



THE PAST, PRESENT, AND FUTURE OF SUBSIDENCE IN THE HOUSTON REGION

Harris-Galveston Subsidence District

Michael J. Turco – General Manager

Outline

- Who we are and why we do what we do...
- Hydrogeology of the Gulf Coast and Subsidence
- Impacts of subsidence on the landscape
- Groundwater regulation
- Priority issues of the District



Two Districts – Same Mission

- Through an inter-local agreement, the staff of the Harris-Galveston Subsidence District provides the administration of the Fort Bend Subsidence District.
- Each board consists of 19 (HGSD) and 15 (FBSD) appointed members that serve a two year term.
- The cooperation between the two Districts provided by the inter-local agreement is a great example of maximizing resources to complete missions objectives.



What is Subsidence?

- Subsidence is the lowering of the elevation of land surface over time.
- Subsidence can have a wide range of consequences depending on the location of the occurrence and its proximity to surface drainage and coastal zones
- In this area, clay compaction resulting from groundwater withdrawal is the primary cause for subsidence



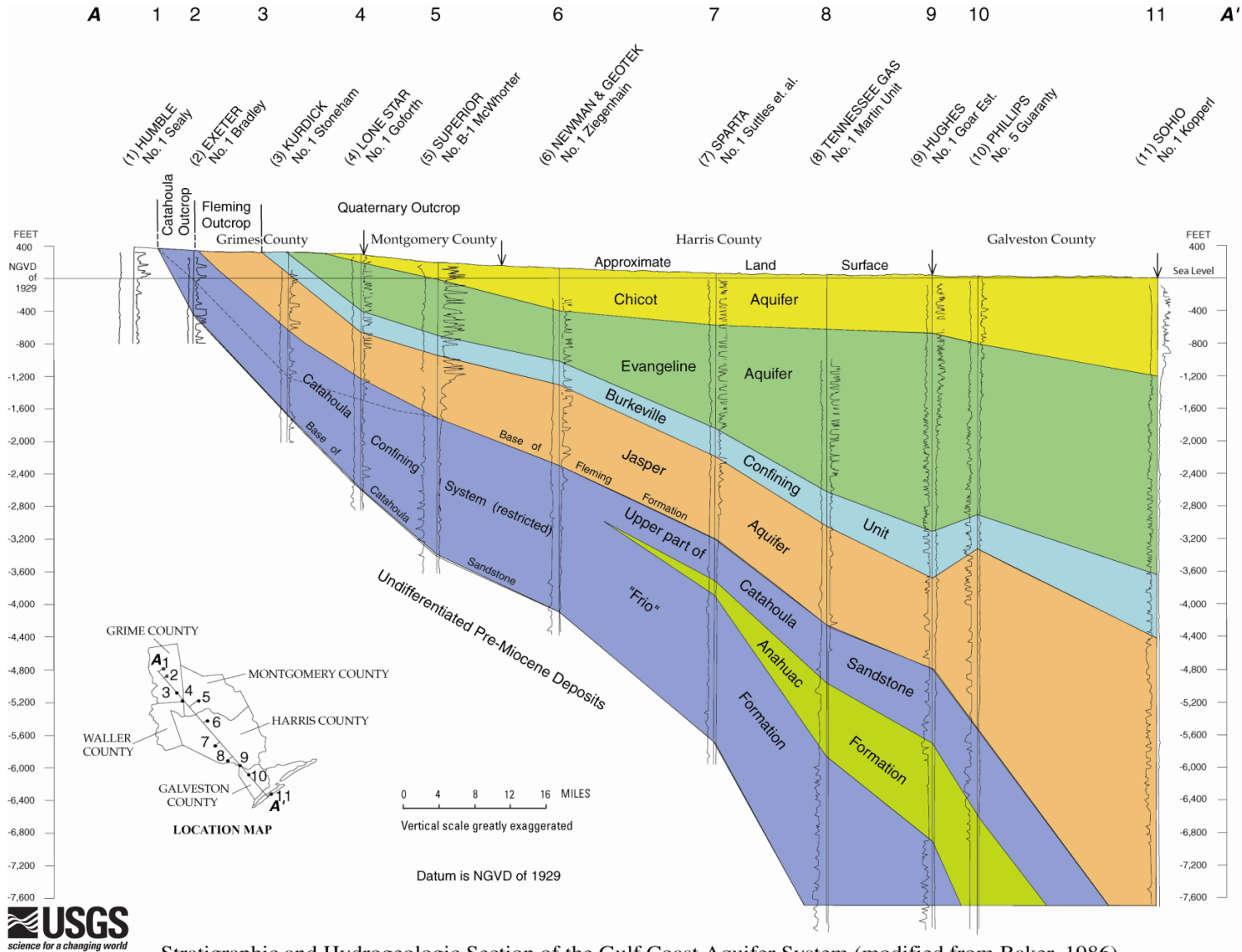
USGS
science for a changing world



- The Harris-Galveston Subsidence District was created to prevent land subsidence in Harris and Galveston counties through the management 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 create a more resilient infrastructure that:
 - Mitigates flooding
 - Secures reliable water for the future



Hydrogeology

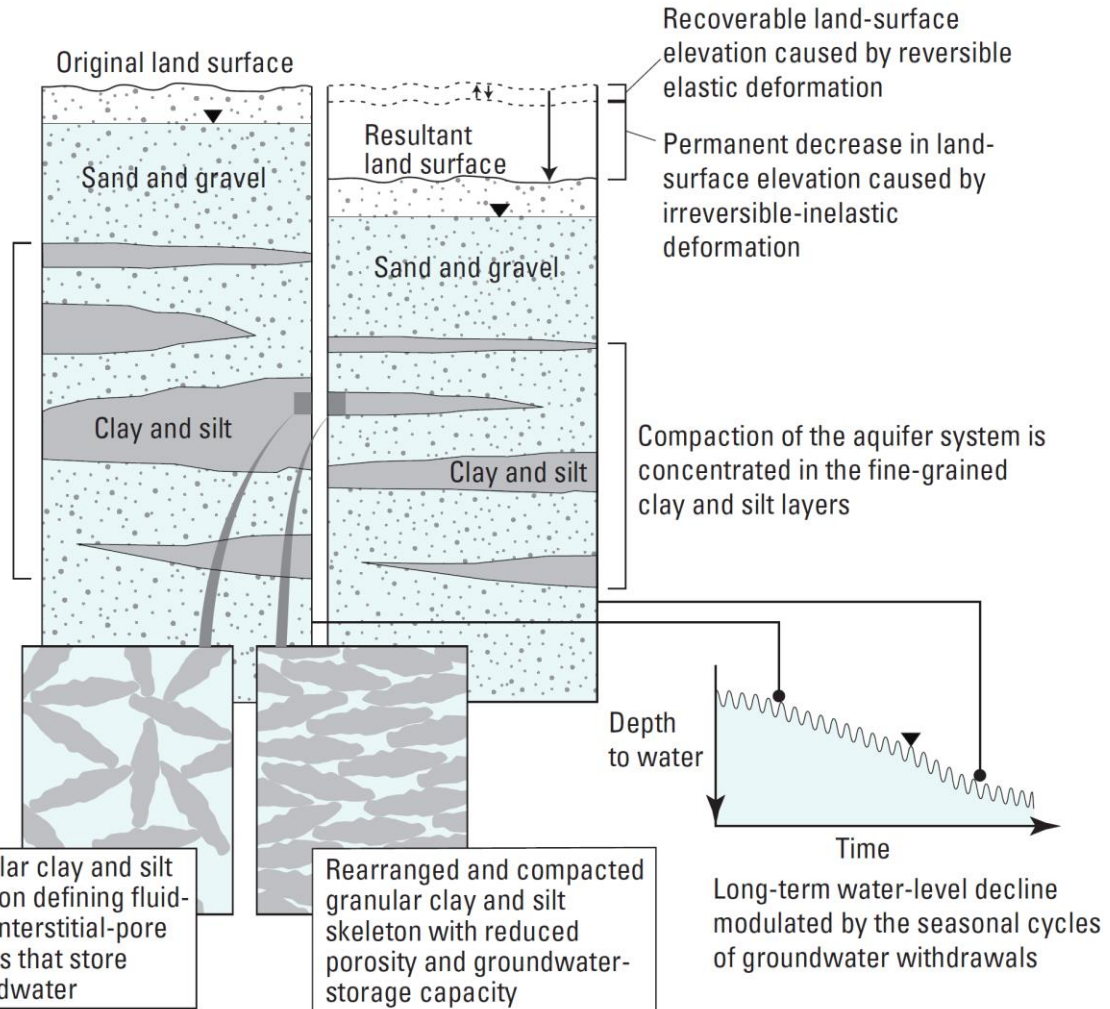


Stratigraphic and Hydrogeologic Section of the Gulf Coast Aquifer System (modified from Baker, 1986).

