



Presented at the FIG Working Week 2023,
28 May - 1 June 2023 in Orlando, Florida, USA

FIG WORKING WEEK 2023

28 May - 1 June 2023 Orlando Florida USA

Protecting
Our World,
Conquering
New Frontiers

Southeast Texas Subsidence Adjustment Project (12029)

Dr. Davey EDWARDS and Ibraheem ALI, United States of America



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Discussion

- Subsidence Area of Southeast Texas
- Suppression of published Vertical datum
- Collaboration with the Public and Private Surveying Industry
- GNSS Observation Campaign
- Resulting improved Geodetic Network



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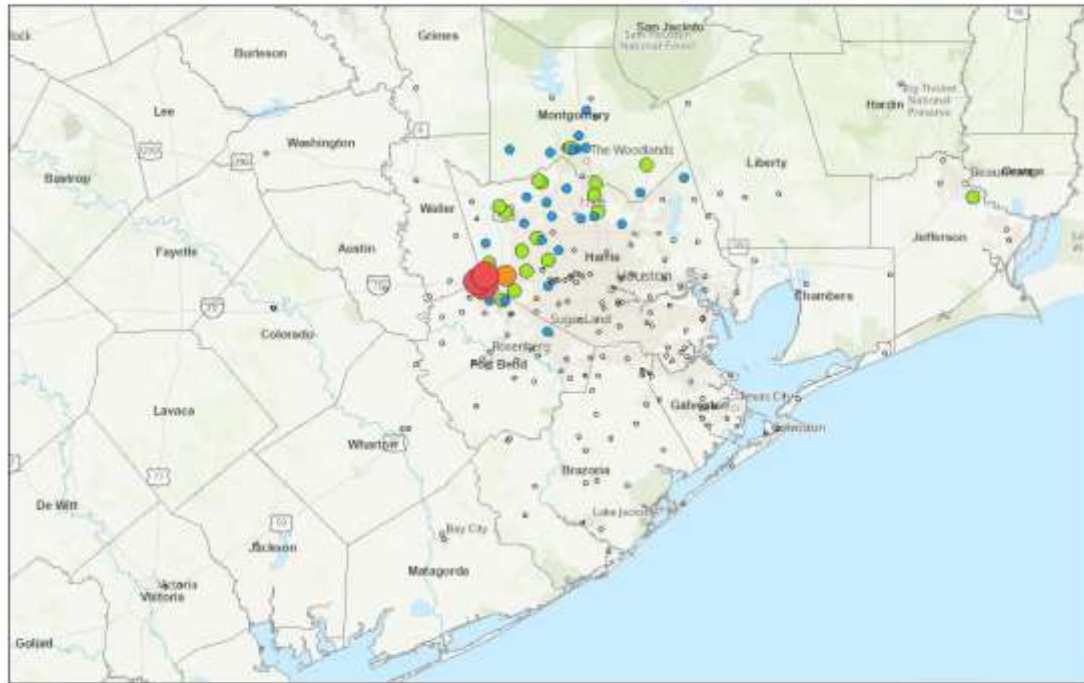


