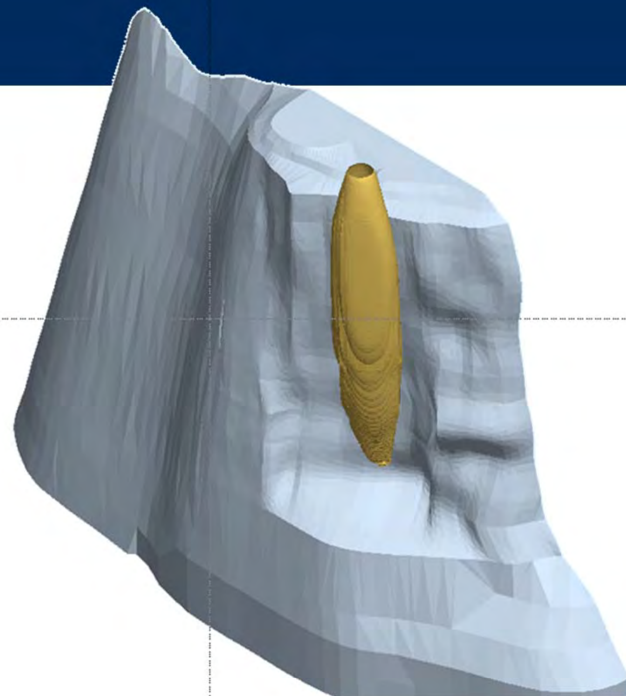


Blue Ribbon Commission Initial Technical Briefing

April 5, 2013

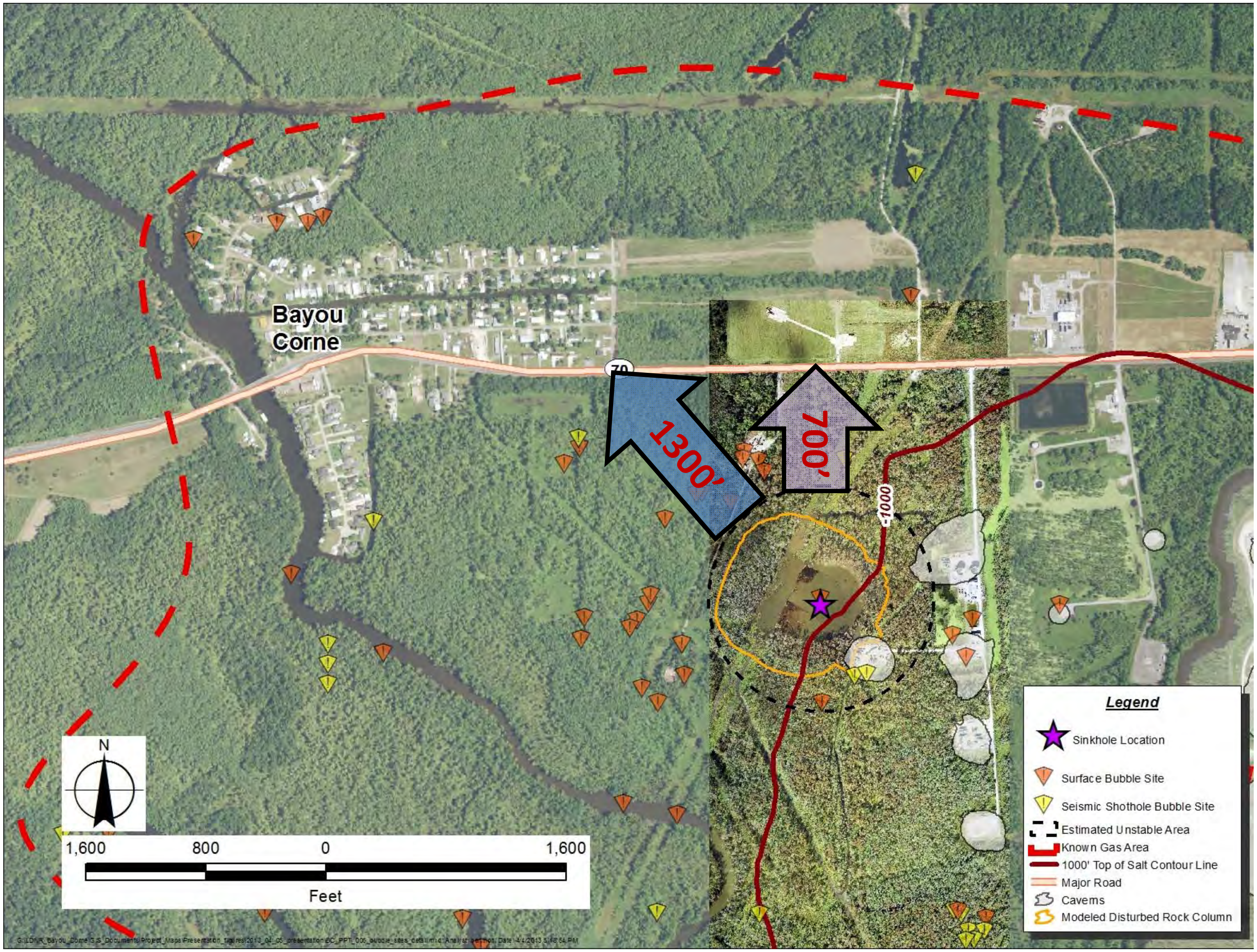
LSU

Why Are We Here?

Emergency Situation with Evacuation Order

- Residents been out of 150 homes since August 3, 2012
- 245 days, 35 weeks, 9 months

Bayou Corne Community



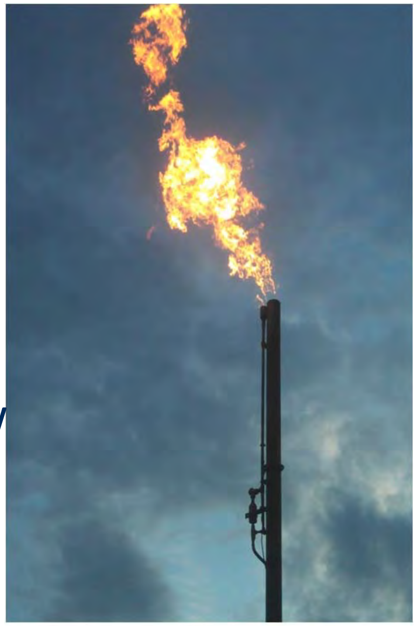
Major Issues to Address

1. Determine the amount of natural gas that may remain in the Mississippi River Alluvial Aquifer (MRAA) and shallow subsurface underlying the evacuation area to allow community members to safely return to the evacuation area.
2. Determine the current and future structural stability of the western edge of the Napoleonville Salt Dome with consideration of salt cavern operations and public safety.
3. Determine the stability and management of the sinkhole and underlying DRZ to protect public safety.

Commission Must Address Two Key Factors:

1. Establish appropriate remediation/monitoring benchmarks or conditions to ensure sustained public safety.
2. Define additional data needed to assess current conditions and define remediation/monitoring benchmarks.

Ongoing Remediation/Response Activities

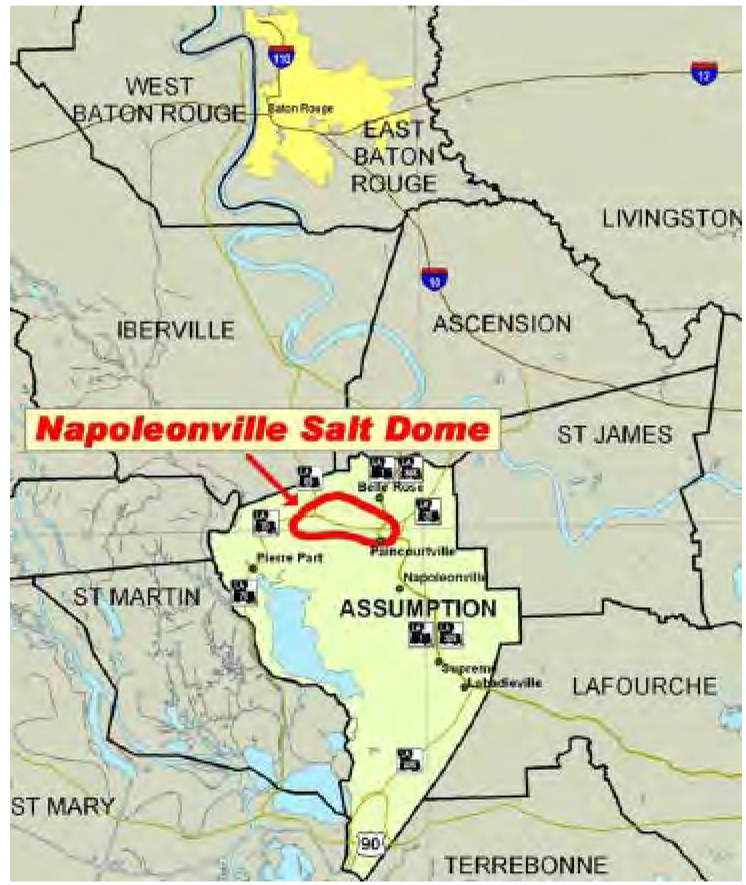


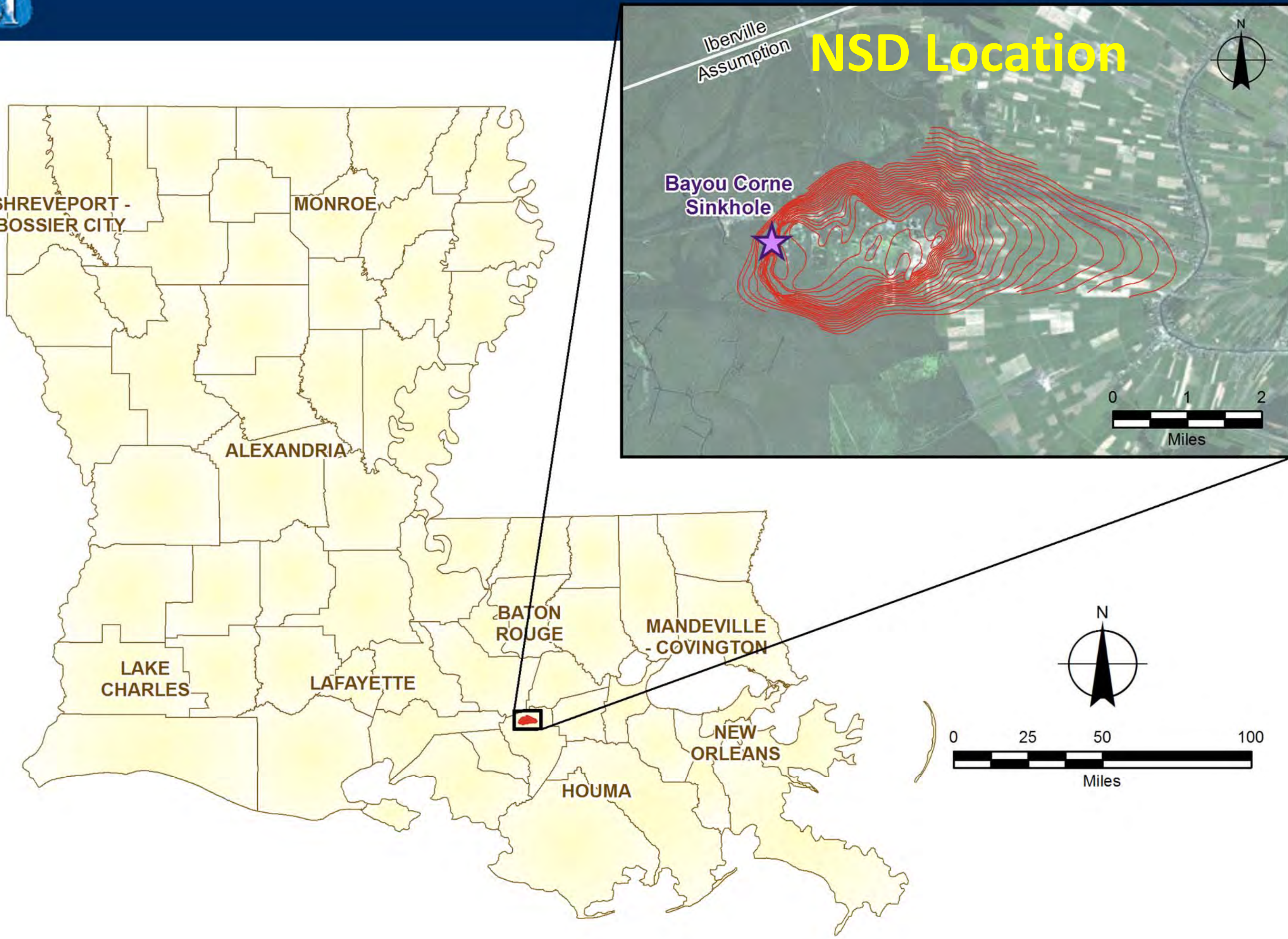
- Observation/Relief Wells
  - 30 installed, 16 flaring gas
  - 85-100 mcf/day
  - None installed in community to date
  - Studying feasibility of horizontal wells to vent gas below community
- Berm
  - Initial berm installed along estimated boundary of sinkhole
  - Work ongoing to make structure permanent
- Ongoing pressure monitoring in nearby caverns, seismic monitoring from surface arrays, 450-ft. subsurface array
- Home monitoring
  - 80 LEL/H2S monitor sets installed on 35 properties
  - Under-slab sampling beginning, some methane detected