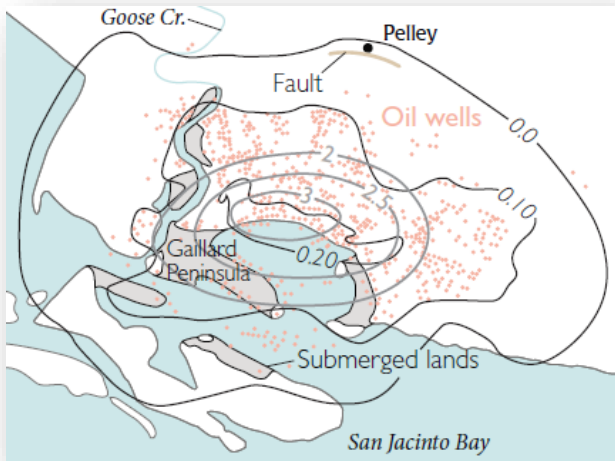
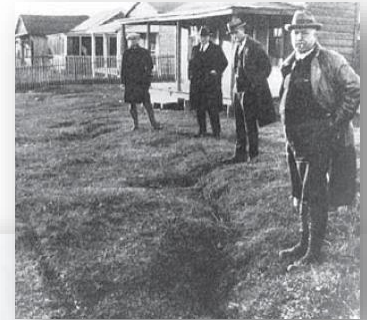
Mechanism for Subsidence in the Gulf Coast

When long-term withdrawals lower groundwater levels and raise pressure on the clay and silt layers beyond a threshold amount, the clay and silt layers compact, and the land-surface elevation decreases permanently

Initial aquifer sediment thickness before groundwater withdrawals began



Permanent Inundation due to Subsidence – Goose Creek Oil Field 1918-1926



Nearly 3 feet of subsidence occurred due to shallow fluid withdrawal.

Today, remnants exist in San Jacinto Bay as much of the field has been inundated.



Consequences of Subsidence



- *Infrastructure damage*
 - *Wellhead, roads, bridges, canals, etc.*
- *Faulting*
 - *Structural damage due to increased velocity along fault scarp*
- *Wetlands loss*
- *Flooding*



