
Public Briefing
Residents out of homes
411 days—1 year, 1 month, 15 days
September 17, 2013

Agenda

- 3D Seismic—Don Marlin
- Stability—Will Pettitt
- Blue Ribbon Commission—Perry Franklin
- Situational update—Gary Hecox

3D Seismic Results

Don Marlin, CPG

BAYOU CORNE 3D SEISMIC FINDINGS

MARCH 2013 DATA INTEGRITY CONFIRMED AND ENHANCED BY REPROCESSING

REPEATED A SIX STEP APPROACH AFTER GETTING ALL DATA:

1) ESTABLISH THE SALT INTERFACE by historical wellbores, 2010 and 2013 VSP surveys, review of three 3D processing volumes (2007 Legend, April 2013 TBC processing, and August 2013 LDNR re-processing), and 2013 (NMO) corrected gathers;

2) LOOK FOR DISTURBANCE EXTERIOR TO THE SALT interface by using stack volumes from all 3D datasets but primarily using Spectral Balanced Local Attribute (SBLA or high frequency resolution LDNR re-processing), Energy Ratio (LDNR 3D), and Similarity (TBC 3D) volumes to indicate where reflectors from sedimentary layer boundaries were not uniform or layered;

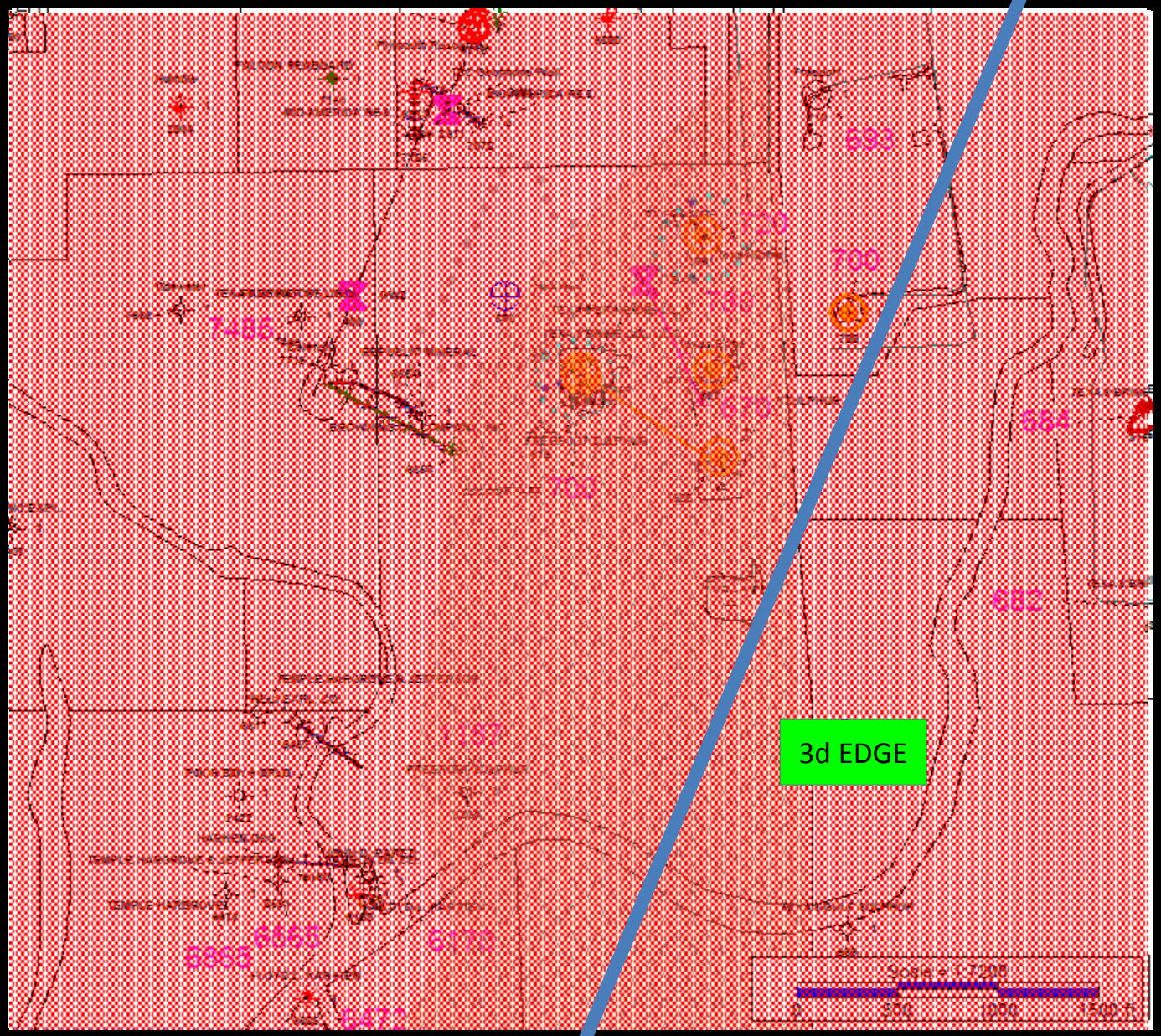
3) MAP THE EXTERIOR GEOLOGIC CONDITIONS. Look for faulting and competent lithologic markers tied to seismic from well control around the disturbance area;

4) IDENTIFY SUGGESTIONS OF HYDROCARBONS by analyzing AVO volumes and NMO gathers *in and adjacent to the disturbance;*

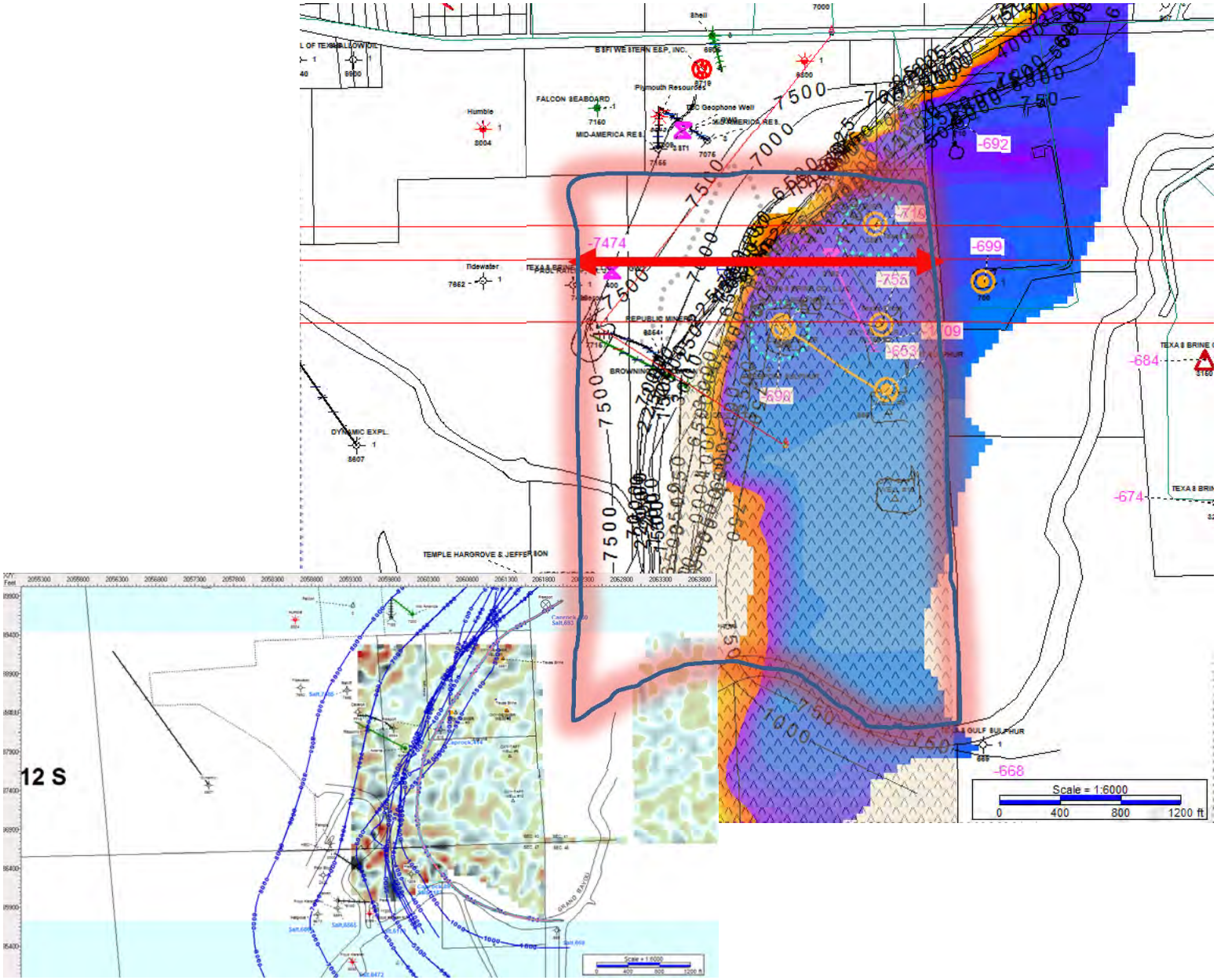
5) *MAKE FORWARD 1D & 2D* synthetic fluid-substitution models from well logs to compare to AVO, stack, NMO gather responses for hydrocarbon saturation validation, and log data;

6) ESTIMATE A HYDROCARBON VOLUME by using well log control thickness, porosity, water saturation or by using anomaly boundaries as a limit.

AUGUST



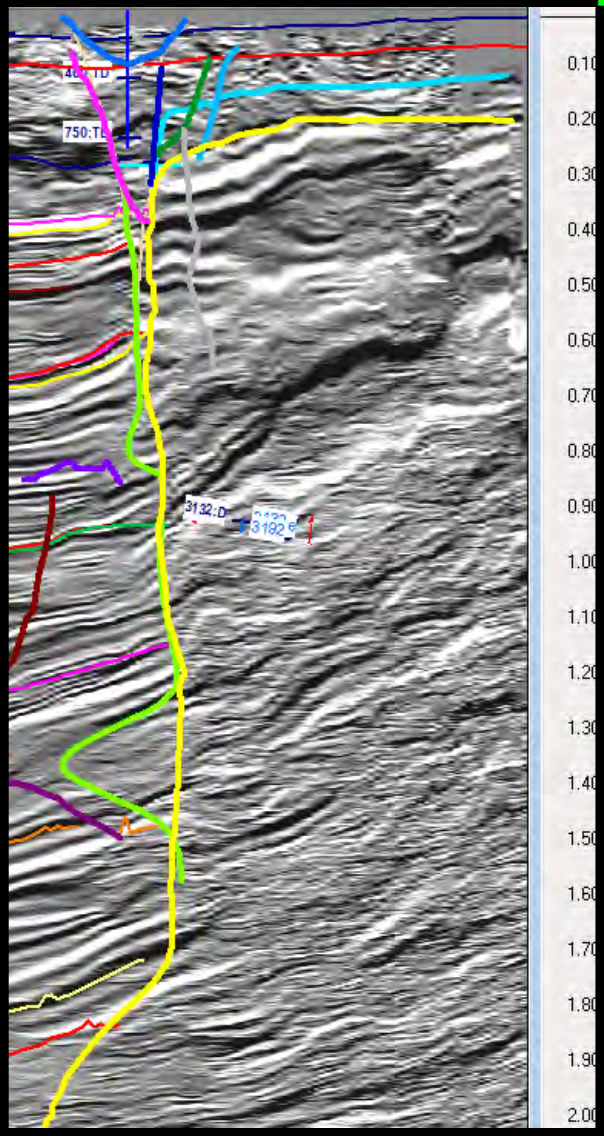
E-W Vertical Slice through the Salt Interface and Sinkhole Center Resulting Final Salt Contour Lines versus Caprock area in Blue