Definitions and Acronyms

- 3D seismic—seismic investigative method used to image geologic formations, and gas and oil reservoirs in subsurface
- CB&I—formerly Shaw, Shaw purchased by CB&I on Feb. 13, 2013
- CERI—Center for Earthquake Research and Information @ Univ. Memphis
- DRZ—Disturbed Rock Zone, zone of fractured and broken rock adjacent to and above Oxy 3 cavern, also called collapse zone
- Gas—Natural gas migrating through DRZ into MRAA and spreading out over 2 square miles of MRAA, >95% methane
- MEQ—Microearthquake, seismic event from rock breaking
- MIT—Mechanical integrity test
- MRAA—Mississippi River Alluvial Aquifer, sand and grave aquifer used for industrial water supply in vicinity of Napoleonville Salt Dome
- ORW—Observation/relief well, aka vent well, for flaring gas
- TBC—Texas Brine Corporation
- VLP—Very long period seismic event (indicates fluid flow)
- VSP—Vertical seismic profile

Napoleonville Salt Dome Location





SITE LOCATION

- South Louisiana shallow/surface geology relatively young
- Primarily Holocene/Pleistocene-age sediment deposition from shifting courses of Mississippi River
- Interbedded sand, silt and clay in shallower formations, trending toward alternating thicker units at depth
- Deeper units Miocene and older
- Production units named from forams (tiny fossils)
- Numerous faults around flanks of dome

South Louisiana Salt Domes

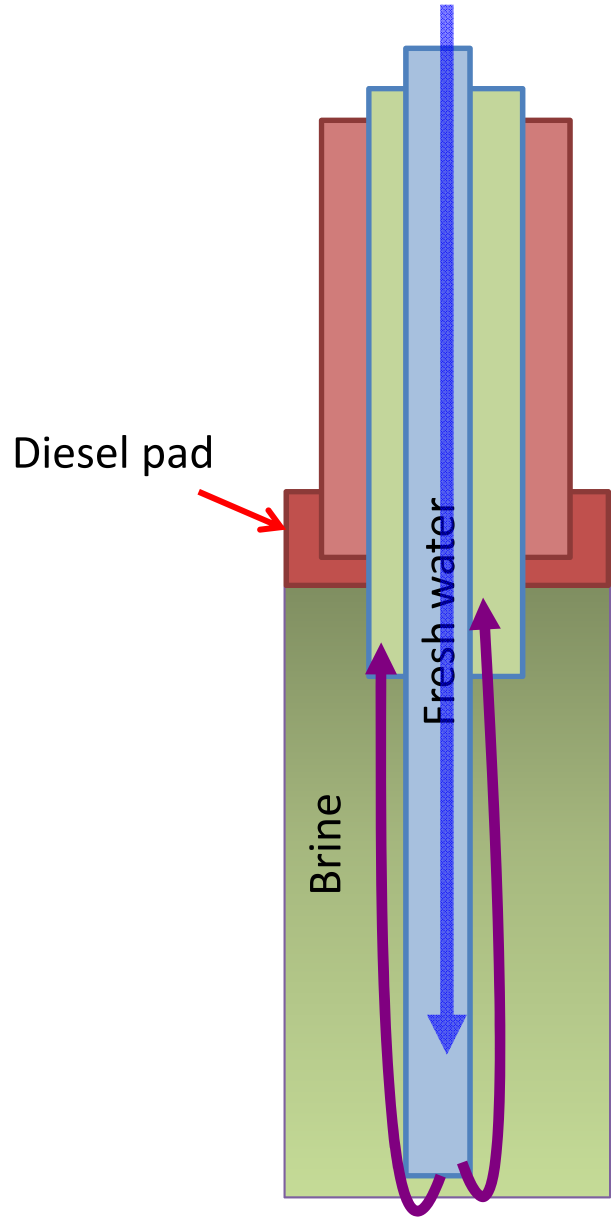
- Salt domes common across South Louisiana
- LouAnn Salt—Thick early Jurassic salt layer at approximately 40,000 feet
- Salt deposition from marine waters as North and South America separated
- Weight/pressure of overlying formations pushes salt upward through fractures and/or discontinuities in overburden toward surface because salt has lower density than overlying formations

Salt Dome Interaction

- Salt forms column as it rises – friction commonly creates brittle, porous cap rock and highly pressured, impermeable side boundary creating shale sheath
- Salt dome column creates complexity in nearby geologic formations by pushing upward and piercing overlying layers
- Formations develop local fractures and faults as they dip upward and pinch out around salt dome boundaries
- Irregular side boundaries of salt domes can create hydrocarbon traps in producing formations on flanks of dome

Solution Mining in Salt Domes

- Freshwater injected into salt dome formation to dissolve salt and return it to surface – creates brine-filled cavern over time
- Some strictly used to create brine for use by industry for various purposes
- Some brine-mined caverns have been converted to storage of hydrocarbons – impermeability of salt formations considered ideal for hydrocarbon storage
- Some caverns solution mined specifically to create hydrocarbon storage space

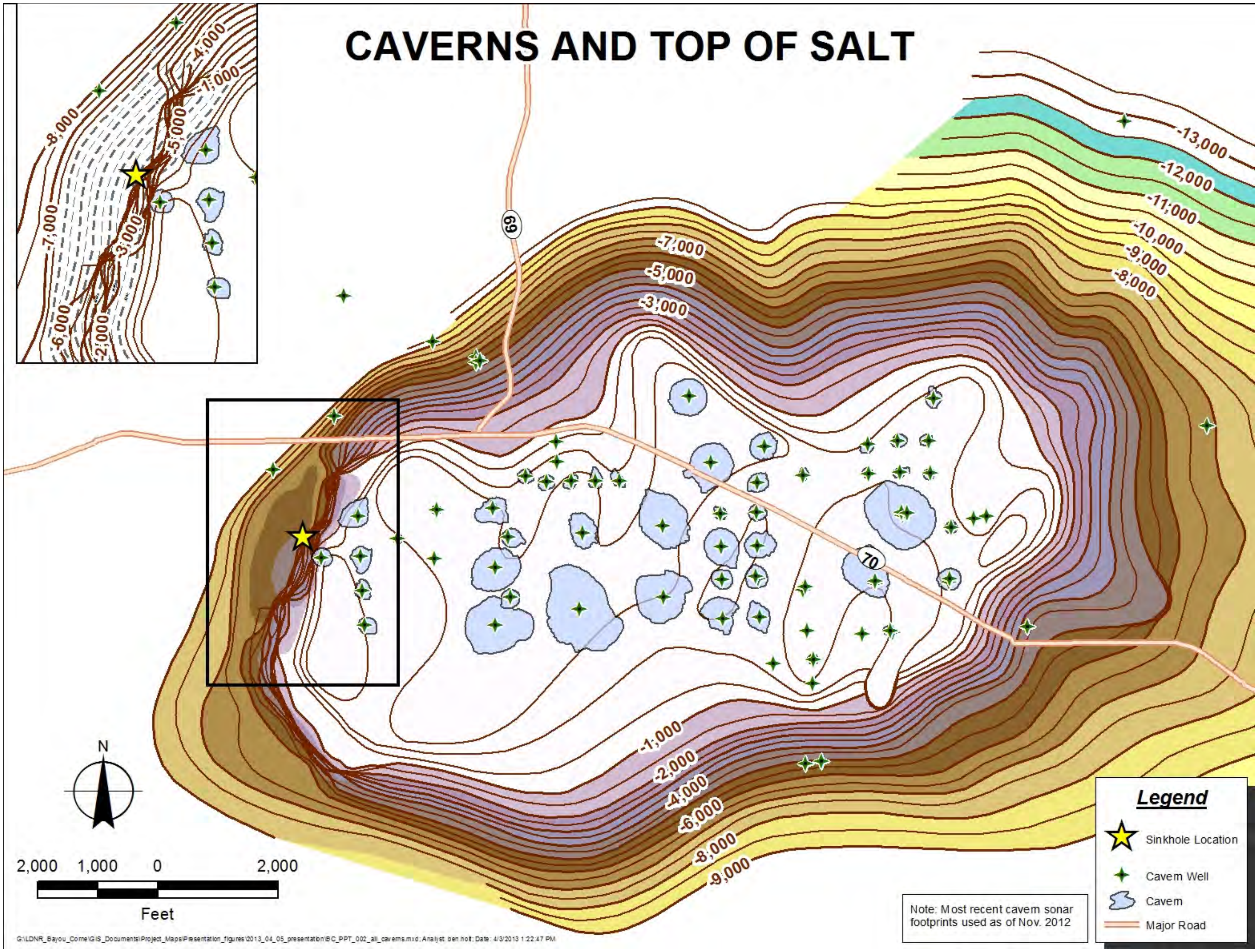


Historic Issues in Solution Mining

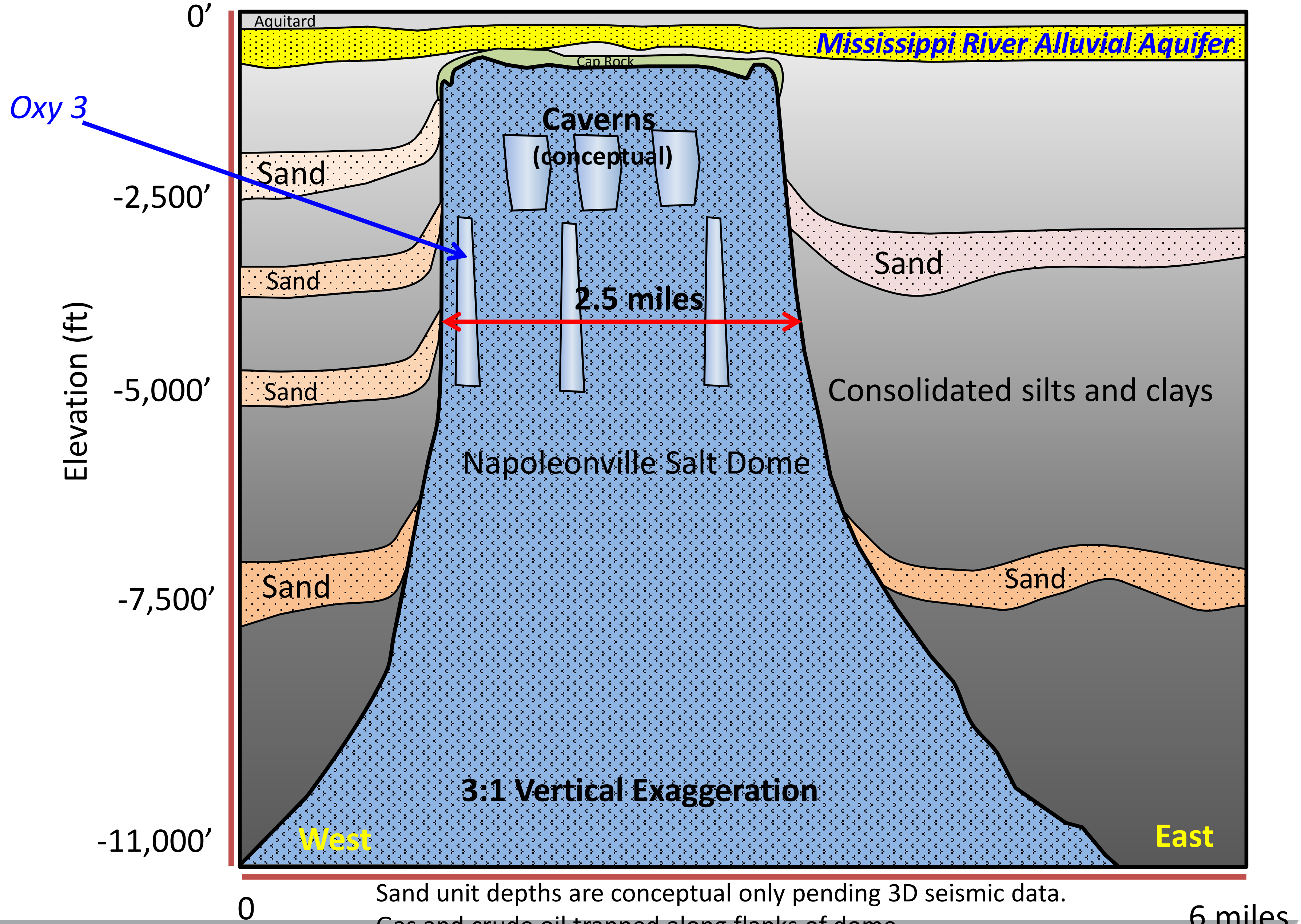
- "Salt creep" – Effects of pressure of surrounding formations and plasticity of salt, salt caverns can begin to close, pressure rises when shut in or plugged
- "Gassy salt" – Some salt domes release natural gas trapped in formation as salt is dissolved during brining
- Casing/wellbore failure – Pipe/well infrastructure fails due to pressure/age, creating loss of mechanical integrity
- Cavern collapse – Solution-mined caverns brined too close to top of salt dome have collapsed to surface due to weight of overlying formations (No known incidence of sidewall collapse previous to Oxy 3 in 2012)

- Actively operated over area of about 1 mile (N-S) by 3 miles (E-W) – 54 caverns created since 1950s
- Mix of brine mining to support petrochemical industry, hydrocarbon storage –
- No previous cavern collapse history –
- One previous hydrocarbon storage cavern casing failure leading to release and evacuation in 2003 (Gulf South incident)
- 3 caverns plugged and abandoned

Napoleonville Salt Dome Caverns



Conceptual Cross-section Of Napoleonville Salt Dome



Sand unit depths are conceptual only pending 3D seismic data.
Gas and crude oil trapped along flanks of dome.

