

# Welcome to the Public Hearing for the 2021 Annual Groundwater Report



- Participants will be muted for the entire hearing.
- Public testimony will be available for participants at the end of the hearing. The hearing is presented virtually for viewing purposes only.
- The webinar is being recorded including all chat between participants.
- For any problems, please chat with the organizer.

HARRIS-GALVESTON



SUBSIDENCE  
DISTRICT

# 2021 Annual Groundwater Report

Public Hearing – April 28, 2022

# Harris-Galveston Subsidence District Mission

- The Harris-Galveston Subsidence District was created in 1975 to prevent land subsidence in Harris and Galveston counties through the regulation of groundwater.
- Land subsidence contributes to flooding, threatening the economic health of the area.
- Efforts to prevent subsidence by the District and the regulated community have required significant investment to create a more resilient infrastructure while securing reliable water sources for future needs.
- An annual groundwater hearing is required by enabling the act to receive testimony regarding the effects of groundwater withdrawals on subsidence.



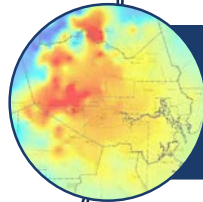
# Agenda



Climate



Groundwater Use



Groundwater Levels



Subsidence Data

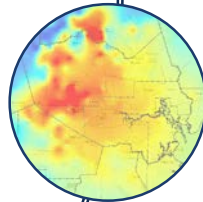
# Agenda



Climate



Groundwater Use



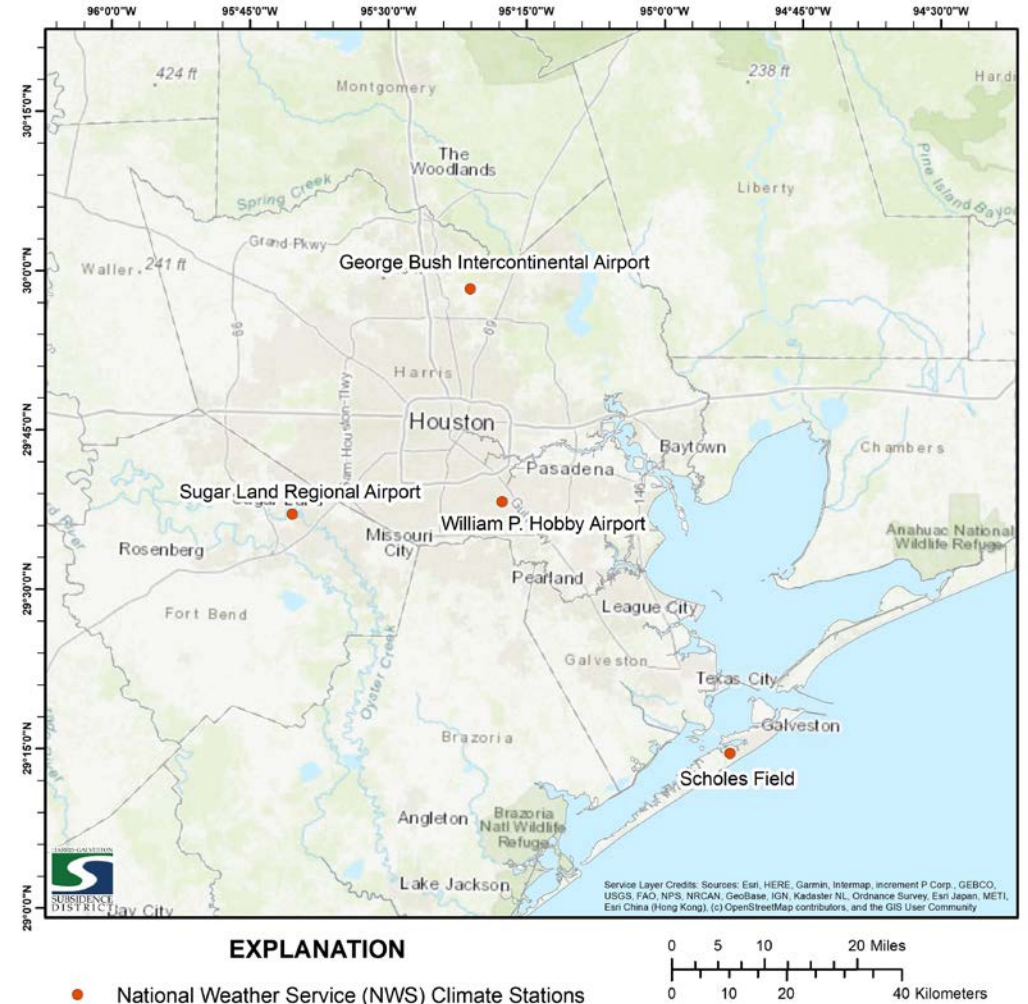
Groundwater Levels



Subsidence Data

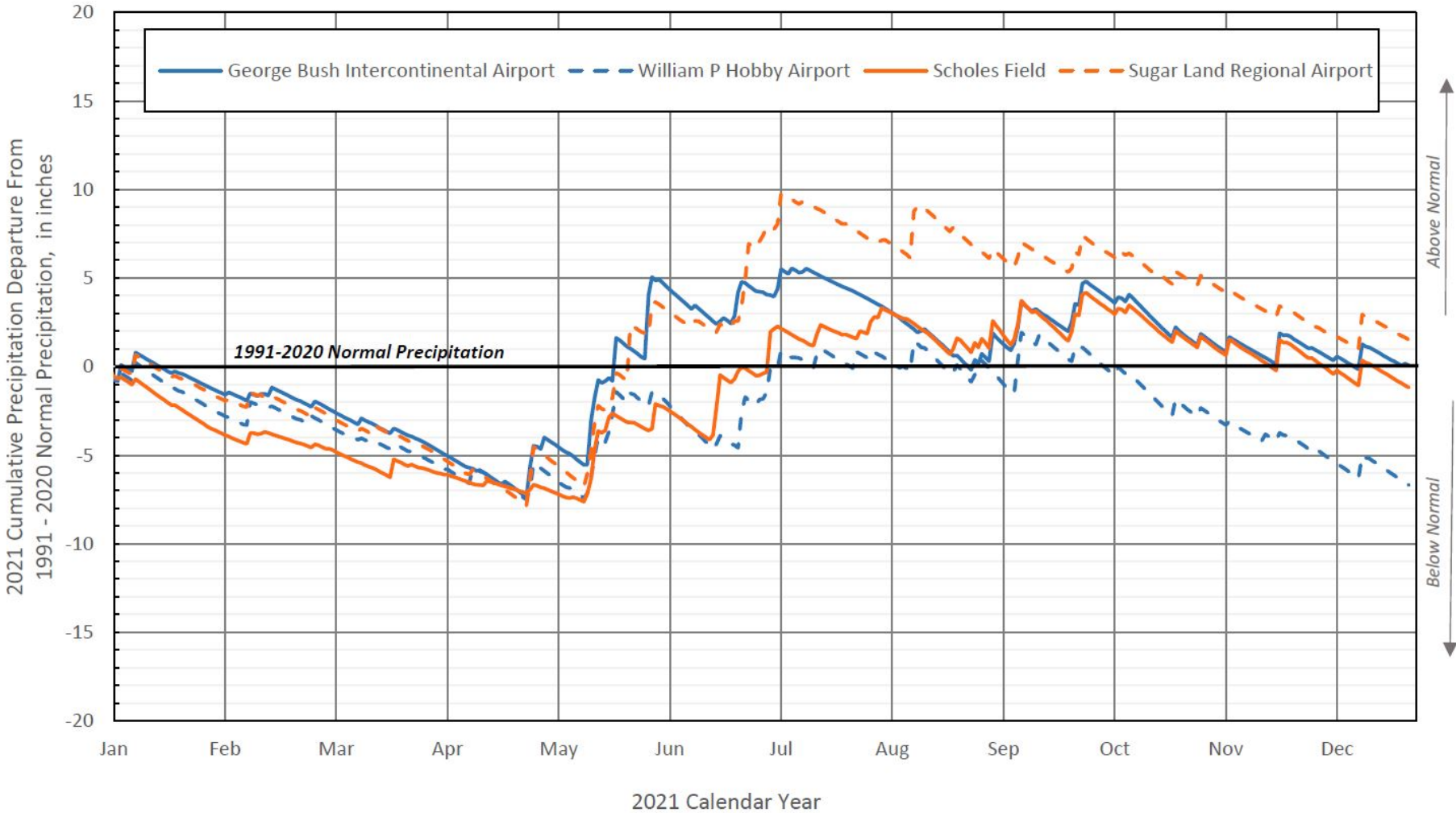
# NWS Climate Stations | Exhibit 1

Location of National Weather Service (NWS) climate stations used for precipitation data for the 2021 calendar year.





# 2021 Precipitation Data | Exhibit 2



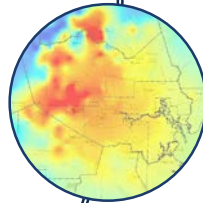
# Agenda



Climate



Groundwater Use



Groundwater Levels



Subsidence Data



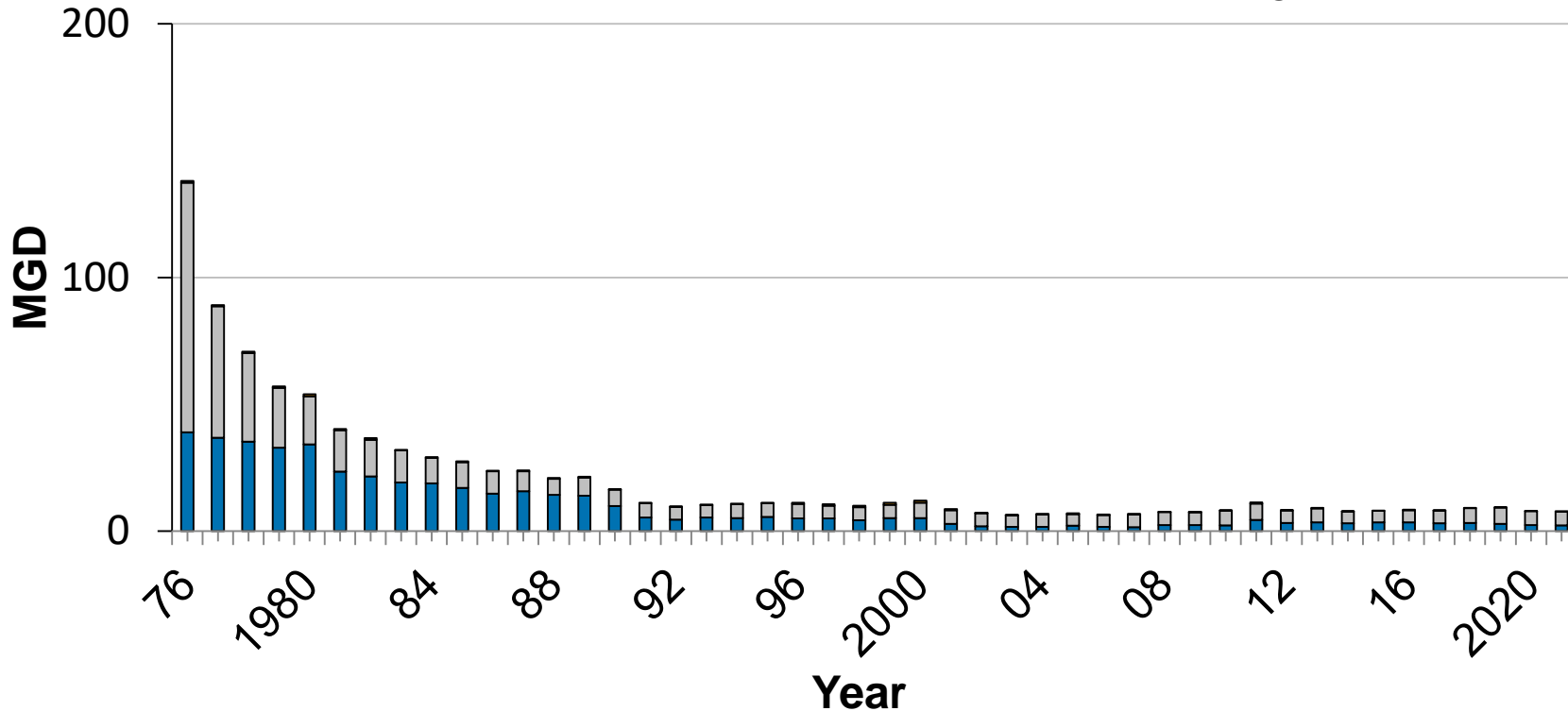
# Groundwater Withdrawals | Exhibit 3



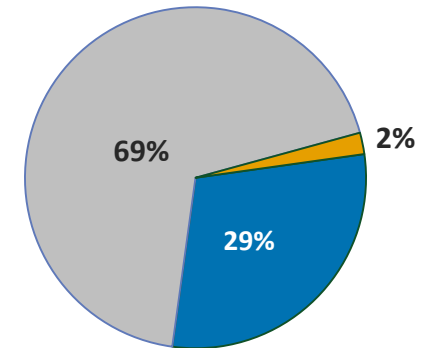
## Regulatory Area One

Groundwater Withdrawals - Grouped by Use

■ *Public*    ■ *Indust.*    ■ *All Irrig.*



**2021 - 7.9 MGD**  
(2020 – 8.1 MGD; -4% change)

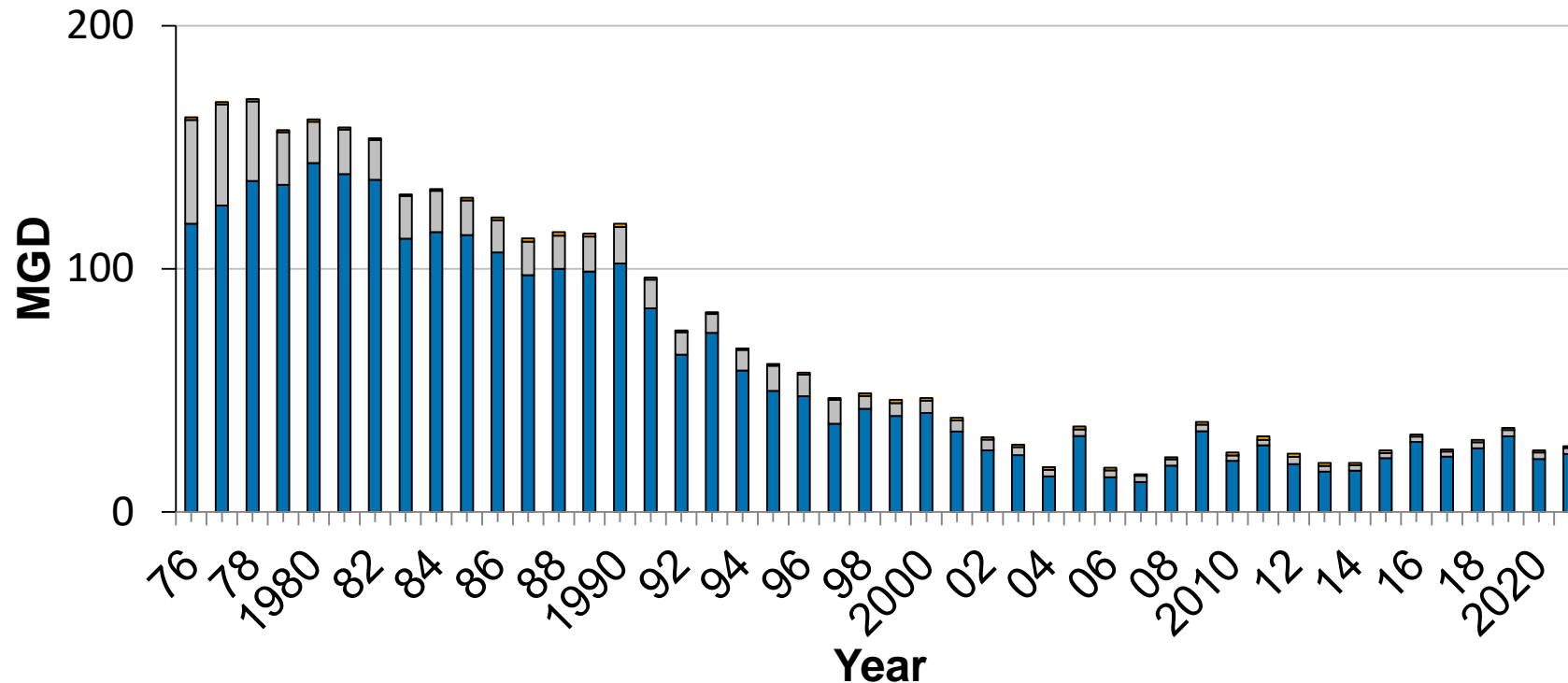


# Groundwater Withdrawals | Exhibit 4

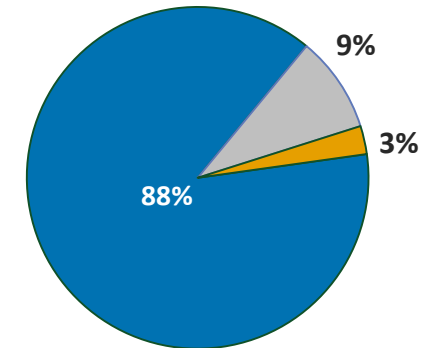


## Regulatory Area Two Groundwater Withdrawals - Grouped by Use

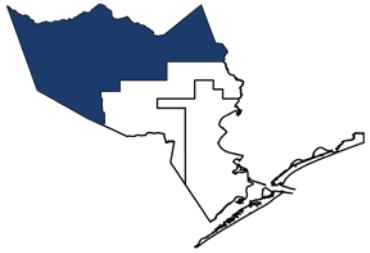
■ *Public*    ■ *Indust.*    ■ *All Irrig.*