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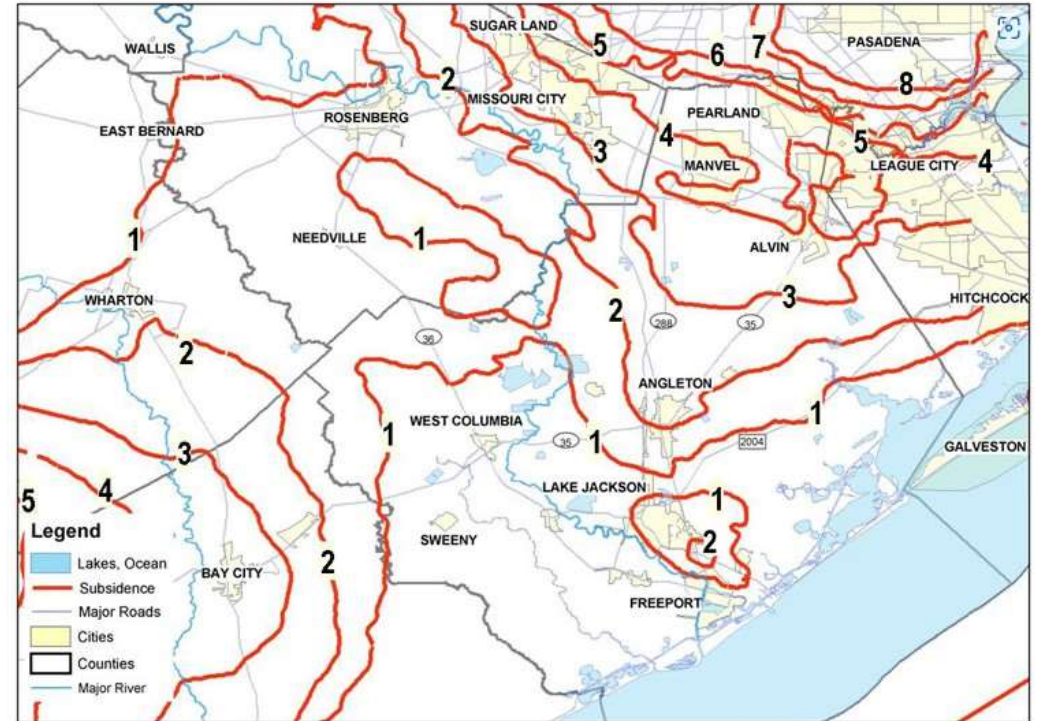
Subsidence Rates in Harris and Surrounding Counties, 2017-2021



5/23/2023
 Subsidence Rate (cm/yr) from 2017 to 2021
 ● Greater than 2.0
 ● >1.0 - 1.5
 ● <1.0 - 0.5
 ● <1.0 - 0.5
 * Less than 0.5 or period of record less than 3 years

1:1,596,782
 0 12.5 25 50 MI
 0 20 40 80 km
City of Houston, City of Missouri City, Texas, Public Affairs, CSD&RF, Inc. HERE, Garmin, FMO, NOAA, USGS, EPA, MPO, Esri, IGNAR, USGS

Projected Subsidence in Feet: 1906 - 2050
 (based on preliminary data)



Source: Northern Gulf Coast Groundwater Availability Model developed by USGS and 2002 RWPG Pumping Estimates by Regional Water Planning Groups and TWDB.

SUPPRESSION OF ORTHOMETRIC HEIGHTS

The NGS Data Sheet

See file [data.pdf](#) for more information about the datasheet.

```
PROGRAM = datasheet95, VERSION = 8.12.5.15
Starting Datasheet Retrieval...
1 National Geodetic Survey, Retrieval Date = MAY 24, 2023
DM7882 *****
DM7882 HT_MOD - This is a Height Modernization Survey Station.
DM7882 DESIGNATION - PAM 29 ARP
DM7882 PID - DM7882
DM7882 STATE/COUNTY- TX/FORT BEND
DM7882 COUNTRY - US
DM7882 USGS QUAD - KATY (2819)
DM7882
DM7882 *CURRENT SURVEY CONTROL
DM7882
DM7882 *-----*
DM7882* NAD 83(2011) POSITION- 29 46 08.45212(N) 095 49 19.83773(W) ADJUSTED
DM7882* NAD 83(2011) ELLIP HT- 14.861 (meters) (06/27/12) ADJUSTED
DM7882* NAD 83(2011) EPOCH - 2010.00
DM7882* NAVD 88 ORTHO HEIGHT - *(meters) *(feet) NOT PUB
DM7882 **This station is in an area of suspected vertical motion (see below).
DM7882
```

```
DM7882
DM7882.** This station is in an area of suspected land subsidence, uplift, or
DM7882.** crustal motion. NGS recommends this and all published orthometric
DM7882.** heights in such areas be validated before use as vertical control.
DM7882.** Click here to see a list and map of nearby stations with valid
DM7882.** orthometric heights. Note: while datasheets are updated in real-time,
DM7882.** updates to archived datasheets and the SE TX Valid OH map occur
DM7882.** monthly. NGS discourages the use of scaled, VERTCON, or superseded
DM7882.** heights as vertical control as they are deemed unreliable.
DM7882.**
DM7882.** If an established orthometric height is unavailable in the survey control
DM7882.** section, it should be considered suspect. To view suspect heights,
DM7882.** (in the superseded section), select 'Include suspect heights in vertical
DM7882.** motion areas' box from the datasheet retrieval page.
DM7882
```

