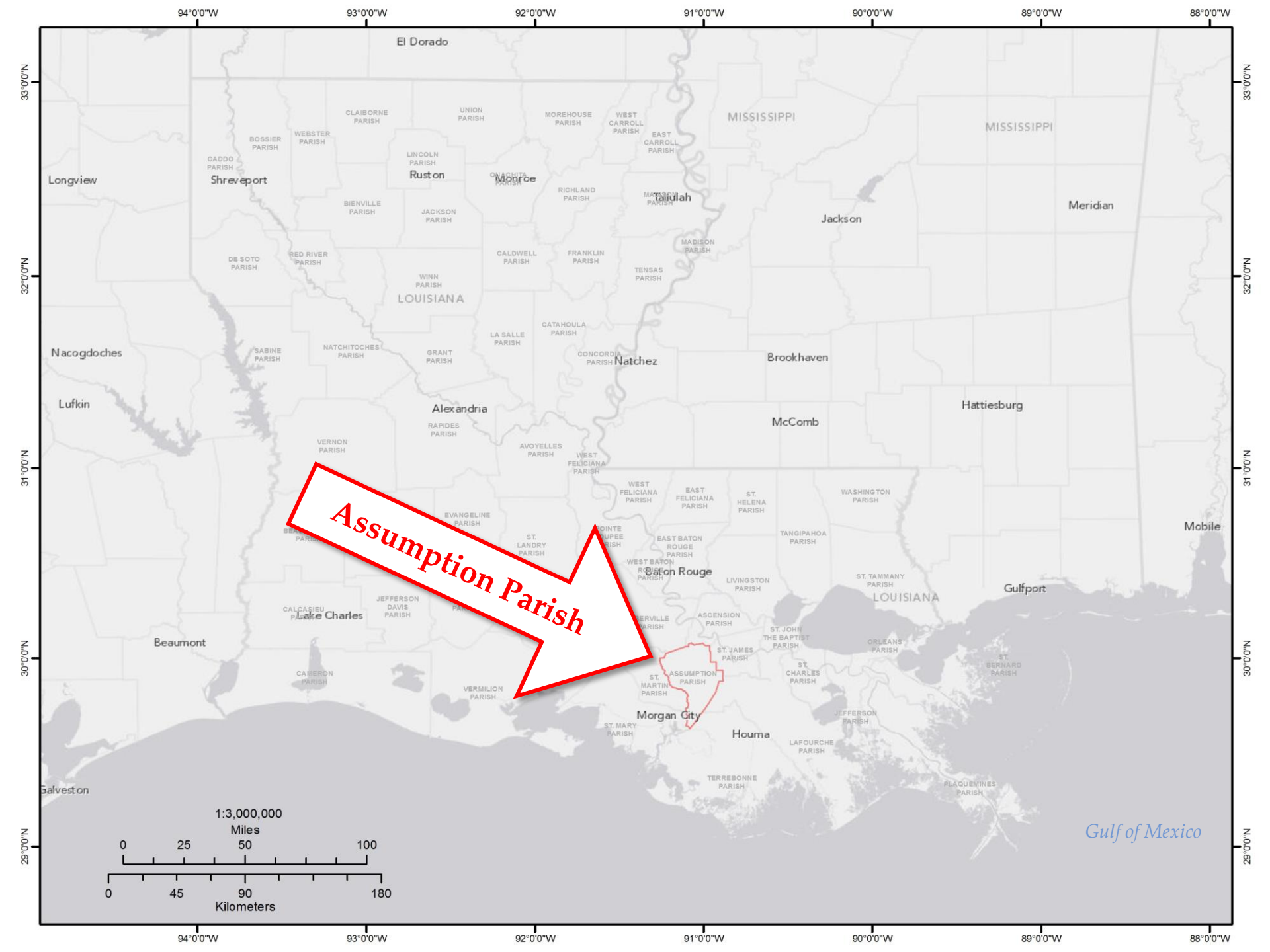
CORS911: Real-Time Subsidence Monitoring of the Napoleonville Salt Dome Sinkhole Using GPS

LSU Center for GeoInformatics
Joshua D. Kent, Larry E. Dunaway, Randy Osborne, & Cliff Mugnier

NGS Height Modernization Coordination Meeting
July, 12, 2013

Presentation Overview

- The Situation
- A Timeline
- Nature of the Sinkhole
- Efforts by the C4G
- Current Status
- Long-term Plans
- Conclusion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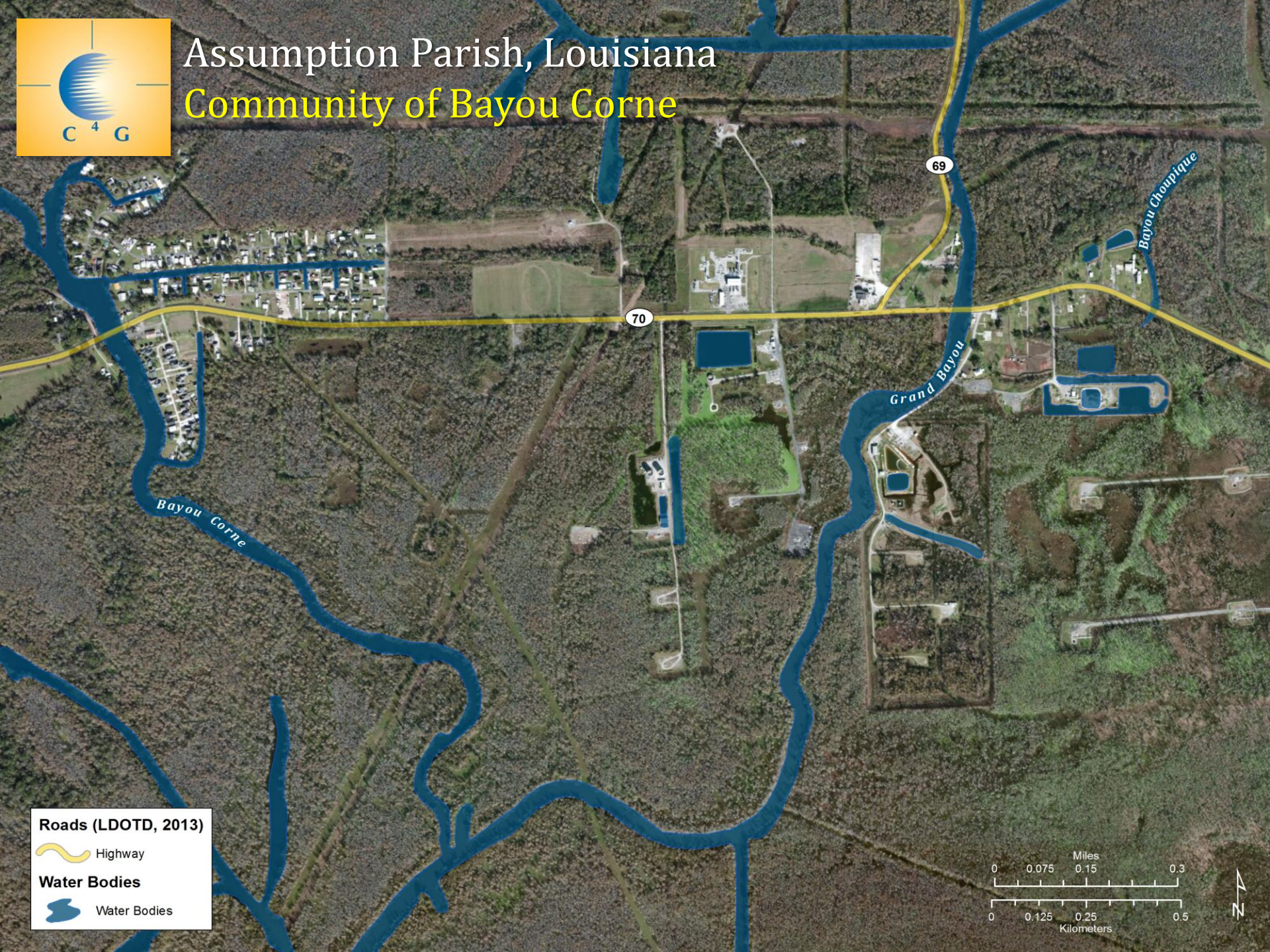
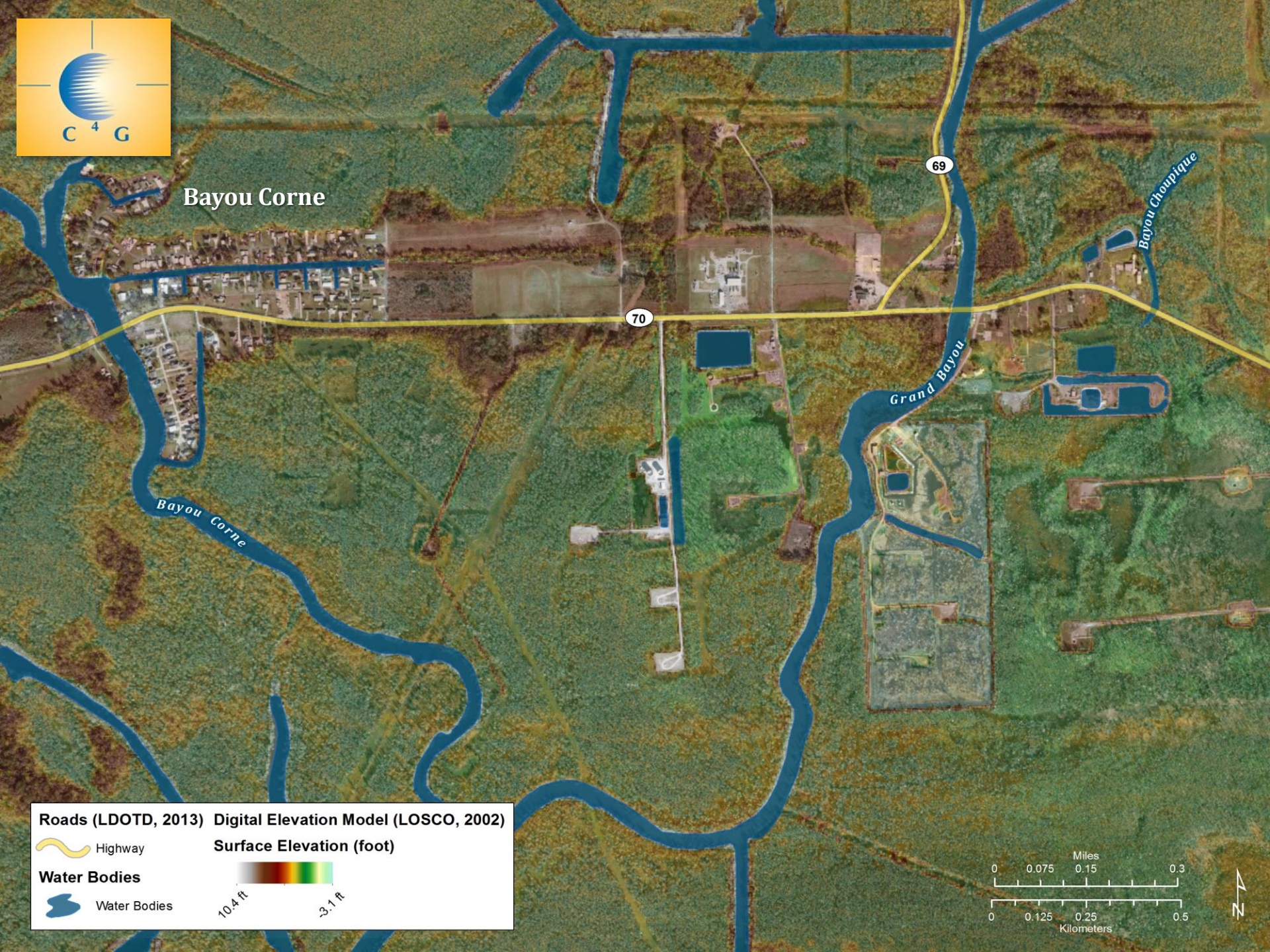
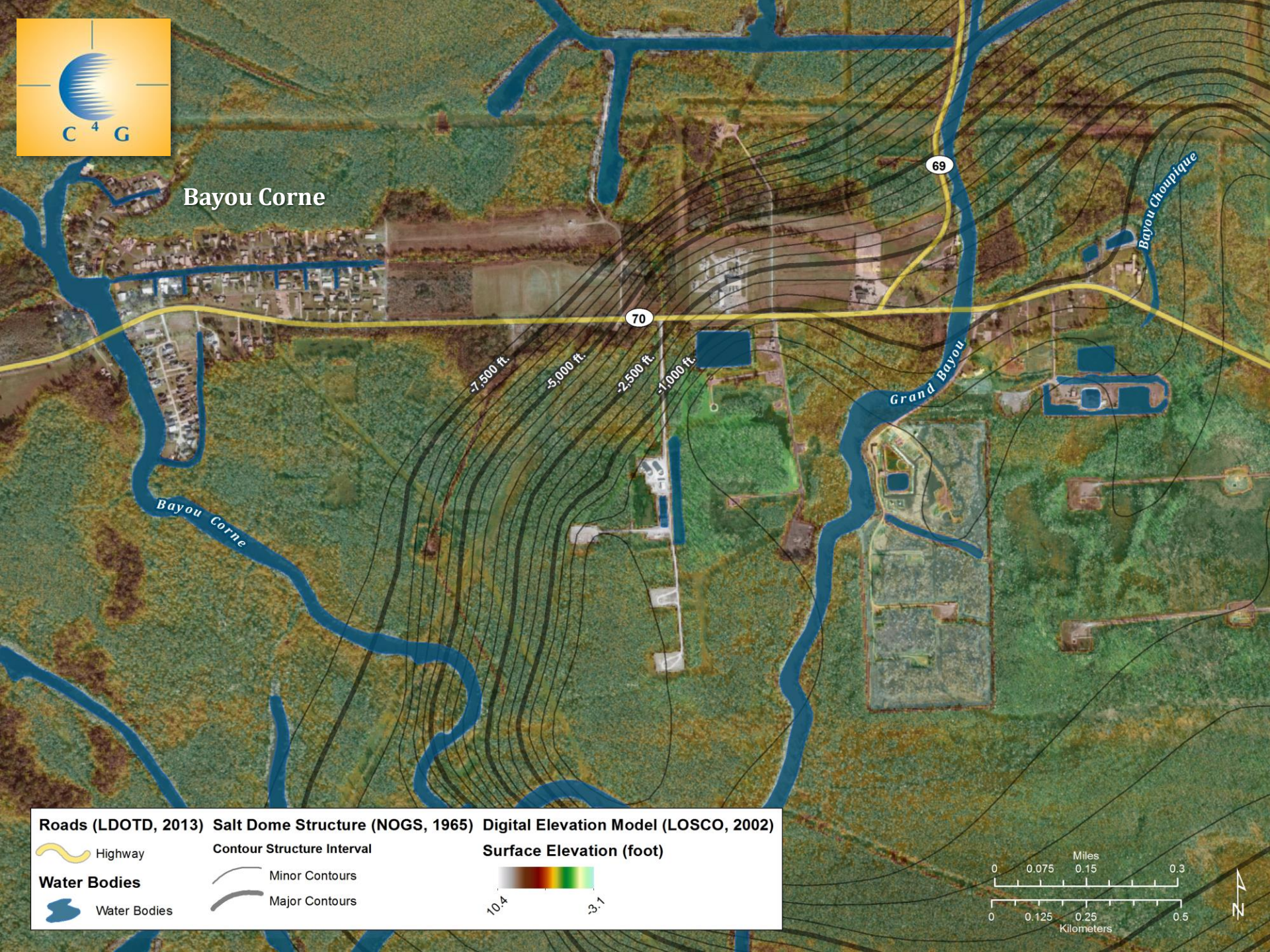
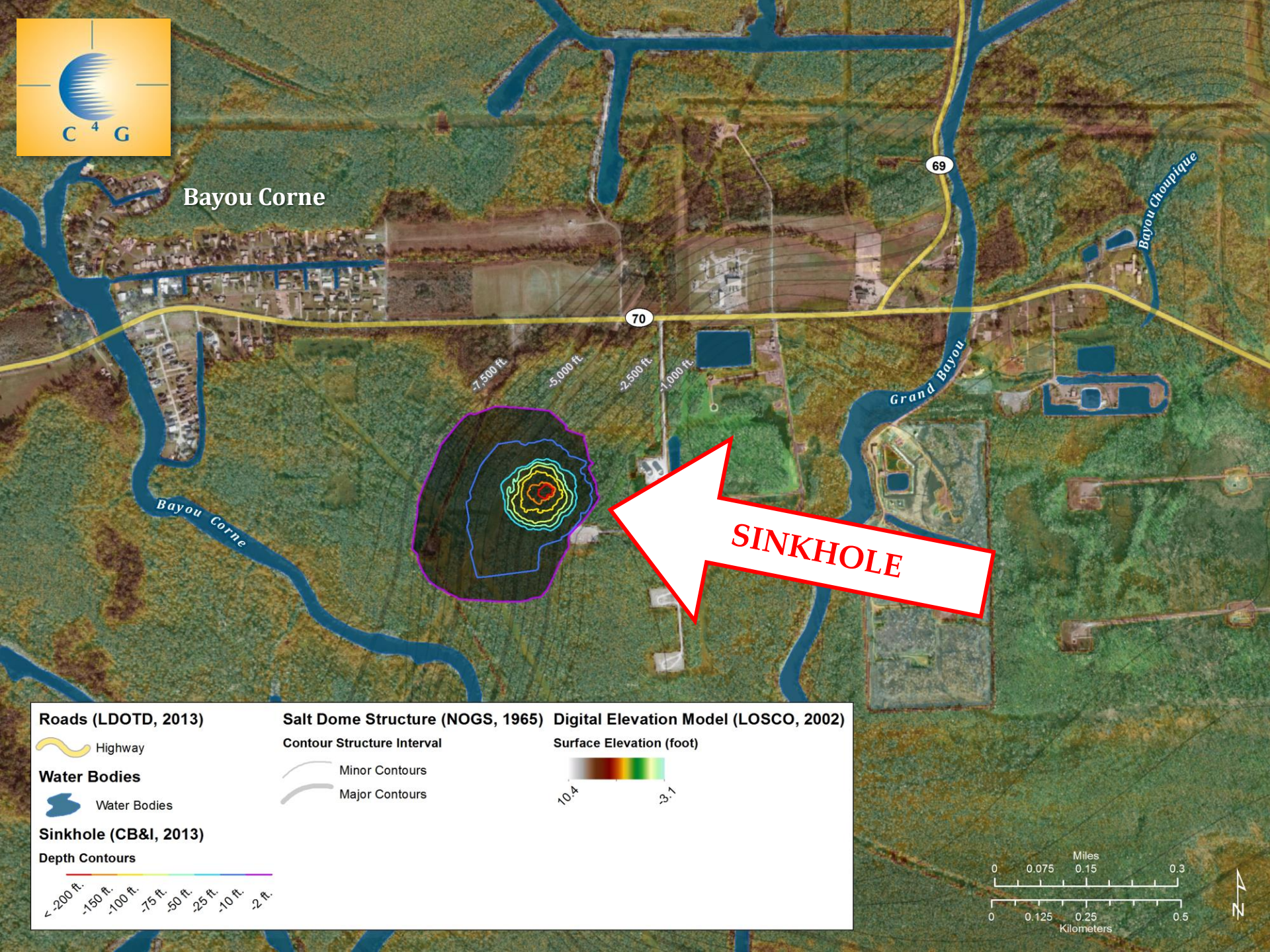
El Dorado
Longview
Shreveport
Ruston
Monroe
Tallulah
Jackson
Meridian
MISSISSIPPI
LOUISIANA
Nacogdoches
Lufkin
Alexandria
Natchez
Brookhaven
McComb
Hattiesburg
Mobile
Gulfport
Baton Rouge
Lake Charles
Beaumont
Morgan City
Houma
Galveston
Gulf of Mexico
1:3,000,000
Miles
0 25 50 100
0 45 90 180
Kilometers
94°0'0"W
93°0'0"W
92°0'0"W
91°0'0"W
90°0'0"W
89°0'0"W
88°0'0"W
33°0'0"N
32°0'0"N
31°0'0"N
30°0'0"N
29°0'0"N

Assumption Parish, Louisiana
Community of Bayou Corne




C 4 G
Bayou Corne
69
70
Bayou Choupique
Grand Bayou
Bayou Corne
Roads (LDOTD, 2013)
Highway
Water Bodies
Water Bodies
Digital Elevation Model (LOSCO, 2002)
Surface Elevation (foot)
10.4 ft
-3.1 ft
Miles
0
0.075
0.15
0.3
0
0.125
0.25
0.5
Kilometers
N


C 4 G
Bayou Corne
69
70
Bayou Choupique
Grand Bayou
Bayou Corne
-7,500 ft.
-5,000 ft.
-2,500 ft.
-1,000 ft.
Roads (LDOTD, 2013)
Highway
Water Bodies
Water Bodies
Salt Dome Structure (NOGS, 1965)
Contour Structure Interval
Minor Contours
Major Contours
Digital Elevation Model (LOSCO, 2002)
Surface Elevation (foot)
10.4
-3.1
Miles
0
0.075
0.15
0.3
0
0.125
0.25
0.5
Kilometers
N


Bayou Corne
69
70
Bayou Choupique
Grand Bayou
Bayou Corne
-7,500 ft.
-5,000 ft.
-2,500 ft.
-1,000 ft.
SINKHOLE
Roads (LDOTD, 2013)
Highway
Water Bodies
Water Bodies
Sinkhole (CB&I, 2013)
Depth Contours
< -200 ft.
-150 ft.
-100 ft.
-75 ft.
-50 ft.
-25 ft.
-10 ft.
-2 ft.
Salt Dome Structure (NOGS, 1965)
Contour Structure Interval
Minor Contours
Major Contours
Digital Elevation Model (LOSCO, 2002)
Surface Elevation (foot)
10.4
-3.1
Miles
0
0.075
0.15
0.3
0
0.125
0.25
0.5
Kilometers
N