Site Geology

- Mississippi River Alluvial Aquifer
  - Top aquifer—120 ft.
  - Base between—400-600 ft.
  - Water not used as drinking water due to dissolved solids (5,000) and chlorides (2,500)
- Cap rock above salt dome
  - Top—475'
  - Bottom— 700-1,000' feet'
  - Anhydrite and gypsum
- Miocene soft rock, sands, silts, clays, on western flank of dome
- Salt dome – extends from ~ 700-1,000 feet down to source layer at approx. 40,000 ft.

Local Hydrocarbon Production

- Area around salt dome has been explored over time for oil/gas production potential
- Little production at depths shallower than base of Oxy 3 (5,600 feet)
- Mixed results at depths correlating to Oxy 3 cavern base (6,000 ft. to 8,000 ft.) – many dry holes, producing wells have not generally had strong initial production and have tended to play out relatively quickly
- Complex nature of geology near salt dome (updips, localized faults etc.) mean productive depths/formations not homogenous over wider area

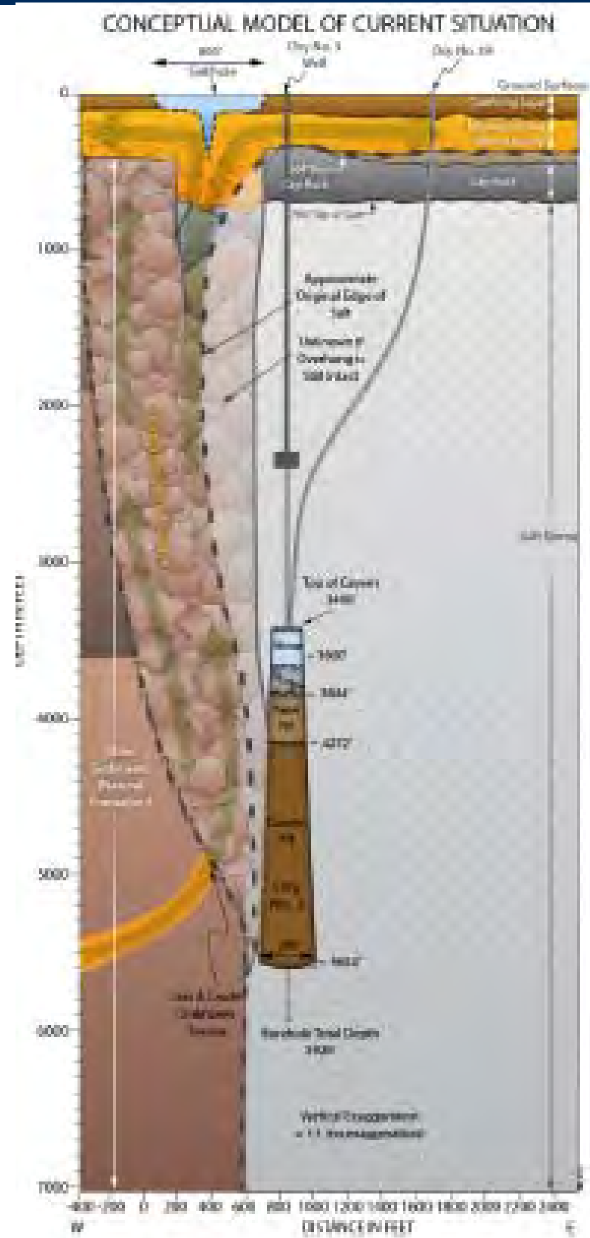
Oxy 3 Operational Timeline

- Oxy Geismar 3 permitted/began brining in 1982
- Operated without incident until September 2010
- Operator (Texas Brine) prepared to set new casing seat at about 2,400 feet – milled out section of casing
- Attempt to perform MIT failed, system would no longer hold pressure
- Texas Brine plugged cavern well with cement from 2,500 ft. to surface in June 2011

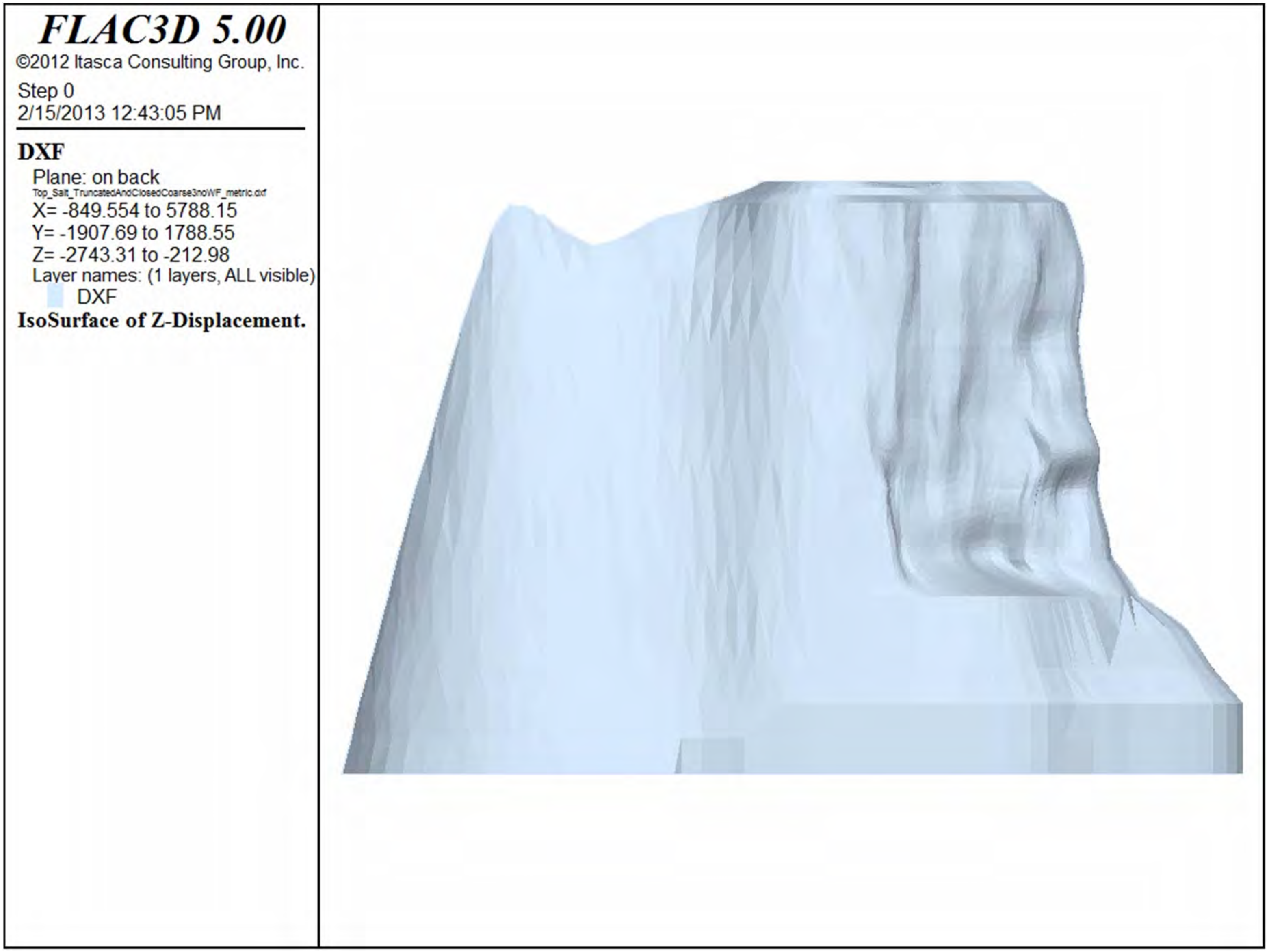
Initial Indications of Oxy 3 Cavern Collapse

- Vertical Seismic Profile (VSP) indicated base of cavern closer to edge of salt than previously believed but cavern collapse was not concern at time
- No indication of problems until reports of tremors & gas bubbling in nearby waterways in May/June 2012
- Tremors felt by nearby residents, USGS seismic monitors installed in July indicated seismic activity centered on western side of dome
- Monitoring indicated several hundred significant seismic events a day in days before sinkhole observed on Aug. 3, 2012
  - Termed slurry hole because it was full of debris
  - Evacuation order issued by parish

- Closest cavern to western boundary of salt dome
- Top of salt at 700 ft., cavern roof at 3,400 feet, base of cavern at 5,600 ft.
- Failure/collapse of sidewall of brine-mined salt cavern Oxy Geismar 3
- Likely began several months prior to initial indications at surface
- Collapse at ~5,600 feet fractured to surface creating Disturbed Rock Zone (DRZ), zone of broken rock
- DRZ now pathway for formation water, crude oil, natural gas to flow from deep formations to surface
- MRAA aquifer sands flow down into DRZ,
- Unknown if salt involved in collapse



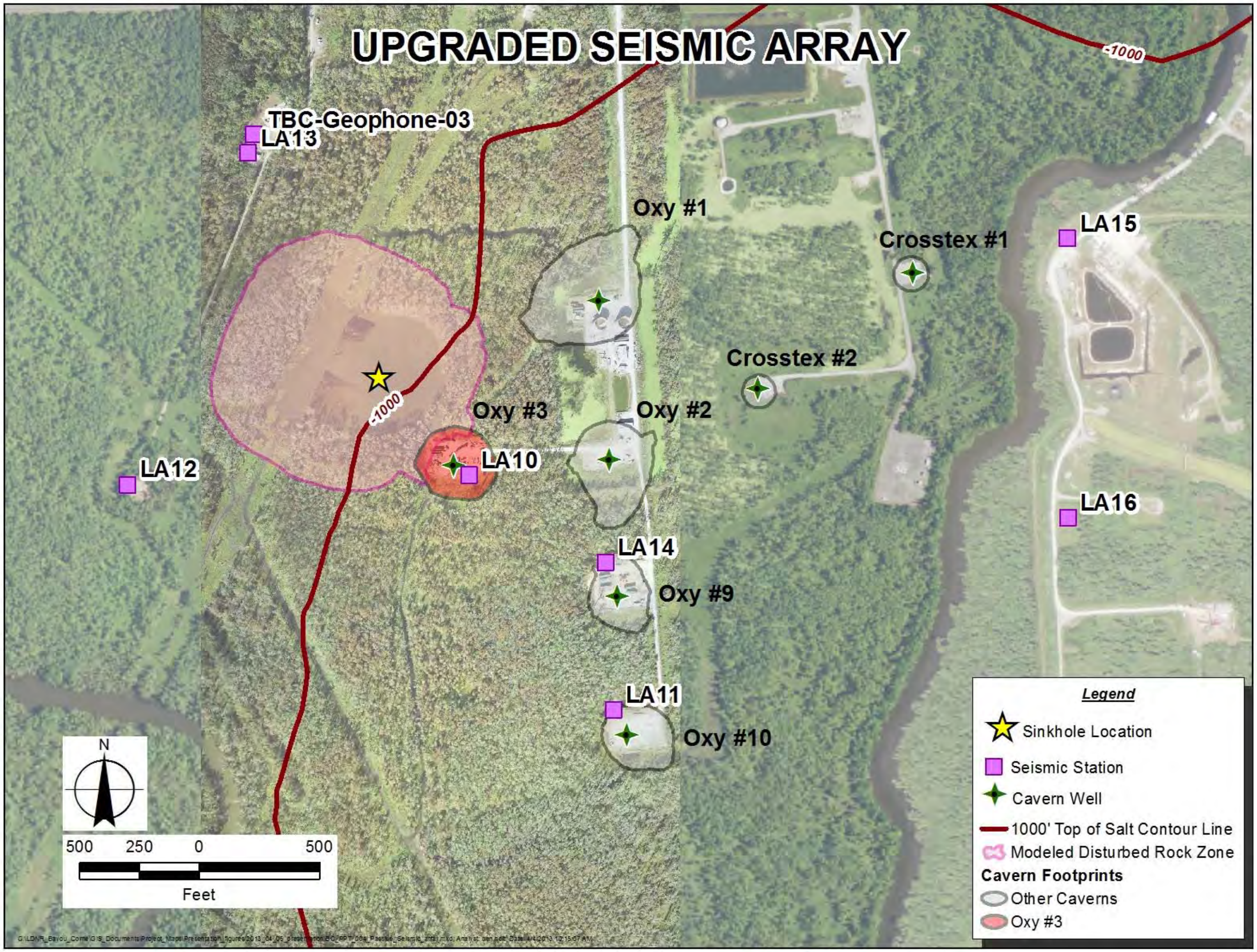
Growth of DRZ (view towards SE)