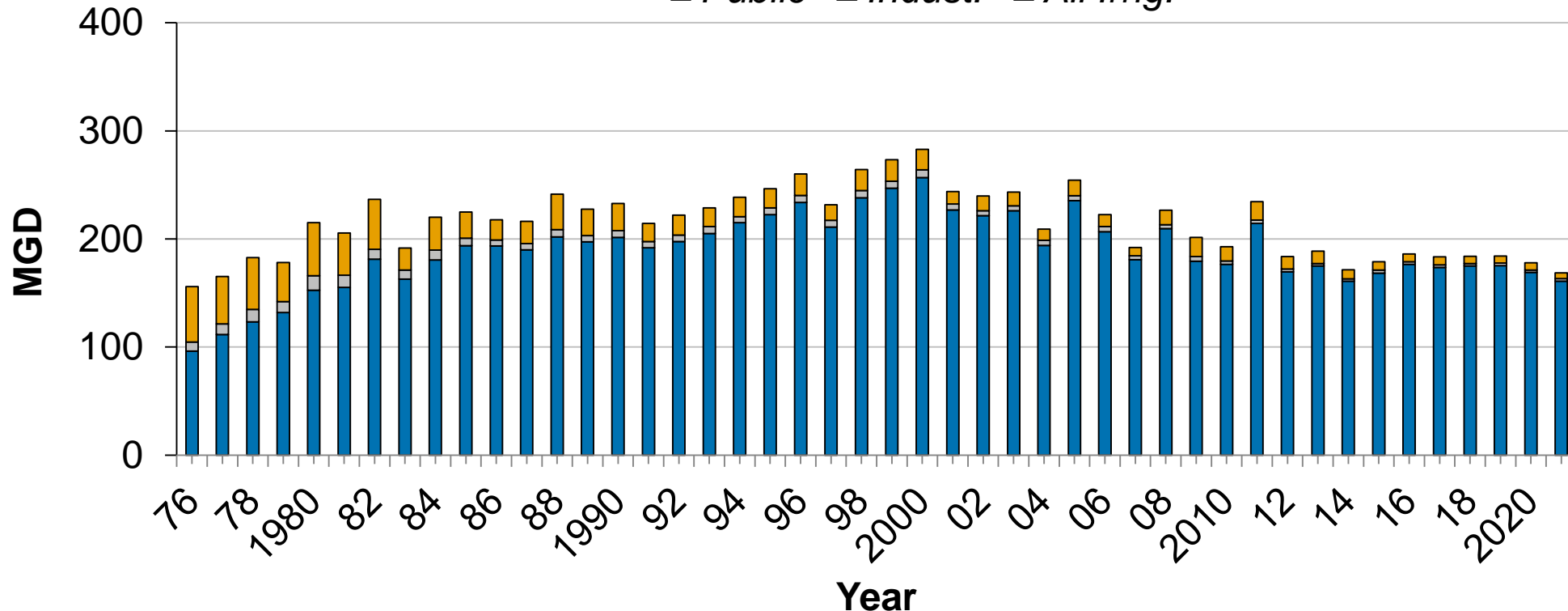
**2021 - 27 MGD**  
(2020 – 25.3 MGD; 7% change)



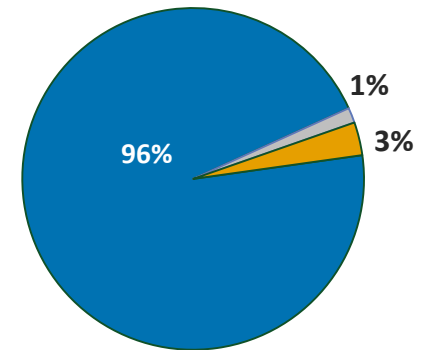
# Groundwater Withdrawals | Exhibit 5



**Regulatory Area Three**  
 Groundwater Withdrawals – Grouped by Use  
 ■ Public ■ Indust. ■ All Irrig.



**2021 - 168.7 MGD**  
 (2020 – 178 MGD; -5% change)

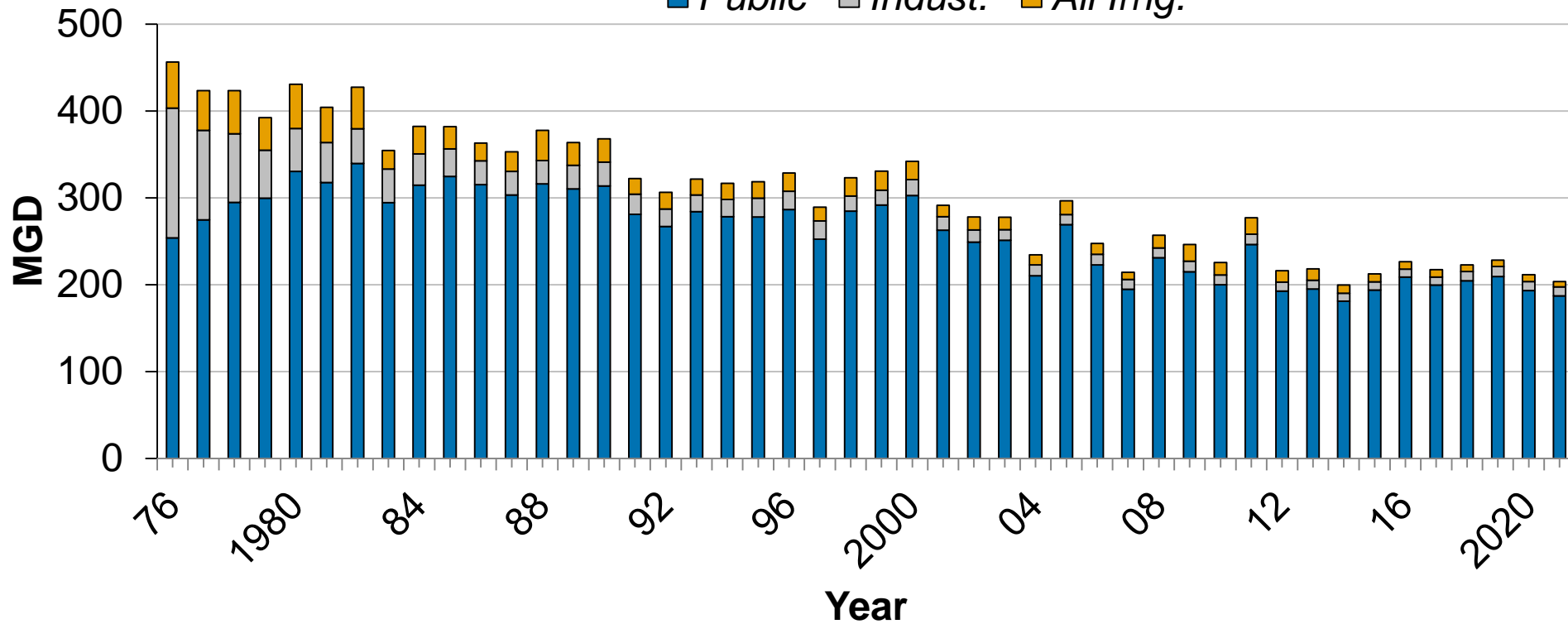


# Groundwater Withdrawals | Exhibit 6

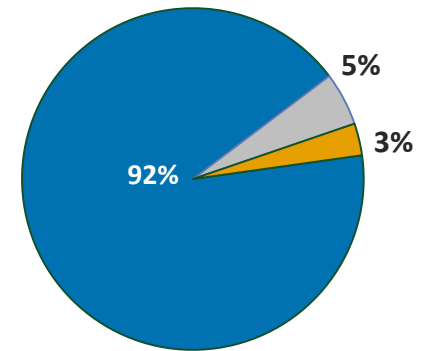
## Entire District

Groundwater Withdrawals - Grouped by Use

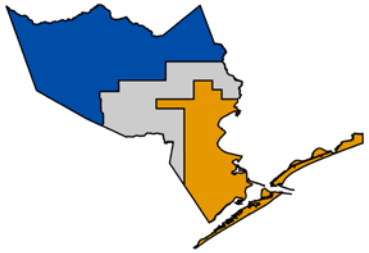
■ Public ■ Indust. ■ All Irrig.



**2021 - 203.6 MGD**  
(2020 – 211.4 MGD; -4% change)



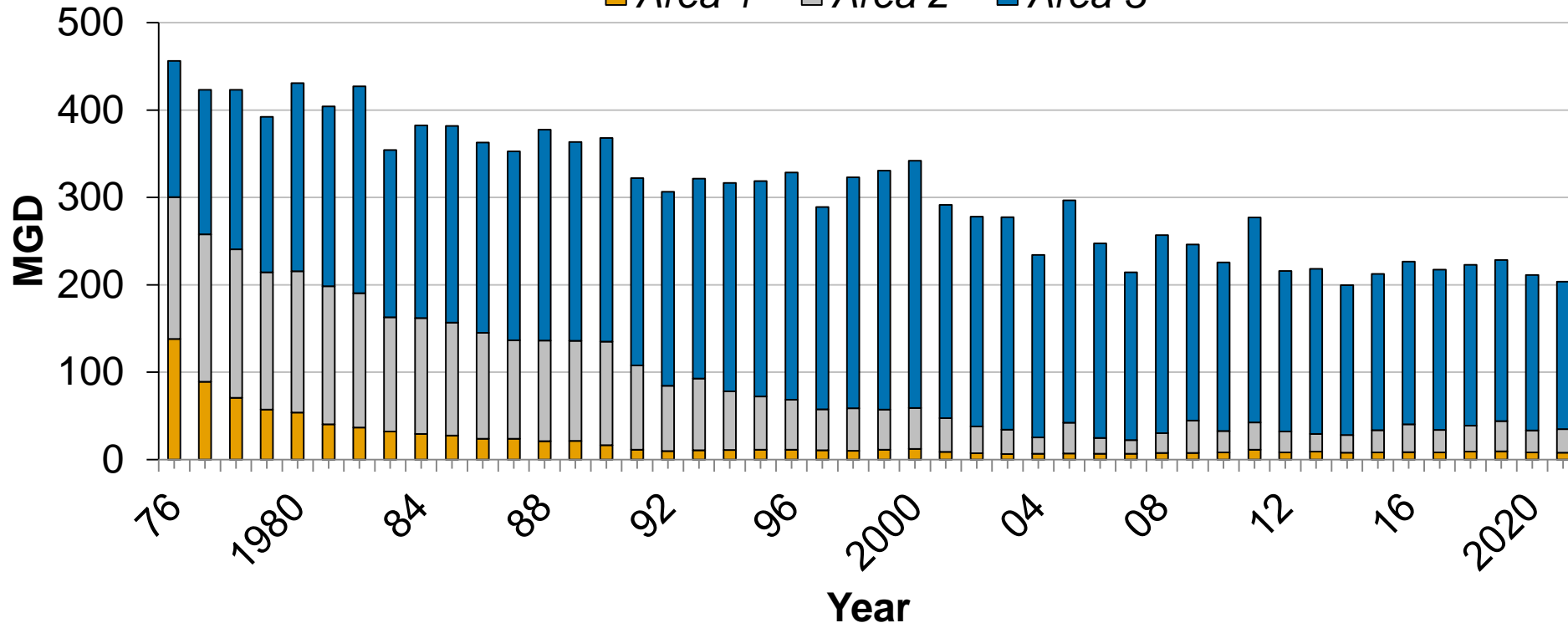
# Groundwater Withdrawals | Exhibit 7



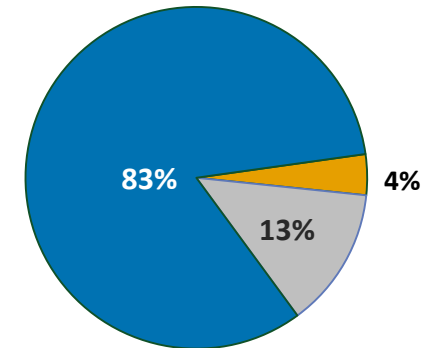
## Entire District

Groundwater Withdrawals - Grouped by Regulatory Area

Area 1 Area 2 Area 3



2021 - 203.6 MGD  
(2020 - 211.4 MGD; -4% change)

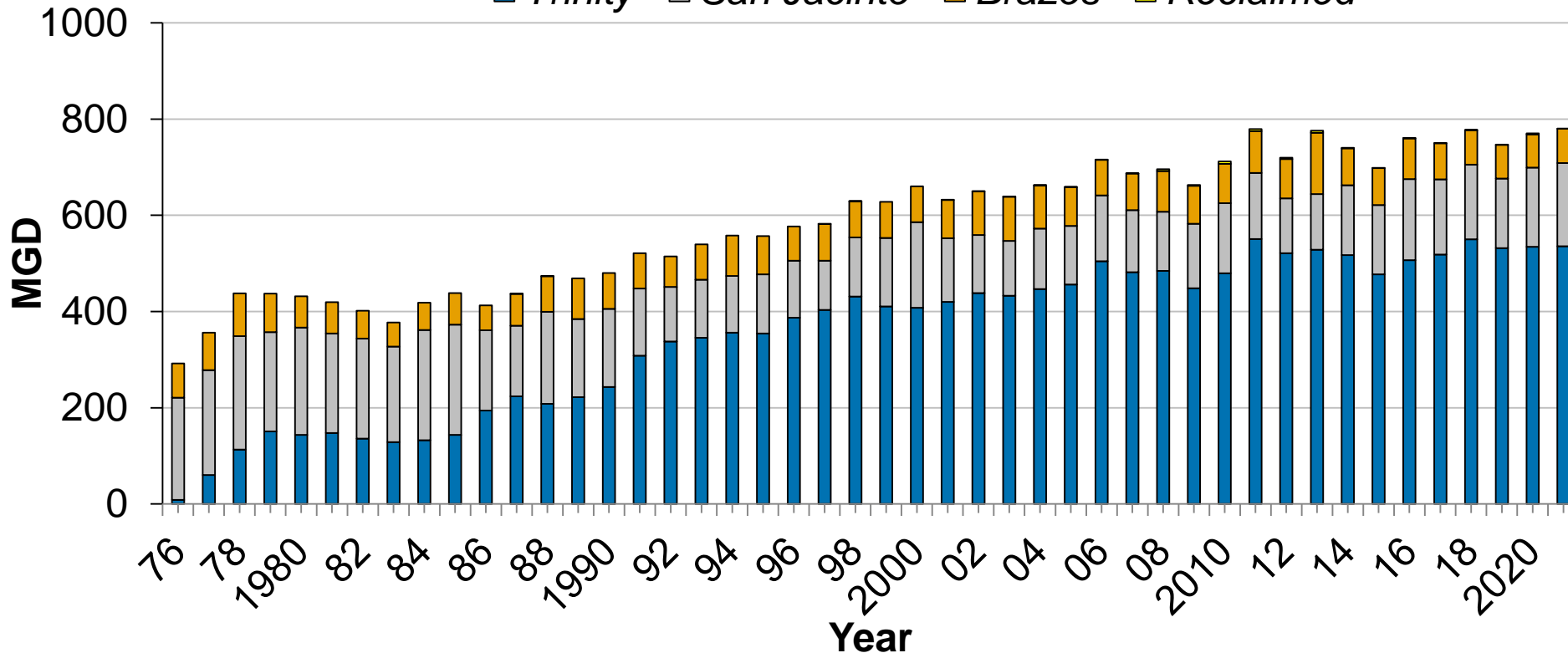


# Alternative Water Utilized | Exhibit 8

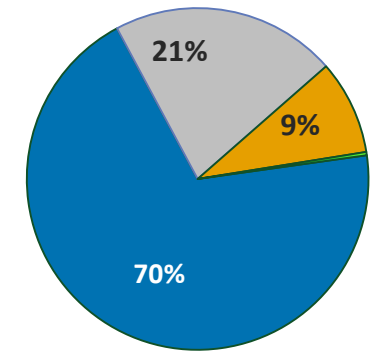
## Surface and Reclaimed Water Used

Grouped by Source - Entire District

Trinity San Jacinto Brazos Reclaimed



**2021 - 779.9 MGD**  
(2020 – 770.5 MGD; 1% change)



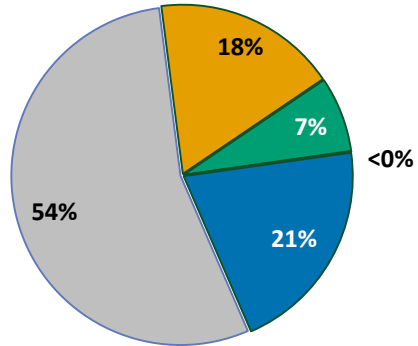
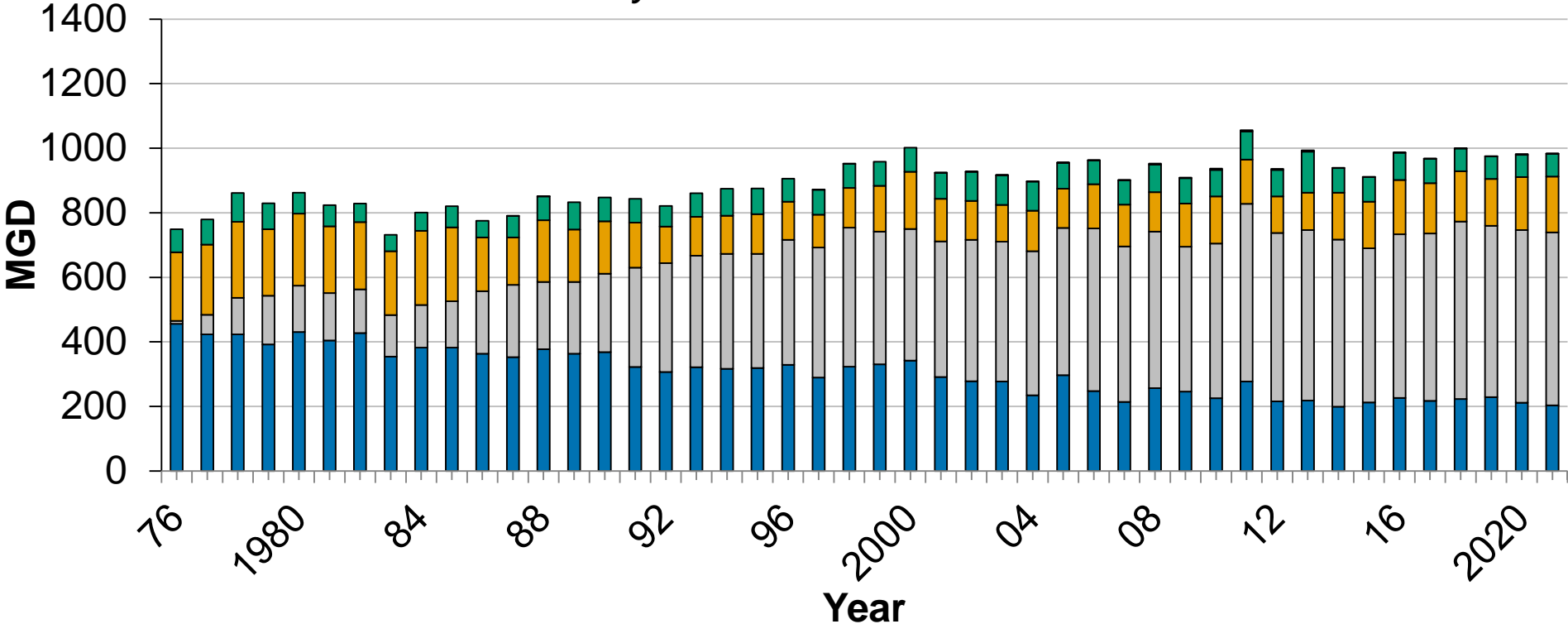