Bayou Corne Sinkhole:

Air Photos - LADOTD 08/15/2012

Bayou Corne Sinkhole:

Air Photos - Environmental Protection Agency 08/23/2012

Bayou Corne Sinkhole:

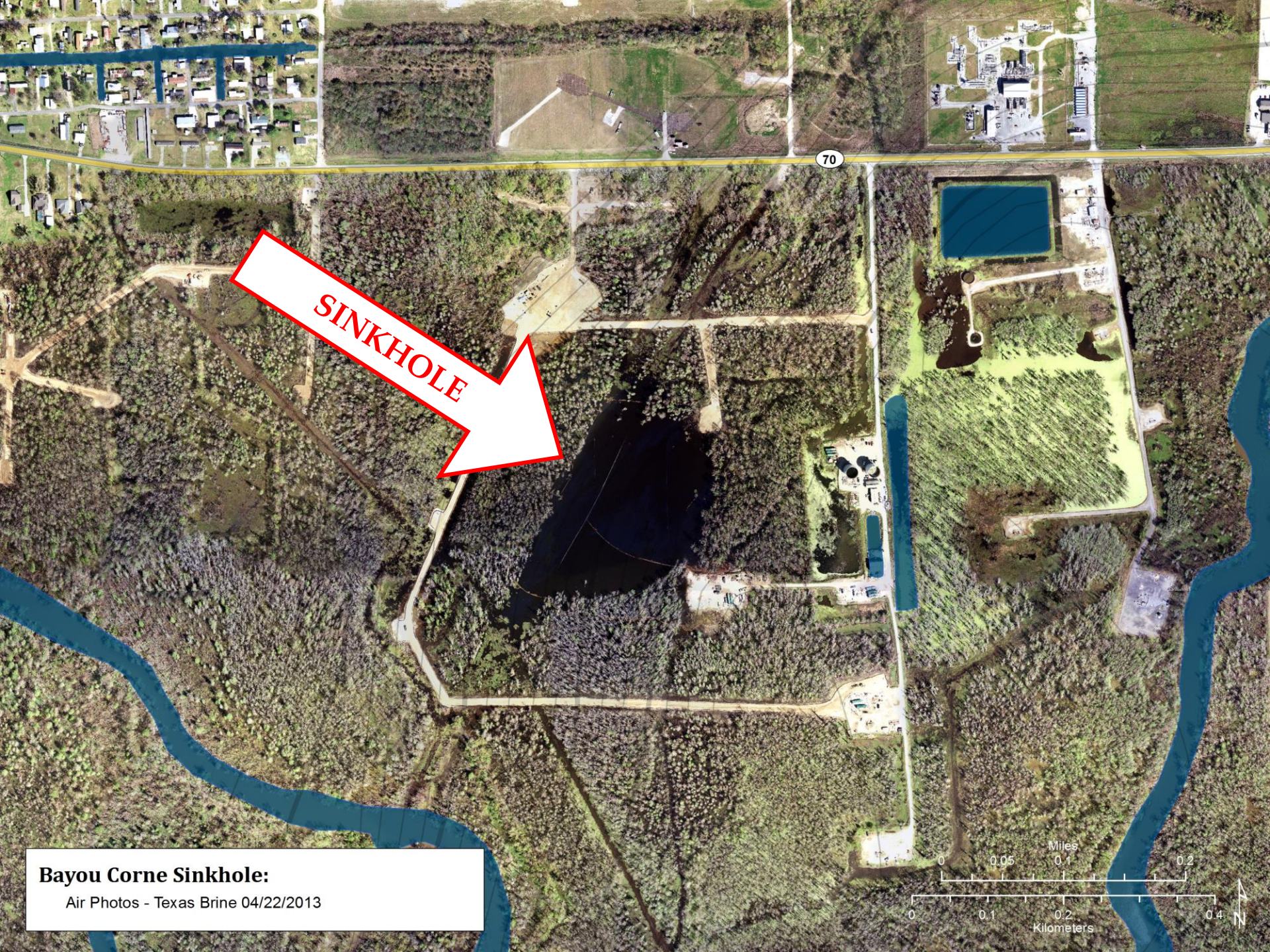
Air Photos - LA Civil Air Patrol 09/28/2012

Bayou Corne Sinkhole:

Air Photos - LDOTD 01/07/2013

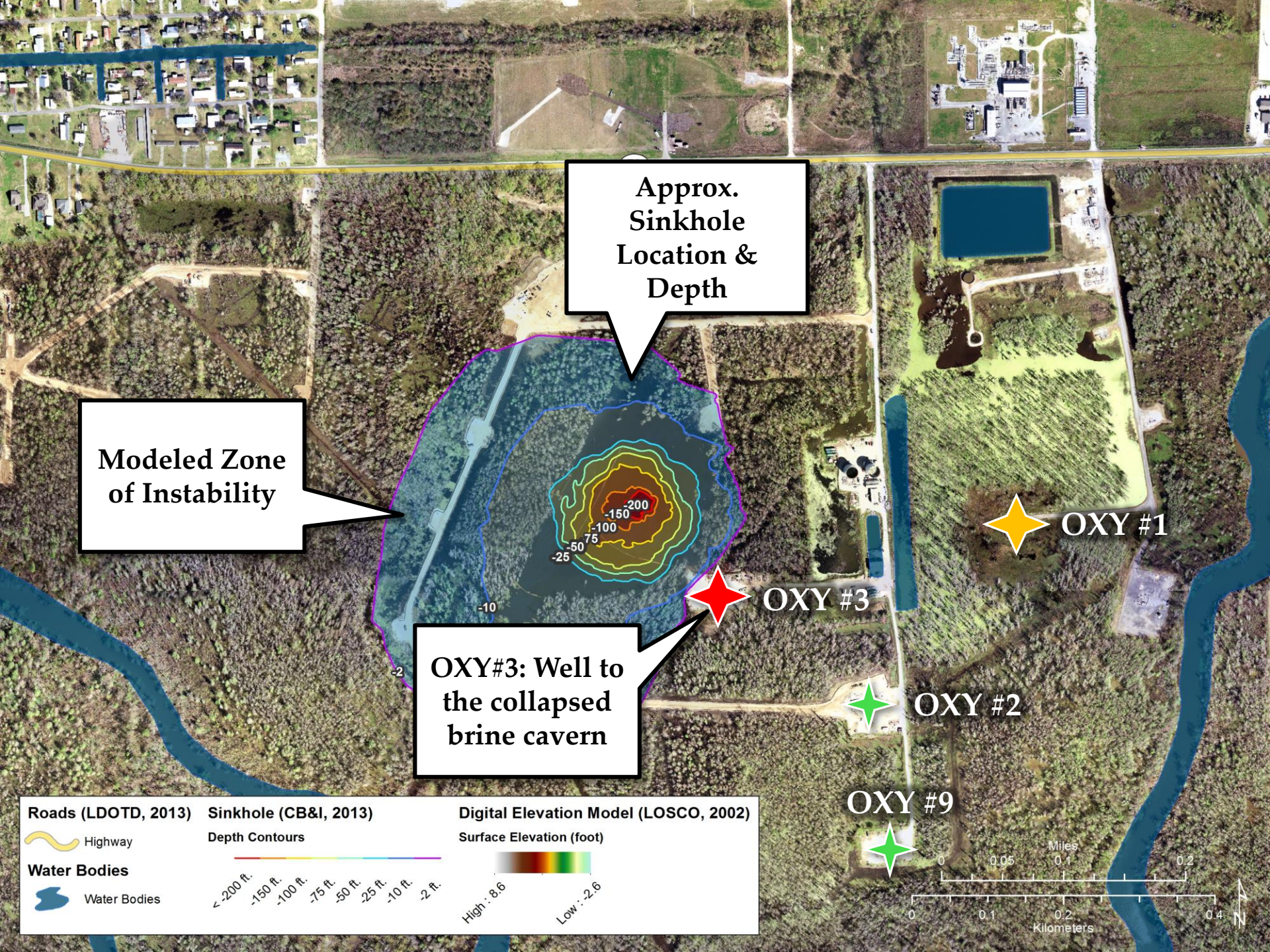
Bayou Corne Sinkhole:

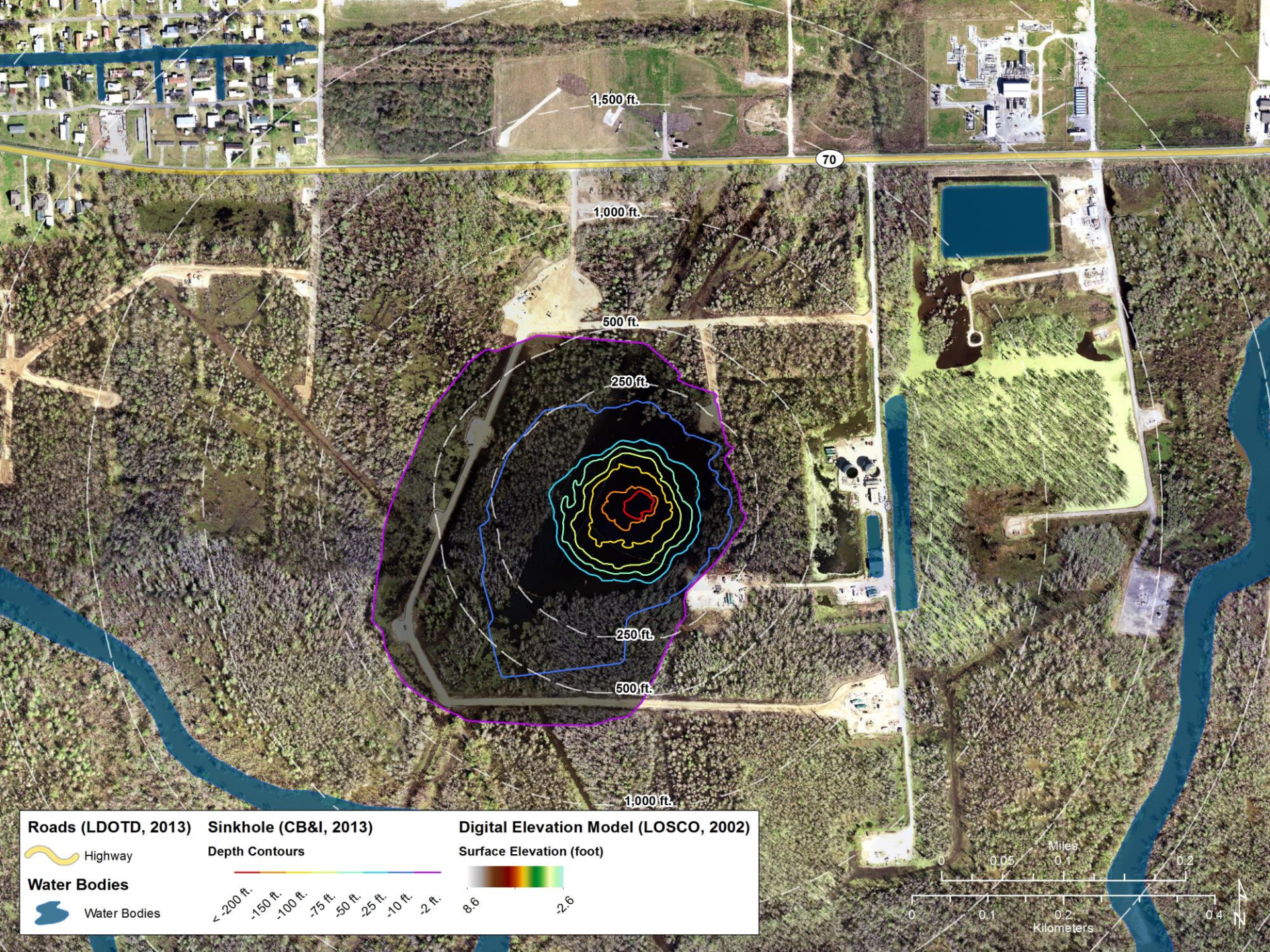
Air Photos - LDOTD 04/12/2013



Bayou Corne Sinkhole:

Air Photos - Texas Brine 04/22/2013


Approx. Sinkhole Location & Depth
Modeled Zone of Instability
OXY#3: Well to the collapsed brine cavern
OXY #1
OXY #3
OXY #2
OXY #9
-200
-150
-100
-75
-50
-25
-10
-2
Roads (LDOTD, 2013)
Highway
Water Bodies
Water Bodies
Sinkhole (CB&I, 2013)
Depth Contours
< -200 ft.
-150 ft.
-100 ft.
-75 ft.
-50 ft.
-25 ft.
-10 ft.
-2 ft.
Digital Elevation Model (LOSCO, 2002)
Surface Elevation (foot)
High : 8.6
Low : -2.6
Miles
0
0.05
0.1
0.2
0
0.1
0.2
0.4
Kilometers
N


1,500 ft.
70
1,000 ft.
500 ft.
250 ft.
250 ft.
500 ft.
1,000 ft.
Roads (LDOTD, 2013)
Highway
Water Bodies
Water Bodies
Sinkhole (CB&I, 2013)
Depth Contours
< -200 ft.
-150 ft.
-100 ft.
-75 ft.
-50 ft.
-25 ft.
-10 ft.
-2 ft.
Digital Elevation Model (LOSCO, 2002)
Surface Elevation (foot)
8.6
-2.6
Miles
0
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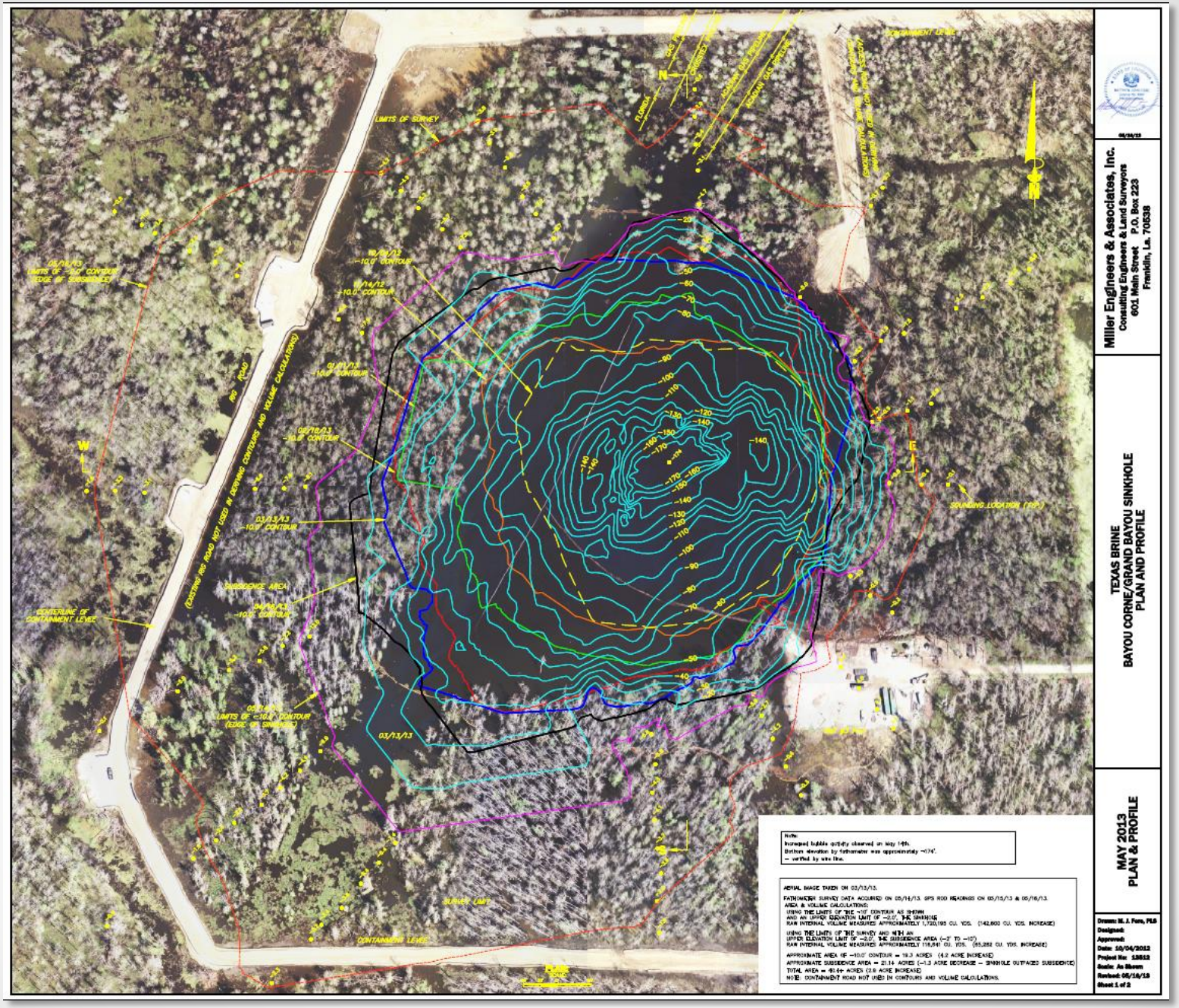
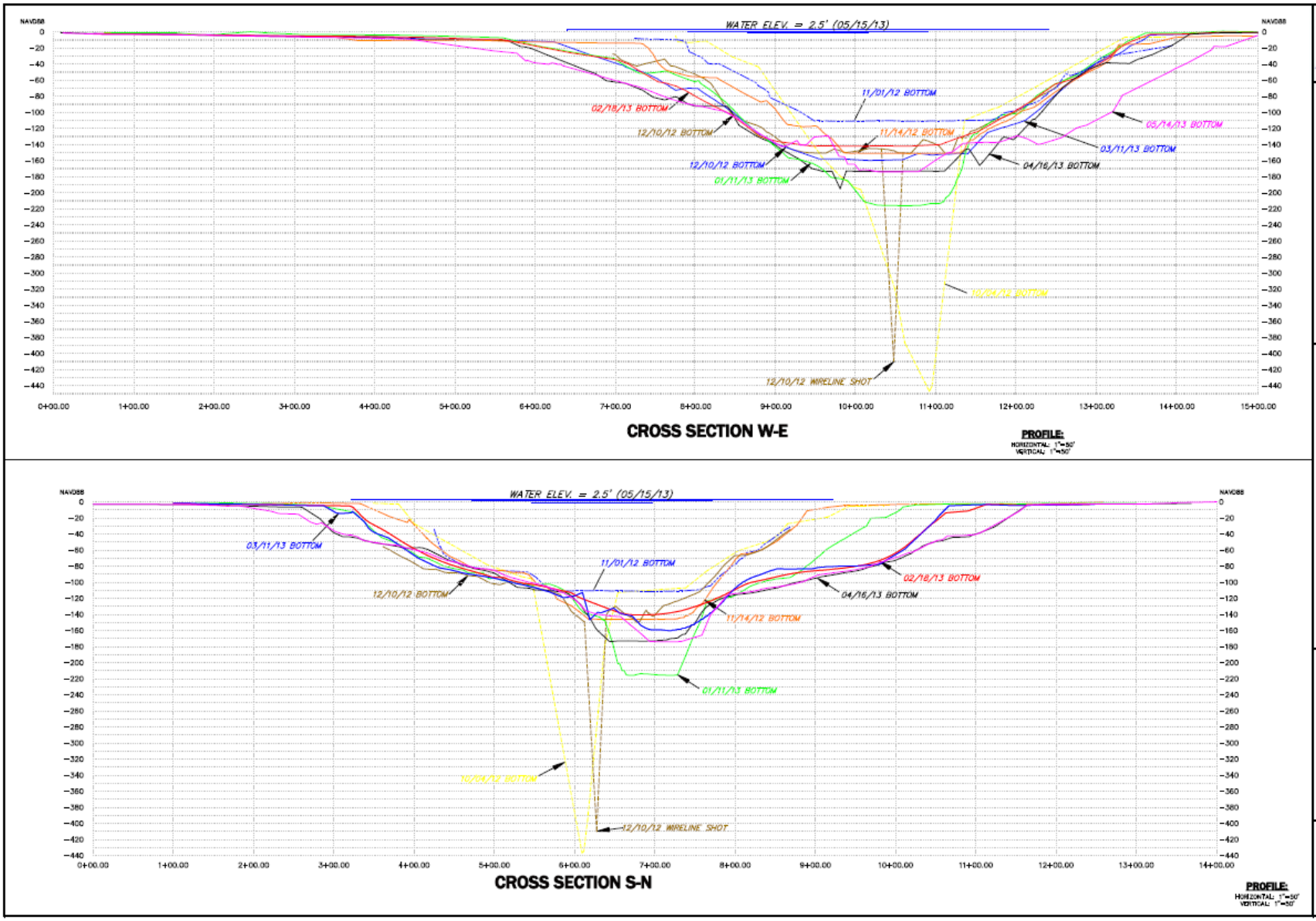
0.1
0.2
0
0.1
0.2
0.4
Kilometers
N


Miller Engineers & Associates, Inc.
Consulting Engineers & Land Surveyors
601 Main Street P.O. Box 223
Franklin, La. 70538
TEXAS BRINE
BAYOU CORNE/GRAND BAYOU SINKHOLE
PLAN AND PROFILE
MAY 2013
PLAN & PROFILE
LIMITS OF SURVEY
CENTERLINE OF CONTAINMENT LEVEE
SUBSIDENCE AREA
SURVEY LIMIT
SOUNDING LOCATION (TYP.)
(EXISTING PIPE ROAD NOT USED IN DERIVING CONTOURS AND VOLUME CALCULATIONS)
AERIAL IMAGE TAKEN ON 03/13/13.
FATHOMETER SURVEY DATA ACQUIRED ON 05/14/13. GPS ROD READINGS ON 05/15/13 & 05/16/13.
AREA & VOLUME CALCULATIONS:
USING THE LIMITS OF THE -10' CONTOUR AS SHOWN
AND AN UPPER ELEVATION LIMIT OF -2.0', THE SINKHOLE
RAW INTERNAL VOLUME MEASURES APPROXIMATELY 1,720,193 CU. YDS. (142,800 CU. YDS. INCREASE)
USING THE LIMITS OF THE SURVEY AND NEW AN
UPPER ELEVATION LIMIT OF -2.0', THE SUBSIDENCE AREA (-2' TO -10')
RAW INTERNAL VOLUME MEASURES APPROXIMATELY 118,841 CU. YDS. (65,282 CU. YDS. INCREASE)
APPROXIMATE AREA OF -10.0' CONTOUR = 19.2 ACRES (4.2 ACRE INCREASE)
APPROXIMATE SUBSIDENCE AREA = 21.14 ACRES (-1.3 ACRE DECREASE – SINKHOLE OUTPACED SUBSIDENCE)
TOTAL AREA = 40.44+ ACRES (2.9 ACRE INCREASE)
NOTE: CONTAINMENT ROAD NOT USED IN CONTOURS AND VOLUME CALCULATIONS.