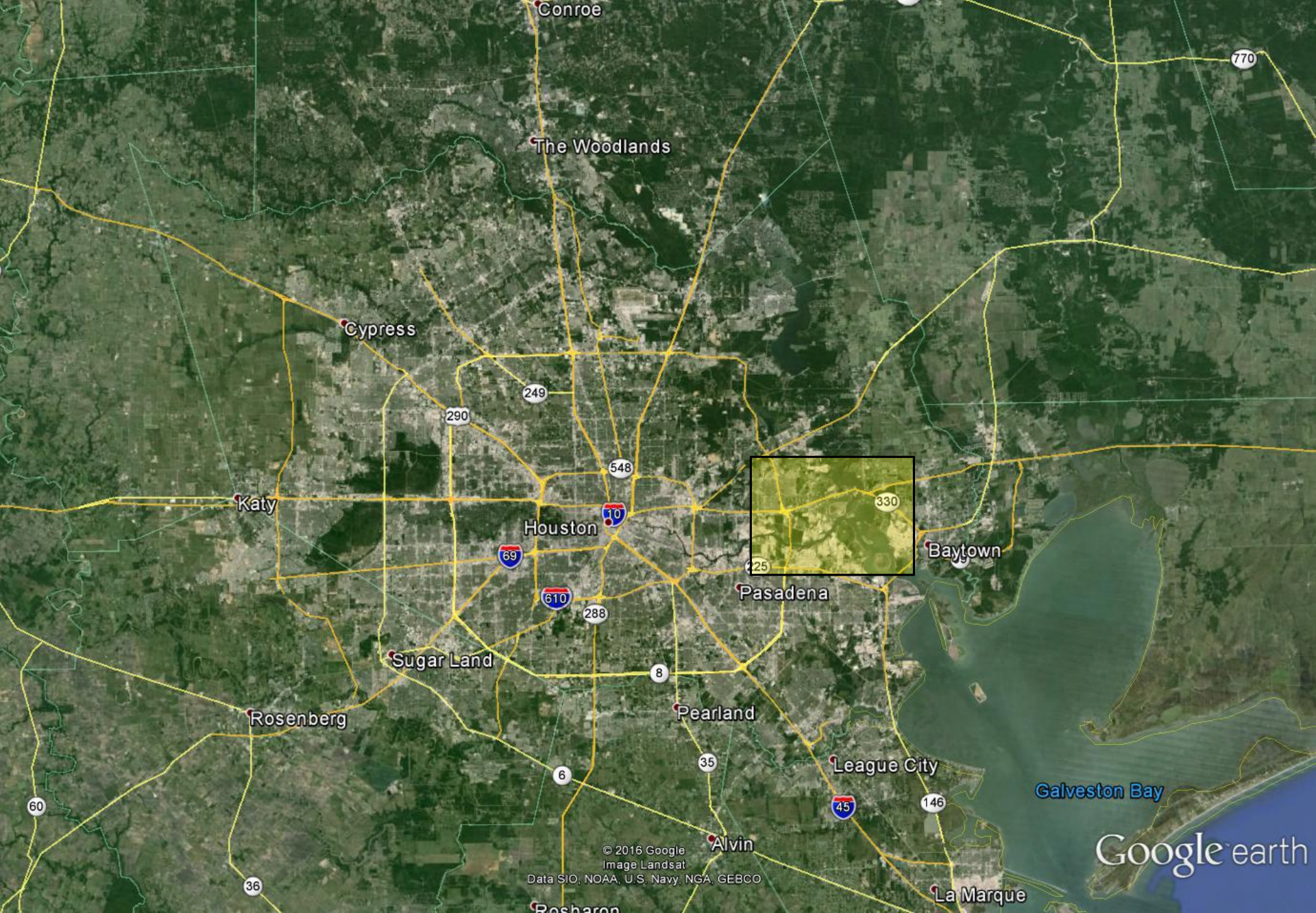


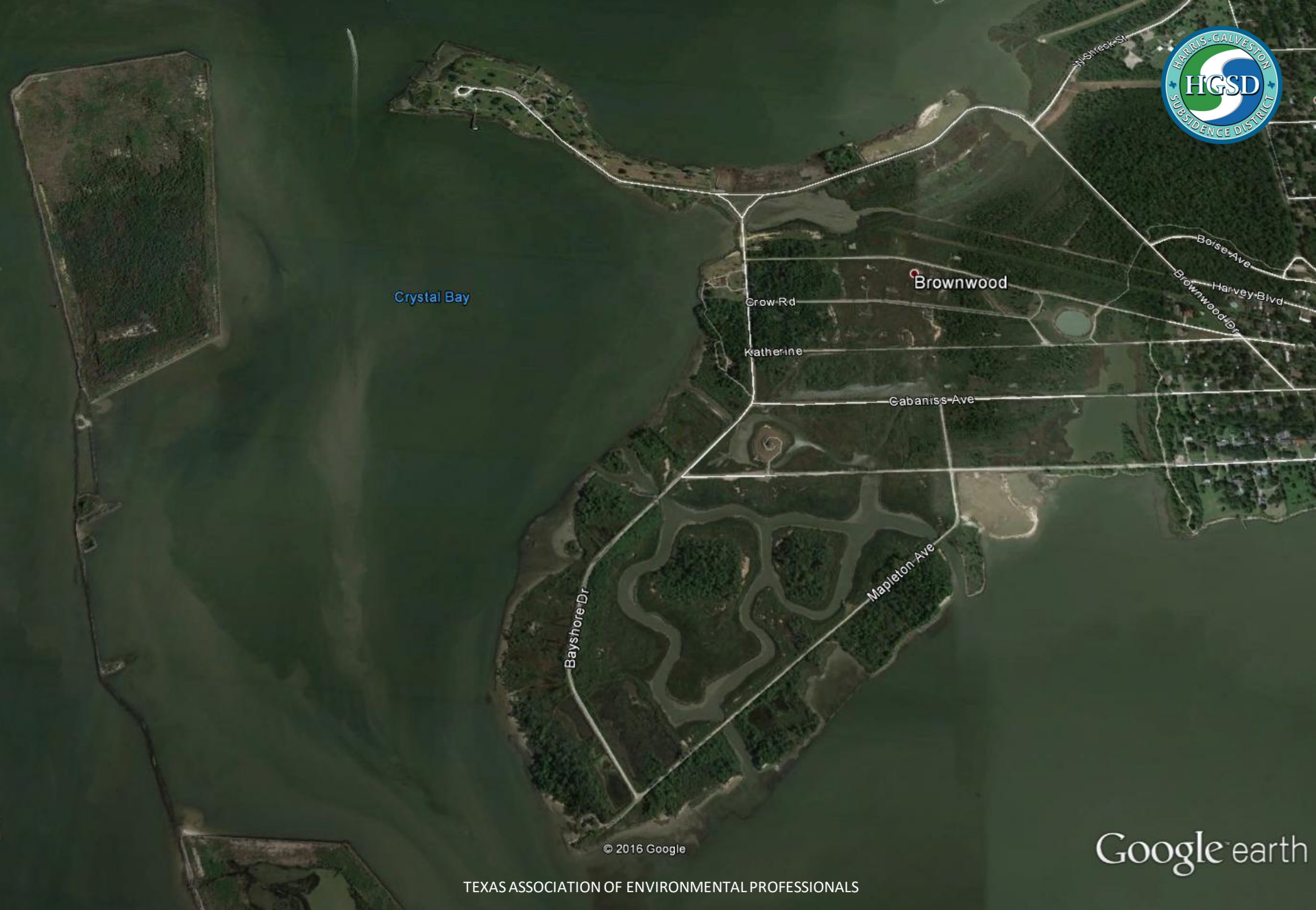




Image Texas General Land Office

Google earth

TEXAS ASSOCIATION OF ENVIRONMENTAL PROFESSIONALS



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Google earth

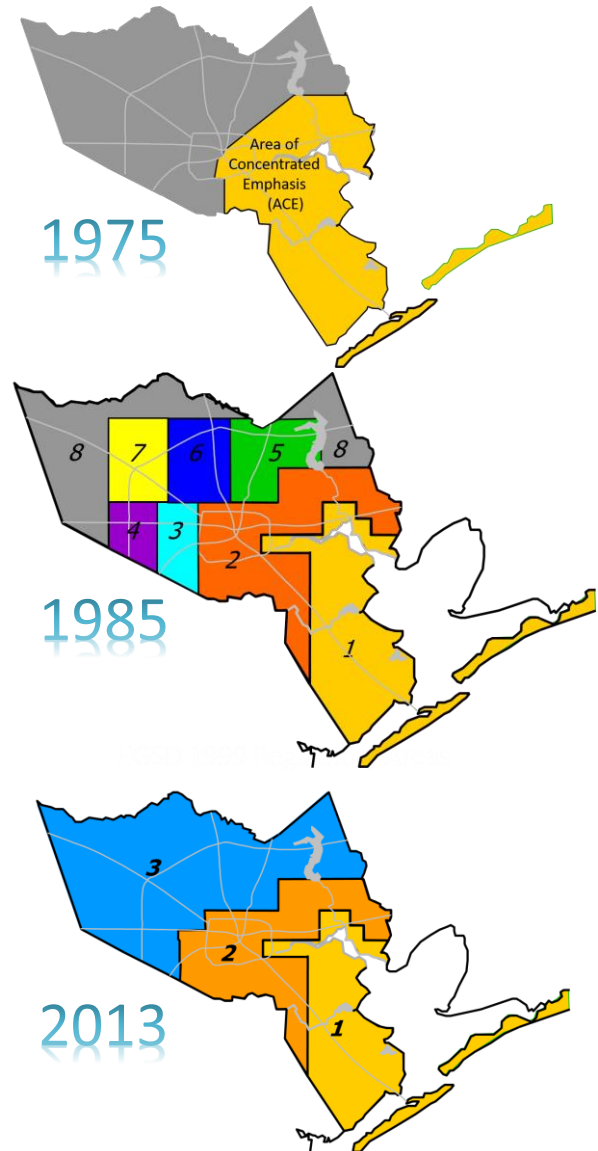
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Subsidence at the wellhead - Baytown



Regulating Groundwater to Stop Subsidence

- *Following the creation of the District, groundwater regulation began nearest the coast in the ACE*
- *As population spread to the north and west and water use increased numerous regulatory plans were developed and implemented*
- *The 1999 regulatory plan designated the 3 regulatory areas that exist today*
- *Both the HGSD and FBSD Regulatory plans were updated in 2013.*



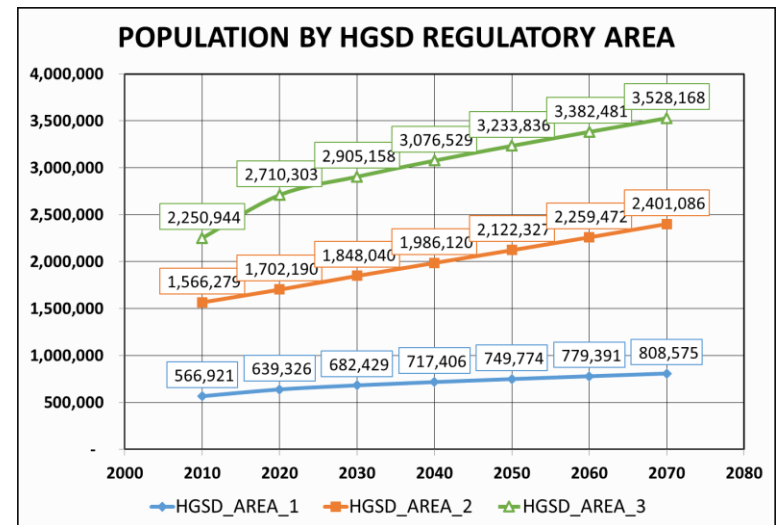
2013 Regulatory Plan Update



Utilized data from the 2010 Census and Annual Water-Level and Subsidence Data collected by the USGS and the Subsidence District

Brought together a group of consultants to help develop the plan:

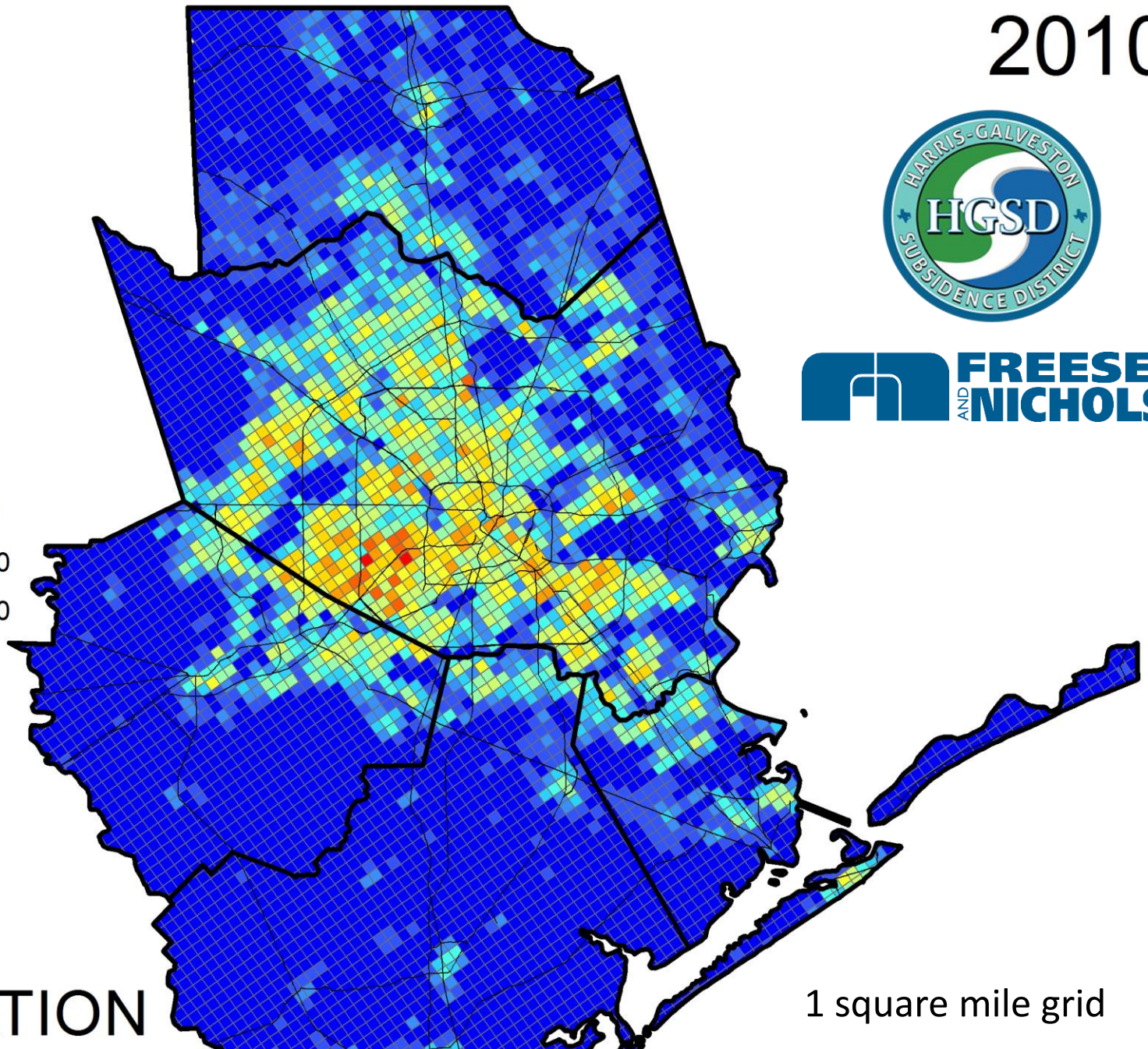
- Conducted population projections and migration prediction
- Updated multiple local scale analytical subsidence models in the Houston Region
- Updated the regional groundwater flow model
- Developed the predictive model data sets