# Total Water Demand | Exhibit 9

## Total Water Demand Grouped by Source - Entire District

■ Groundwater 
 ■ Trinity 
 ■ San Jacinto 
 ■ Brazos 
 ■ Reclaimed Water

**2021 - 983.4 MGD**  
 (2020 – 981.9 MGD; 0.2% change)



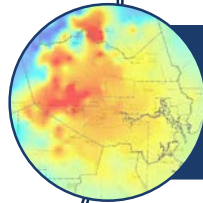
# Agenda



Climate



Groundwater Use



Groundwater Levels



Subsidence Data

Groundwater-level Altitudes  
(2022) and Changes Over  
Time in the Chicot and  
Evangeline (Undifferentiated)  
and Jasper Aquifers and  
Compaction in the Chicot and  
Evangeline Portions of the  
Undifferentiated Aquifer  
(1973-2021)



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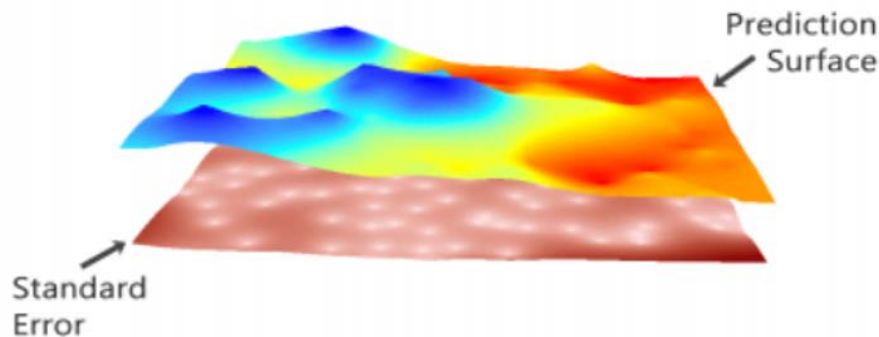
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# 2022 Water-Level Altitude Map Series

- Chicot and Evangeline Aquifer (undifferentiated)
  - 2022 Water-Level Altitude
  - 2021 to 2022 Water-Level Change
  - 2017 to 2022 Water-Level Change
  - 1990 to 2022 Water-Level Change
  - 1977 to 2022 Water-Level Change
- Jasper Aquifer
  - 2022 Water-Level Altitude
  - 2021 to 2022 Water-Level Change
  - 2017 to 2022 Water-Level Change
  - 2000 to 2022 Water-Level Change
- Compaction 1973-2021
  - Compaction Data from 14 Extensometers

# Geology and Hydrogeology

- Chicot and Evangeline aquifers (undifferentiated) have been combined into a “shallow” aquifer system
  - GULF 2023 model – updated tops and bases
  - Chicot thickened significantly in much of the region, particularly in central and southeast Harris County.
  - Many of the wells previously designated as Evangeline are now designated as Chicot.
- Altitude and long-term change maps are now represented by shaded grids (Kriging)



Geologic timescale		Prior to 2021		In 2021 and Moving Forward		
System	Series	Geologic units	Hydrogeologic units	Geologic units <sup>1</sup>	Hydrogeologic units <sup>1</sup>	
Quaternary	Holocene	Alluvium	Chicot aquifer	Alluvial, terrace, and dune deposits	Chicot - Evangeline aquifer (undifferentiated)	
	Pleistocene	Beaumont Formation		Beaumont Formation		
		Lissie Formation		Montgomery Formation		Lissie Formation
				Bentley Formation		Montgomery Formation
Willis Sand	Willis Sand					
Tertiary	Pliocene	Goliad Sand	Evangeline aquifer	Goliad Sand (upper part)	Chicot - Evangeline aquifer (undifferentiated)	
				Goliad Sand (lower part)		
	Miocene	Fleming Formation	Burkeville confining unit	Lagarto Clay (upper part)	Burkeville confining unit	
		Lagarto Clay		Lagarto Clay (middle part)		
		Oakville Sandstone	Jasper aquifer	Lagarto Clay (lower part)	Jasper aquifer	
					Oakville Sandstone	
Oligocene	Upper part of Catahoula Sandstone	Catahoula Confining System	Catahoula Formation	Upper Catahoula Formation		
	Catahoula Sandstone			Frio Formation	Catahoula Confining System	
	Anahuac Formation					

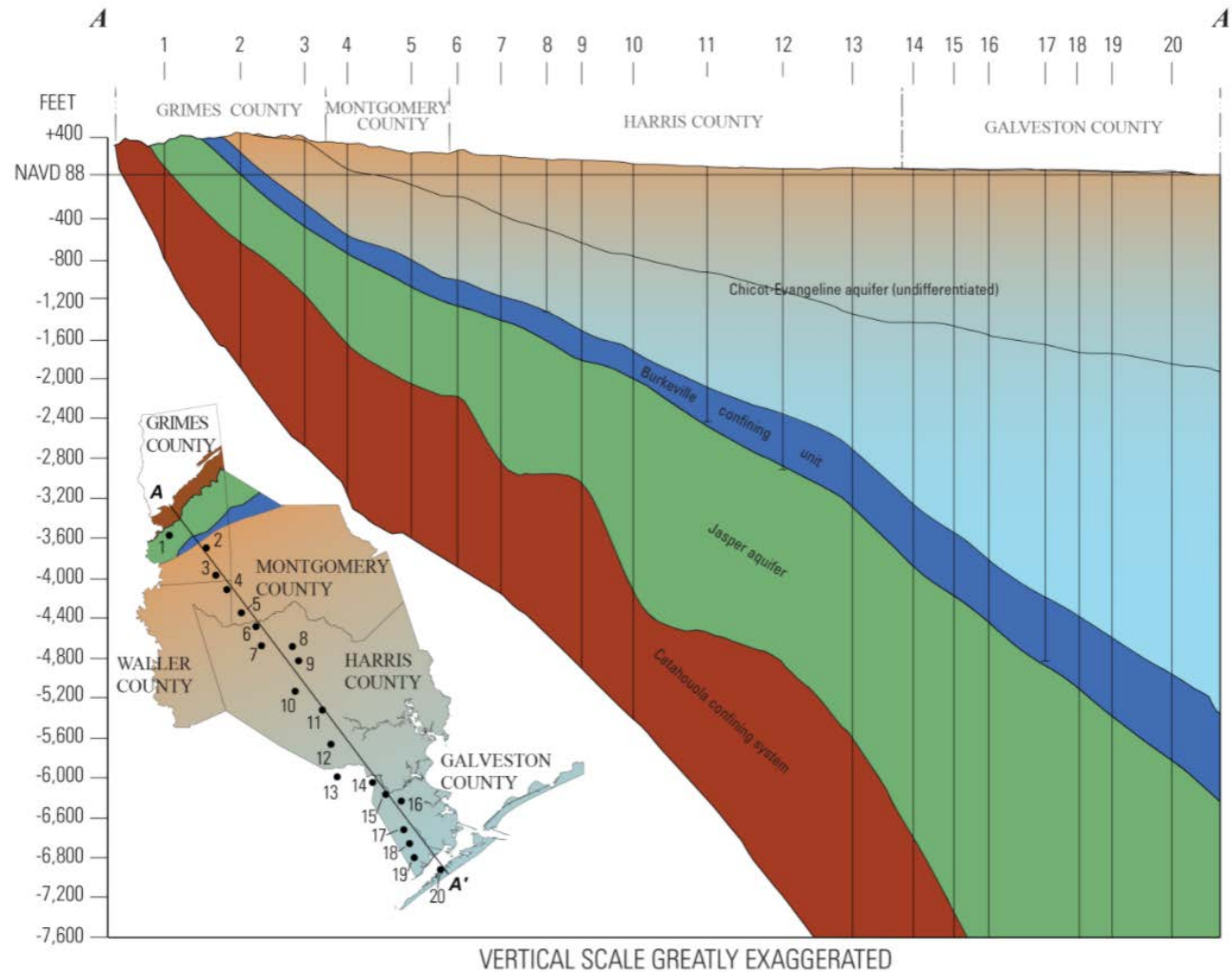
From Braun and Ramage, 2022 (in press) to be published in June 2022

# Groundwater Well Network

- Data were collected across 11 counties (Harris and surrounding) from 11-29-2021 to 3-11-2022
- Requires collaboration and agreements with well owners and operators (MUDs)
- Variety of well types including public supply, irrigation, industrial, and observation
- Number of Chicot and Evangeline water-levels collected: **537**
- Number of Jasper water-levels collected: **104**
- Number of wells used to create 2021 Altitude maps
  - Chicot and Evangeline: **498**
  - Jasper: **104**



# Stratigraphic Cross Section

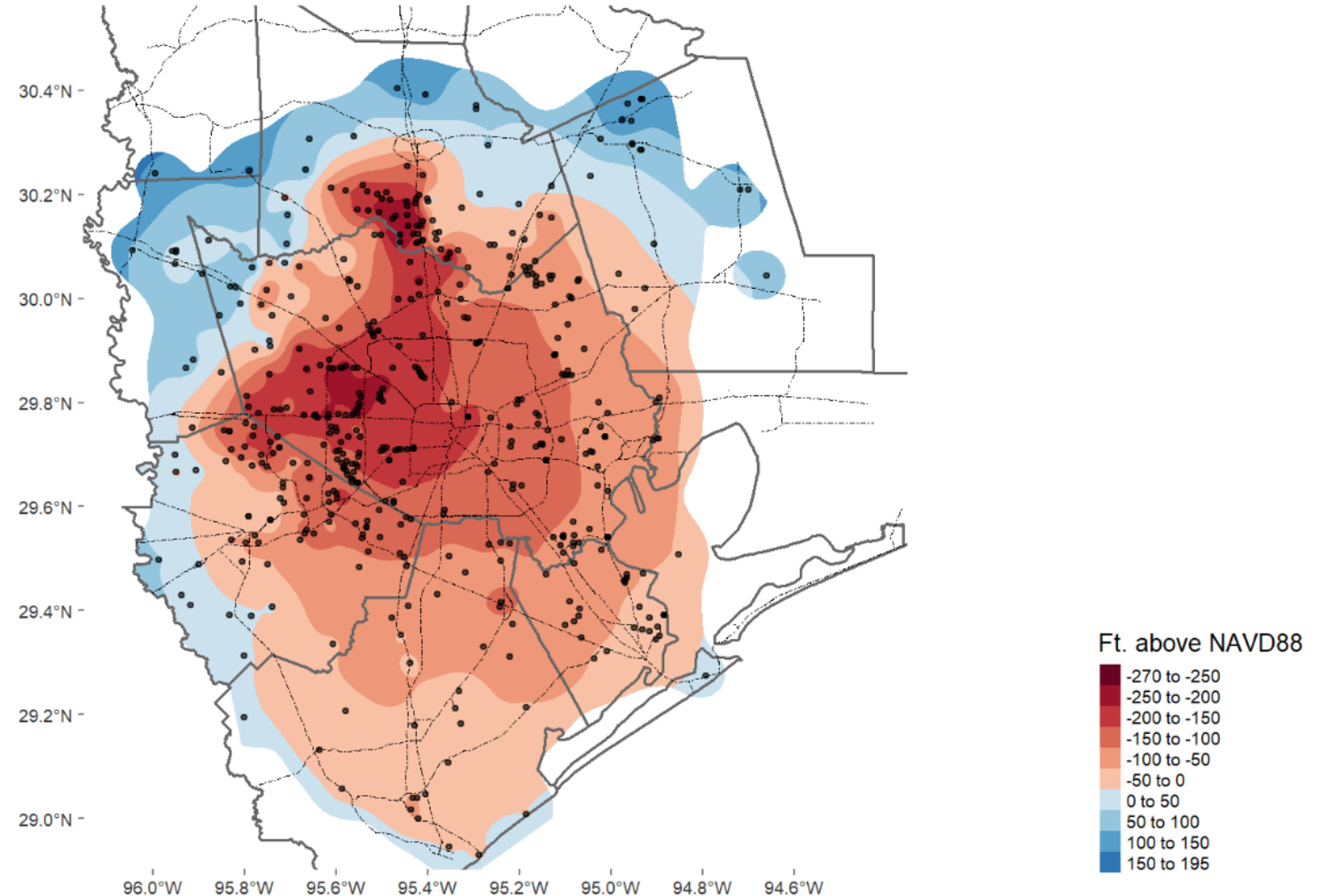


From Braun and Ramage, 2022 (in press) to be published in June 2022

(Provisional - Subject to Revision)

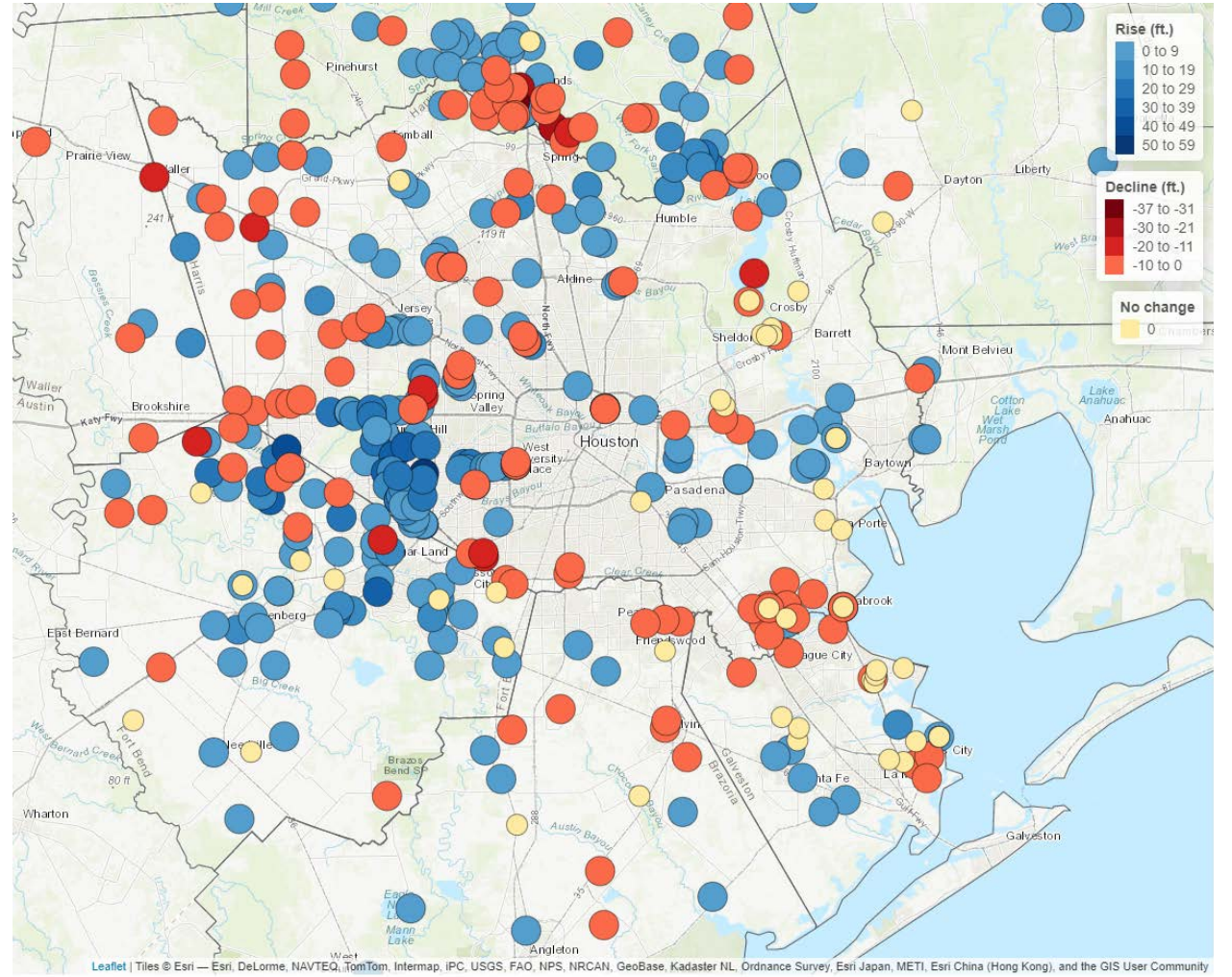
# 2022 Chicot and Evangeline (Undifferentiated) Water-Level Altitude