WATER ELEV. = 2.5' (05/15/13)
02/18/13 BOTTOM
12/10/12 BOTTOM
11/01/12 BOTTOM
11/14/12 BOTTOM
05/14/13 BOTTOM
03/11/13 BOTTOM
04/16/13 BOTTOM
01/11/13 BOTTOM
12/10/12 WIRELINE SHOT
CROSS SECTION W-E
PROFILE:
WATER ELEV. = 2.5' (05/15/13)
03/11/13 BOTTOM
11/01/12 BOTTOM
12/10/12 BOTTOM
02/18/13 BOTTOM
04/16/13 BOTTOM
11/14/12 BOTTOM
01/11/13 BOTTOM
12/10/12 WIRELINE SHOT
CROSS SECTION S-N
PROFILE:
Miller Engineers & Associates, Inc.
Consulting Engineers & Land Surveyors
601 Main Street P.O. Box 223
Franklin, La. 70538
TEXAS BRINE
BAYOU CORNE/GRAND BAYOU SINKHOLE
PLAN AND PROFILE
MAY 2013
PLAN & PROFILE
Drawn: M. J. Fore, PLS
Designed:
Approved:
Date: 10/04/2013
Project No: 13512
Scale: As Shown
Revised: 05/16/13
Sheet 2 of 2

Assumption Parish
LOUISIANA

Assumption
Emergency Notification
Self Registration Portal

SORUCES OF INFORMATION IN THIS PRESENTATION

http://www.assumptionla.com/bayoucorne

- Bayou Corne/Grand Bayou Sinkhole
- Home
- Parish Blog
- Tropical Storm/Hurricane Updates
- About Assumption Parish
- Community
- Parish Government
- Tourism
- Police Jury Meeting Agendas
- Police Jury Meeting Minutes
- Homeland Security/Emerg Preparedness
- Parish Permit Office
- Business Guide
- Parish Forms
- Assumption Parish Community Center
- Links
- Assumption Flood Risk Maps
- Calendar of Events
- Assumption Parish Recovery
- Hurricane Preparedness
- Local Emergency Planning Committee
- Photo Gallery
- Contact Us

News & Updates

Upcoming Events

Assumption Parish Police Jury

Bayou Corne/Grand Bayou Sinkhole

Home

On May 31, 2012, parish officials were notified of areas of bubbling spots in the Bayou Corne and Grand Bayou waterways. Early on, it was determined that the bubbling was caused by a release of natural gas and not "swamp gas". Monitoring for carbon monoxide, H2Sm and Lower Explosive Levels (LEL) at the bubbling spots began on June 22, 2012. During this monitoring, no dangerous levels were detected. Residents within the community experienced and reported tremors and the parish requested the assistance of USGS in determining the locations and probable cause(s) for this seismic activity. USGS immediately detected seismic activity through their monitors and began recording this data; however, no probable cause was able to be detected.

Early in the morning on Friday, August 3, 2012, Assumption Parish Office of Homeland Security & Emergency Preparedness Director John Boudreaux was notified by local industry that a sinkhole had formed overnight in the swamp in the area. The hole was discovered after a strong diesel smell was experienced

Bayou Corne Sinkhole: Current Situation (06/13)

- **Sinkhole area is ~12 acres and ~200' deep.**
- **Subsidence Zone is ~20 acres.**
- **Salt cavern breached** approx. 1 mile beneath surface
- 45 million cubic ft. of **natural gas seeping** up into the water table.
- 19 **wells venting natural gas** from beneath the aquifer.
- **Cavern remains unstable.**
- Various **monitoring strategies in place** and planned.
- **Earthen berm** built around sinkhole to avoid environmental contamination.

Brief Timeline

Oxy Geismar Well No. 3 Timeline

- **1982:** Oxy Geismar Well No. 3 permitted for solution-mining of brine.
- **1995:** Texas brine received permission from Louisiana Department of Natural Resources to store Naturally Occurring Radioactive Material (NORM) in the well.
- **2010:** DNR issues permit to mine a section of salt above the existing cavern roof (~3,400 feet deep).
- **June 2011:** Texas Brine notifies DNR that integrity of the well had been lost. Wellbore above the cavern was plugged with cement.

Brief Timeline

Oxy Geismar Well No. 3 Sinkhole Timeline

- **May 2012:** Parish officials were notified of areas of bubbling spots in the Bayou Corne and Grand Bayou waterways.
- **June 2012:** Parish Emergency Declared.
- **Aug. 2012:** 372' diameter sinkhole forms overnight. State Emergency Declared.
- **Aug. 2012:** "Mandatory" Evacuation Ordered for >150 Residents.
- **Dec. 2012:** Sinkhole expands to 8.4 acres. Gas venting underway.
- **March 2013**: Gov. Jindal visits sinkhole.
- **April 2013:** 'Blue Ribbon' Commission convenes to provide science-based recommendations for public safety.
- **May 2013:** Containment levee built around the sinkhole to prevent further environmental contamination.
- **June 2013:** Cavern instability persists.

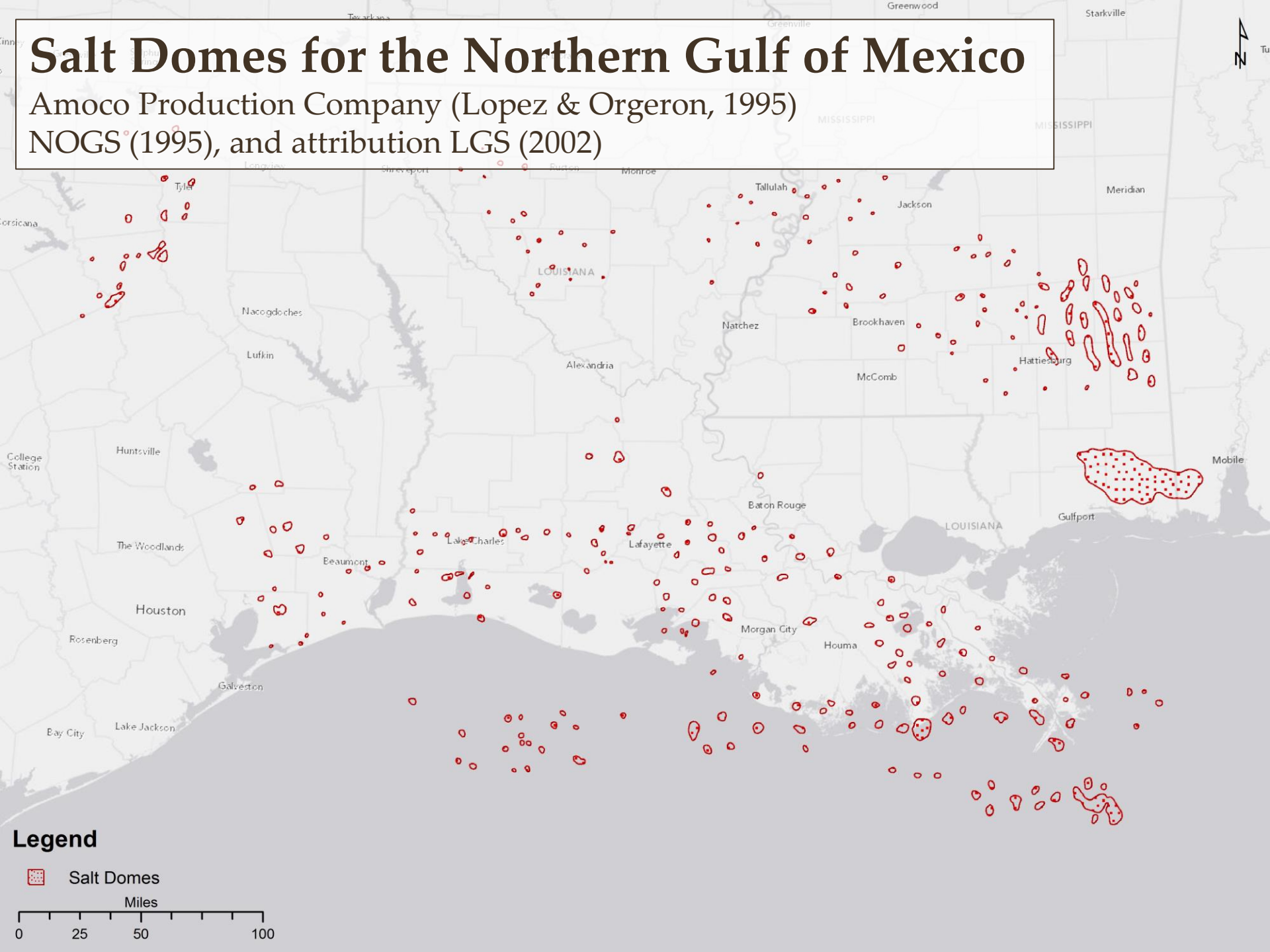
Nature of the Sinkhole

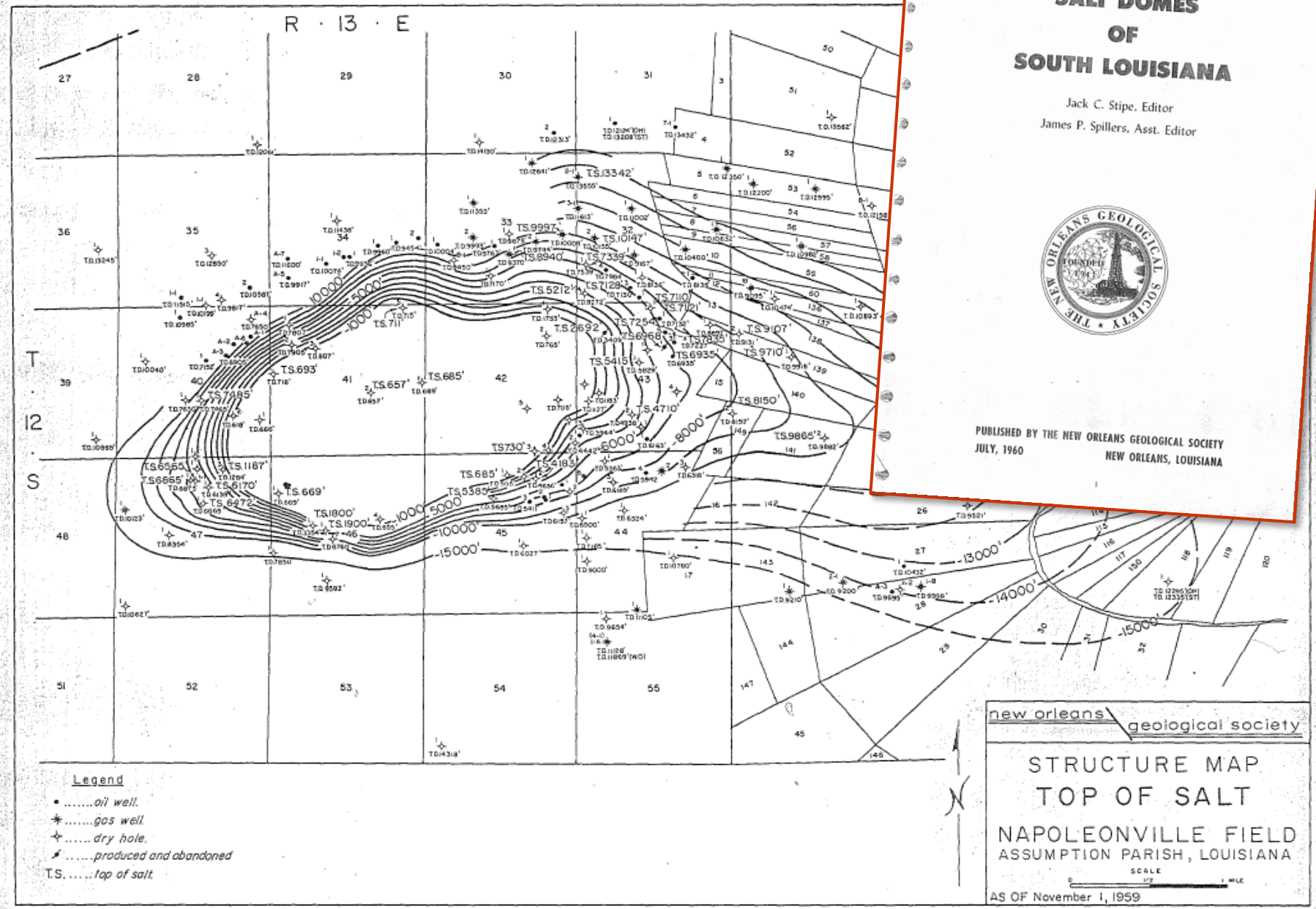
The Sinkhole is associated with the Napoleonville Salt Dome Structure

- **Background on Salt Domes** in Louisiana
- **3D Model** of the Napoleonville Salt Dome
- Location of the **Sinkhole and the Oxy3 Cavern**
- Cartoon Depicting the **Current Hypothesis** of the Sinkhole's Formation.

Salt Domes for the Northern Gulf of Mexico

Amoco Production Company (Lopez & Orgeron, 1995)
NOGS (1995), and attribution LGS (2002)





SALT DOMES OF SOUTH LOUISIANA

Jack C. Stipe, Editor

James P. Spillers, Asst. Editor

THE NEW ORLEANS GEOLOGICAL SOCIETY ★ FOUNDED 1941

PUBLISHED BY THE NEW ORLEANS GEOLOGICAL SOCIETY

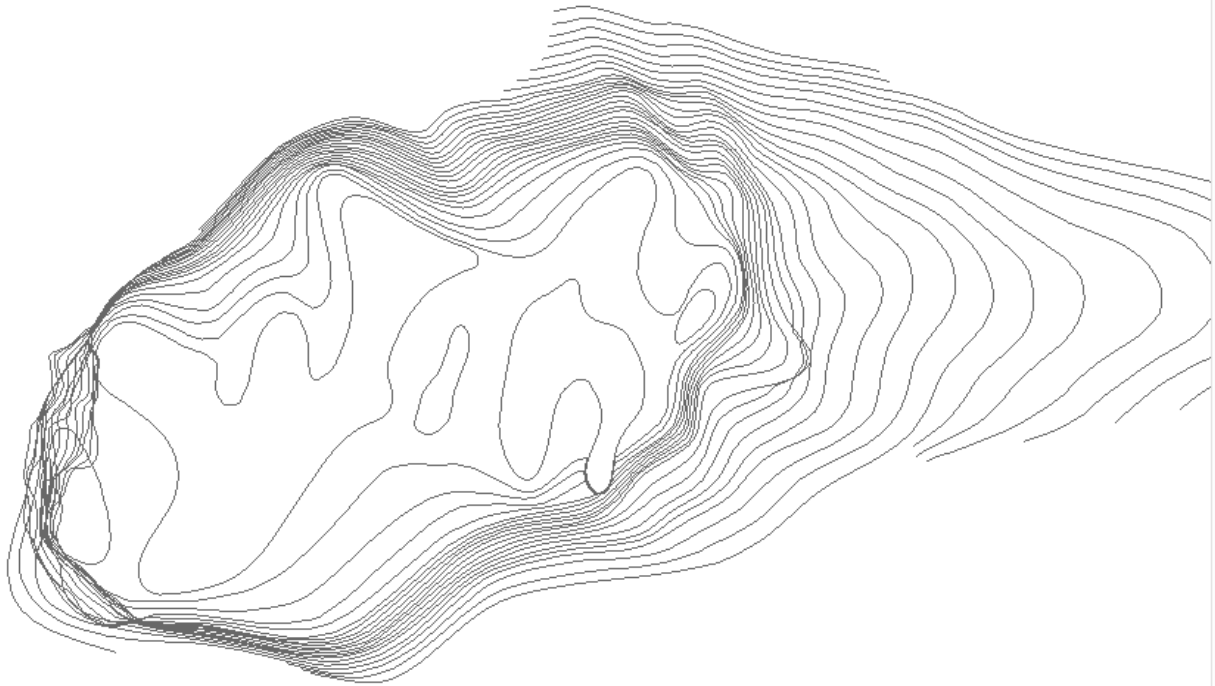
JULY, 1960 NEW ORLEANS, LOUISIANA

Sinkhole Caverns 201304.sxd - ArcScene

File Edit View Bookmarks Selection Geoprocessing Customize Windows Help

Table of Contents

Scene layers
- Salt Dome
- Sinkhole_Survey_Contours_3I
  - Contour
  - -200 ft
  - -150 ft
  - -100 ft
  - -75 ft
  - -25 ft
- 3D Sonar
  - Caverns
  - Others
  - Oxy-01
  - Oxy-03
  - Oxy-03A



Results ArcToolbox Catalog Search

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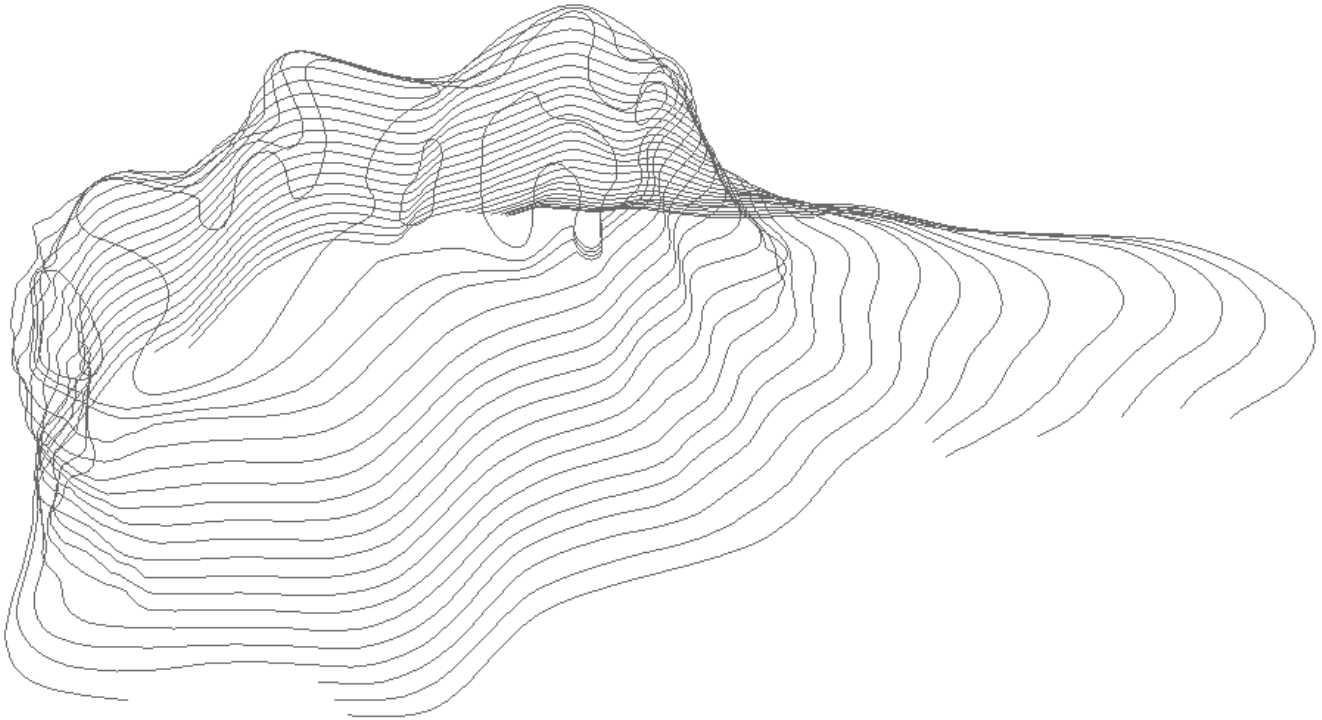

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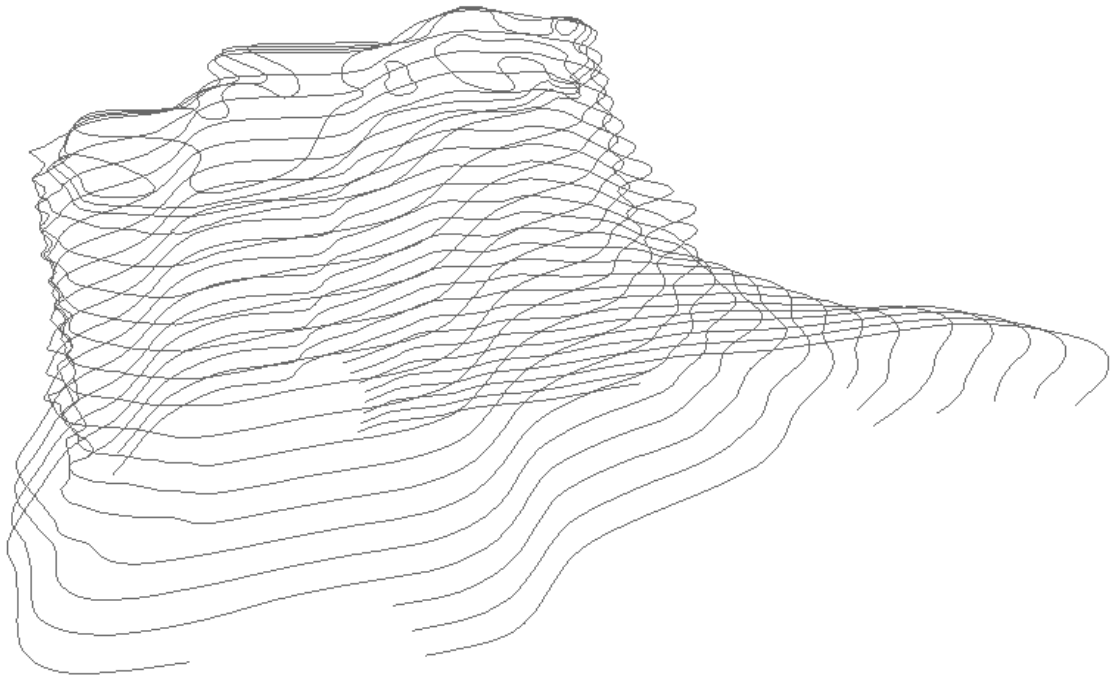

