Phase 3
Site-Specific
Subsidence Investigations

Stakeholder Meeting

December 12, 2022

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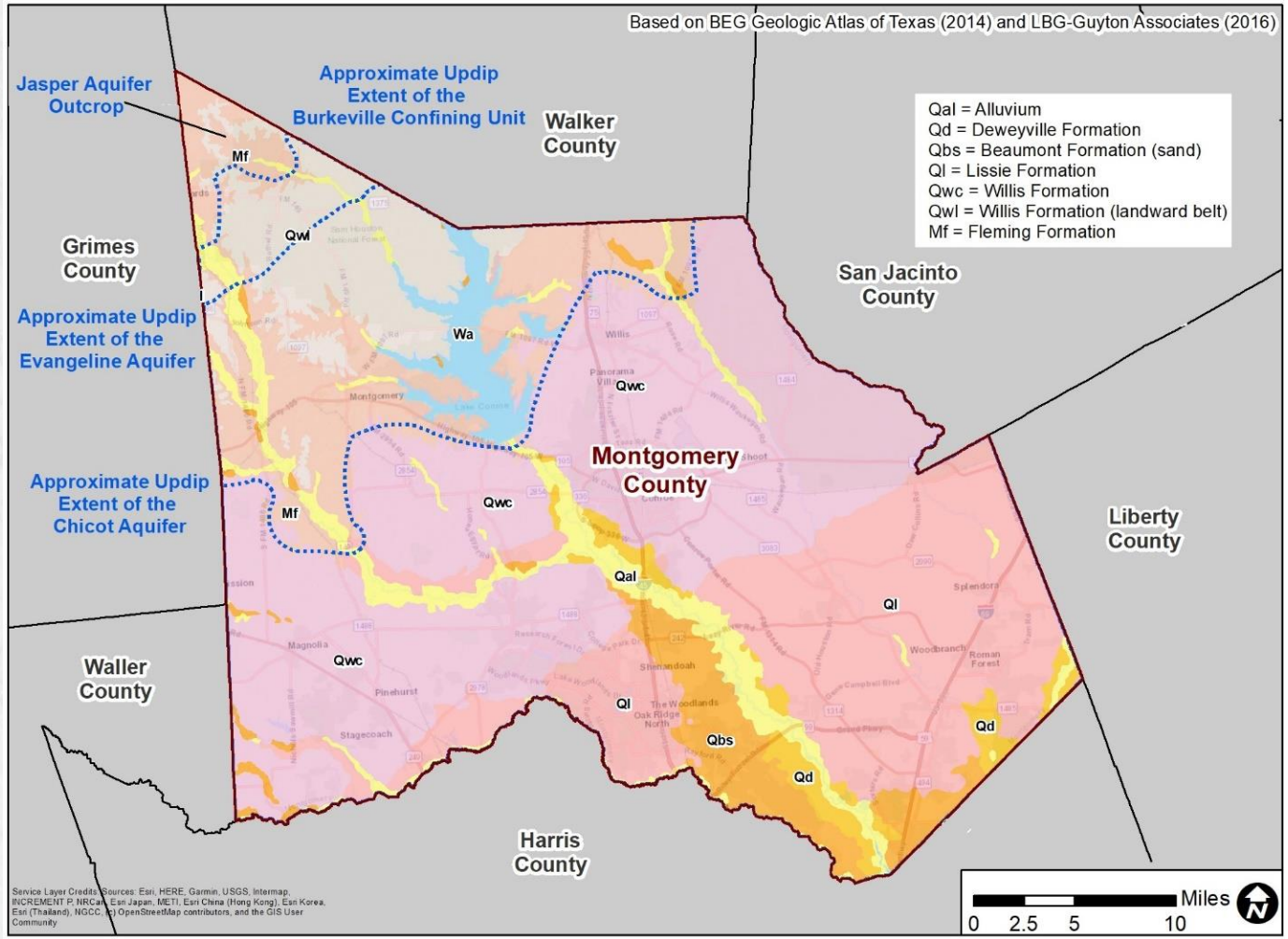
GROUNDWATER RESOURCE PROFESSIONALS