- Data summary:
  - Min: **-270**
  - Mean: **-42**
  - Max: **195**
- Highest areas of usage in western Harris County, and the south-central portion of Montgomery County



# Chicot and Evangeline (Undifferentiated) 1-Year Change

- Number of wells: **457**
- Rises: **56.7%**
- Declines: **30.4%**
- No change: **12.9%**
  
- More than 20 ft. rise: **32**
- More than 30 ft. rise: **7**
  
- More than 20 ft. decline: **3**
- More than 30 ft. decline: **1**

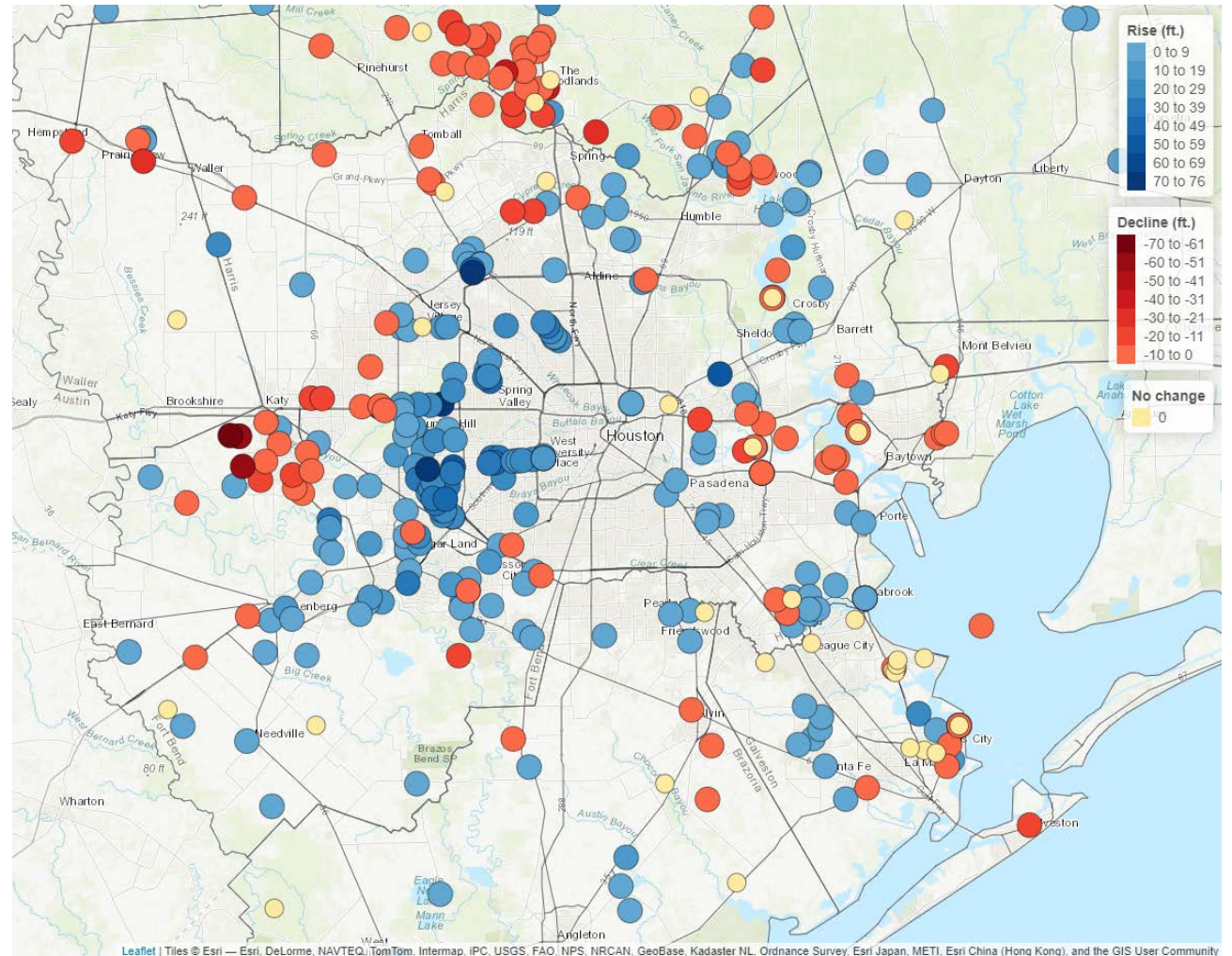


(Provisional - Subject to Revision)



# Chicot and Evangeline (Undifferentiated) 5-Year Change

- Number of wells: **388**
- Rises: **58.8%**
- Declines: **31.2%**
- No change: **10.1%**
  
- More than 30 ft. rise: **22**
  
- More than 30 ft. decline: **5**



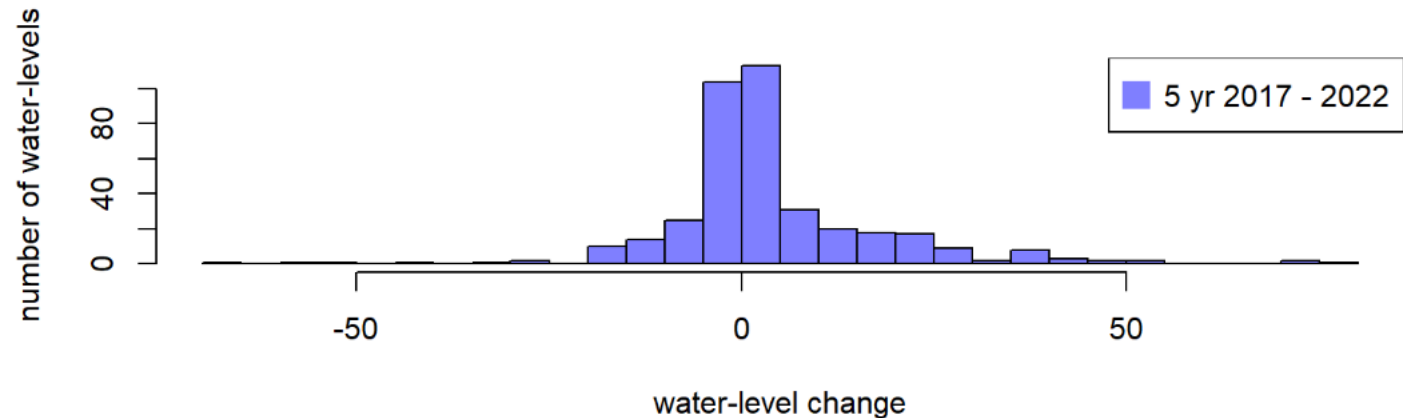
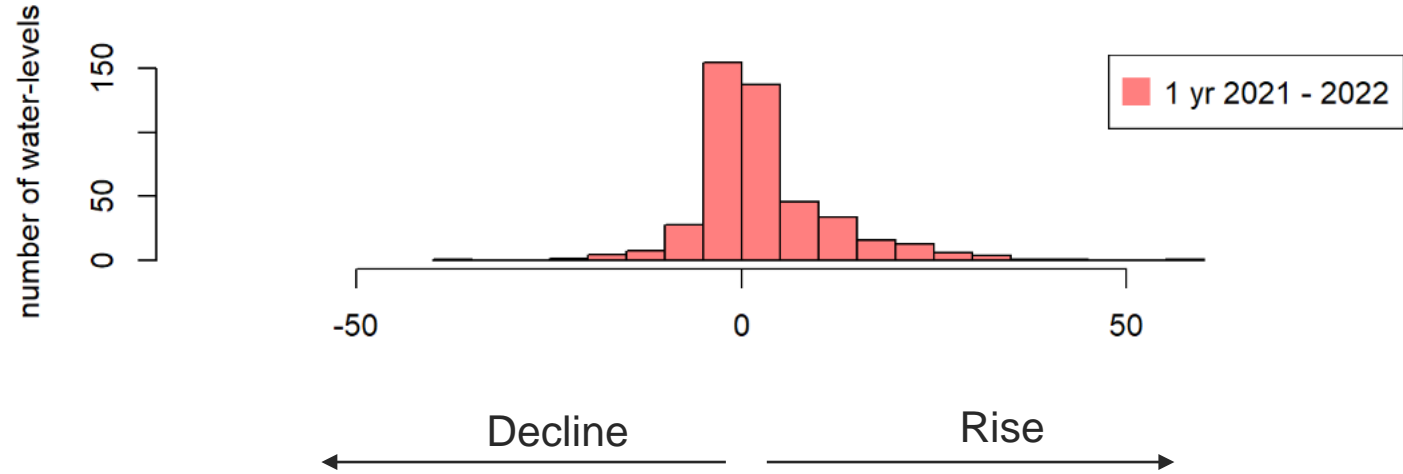
# Chicot and Evangeline (Undifferentiated) 1 and 5 Year Comparison

- 2021-2022 Changes

- Rises: **57%**
- Declines: **30%**
- No change: **13%**
- Rises in the 0-5 ft. range: **~53% (137)**
- Declines in the 0-5 ft. range: **~73% (102)**

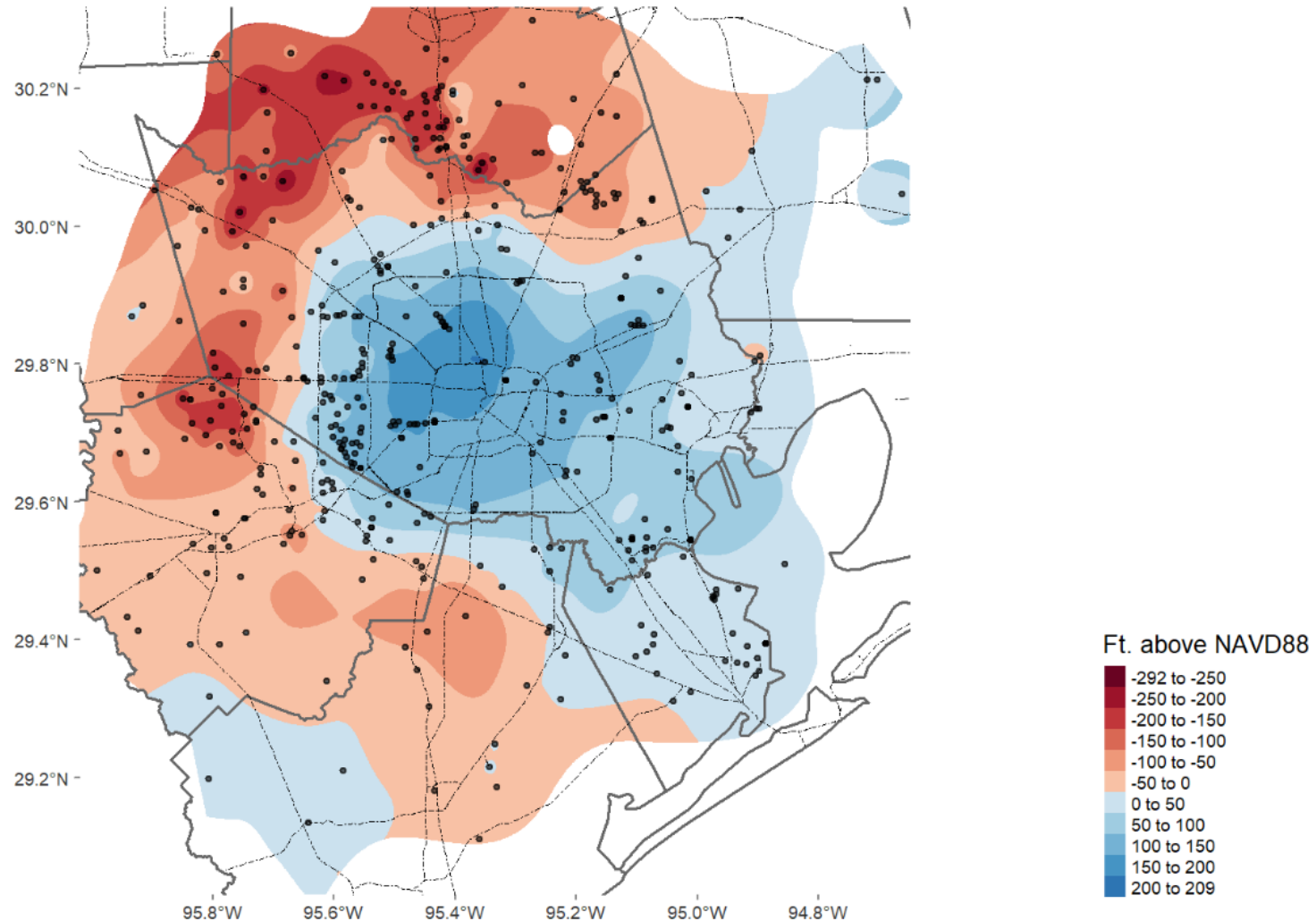
- 2017-2022 Changes

- Rises: **59%**
- Declines: **31%**
- No change: **10%**
- Rises in the 0-5 ft. range: **~50% (113)**
- Declines in the 0-5 ft. range: **~60% (73)**



# Chicot and Evangeline (Undifferentiated) Water-Level Change Since 1990

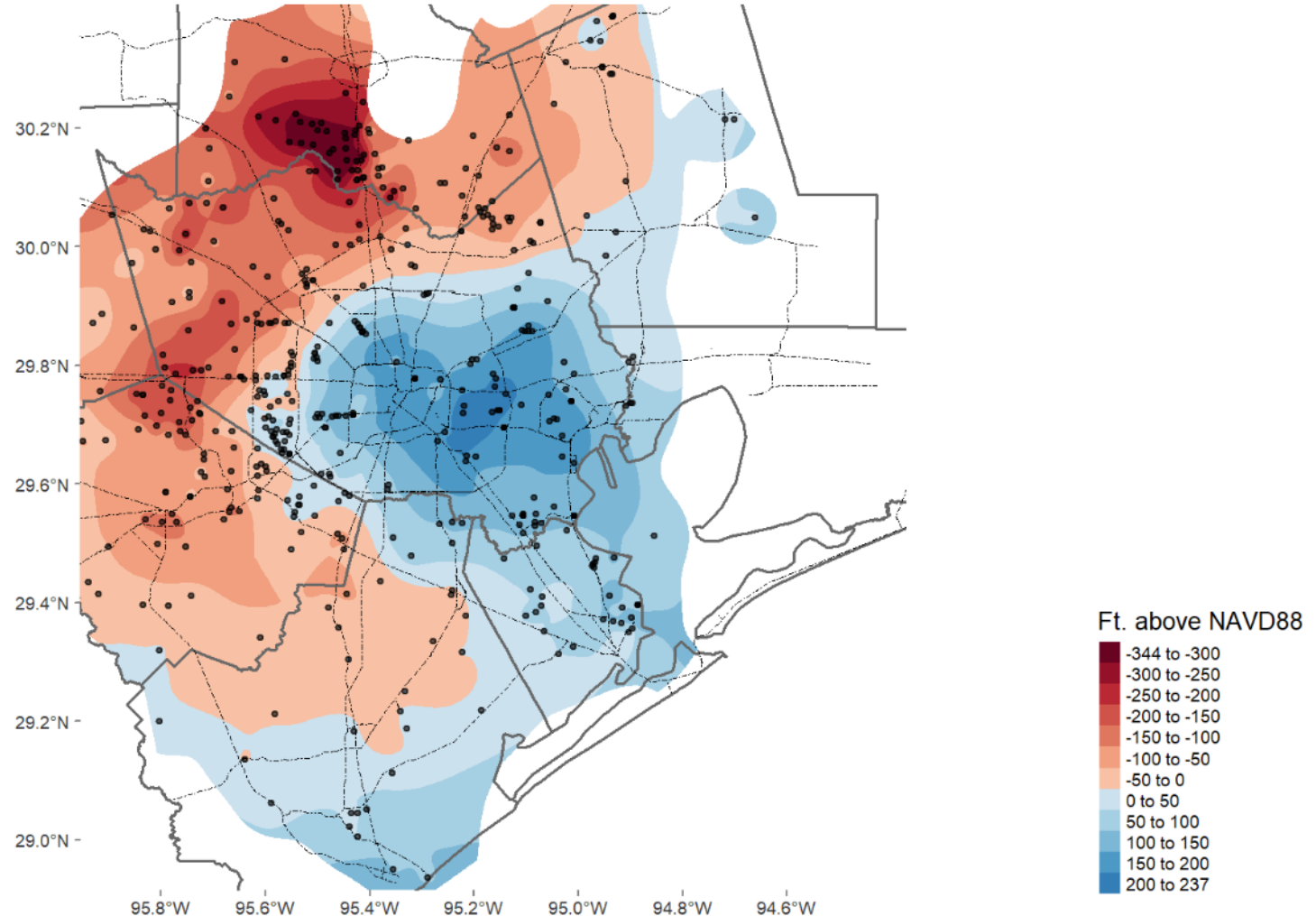
- Data summary:
  - Min: **-292**
  - Mean: **-6**
  - Max: **209**
- Water-level rises across most of central and eastern Harris County as well as Galveston County
- Water-level declines in the northern part of Fort Bend County, NW portions of Harris County, and Montgomery County