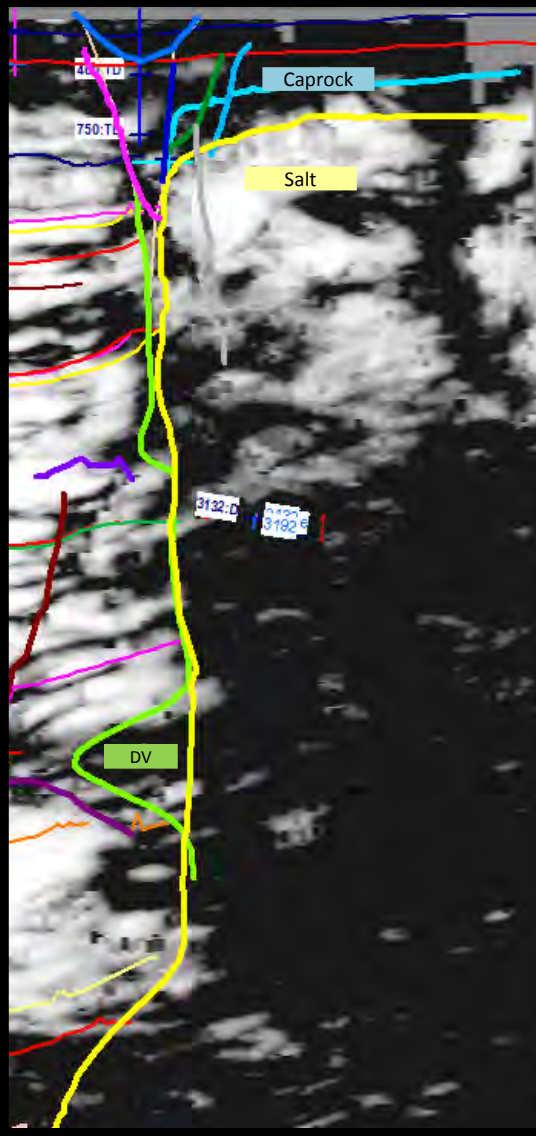
LINE LOCATION

DNR Processing vs. ~Coherence

Interpreted SBLA

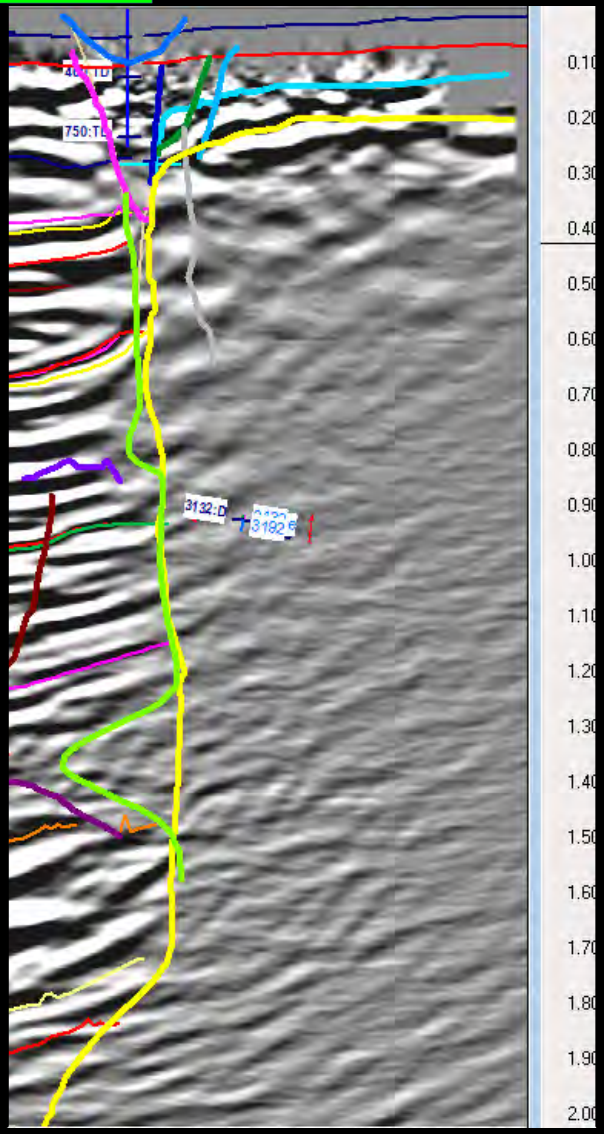


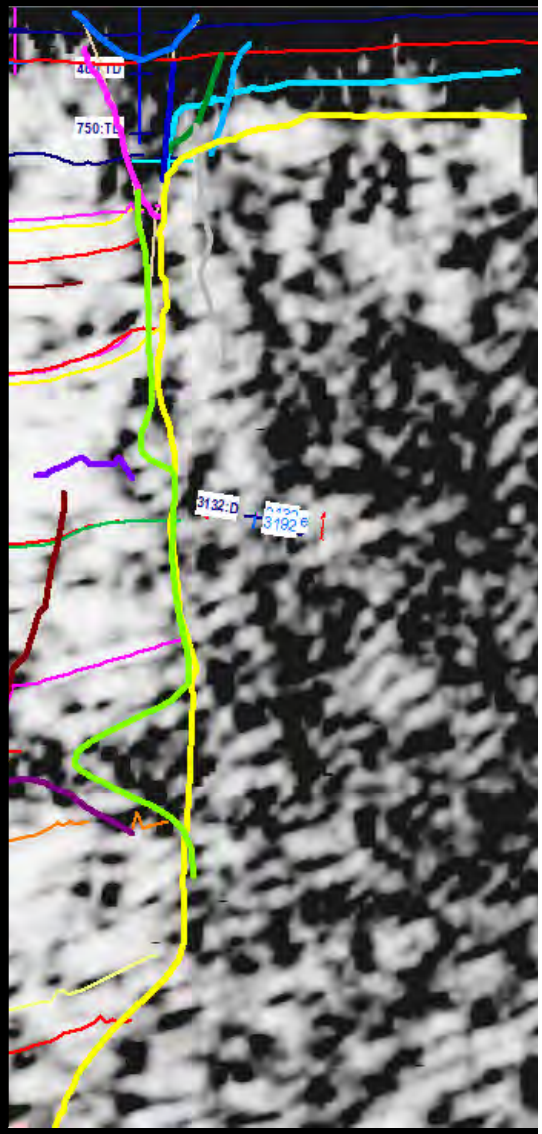
Energy Ratio



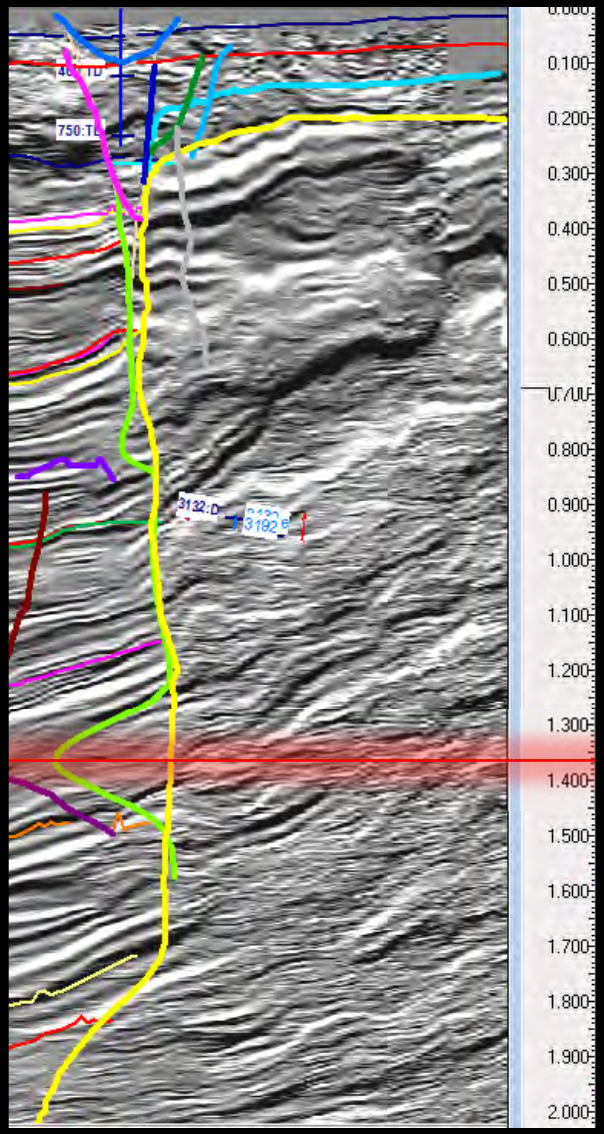
TBC Processing vs. ~Coherence

Applied SBLA interpretation to TBC data

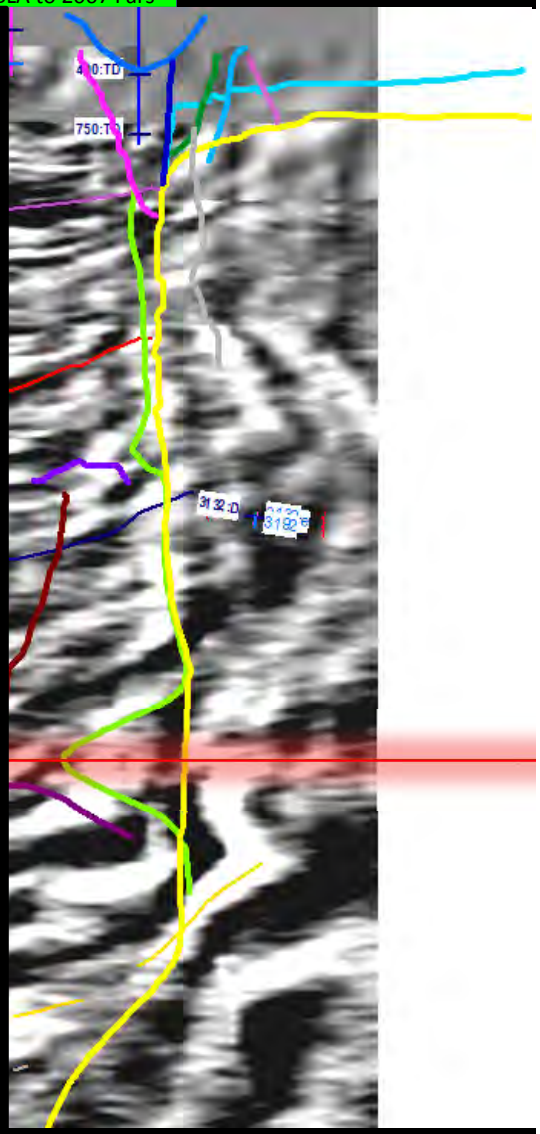




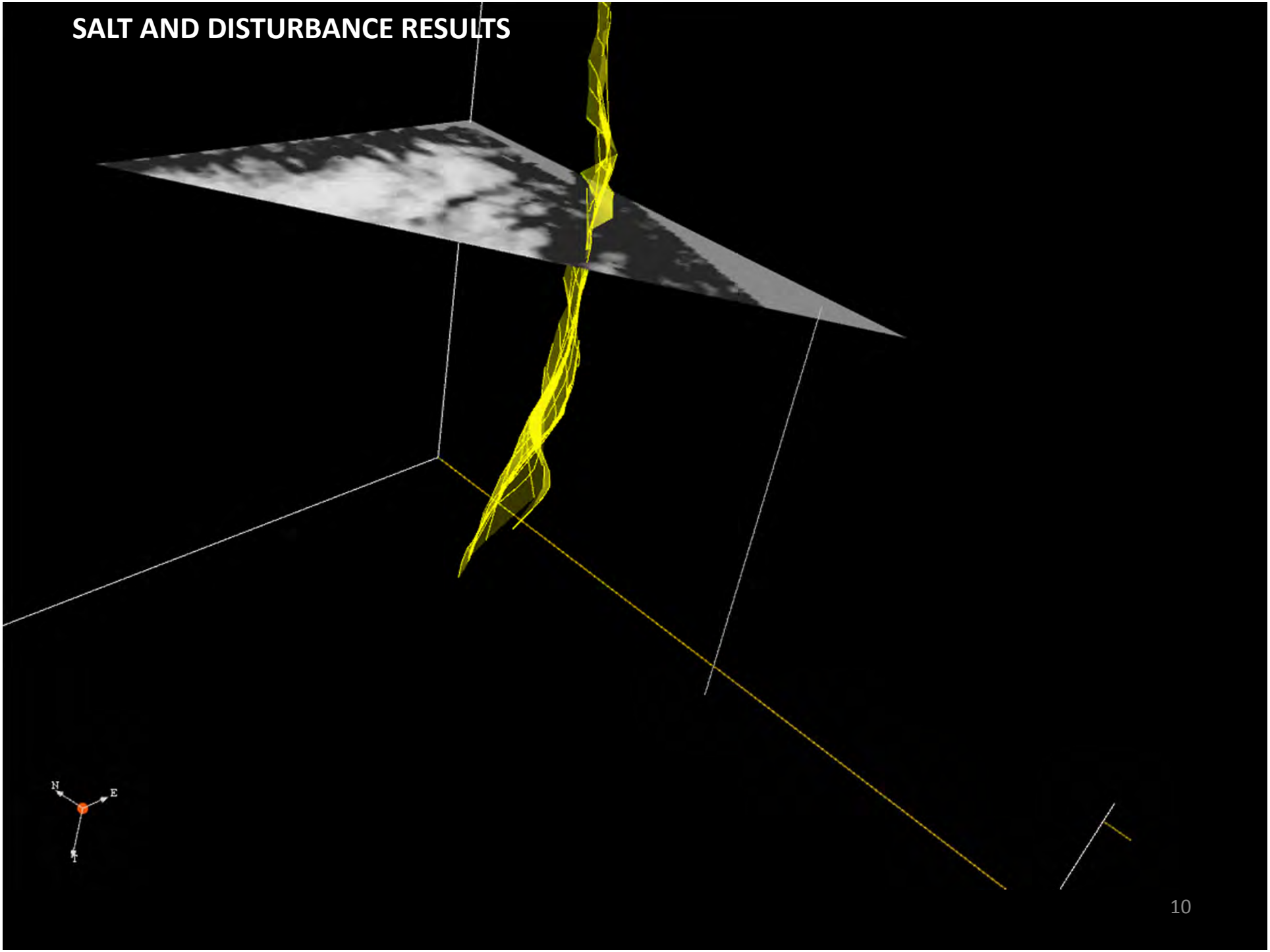
DNR Processing vs. Legend Processing (Far Angle)