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- Area of high rate of subsidence
- NGS control suspect of significant movement
- Only 28 out of 7,500 published marks were considered valid
- Remaining marks orthometric heights were suppressed



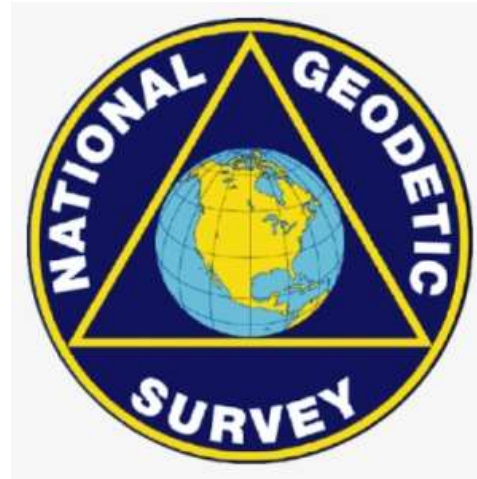


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COLLABORATING PARTNERS



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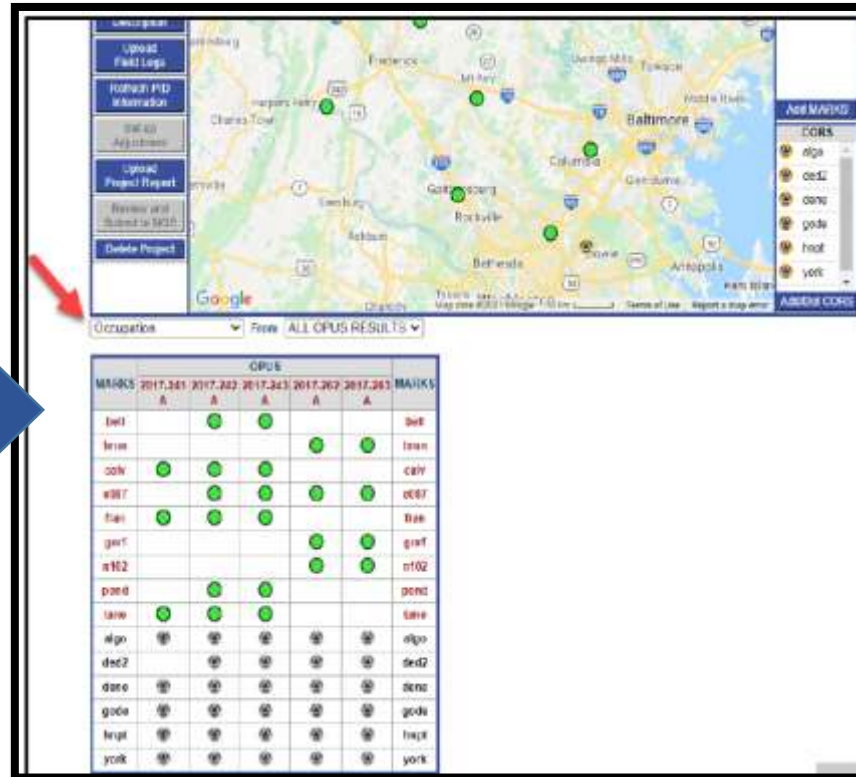