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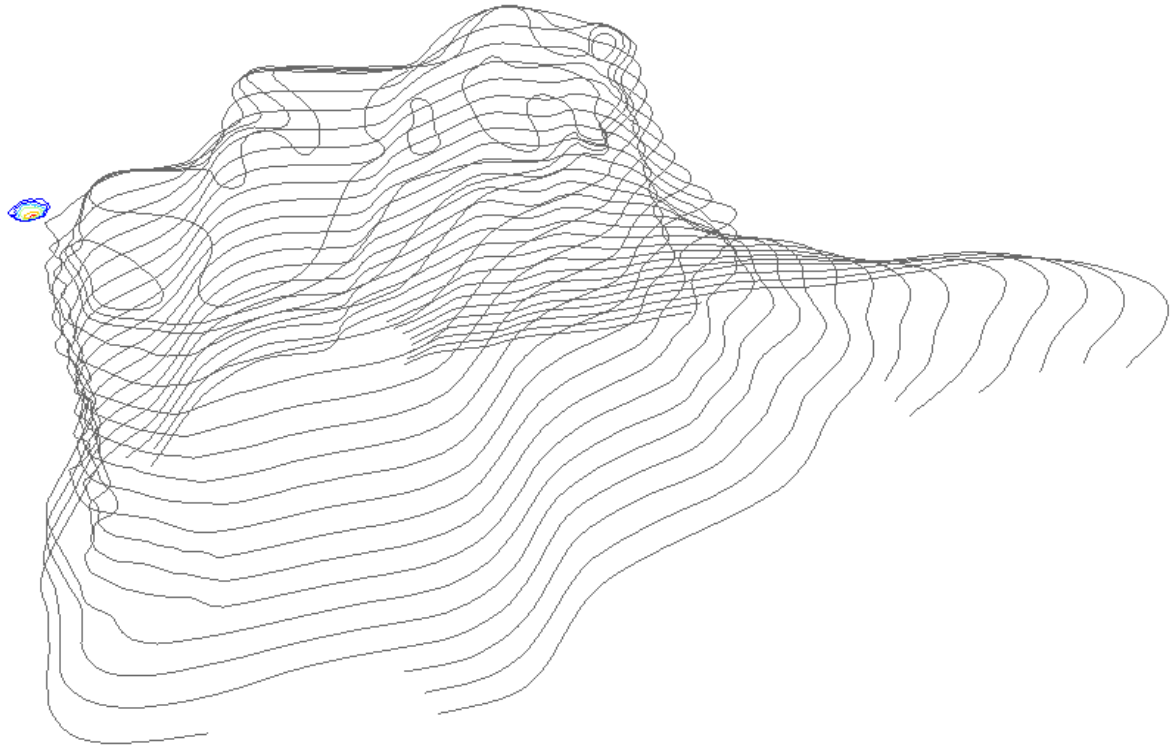

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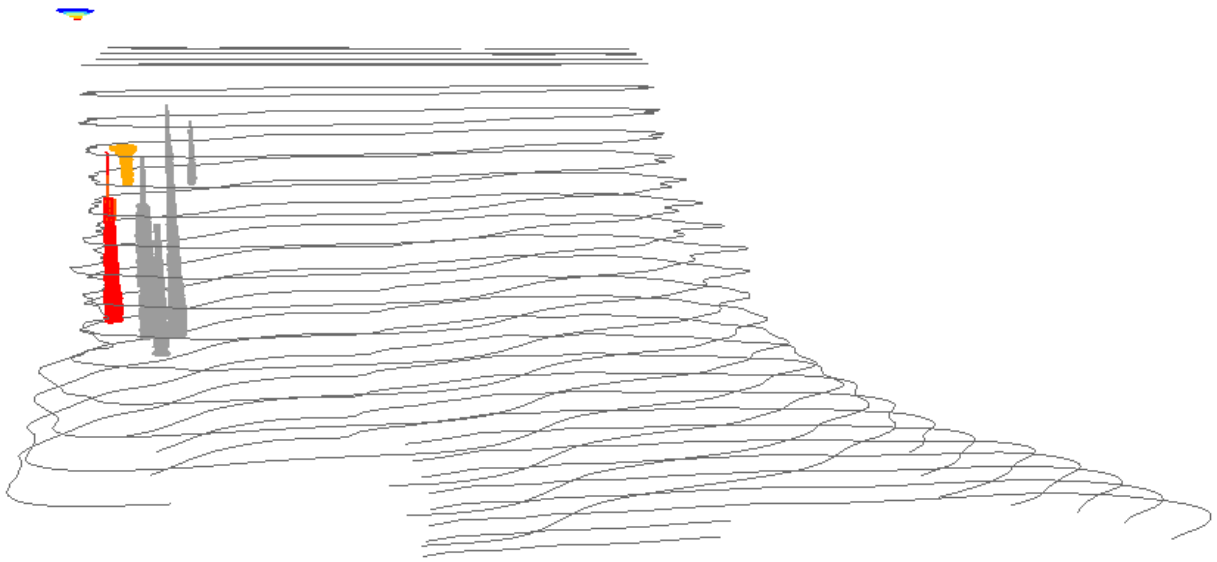

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    - -25 ft
  - 3D Sonar
    - Caverns
    - Others
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    - Oxy-03A

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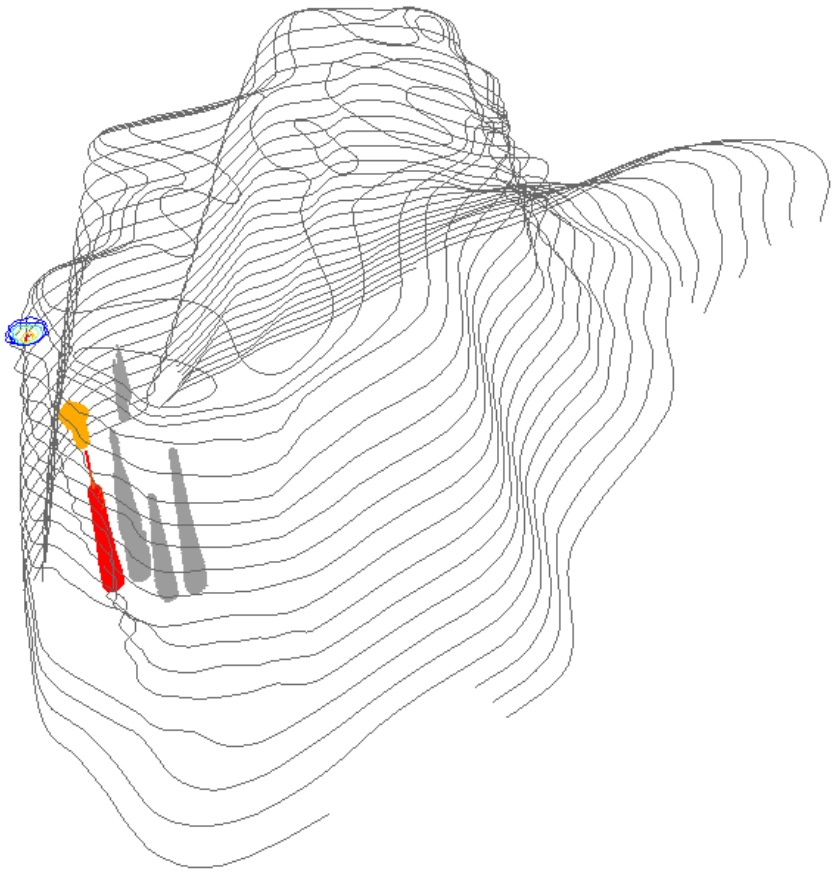

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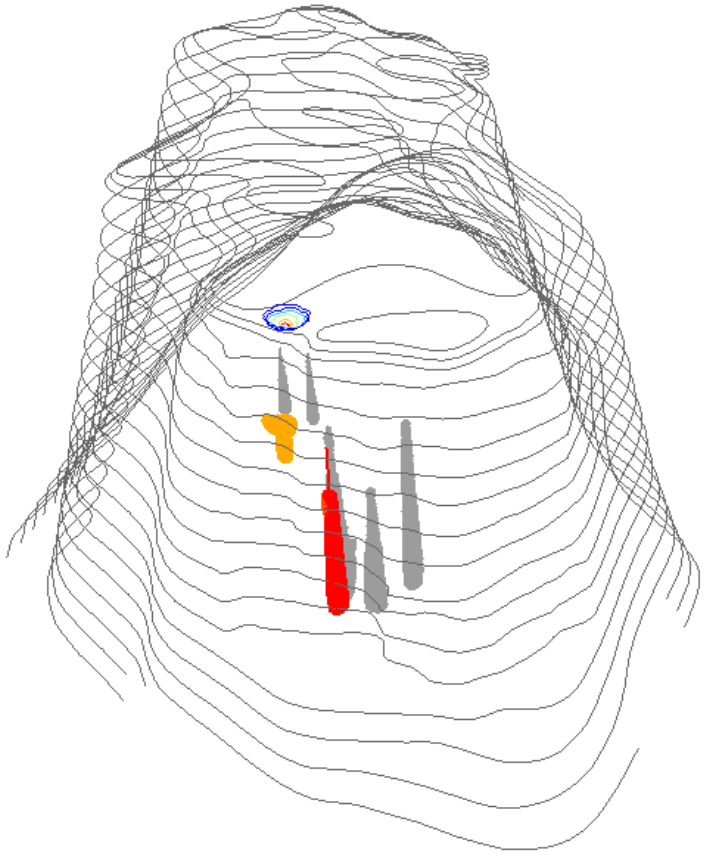

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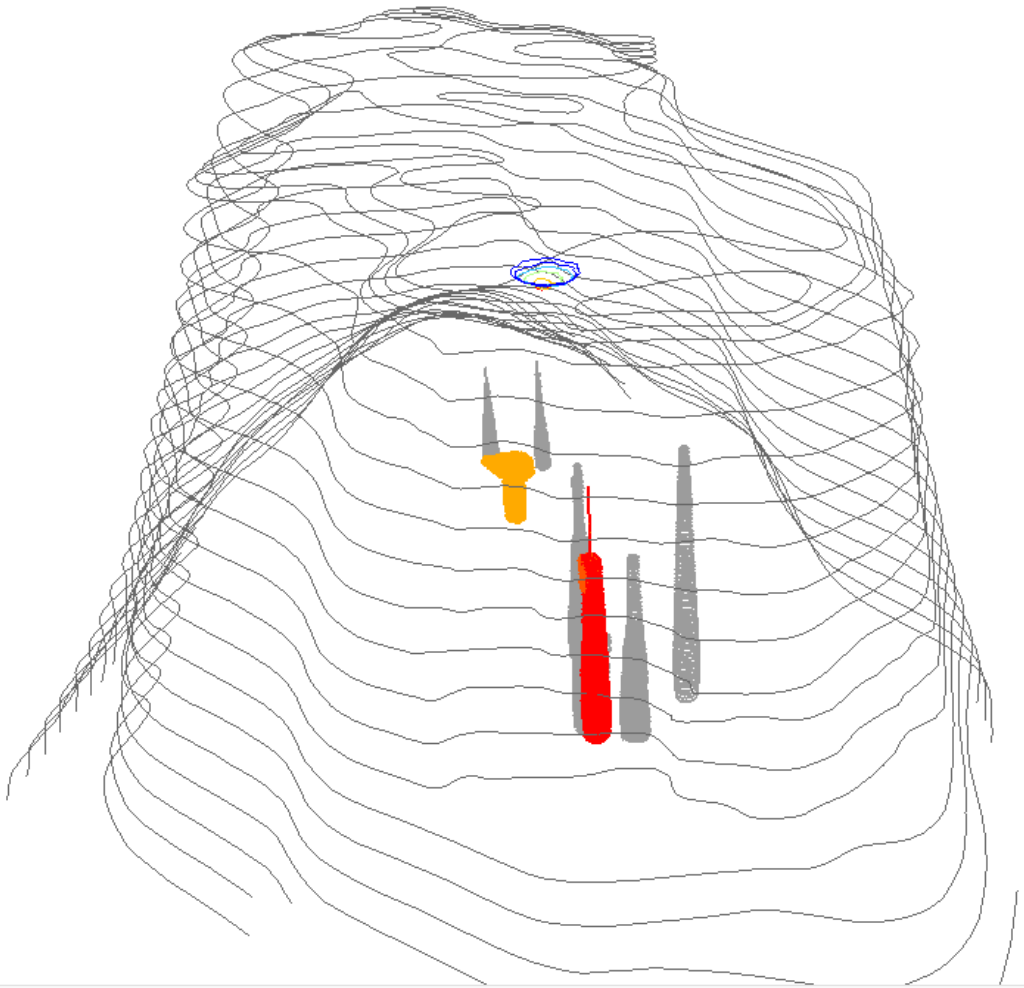

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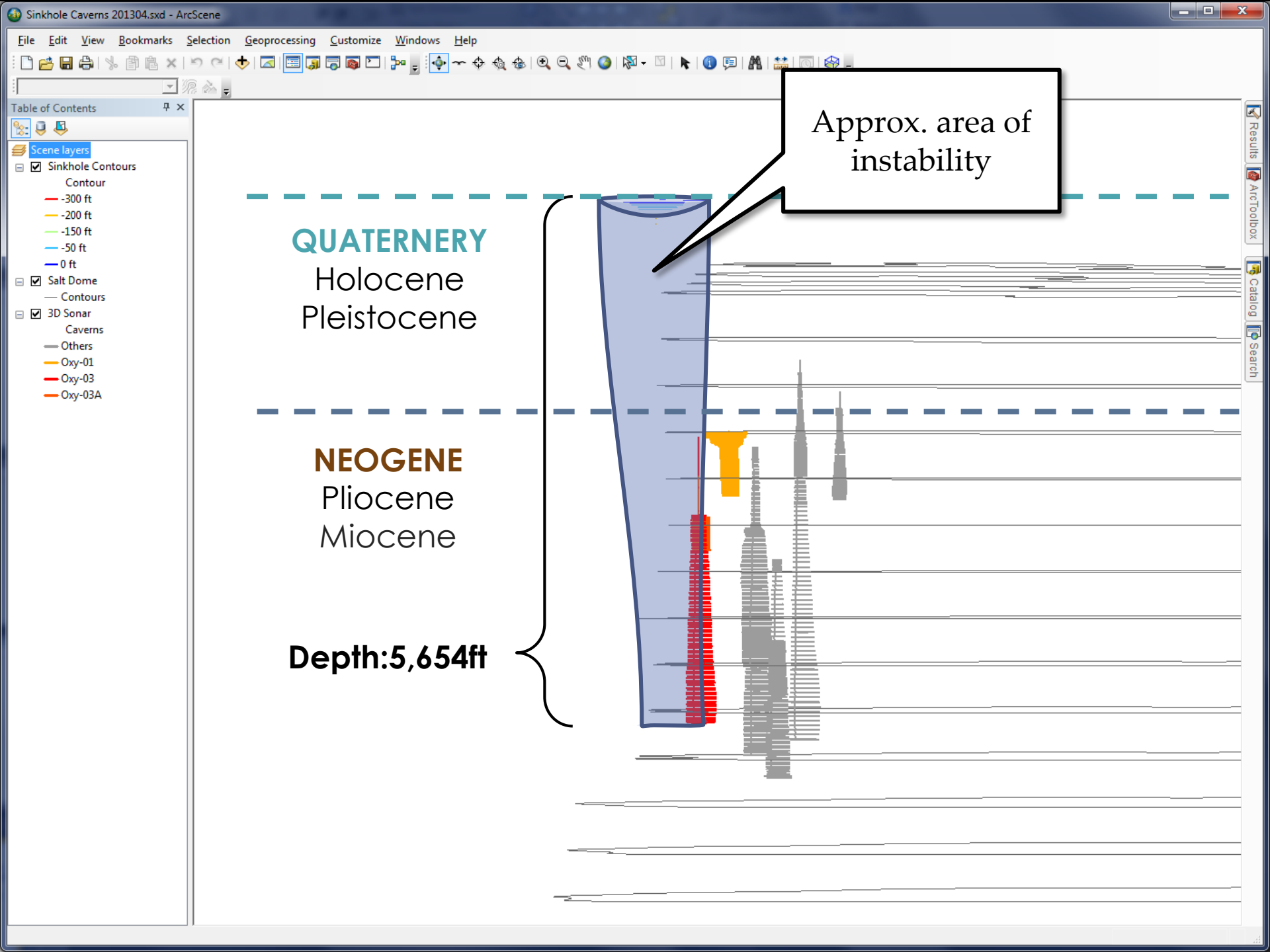

Sinkhole Caverns 201304.sxd - ArcScene
File Edit View Bookmarks Selection Geoprocessing Customize Windows Help
Table of Contents
Scene layers
Sinkhole Contours
Contour
-300 ft
-200 ft
-150 ft
-50 ft
0 ft
Salt Dome
Contours
3D Sonar
Caverns
Others
Oxy-01
Oxy-03
Oxy-03A
Approx. area of instability
QUATERNERY
Holocene
Pleistocene
NEOGENE
Pliocene
Miocene
Depth:5,654ft
Results
ArcToolbox
Catalog
Search

Research Awarded

LA Transportation Research Center Awards Two Grants to the Center for GeoInformatics to Monitor and Assess the Stability of Highway 70

- **September 2012:** C4G to Measure the Horizontal and Vertical Positions of Control Points Along Highway 70
- **April 2013:** C4G to Install and Maintain Five Continuous GPS Monitoring Stations to Measure Positions 24-7-365

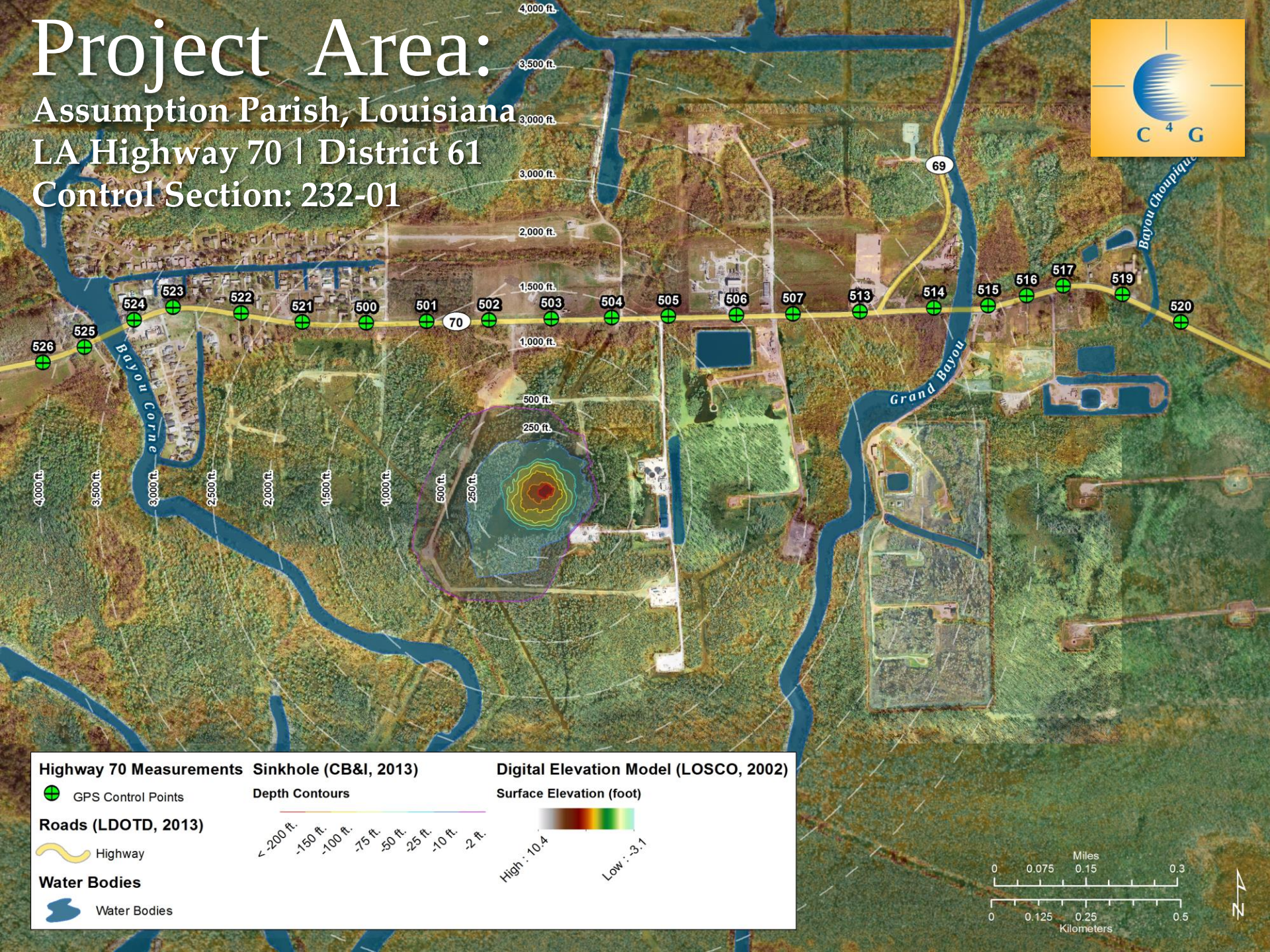
Control Point Project

Workflow Consisting of 3 Tasks Executed Over 9 Months:

1. Collect and measure horizontal and vertical positions at select control points located along Highway 70 in Assumption Parish.
2. Process the data for use in a GIS.
3. Distribute the data via FTP.

