GMA 14 Discussions of Impact on Subsidence

Groundwater Management Area 14

May 28, 2025

Desired Future Conditions (“DFCs”) TWC 36.108(d-2)

Highest Practicable Level
of Groundwater Production

Conservation,
Preservation, Protection,
Recharging, and Prevention
of Waste of Groundwater
and Control of Subsidence

DFC Considerations TWC 36.108(d)

(1) Aquifer Uses or Conditions

(2) Supply Needs and Management Strategies

(3) Hydrological Conditions

(4) Environmental Impacts

(5) Subsidence Impacts

(6) Socioeconomic Impacts

(7) Private Property Rights

(8) Feasibility

(9) Other Relevant Information

Subsidence Concepts

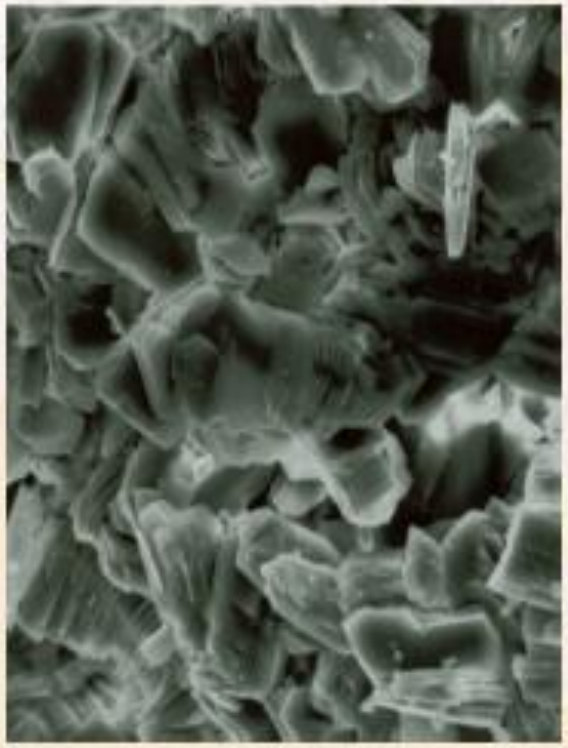
- Lowering or sinking of the land surface, typically in response to removal of subsurface support
- Reference is land surface
- Cumulative effect of subsurface processes, such as
  - Formation compaction
  - Fault movement
  - Plate tectonics

Modified from GMA 14 Presentation on July 15, 2020

Subsidence Concepts

Sand Grains: Larger – Round(ish)

Image Source: Wilson44691 - Own work, CC0, https://commons.wikimedia.org/w/index.php?curid=37934665



Clay Grains: Very Small – Flat

Image Source: USGS, Public Domain

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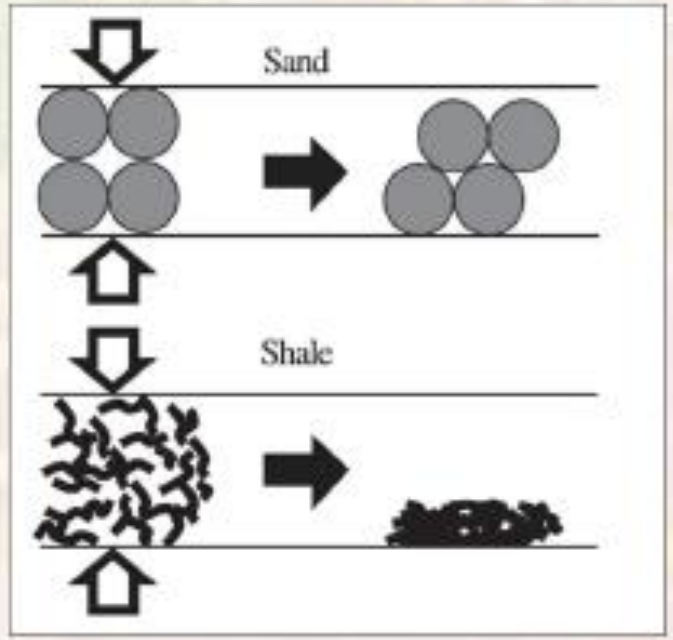
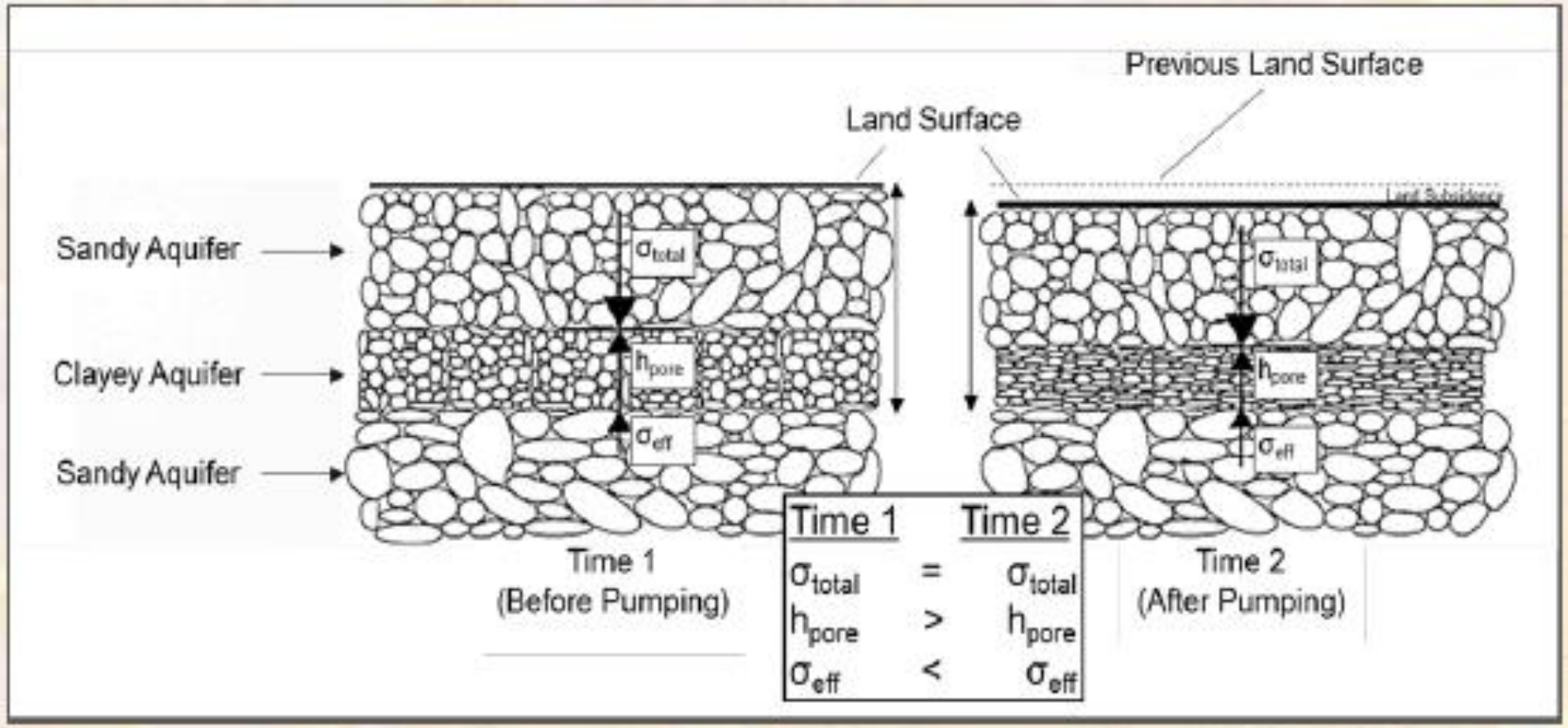
Subsidence Concepts