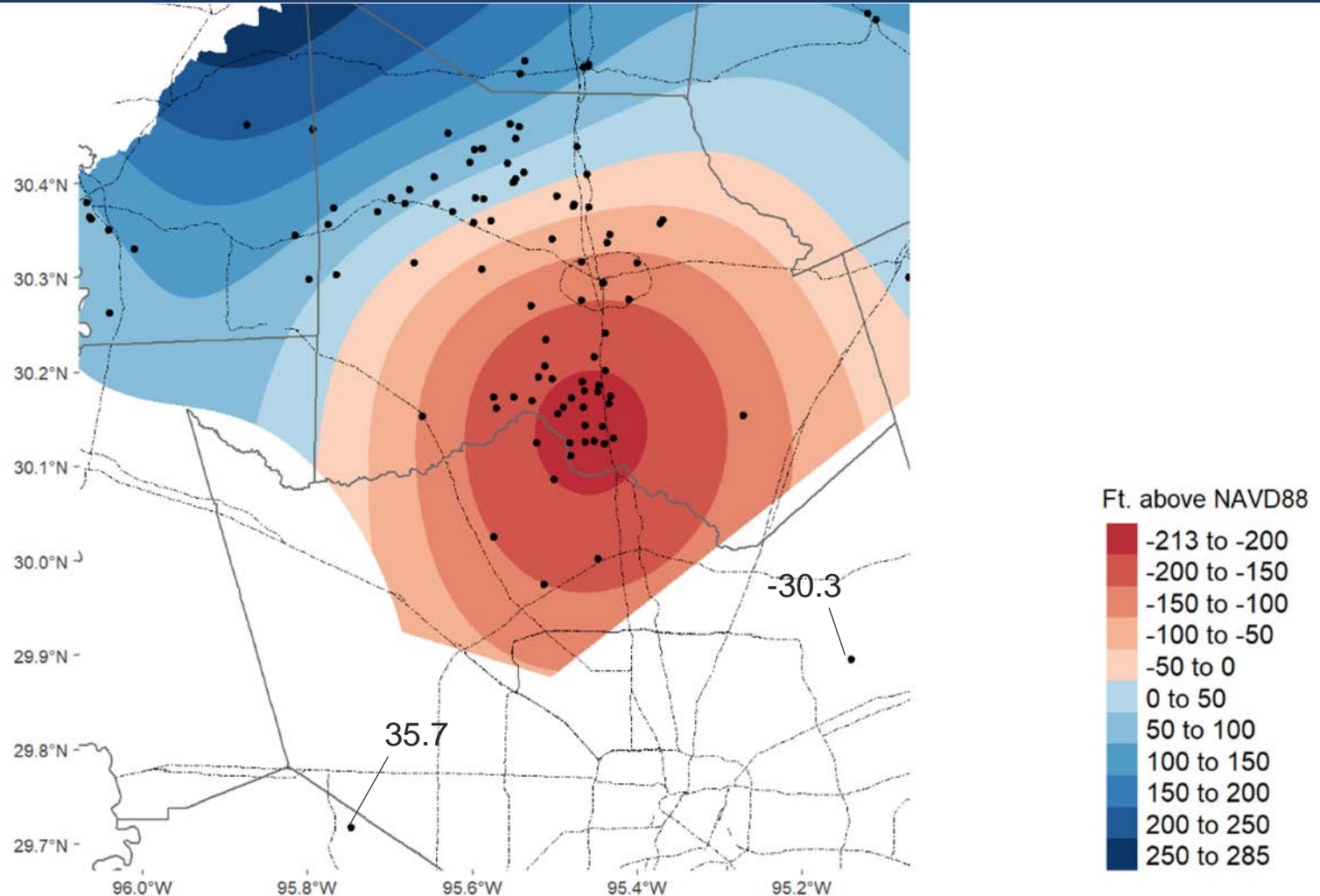
# Chicot and Evangeline (Undifferentiated) Water-Level Change Since 1977

- Data summary:
  - Min: **-344**
  - Mean: **-7**
  - Max: **237**
- Water-level rises across most of central and eastern Harris County as well as Galveston County
- Water-level declines in the northern part of Fort Bend County, NW portions of Harris County, and most of Montgomery County



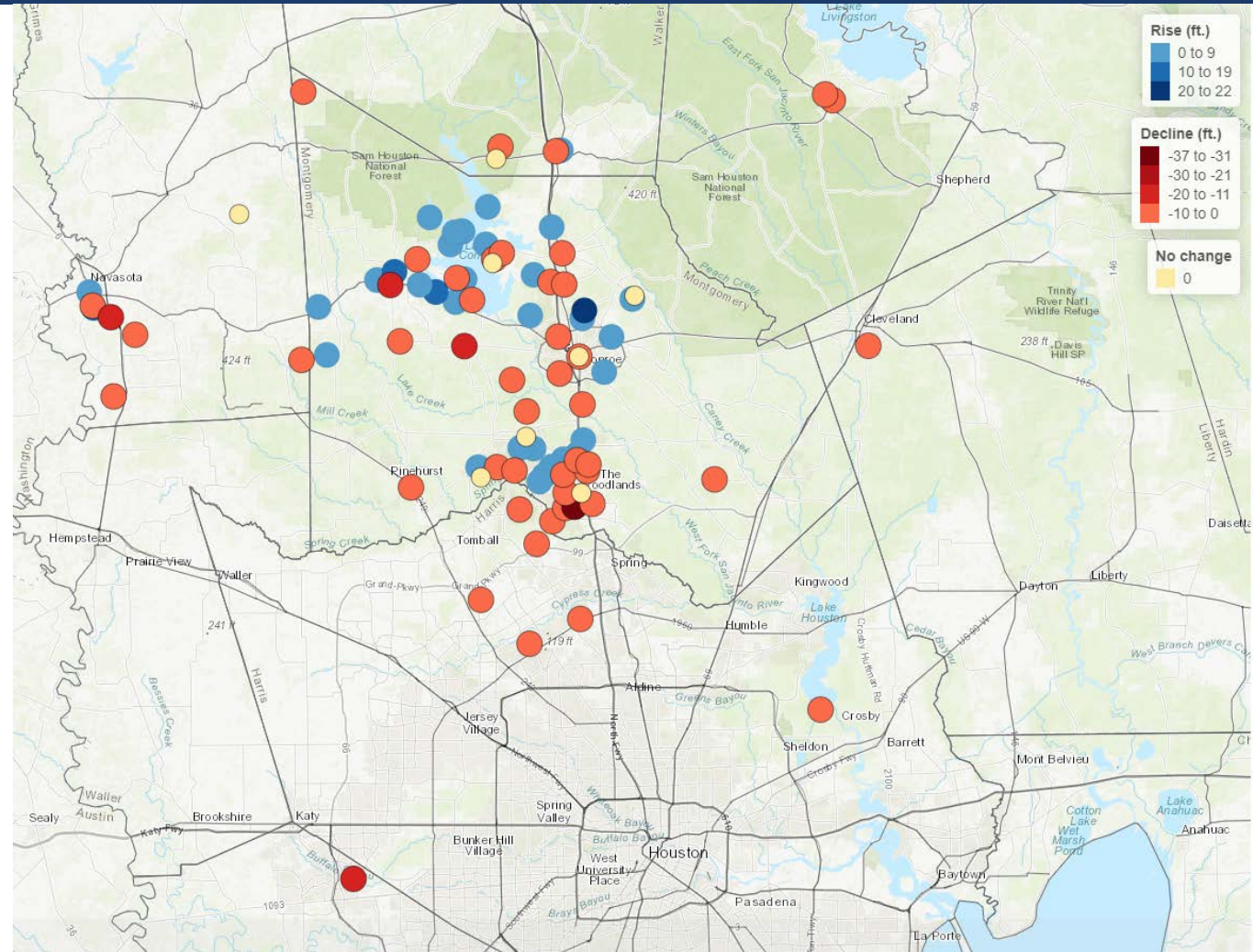
# 2022 Jasper Aquifer Altitude

- Data summary:
  - Min: **-213**
  - Mean: **10**
  - Max: **285**
- General trend of deepening water levels in downdip (NW-SE) direction
- Deepest water levels in south-central Montgomery County near border with Harris County



# Jasper Aquifer 1-Year Change

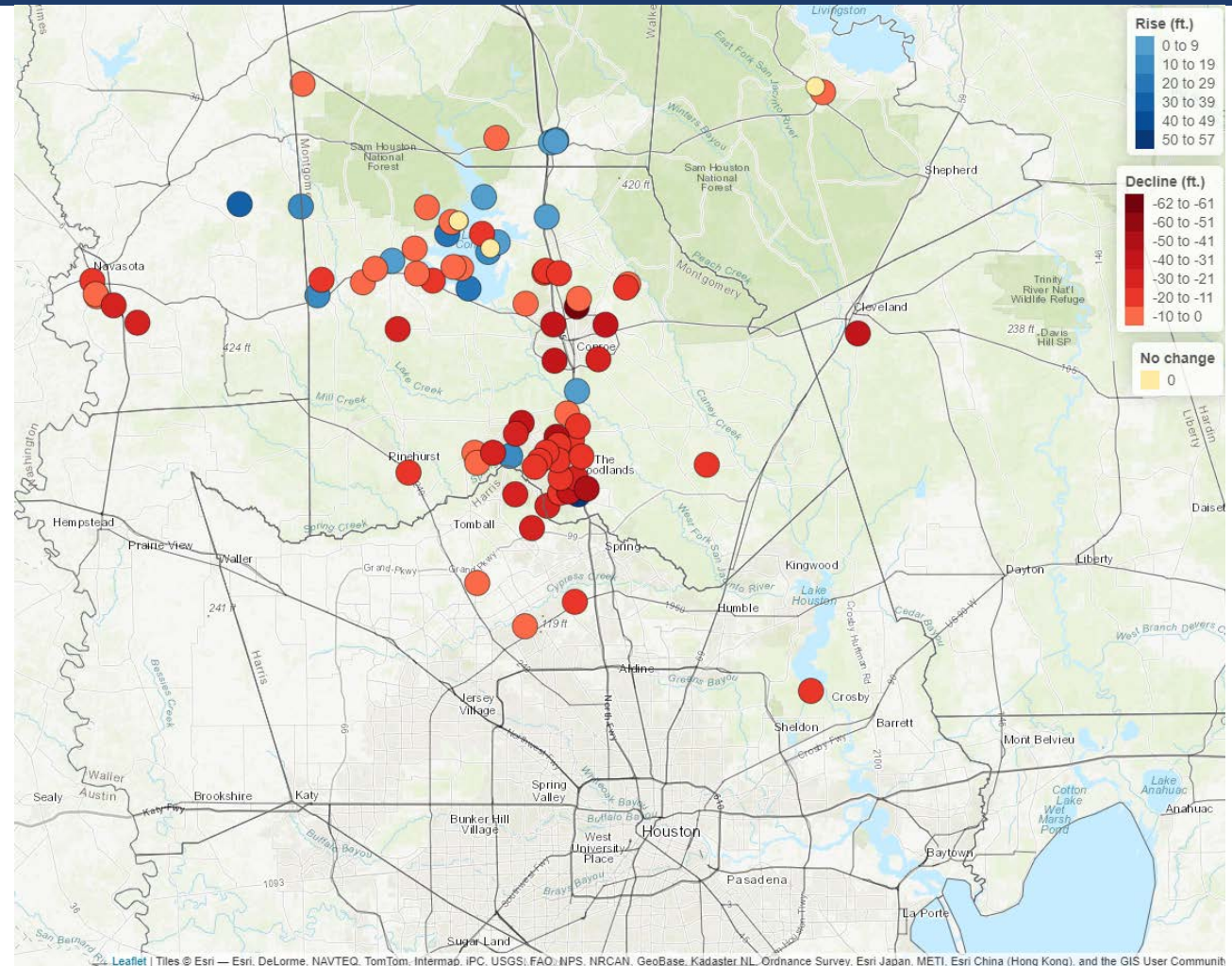
- Number of wells: **91**
- Rises: **38.5%**
- Declines: **52.7%**
- No change: **8.8%**





# Jasper Aquifer 5-Year Change

- Number of wells: **82**
- Rises: **19.5%**
- Declines: **75.6%**
- No change: **4.9%**



(Provisional - Subject to Revision)

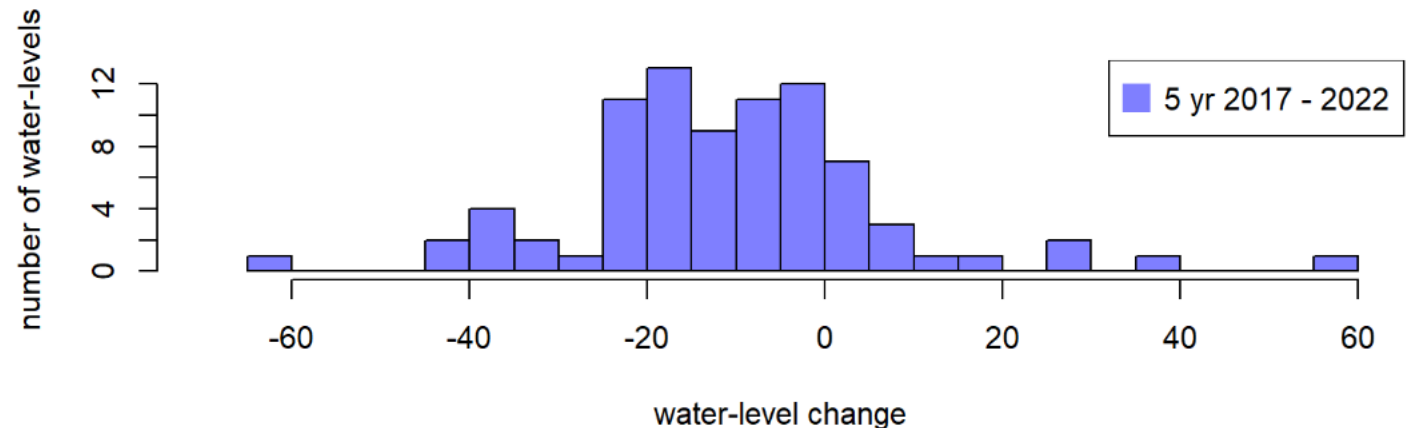
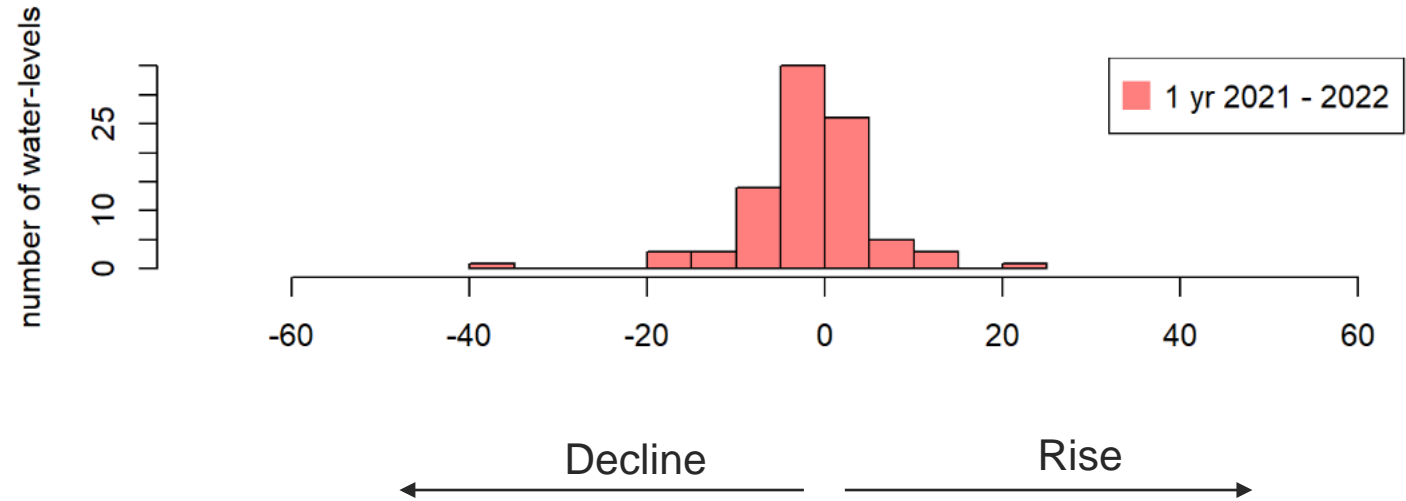
# Jasper Aquifer 1 and 5 Year Comparison

- 2021-2022 Changes

- Rises: **38%**
- Declines: **53%**
- No change: **9%**
- Rises in the 0-5 ft range: **~74% (26)**
- Declines in the 0-5 ft range: **~69% (33)**