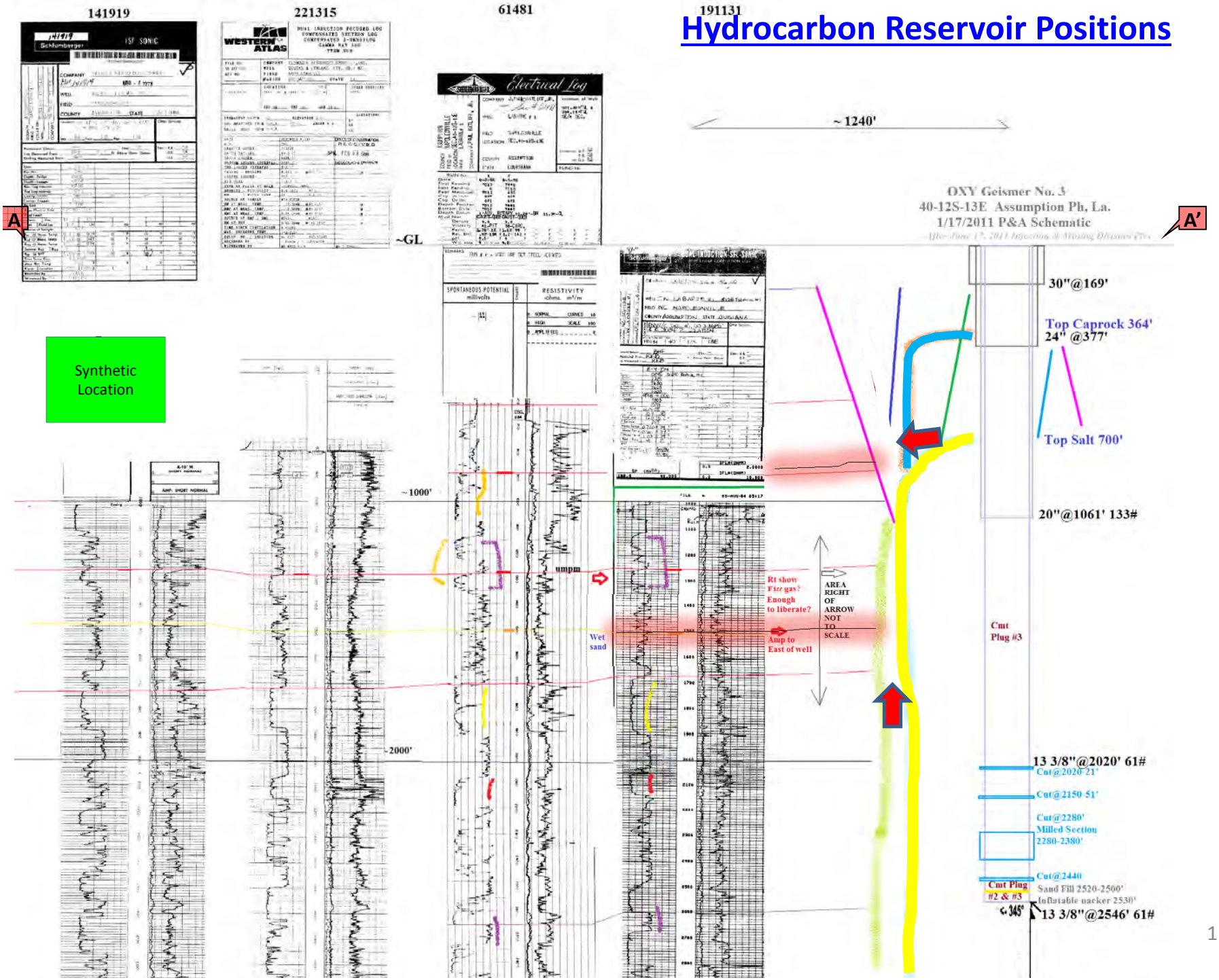
Applied SBLA to 2007 Fars



SALT AND DISTURBANCE RESULTS

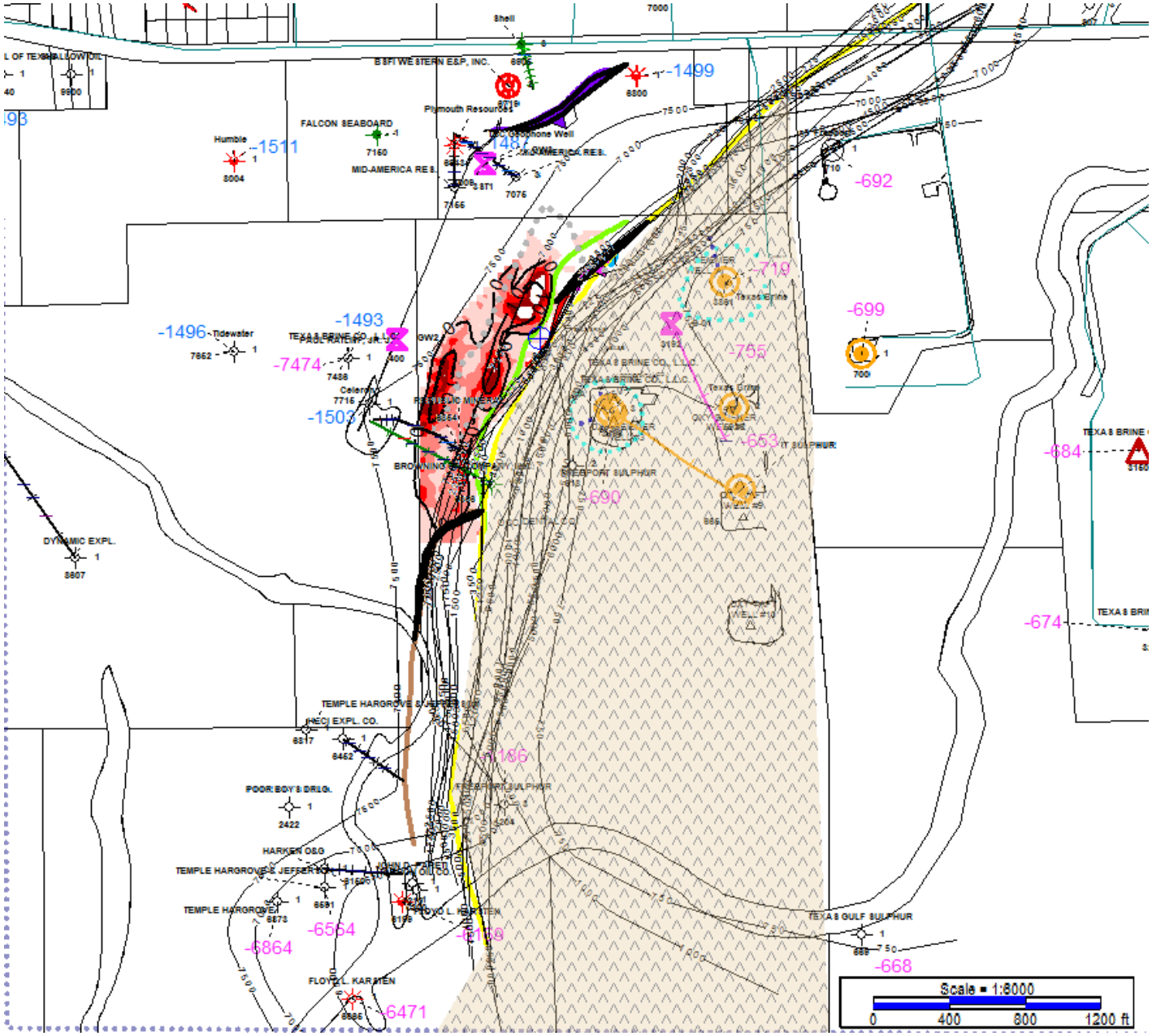


Hydrocarbon Reservoir Positions



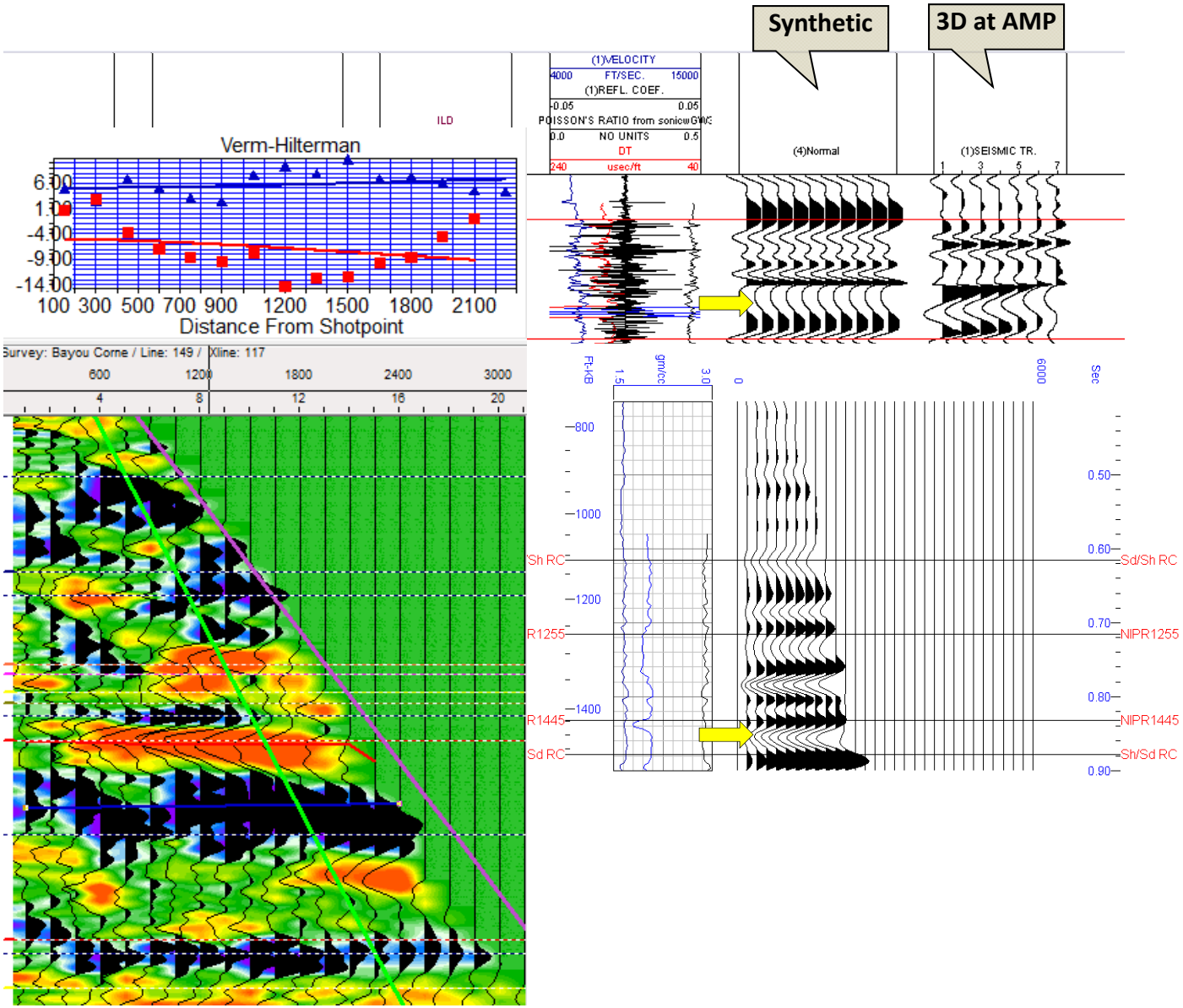
Salt Contours versus the Sinkhole and Hydrocarbons
March 2013 Positions

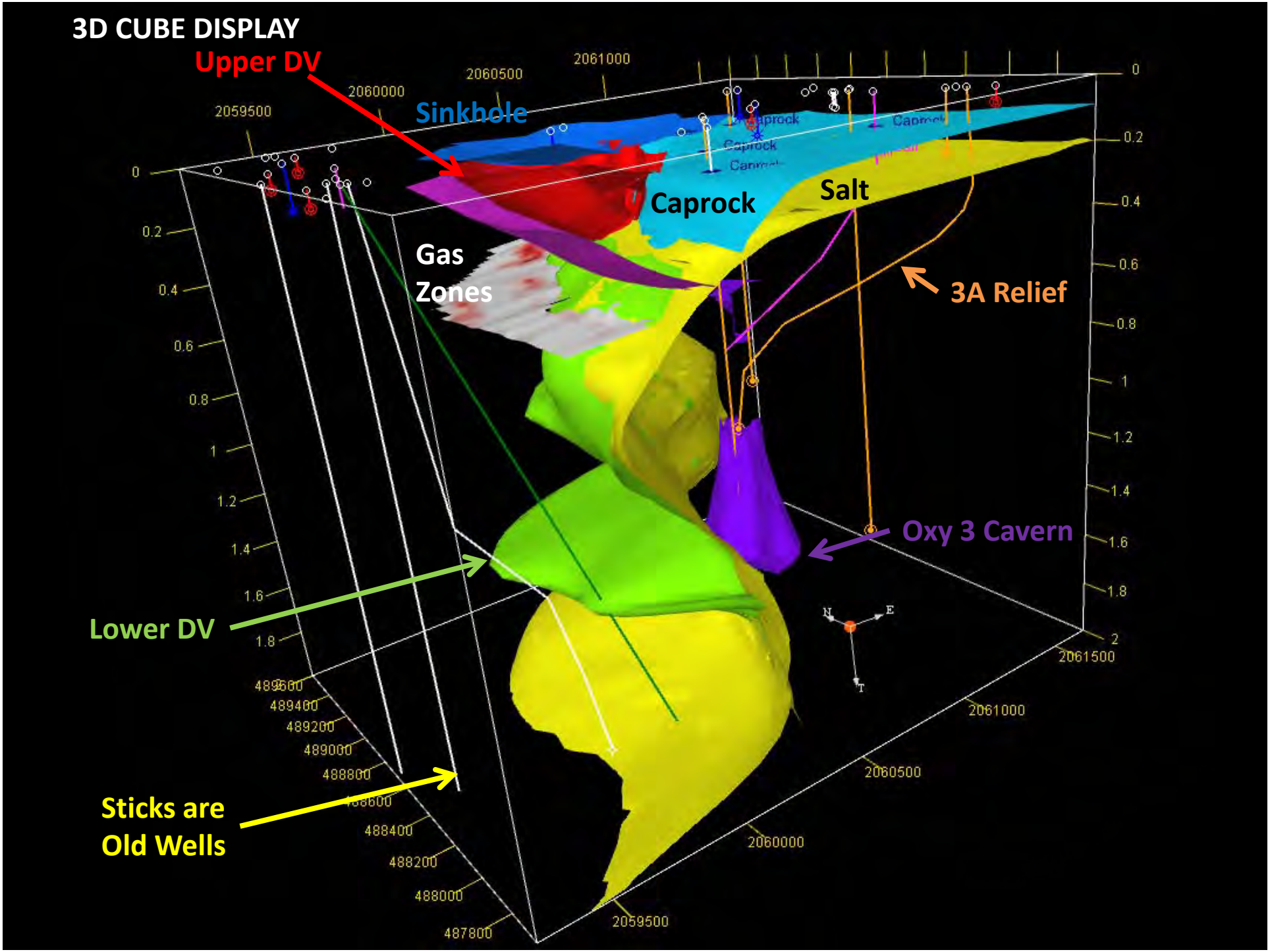
Near 1450’ Gas



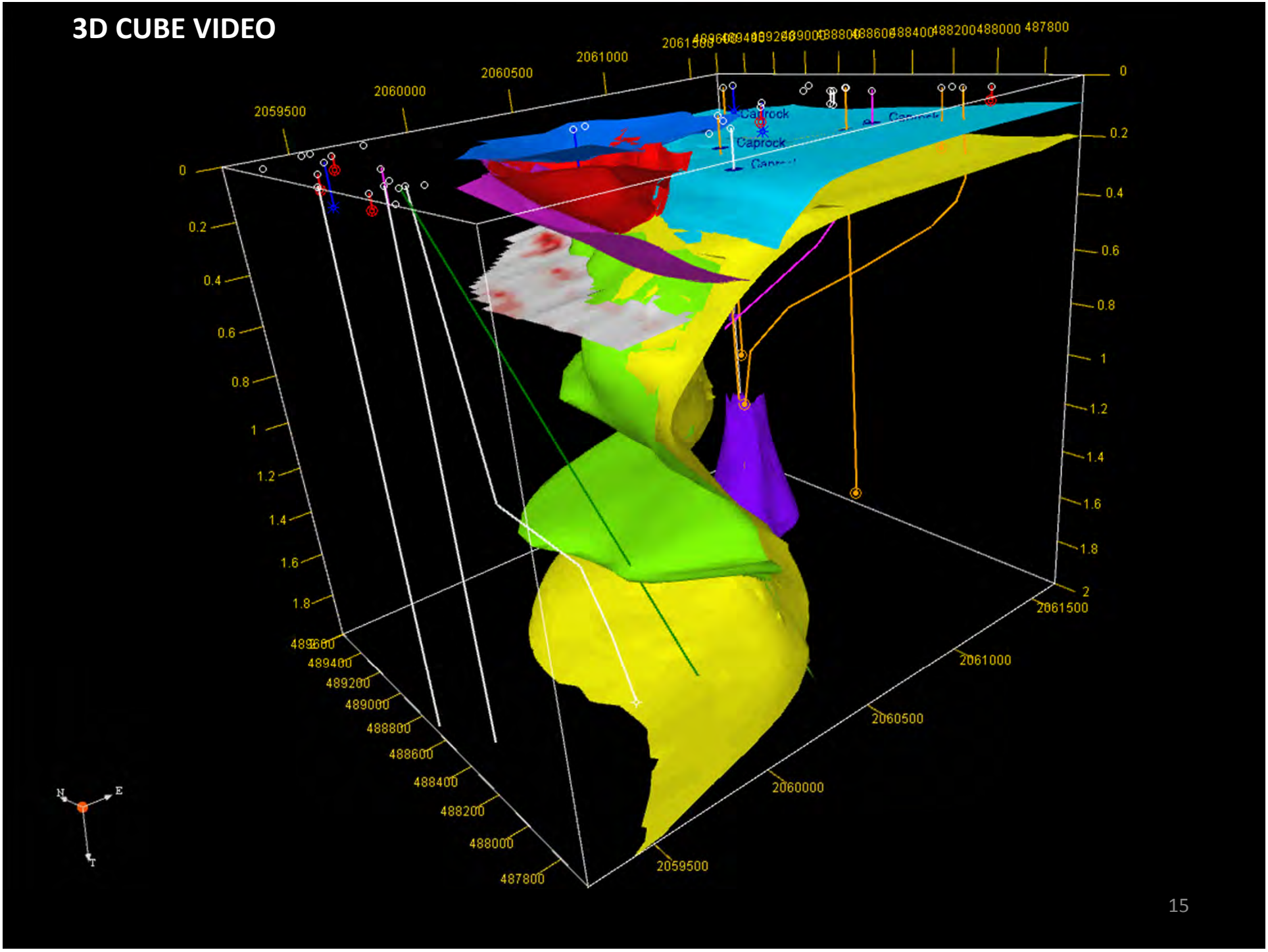
1450’ Fluid Substitution Models

1D & 2D Fluid Substitution Model using Patrick Petroleum Dugas & LeBlanc #1

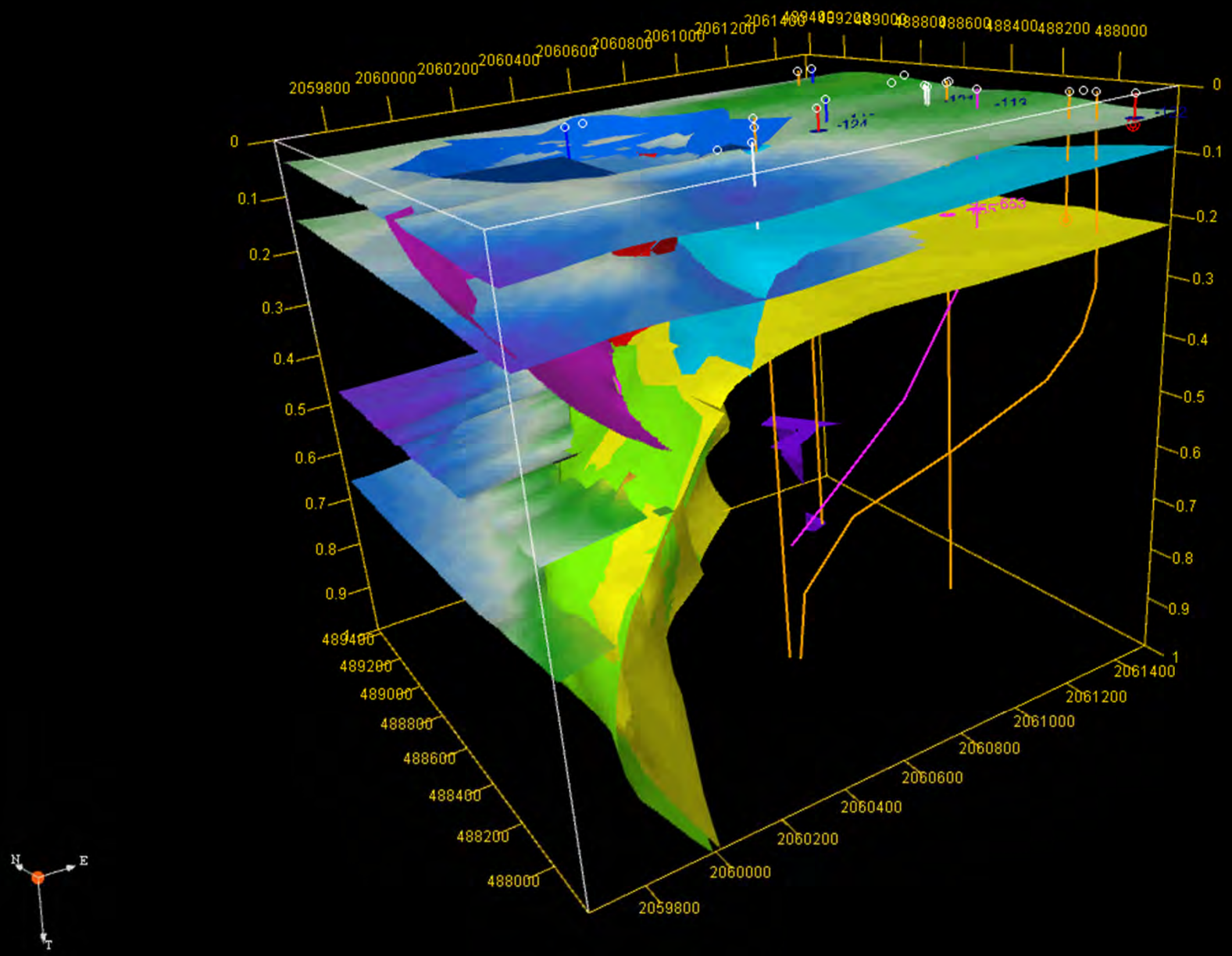



3D CUBE DISPLAY
Upper DV
Sinkhole
Caprock
Salt
Gas
Zones
3A Relief
Oxy 3 Cavern
Lower DV
Sticks are
Old Wells
2059500
2060000
2060500
2061000
2061500
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
489600
489400
489200
489000
488800
488600
488400
488200
488000
487800
N
E
T

3D CUBE VIDEO



UPPER 3000’ OF THE 3D CUBE VIDEO WITH KEY SEDIMENTARY LAYERS (HORIZONS)

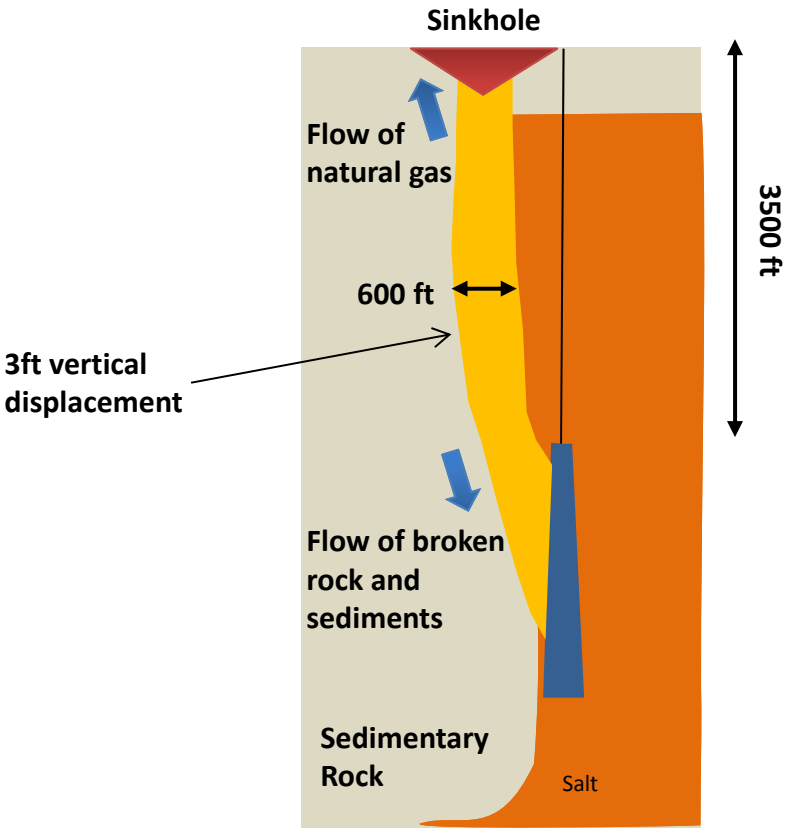


Stability Update

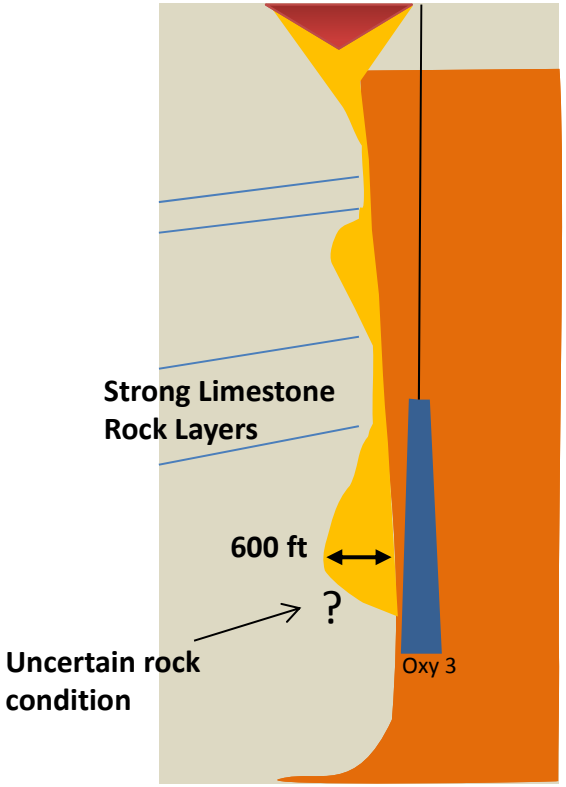
Will Pettitt, Ph.D.