Project Area:

Assumption Parish, Louisiana
LA Highway 70 | District 61
Control Section: 232-01



Control Point Methodology

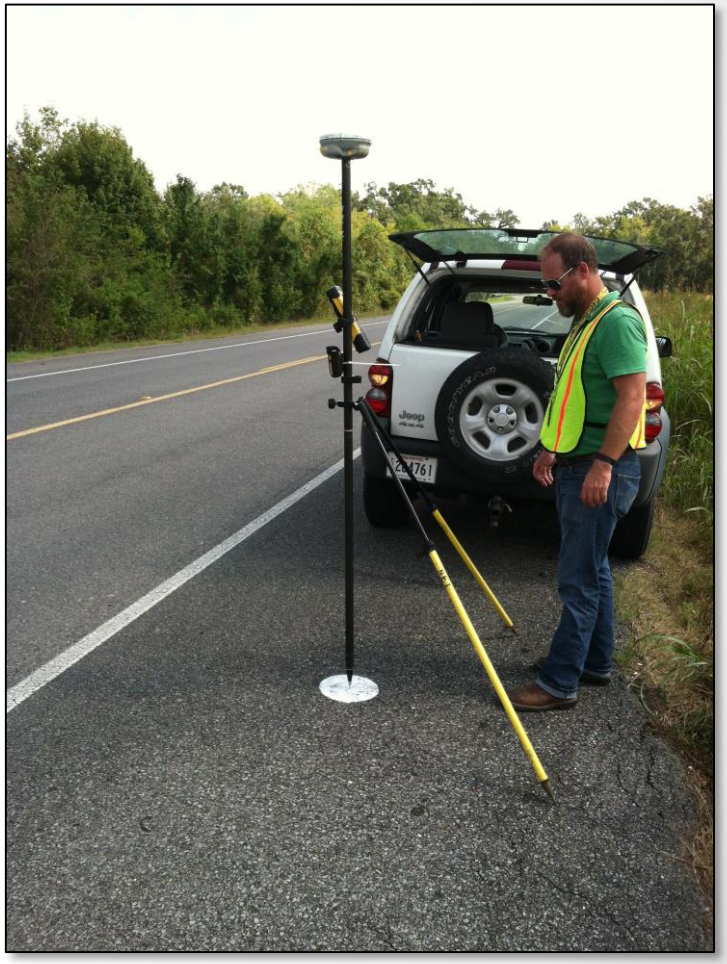
Survey & Capture Point Measurements Along Highway 70 Using GPS:

- Points on Hwy 70 along north shoulder.
- Points on bridges at Grand Bayou and Bayou Corne.
- Hwy measurements on the captured at 5-minute occupations (300 epochs).
- Bridge measurements captured in 10-minute occupations (600 epochs).
- All GPS measures enhanced using C4Gnet Real-Time Network:
  - Horizontal: ~10-mm (0.39 inches)
  - Vertical: ~20-mm (0.79 inches)

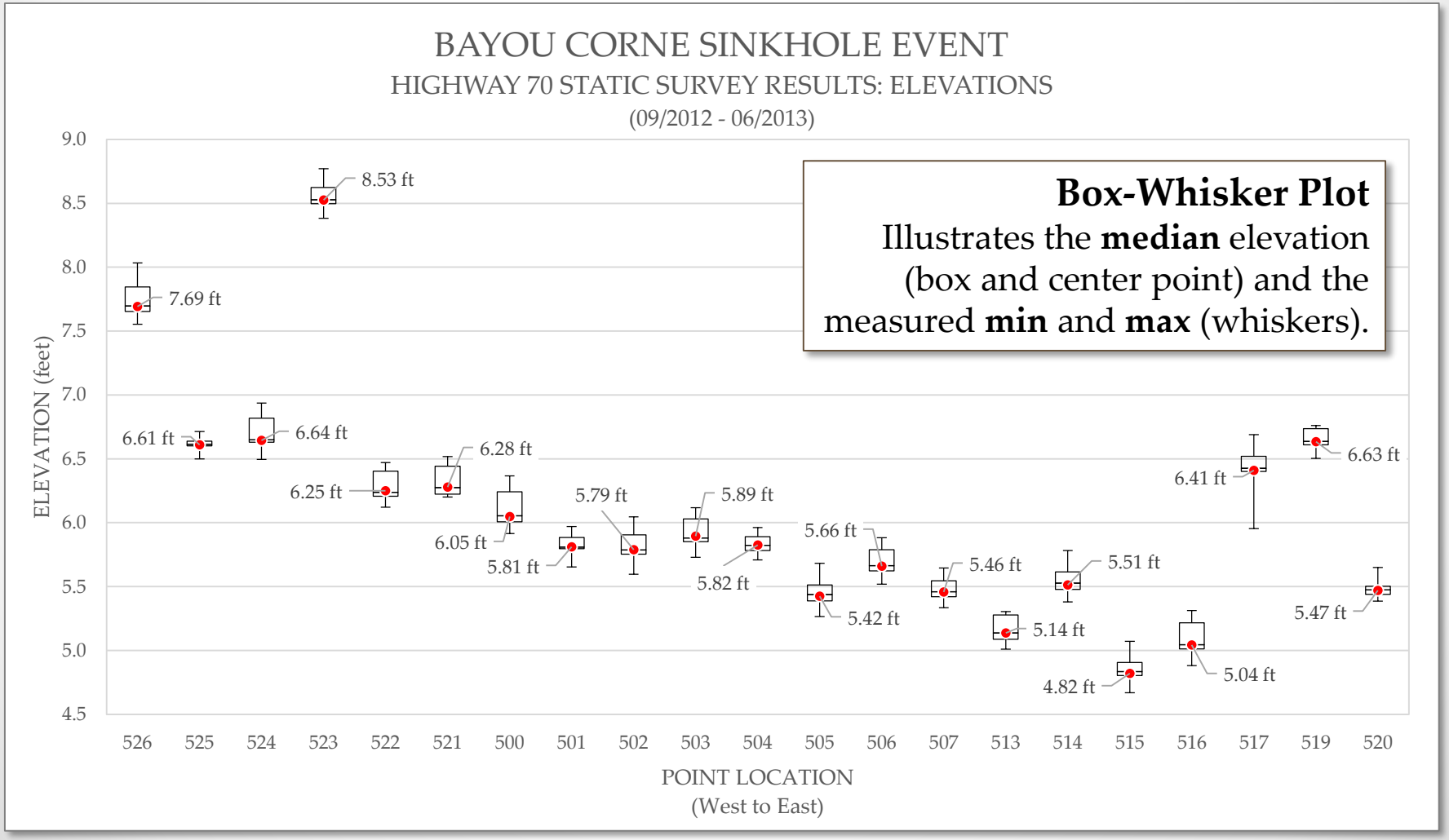
Control Point Work Schedule

Time Period of Observations:

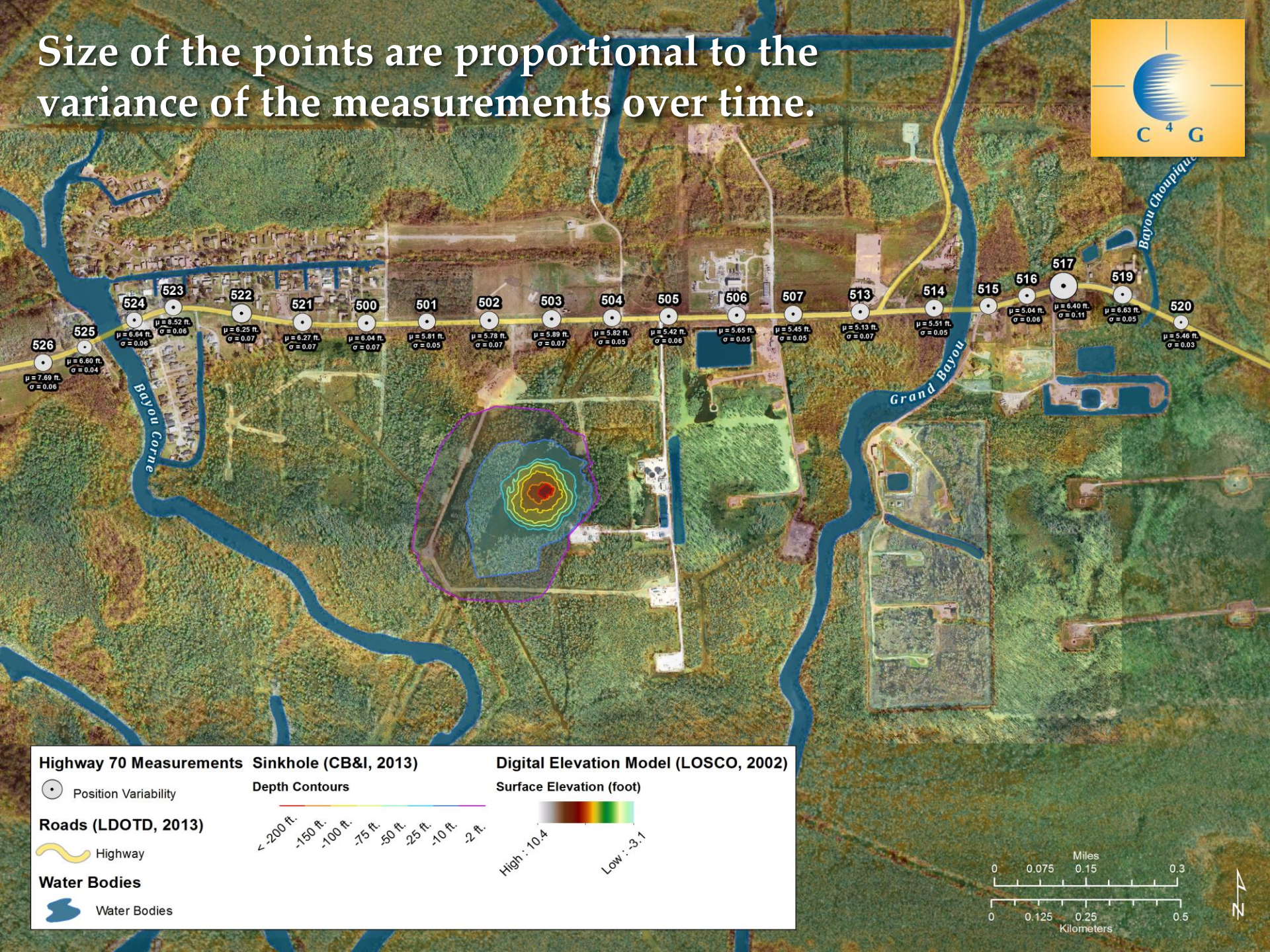
- **Biweekly Observations:** 9/12 – 10/12
- **Weekly Observations:** 11/12 – 12/12
- **Monthly Observations:** 01/13 – 07/13



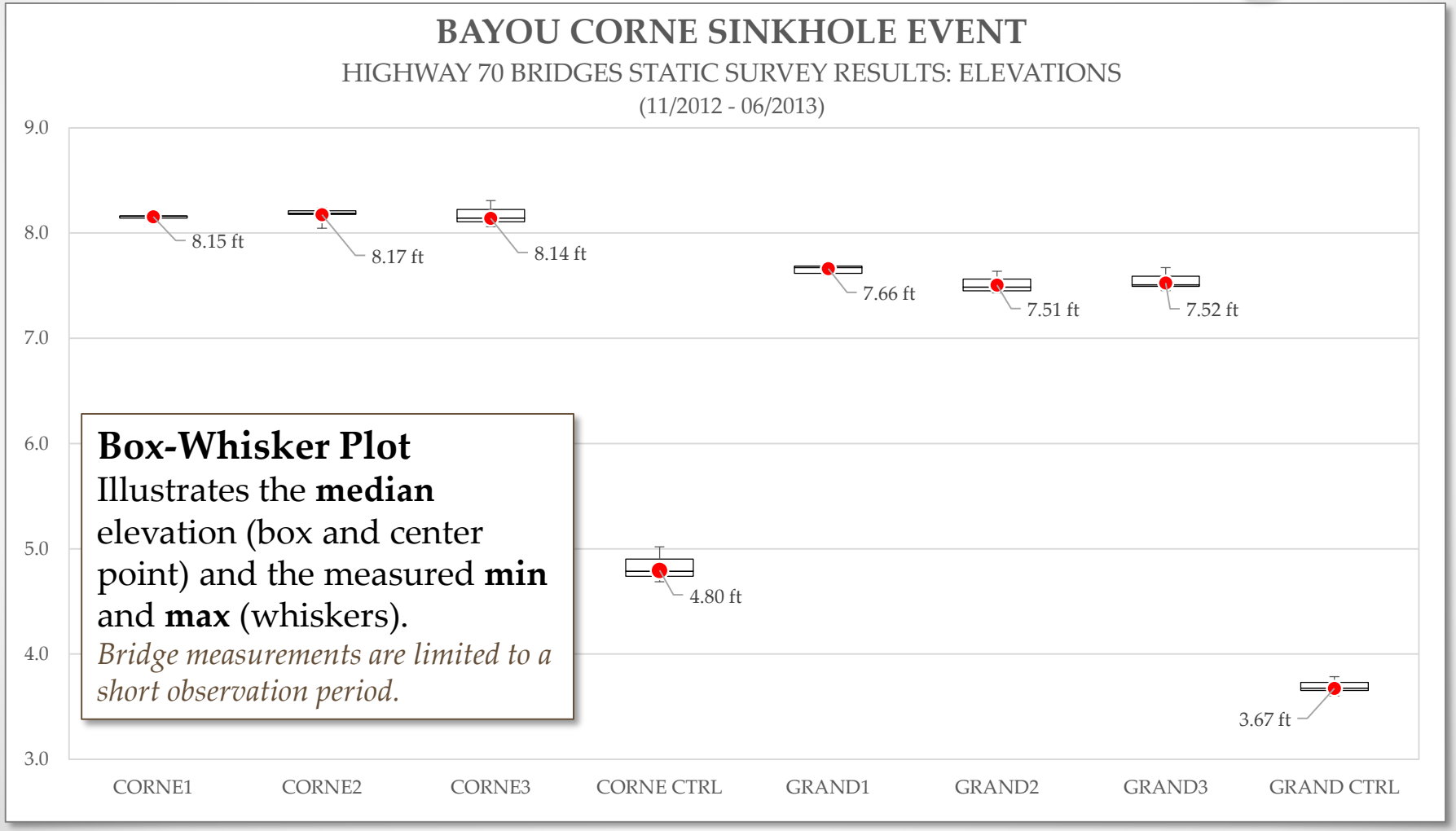
Control Point Tentative Results: Road

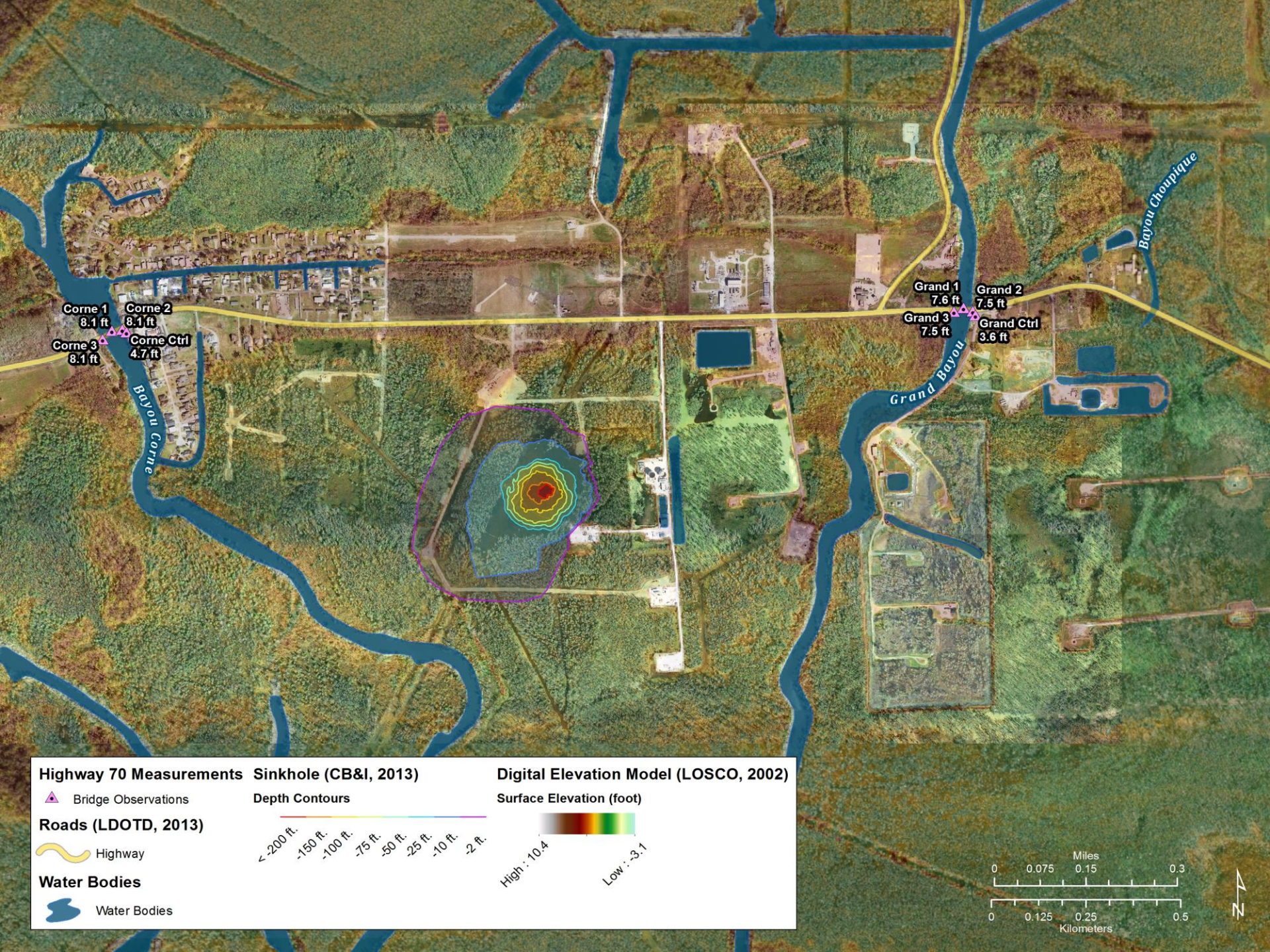


Size of the points are proportional to the variance of the measurements over time.



Control Point Tentative Results: Bridges




Corne 1
8.1 ft
Corne 2
8.1 ft
Corne 3
8.1 ft
Corne Ctrl
4.7 ft
Bayou Corne
Grand 1
7.6 ft
Grand 2
7.5 ft
Grand 3
7.5 ft
Grand Ctrl
3.6 ft
Grand Bayou
Bayou Choupique
Highway 70 Measurements
Bridge Observations
Roads (LDOTD, 2013)
Highway
Water Bodies
Water Bodies
Sinkhole (CB&I, 2013)
Depth Contours
< -200 ft.
-150 ft.
-100 ft.
-75 ft.
-50 ft.
-25 ft.
-10 ft.
-2 ft.
Digital Elevation Model (LOSCO, 2002)
Surface Elevation (foot)
High : 10.4
Low : -3.1
Miles
0
0.075
0.15
0.3
0
0.125
0.25
0.5
Kilometers
N

Methodological Limitations

Sporadic vs. Long-Term Occupation

Individual measurements exhibit both ***random*** and ***systematic*** error.

- **Random Errors:**
  Caused by unknown and unpredictable changes in environmental conditions:
  - Signal multipath & tree canopy
  - Atmospheric conditions
  - Poor satellite geometry
  - EM interference from nearby transmitters
  - Environmental Disruptions (wind, aerodynamic drag, etc.)
- **Systematic Errors:**
  Caused by predictable changes in environmental conditions and procedures:
  - User & instrument error
  - Tidal effects on the landscape
  - Actual Movement of the surface…

Methodological Limitations

Sporadic vs. Long-Term Occupation

Long-term occupations are less susceptible to ***random*** and ***systematic*** error.

- **Random Errors:**
  Reduced by long-term occupations to provide more precise measurements:
  - Isolate and mask signal multipath & tree canopy
  - Atmospheric conditions less significant
  - Poor satellite geometry less significant
- **Systematic Errors:**
  Constrained when following best practices. Predictable environmental conditions can be removed using data models:
  - Mitigates predictable errors to provide more accurate measurements of surface conditions.