THORNHILL GROUP, INC.
Professional Hydrogeologists • Water Resources Specialists

AGS
Advanced Groundwater Solutions, LLC

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
			Lagarto Middle
	Upper Jasper Aquifer		Lagarto Lower
	Lower Jasper Aquifer		Oakville
Oligocene	Catahoula		Catahoula

LSGCD Subsidence Investigations

- Phase 1 – Background
  - Assessment of Past and Current Investigations
  - 2019-2020
- Phase 2 – Focused Evaluations
  - Specific items from Phase 1
  - 2021-2022
- Phase 3 – Site-Specific Geotechnical
  - Real world data
  - 2023 - ??
- Phase 4 – Monitoring

Questions from Phase 2

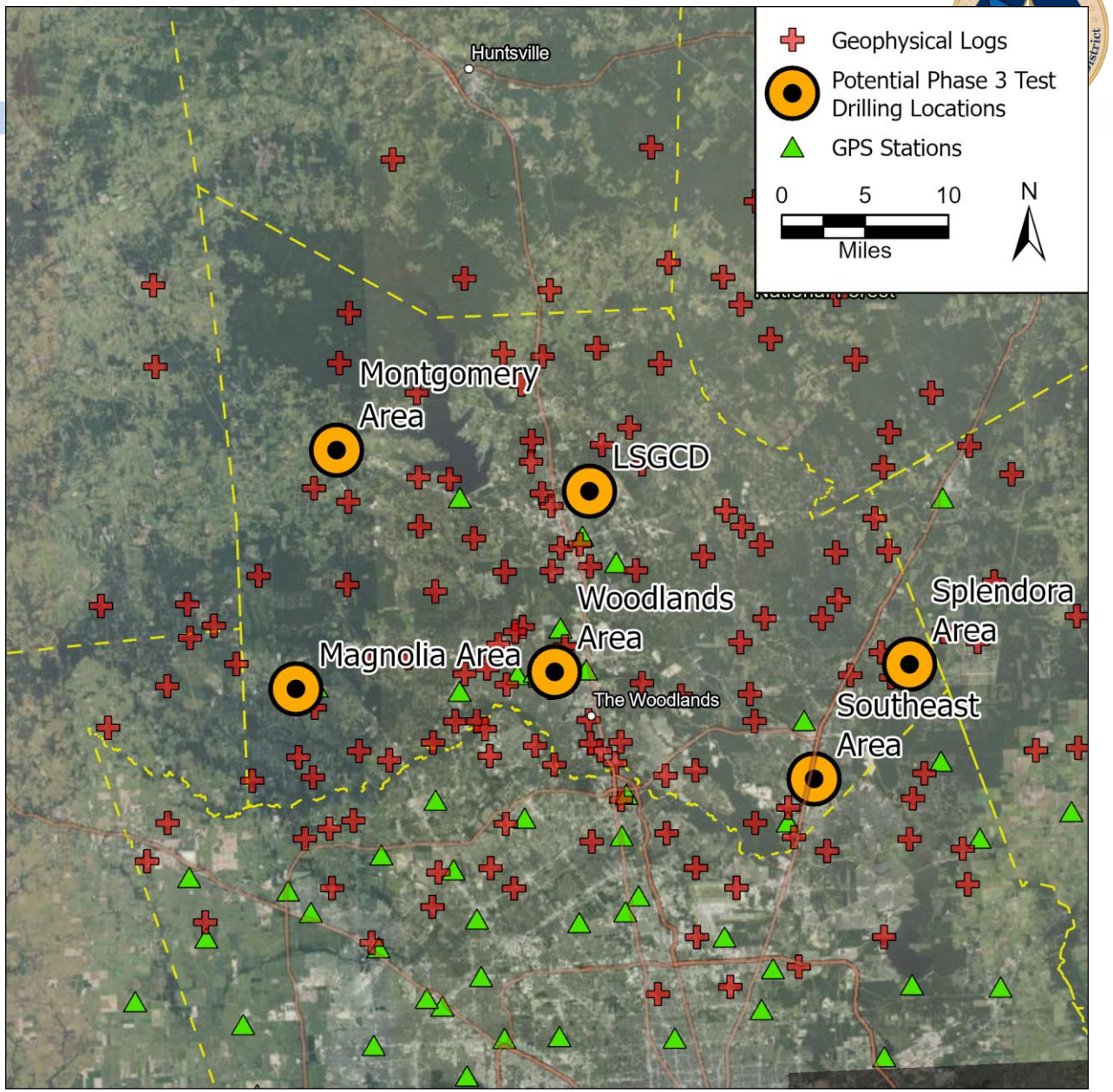
- What are the compaction properties of the subsurface clays within Montgomery County?
- How do the compaction properties of the subsurface clays within Montgomery County change with depth?
- Does the (vertical) permeability of the clays change with depth?
- Does the mineralogy of the clays change with the formations? And, does it affect the compaction properties?
- How can we get a better understanding of stratigraphy where data are sparse?
- (and several other questions)