	What we thought at the start of 2013	What we think now based on knowledge gained	Future uncertainty and knowledge to gain – input being provided by BRC
DRZ shape and size	• Known material properties predicted a smooth banana shape to surface. 3 ft vertical displacement at 600 ft from salt.	• More complicated DRZ caused by geological structure – funnel shaped upper DRZ to 1200 ft depth with pinching of lower DRZ. • Consistent with mechanics in models.	• Uncertain structure of lower DRZ and condition of rock? • Essential to understand DRZ accurately as it drives the sinkhole, subsidence and gas.
Sinkhole Size	• Original estimate of sinkhole size is a maximum of 1500 ft circular diameter. Typical 25° angle of repose, 300 ft diameter DRZ, bulking to 1.3.	• Shape is an oval. Weak surface materials causing low angle of repose and bulking factor - meaning increased size.	• Final stable angle of repose? • Contribution of DRZ and bulking? • Salt dissolution around collapsed Oxy 3 wall – volume of salt in collapse?
Cavern Fill	• >85% with solid material.	• Consolidating mud in upper section with more solid plug beneath.	• Material settlement and densification? • Effect of mixing is to reduce bulking?
Salt Dome Stability	• Unknown stability of Oxy 3 cavern and effect on surrounding salt and caverns.	• Models predict minor effects in cavern walls and above Oxy 3. • No indication of instability in Oxy 1. • Shallow seismic array shows activity in and around salt cap rock.	• Salt structure could give uncertainty in predictions? • Behavior of the cap rock? • Microseismic array being installed to help image stability around deep caverns.

DRZ Shape and Size



Geomechanical Model



DNR/Don 3D Seismic

To Scale

Consistent with model but broader base and pinching of DRZ at strong layers

ITASCA™

Conceptual Model – Mechanics of a "Burp"

Sinkhole pre August 21 event

Sinkhole post August 21 event

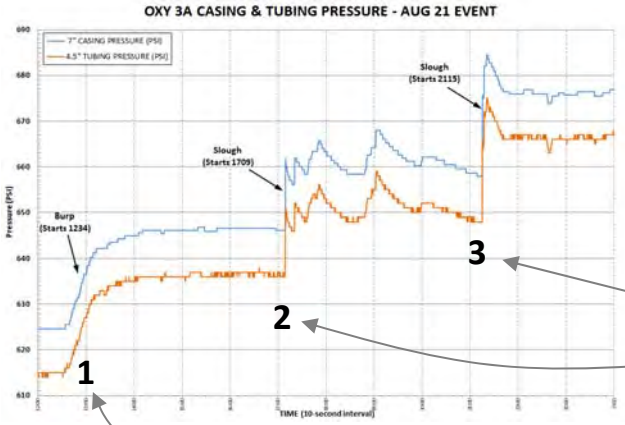
Soil debris and vegetation plug

Very loosely consolidated

Gas release (high amplitude VLP)

More highly consolidated but mobile DRZ

Monitored pressure in Oxy-3A



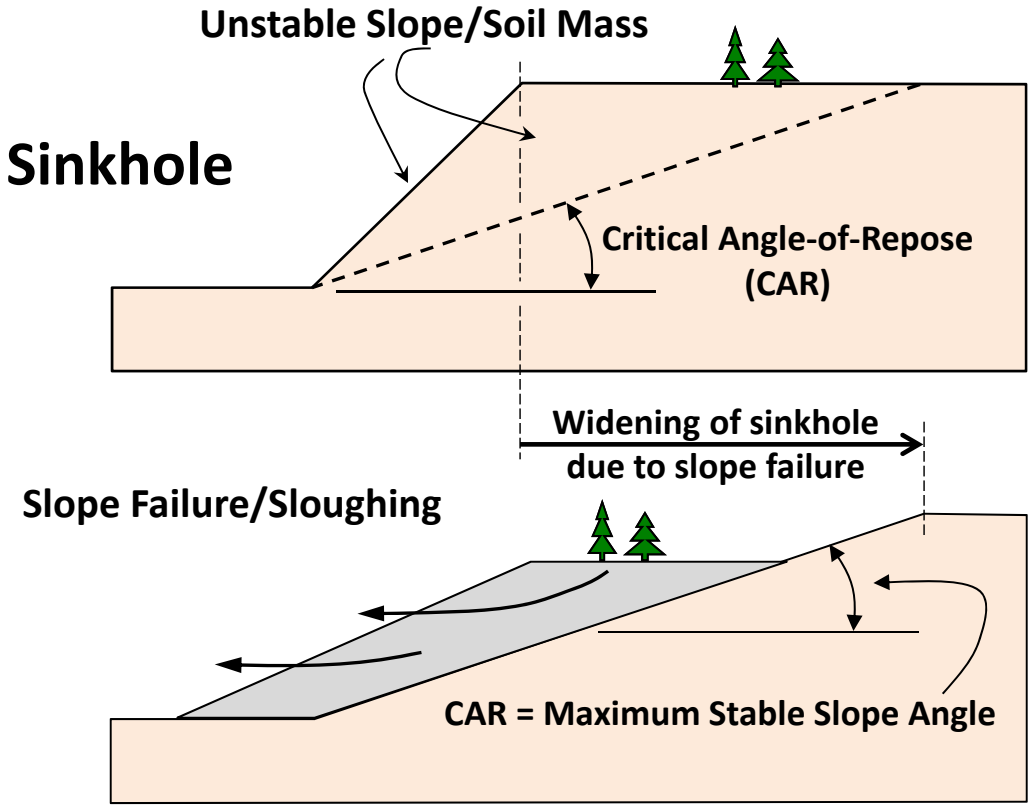
Three sinkhole sloughing episodes registered as pressure increase in Oxy-3A

Sloughing adding weight to the mobilized DRZ. The DRZ is connected to the cavern and debris plug. The plug acts as a piston pressurizing the cavern top brine.

ITASCA™

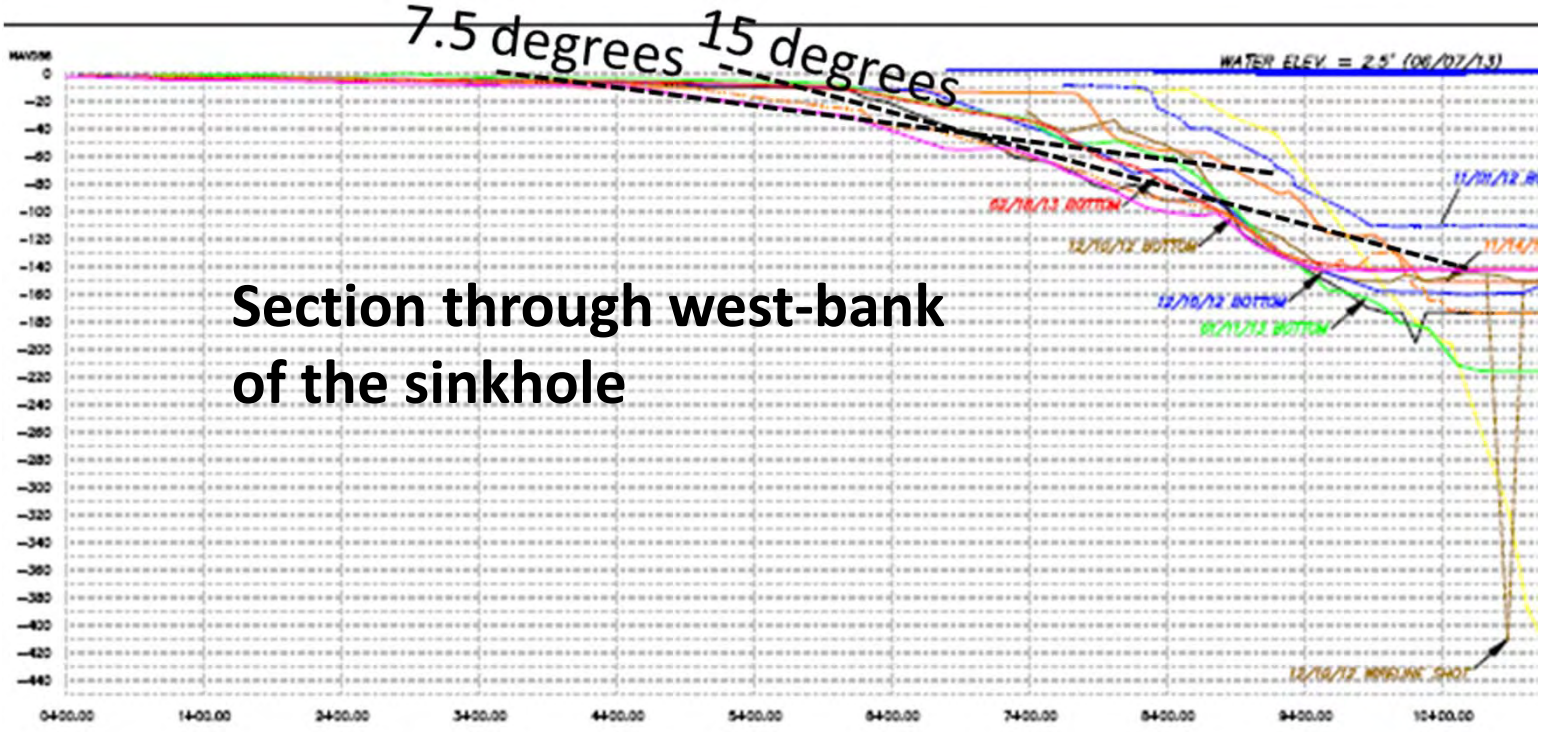
Critical Angle-of-Repose (CAR)

Critical Angle-of-Repose: A characteristic property of the soil strength

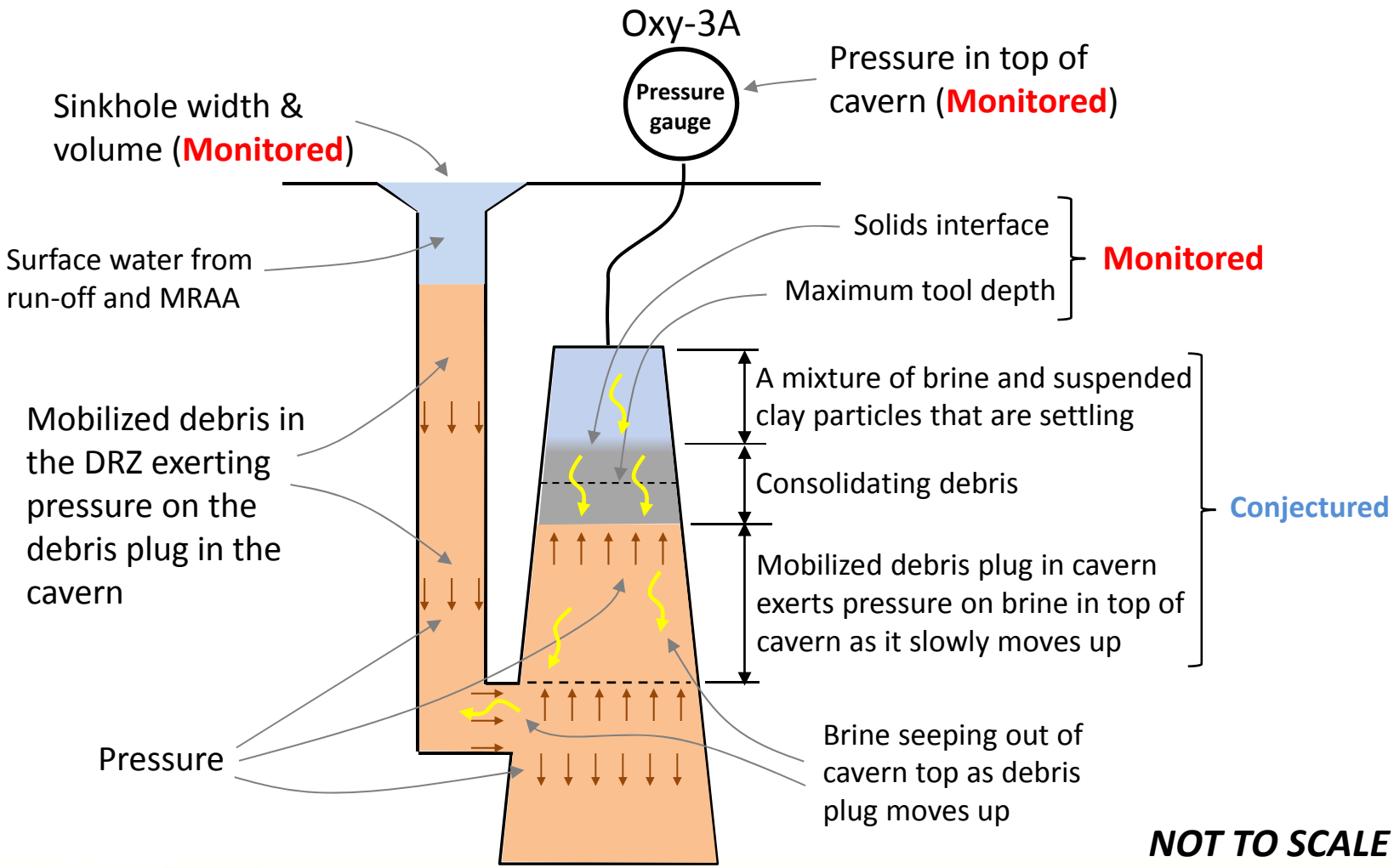


Estimated Critical Angle-of-Repose

7.5 degrees minimum CAR estimated from June 6, 2013
Miller Engineering and Associates sinkhole survey