Continuous GPS Monitoring Project

CORS911: Continuously Operating Reference Stations for the Bayou Corne Sinkhole

Long-term monitoring and assessment of surface stability:

- **Monitor** horizontal and vertical positions 24-7-365 using Continuous GPS Reference Stations (*CORS911*)
- Quantify **Differential** and **Network** motions

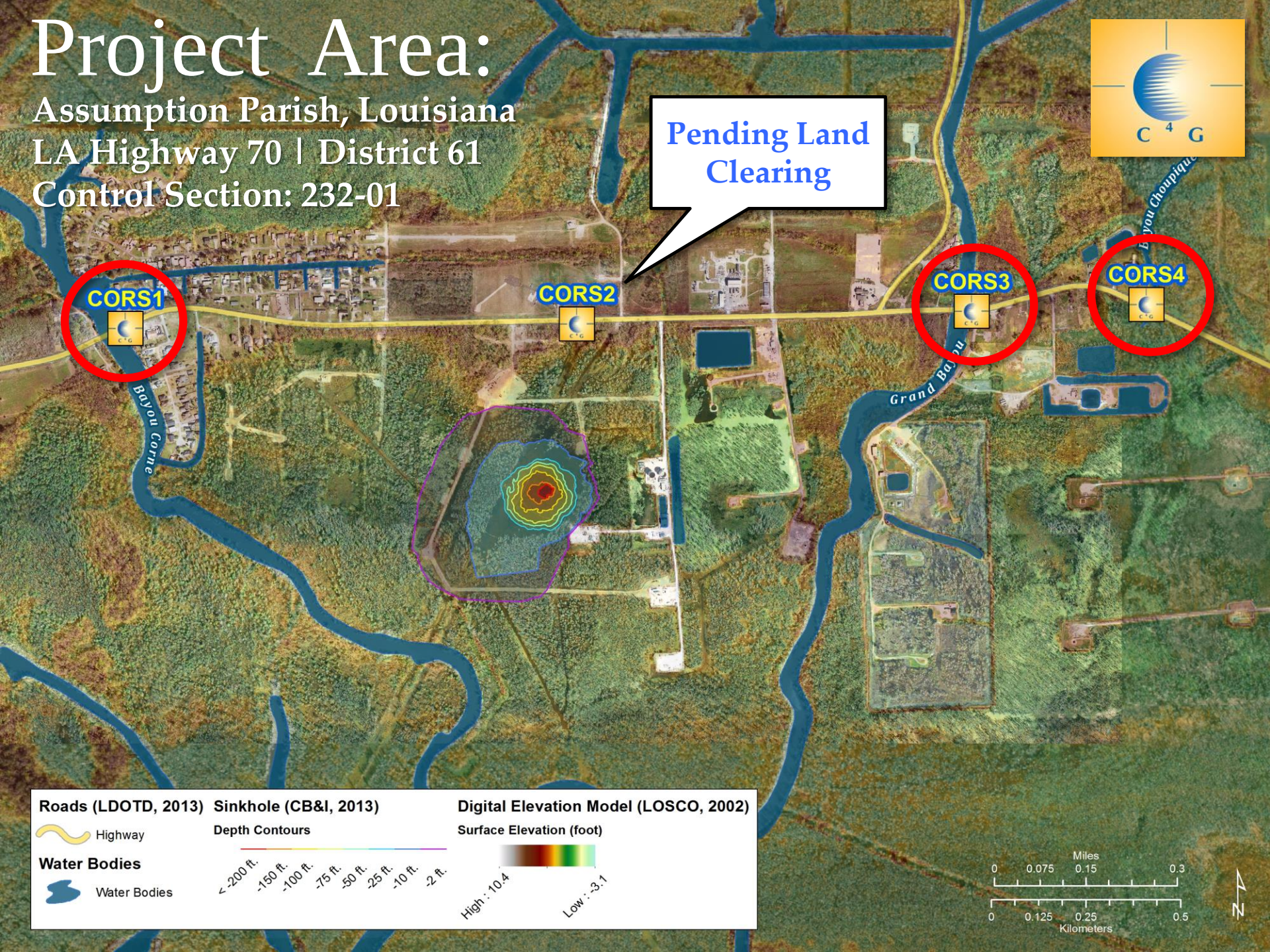
CORS911 Project Tasks

Workflow Consisting of 7 Tasks Executed Over 12 Months:

1. Perform Site Assessments
2. Custom CORS Fabrication
3. Deploy CORS
4. Monitoring Implementation
5. Utilization & Client Support
6. Maintenance
7. Reporting

Project Area:

Assumption Parish, Louisiana
LA Highway 70 | District 61
Control Section: 232-01



Benefits of a CORS Network

Improve Monitoring of Highway Stability using CORS Technology

Software to Monitor the Locations of Individual CORS sites Relative to the Continent and to Each Other

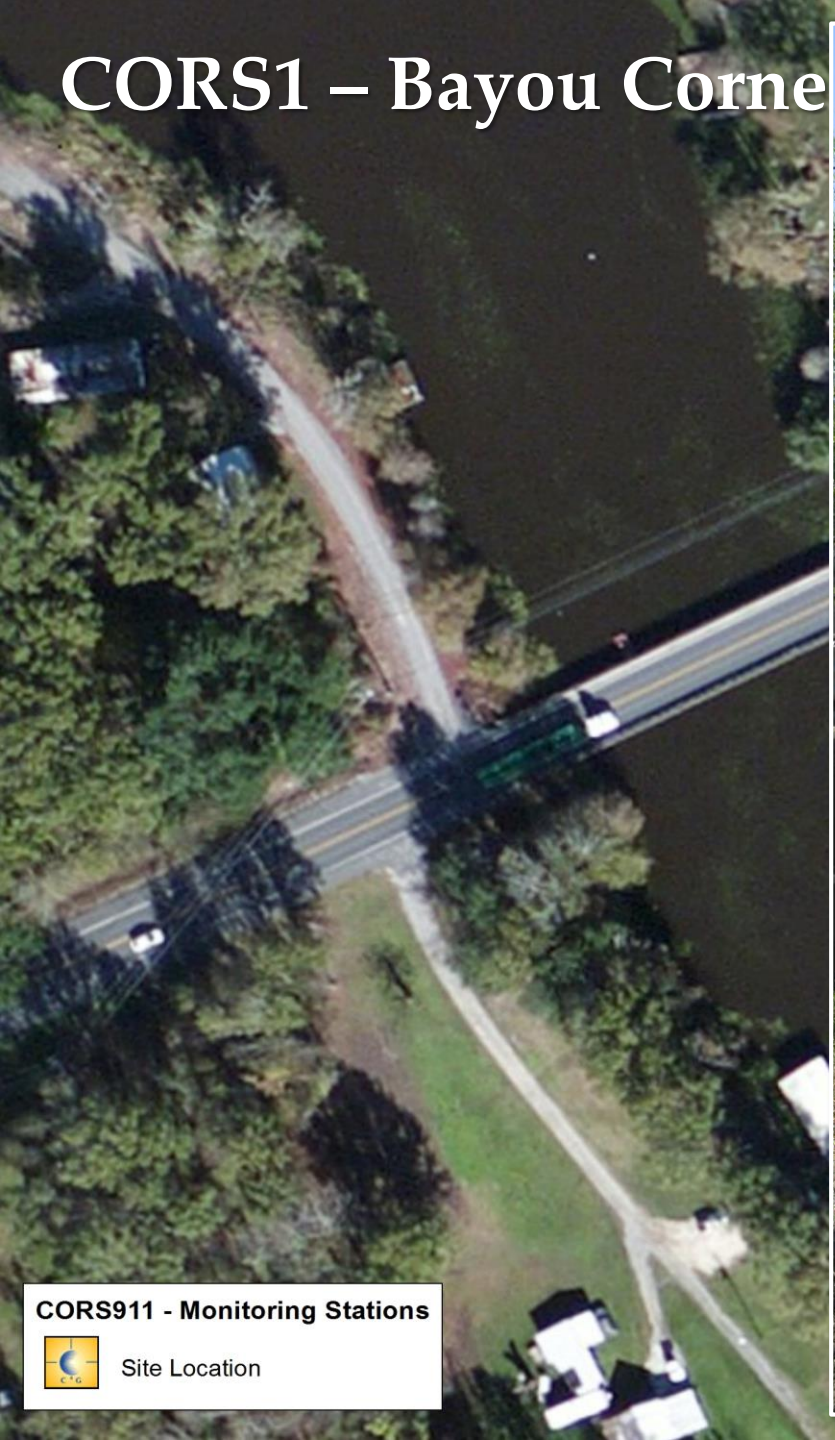
- **Coordinate Monitoring:** real-time measurements relative to the North American continent.
- **Rapid Motion Detection:** measure rapid changes of an antenna's position.
- **Differential Motion Detection:** monitor short and long-term positional changes relative to a fixed location.
- **Data Storage Integrity:** local storage for fault tolerant recording of telemetry in the event of communication outages.
- **Real-time and Web-based Monitoring:** with user configured notification and alarms.

CORS911 Methodology

- **Install CORS911 Sites:** Coordinate site prep with LADOTD
  - Clear site of debris and sources of GPS interference
  - Pour foundation slab: 4.5'x4.5'x2'
  - Utilities added to each location.
  - Install CORS911 mast, enclosure, antenna, receiver, and cell
- **Add CORS to the RTN:** Add the CORS sites to the network synchronizers
- **Establish Coordinate Precision:** Allow CORS positions to "cook-down" for ~3-Days
  - Adjust positions to match Network Solution relative to Oakdale, LA
  - Validate positions with OPUS
- **Monitor Position Integrity:** Provide 24/7/365 Observations
  - Coordinate Monitoring
  - Differential Network Motions
  - Rapid Motion

CORS1 – Bayou Corne

CORS1 – Bayou Corne



CORS911 - Monitoring Stations

Site Location

CORS3 – Grand Bayou

CORS3 – Grand Bayou

CORS911 - Monitoring Stations

Site Location


CORS4
CORS4 –
Bayou Choupique
CORS911 - Monitoring Stations
Site Location
Miles
0
0.01
0.02
0.04
1:1,000
N

CORS4 – Bayou Choupique

CORS911 - Monitoring Stations

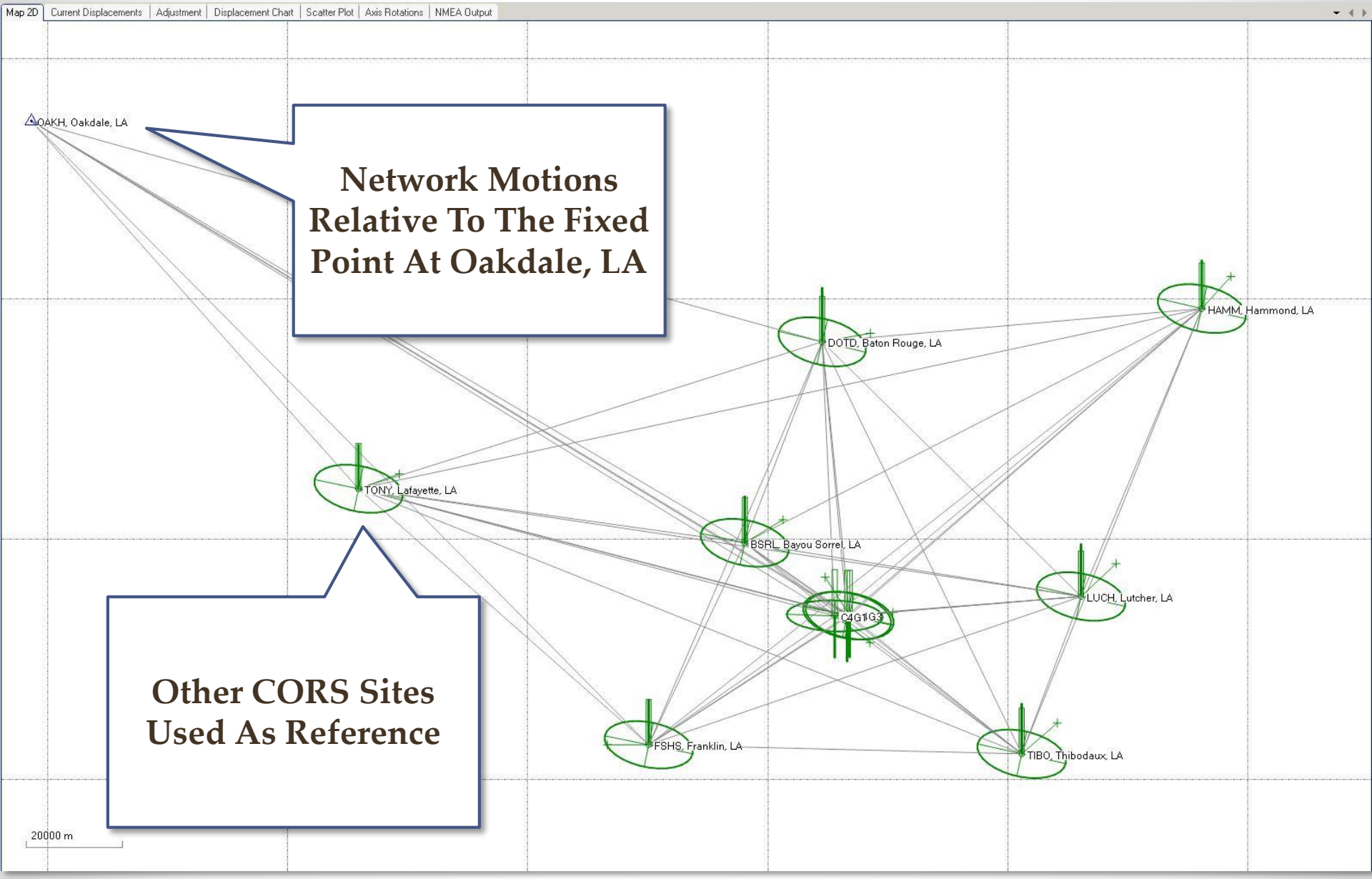
Site Location

Detecting Motion

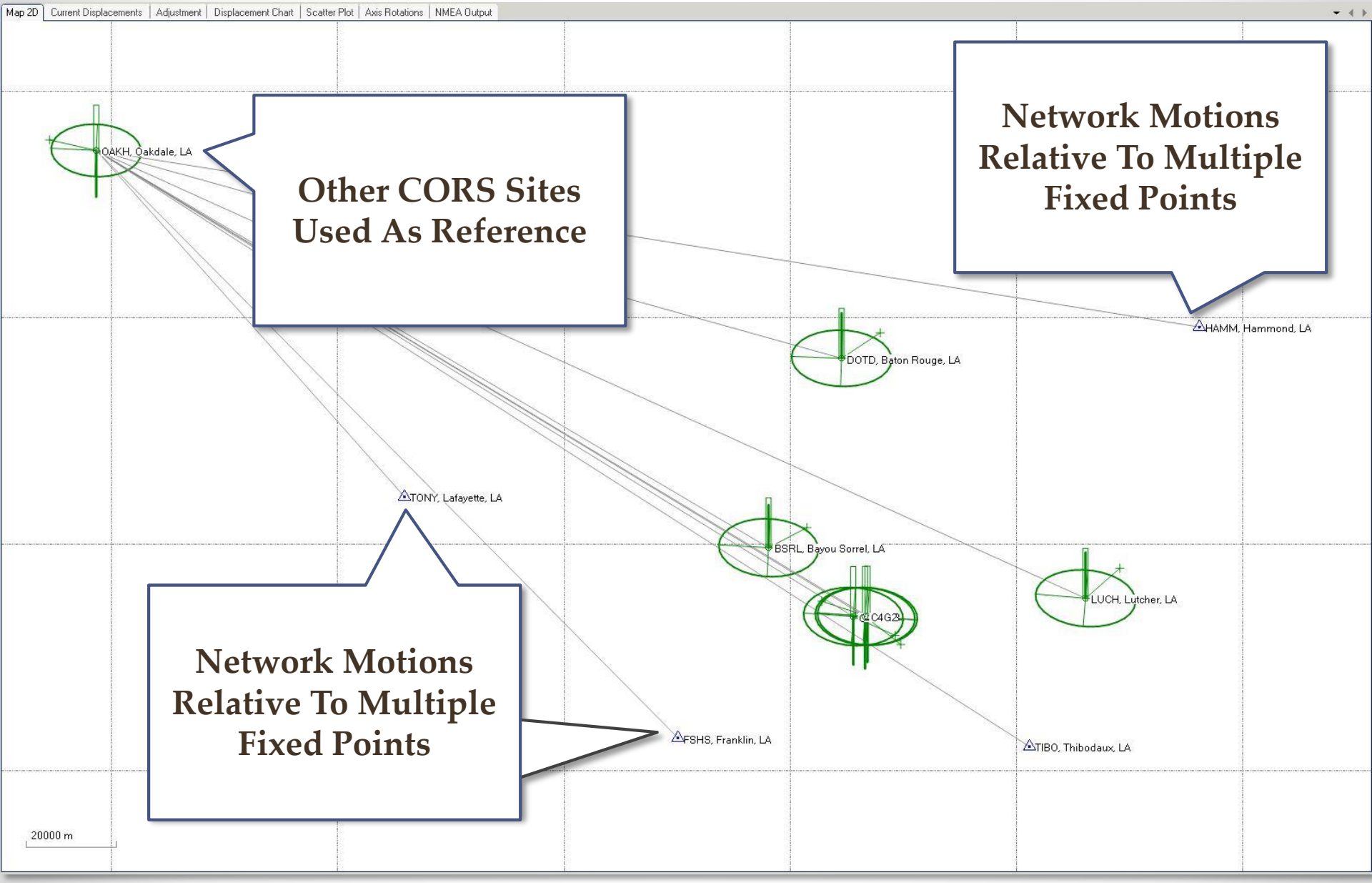
C4GNet RTN Uses Integrity Monitoring Algorithms to Detect Motions

- Set **integrity monitoring** relative to other CORS within the network
- Anchor to a **single**, central location:
  - Oakdale, LA (central LA)
- Anchor to **multiple**, surrounding locations:
  - Hammond, LA (NE), Thibodaux, LA (SE),Lafayette, LA (NW), and Franklin (SW)
- Use **floating reference** sites to aid interpretation

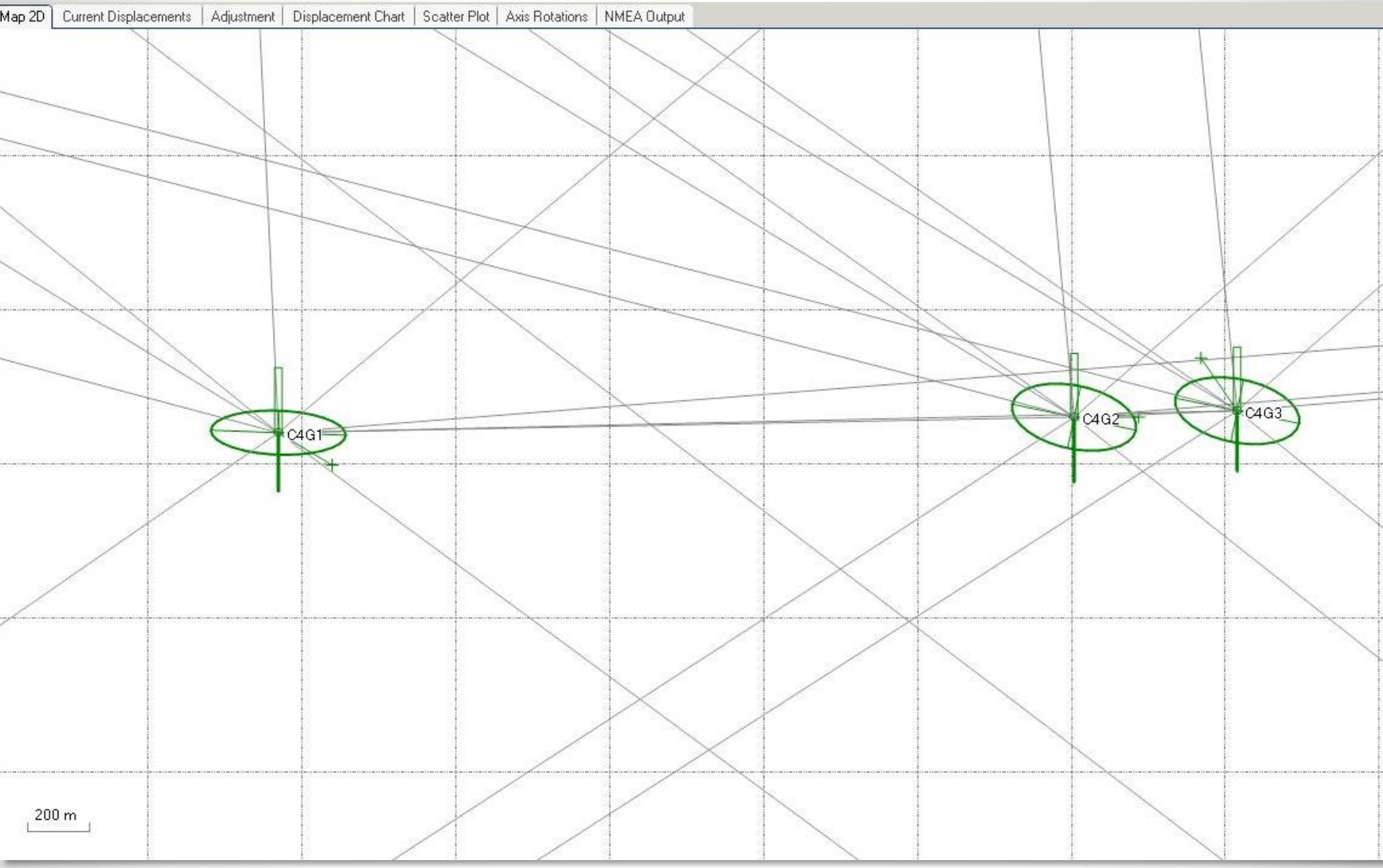
Synchronizing CORS911 Relative to the C4GNet RTN