GPS Observation



Static Observation

OPUS Projects



Occupation

Upload Field Logs

Upload PID Measurement

Upload Project Report

Review and Submit to NGS

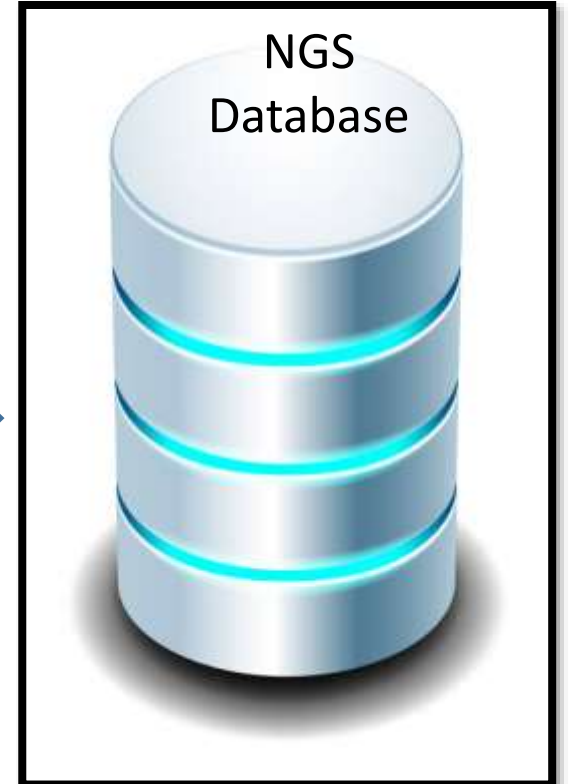
Delete Project

ALL OPUS RESULTS

MARKS	2017.241	2017.242	2017.243	2017.247	2017.248	MARKS
lwt	A	●	●			lwt
lwn				●	●	lwn
colv	●	●	●			colv
wb7	●	●	●	●	●	wb7
fas	●	●	●			fas
grf				●	●	grf
n102				●	●	n102
pond	●	●	●			pond
lax	●	●	●			lax
algo	●	●	●	●	●	algo
dec2	●	●	●	●	●	dec2
dno	●	●	●	●	●	dno
gode	●	●	●	●	●	gode
hux	●	●	●	●	●	hux
york	●	●	●	●	●	york

Session Processing & Network Adjustment

Publish



NGS Database



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Continous & Correlated Observations

	Session#1	Session#2	Session#3	Session#4	Session#5	Session#6
	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6
Mark#1	X					
Mark#2	X					
Mark#3	X					
Mark#4	X	X				
Mark#5	X	X				
Mark#6	X	X				
Mark#7		X	X			
Mark#8		X	X			
Mark#9		X	X			
Mark#10			X	X		
Mark#11			X	X		
Mark#12			X	X		
Mark#13				X	X	
Mark#14				X	X	
Mark#15				X	X	
Mark#16					X	X
Mark#17					X	X
Mark#18					X	X
Mark#1						X
Mark#2						X
Mark#3						X

X = 6-Hour Session

Two 6-hour static sessions for each mark

Continous & Correlated Observations

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MARKS	Adjustments						MARKS
	network final	network final-horizontal free	network final-horizontal constrained	network final-vertical free	network final-vertical constrained	MARKS	
ball	●	●	●	●	●	ball	
brun	●	●	●	●	●	brun	
carv	●	●	●	●	●	carv	
e067	●	●	●	●	●	e067	
fran	●	●	●	●	●	fran	
gorf	●	●	●	●	●	gorf	
n102	●	●	●	●	●	n102	
pond	●	●	●	●	●	pond	
tane	●	●	●	●	●	tane	
algn	●	●	●	●	●	algn	
ded2	●	●	●	●	●	ded2	
dene	●	●	●	●	●	dene	
gode	●	●	●	●	●	gode	
hrqt	●	●	●	●	●	hrqt	
york	●	●	●	●	●	york	