Population



2010

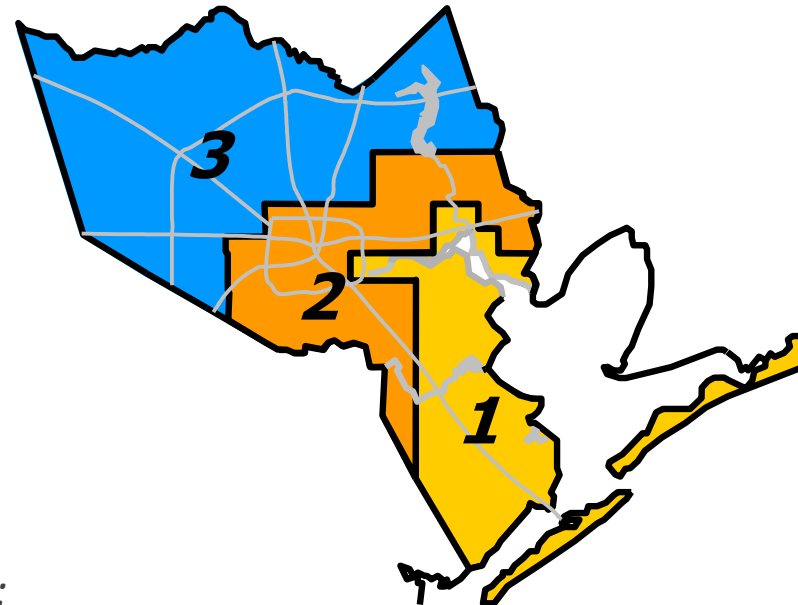


POPULATION

1 square mile grid

Harris-Galveston Subsidence District Regulatory Plan

- *Updated in 2013*
- **Areas 1 and 2 – Fully Converted**
 - *Area 1 GW Reduced to 10% or less of TWD*
 - *Area 2 GW Reduced to 20% or less of TWD*
- **Area 3**
 - *GW Reduced to 70% or less of TWD 2010*
 - *GW Reduced to 40% or less of TWD 2025*
 - *GW Reduced to 20% or less of TWD 2035*
- *Exemptions: Agricultural Irrigation*
- *Groundwater Reduction Plans were due in 2003:*
- *4 main Area 3 GRPs (Houston, NHCRWA, WHCRWA & CHCRWA)*
- *Non compliance subject to disincentive fee = \$9.00/1,000 gallons*



Harris-Galveston Subsidence District Regulatory Plan

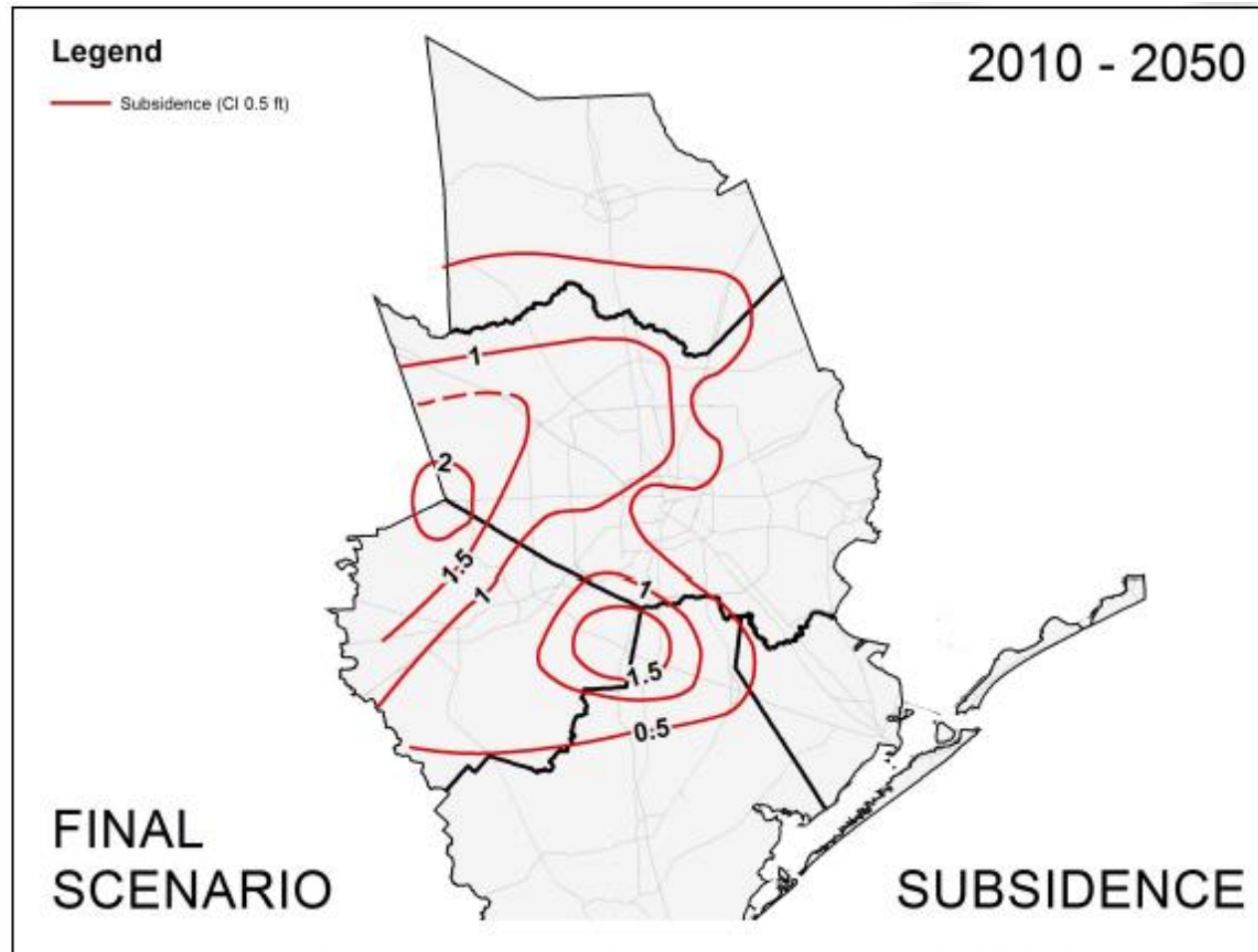


Figure 10. Final Scenario Subsidence: 2010-2050



Regulating Groundwater Withdrawal

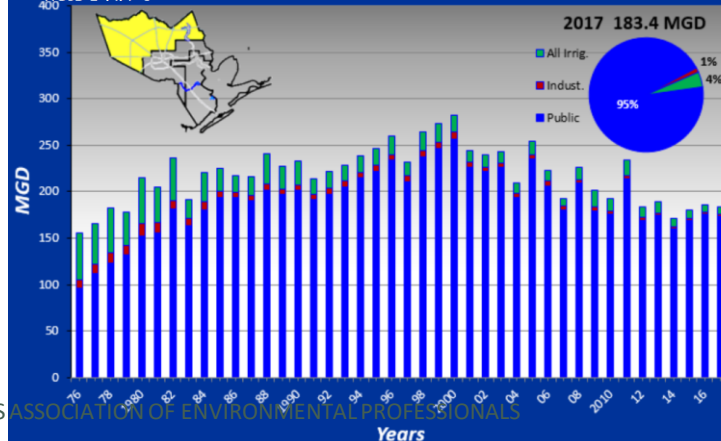
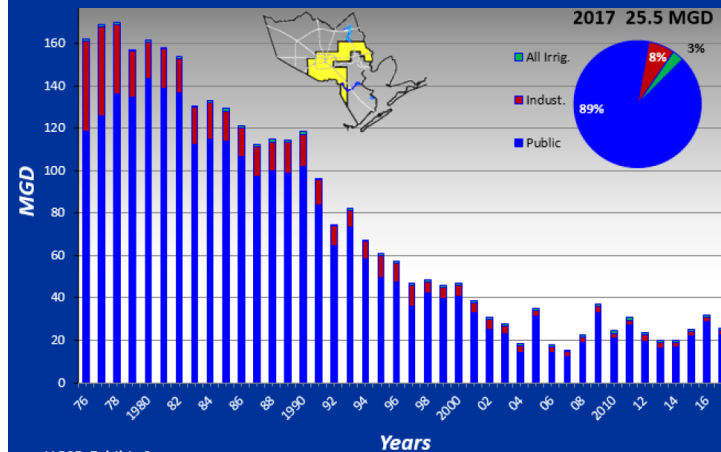
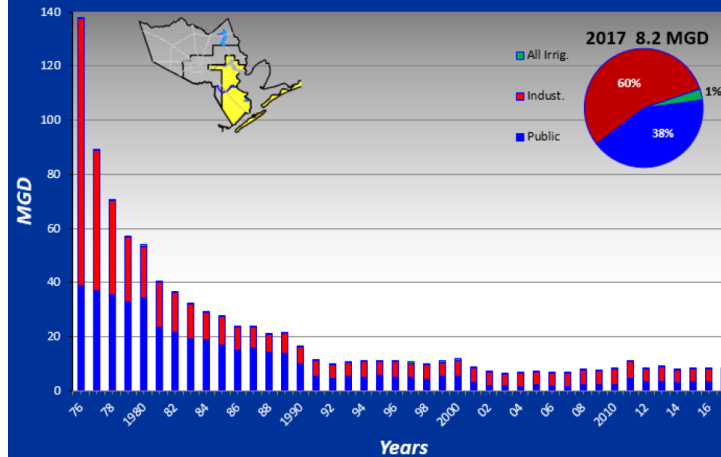
The reduction in groundwater withdrawal in areas 1 and 2 due to the regulatory policies established by the District has resulted in the increase in water levels of the aquifer and reduction in the rate of subsidence.

Areas 1 and 2 are currently considered “fully converted” where no more than 10% and 20% of the users total water demand can be sourced from groundwater, respectively.

Area 3 is currently in the process of conversion. In 2010, the area converted to 70% groundwater. Future conversion deadlines occur in 2025 (40%) and 2035 (20%). By 2035, alternative sources of water will comprise 80% of the total water demand in Area 3

Groundwater Withdrawals

Grouped By Use - Regulatory Area 1





Texas Gulf Coast Groundwater and Land Subsidence

Forty Years of Research in the Houston-Galveston Region

In cooperation with [Harris-Galveston Subsidence District](#), the [City of Houston](#), [Fort Bend County Subsidence District](#), [Lone Star Groundwater Conservation District](#), and [Brazoria County Groundwater Conservation District](#), the U.S. Geological Survey Texas Water Science Center Gulf Coast Program collects, processes, and interprets groundwater-level and aquifer-sediment-compaction data to understand the effects of groundwater withdrawal on land subsidence in the Houston-Galveston region, Texas.