Reproduced from GMA 14 Presentation on July 15, 2020

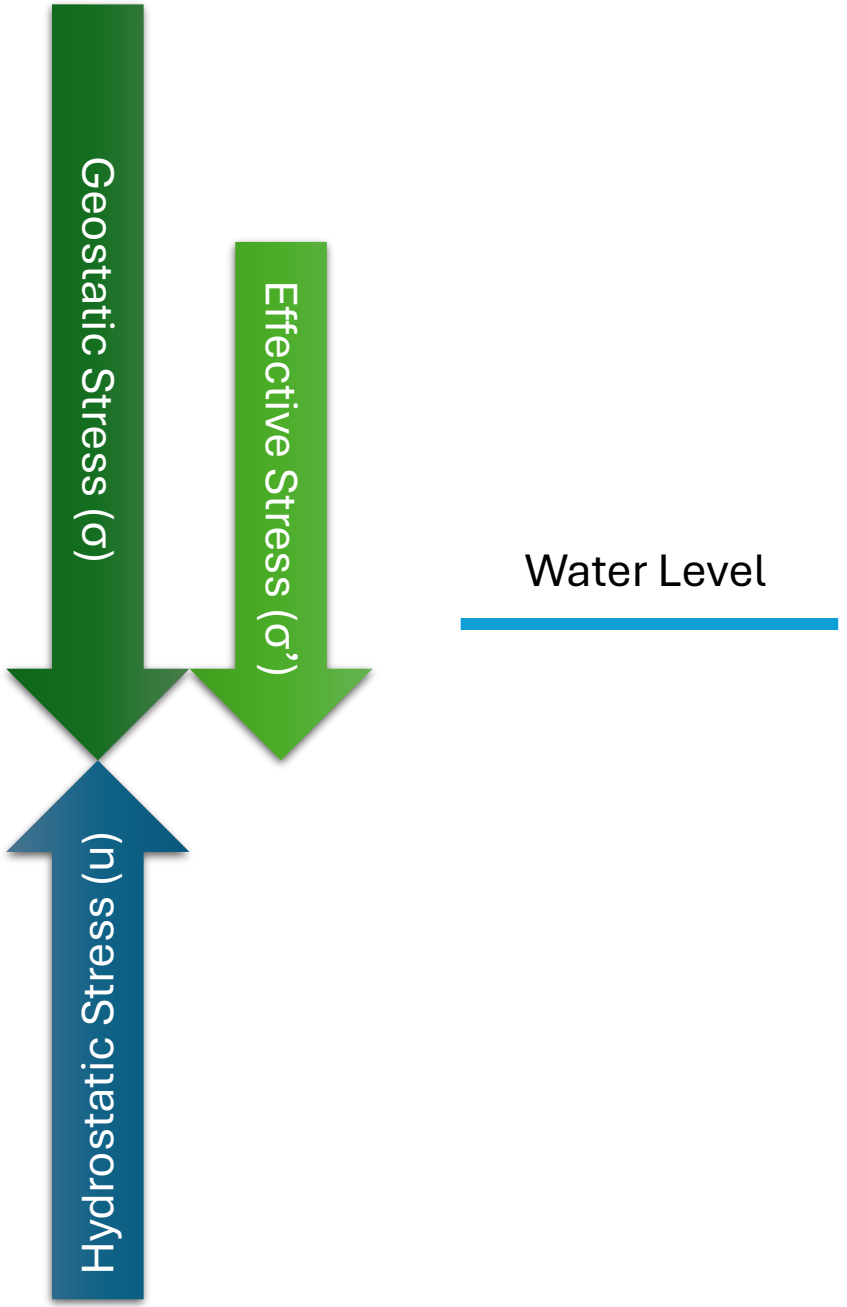
Formation Compaction

- A thinning of a geologic formation
- Beneath land surface
- Our focus is compaction correlated with groundwater withdrawal
- Change in water levels causes a change in effective stress

Compaction

$$\sigma' = \sigma - u$$

- Geostatic stress (σ)
  - Sediments and fluids
  - Urban loading
- Hydrostatic stress (u)
  - Pore pressure
- Effective stress (σ’)
  - Difference between geostatic and hydrostatic



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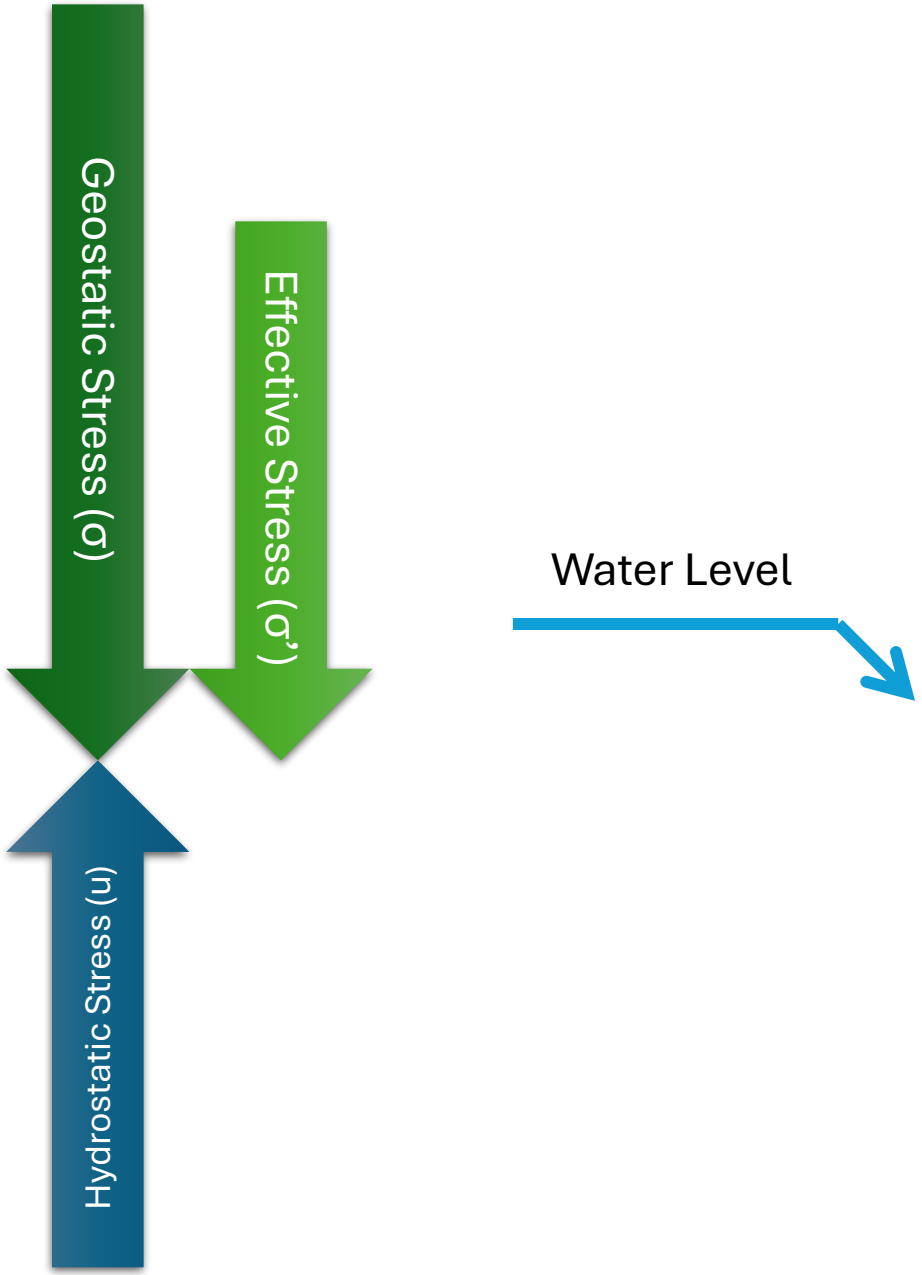

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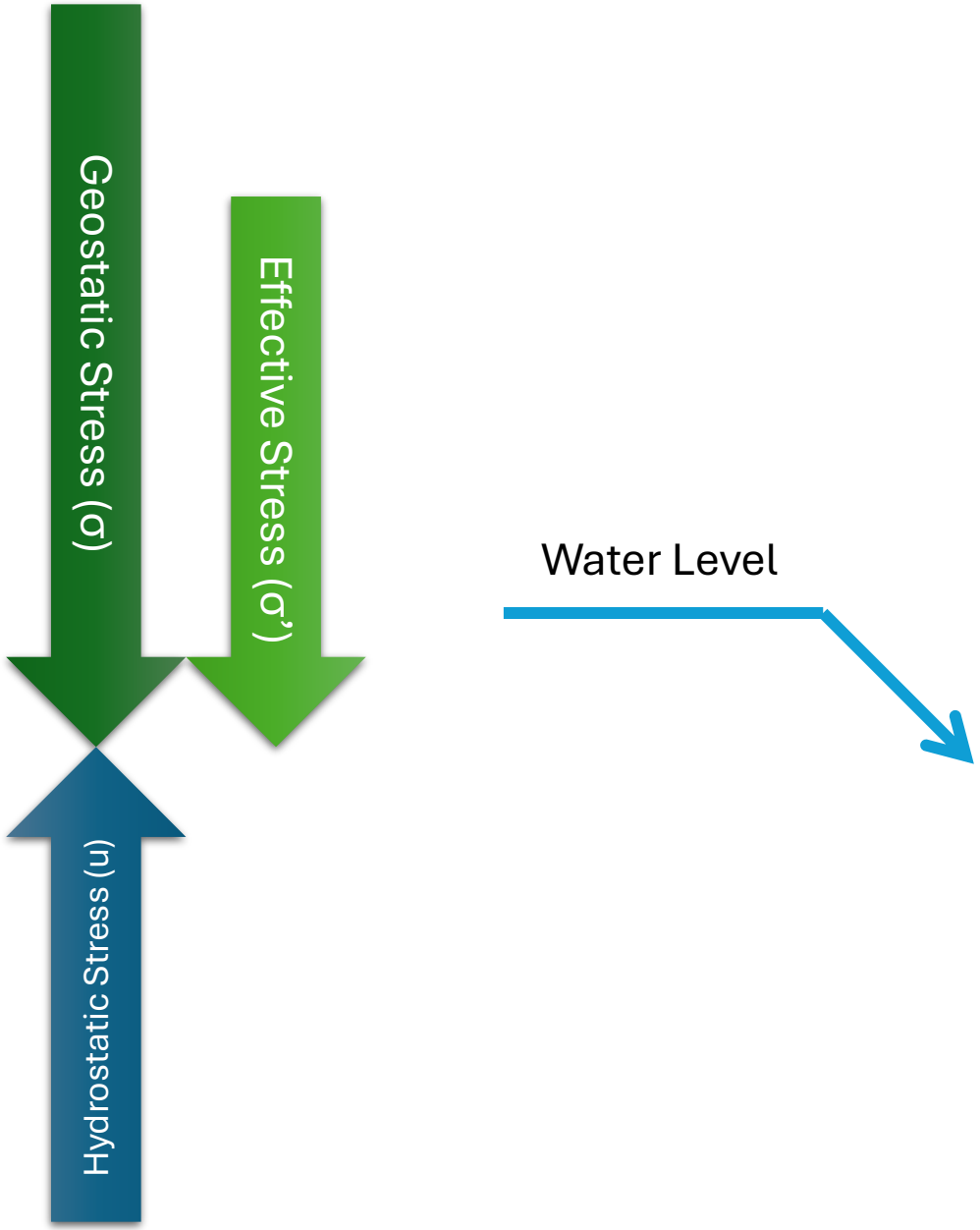