Phase 3 Benefits

- Obtain site-specific data in Montgomery County related to compaction
  - No data currently exist
  - Harris County investigations of this type occurred 50 years ago
- Inform our understanding of past compaction
- Improve regulatory groundwater models
- Directly relates to data-driven resource management

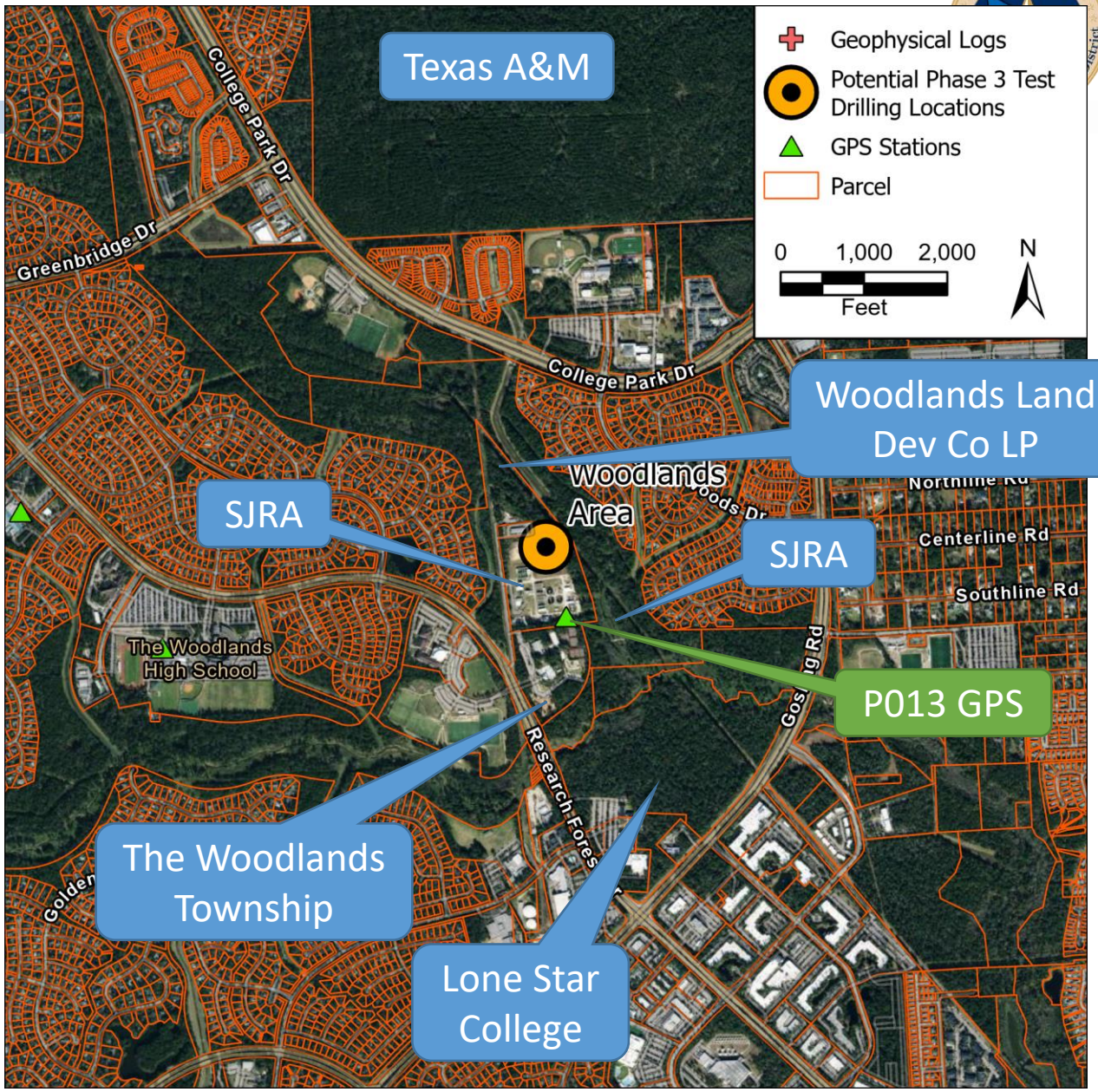
Proposed Locations

- Six sites
- Spread across the county
- Where to start?