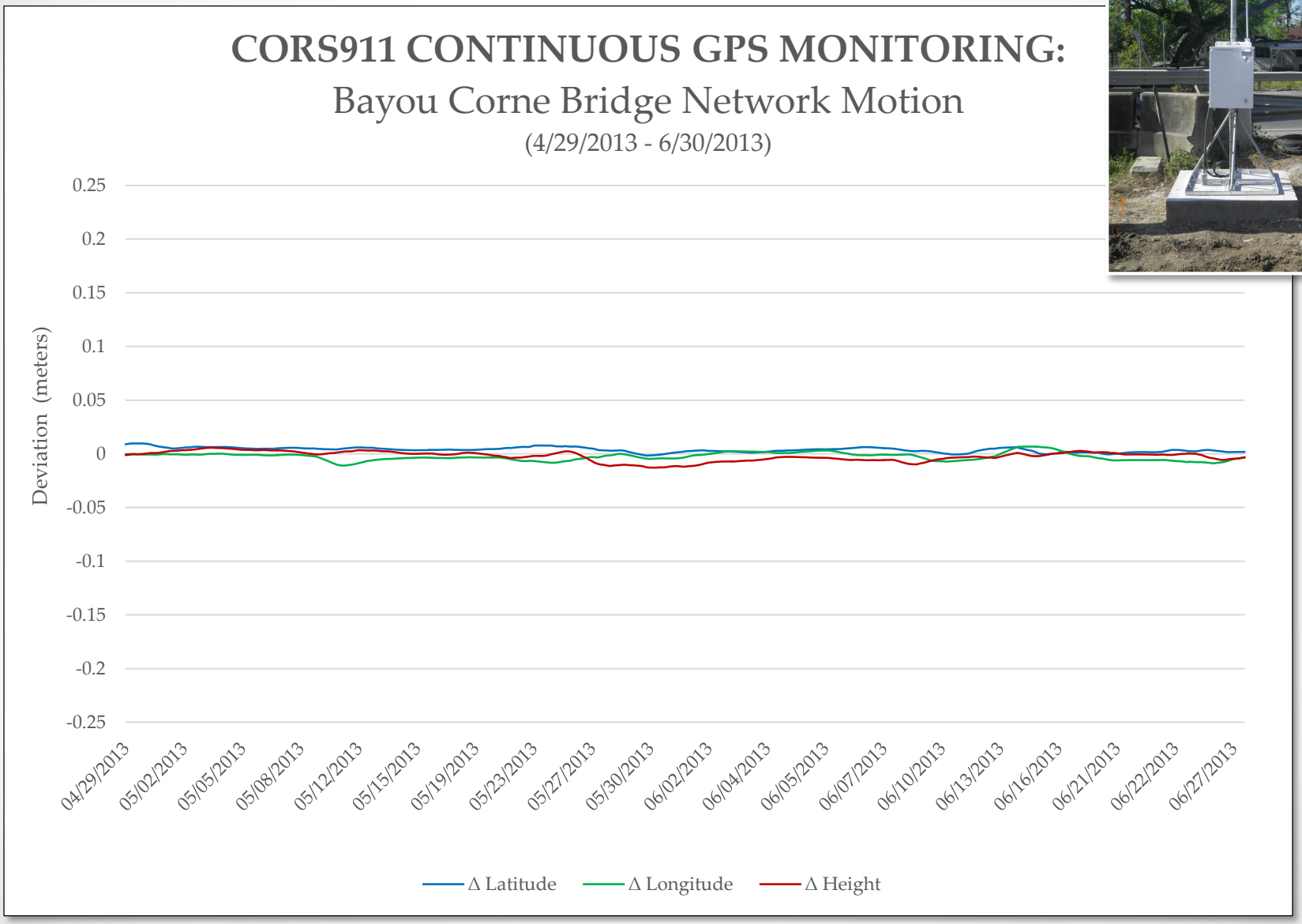
Synchronizing CORS911 Relative to the C4GNet RTN



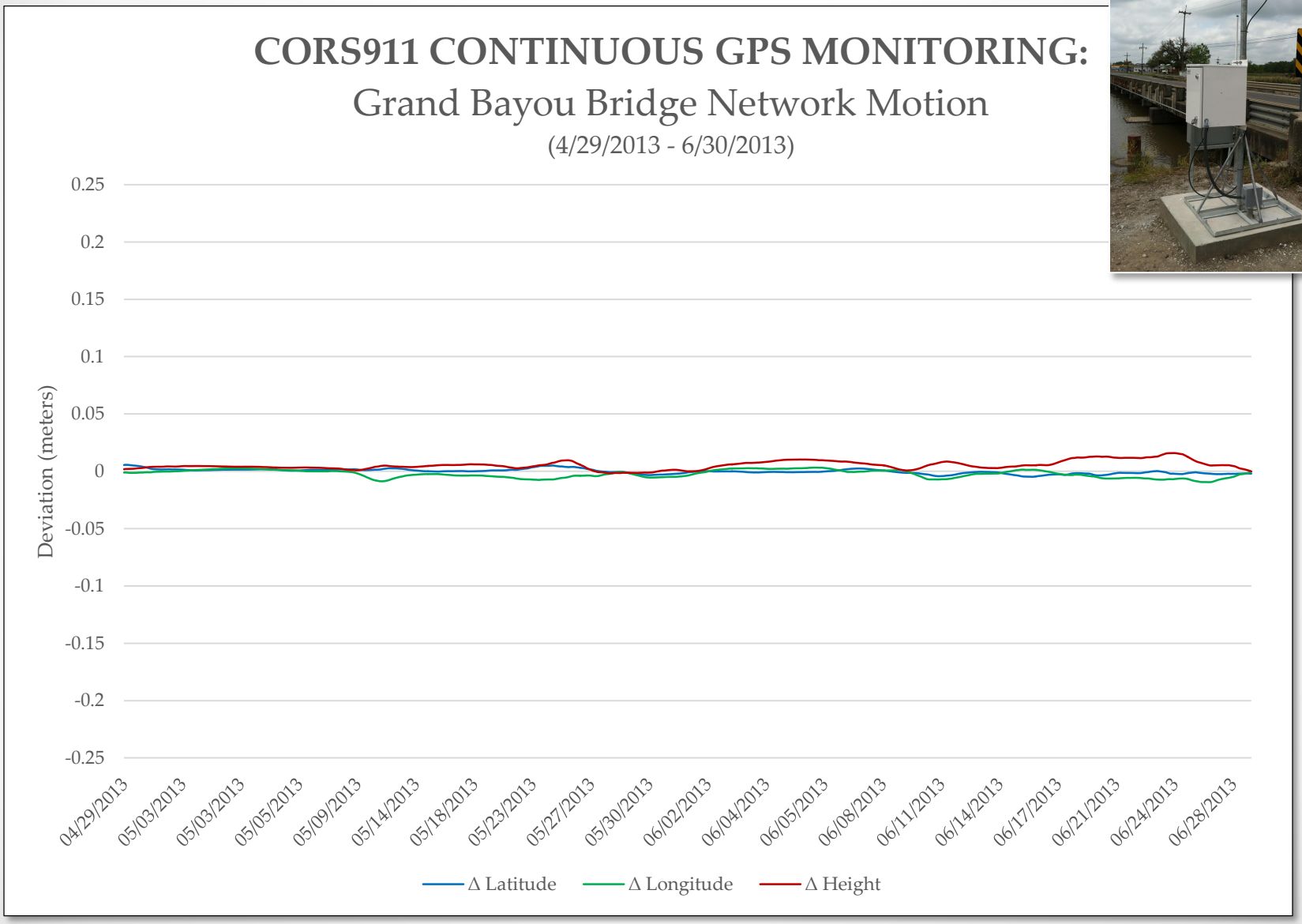
Synchronizing CORS911 Relative to the C4GNet RTN



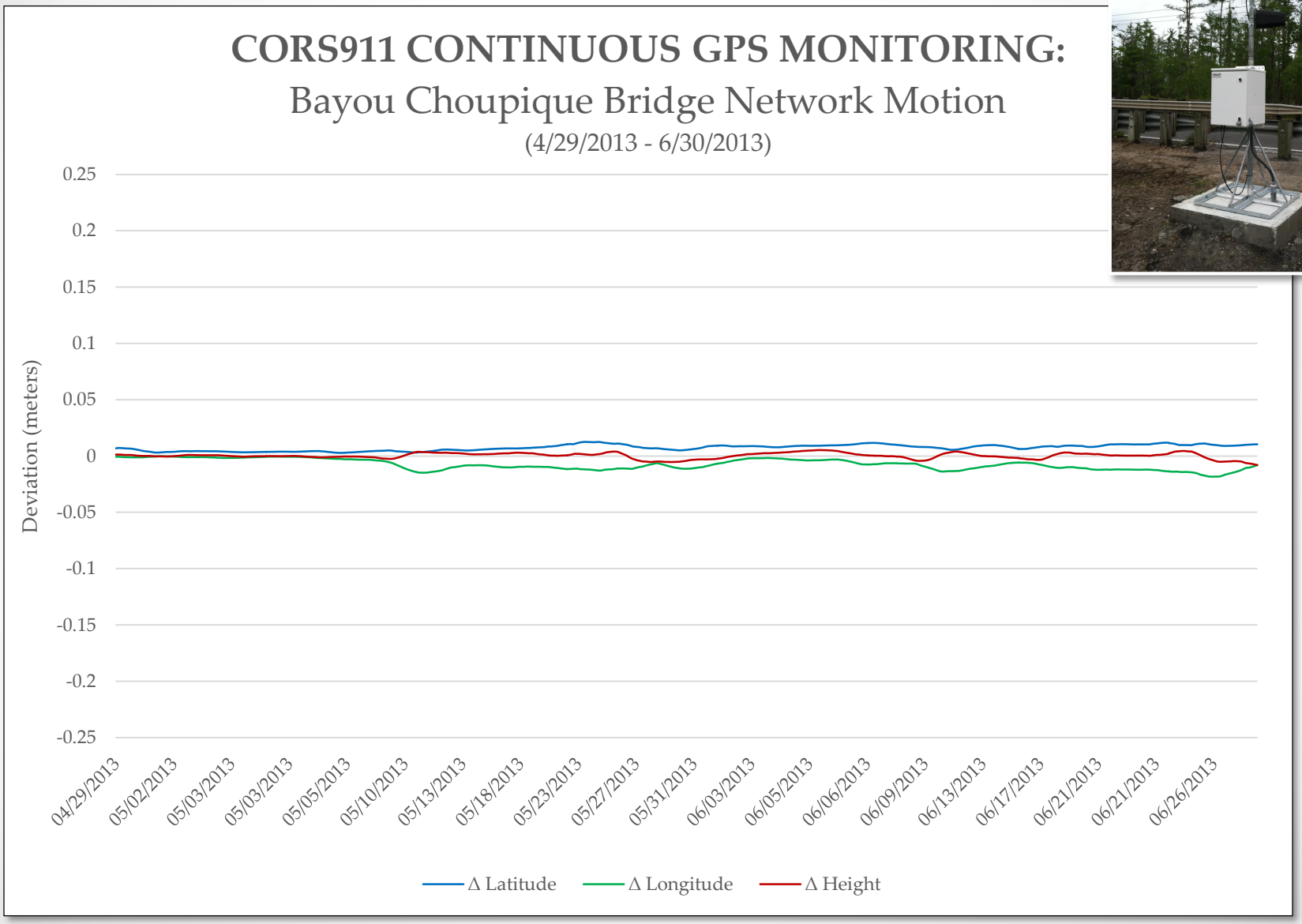
CORS1 – Bayou Corne



CORS3 – Grand Bayou



CORS4 – Bayou Choupique

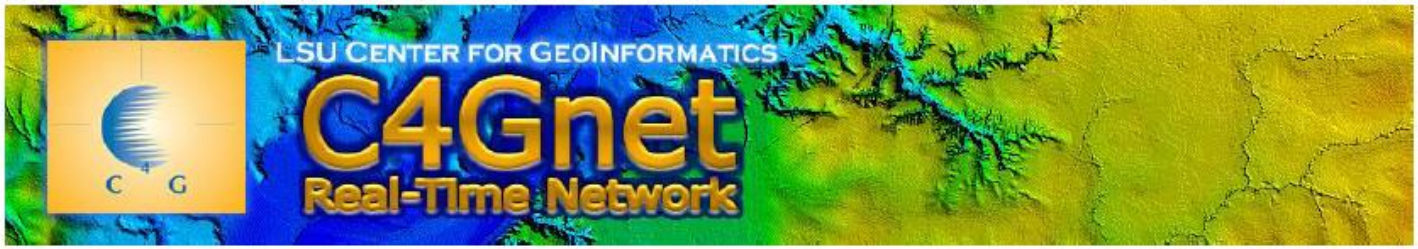


Implementing a Notification System

Monitoring & Alert System

- **Provide Decision Support:** the Integrity Monitoring System will Issue Daily Reports and Email Alerts
- **Daily Reports:** Monitor the positions of each CORS site relative to the Oakdale, LA, reference station
- **Email Alerts:** Establishes thresholds that, if crossed, will trigger an alert:
  - **WATCH ALERT:** threshold is briefly violated.
  - **WARNING ALERT:** threshold is violated for an extended period of time.
- **Assessments:** Develop a method for the interpreting the Alert

Example of an Integrity Monitor Report

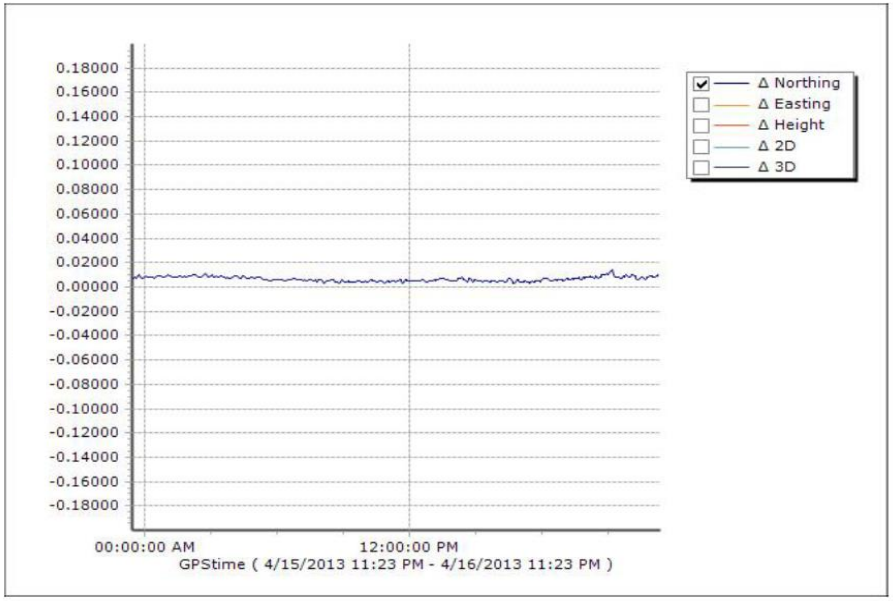


Integrity Monitor Module

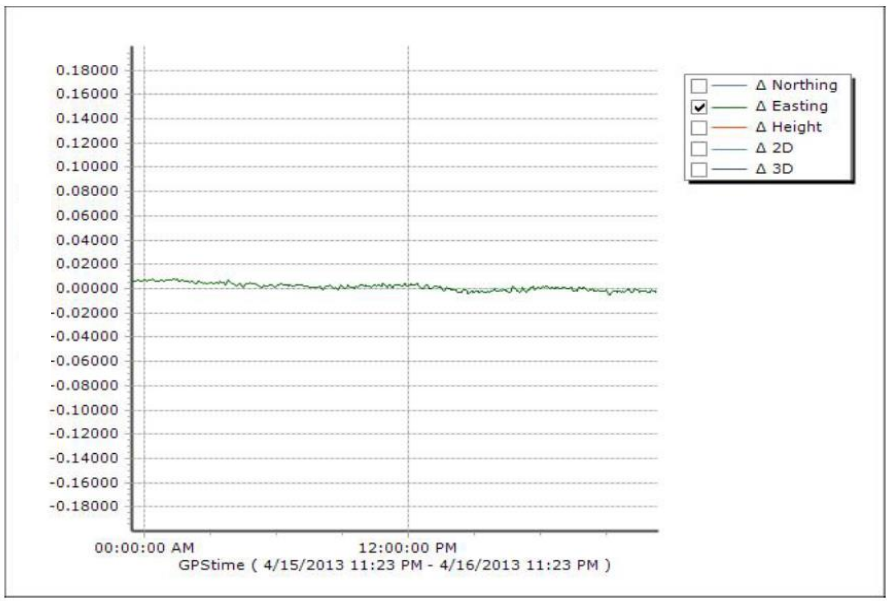
Company:	LTRC/LDOTD Sinkhole
Operator:	LSU C4G
Address:	
Creation Date:	4/17/2013 11:24:41 PM
Time System:	GPStime
Report Interval:	
Start Time:	4/15/2013 11:23:01 PM
End Time:	4/16/2013 11:23:01 PM
Duration:	1 Day(s), 0 Hour(s)

Generate PDF Reports

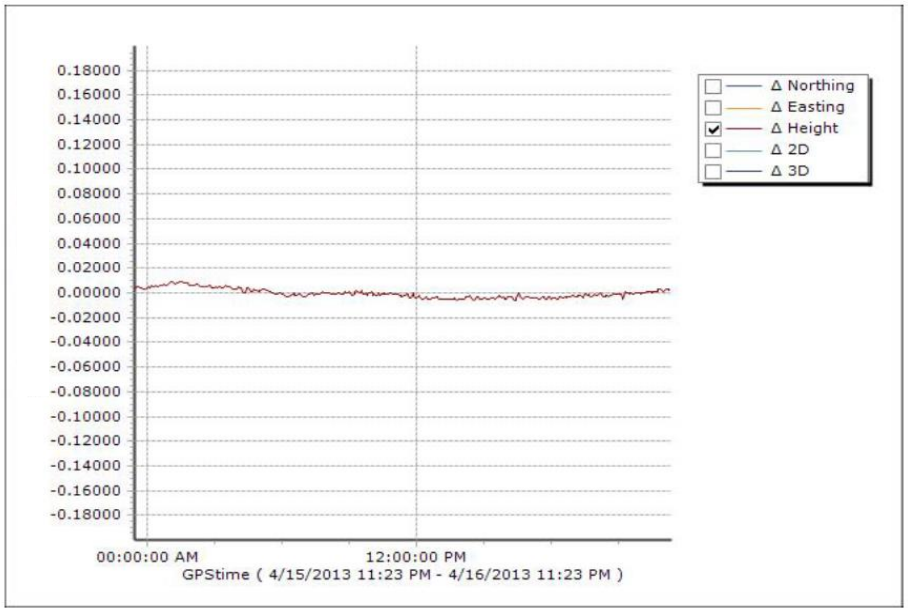
Displacement for component Northing:

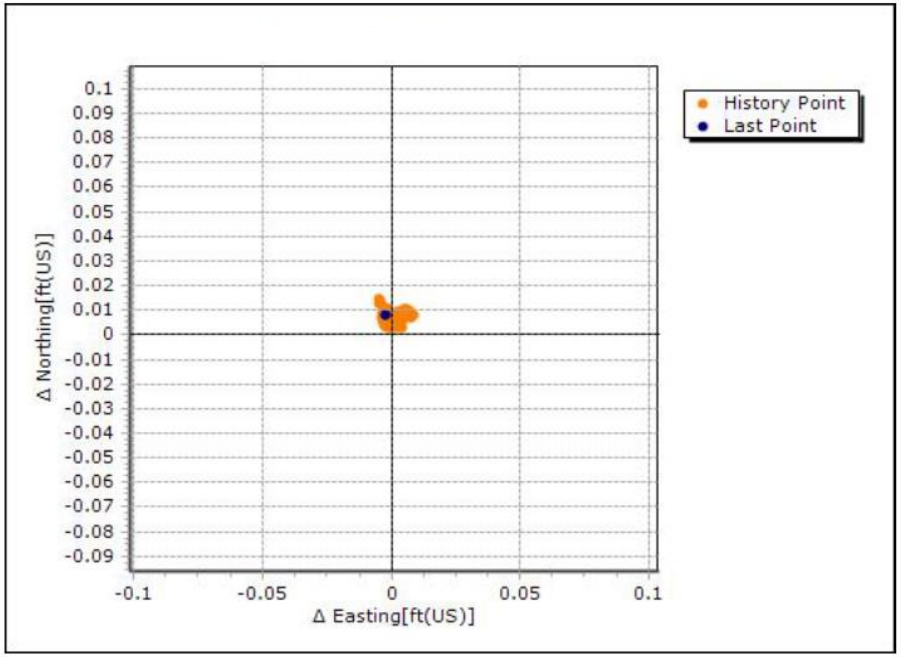


Displacement for component Easting:



Displacement for component Height:





LSU Center 4 GeoInformat | Integrity Monitor Module

KB Parallels | geoconops - Google... | NISAC | National Inf... | FEMA | USNORTHCOM SAGE | LSU Center for GeoI... | Bayou Corne Sinkho... | Mars Science Labora...