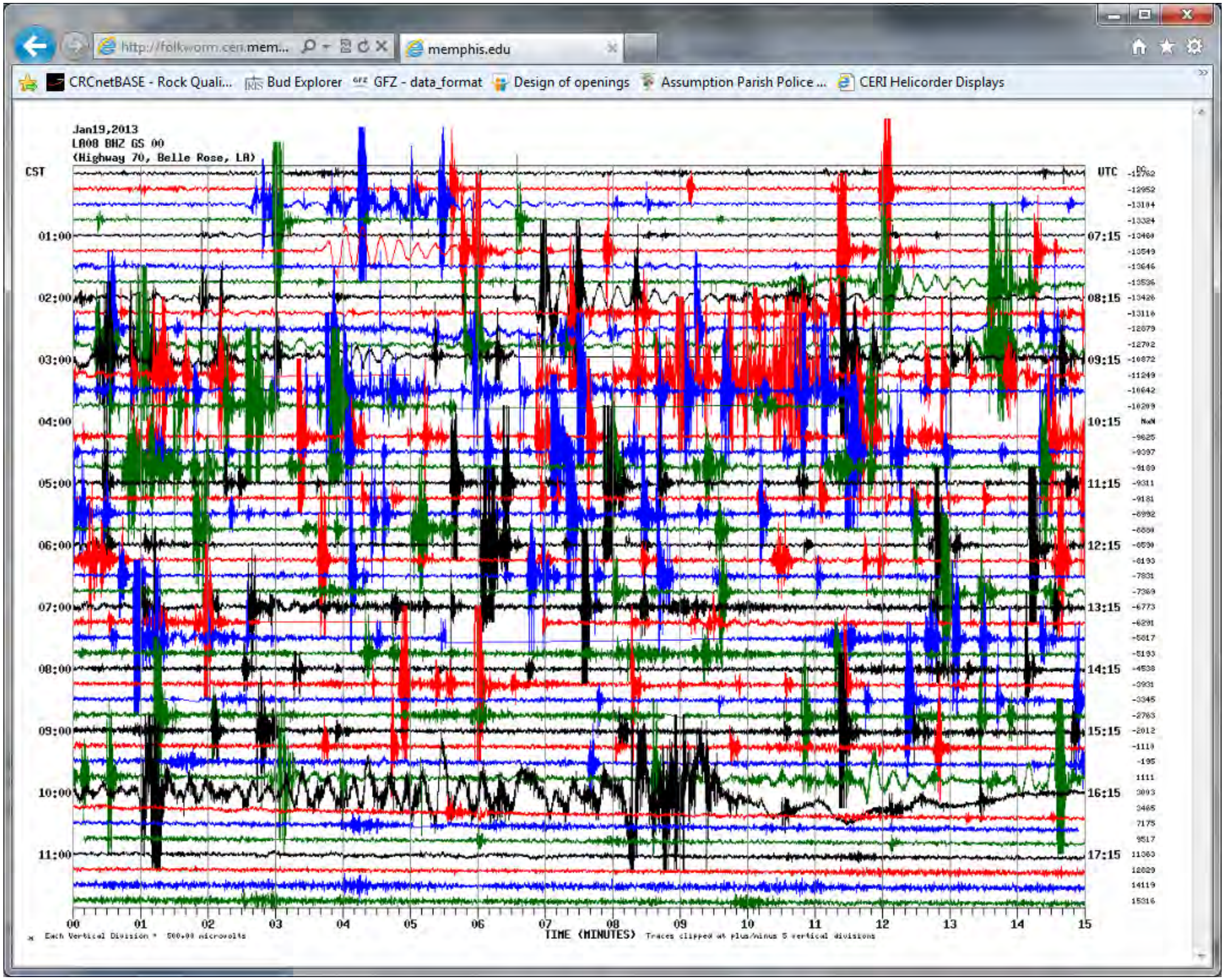
Ongoing Cavern Collapse

1. Collapse of cavern still ongoing as cavern space continues to fill in with sedimentary material
2. Subsurface movement continually changing width/depth of sinkhole as cavern fills and natural gas/crude oil are released from disturbed rock zone
3. Natural gas still flowing to surface/aquifer, occasional "burps" through sinkhole as void spaces shift
4. Natural gas bubbling to surface over ~ 2 square miles

Seismic Monitoring Array

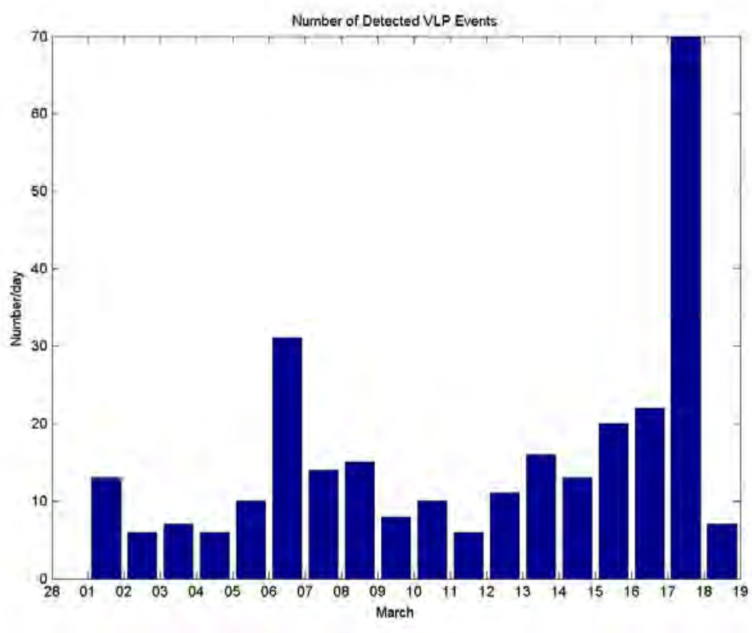


Example: Active Seismic Period, 1/19/2013

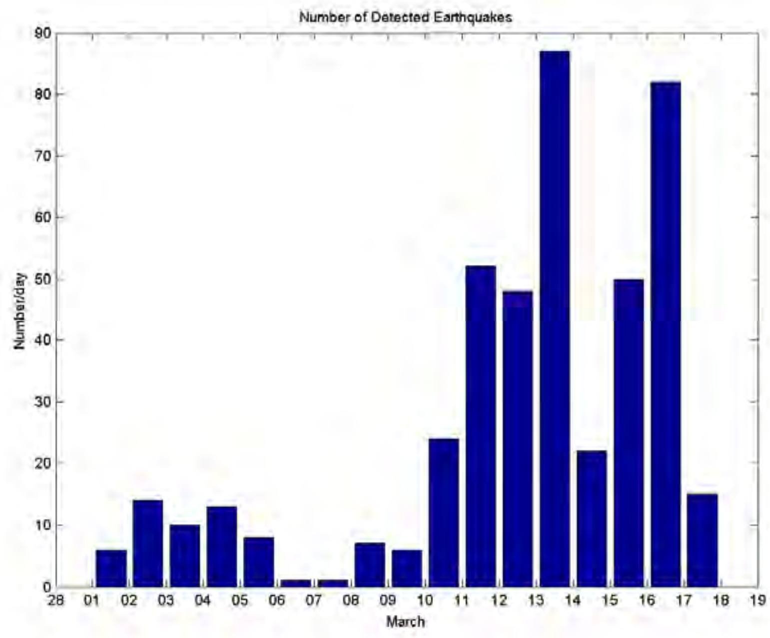


Seismic Events Histograms Associated With Oxy 3 Collapse

VLP Events—Very Long Period events indicting fluid movement

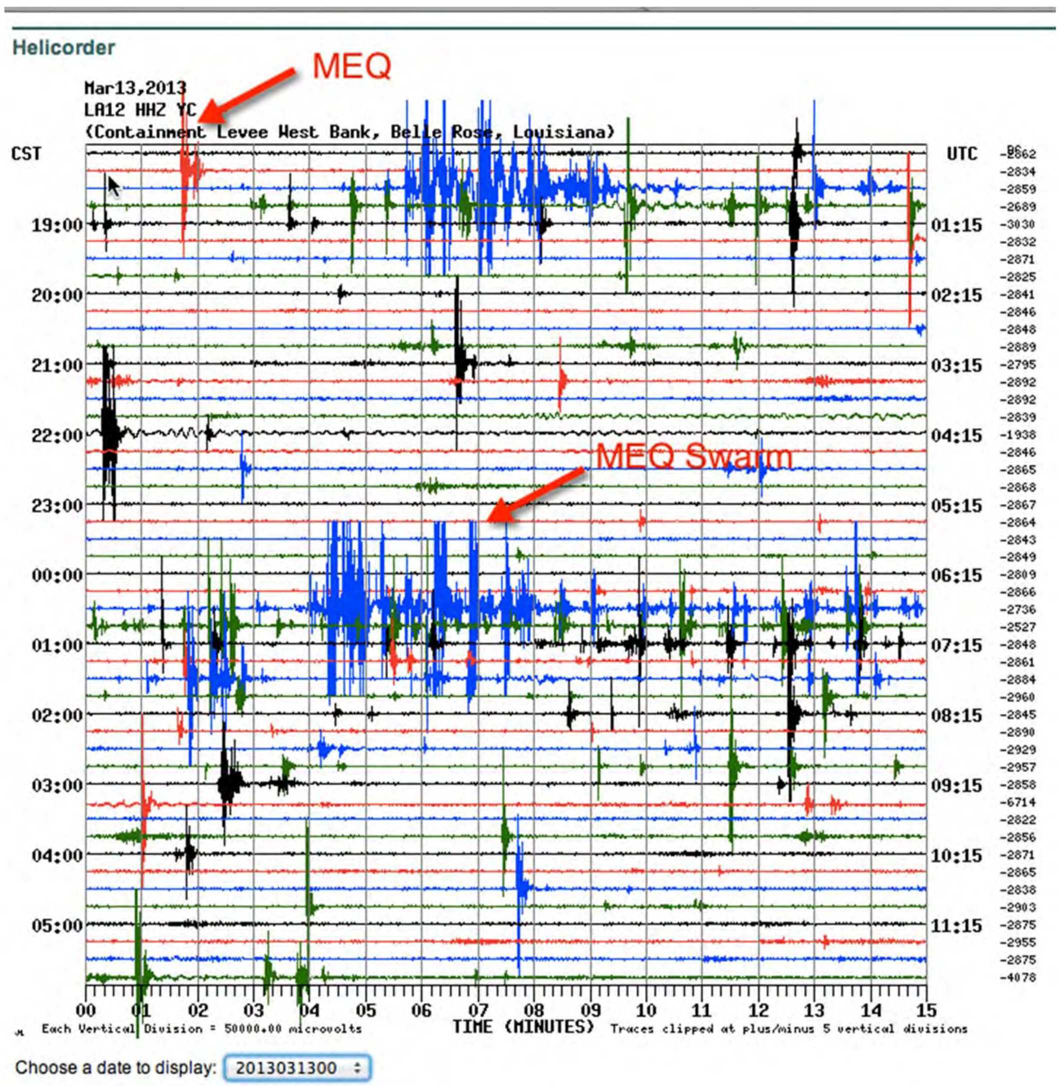


MEQ Events—MicroEarthQuakes indicating rock breaking



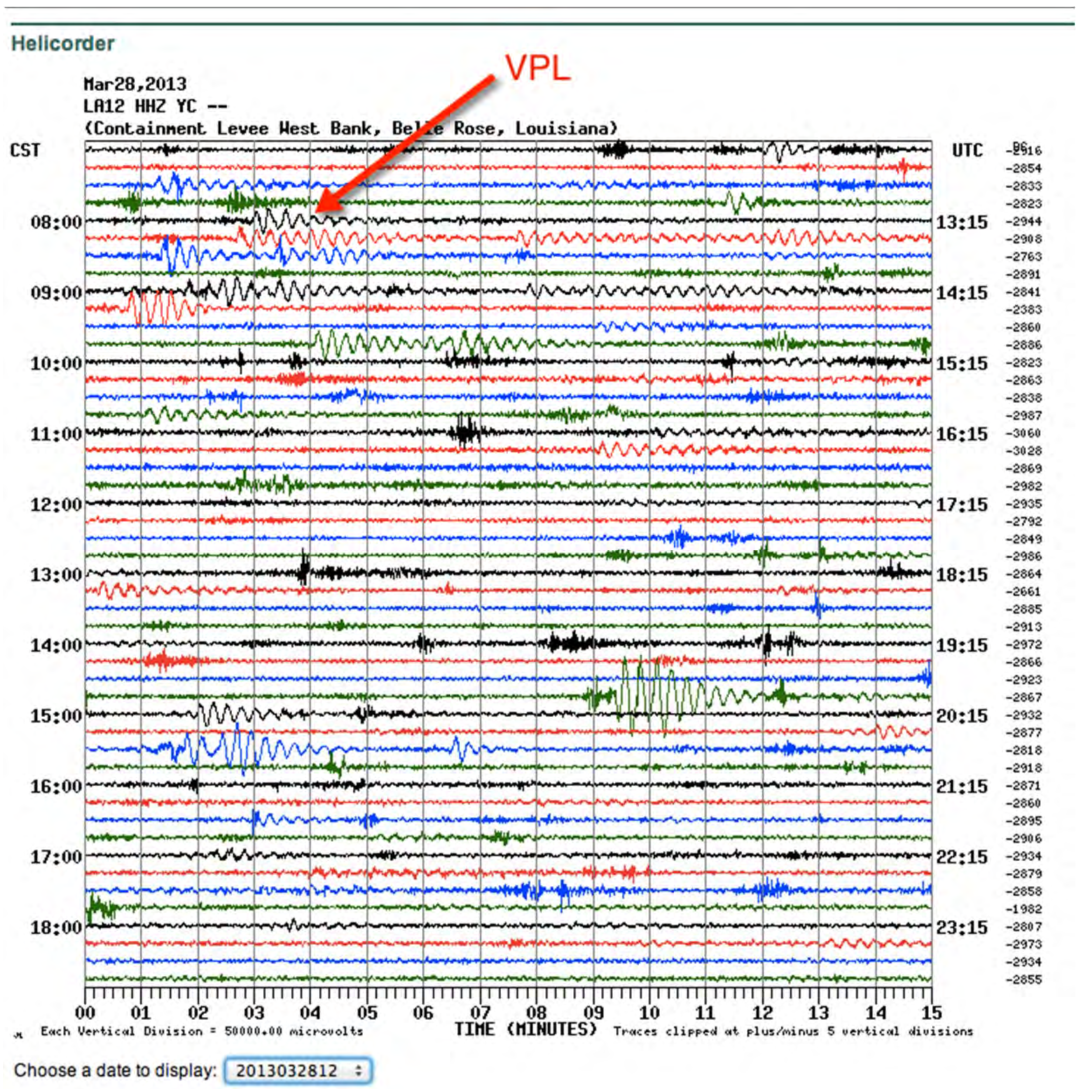
Ongoing data processing and analysis by Dr. Horton, CERI, and Dr. Pettitt, Itasca
March 2013 data