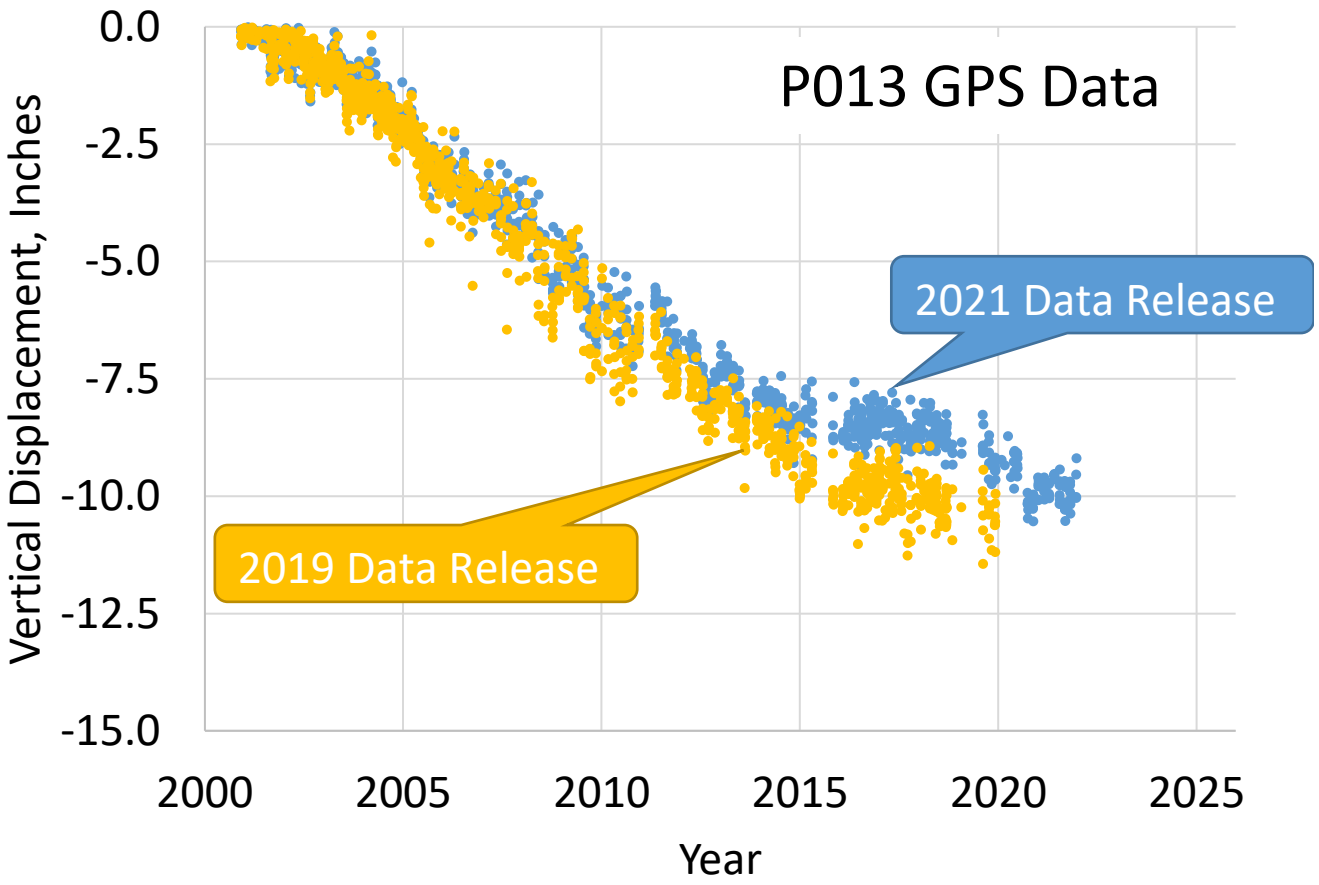
Woodlands Area

- Best place to start
- Why?
  - Near existing GPS stations
  - Near existing water-level monitoring wells
  - Near existing production wells
- Multiple open areas for potential drilling



GPS Data

- Useful tool for analysis of surface changes
- Limitations
  - Reports total vertical displacement
    - All subsurface compaction
    - Natural and anthropogenic
  - Requires specialized data processing
  - Can vary based on new data and assumptions