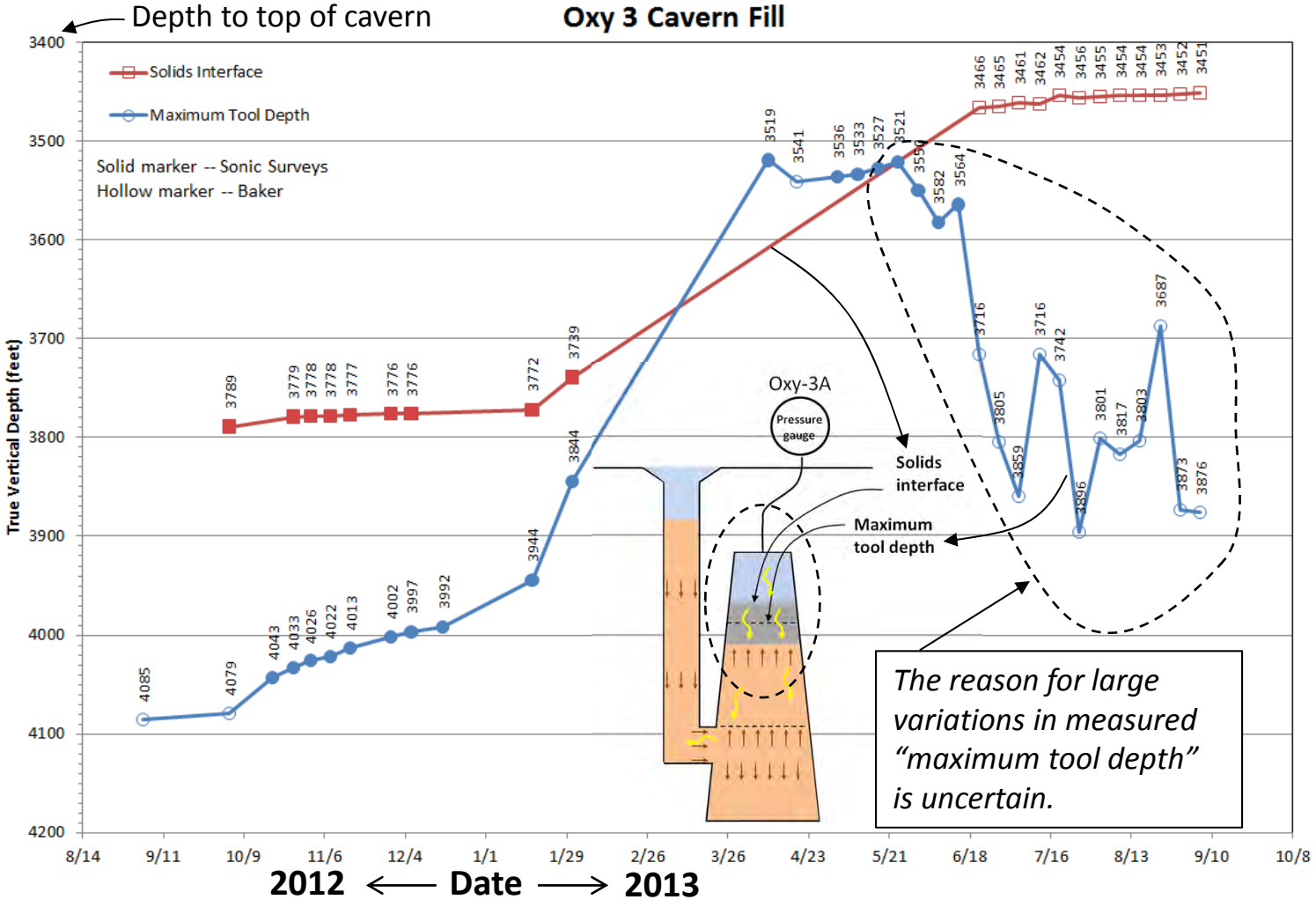


Current Sinkhole – DRZ – Cavern Connection



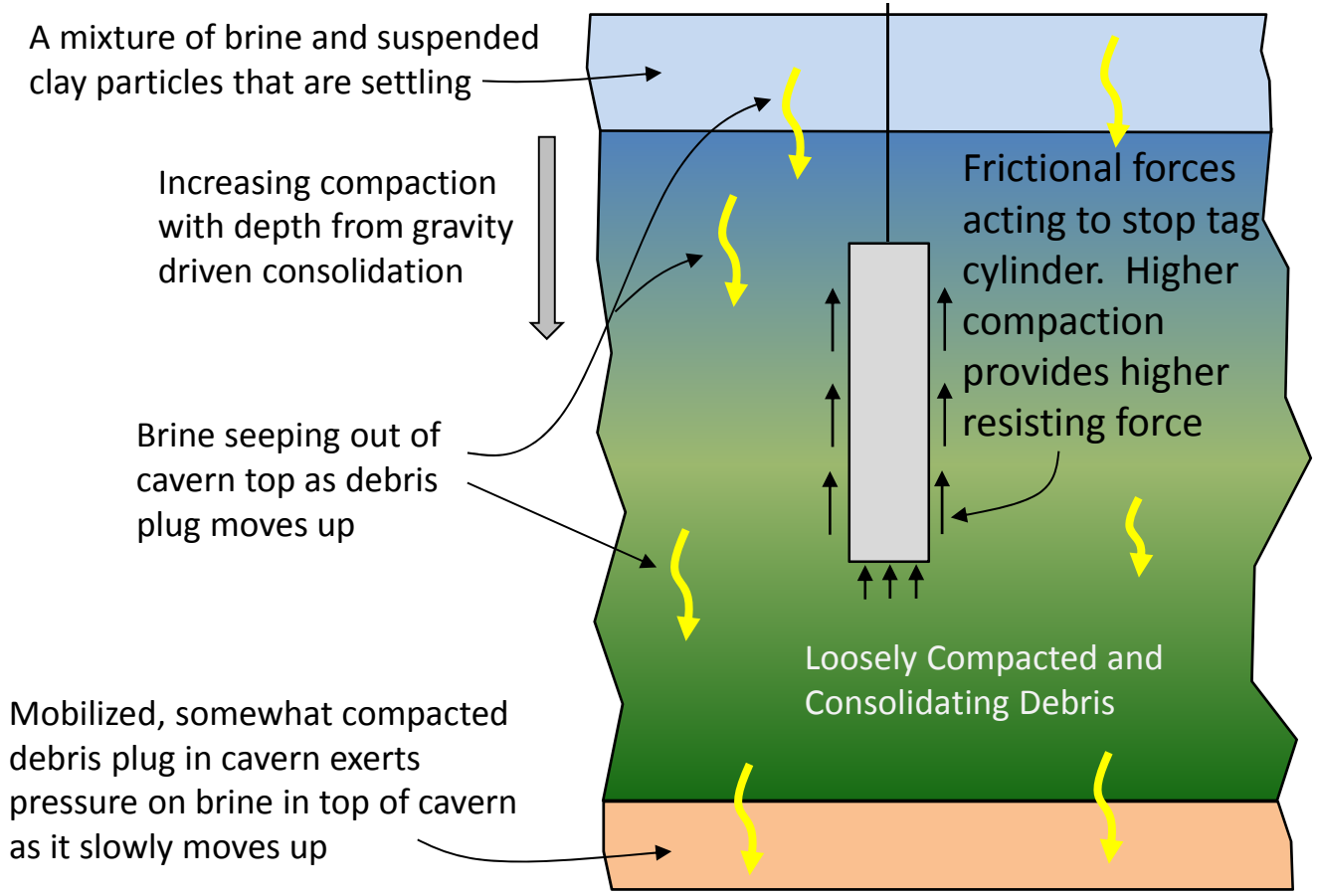
ITASCA™

Monitoring of Cavern Debris Floor



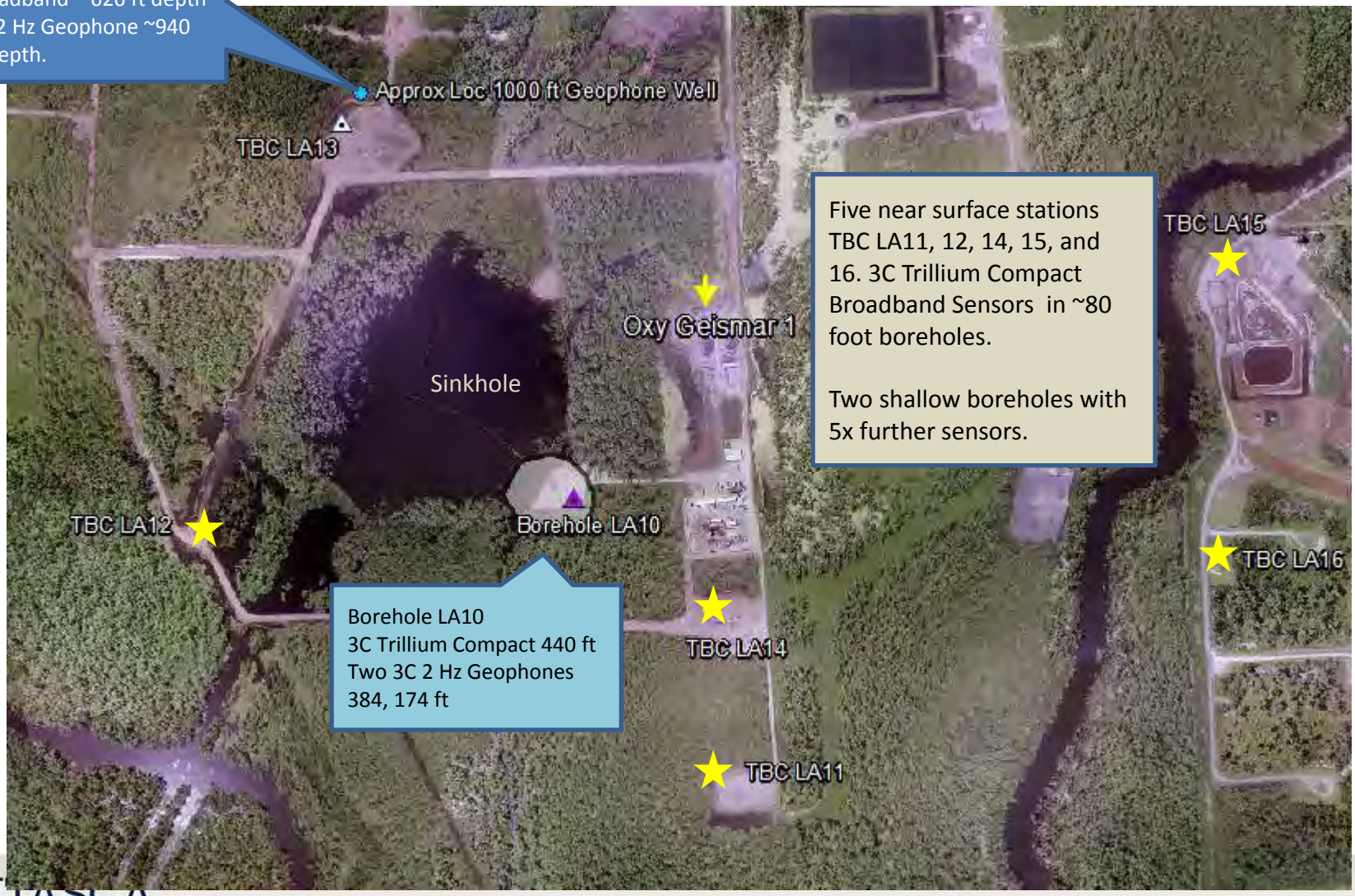
ITASCA™

Resistance to Tag movement in the Debris



TBC near-surface seismic array

LA17 1000 ft geophone well.
3C Trillium Compact Broadband ~626 ft depth
3C 2 Hz Geophone ~940 ft depth.



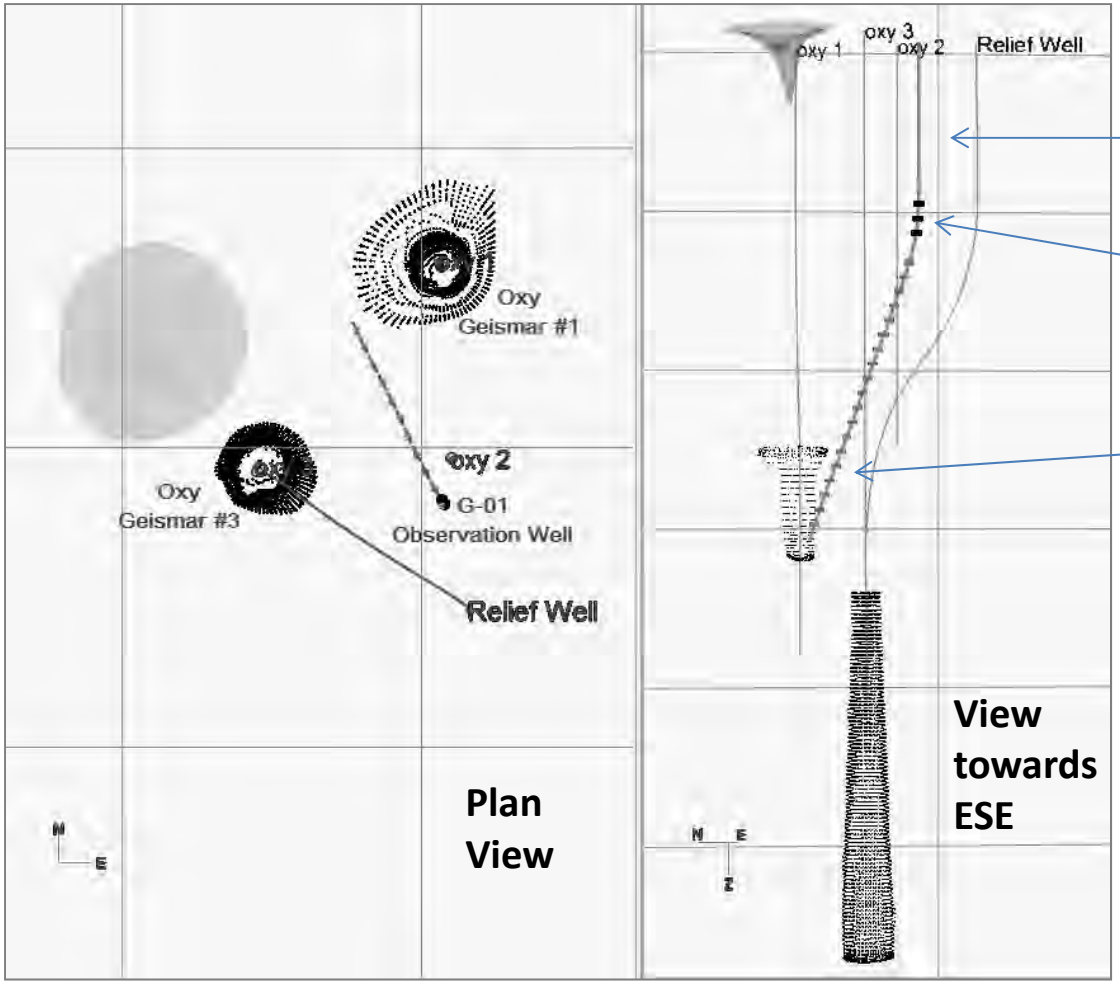
Five near surface stations TBC LA11, 12, 14, 15, and 16. 3C Trillium Compact Broadband Sensors in ~80 foot boreholes.

Two shallow boreholes with 5x further sensors.