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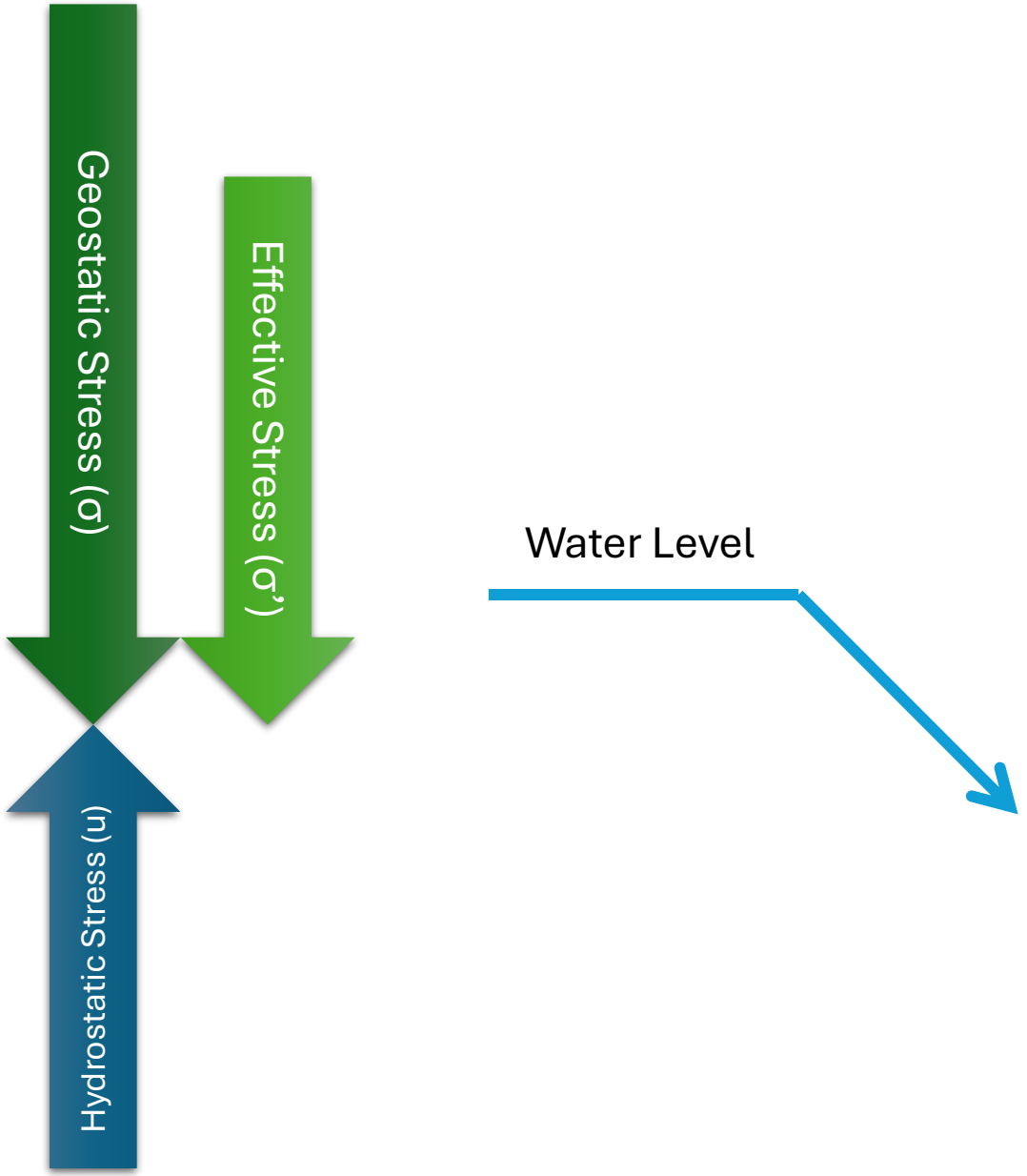