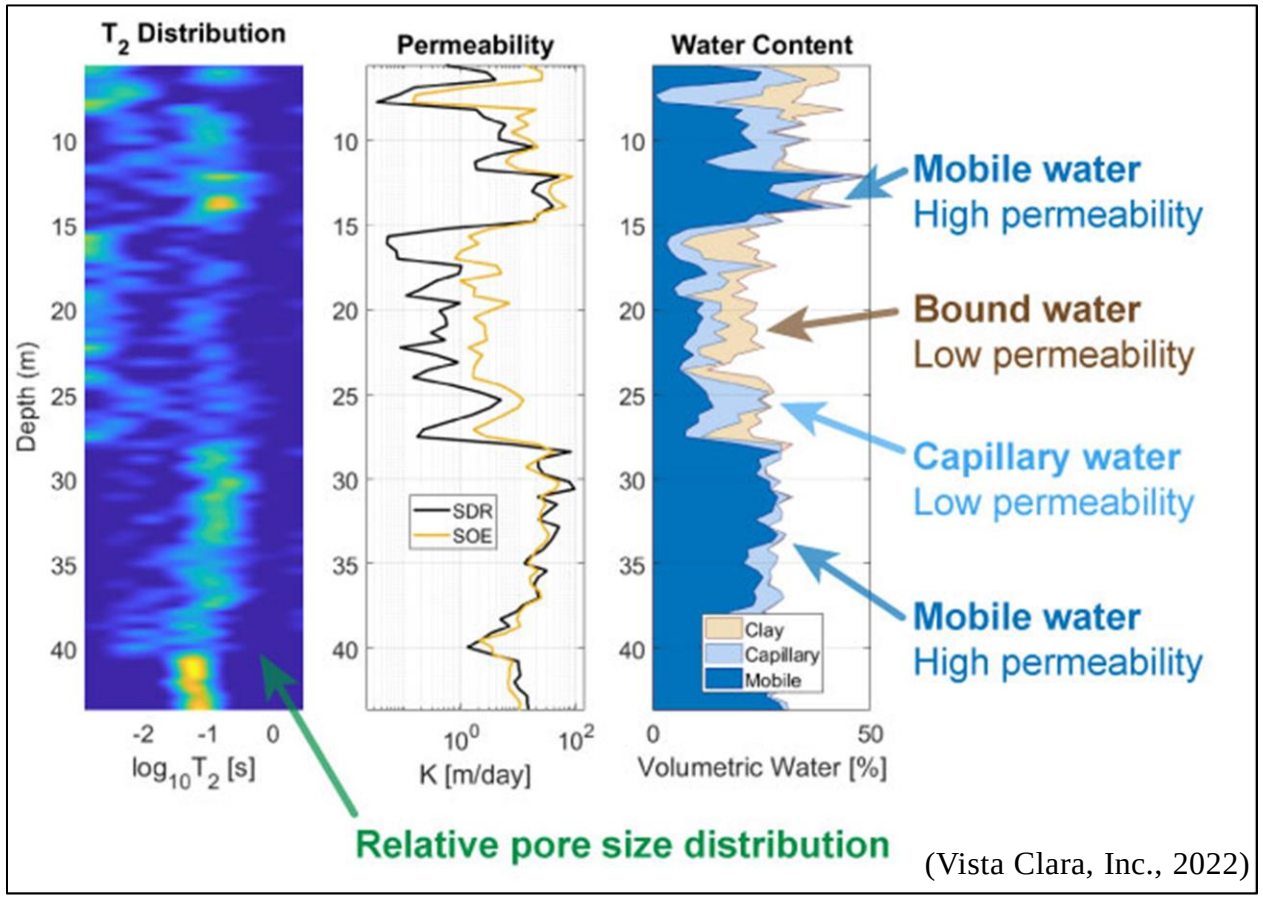


Drilling Process

- Mobilize to site
- Drill pilot hole
- Geophysical logging
- Complete extensometer
- Move rig for coring
- Drill for core samples
- Complete monitoring well

Geophysical Logging

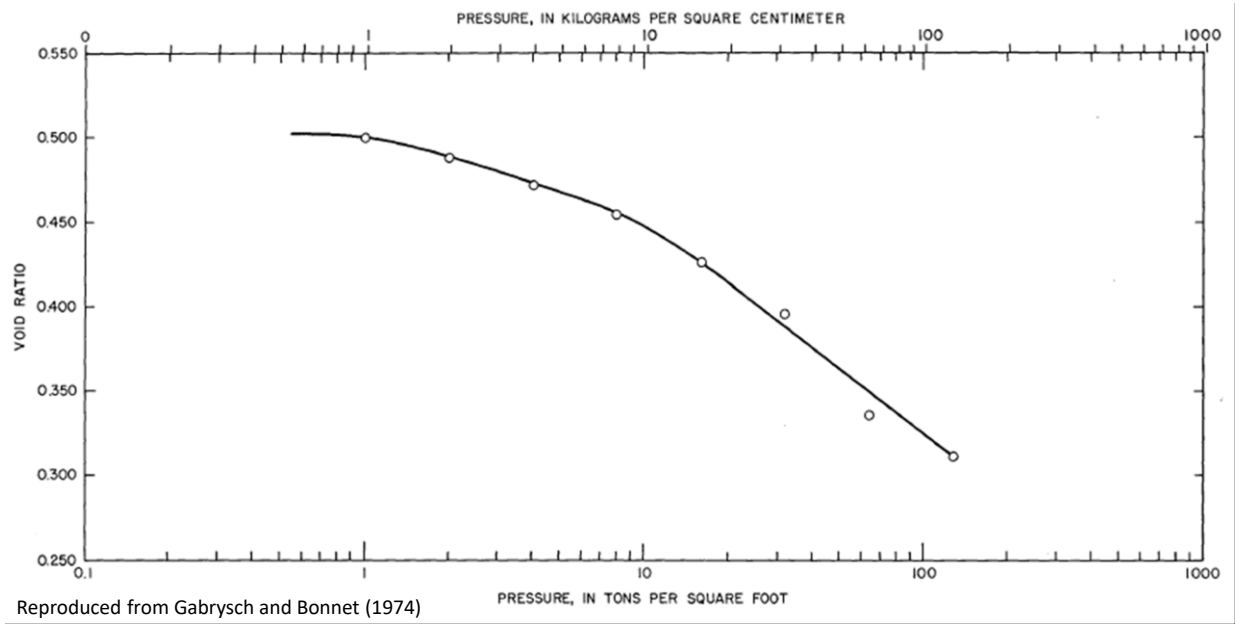
- Triple Combo (Resistivity, Natural Gamma, and Neutron/Density porosity)
  - Lithology
  - Water quality
  - Porosity
- Micro-normal/micro-inverse resistivity
  - Relative permeability (qualitative)
  - Water quality
- Spectral Gamma
  - Lithology
  - Clay mineral composition
- Magnetic Resonance
  - Permeability (quantitative)
  - Porosity
  - Movable water



(Vista Clara, Inc., 2022)

Lab Analysis of Core Samples

- Vertical permeability
- Clay mineralogy
- Oedometer testing
  - Void ratio change with increased pressure
  - Calculate porosity and compressibility change with increased pressure