MicroEarthQuake (MEQ) Events



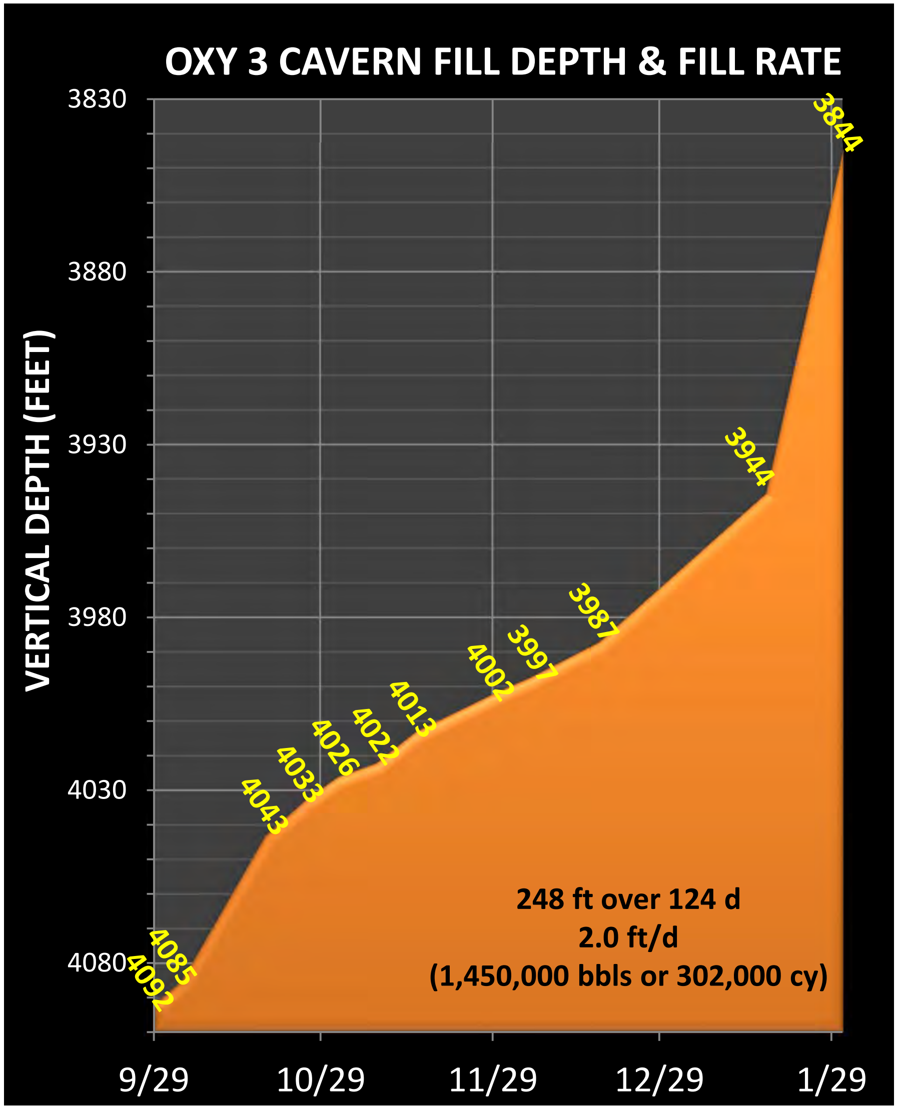
March 13, 2013 events

Very Long-Period (VLP) Events



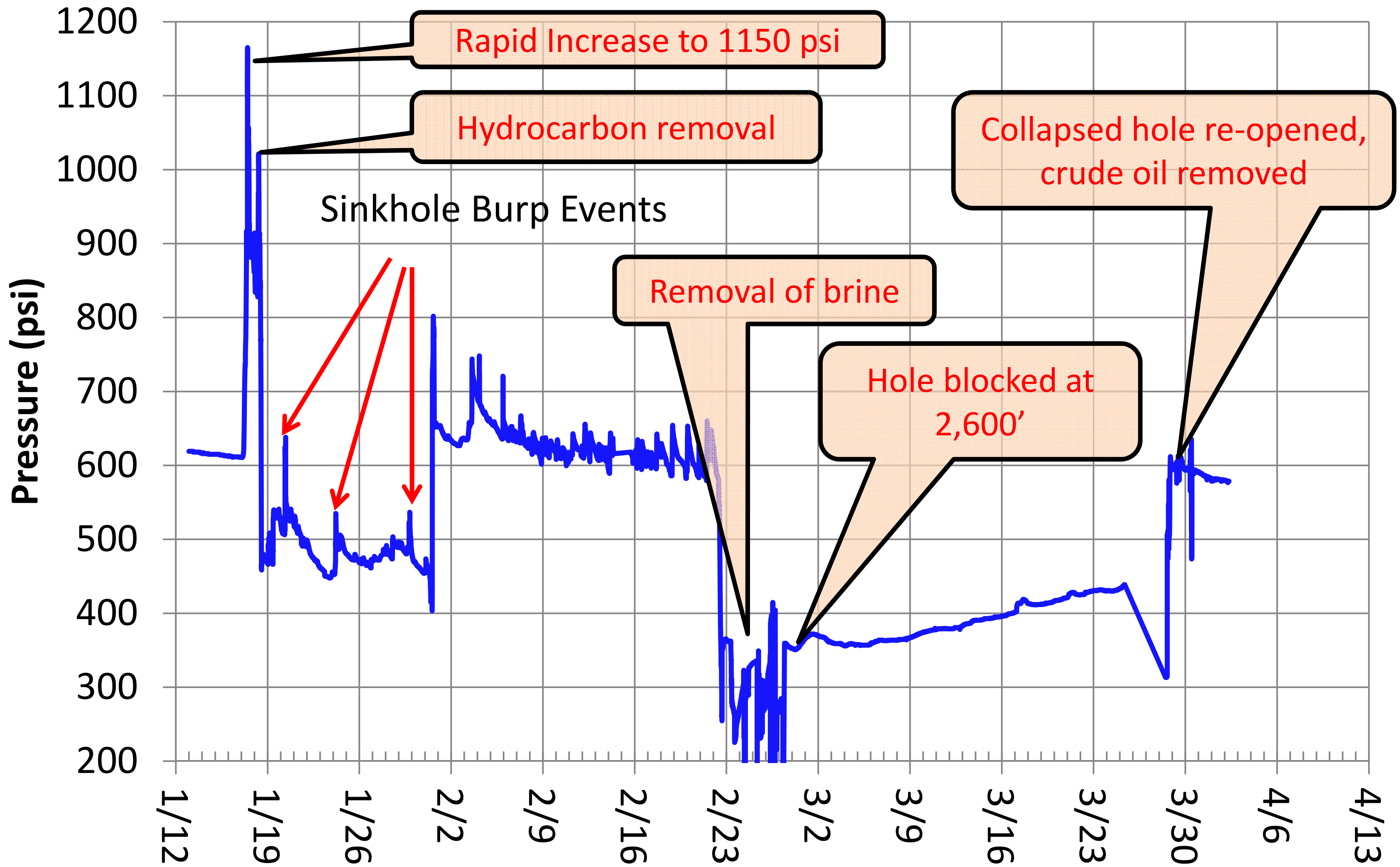
March 28, 2013 events

Cavern In-filling Rate

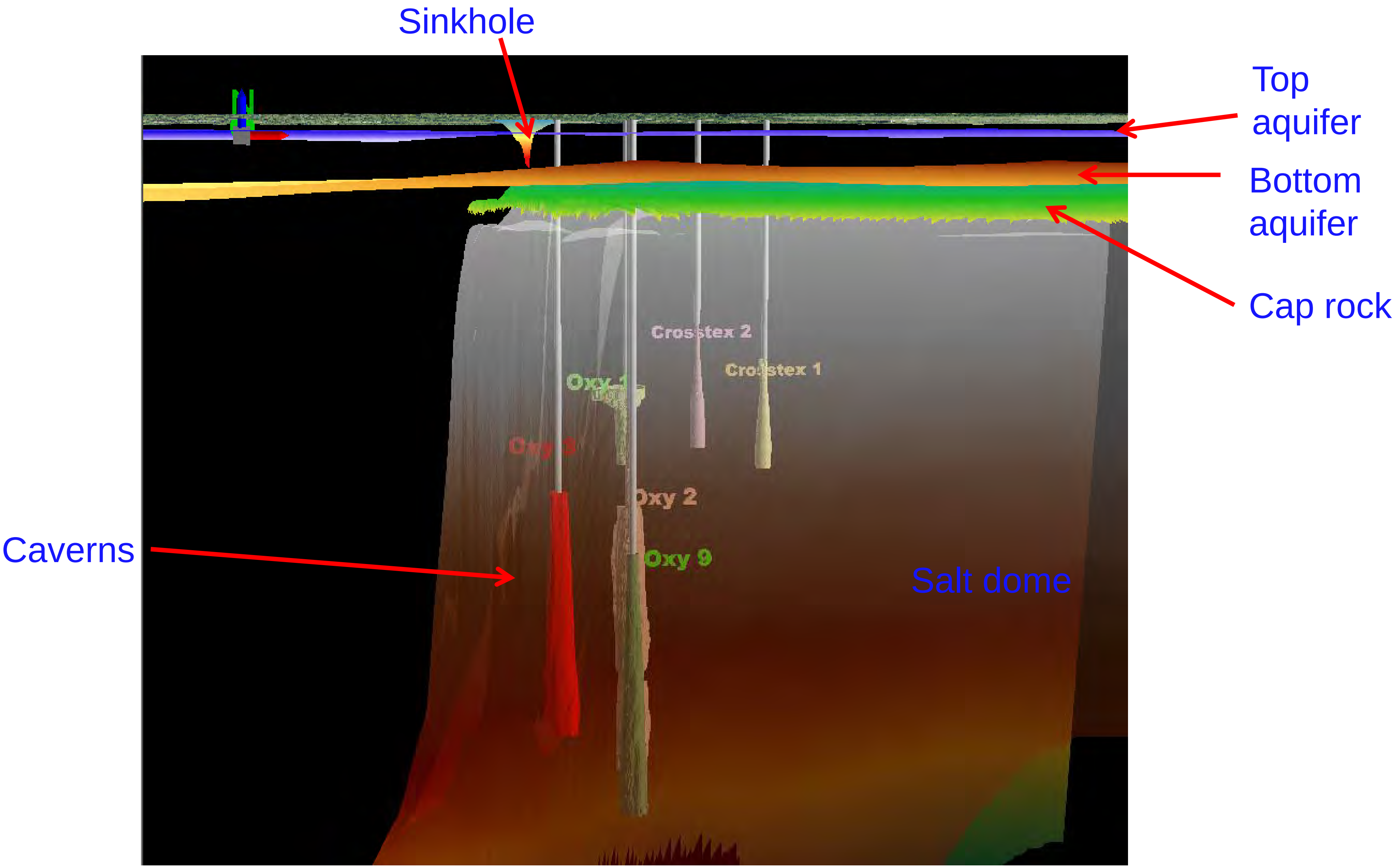


- Cavern filling in over time as rock breaks and fills in
- Filling rate 1-2 feet per day
- Western wall of cavern still collapsing
- Major fill event of 100’ from 1/17/2013 to 1/31/2013—related to seismic activity
- Roof of cavern at 3400’, ~450’ to fill and January 29,2013
- Next Oxy 3A bottom tag and sonar scheduled for April 9, 2013
- Instability will likely continue at least until cavern is full