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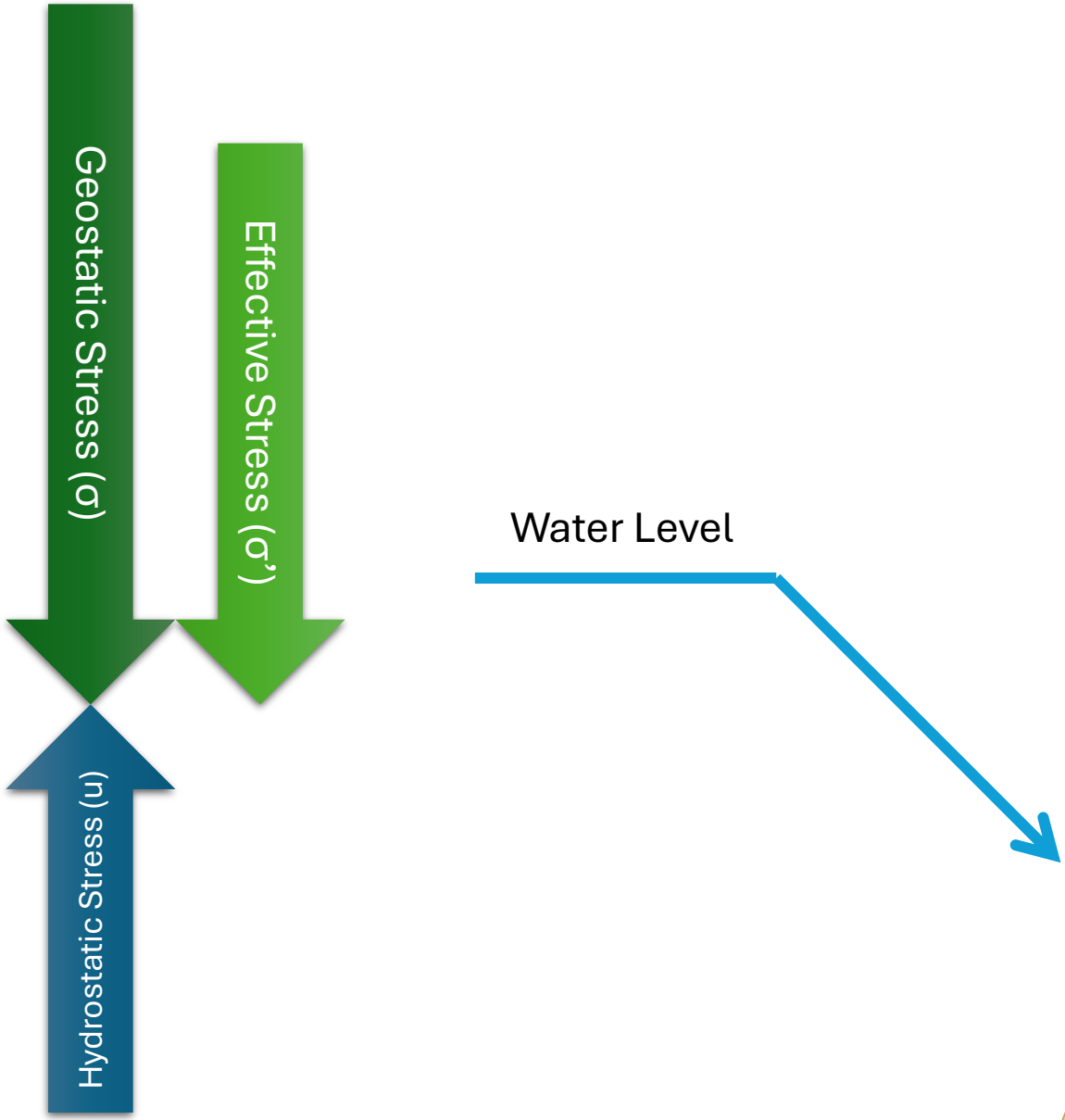
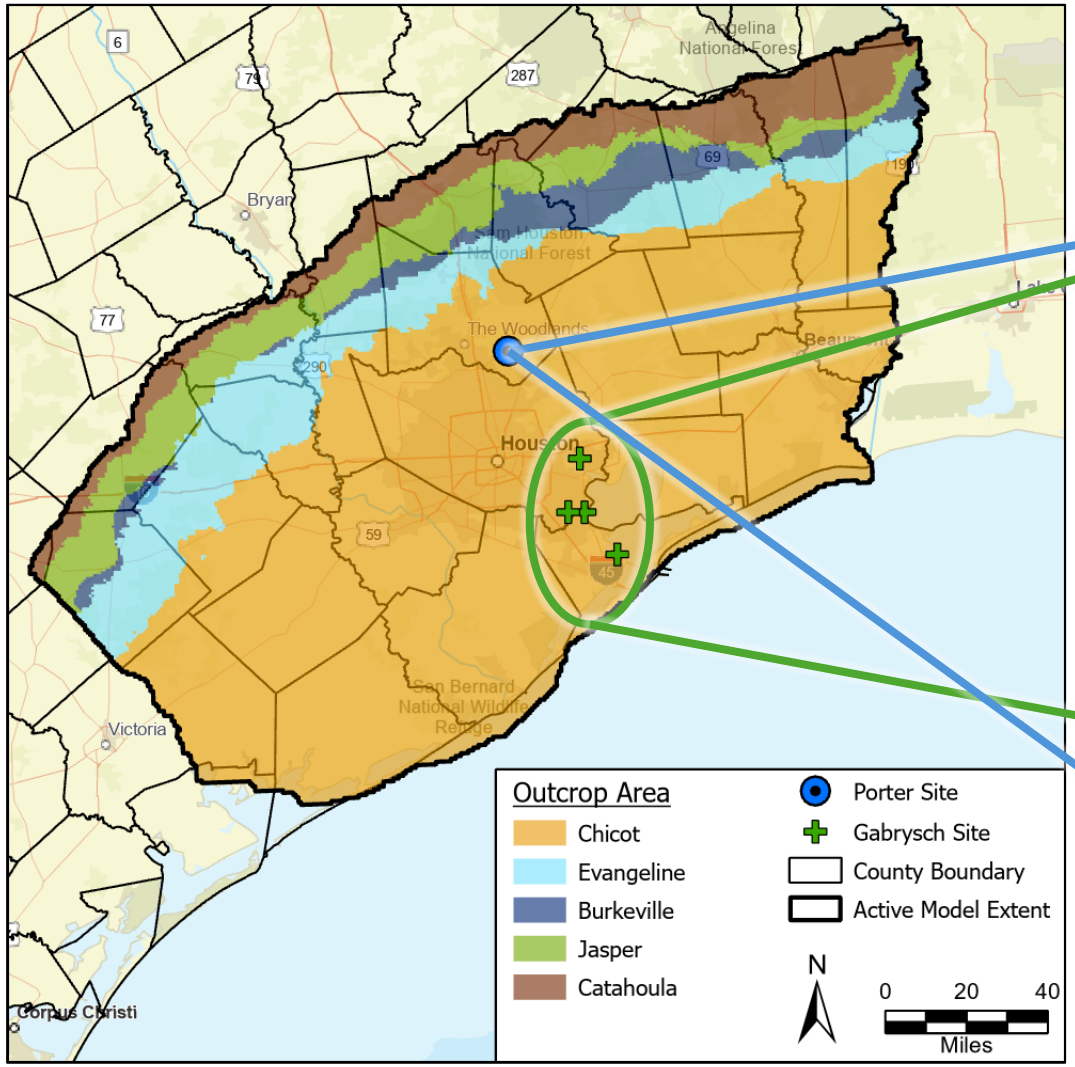
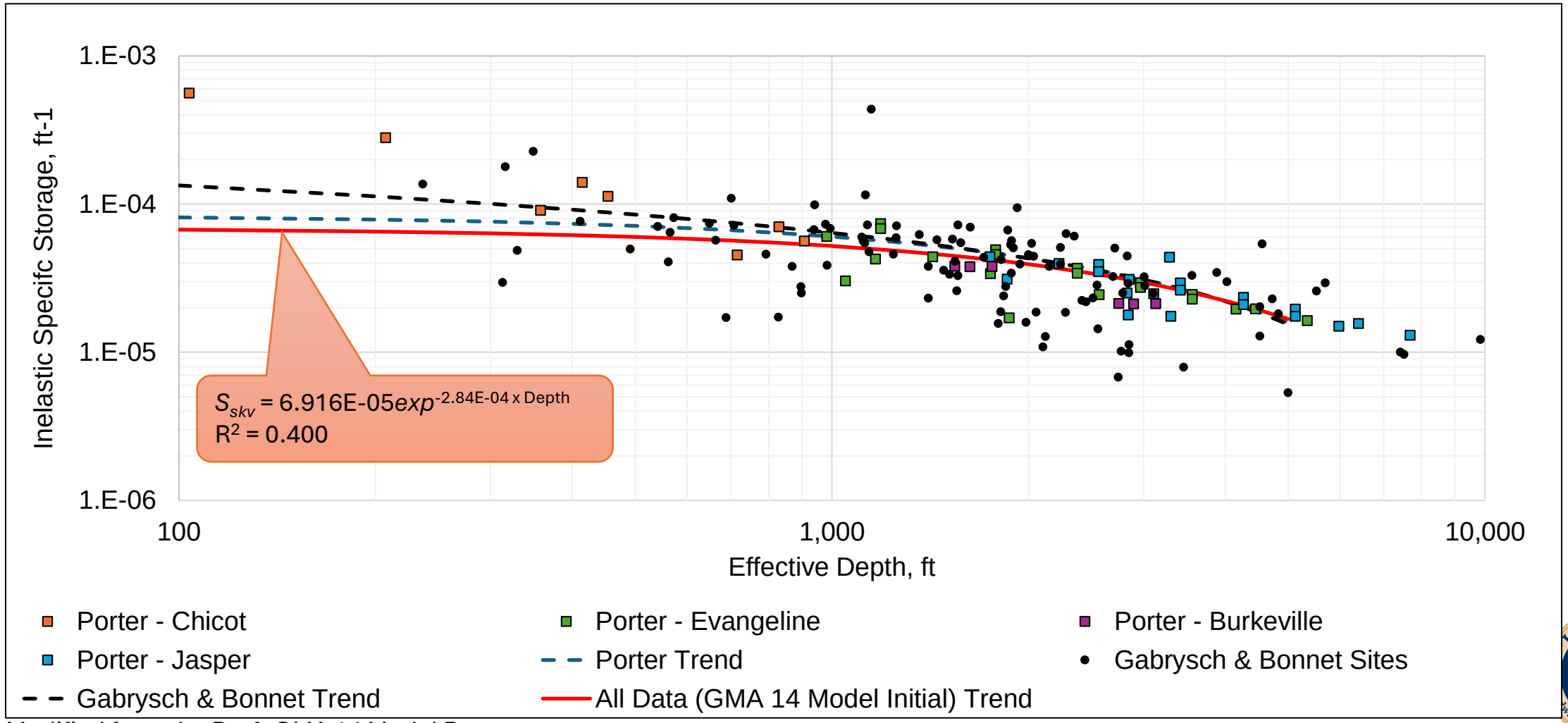


Gulf Coast Aquifer System



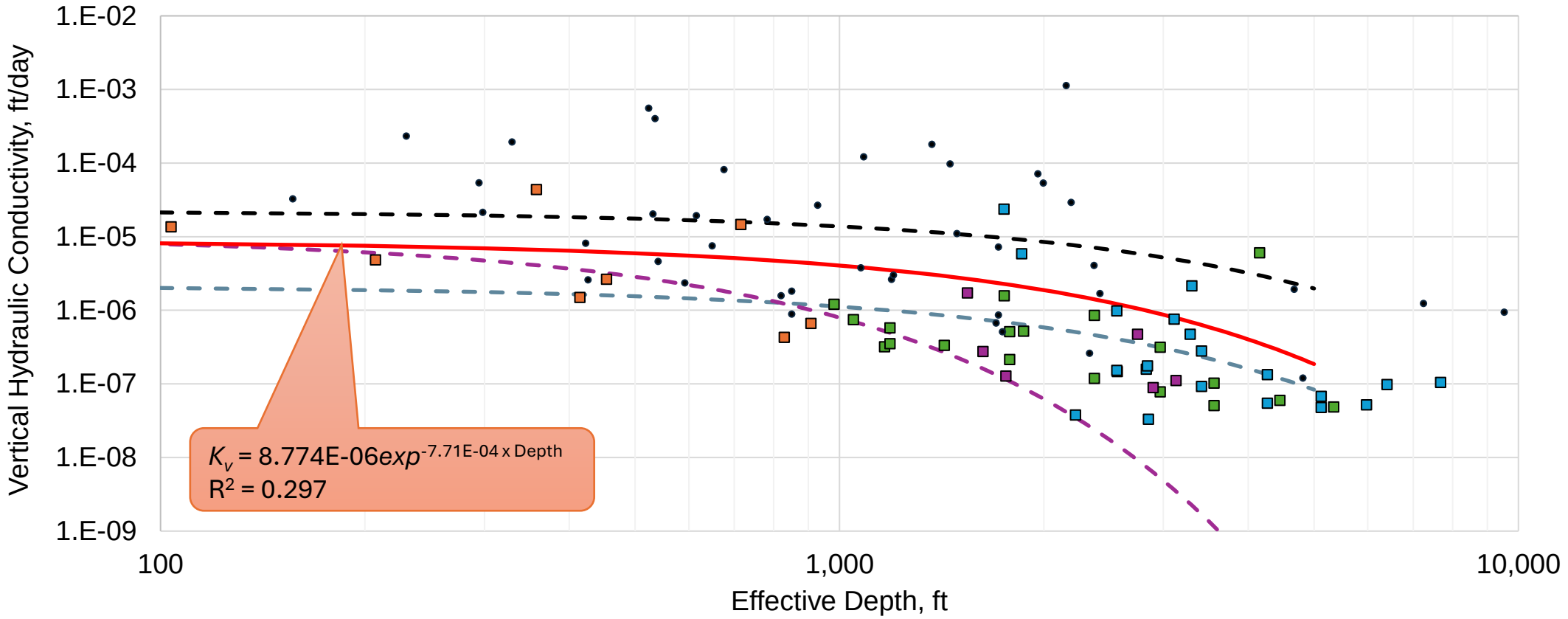
Epoch	Hydrogeologic Unit	Geologic Unit		
Holocene	Alluvium			
Pleistocene	Chicot Aquifer	Beaumont Clay		
		Lissie Formation		
Pliocene		Willis Formation		
Miocene	Evangeline Aquifer	Goliad Sand		Upper
				Lower
	Burkeville Confining Unit	Fleming Formation	Lagarto	Upper
				Middle
	Upper Jasper Aquifer			Lower
	Lower Jasper Aquifer		Oakville	
Oligocene	Catahoula		Catahoula	