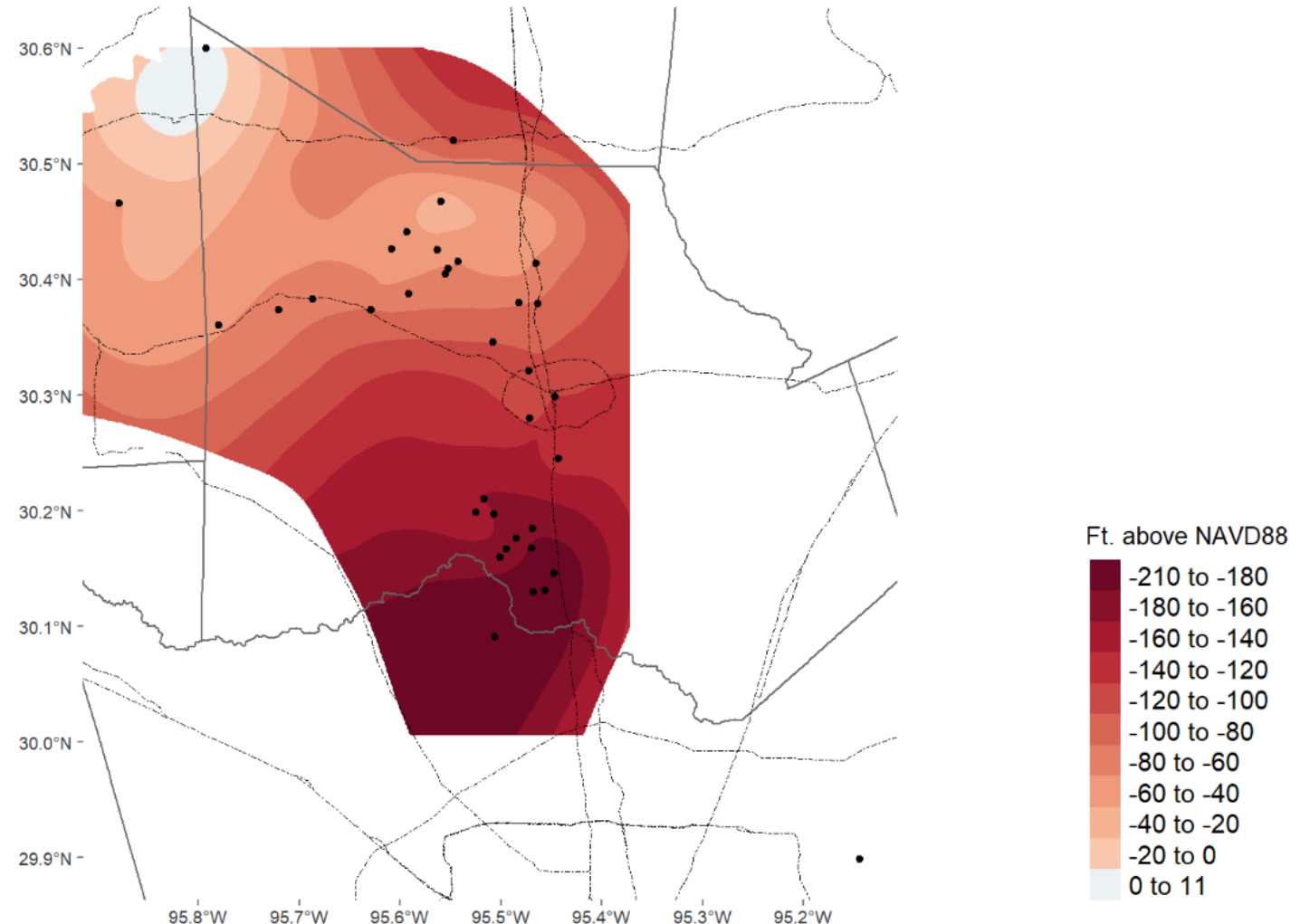
- 2017-2022 Changes

- Rises: **19%**
- Declines: **76%**
- No change: **5%**
- Rises in the 0-5 ft range: **~43% (7)**
- Declines in the 0-20 ft range: **~69% (43)**



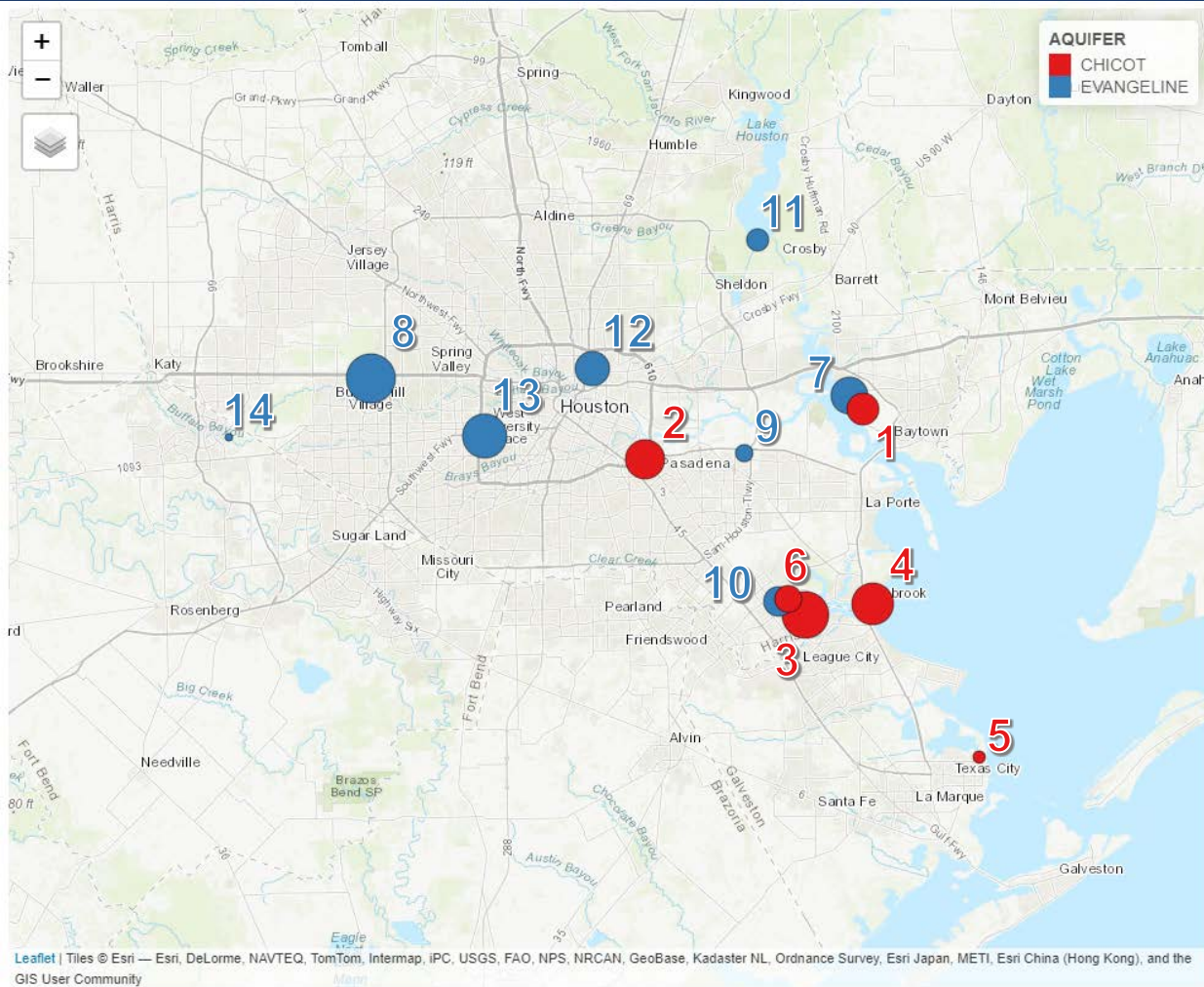
# Jasper Aquifer Water-Level Change Since 2000

- Data summary:
  - Min: **-210**
  - Mean: **-98**
  - Max: **11**
- General trend of declining water levels in downdip (NW-SE) direction
- Area with greatest declines along Harris – Montgomery County border





# Cumulative Compaction Recorded at Each Location as of December 2021



Size of symbol reflects amount of total cumulative compaction

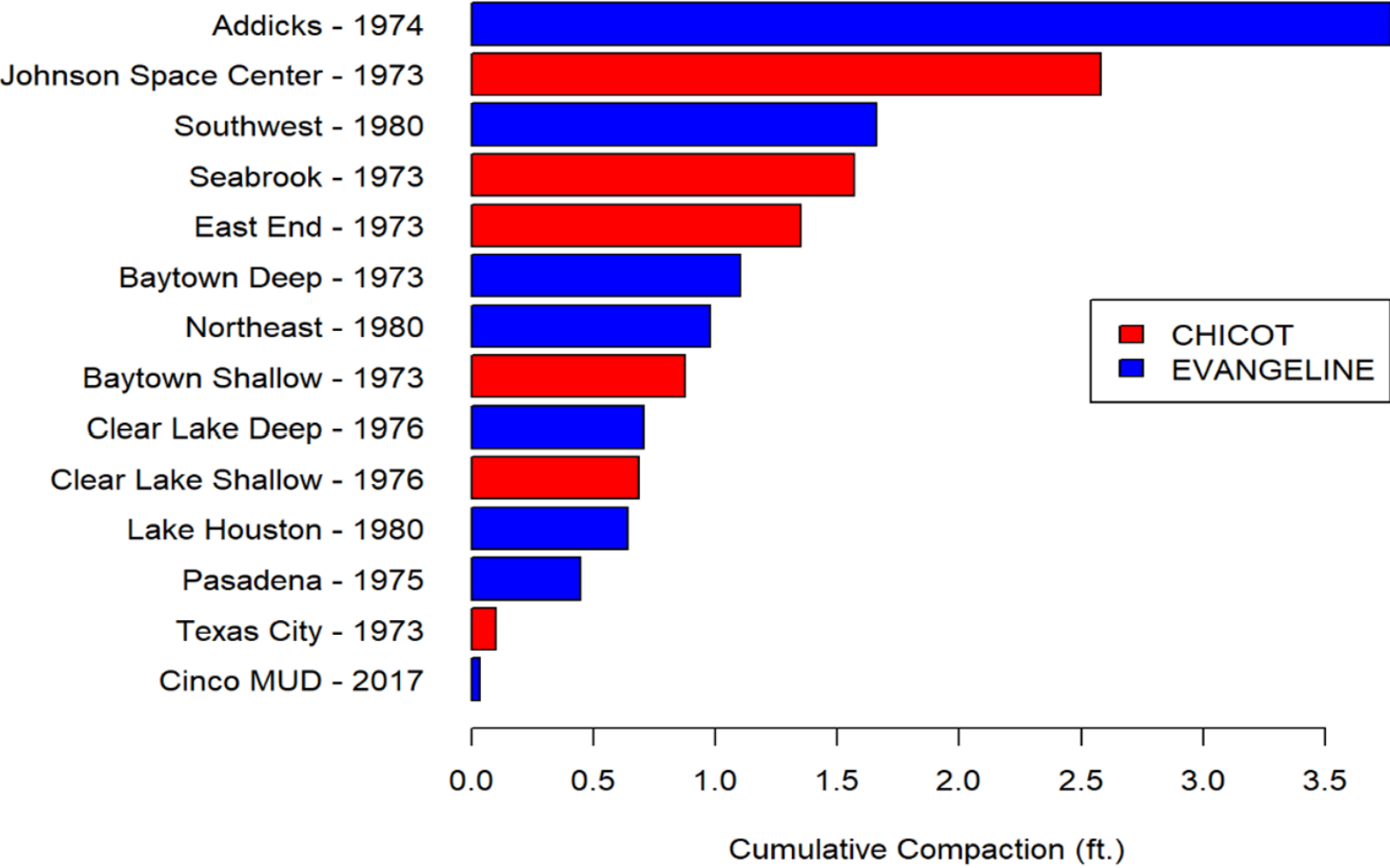
## Chicot Aquifer

1. 1973 | Baytown Shallow – 0.875 ft.
2. 1973 | East End – 1.350 ft.
3. 1973 | Johnson Space Center – 2.580 ft.
4. 1973 | Seabrook – 1.570 ft.
5. 1973 | Texas City – 0.096 ft.
6. 1976 | Clear Lake Shallow – 0.685 ft.

## Evangeline Aquifer

7. 1973 | Baytown Deep – 1.100 ft.
8. 1974 | Addicks – 3.770 ft.
9. 1975 | Pasadena – 0.446 ft.
10. 1976 | Clear Lake Deep – 0.705 ft.
11. 1980 | Lake Houston – 0.640 ft.
12. 1980 | Northeast – 0.978 ft.
13. 1980 | Southwest – 1.660 ft.
14. 2017 | Cinco MUD – 0.031 ft.

# Total Compaction Recorded Since Date of Initial Recording through December 2021



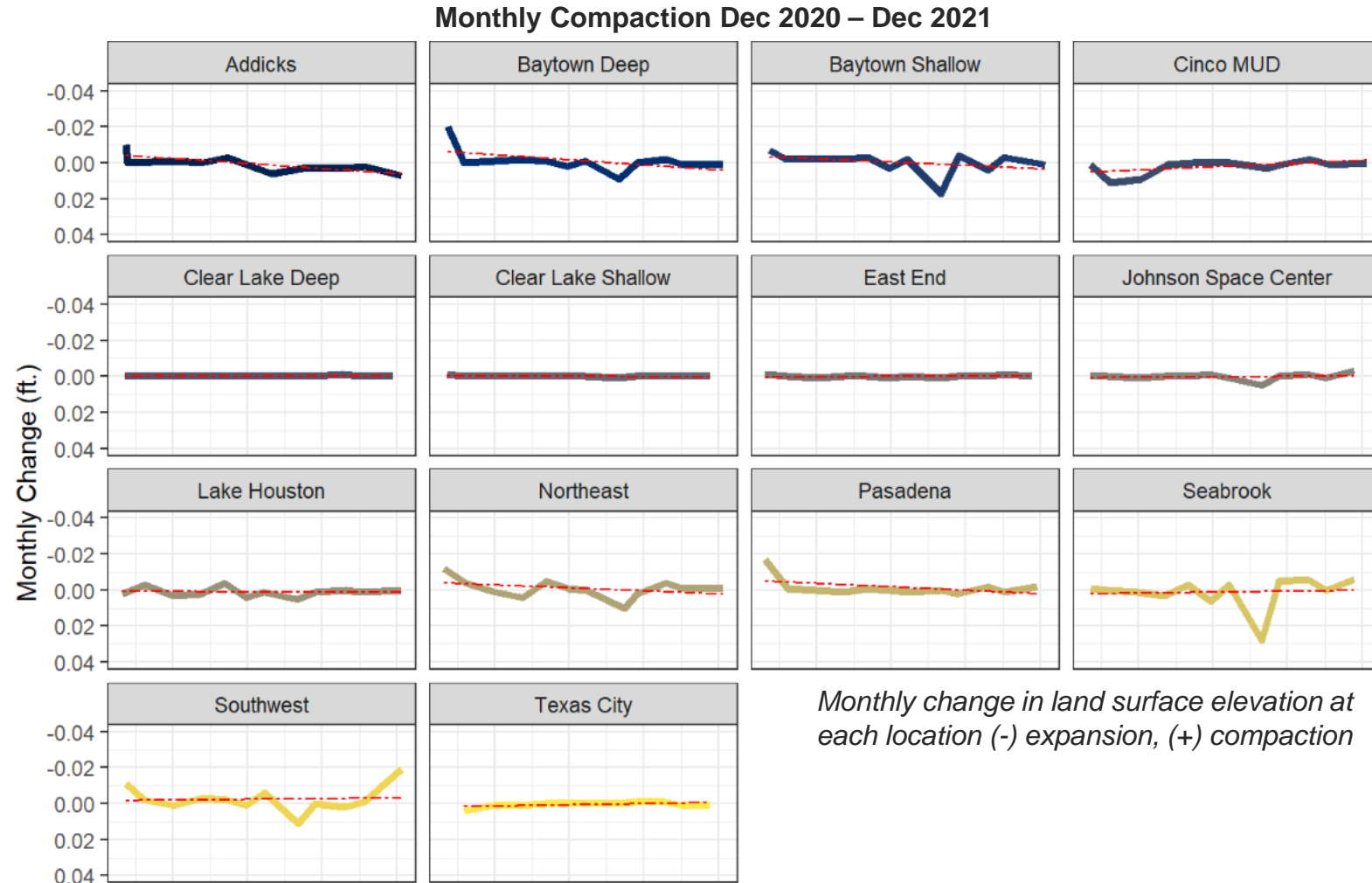
# Compaction 1-Year Monthly Changes

- Slight increase in trend (compaction)

- Addicks
- Baytown Deep
- Baytown Shallow
- Northeast
- Southwest

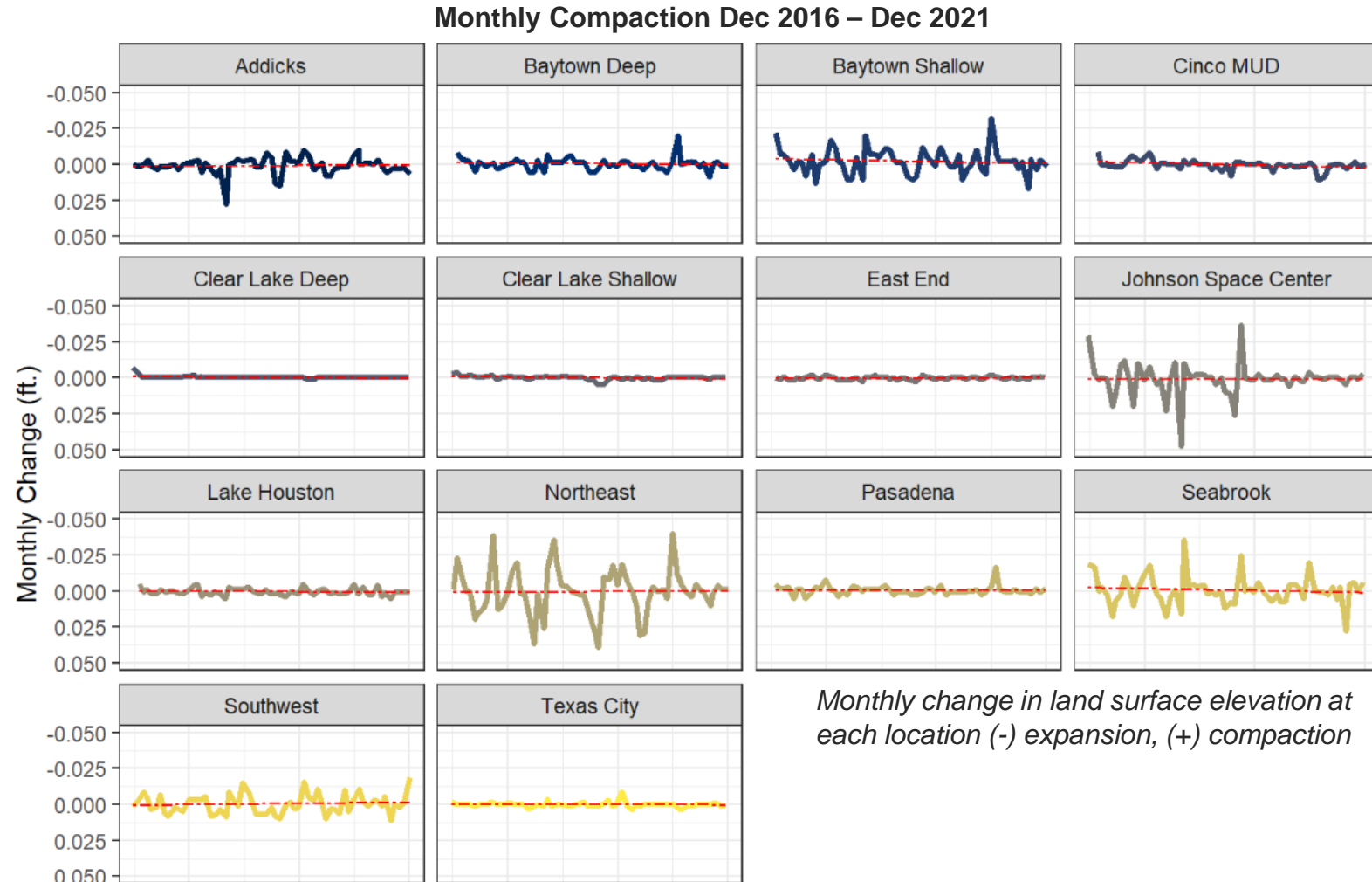
- Slight decrease in trend (expansion)