Oxy 3a Cavern Pressure Related To Burps In Sinkhole



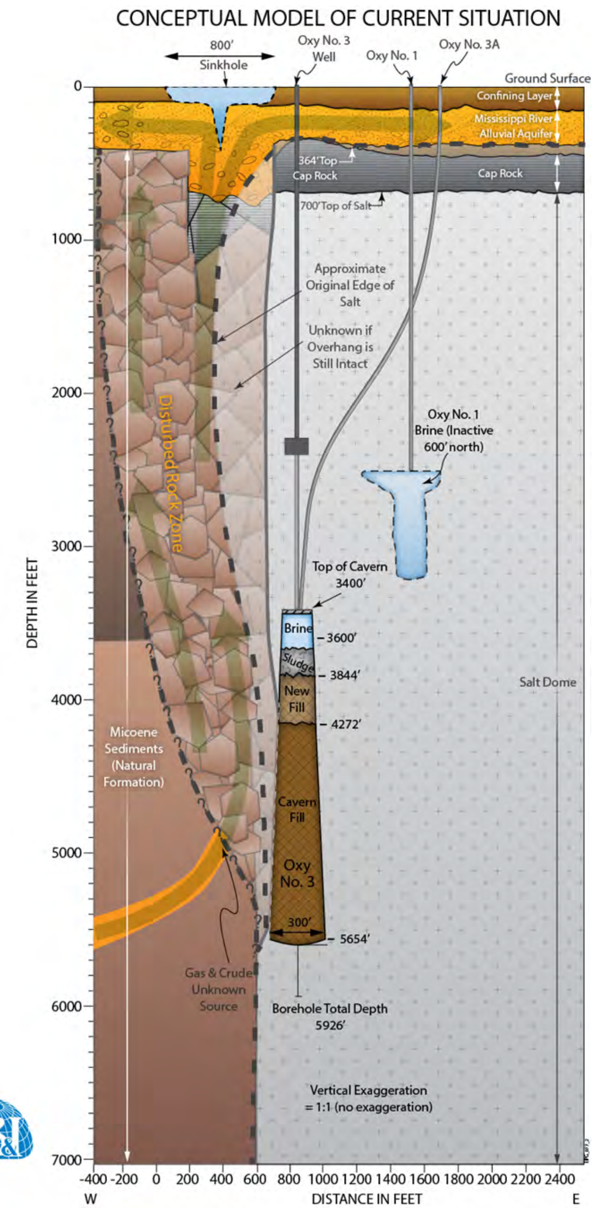
Other Caverns in Vicinity of Oxy 3



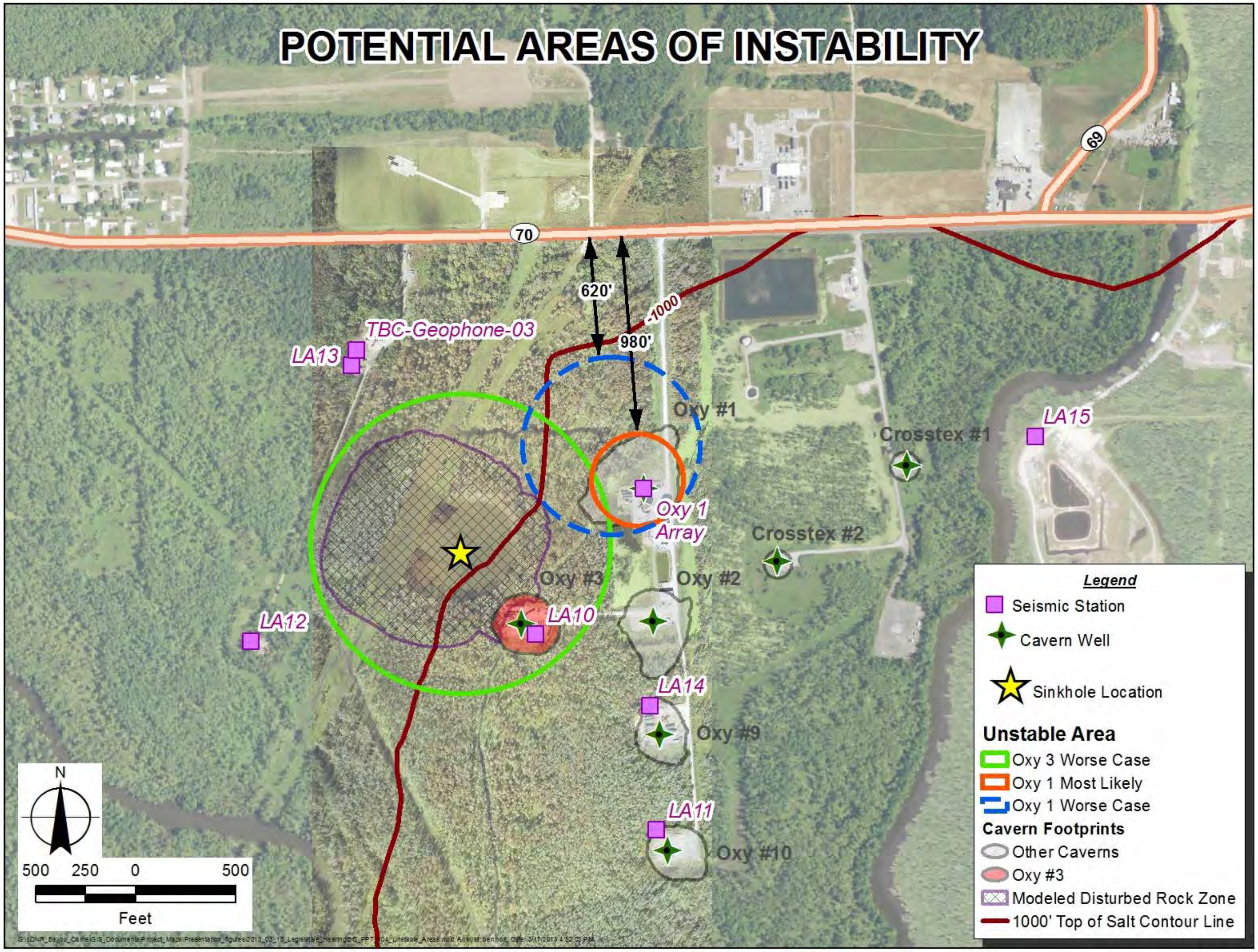
Looking north, no vertical exaggeration

Oxy 1 Stability

- 2013 VSP data delivered March 2013 indicates Oxy 1 is near the edge of salt.
- Initial sinkhole analysis of potential Oxy 1 collapse
  - Sinkhole most likely diameter estimation (if it happened) is 460 ft
  - Sinkhole most likely depth estimation (if it happened) is 80 ft
- Oxy 1 has been evaluated by DNR's four cavern experts—no indication of instability at present.
- Most seismic events adjacent to Oxy 3.
- Best thing to do with Oxy 1 is maintain pressure and monitor microseismic activity.
- Any future collapse would be preceded by months of seismic activity near Oxy 1.

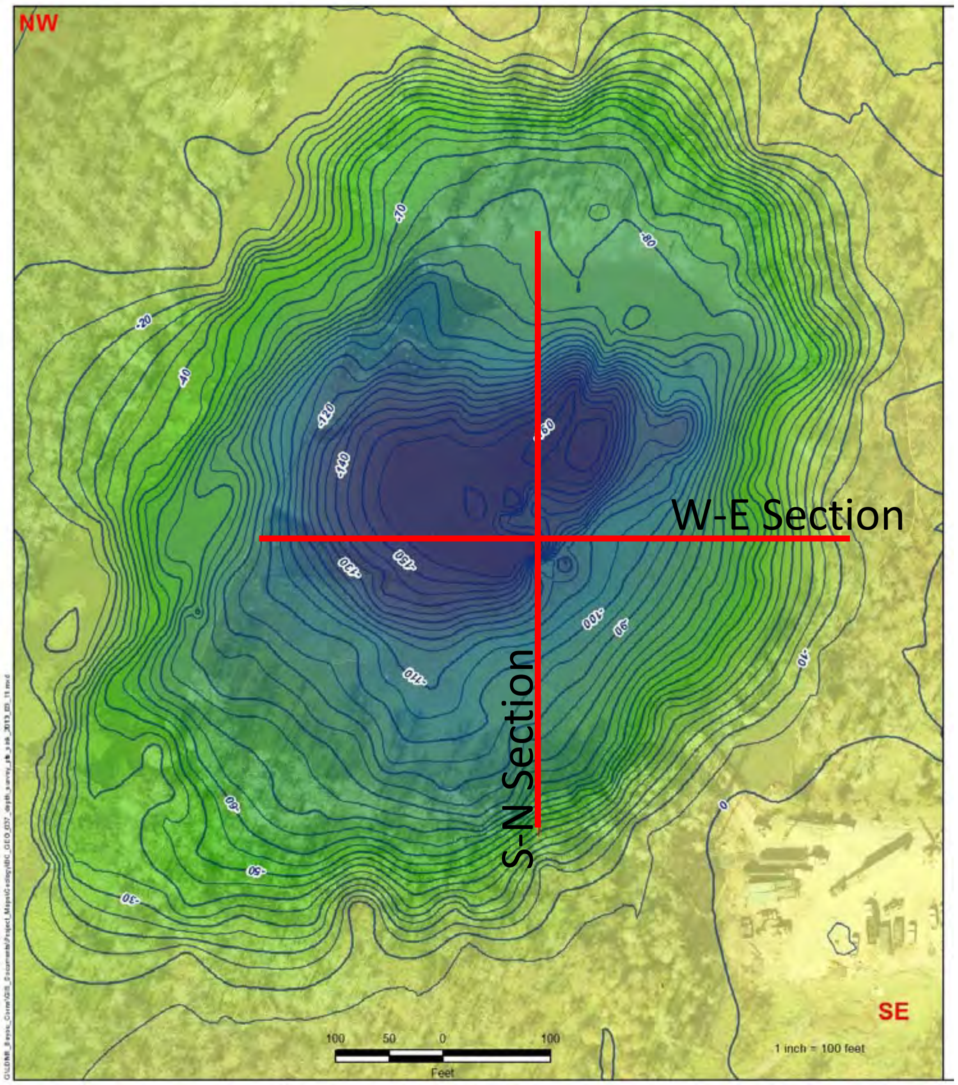


Sinkhole Size Itasca Model Results for Oxy 1 Collapse



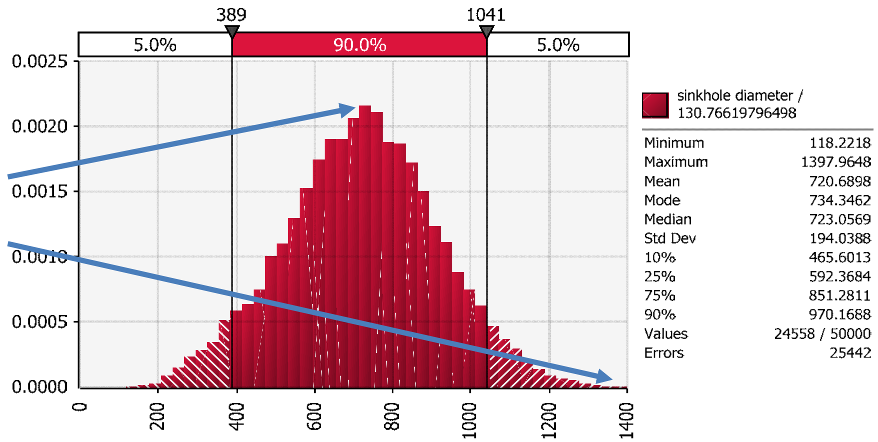
2. BAYOU CORNE SINKHOLE

Sinkhole March 2013

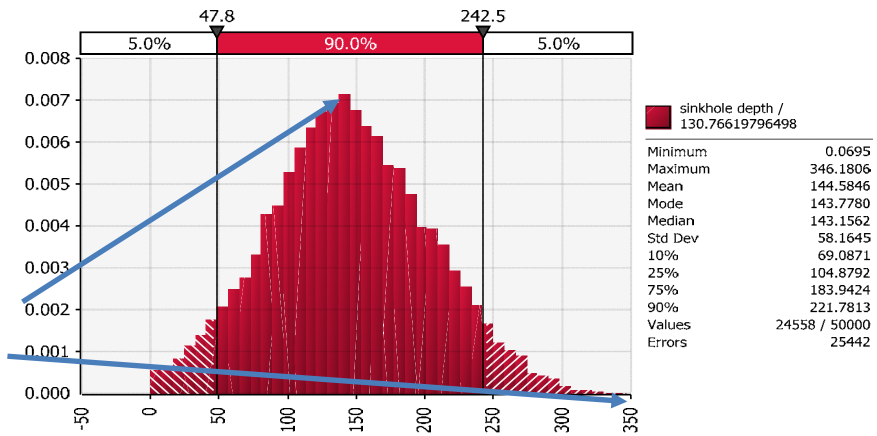


- Main sinkhole area—12+acres
- Settlement area—25 acres
- Volume 1.2 million yd^3 – increased from 550,000 yd^3 in October 2012
- ~700,000 yd^3 migrated down DRZ
- Berm around outside of sinkhole to contain contamination