Borehole LA10
3C Trillium Compact 440 ft
Two 3C 2 Hz Geophones
384, 174 ft

ITASCA

In-salt Microseismic Array



Approx. top of salt

3x 4.5 Hz geophones

19x 15 Hz geophones

3000 ft Depth

ITASCA™

Diagram from MEQ Inc. – Sep 2013

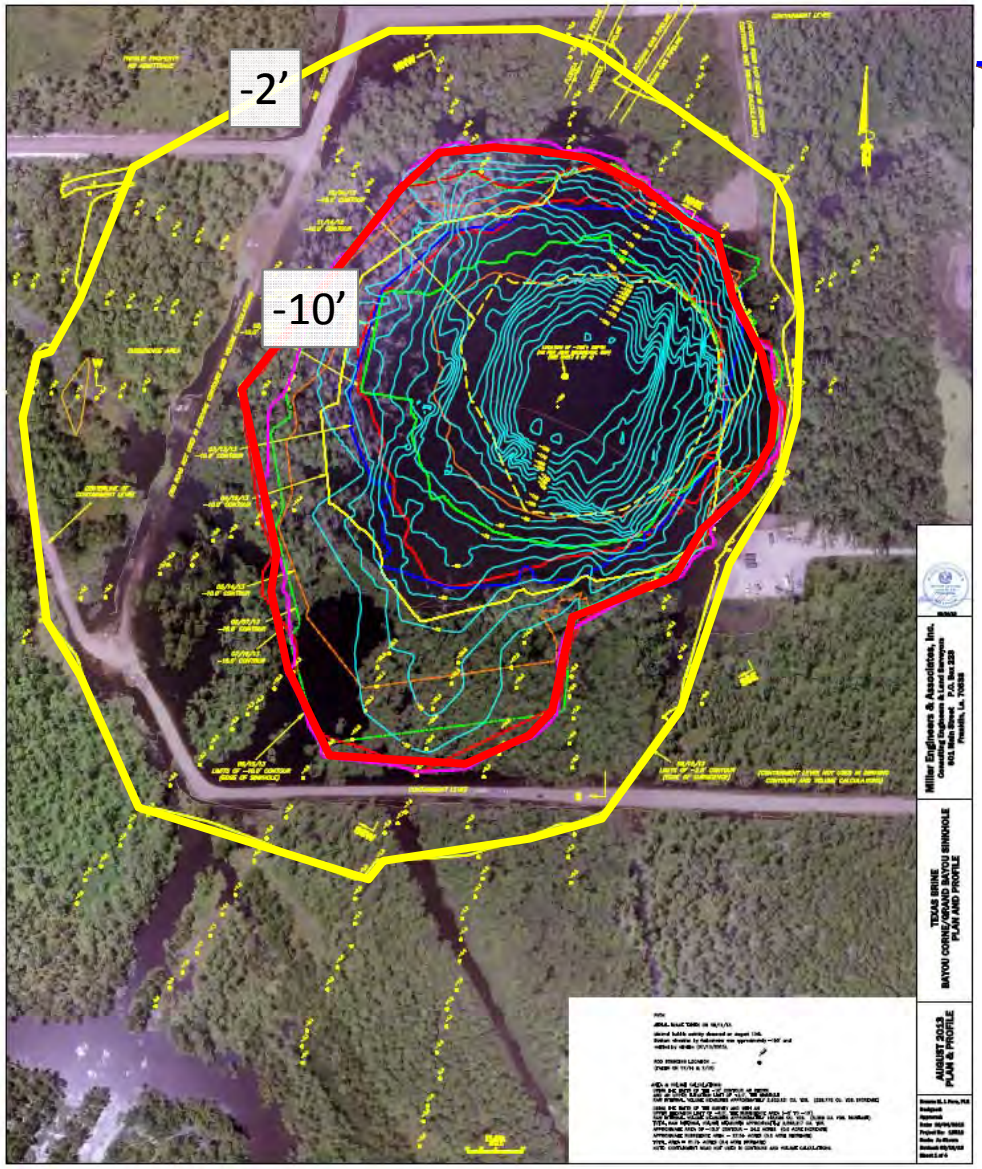
Long Term Seismic Monitoring

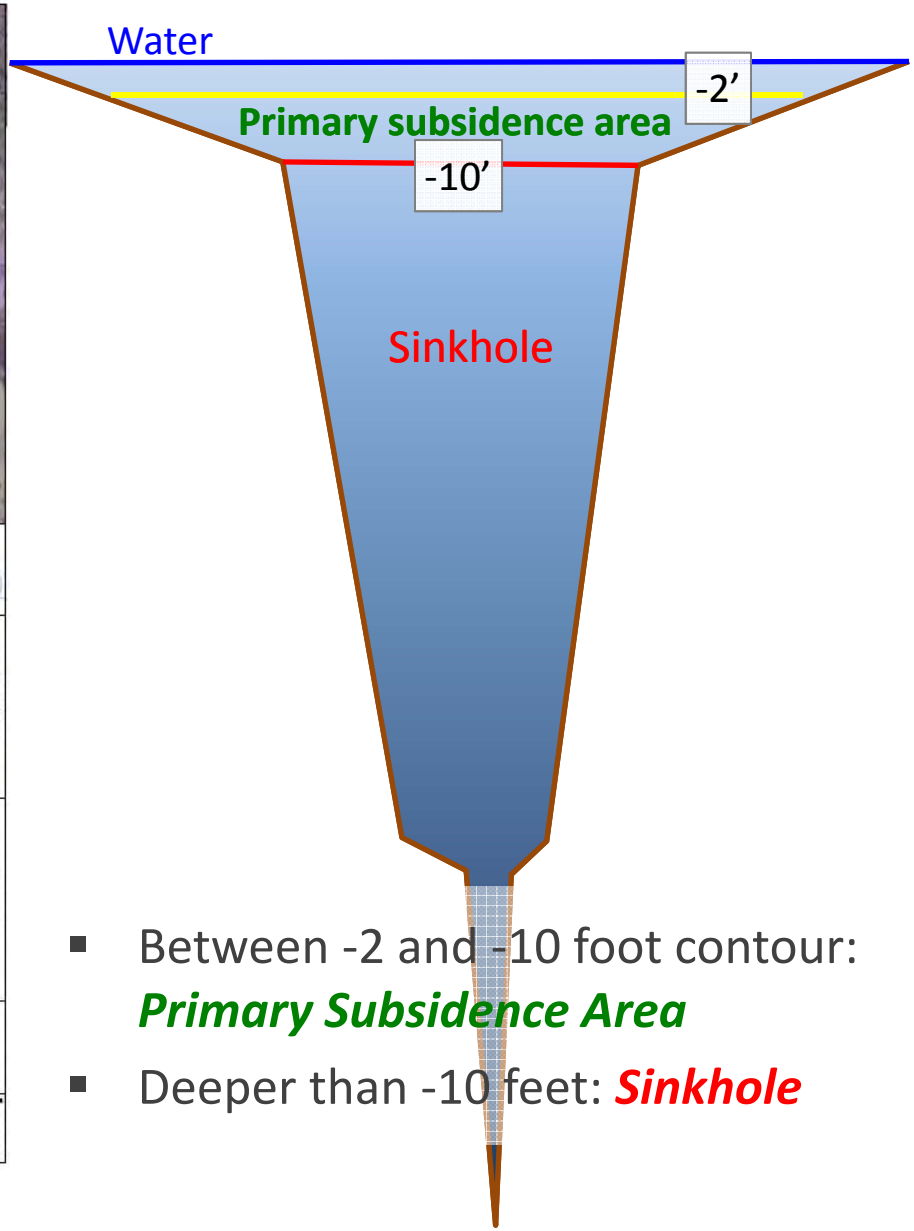
- What does it do for us?
  - We now have a capacity to observe rock disturbance around the caverns and DRZ.
  - We can observe progressive build up of activity leading to a sinkhole burp.
  - We are able to provide advice on the daily safety level.
  - We can observe progressive disturbance of the rock – and combine with numerical models to simulate long term behavior.
  - We can use this to assess stability and formulate further emergency response plans and monitoring if needed.
  - The measurements can provide feedback to our simulations and risk assessments on an ongoing basis.
- We are monitoring and responding…

Situational Update

Gary R. Hecox, Ph.D.

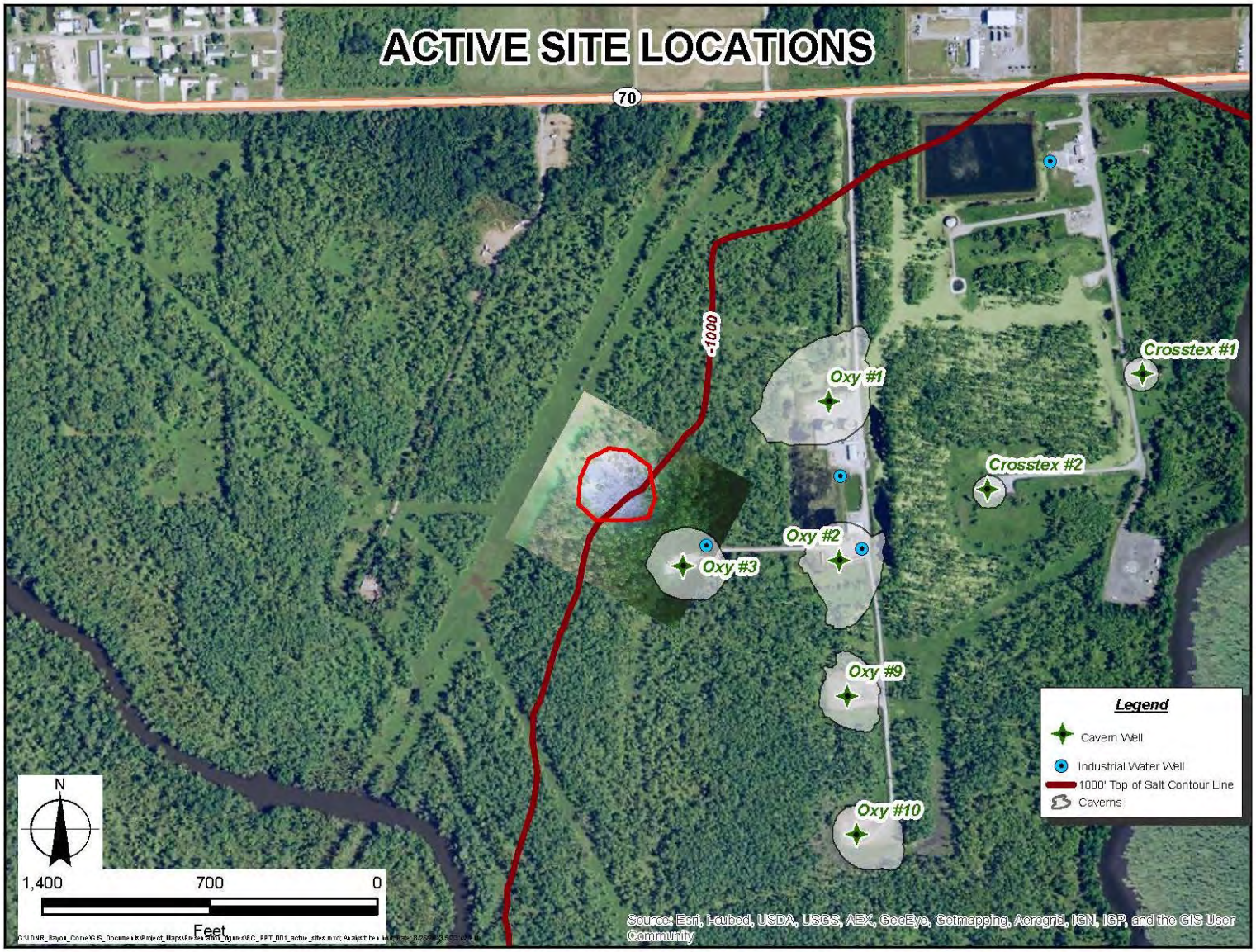
Sinkhole Nomenclature



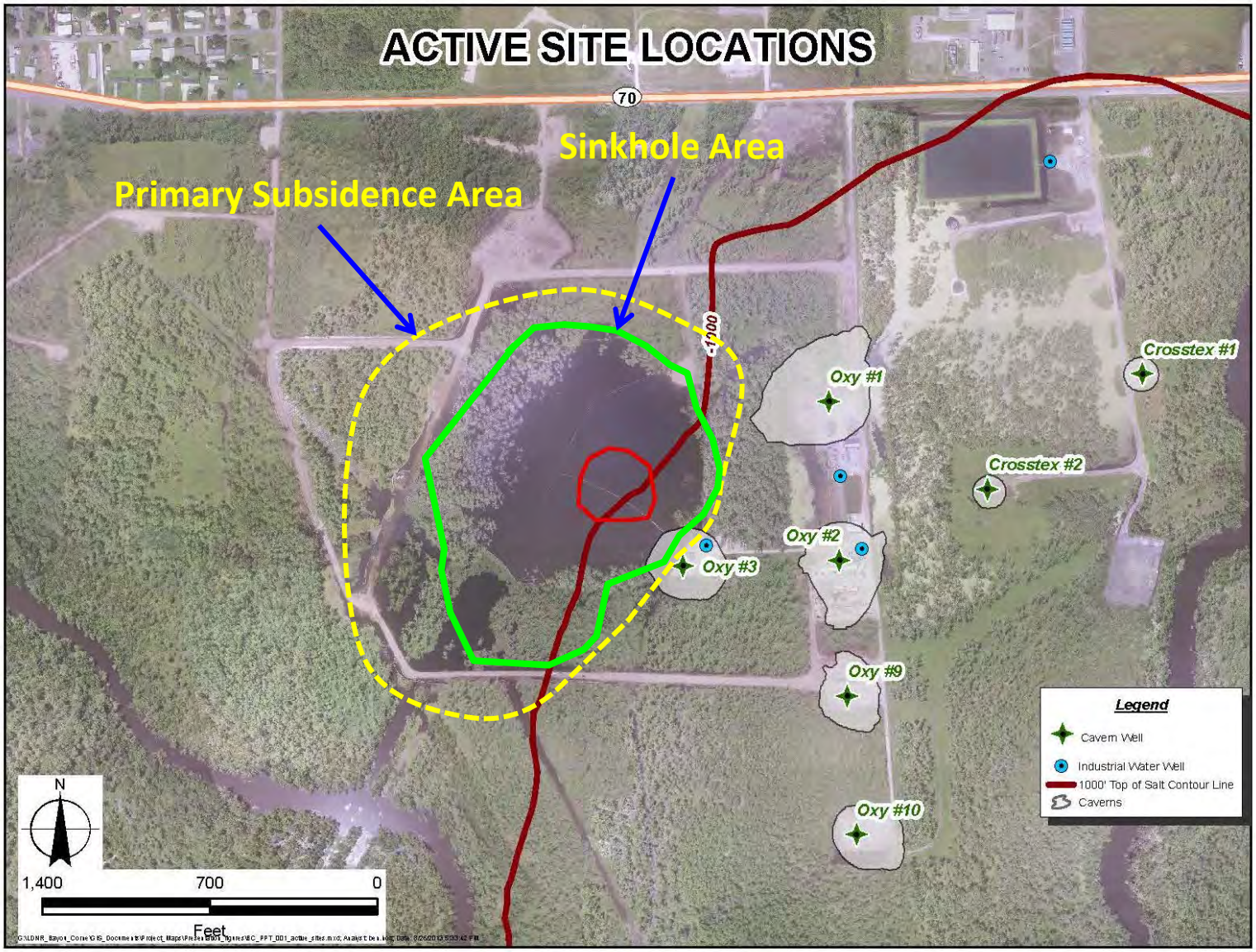


- Between -2 and -10 foot contour: ***Primary Subsidence Area***
- Deeper than -10 feet: ***Sinkhole***