OPUS – Online Positioning User Service

OPUS Projects is an NGS web-based geodetic application which enables the baseline processing of simultaneous, static GNSS observations, called **sessions**, followed by a **least squares** adjustment of the sessions. Results are tied to the National Spatial Reference System (NSRS)

SE TX Subsidence OPUS Projects – Phase I

Processed, Submitted, Approved, and Published

Performed the following steps:

1. OPUS Solution
2. Session Processing
3. Network Free Adj.
4. Horizontal-Free Adj.
5. Horizontal-Constrained Adj.
6. Vertical-Free Adj.
7. Vertical-Constrained Adj.

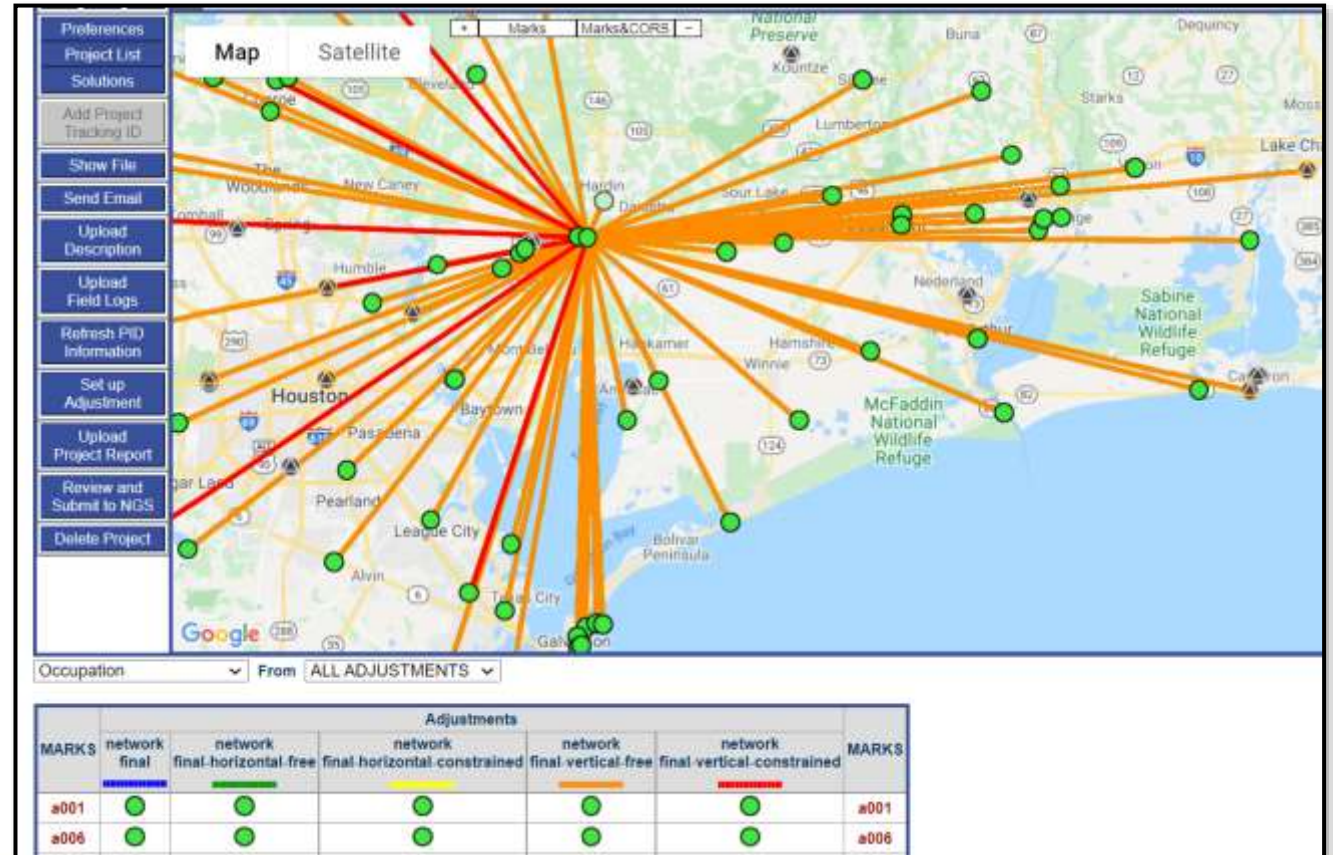









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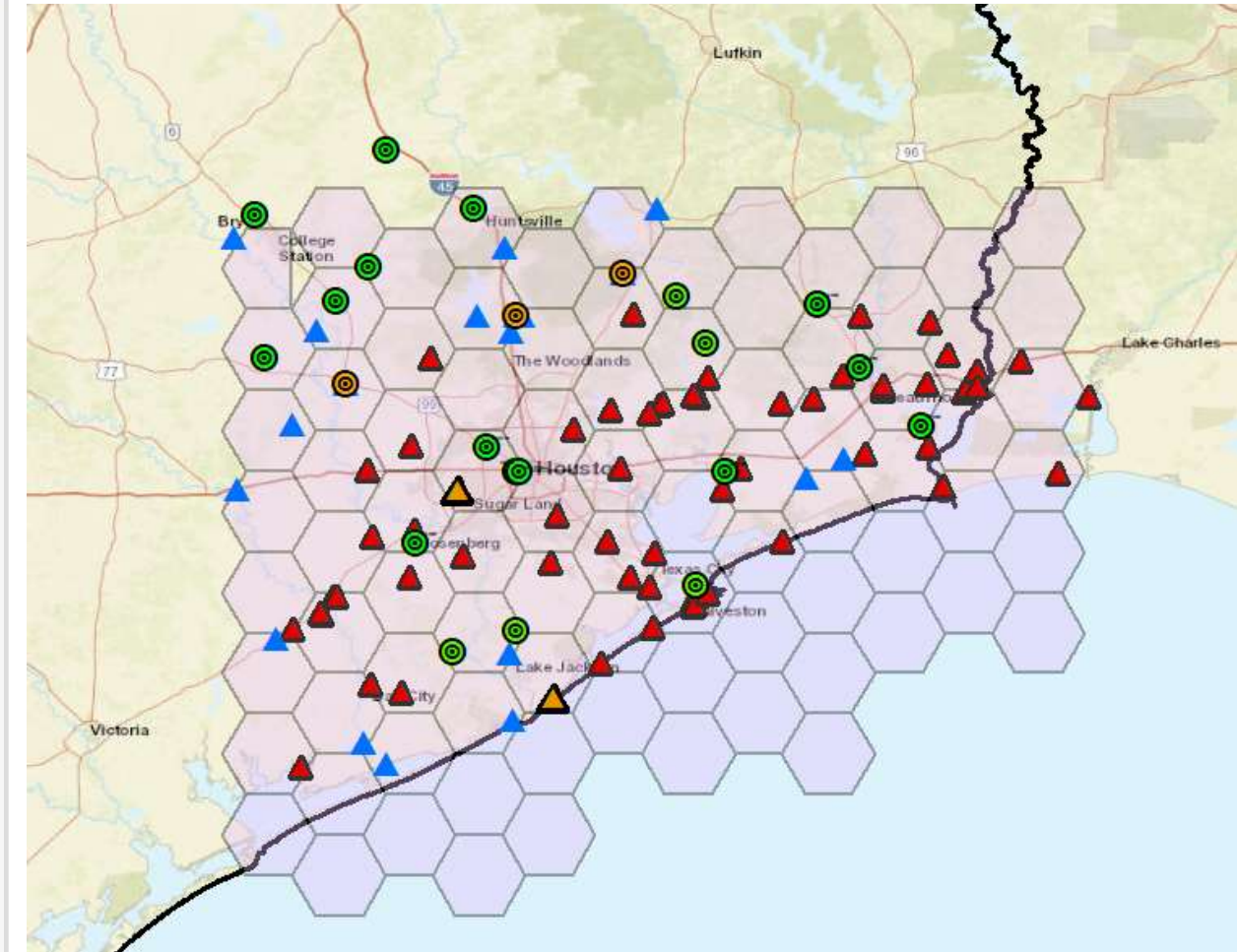
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Project's Area:
SE TX
Subsidence
Adjustment –
Phase II
(May 2022)