Sinkhole Diameter
Most Likely = 734 ft
Worst Case = 1400 ft



Sinkhole Depth
Most Likely = 144 ft
Worst Case = 346 ft



Itasca analysis

Sinkhole Fall 2012

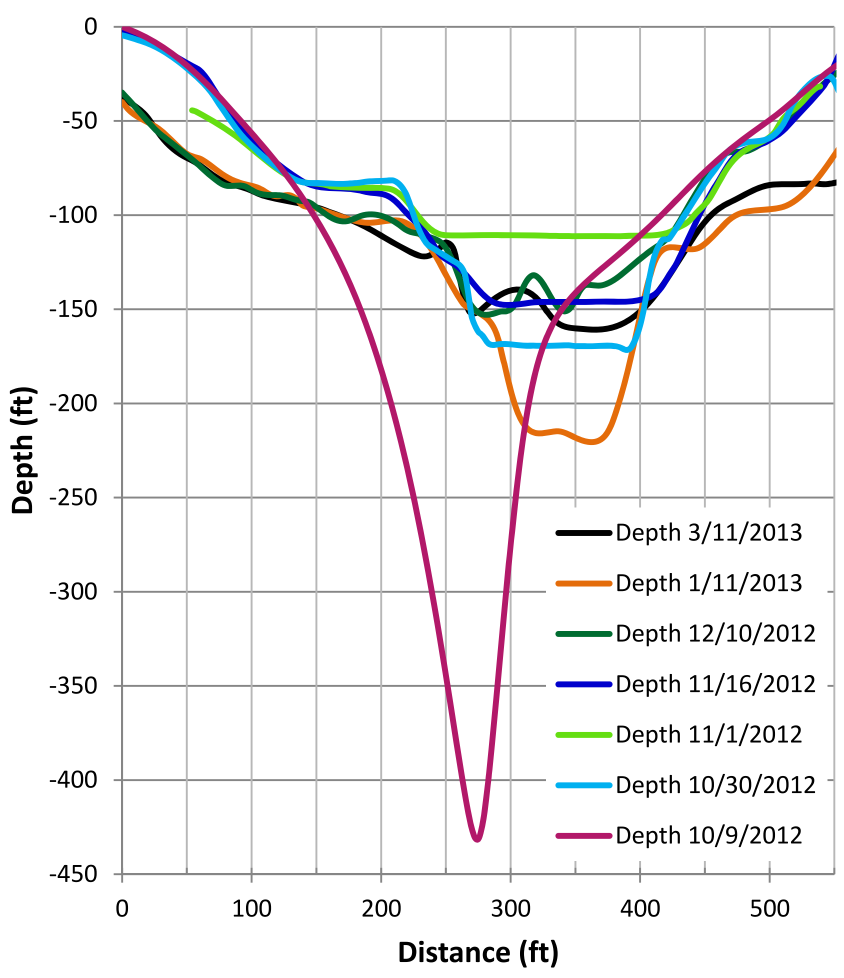
Sinkhole January 2013

Sinkhole with Berm March 2013

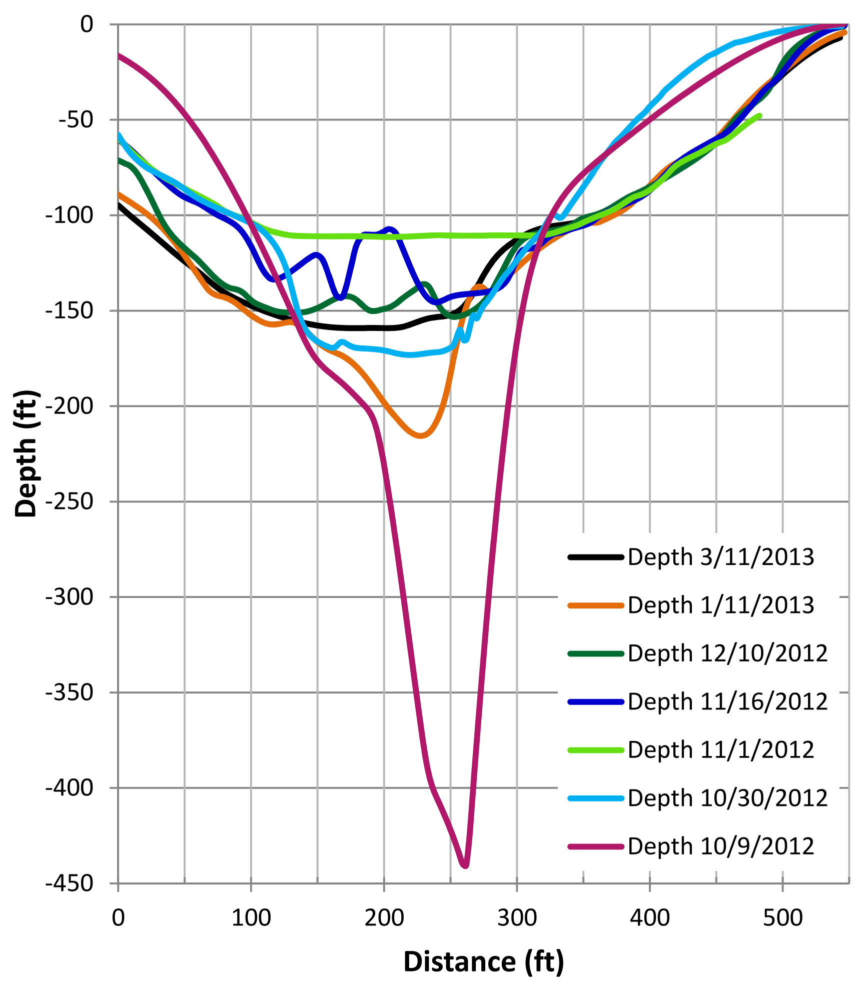
Sinkhole Changes Animation

Sinkhole Cross-Sections

CROSS-SECTION S-N



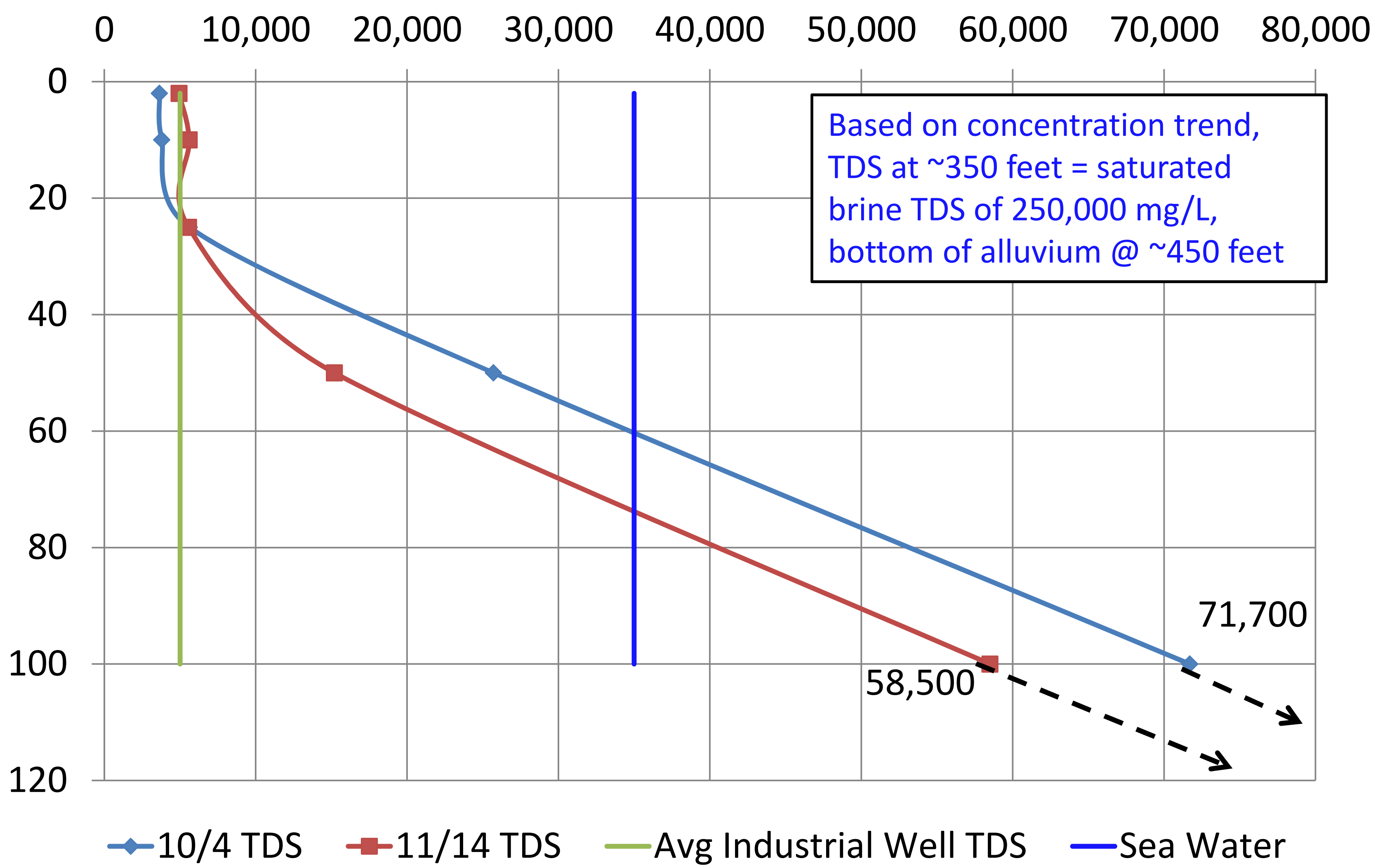
CROSS-SECTION W-E

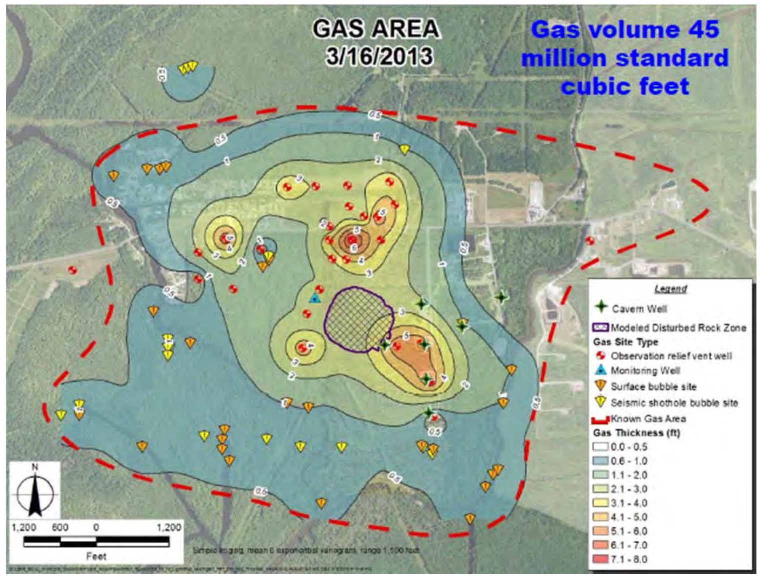


Sinkhole Tides Video

Video courtesy John Boudreaux, Assumption Parish OEP

Sinkhole Total Dissolved Solids



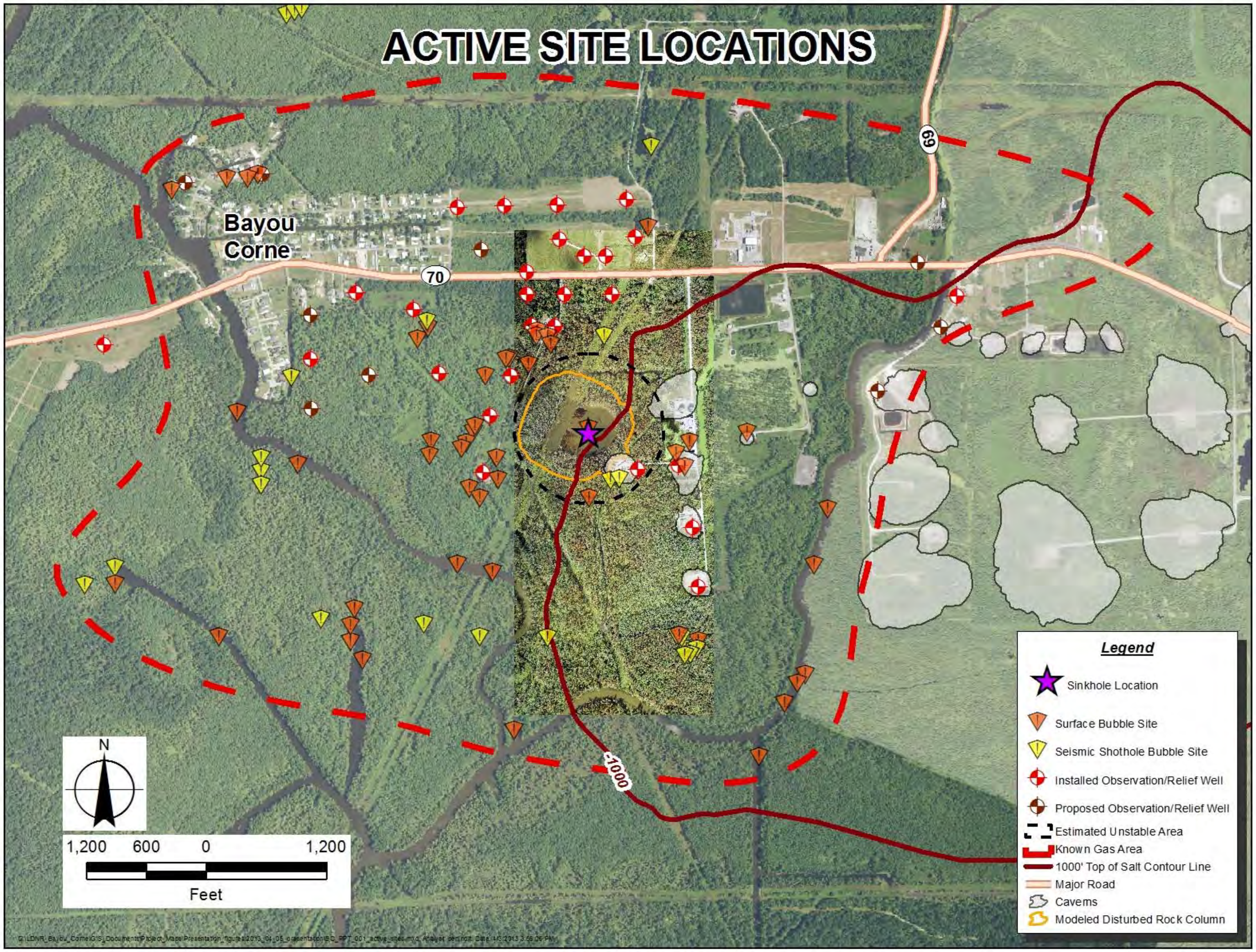


3. Natural Gas (~99% methane) Migrating into MRAA

Natural Gas Metrics

- Natural gas flowing into aquifer thru DRZ and spreading laterally over 2 sq. miles – gas column 2 ft. to 10 ft. thick
- Estimated 45 mmcf (million cubic feet) in place, about 12 mmcf vented to date
- Gas bubbling at over 50 identified bubble sites
- Gas bubbling observed in Bayou Corne community after rains
- Depth and volume of reservoirs feeding natural gas currently being evaluated