Inelastic Specific Storage (Sskv)



Modified from the Draft GMA 14 Model Report

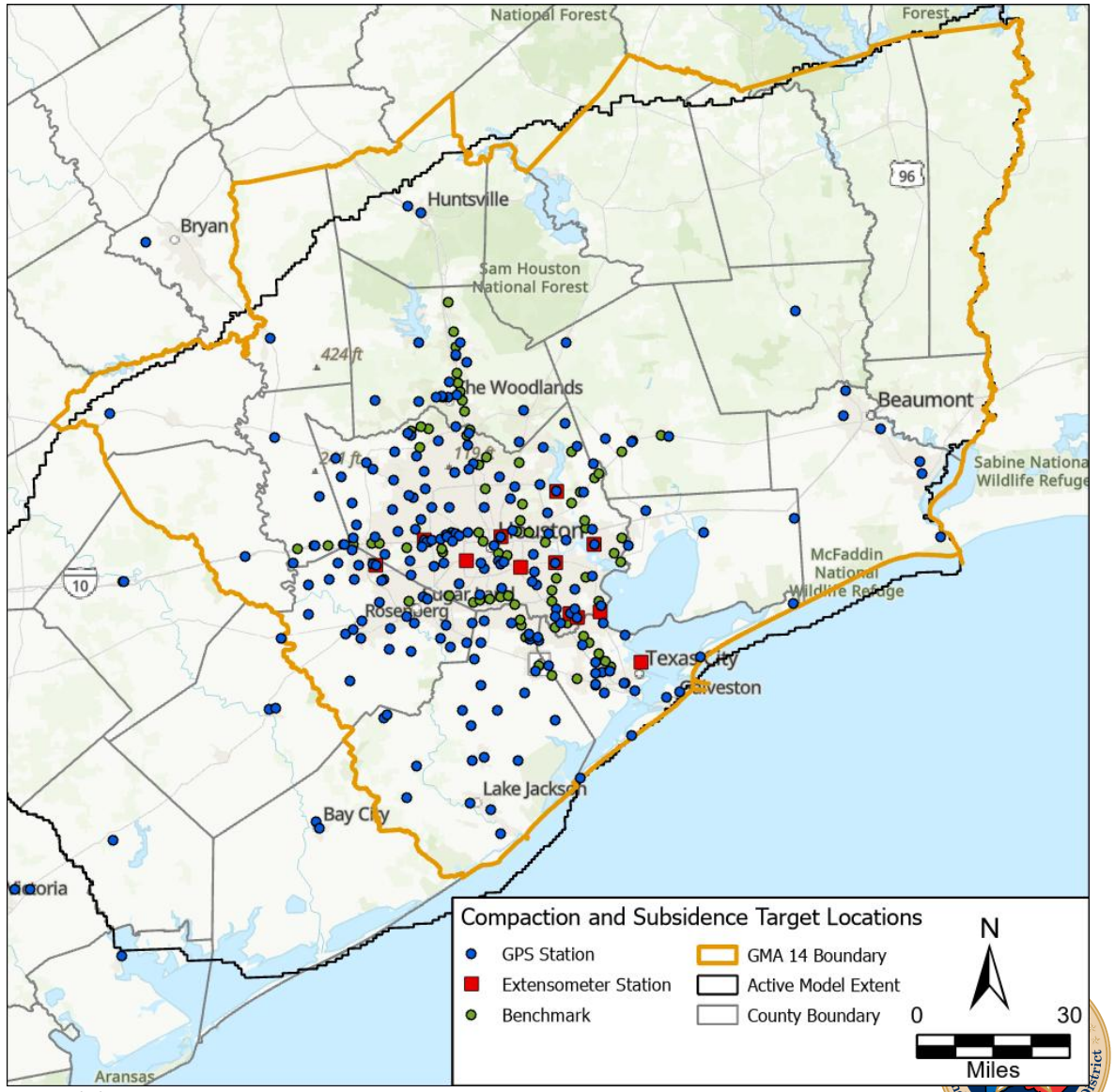
Vertical Hydraulic Conductivity (Kv)



Modified from the Draft GMA 14 Model Report

Compaction and Subsidence Monitoring

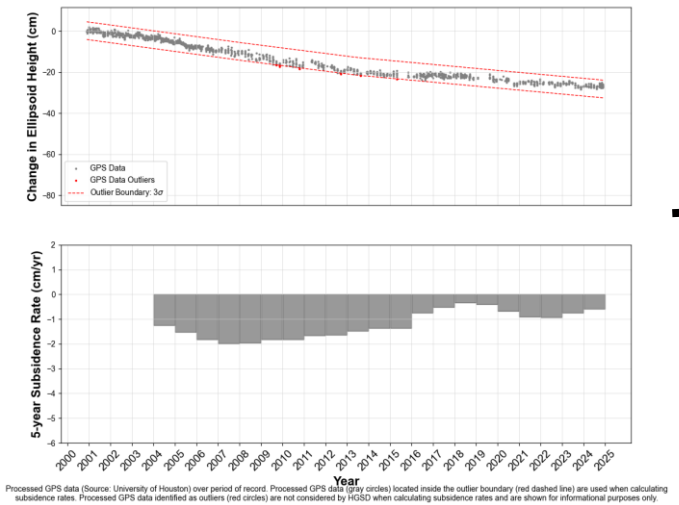
- GPS Stations
  - Measure subsidence
  - 182 in HGSD web map
  - 226 in model domain
- Extensometers
  - Measure compaction
  - 14 at 12 locations
- Benchmarks
  - 82 locations
  - Infrequent measurements
- InSAR

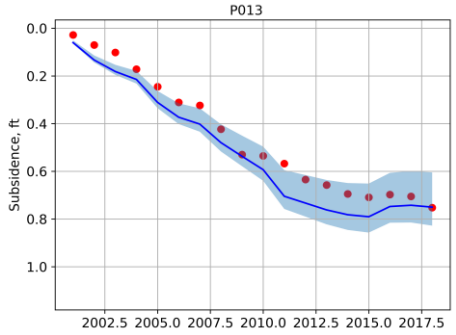


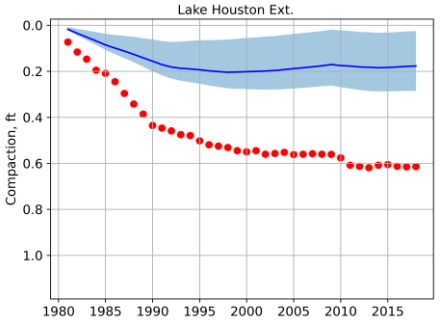
Modified from the Draft GMA 14 Model Report

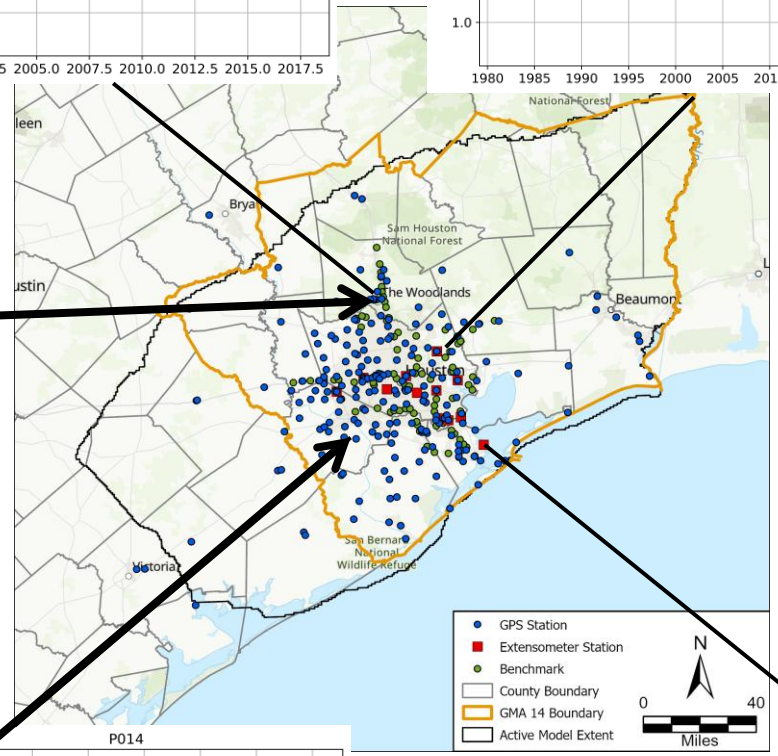
Compaction and Subsidence Monitoring

P013









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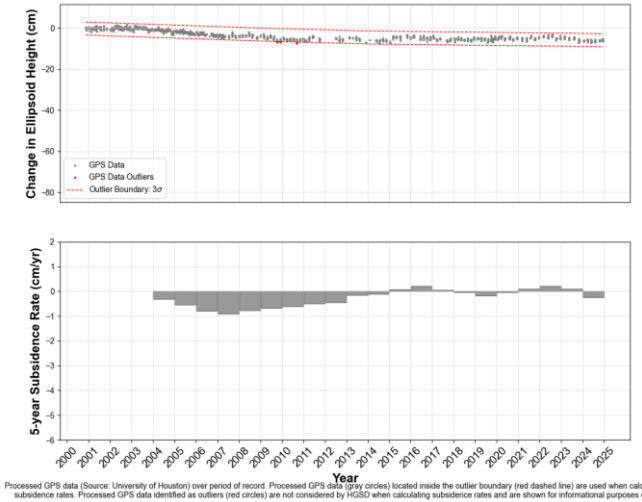
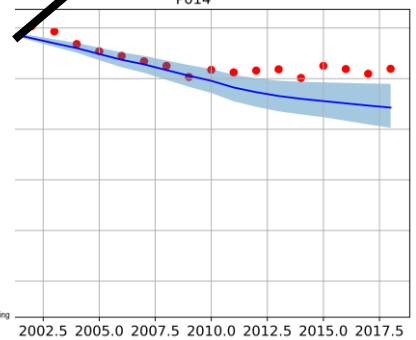
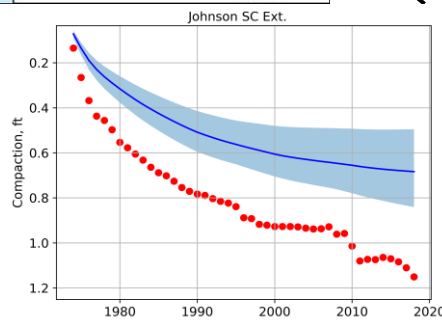