- Cinco MUD
- Northeast
- Pasadena
- Seabrook



# Compaction 5-Year Monthly Changes

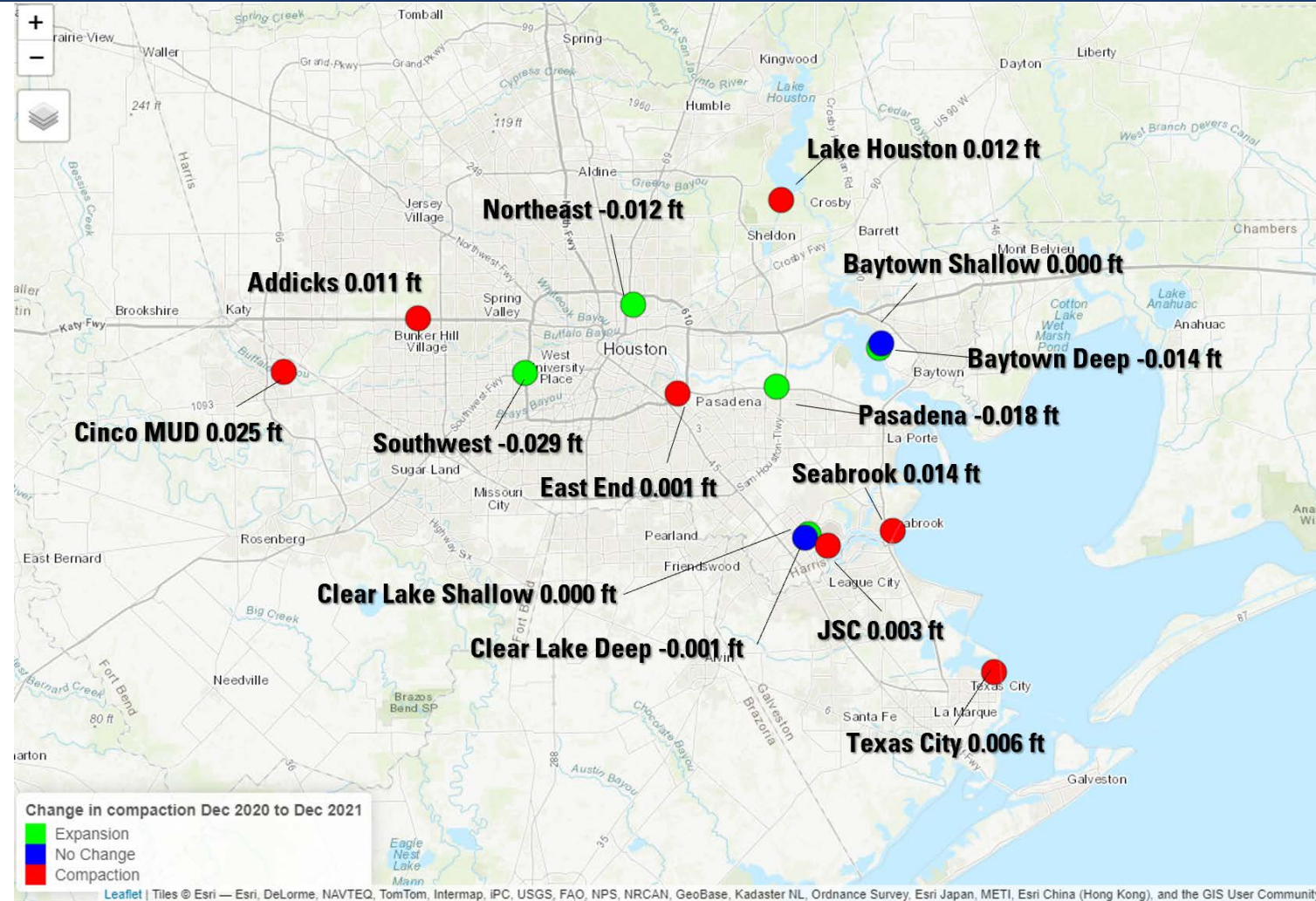
- Slight increase in trend (compaction)
  - Baytown Shallow
  - Cinco MUD
  - Seabrook
- Slight decrease in trend (expansion)
  - Southwest





# Compaction Summary | Absolute changes for the period December 2020 through December 2021

- 5 sites recorded expansion ranging from 0.001 ft. to 0.029 ft.
- 7 sites recorded compaction ranging from 0.001 ft. to 0.025 ft.
- 2 sites recorded no change





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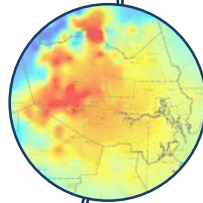
# Agenda



Climate



Groundwater Use



Groundwater Levels



**Subsidence Data**

# Subsidence Measurement Method | Exhibit 10

All Subsidence District operated Global positioning system (GPS) station are constructed in the Port-a-Measure (PAM) design and collect GPS data periodically.

Photo shows P051 located in Humble, TX.



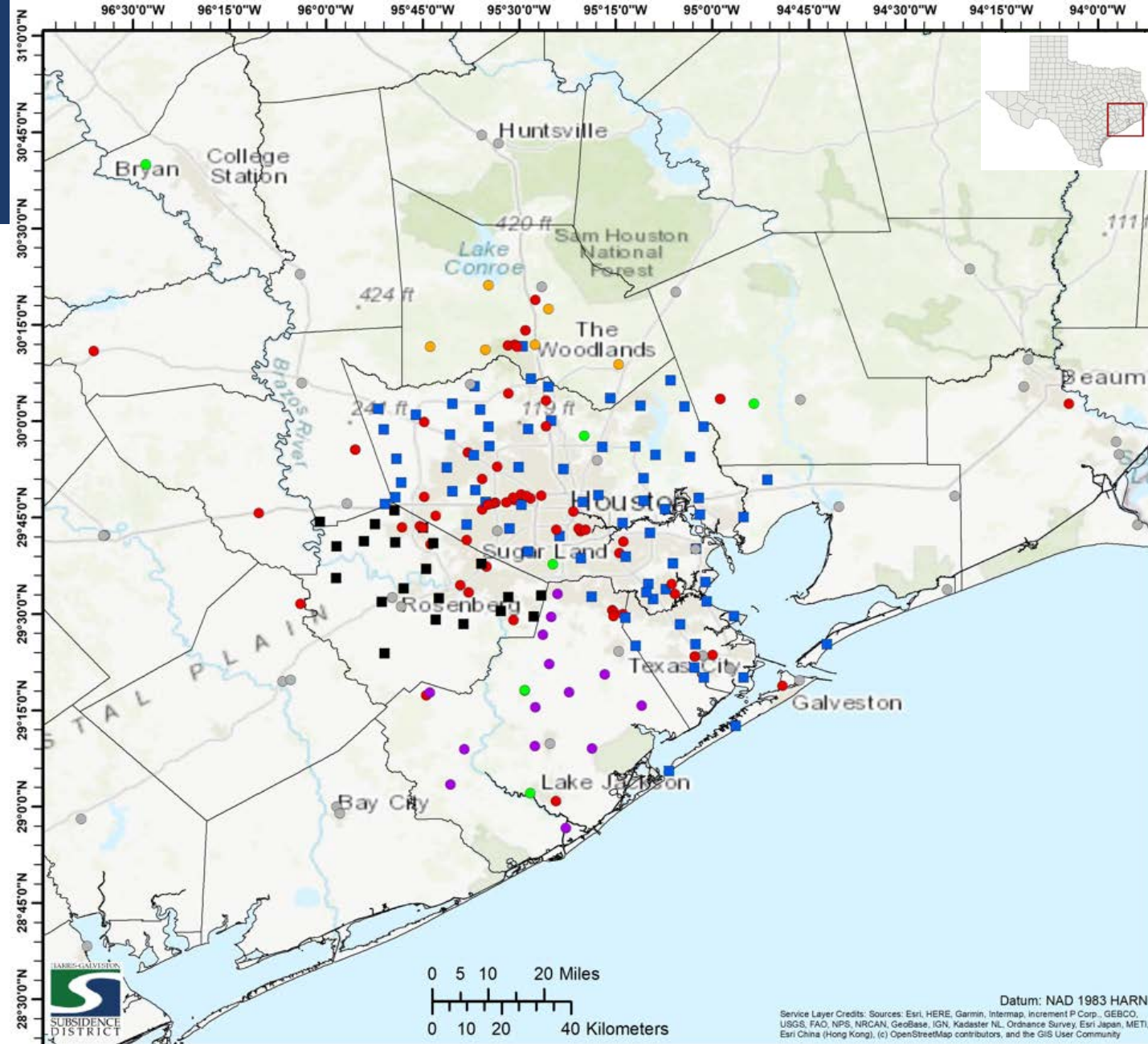
# Subsidence Monitoring Network | Exhibit 11

Location and operator of GPS stations that monitor land-surface deformation periodically or continuously within the greater Houston-Galveston region 2021.

## EXPLANATION

### GPS Station Operators

- Harris-Galveston Subsidence District
- Fort Bend Subsidence District
- Brazoria County Groundwater Conservation District
- Lone Star Groundwater Conservation District
- Texas Department of Transportation
- University of Houston
- Other Agencies





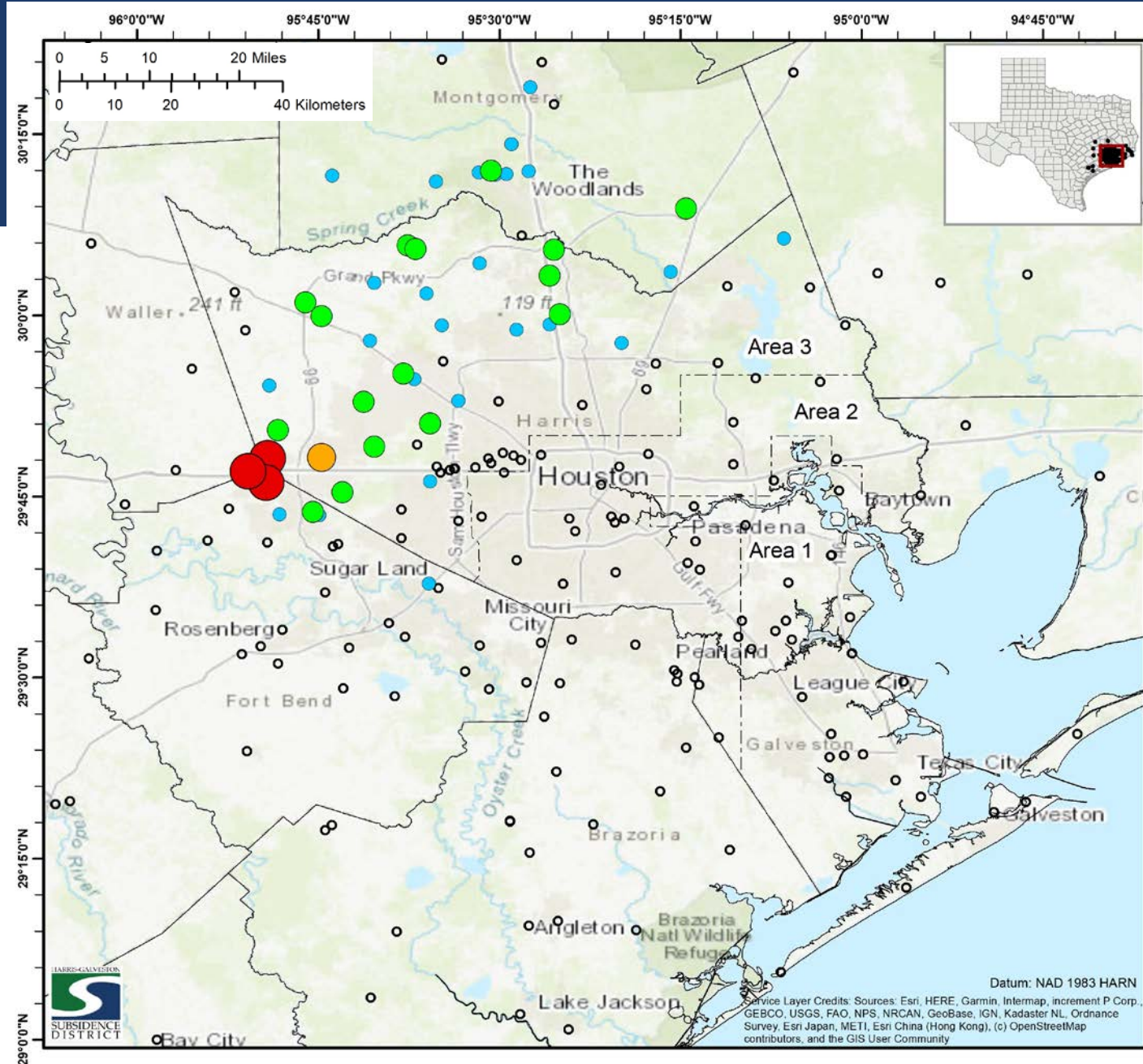
# 2017-2021 Subsidence Rate | Exhibit 12

Annual subsidence rate, in centimeters per year (cm/yr), measured at GPS stations with three or more years of GPS data in Harris and surrounding counties, averaged from 2017 to 2021.

## EXPLANATION

Annual Subsidence Rate (cm/yr) from 2017 to 2021

- Greater than 2.0
- <2.0 - 1.5
- <1.5 - 1.0
- <1.0 - 0.5
- Less than 0.5 or period of record less than 3 years



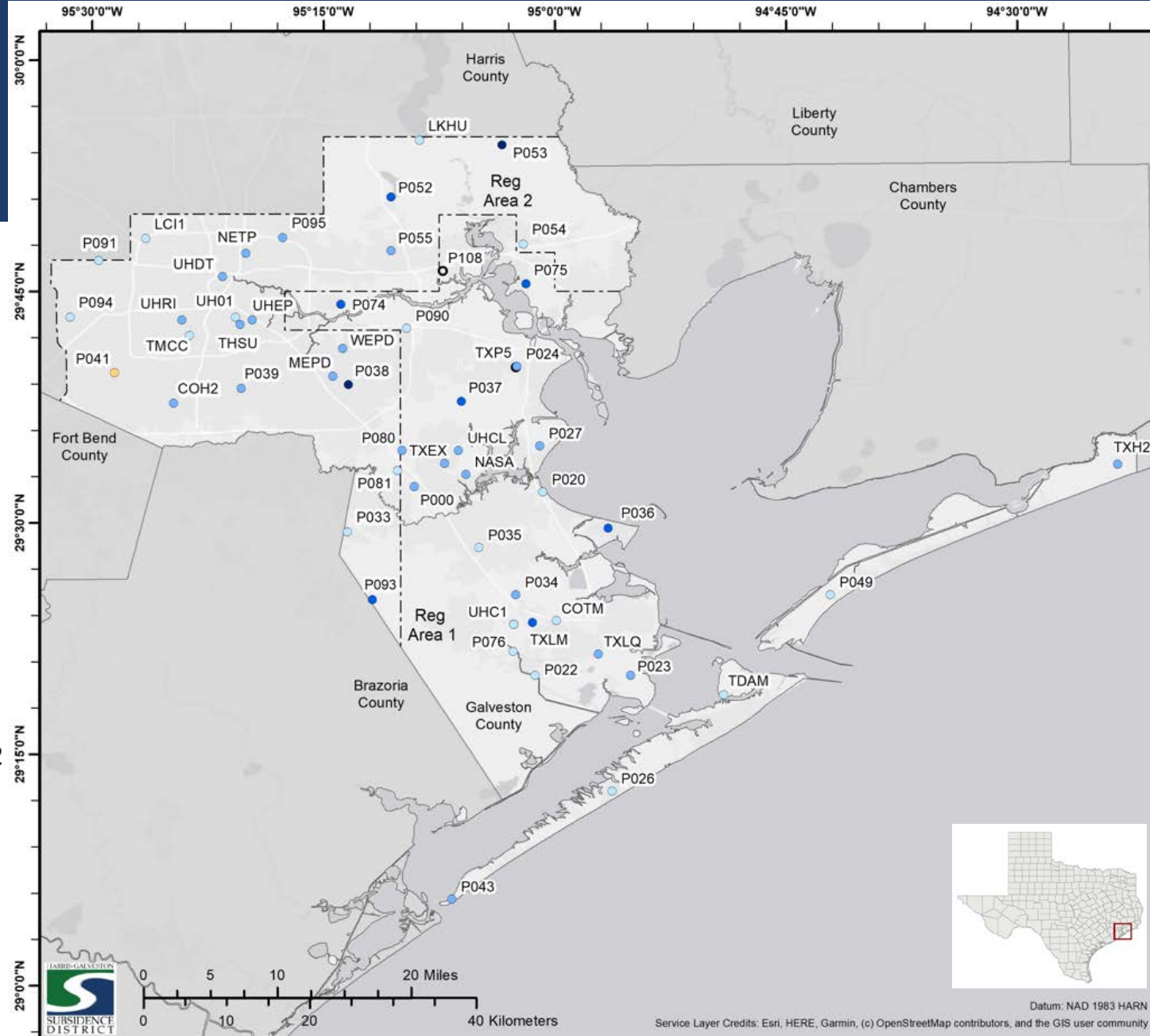
# Regulatory Areas One and Two | Exhibit 13

Annual vertical displacement rate (cm/yr) estimated from three or more years of GPS data measured at GPS stations in Harris and Galveston counties, averaged from 2017 to 2021.

