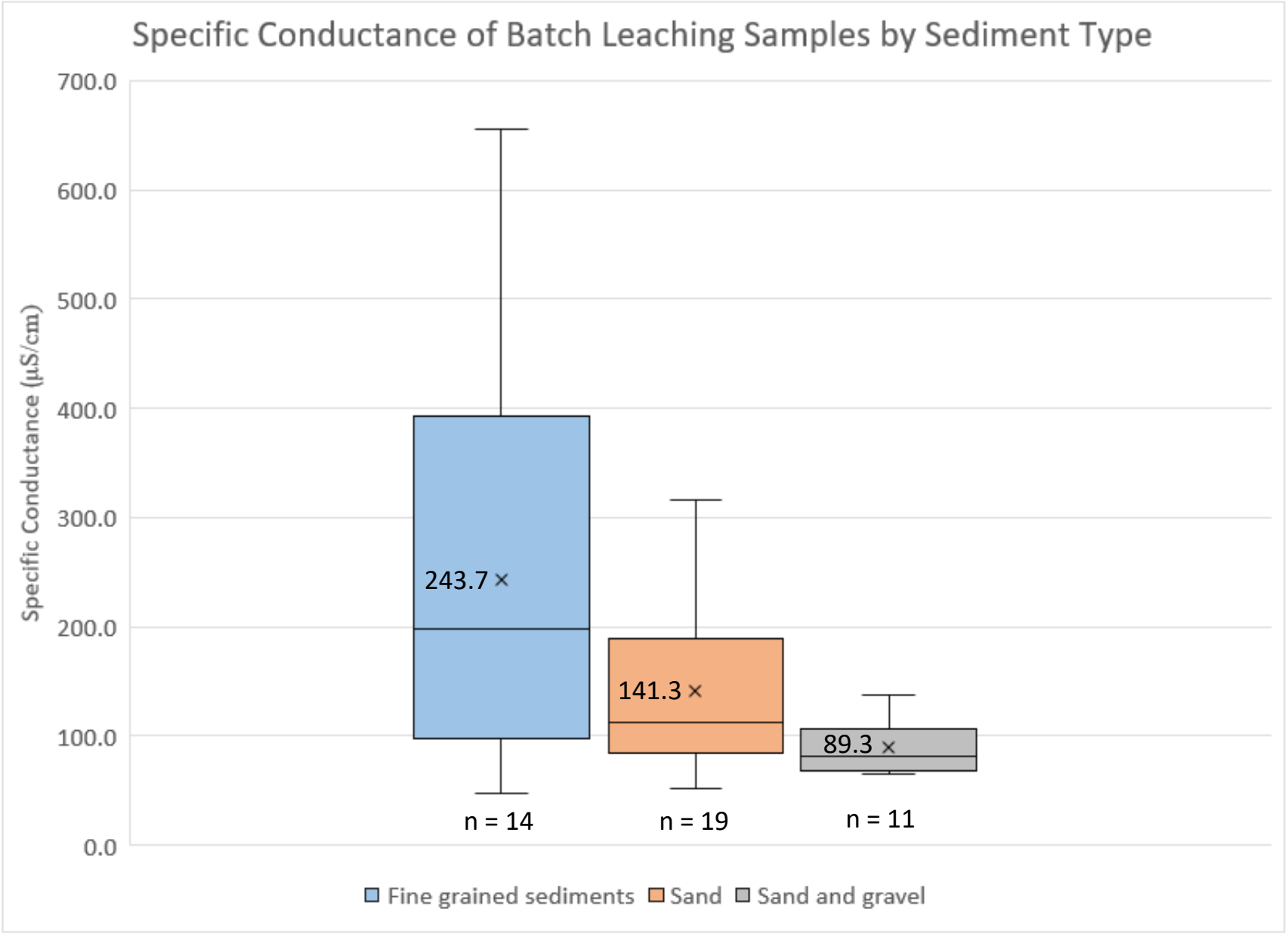
Specific Conductance of Batch Leaching Samples by Sediment Type
Specific Conductance (µS/cm)
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
243.7
141.3
89.3
n = 14
n = 19
n = 11
Fine grained sediments
Sand
Sand and gravel