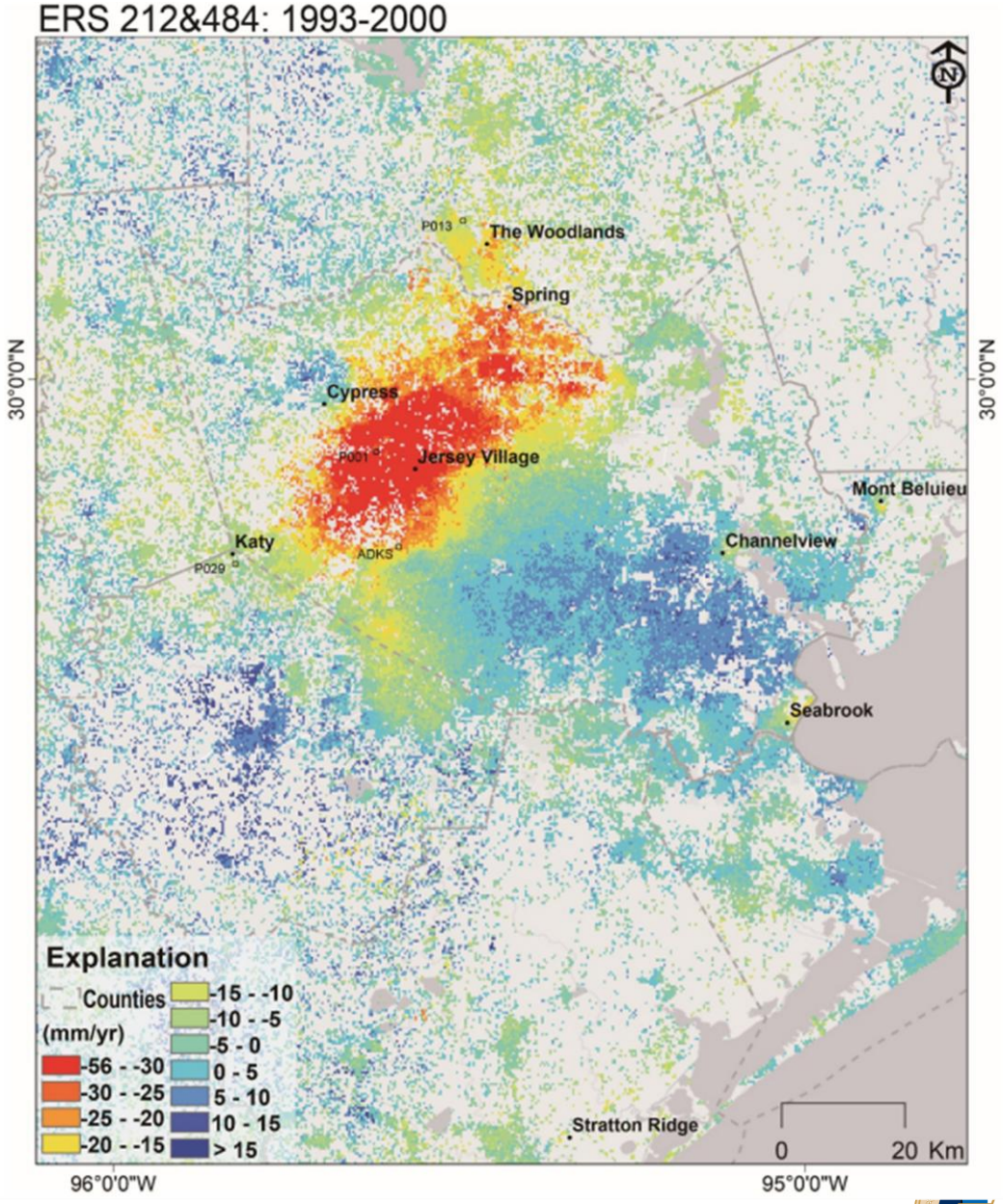




Modified from the Draft GMA 14 Model Report

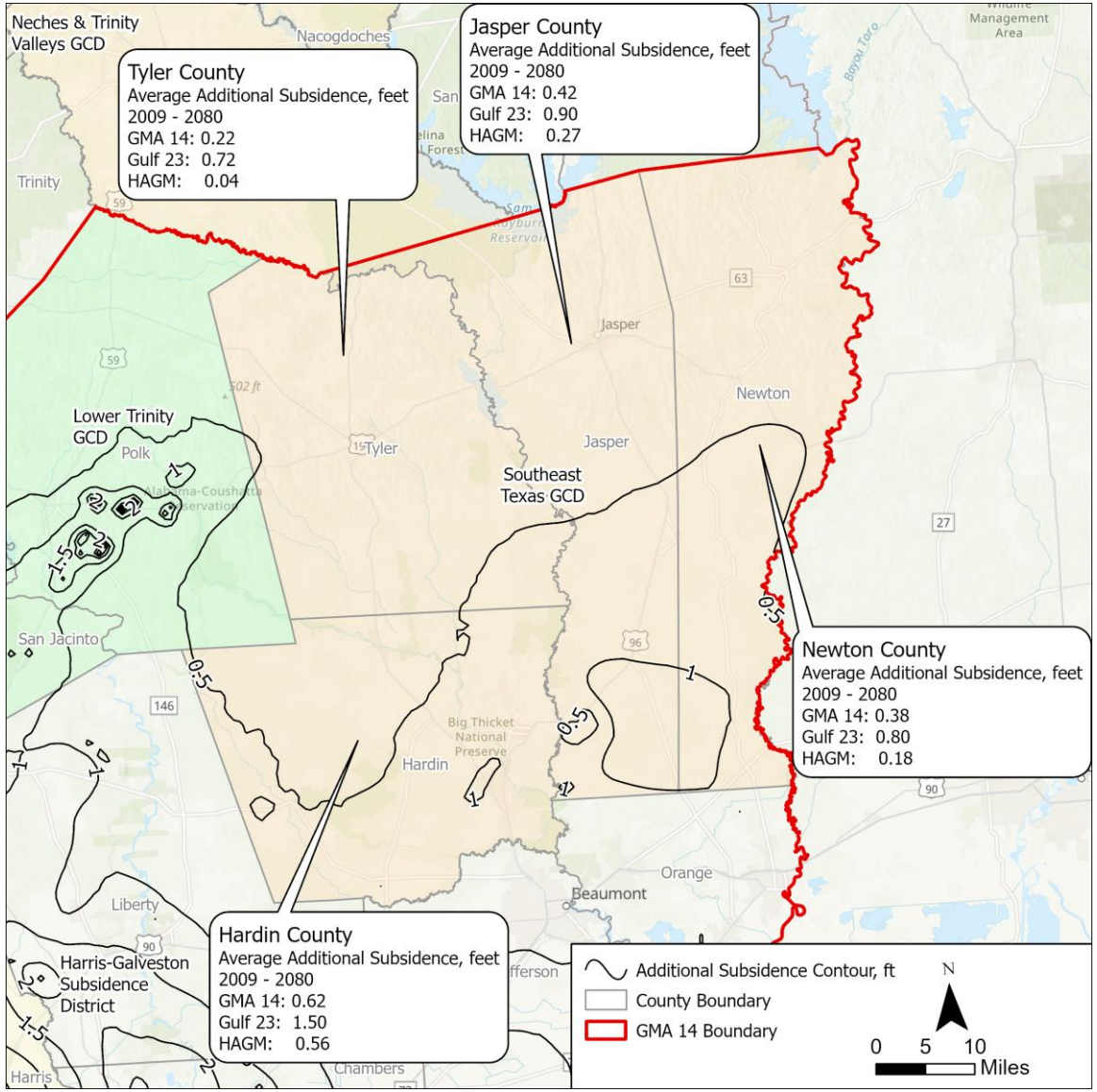
InSAR

- Remote sensing technique
- Allows monitoring of a wide spatial area
- Can identify small changes in elevation
- Best when paired with other observation methods
- Recent article in Nature Cities used approach to focus on urban changes from 2015 to 2021



Reproduced from Qu and Lu (2022): Mapping Deformation Over Greater Houston Using InSAR