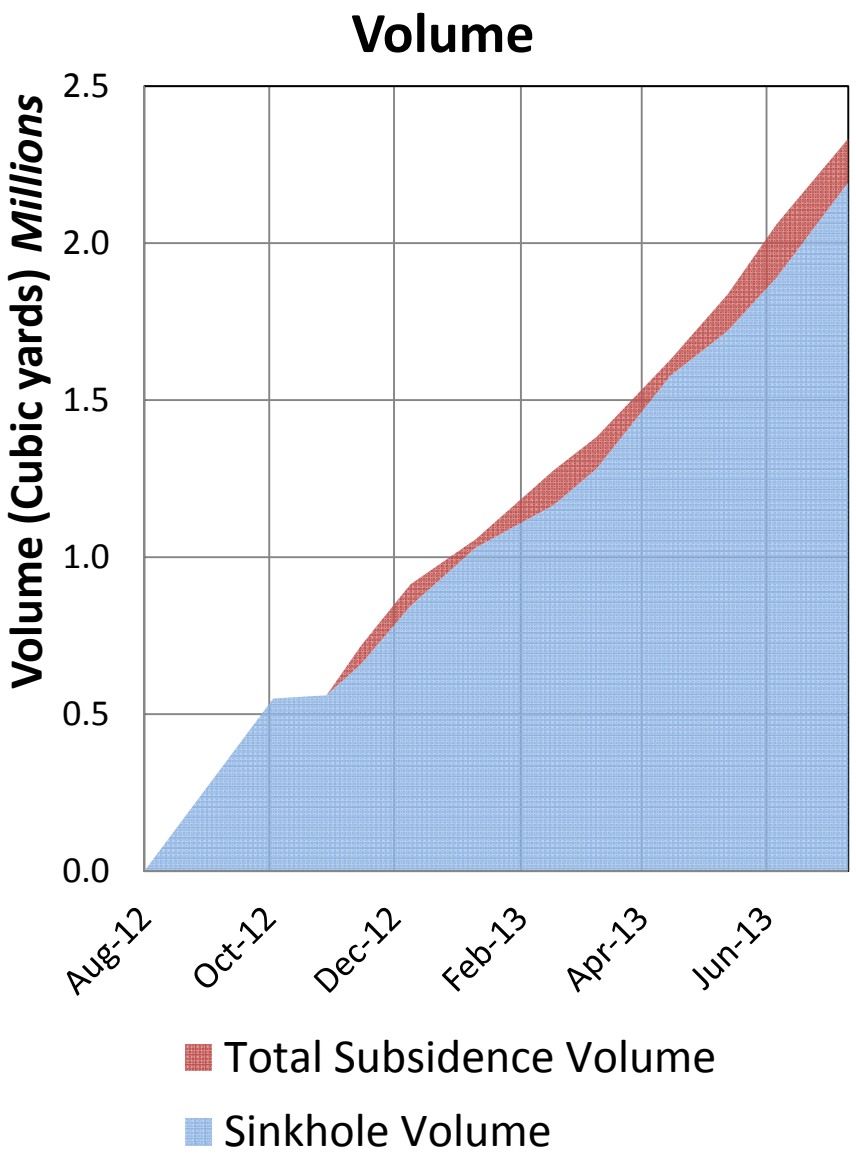
Sinkhole 2012/08/03

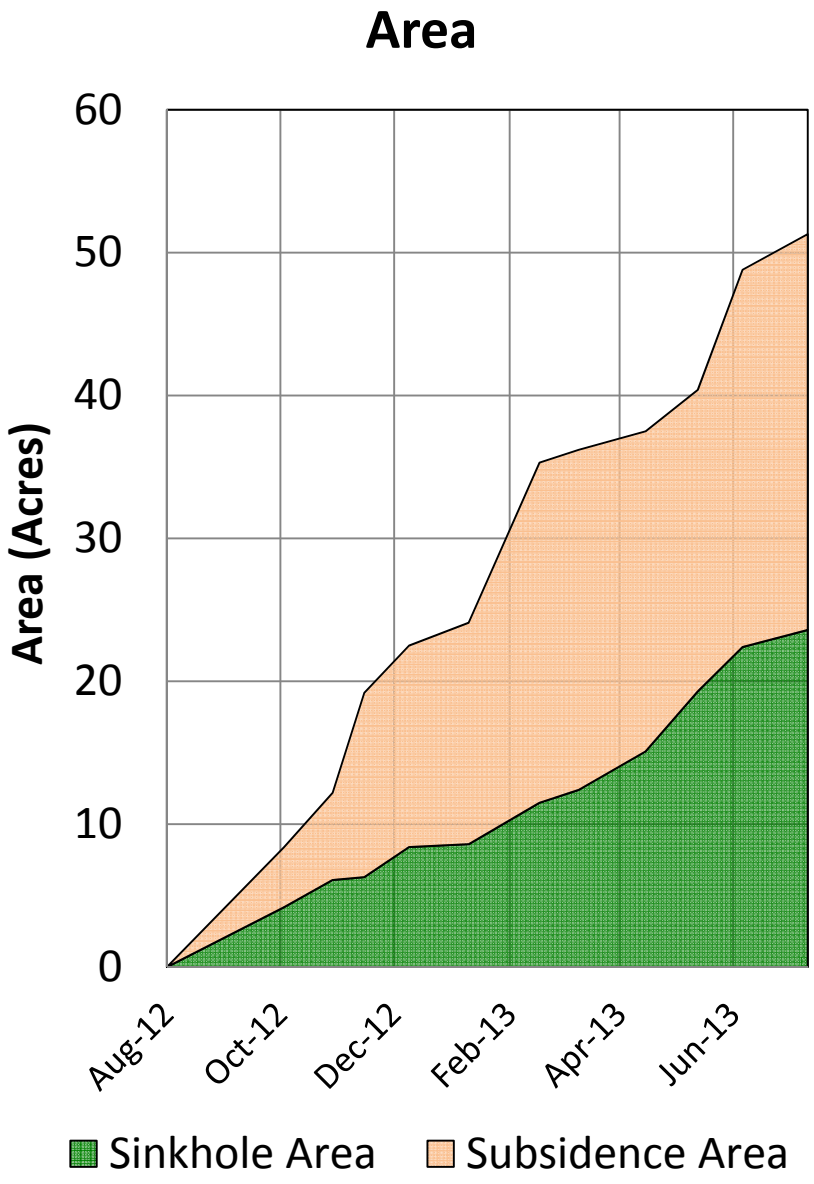


Sinkhole 2013/06/16

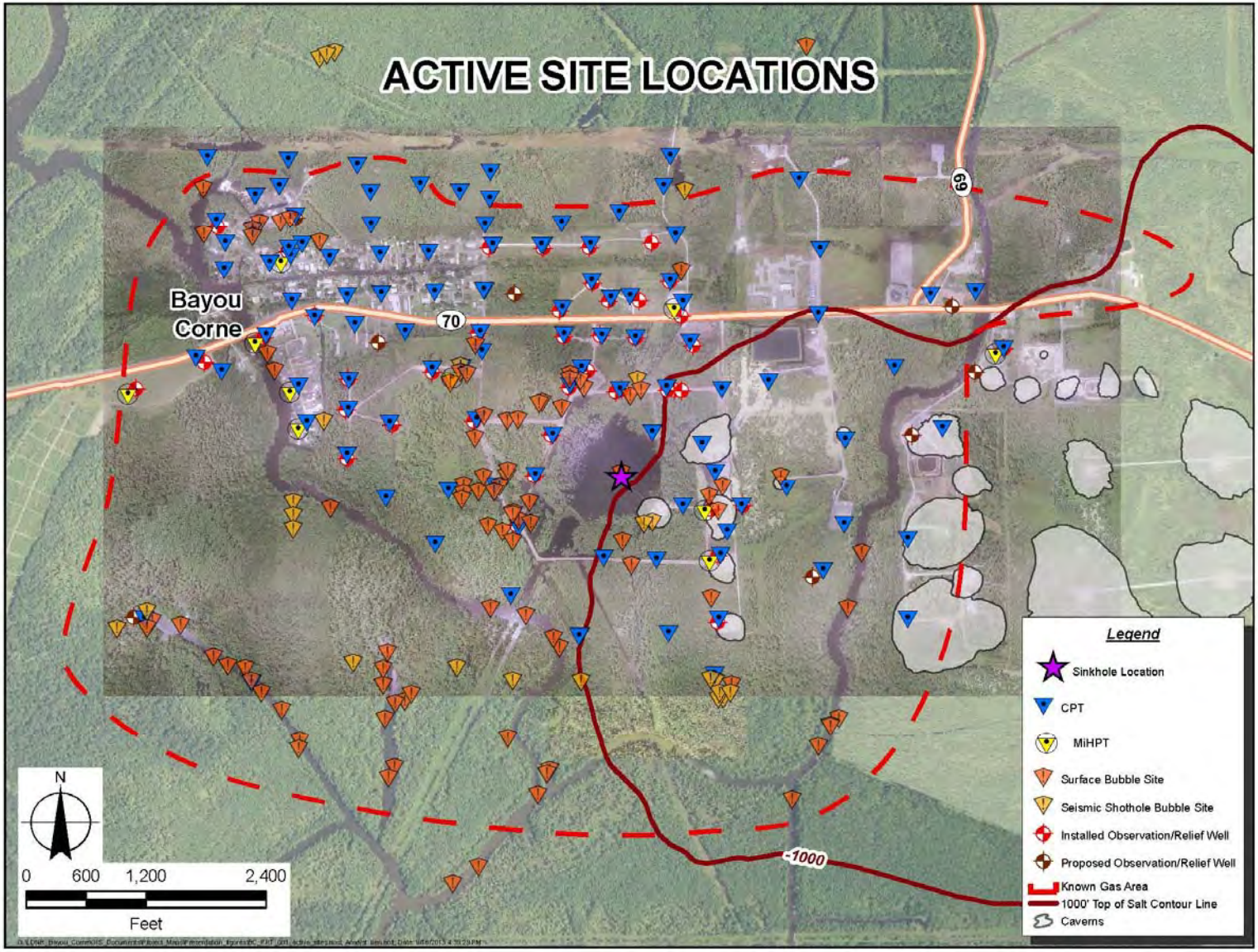


Sinkhole & Subsidence Area Volume and Area

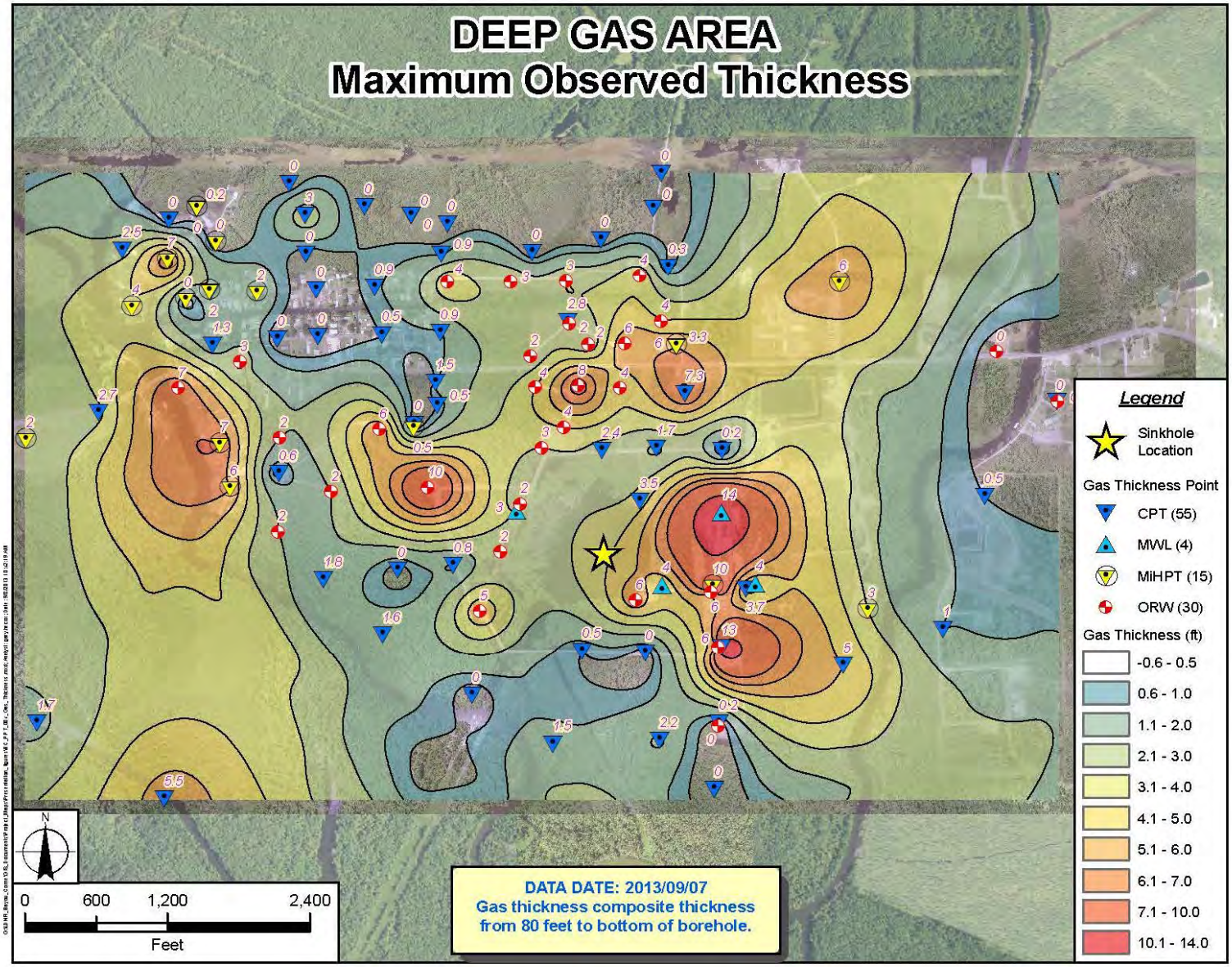




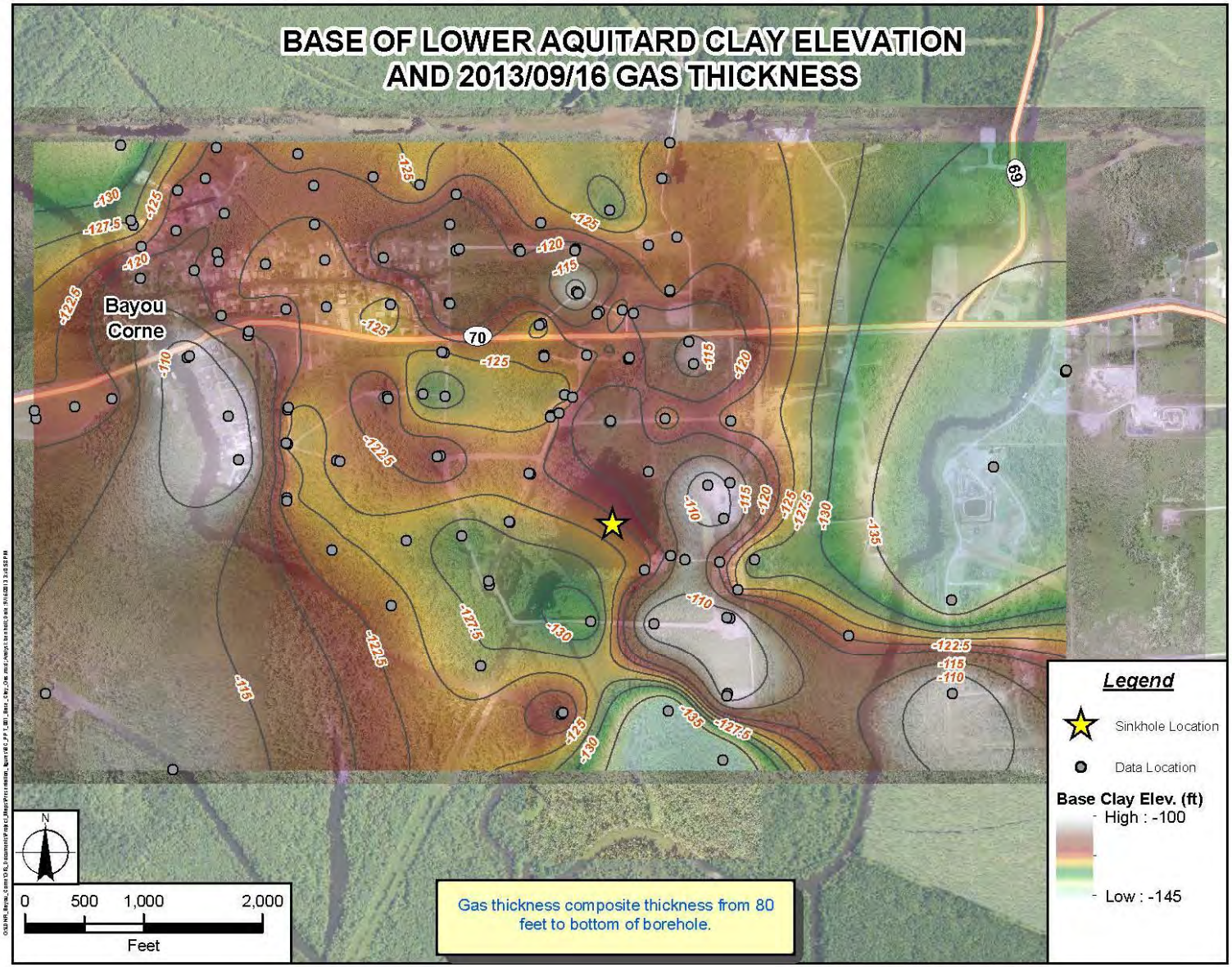
Active Sites



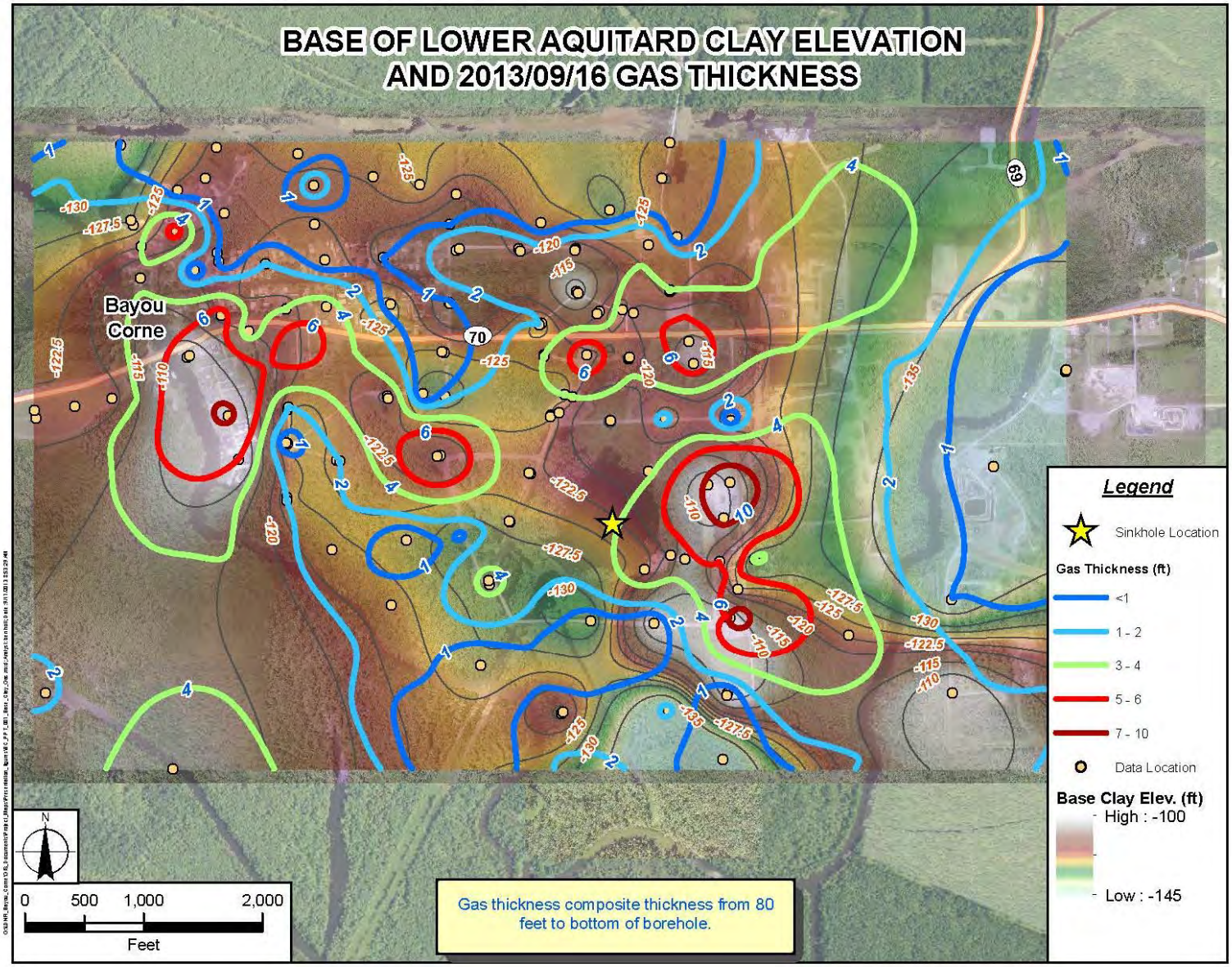
Deep Gas Distribution



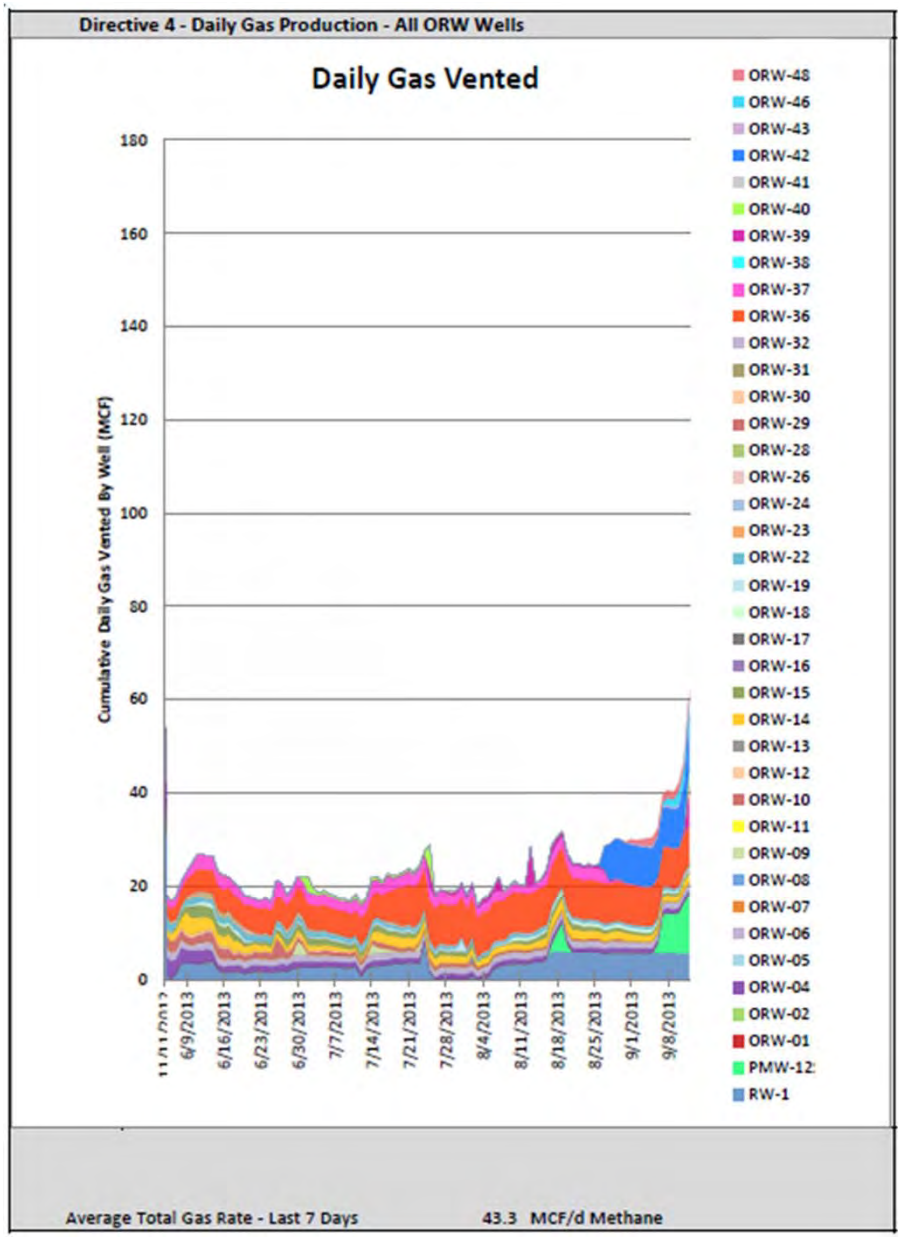
Max Gas Thickness and Base Clay Structure