Land Subsidence

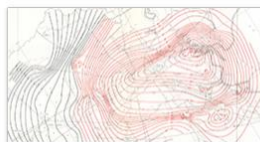
Land subsidence is the gradual lowering of land-surface elevation. In the Houston-Galveston region, land subsidence is caused by [compaction](#) of fine-grained aquifer sediments (silts and clays) below the land surface due to groundwater withdrawals. Removing water from fine-grained aquifer sediments compresses the aquifer leaving less pore space available to store water resulting in the lowering (sinking or settling) of the land-surface. Most compaction that occurs as a result of groundwater withdrawals is irreversible; even if groundwater levels rise, compacted sediments and the associated land-surface lowering would remain as-is.

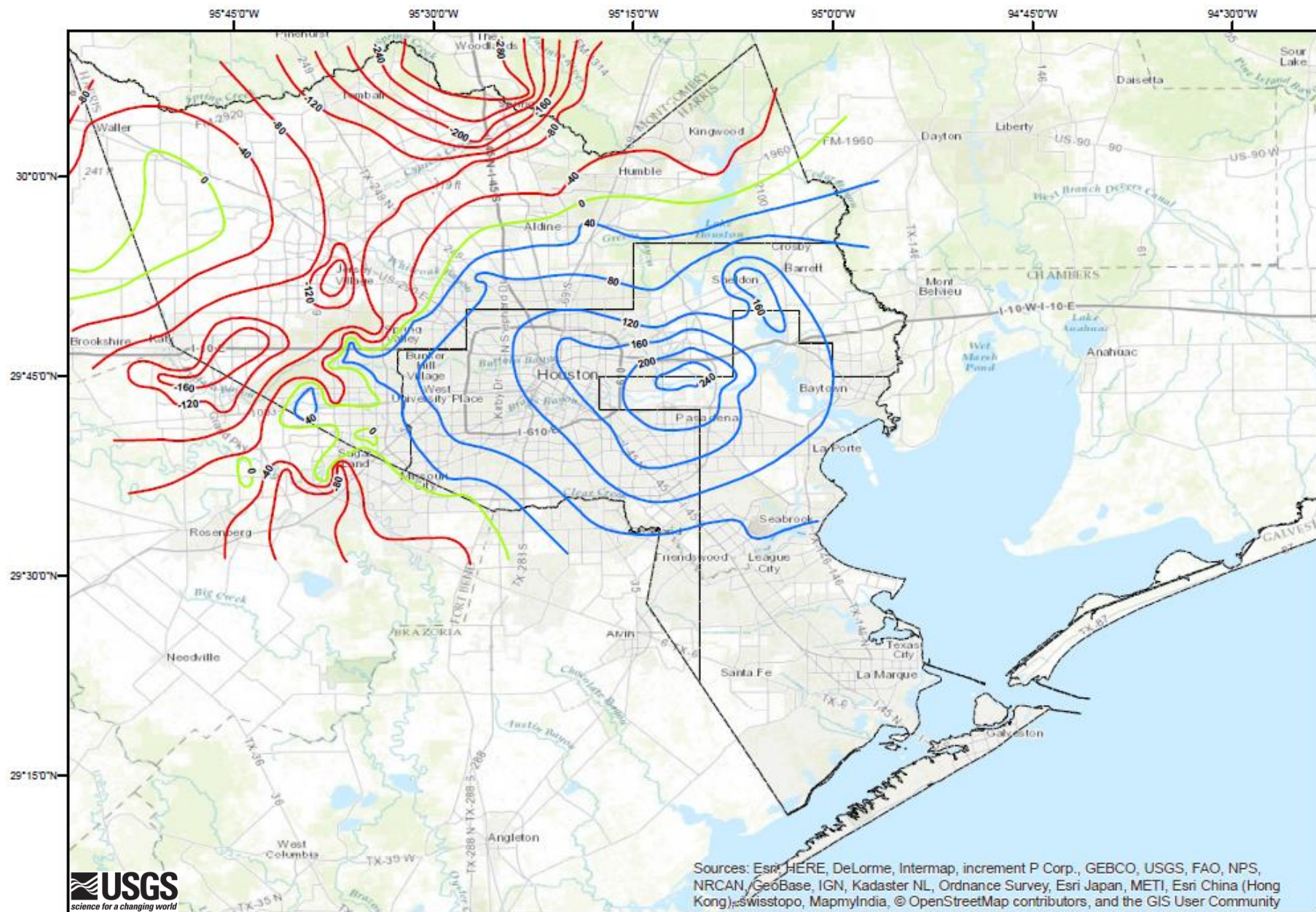
Consequences of land subsidence in the Houston-Galveston Region

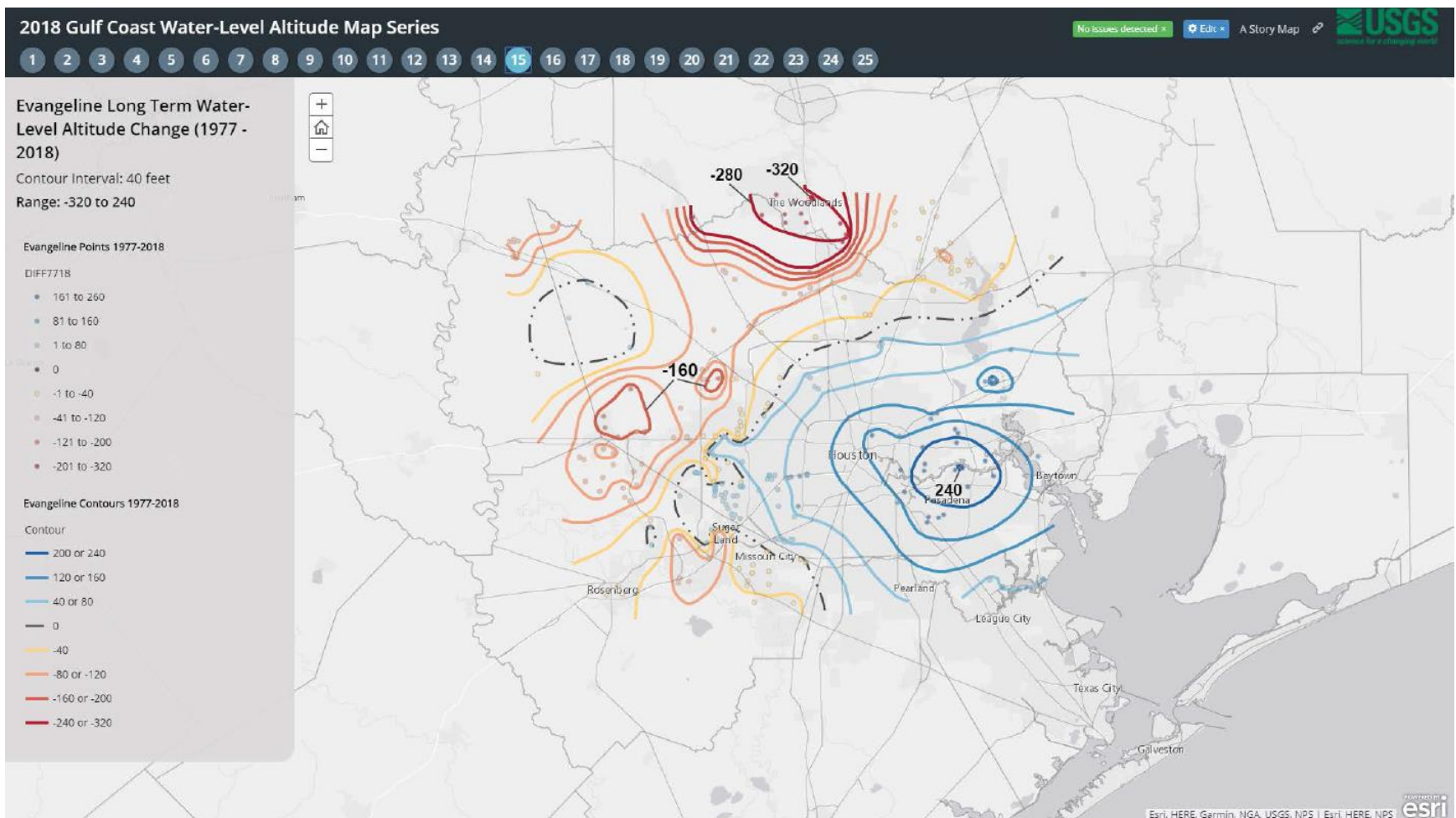
- Reduces the ability to store water in an aquifer.
- Partially or completely submerges land.
- Collapses water well casings.
- Disrupts collector drains and irrigation ditches.
- Alters the flow of creeks and bayous which may increase the frequency and severity of flooding.
- Damages roadways, bridges, building foundations, and other infrastructure.