SETGCD – Results at 2021 Joint Planning MAG



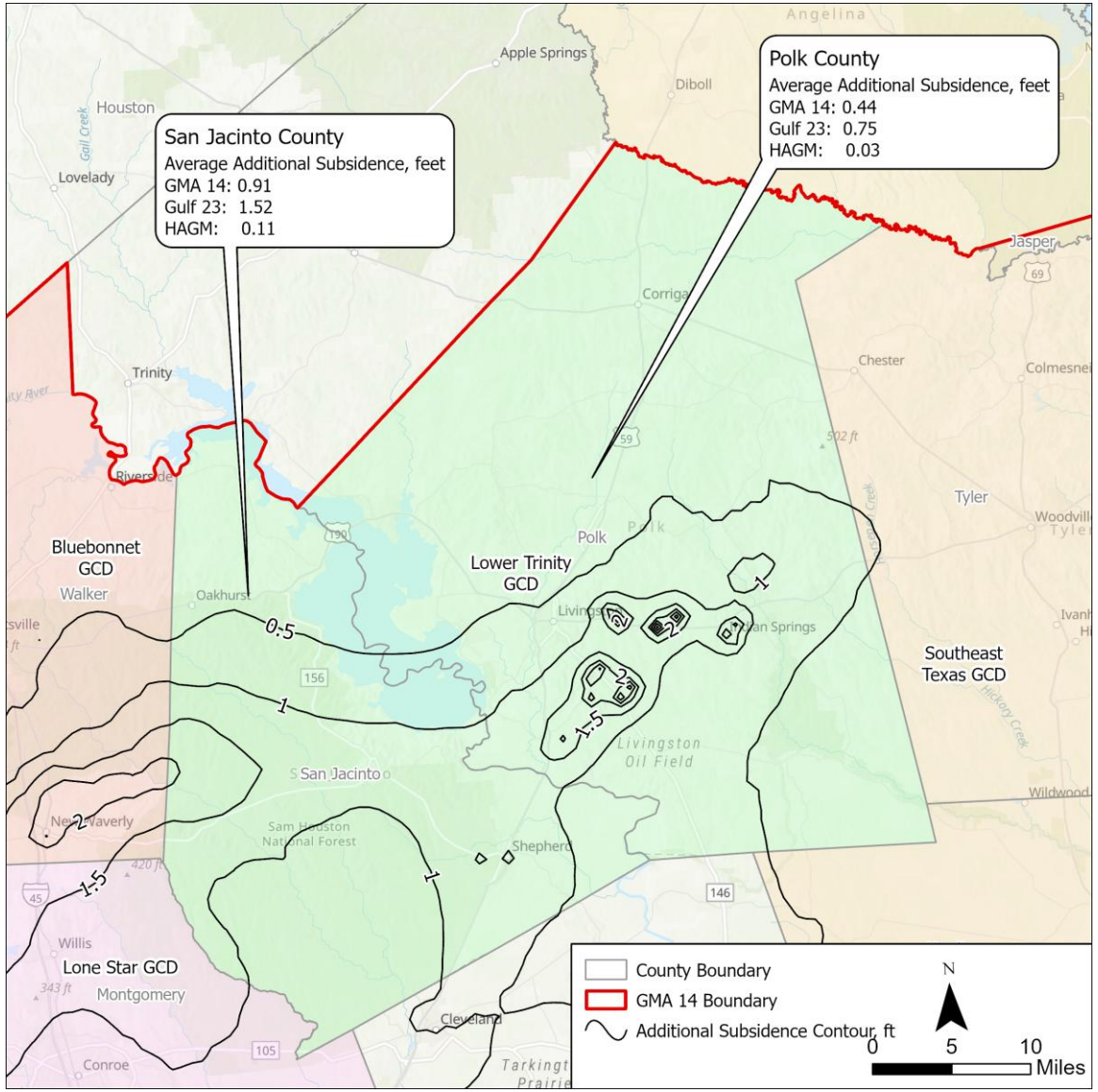
County	MAG (AFY)
Hardin	37,721
Jasper	73,365
Newton	37,508
Tyler	34,390
SETGCD	**182,984**

3 GPS Stations for Monitoring

Period	Maximum (in/yr)	Average (in/yr)
2020-2024	0.11	0.10
>5-year record	0.07	0.02

GPS counts and reported rate from: Subsidence Rates in Harris, Galveston, and Surrounding Counties, 2020-2024

LTGCD – Results at 2021 Joint Planning MAG



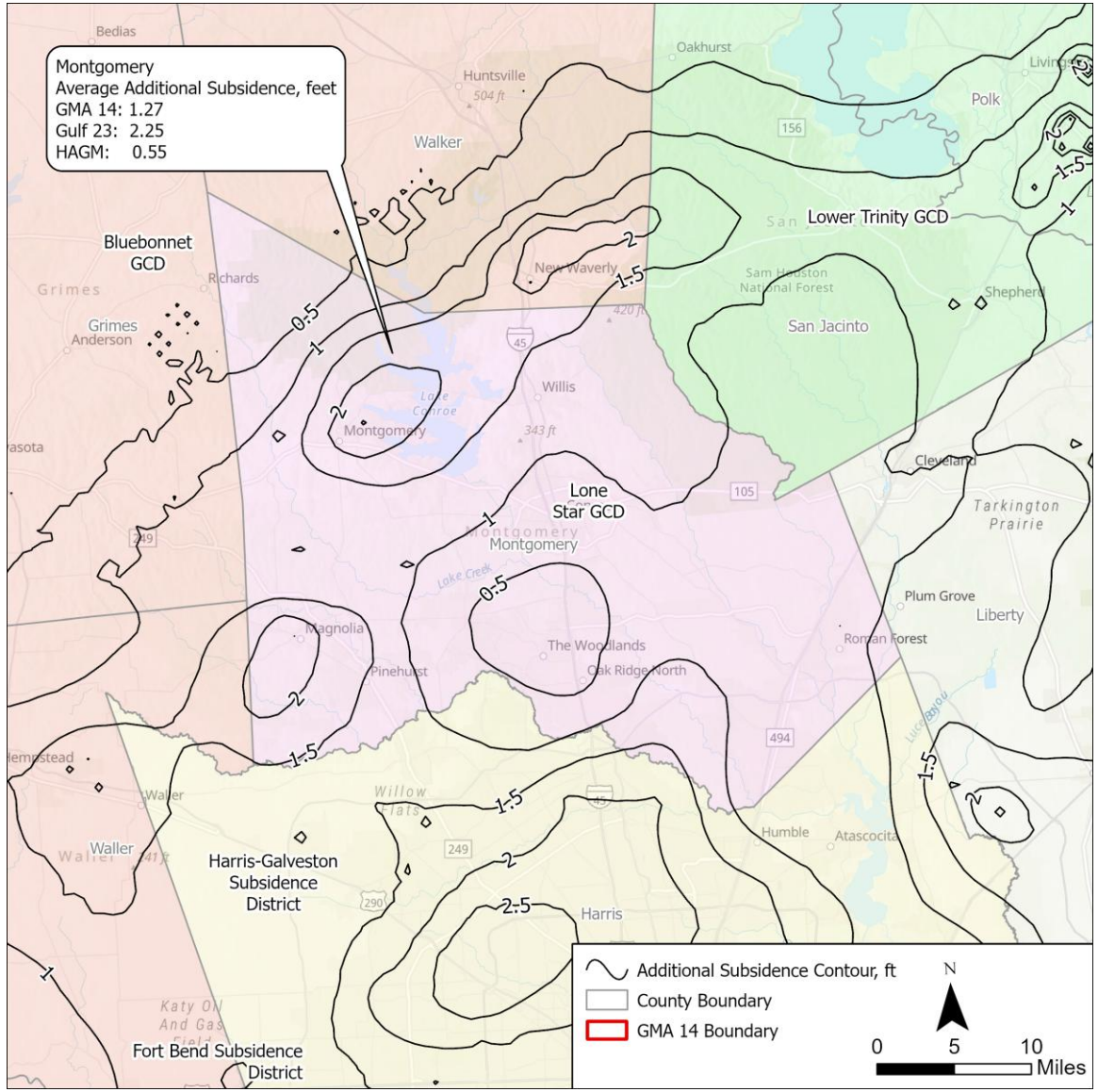
County	MAG (AFY)
Polk	40,746
San Jacinto	35,128
LTGCD	**75,874**

1 GPS Station for Monitoring

Period	Maximum (in/yr)	Average (in/yr)
2020-2024	0.13	0.13
>5-year record	0.01	0.01

GPS counts and reported rate from: Subsidence Rates in Harris, Galveston, and Surrounding Counties, 2020-2024