Legend

-  TXDOT – New Deep Rod Monuments
-  TXDOT - Centimeter Level Height
-  TXDOT - Decimeter Level Height
-  Mark - Centimeter Level Height
-  Mark - Decimeter Level Height
-  Mark - Centimeter Level Height (Upgraded)
-  TXDOT - Centimeter Level Height (Upgraded)

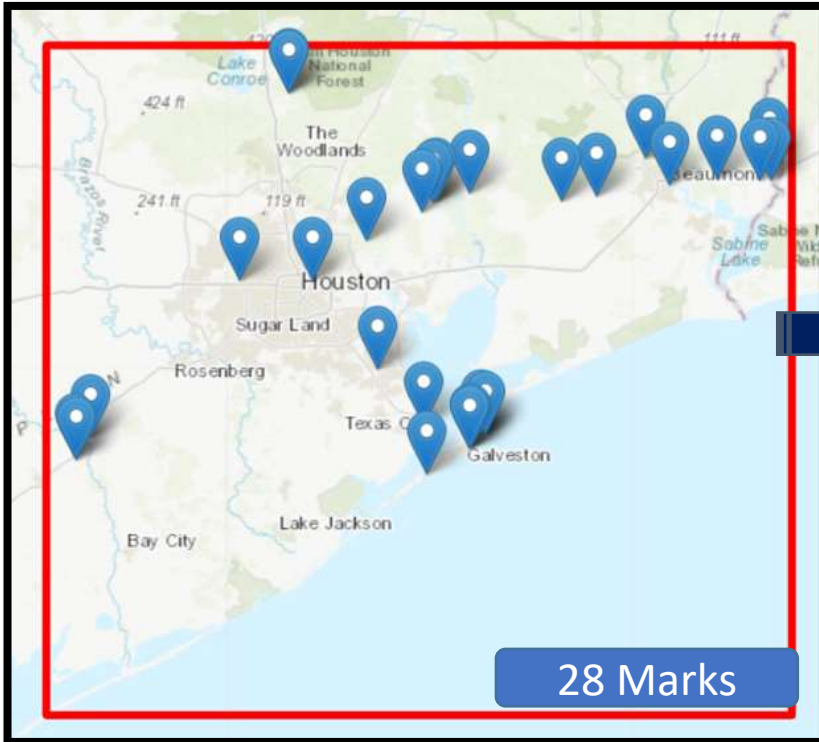


Results: Available Marks in SE TX After Adjustment

Before

After Phase I

After Phase II & HCFCD



Valid Ortho Height

Valid Ortho Height

Valid Ortho Height

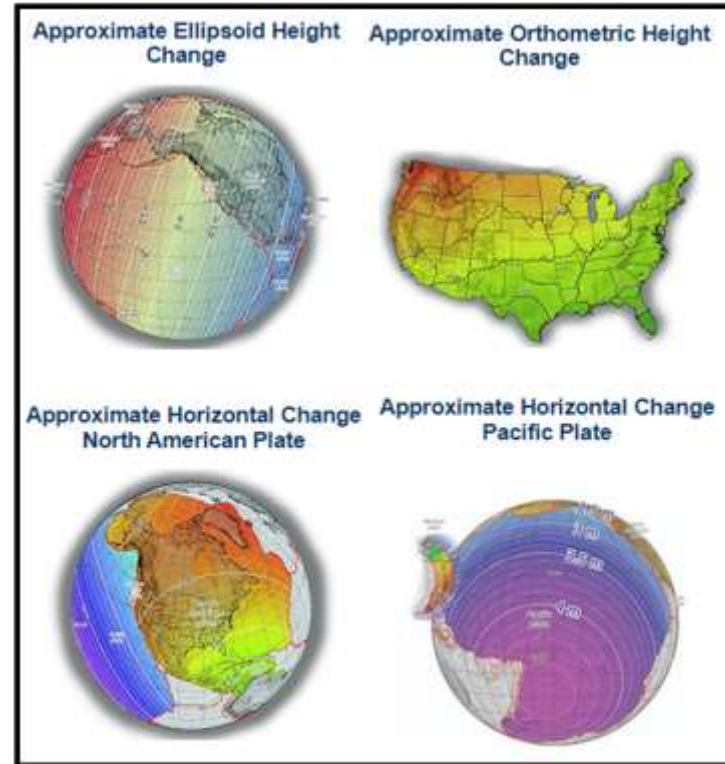
Project Results – Phase I & Phase II

Item	Units
Days Of Field Operation	65 Days
Number of Observed Marks	150 Marks
Number of RTN Stations	6 RTN Published Stations
Observation Sessions	300 (6-Hour Sessions)
Hours of Static Observations	1800 Hours
Field Crews	7 Crews (TxDOT & CBI)
GPS Units Used	Average 7 Units/Day

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- Accurate Orthometric Heights / Flood Mapping
- Used in the Private/Public infrastructure design surveys
- Integrated into the National Spatial Reference System (NSRS)



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REFERENCES

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Davey Edwards, PhD, PLS LSLs CFedS

Davey Edwards is a professional land surveyor in Texas and Oklahoma, a Texas licensed state land surveyor, and a U.S. Federal land surveyor. He is currently the Director of Surveying for Baseline | DCCM.

Davey has his BS from Texas A&M University, MS degree in Geospatial Surveying Engineering from Texas A&M University-Corpus Christi, and Doctorate degree in Geosciences from the University of Texas in Dallas. His studies concentrated on land administration systems and riparian boundary morphology. Davey continues to teach various professional continuing education courses on boundary surveying. He was a professional assistant professor in surveying at Texas A&M University – Corpus Christi.