LSU Center for GeoInformatics

"Positioning Louisiana for the future"

LSRC Louisiana Spatial Reference Center

C4G Webstore

LSU C4G's Real Time Network featuring Trimble® Pivot Web Advanced Technology

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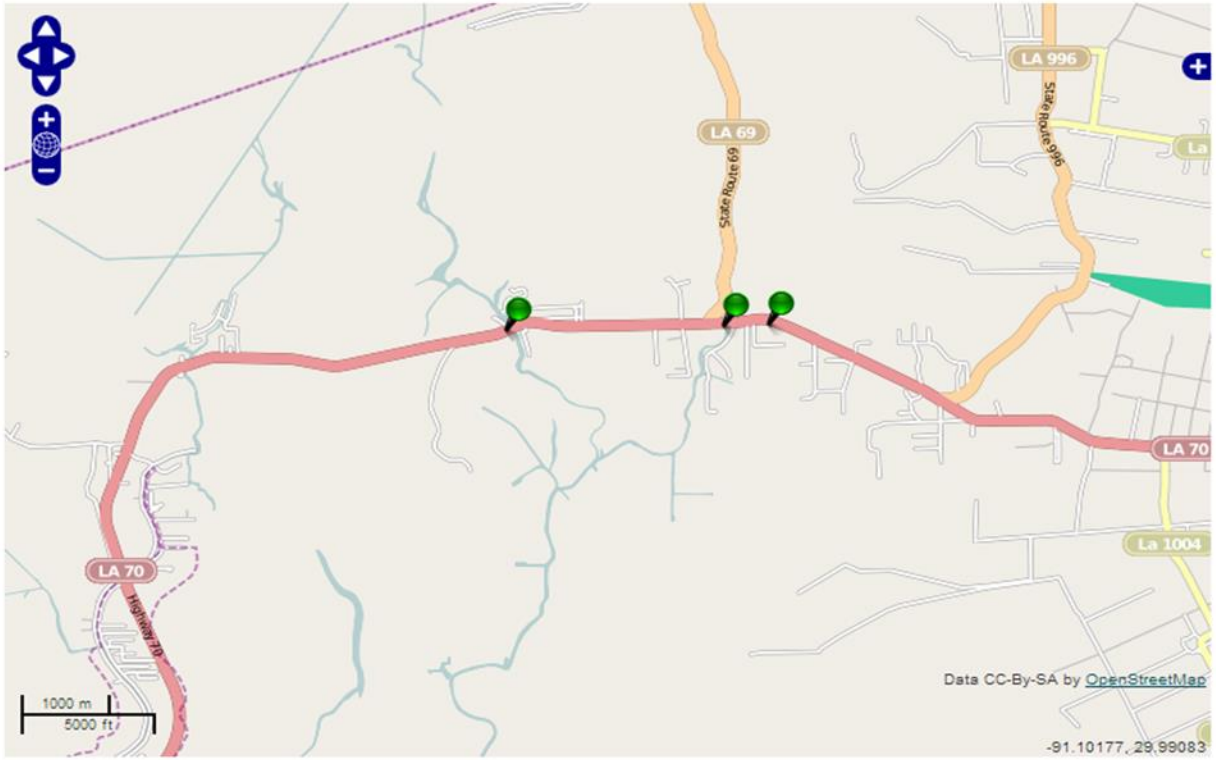
    - Personal Data
    - Change Password
    - Logins
    - Sessions
  - Active Subscriptions
  - Logout
- External Links
  - Trimble

Logged in as LSU/jkent4

LSU Louisiana State University

Sensor Map



69 sensors:

- 1LNT, Plain Dealing, LA
- 1LSU, Baton Rouge, LA
- 1NSU, Natchitoches, LA
- 1ROY, Oak Grove, LA
- 1ULM, Monroe, LA
- AWES, Donaldsonville, LA
- BCHS, Belle Chasse, LA
- BOGA, Bogalusa, LA
- BSRL, Bayou Sorrel, LA
- BVHS, Boothville, LA
- C4G1
- C4G2
- C4G3
- CALC, Calcasieu Pass, LA
- CAMR, Cameron, LA
- COVG, Covington, LA
- DEV1, Eugen Island, LA
- DOTD, Baton Rouge, LA
- DQCY, Dequincy, LA
- DSTR, Desterhan, LA
- FOLK, Jackson, LA
- FSHS, Franklin, LA
- FWTR, Freshwater Bayou, L
- GRIS, Grand Isle, LA
- GVMS, Galvez, LA
- HAMM, Hammond, LA
- HOUM, Houma, LA
- INRL, Loyola University, NO

LSU Center 4 GeoInformat | Integrity Monitor Module

KB Parallels | geoconops - Google... | NISAC | National Inf... | FEMA | USNORTHCOM SAGE | LSU Center for GeoI... | Bayou Corne Sinkho... | Mars Science Labora...

LSU Center for GeoInformatics

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C4G Webstore

LSU C4G's Real Time Network featuring Trimble® Pivot Web Advanced Technology

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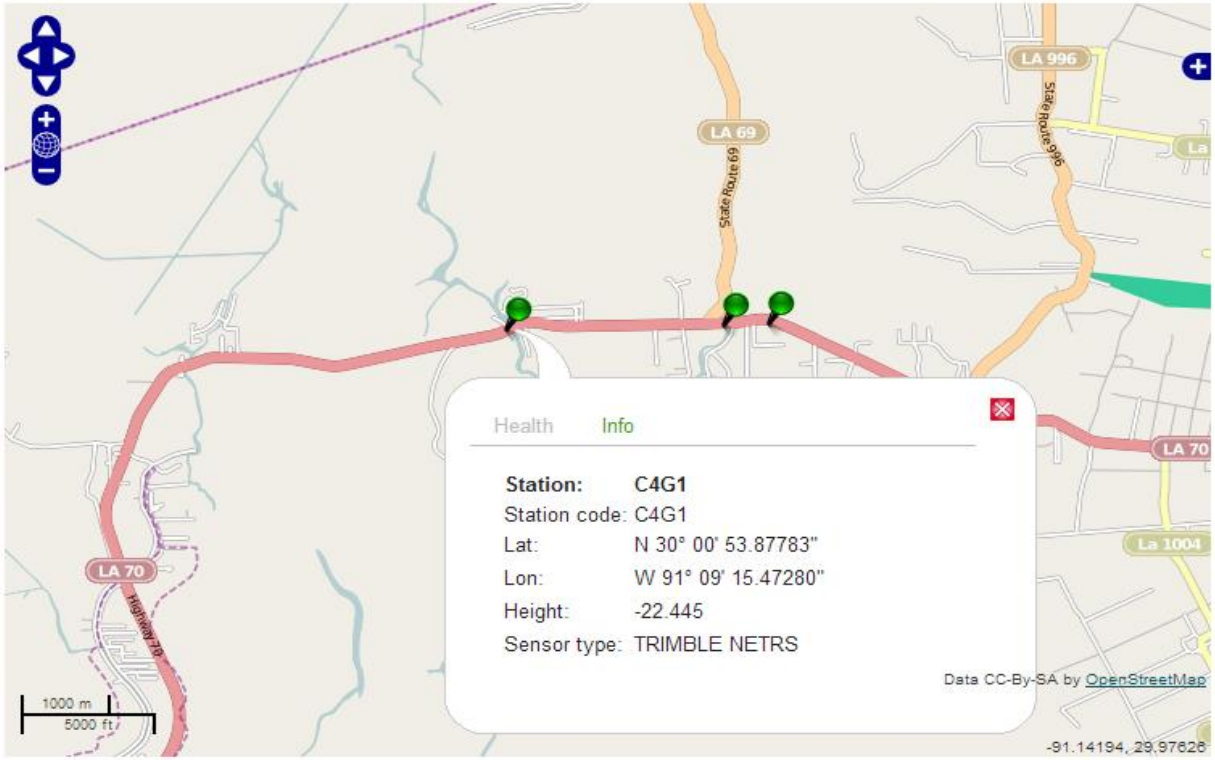
  - Status Messages
  - Network Information
    - I95 Ionosphere
    - IRIM/GRIM
  - Reference Data Shop
  - My Account
    - Personal Data
    - Change Password
    - Logins
    - Sessions
  - Active Subscriptions
  - Logout
- External Links
  - Trimble

Logged in as LSU/jkent4

LSU Louisiana State University

Sensor Map



69 sensors:

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- FOLK, Jackson, LA
- FSHS, Franklin, LA
- FWTR, Freshwater Bayou, L
- GRIS, Grand Isle, LA
- GVMS, Galvez, LA
- HAMM, Hammond, LA
- HOUM, Houma, LA
- INRI, Loyola University, NO

Integrity Monitor Module

Integrity Monitor Report of a given Module configuration

Company:	<company name>
Operator:	jkent4
Address:	<company address>
	<city, postal code>
	<country, state>
Creation Date:	4/18/2013 12:02:16 AM
Time System:	Local Time
Time Zone Name:	
Time Zone Offset:	
Report Interval:	
Start Time:	
End Time:	
Duration:	

Simplified Reporting via Secure Web Site

Configuration:

Name:	CORS911NMEIM
System:	NAD83

Monitored Stations:

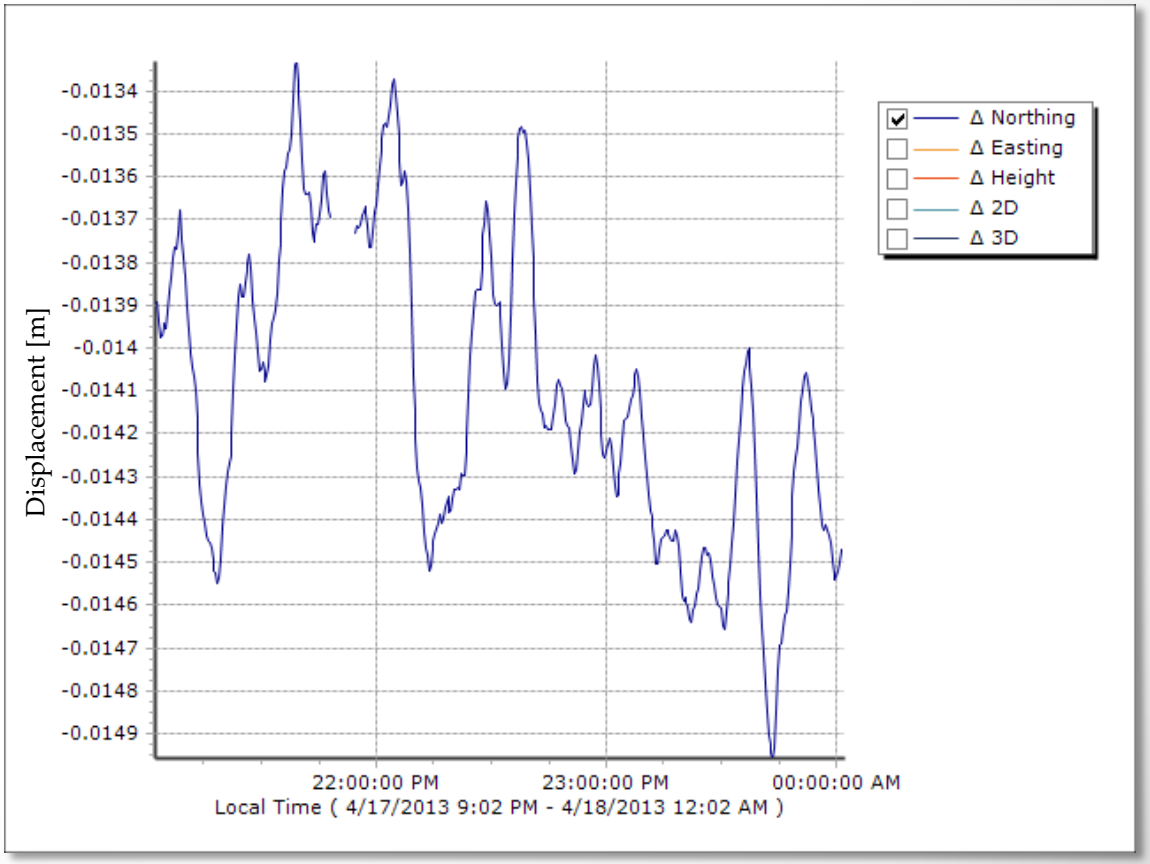
Station Name: C4G1

Station Code:	
Station ID:	911
Reference Position X [m]:	-111349.2807
Reference Position Y [m]:	-5526285.8274
Reference Position Z [m]:	3171709.1587

Reporting Example

Displacement in Northing:

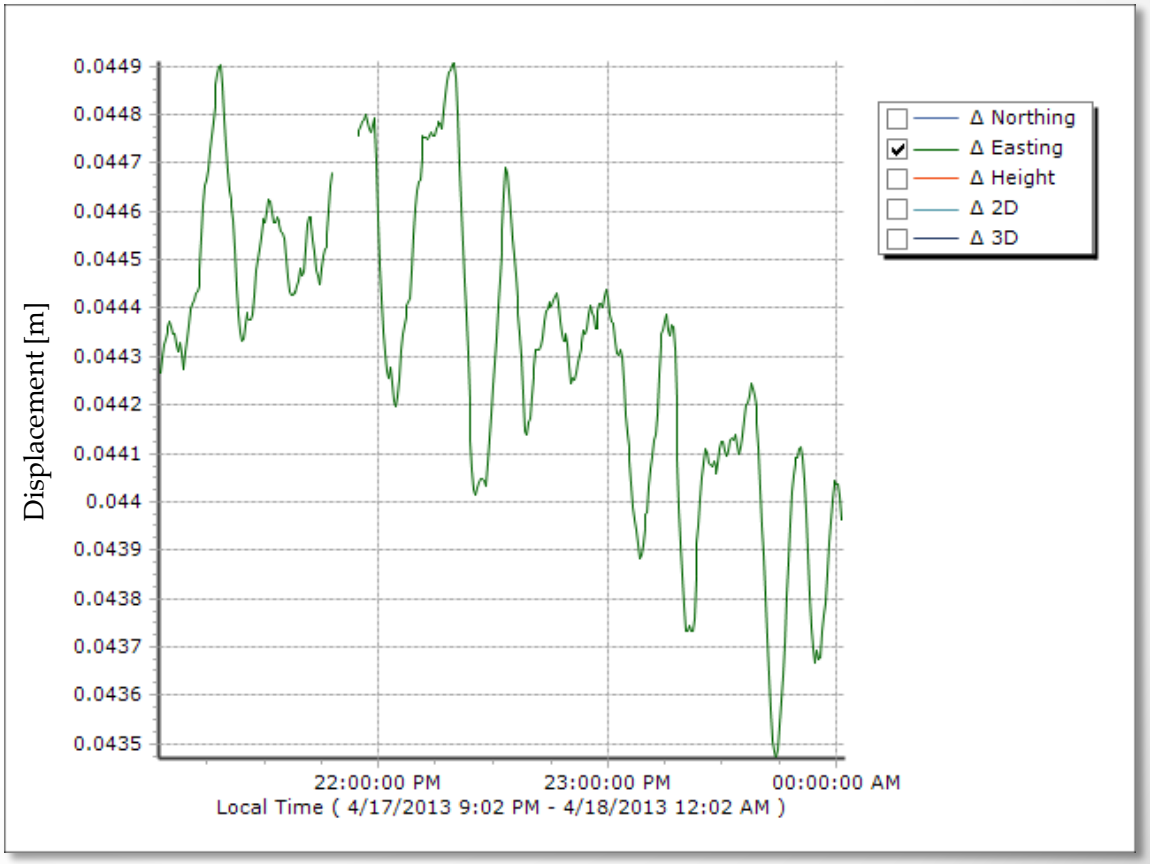
1.5 mm
(0.059”)



Reporting Example

Displacement in Easting:

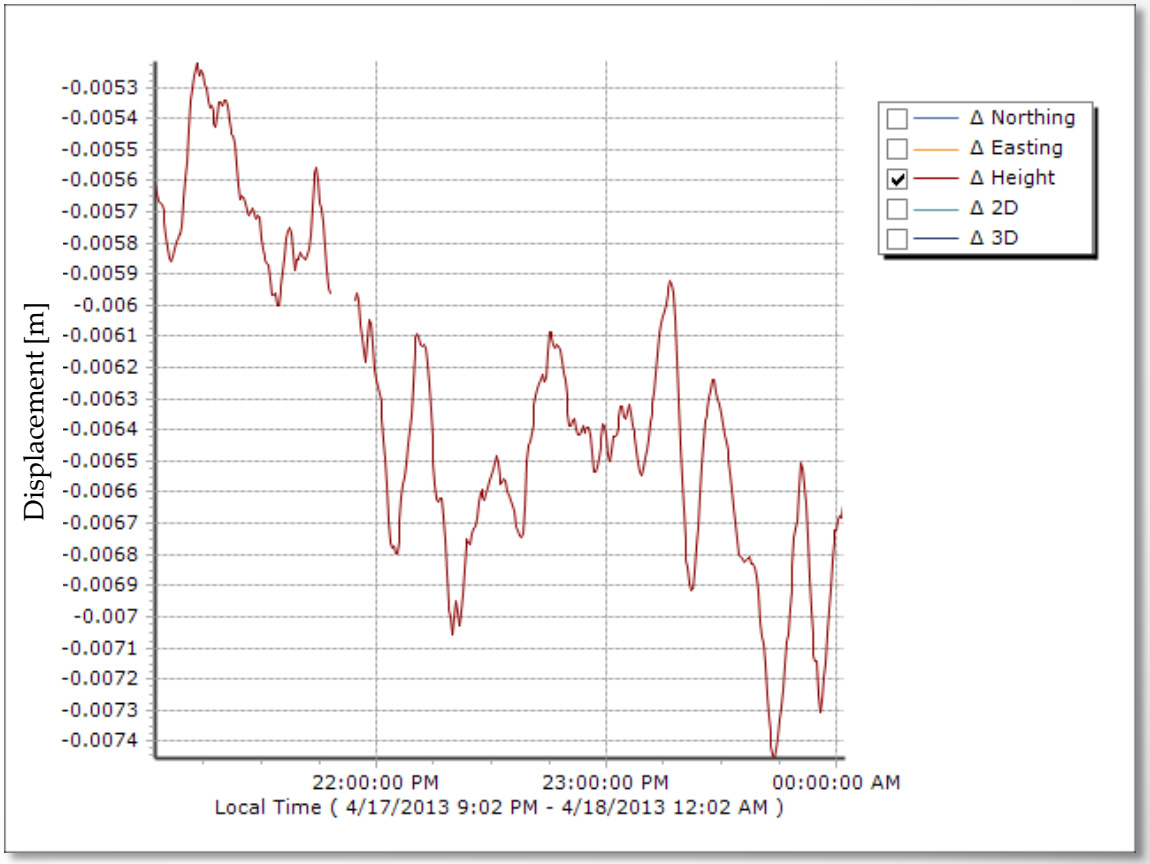
1.4 mm
(0.055”)



Reporting Example

Displacement in Vertical:

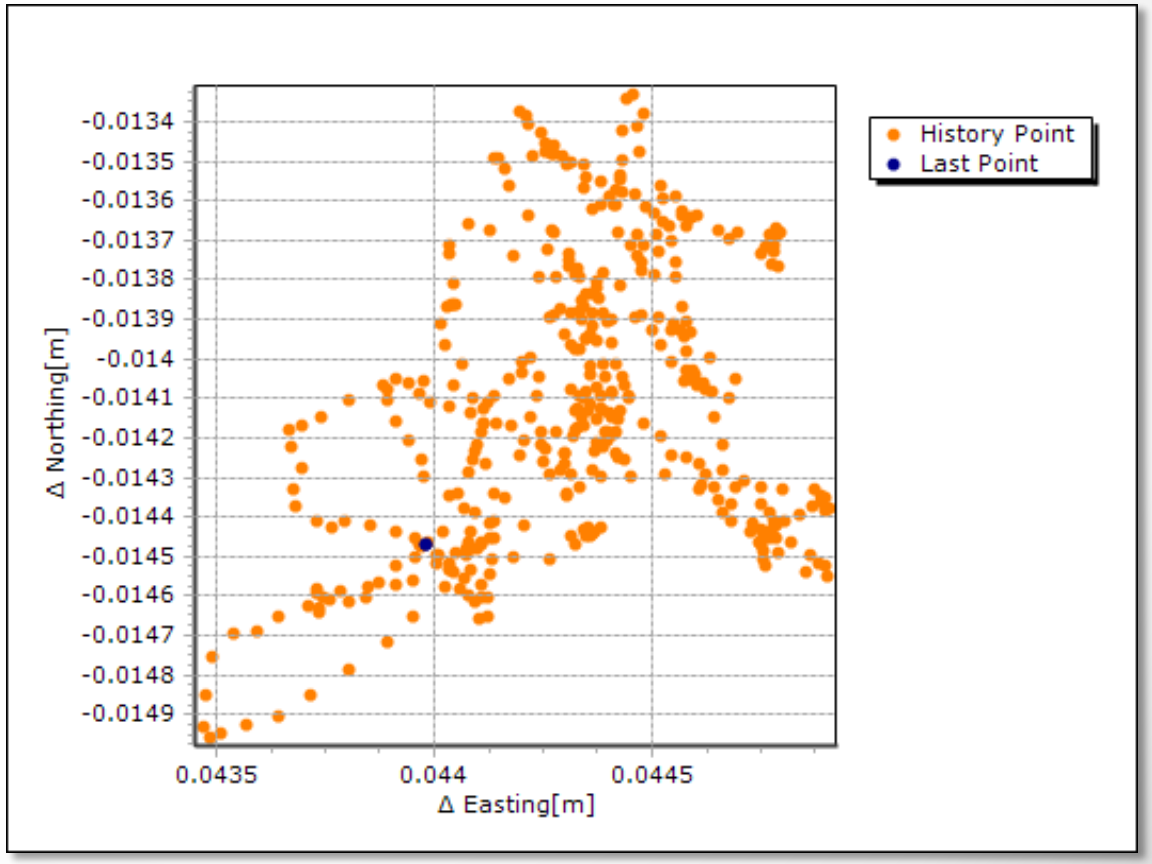
2.1 mm
(0.083”)



Reporting Example

Scatter Plots:

1.5 mm
(0.059”)



Summary & Conclusions

Hazard mitigation of the Napoleonville Salt Dome Sinkhole:

- **Oxy #3 Cavern Breach** along the Western wall of the salt dome.
- **Unstable Material Shifted**, causing sinkhole to form in the Mississippi River alluvial plain.
- **Modeled Output** will be used to develop a long-term strategies for monitoring in the area.
- **Containment Berm Subsiding** ≤ 10' in some locations.
- **Cavern Sill Unstable**, dropping further into the salt dome.
- **Sinkhole Depth** stabilizing; **Sinkhole Area** increasing.
- **Flaring the migrating Methane Gas** trapped beneath the aquifer.

Summary & Conclusions

Two Advanced Geodetic Monitoring Solutions Implemented by the C4G

- **Static GPS Measurements** of horizontal and vertical positions at control points along Hwy 70
- **Continuous GPS Measurements** using CORS911 stations installed at select locations along Hwy 70

Summary & Conclusions

The Findings So Far…

- **No Discernible Anomalous Movement** of Hwy 70 relative to the sinkhole.
- ***Ad hoc* GPS Readings Exhibit Variability** associated with random and systematic error.
- **Long-Term Occupation Using CORS** technology was initiated to assess differential motions and provide more reliable measurements.
- **CORS Technologies Provide** a consistent, accurate, and comprehensive solution with direct access to telemetry in real-time.

Questions & Contact Info

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