Max Gas Thickness and Base Clay Structure



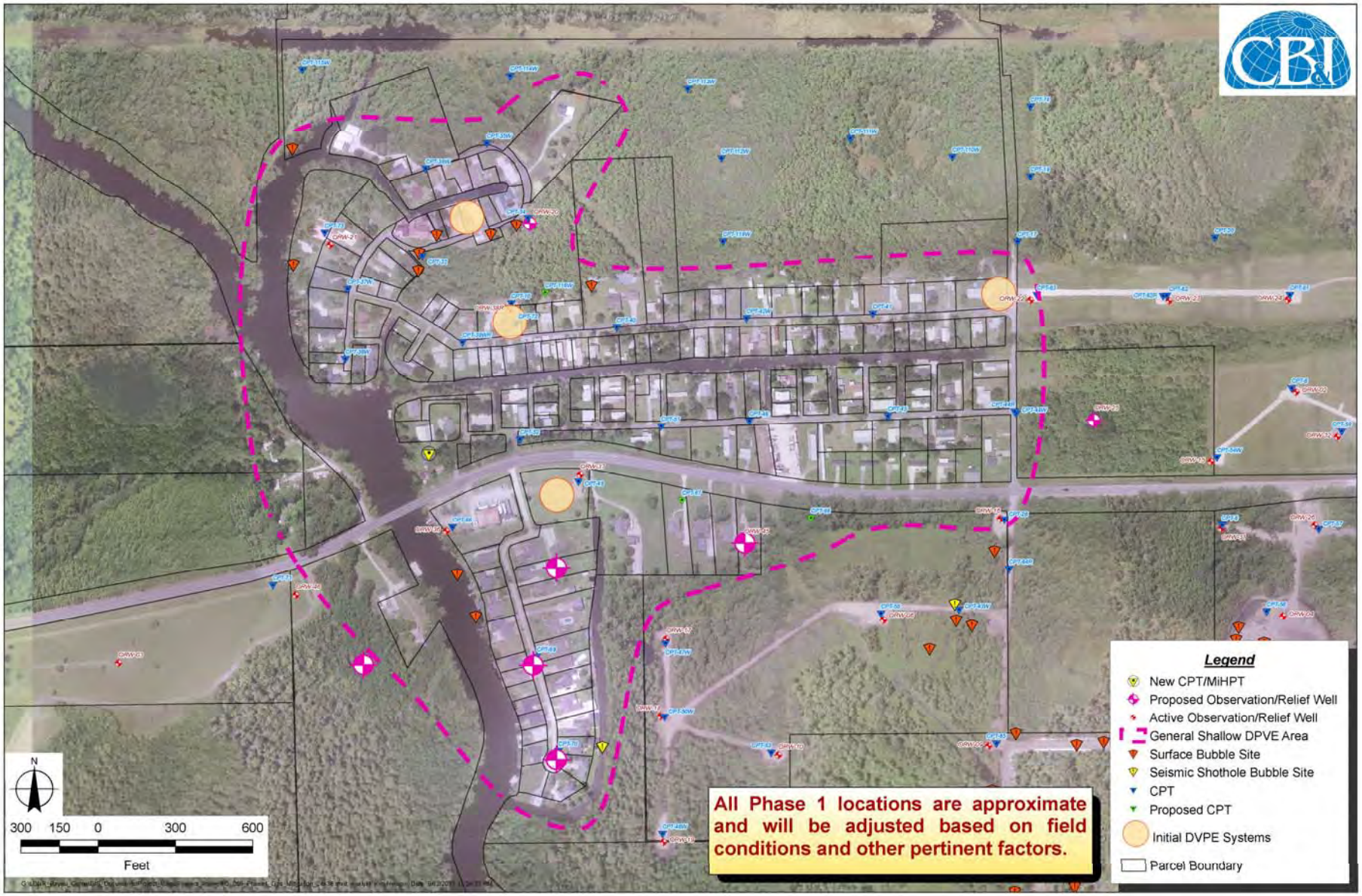
Daily Flare Total



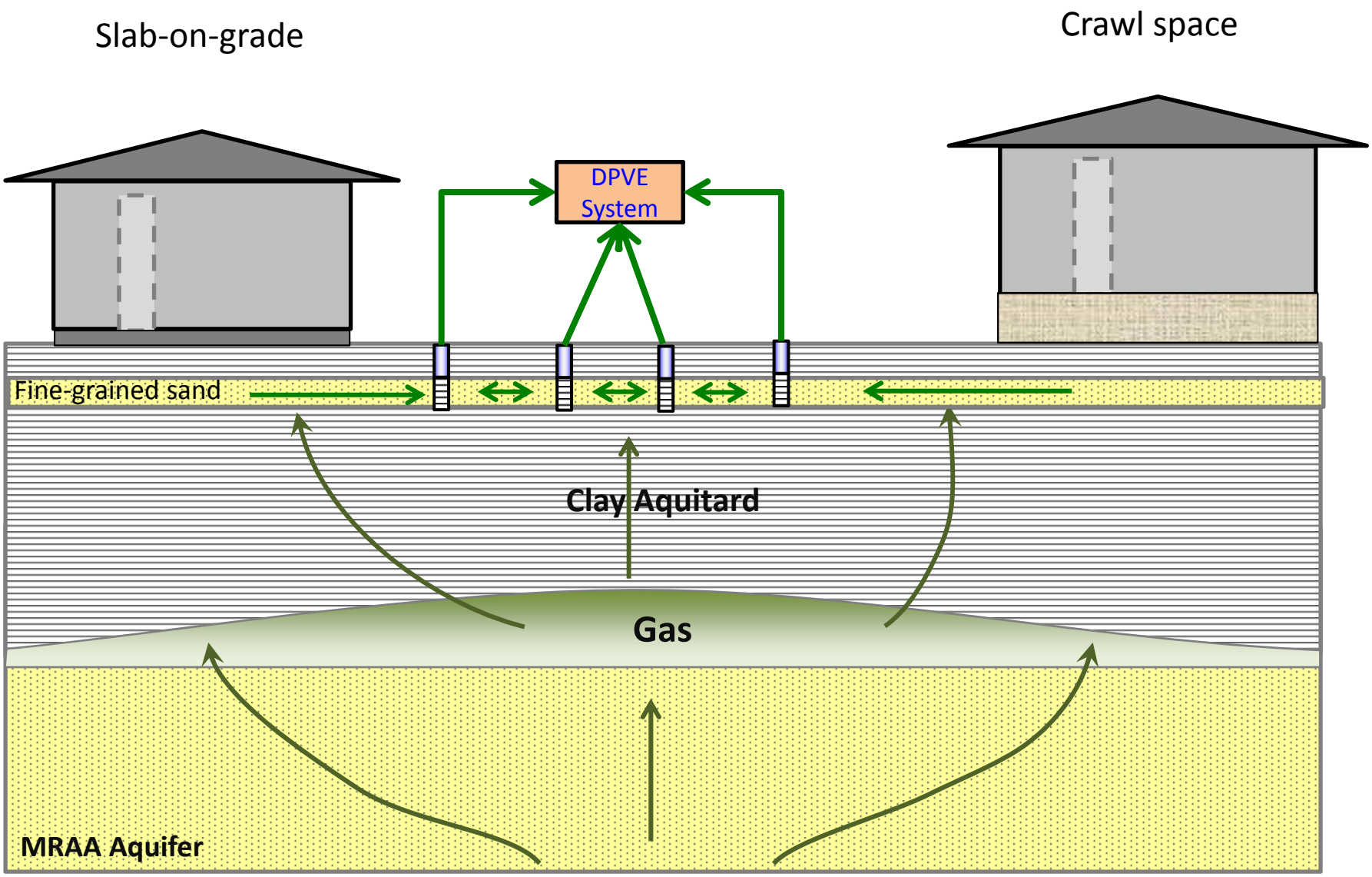
1. *Control shallow gas above the MRAA with dual-phase vapor extraction*

2. *Remove gas from MRAA using similar gas/water extraction*

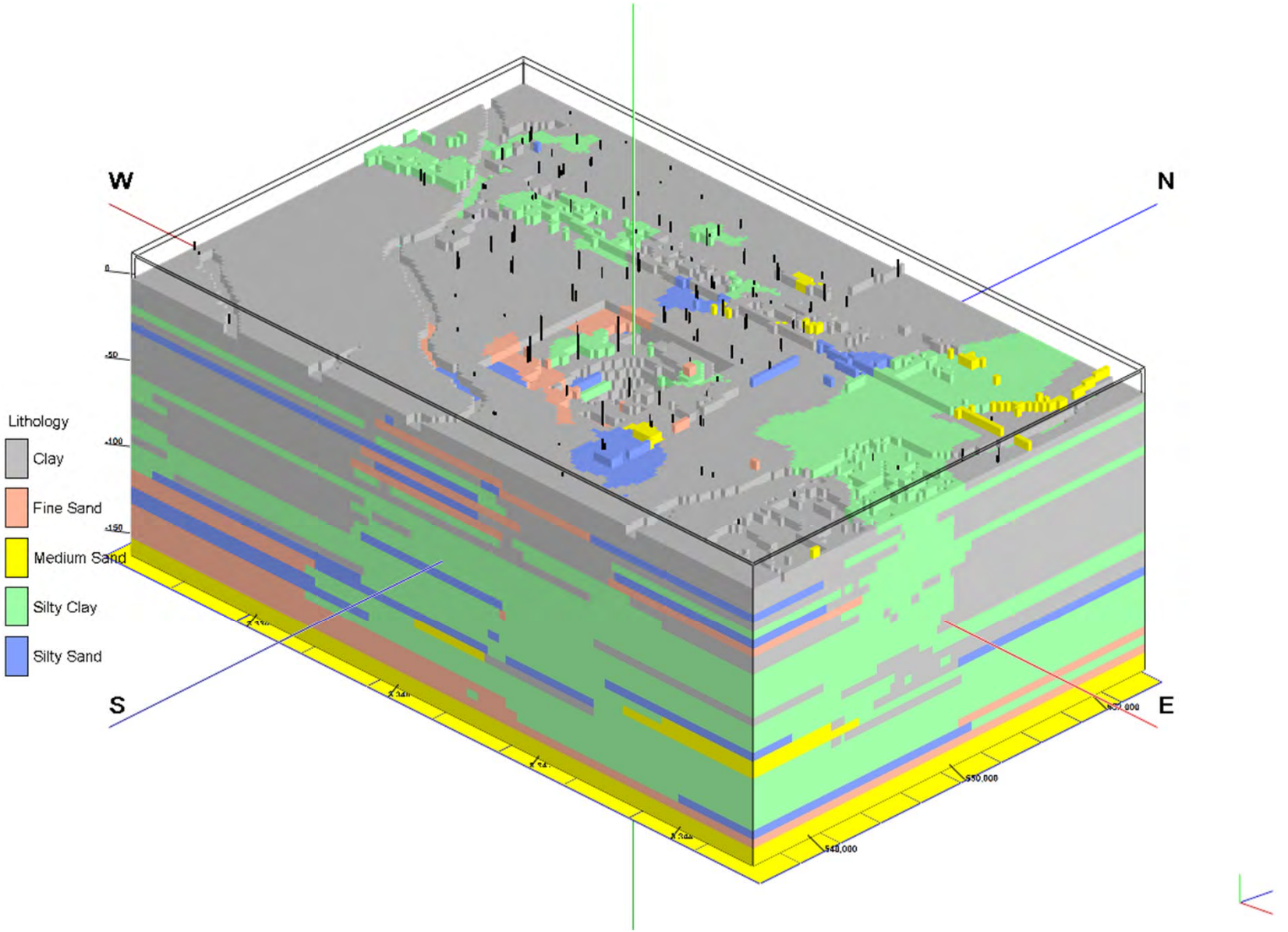
Gas Mitigation Program Initial Locations



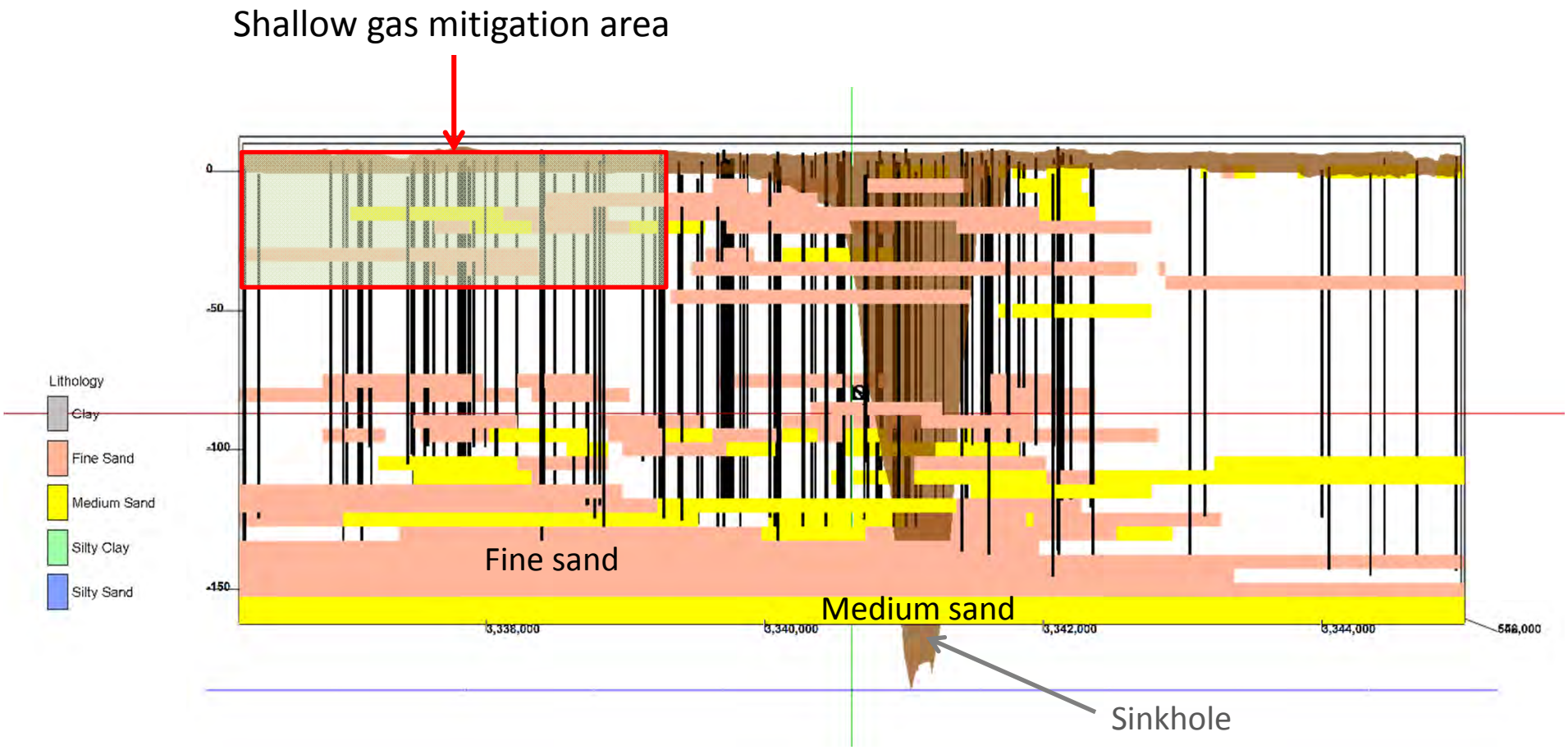
Dual-Phase Vapor Extraction System



3D Lithology Model of Site



Geology from South Looking North



Questions?


Bayou Corne
Community
Grand Bayou
Highway 70
Sinkhole
Bayou Corne