Davey is the current president-elect of the National Society of Professional Surveyors and a past president of the Texas Society of Professional Surveyors. He is the 2006 recipient of the TSPS Young Surveyor of the Year award and the 2007 recipient of the TSPS Chapter President of the Year award. He is currently serving as a survey emeritus member of the Texas Board of Professional Engineers and Land Surveyors and a member of the survey advisory committee. He has served as public member of the Texas Board of Architectural Examiners and as a licensed state land surveyor member of the Texas Board of Professional Land Surveying. He is a former chair of the City of Decatur's planning and zoning commission. He is the former director of the Texas Spatial Reference Center.

Ibraheem Ali, MS, CP CMS-RS

Ibraheem Ali is an experienced geodesist and geoscientist. Mr. Ali is an ASPRS Certified Photogrammetrist (CP), and a Certified Mapping Scientist-Remote Sensing (CMS-RS). Ibraheem holds a Master of Science degree in Earth Science and a Bachelor of Science degree in Surveying Engineering. He has more than 25 years of experience in geodesy, surveying, remote sensing, Geographic Information System (GIS) and the Global Navigation Satellite System (GNSS).

During his career, Ibraheem has worked in a variety of industries and organizations such as government bodies, academic institutes, the oil and gas industry and construction and engineering consulting firms.

He recently worked with the CBI, Texas Spatial Reference Center (TSRC), TxDOT, NGS, and other stakeholders on the Southeast Texas Subsidence Area Adjustment Project. He was also involved in the development of the Low Distortion Projection (LDP) Coordinate System for the state of Texas as part of the new State Plane Coordinate System of 2022 (SPCS 2022).