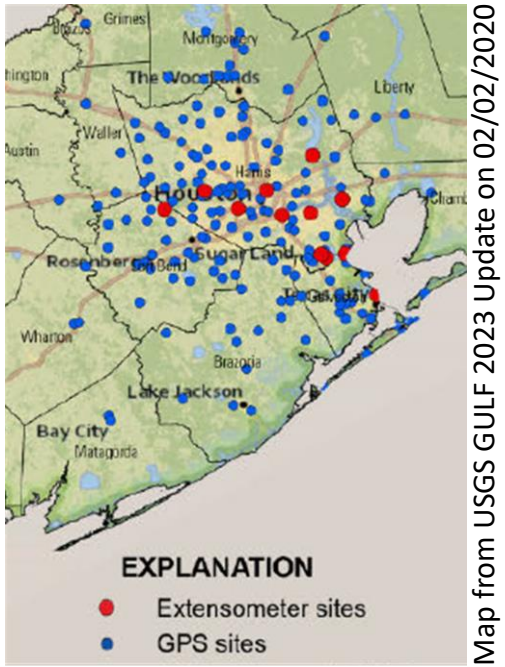


Reproduced from Gabrysch and Bonnet (1974)


https://videohive.net/item/geology-rock-drill-core-samples-in-wooden-box/25738481

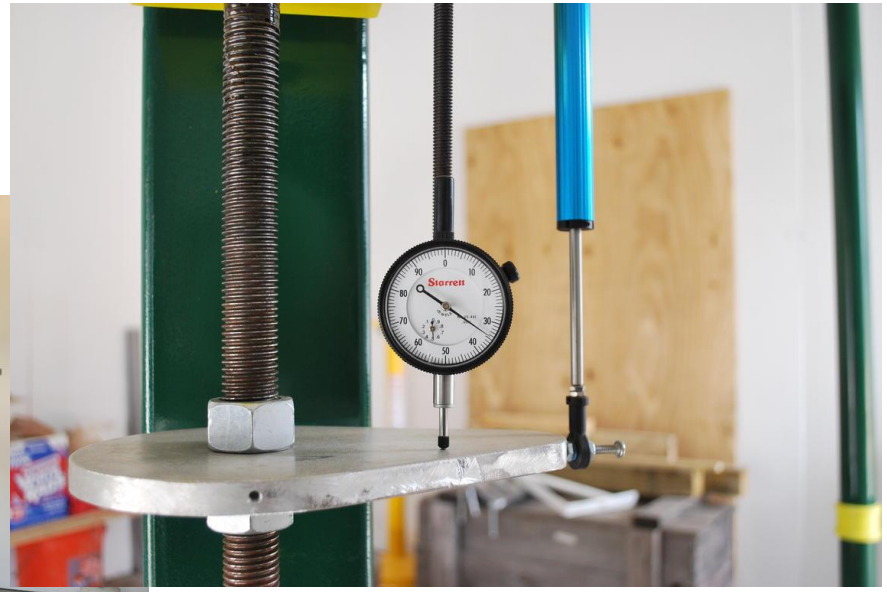
Extensometer

- Used to measure compaction of aquifer sediments above the anchor point in the subsurface
- Currently 12 sites in Houston area
- Proposed Woodlands Area extensometer
  - Anchored at top of the Burkeville
  - Measure compaction of the Chicot & Evangeline
  - Measure water levels in the deep Evangeline
  - Use local GPS station data for total compaction
- Paired water-level monitoring well completed in the Upper Jasper



Map from USGS GULF 2023 Update on 02/02/2020

What does it look like?



Images courtesy of the USGS: https://www.usgs.gov/media/slideshows/extensometer-image-gallery

Phase 3 Projected Cost

- Drilling contractor: $1,702,000 (90% of projected cost)
  - Budgetary estimate
  - Bids due on 12/16/2022
- Laboratory (core analyses): $55,000 (3% of projected cost)
- LSGCD Consulting Team: $129,500 (7% of projected cost)
  - Project Management: $14,900
  - Drilling, Testing, and Well Completion Field Services: $71,400
  - Data Analysis: $8,100
  - Site Completion Report: $6,100
  - Project Report: $29,000

Total Projected Cost: $1,886,500

Questions

- Why only one location?
- What is the benefit to the property owner?
- Why not start in Conroe?
- Why not complete the extensometer in the Upper Jasper?
- Why not complete more than one extensometer at different intervals?

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