Groundwater Withdrawals





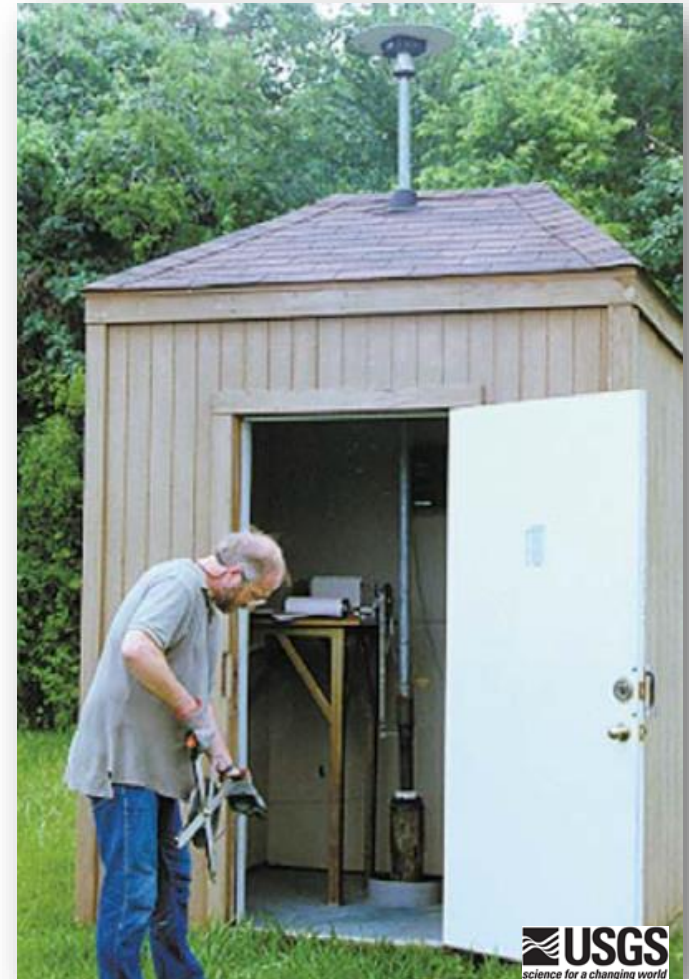


Water-level change in the Gulf Coast Aquifer, 1977 to 2018.

The reduction in pumpage has resulted in the increase of water-level in the aquifer system in those areas and a reduction in subsidence rates. Data provided by the USGS.

Measurement of clay-compaction and subsidence

- The District has a long history of working with multiple agencies and private firms to understand the mechanism and occurrence of subsidence in the region
 - **U.S. Geological Survey:** Determined much of the mechanics and works through a cooperative agreement with each district to monitor water-level, develop groundwater models, and provide technical assistance.
 - **National Geodetic Survey:** Developed the GPS monitoring network and provides technical assistance.
 - **University of Houston:** Cooperation in data collection, processing, and dissemination
 - **Private Consultants**





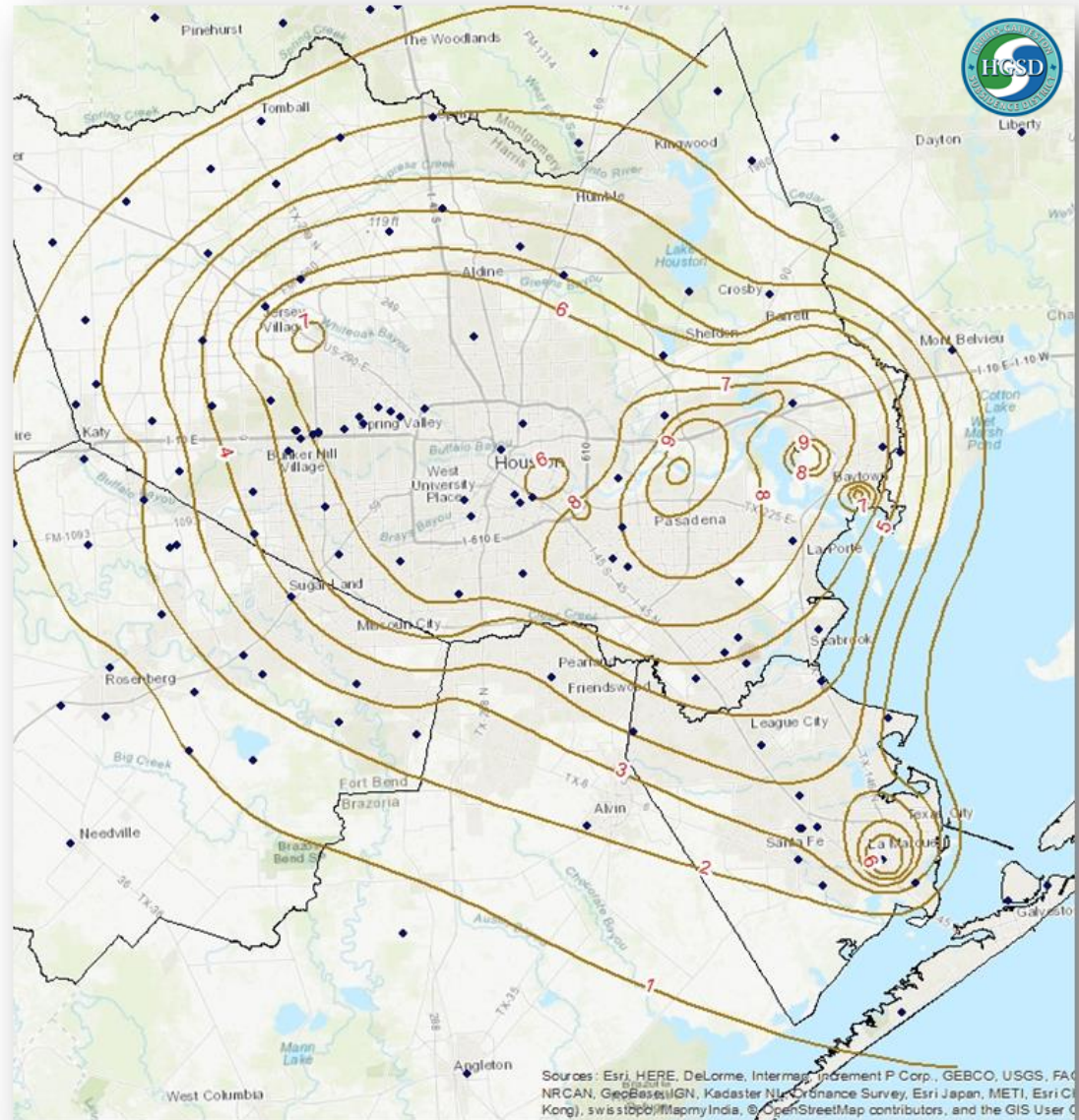
Estimated Subsidence 1906-2000

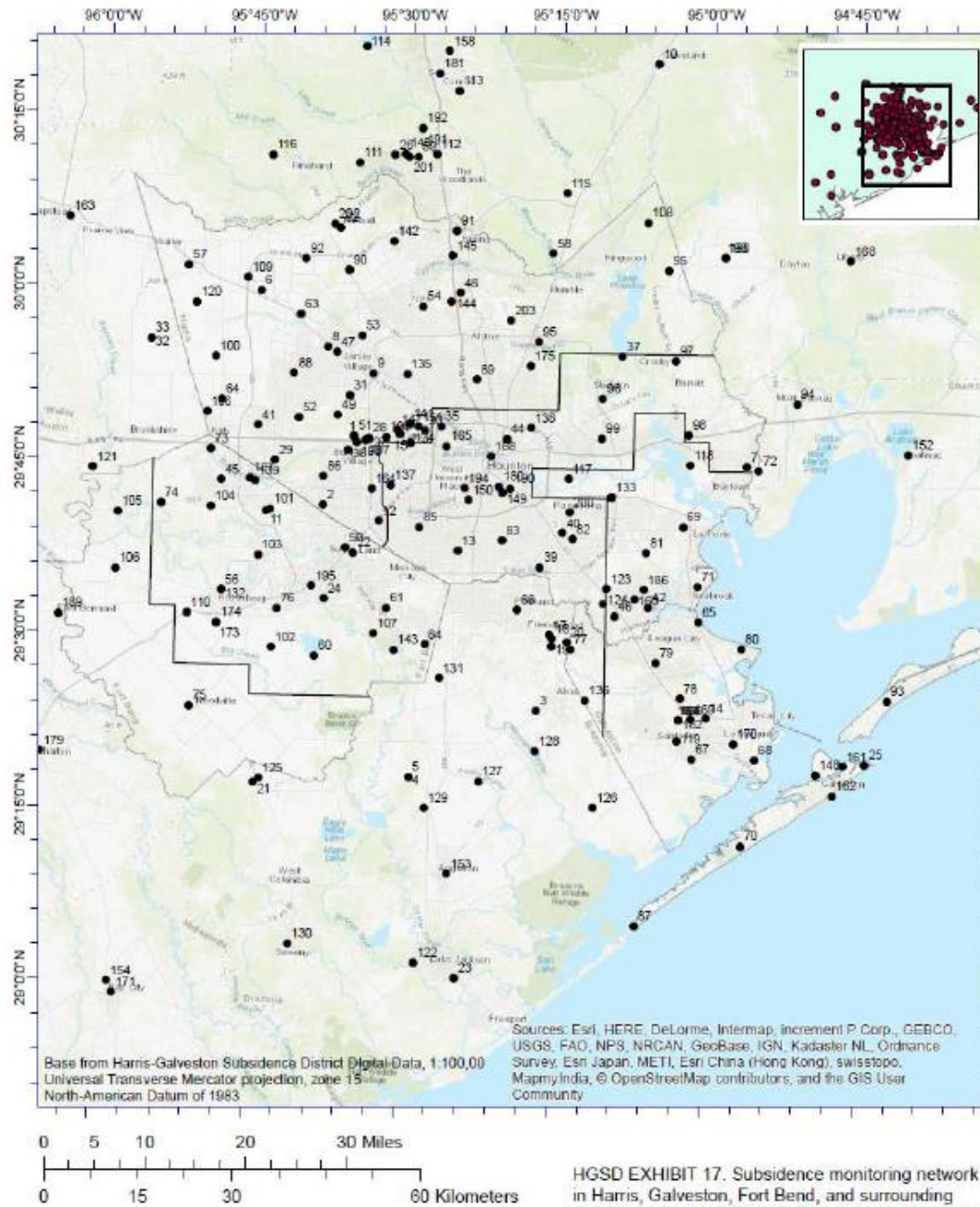
Developed through the comparison of historical topographic information and level surveys conducted by the District in 2000.