## EXPLANATION

Annual Vertical Displacement (cm/yr) from 2017 to 2021 in HGSD Regulatory Areas 1 and 2

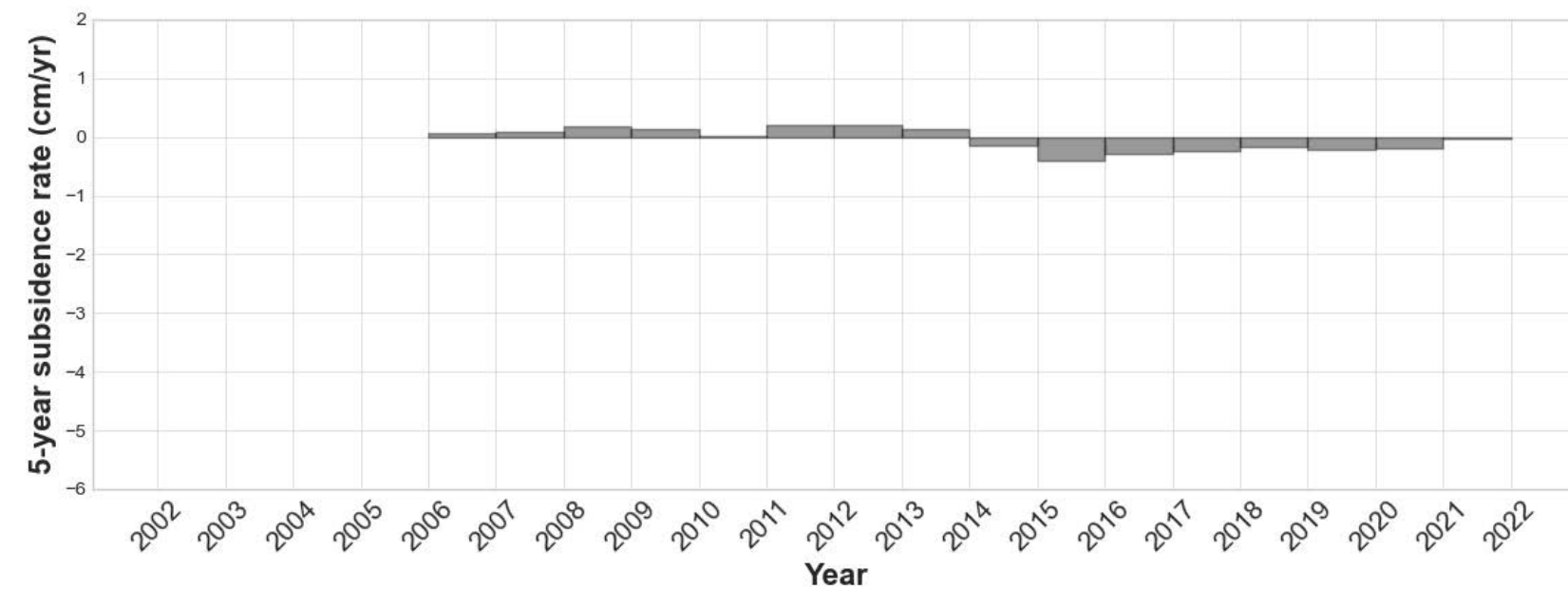
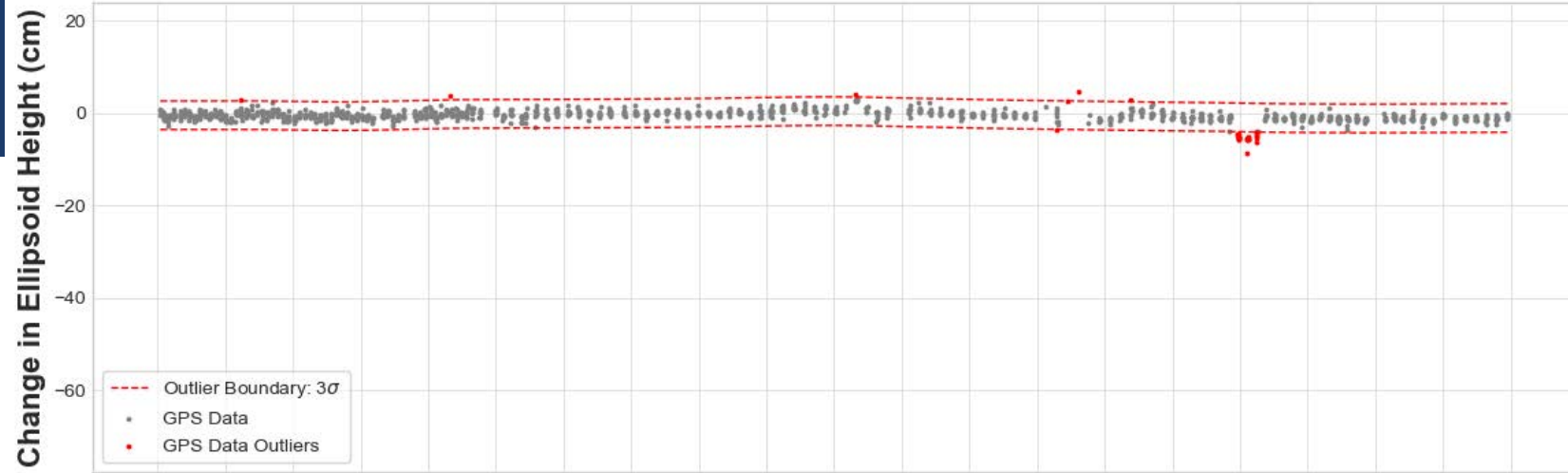
- -0.5 - -0.35
- -0.35 - 0
- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- GPS stations monitoring less than 3 years



# P020 POR Plot | Exhibit 14

GPS station P020, located in Kemah, has measured a total of approximately 0.7 cm of subsidence since 2002.

Processed GPS data (source: UH) over period of record. Processed data (grey circles) located inside the outlier boundary (red dashed lines) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are excluded from subsidence rate calculations and are shown for informational purposes only.





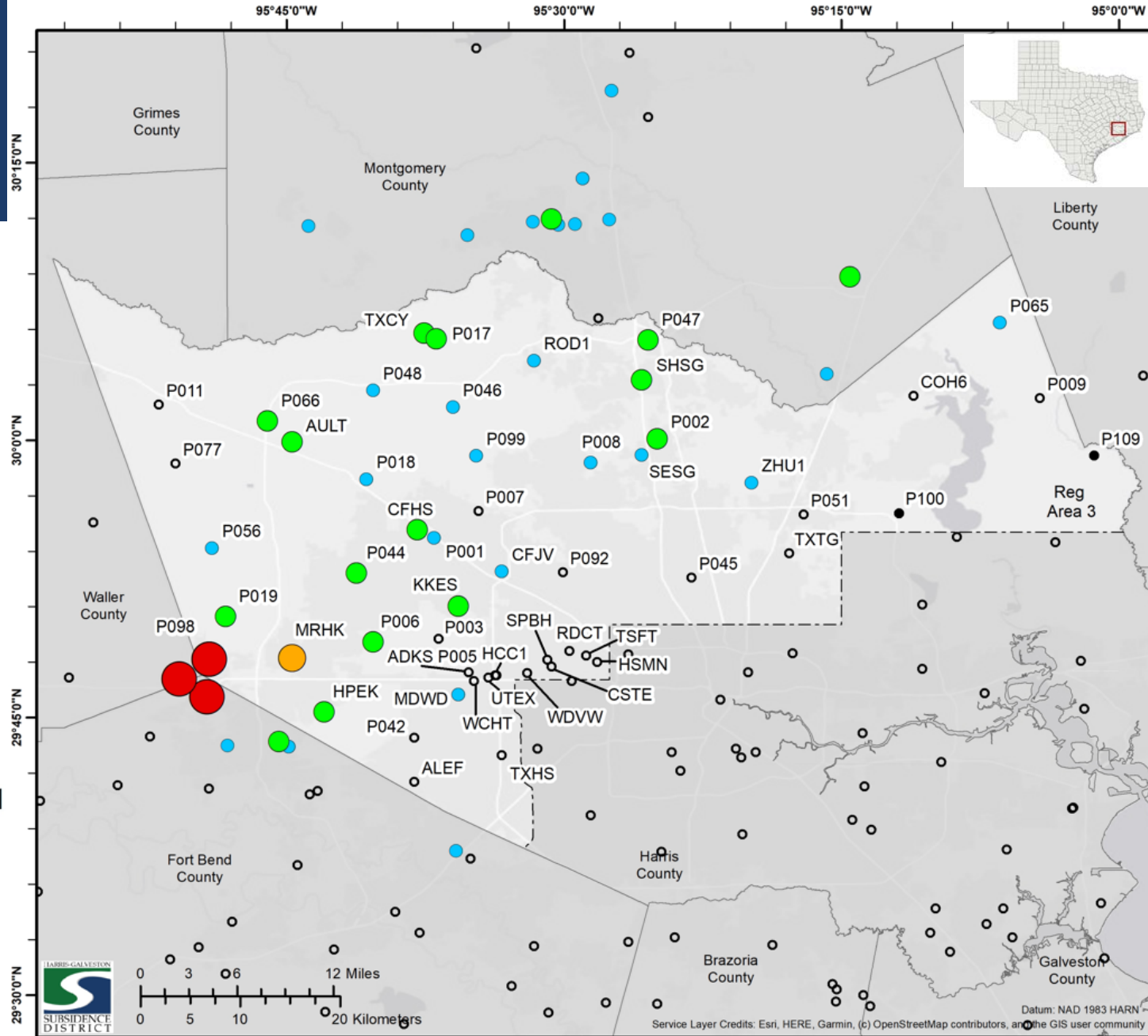
# Regulatory Area Three | Exhibit 15

Annual subsidence rate (cm/yr) estimated from three or more years of periodic or continuous GPS data measured at GPS stations in Harris County, Texas, from 2017 to 2021.

## EXPLANATION

### Annual Subsidence Rate (cm/yr) from 2017 to 2021

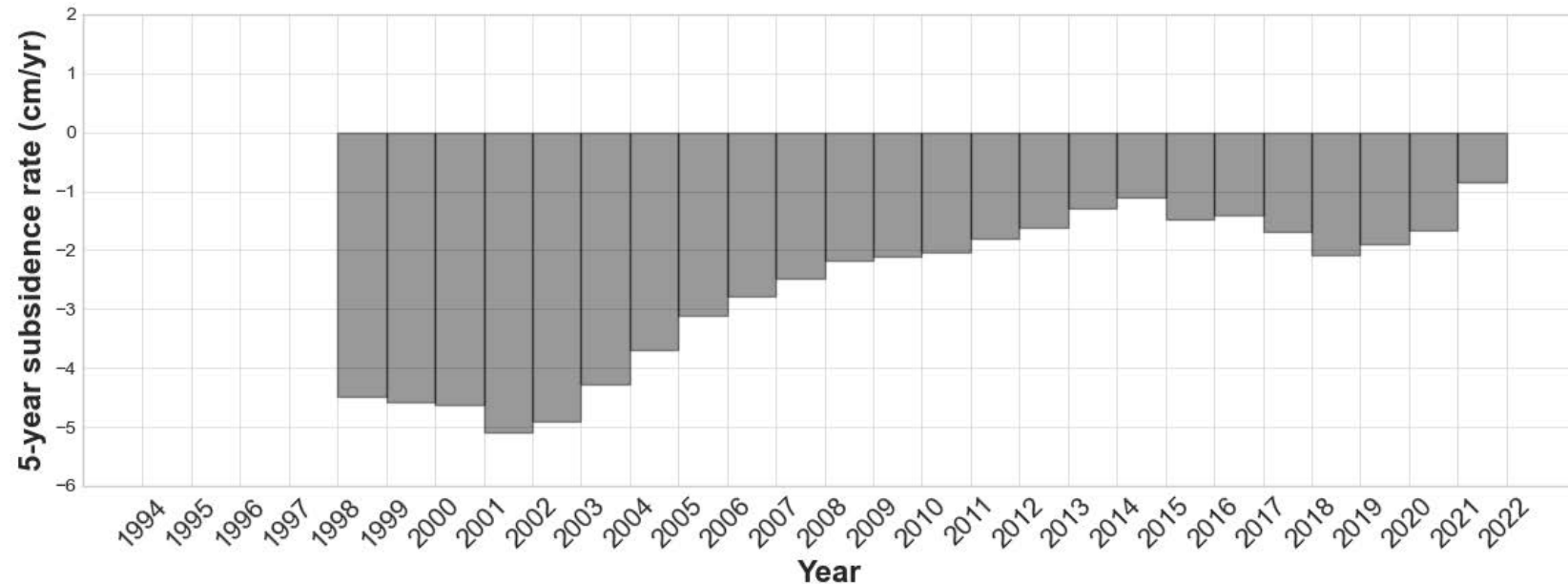
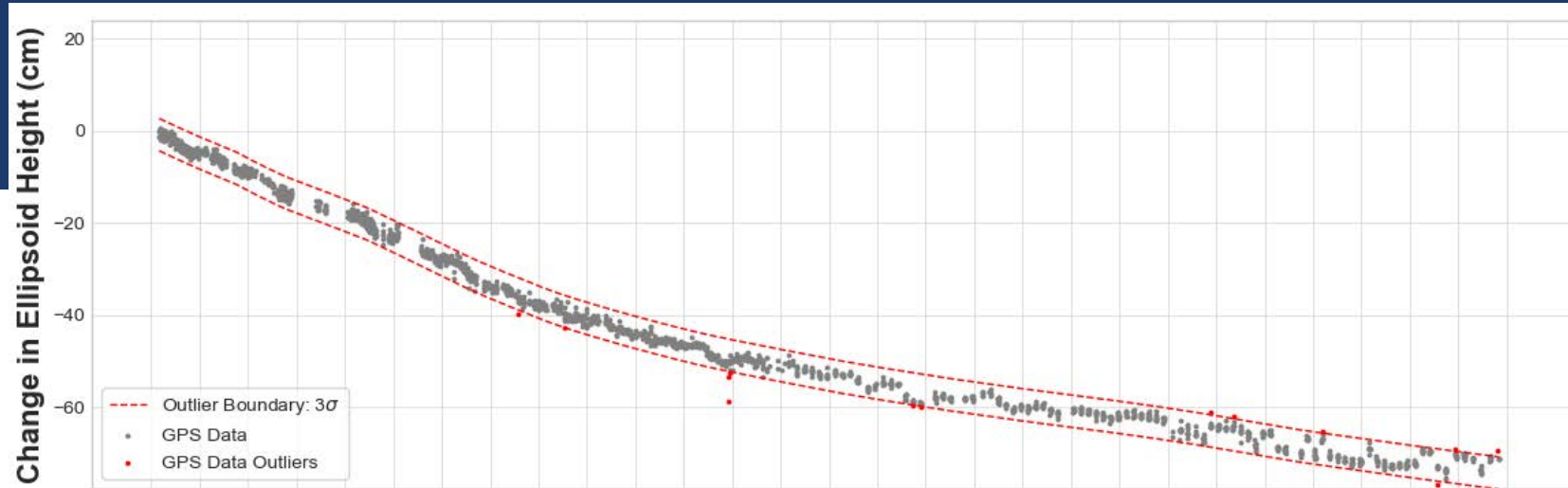
- Greater than 2.0
- <2.0 - 1.5
- <1.5 - 1.0
- <1.0 - 0.5
- Less than 0.5 or period of record less than 3 years



# P001 POR Plot | Exhibit 16

GPS station P001, located in Jersey Village, has measured a total of approximately 71 cm of subsidence since 1994.

Processed GPS data (source: UH) over period of record. Processed data (grey circles) located inside the outlier boundary (red dashed lines) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are excluded from subsidence rate calculations and are shown for informational purposes only.



# Testimony and Public Comment

Any person who wishes to appear at the hearing and present testimony, evidence, exhibits or other information may do so in person, by counsel, via email to [info@subsidence.org](mailto:info@subsidence.org) or any combination of these options.

# Thank you for attending the Public Hearing for the 2021 Annual Groundwater Report



- Record will be open until May 6, 2022. You may provide comments by sending an email to [info@subsidence.org](mailto:info@subsidence.org).
- The 2021 Annual Groundwater Report will be presented to the Harris-Galveston Subsidence District Board of Directors on May 11, 2022.
- The 2021 Annual Groundwater Report will be posted on the District's website ([www.hgsubsidence.org](http://www.hgsubsidence.org)) upon approval of the District's Board of Directors.



HARRIS - GALVESTON  
SUBSIDENCE DISTRICT

## Contact Information

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