LSGCD – Results at 2021 Joint Planning MAG



County	MAG (AFY)
Montgomery	96,873
LSGCD	**96,873**

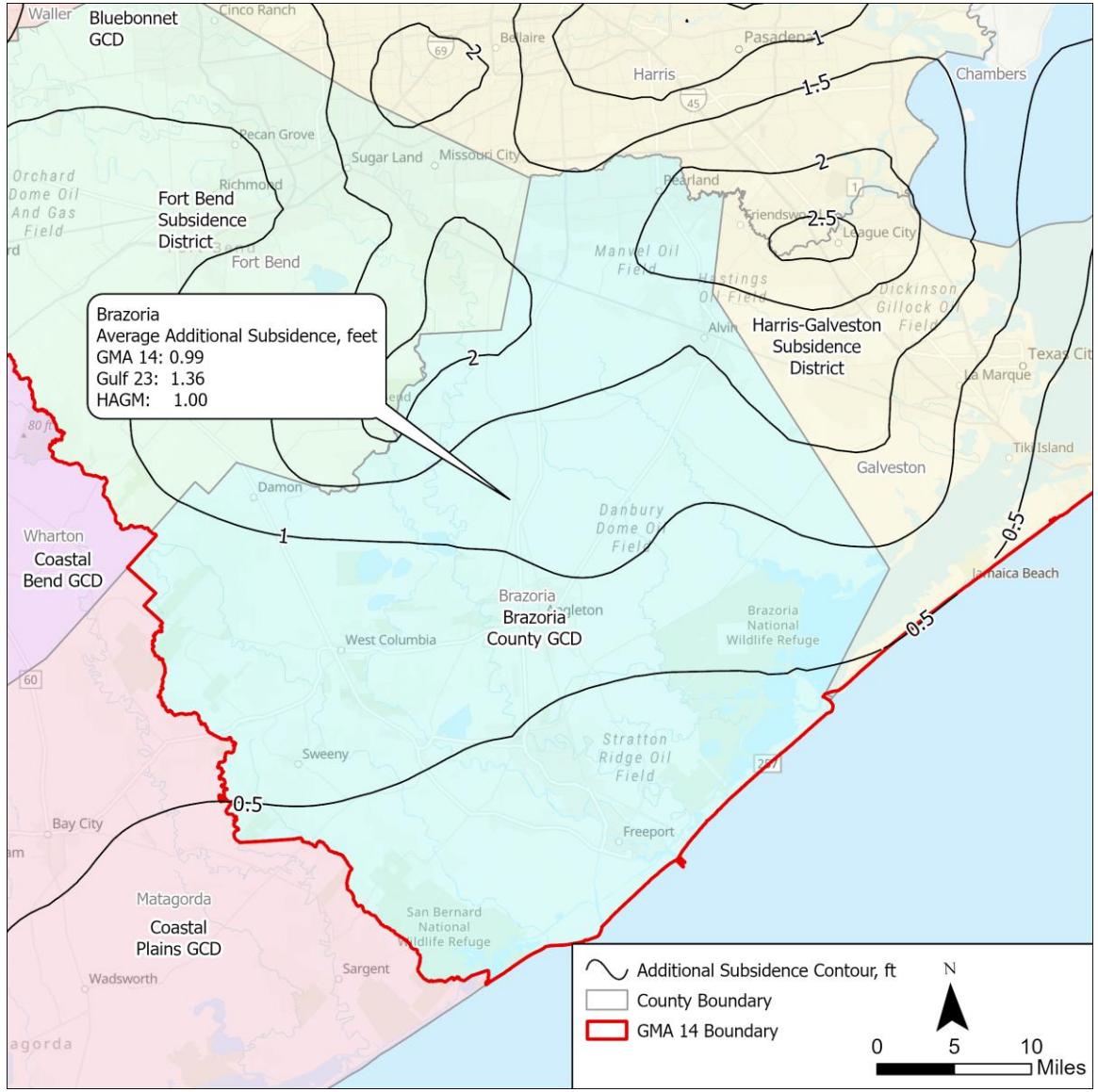
14 GPS Stations for Monitoring

- ½ in The Woodlands
- 11 within 7 miles of southern border

Period	Maximum (in/yr)	Average (in/yr)
2020-2024	0.67	0.40
>5-year record	0.49	0.34

GPS counts and reported rate from: Subsidence Rates in Harris, Galveston, and Surrounding Counties, 2020-2024

BCGCD – Results at 2021 Joint Planning MAG



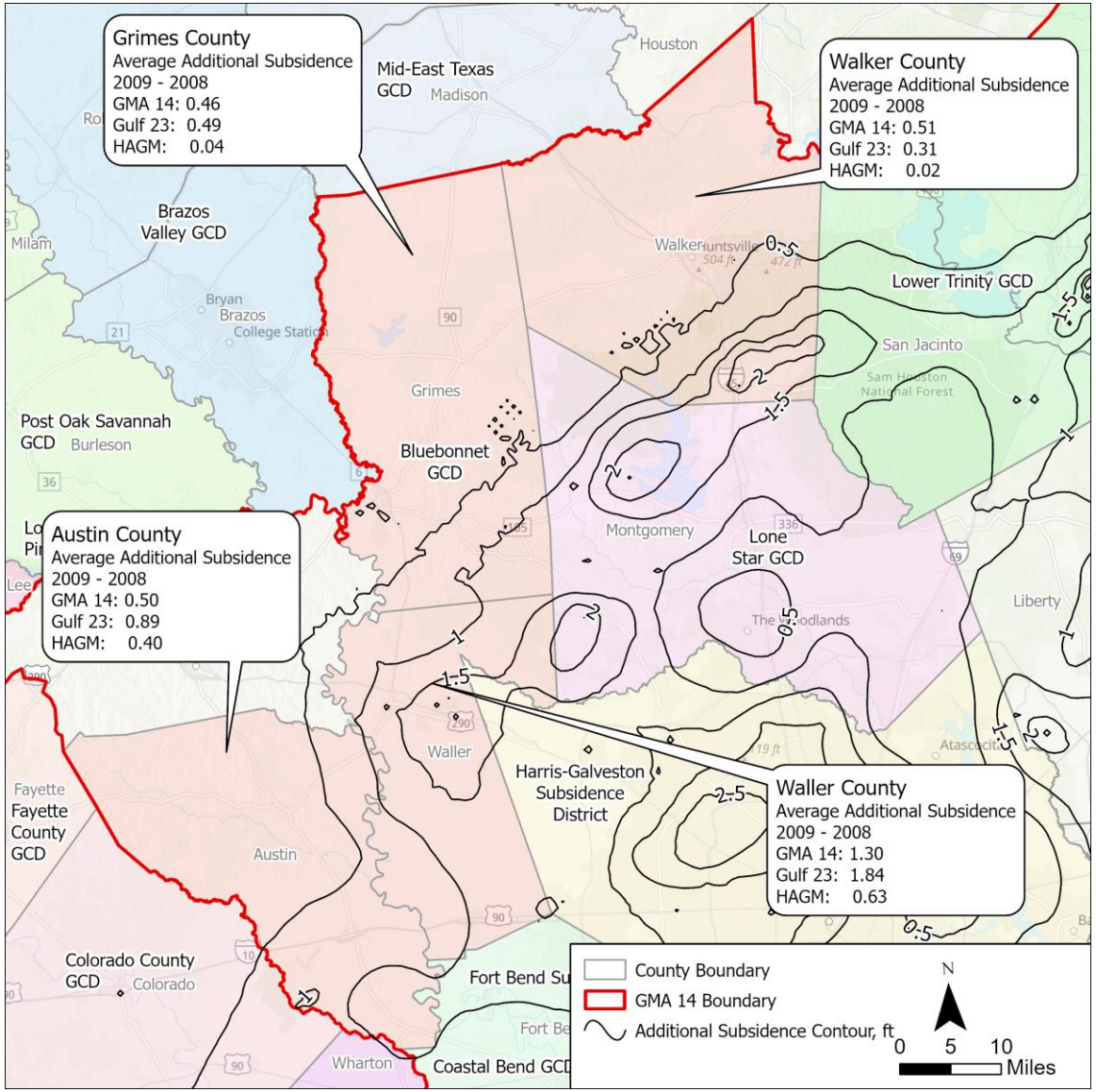
County	MAG (AFY)
Brazoria	54,887
BCGCD	**54,887**

4 GPS Stations for Monitoring

Period	Maximum (in/yr)	Average (in/yr)
2020-2024	0.14	0.09
>5-year record	0.08	0.06

GPS counts and reported rate from: Subsidence Rates in Harris, Galveston, and Surrounding Counties, 2020-2024

BGCD – Results at 2021 Joint Planning MAG



County	MAG (AFY)
Austin	46,560
Grimes	51,487
Waller	42,503
Walker	55,533
BGCD	**196,083**

6 GPS Stations for Monitoring

- 1 x Austin County
- 5 x Waller County

Period	Maximum (in/yr)	Average (in/yr)
2020-2024	0.49	0.16
>5-year record	0.75	0.22

GPS counts and reported rate from: Subsidence Rates in Harris, Galveston, and Surrounding Counties, 2020-2024

GPS Monitoring Summary

District		2020-2024			Stations with Data Record of 5 Years or More		
		Stations	Maximum	Average	Stations	Maximum	Average
BGCD		6	0.49	0.15	6	0.75	0.20
BCGCD		4	0.14	0.09	4	0.08	0.06
LSGCD		14	0.67	0.40	13	0.49	0.34
LTGCD		1	0.13	0.13	1	0.01	0.01
SETGCD		3	0.11	0.10	3	0.07	0.02
FBSD		30	1.30	0.25	28	0.64	0.17
HGSD	**Area 1**	28	0.32	-0.04	28	0.17	0.01
	Area 2	23	0.16	0.05	23	0.19	0.03
	Area3	50	0.81	0.33	49	0.95	0.39

(for reference, a popsicle stick or smartphone (without a case) are each about ⅓-inch thick)

Discussion of Impact on Subsidence

- 1 of 9 factors to consider for the balancing test
- Declining water levels increase effective stress
- Total compaction is not immediate and can be mitigated through water level recovery
- Based on the reported GPS values, average subsidence monitoring period rates are ⅓ inch* per year or less in member districts

*for reference, a popsicle stick or smartphone (without a case) are each about ⅓-inch thick

Questions

GMA 14 Discussion of Impacts on Subsidence

May 28, 2025