Shows broad area of about 6 feet of subsidence encompassing most of the City of Houston and Harris County.

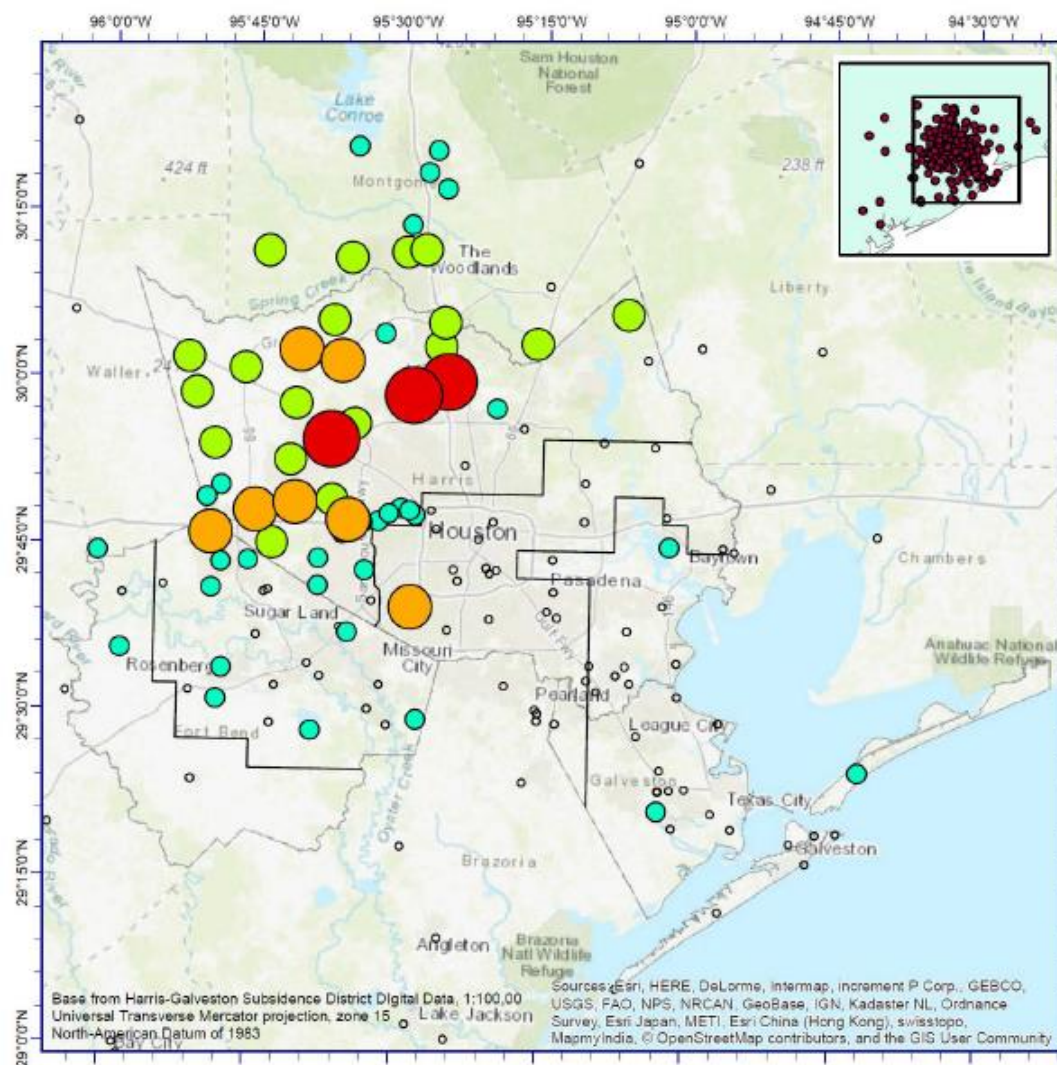
In comparison the amount and breadth of subsidence in the northern and western parts of Harris County just showing the beginning signs of Subsidence.

This data was developed by Bob Gabrysch and pushed at the fifth international symposium on subsidence



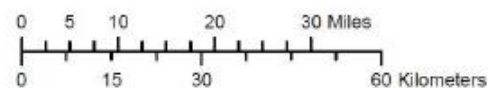
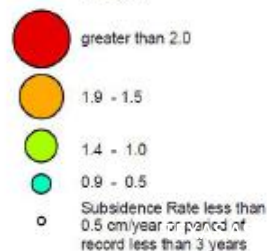


HGSD EXHIBIT 17. Subsidence monitoring network in Harris, Galveston, Fort Bend, and surrounding counties operated in cooperation with the University of Houston, Lone Star Groundwater Conservation District, and the Brazoria County Groundwater Conservation District, 2017.

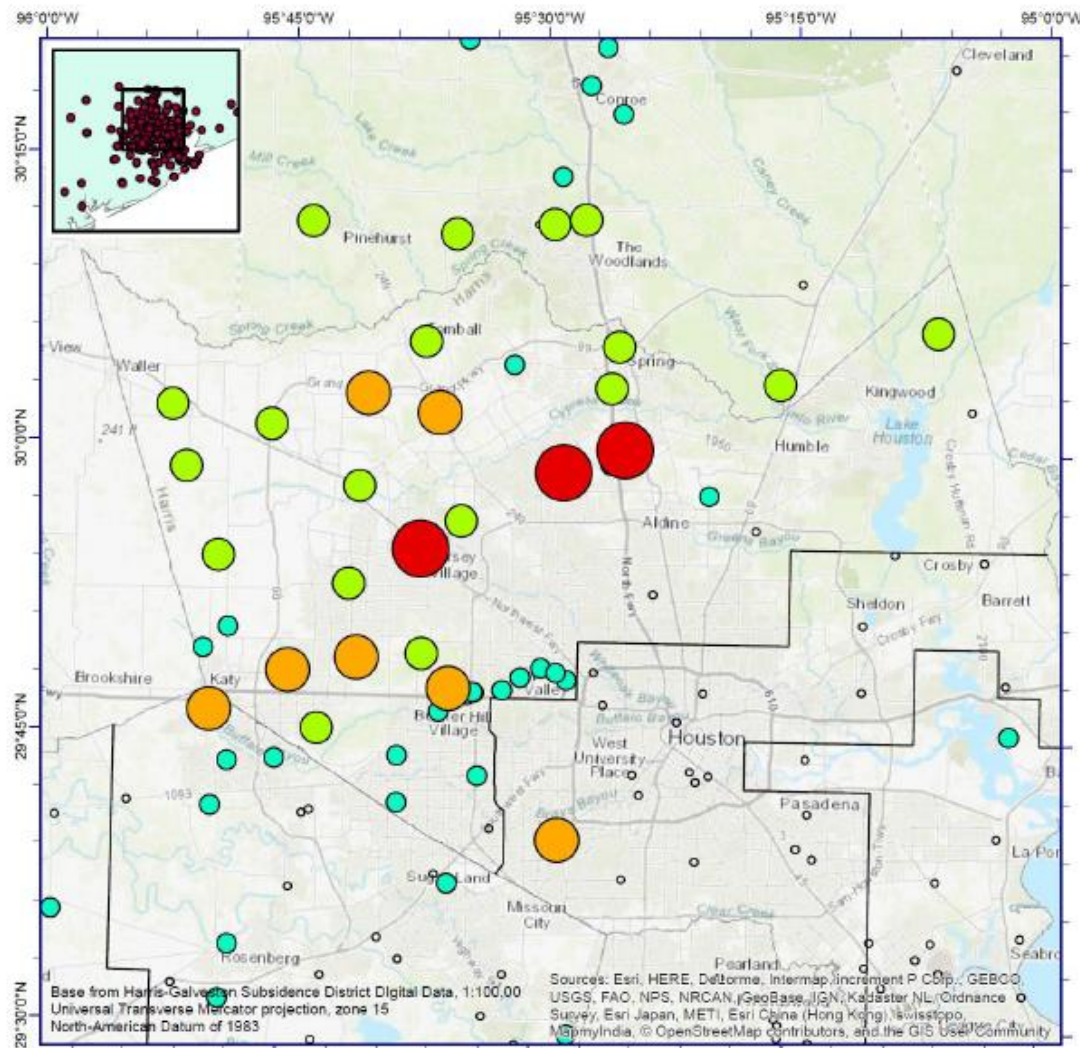


EXPLANATION

Subsidence Rate (2013-2017) cm/year



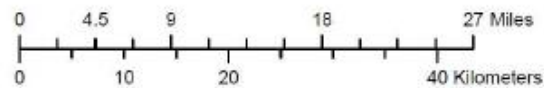
HGSD EXHIBIT 18. Annual estimated subsidence rate, in centimeters per year, from GPS data measured from 2011-2017 at monitoring locations with more than three years of data.



EXPLANATION

Subsidence Rate (2013-2017)
cm/year

- greater than 2.0
- 1.9 - 1.5
- 1.4 - 1.0
- 0.9 - 0.5
- Subsidence rate less than 0.5 cm/year or period of record less than 3 years



HGSD EXHIBIT 19. Annual estimated subsidence rate, in centimeters per year, from GPS data measured from 2011-2017 at monitoring locations with more than three years of data.

Estimated Subsidence 1906-2016

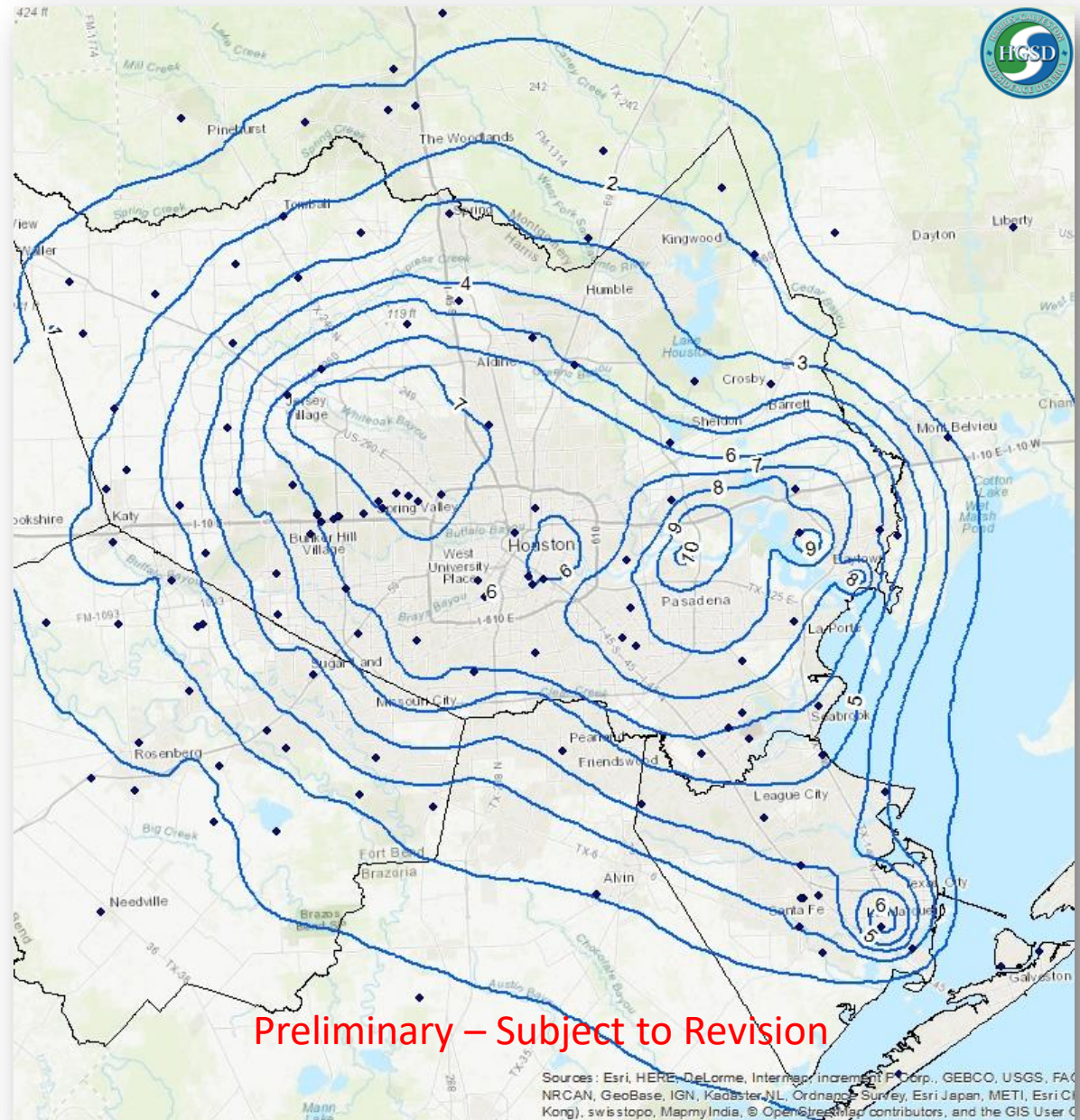
Developed through the assumption that current subsidence rates (2011-2016) remained constant from 2000-2016. Estimated total subsidence was then added to the 1906-2000 surface.

Little change is noted in the areas to the east of downtown Houston, where full conversion has completed.

The area of subsidence expands to include Montgomery and Waller counties. Western Harris County, Northern Fort Bend County, Northern Harris county show change from the 1906-2000 comparison.

This data was developed by the
Subsidence District

This map is preliminary and subject to revision.



Smaller 7-foot feature in the 1906-2000 surface expands considerably.



SCIENCE AND RESEARCH and WATER CONSERVATION PROGRAMS

Current Science and Research

- The District is currently evaluating other alternative water supply strategies for their potential use within the Region. The District's primary concern is that the utilization of these water development methods will not contribute to future subsidence within the District. Ongoing projects include:
 - Desalination of brackish groundwater
 - Technology has made it economically viable
 - **In the gulf coast, withdrawal of brackish groundwater can cause subsidence**
 - Demonstration project ongoing in Fort Bend County in Jasper Aquifer
 - Aquifer Storage and Recovery
 - Successful method in the Carrizo-Wilcox – SAWS
 - Has been attempted here, but has challenges with this aquifer system
 - Evaluation of the Subsidence Neutral Yield

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Detectives Game

Learn About The Water
Detective Program



Larry the Talking Sprinkler

Brought to you by the Harris-Galveston Subsidence District in collaboration with the Texas Living Waters Project



GALVESTON BAY



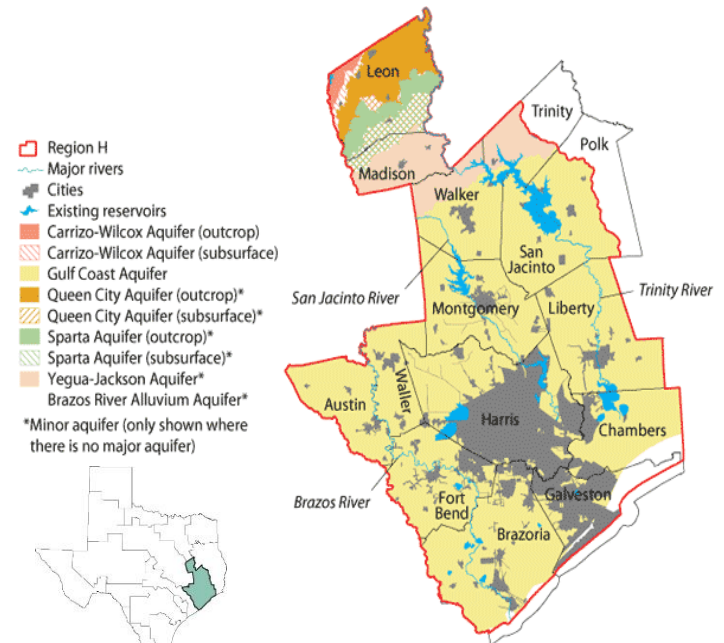
WATER BRIDGE



REGIONAL COORDINATION

Regional Water Planning

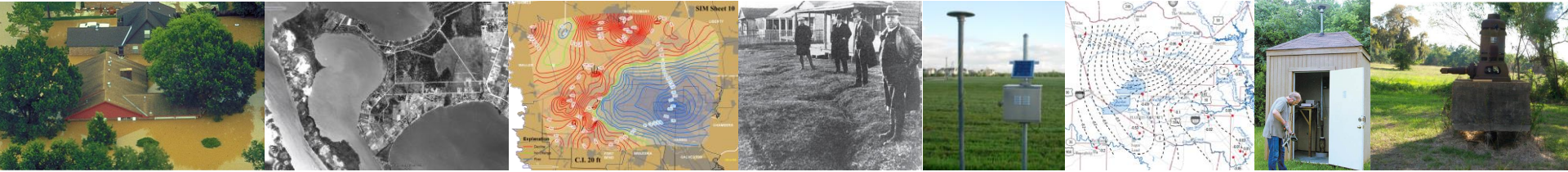
- Funding of the State Water Plan important to the District's mission
- Regional water supply projects insure alternative water supplies are available to offset groundwater use
- Important projects to the District:
 - Luce Bayou interbasin transfer from the Trinity River to Lake Houston
 - Increased treatment capacity at the City of Houston Northeast Water Purification Plant on Lake Houston
 - Expanded conveyance system to move water to northern and western Harris and northern Fort Bend counties.



Future Alternative Water Supplies



- Future alternative water supply infrastructure is consistently being developed in our region
 - **Luce Bayou Interbasin Transfer Project** – Raw water supply transfer from the Trinity River Basin to the San Jacinto River Basin increasing the raw water supply to Lake Houston
 - **Northeast Water Purification Plant Expansion** – Increased capacity to treat the increased supply in Lake Houston
 - New treated water transmission lines from the Northeast Plant
 - Upgraded internal water distribution systems



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SINCE 1975*