Gas Bubble Locations and ORW Vent Wells



Quantify Flow Rates of Gas Bubbles with the Bubble-o-Meter

Results—5 to 50 cubic feet per hour (100 to > 1,000 ft^3/day)

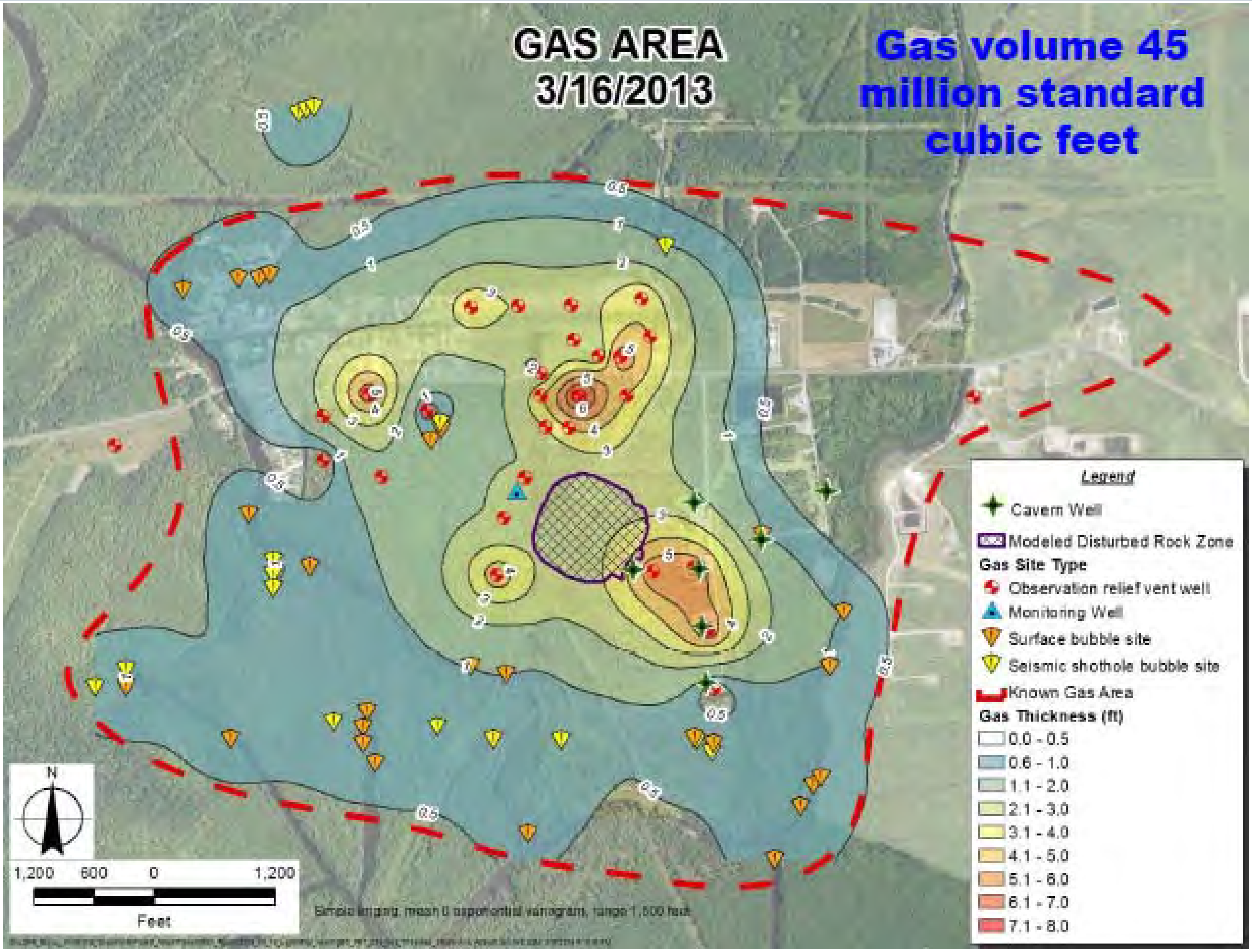
Known bubble sites—15 mcfd total over 26 sites

Used to calibrate biweekly videos

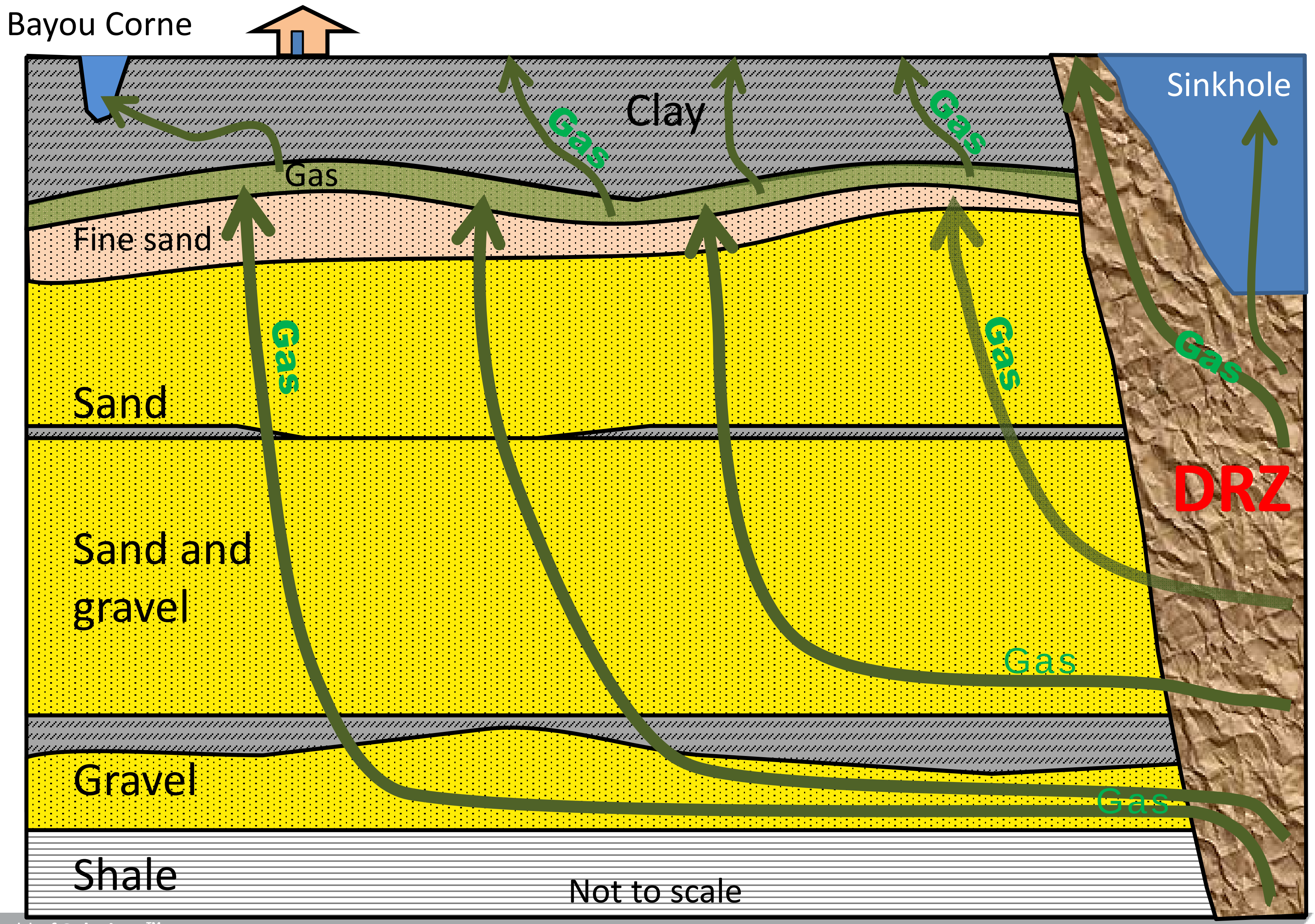
Sinkhole "Rain-drop" Bubbles video

Video courtesy John Boudreaux, Assumption Parish OEP

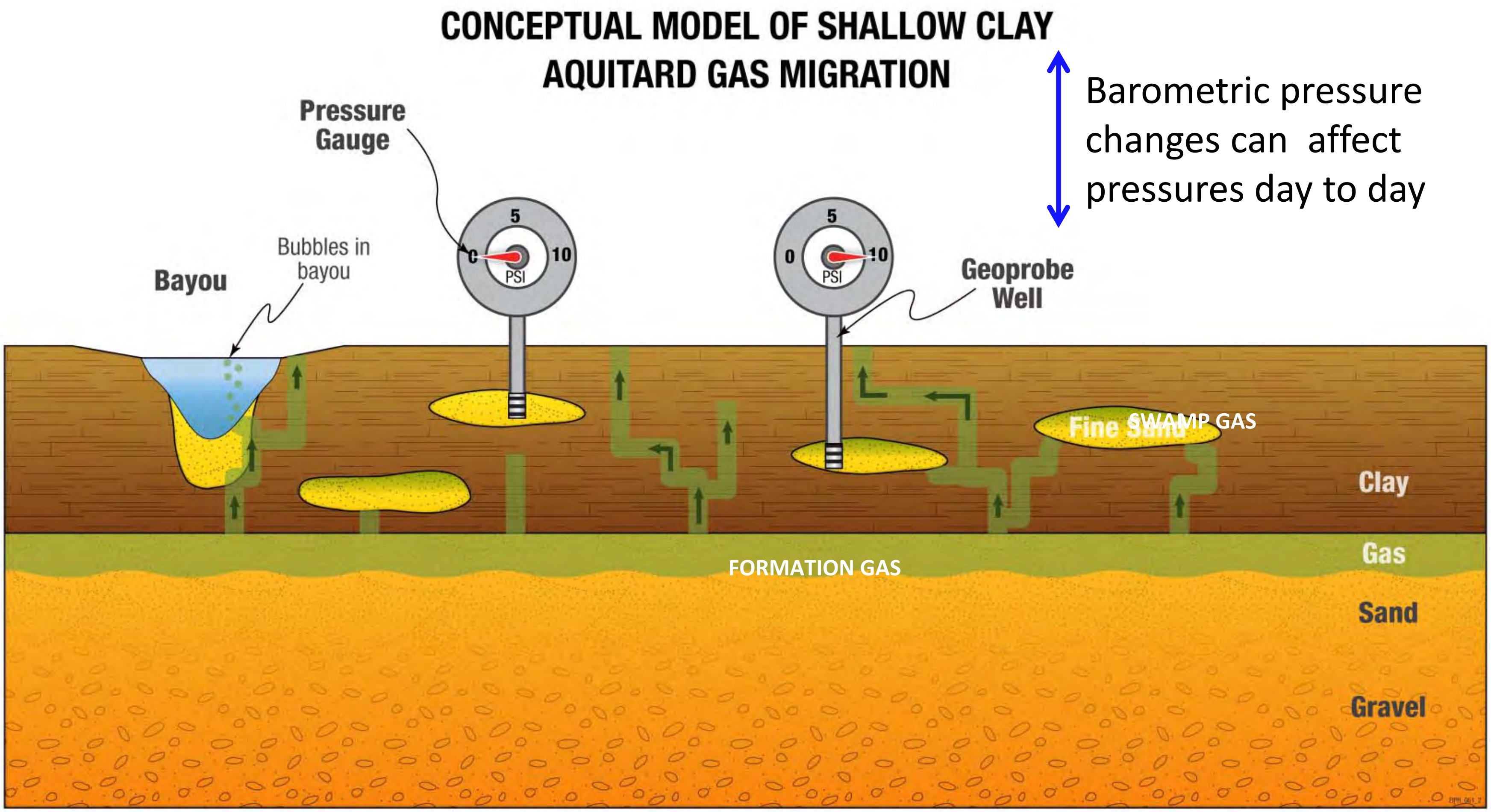
Gas Thickness Map



Gas Migration Conceptual Model



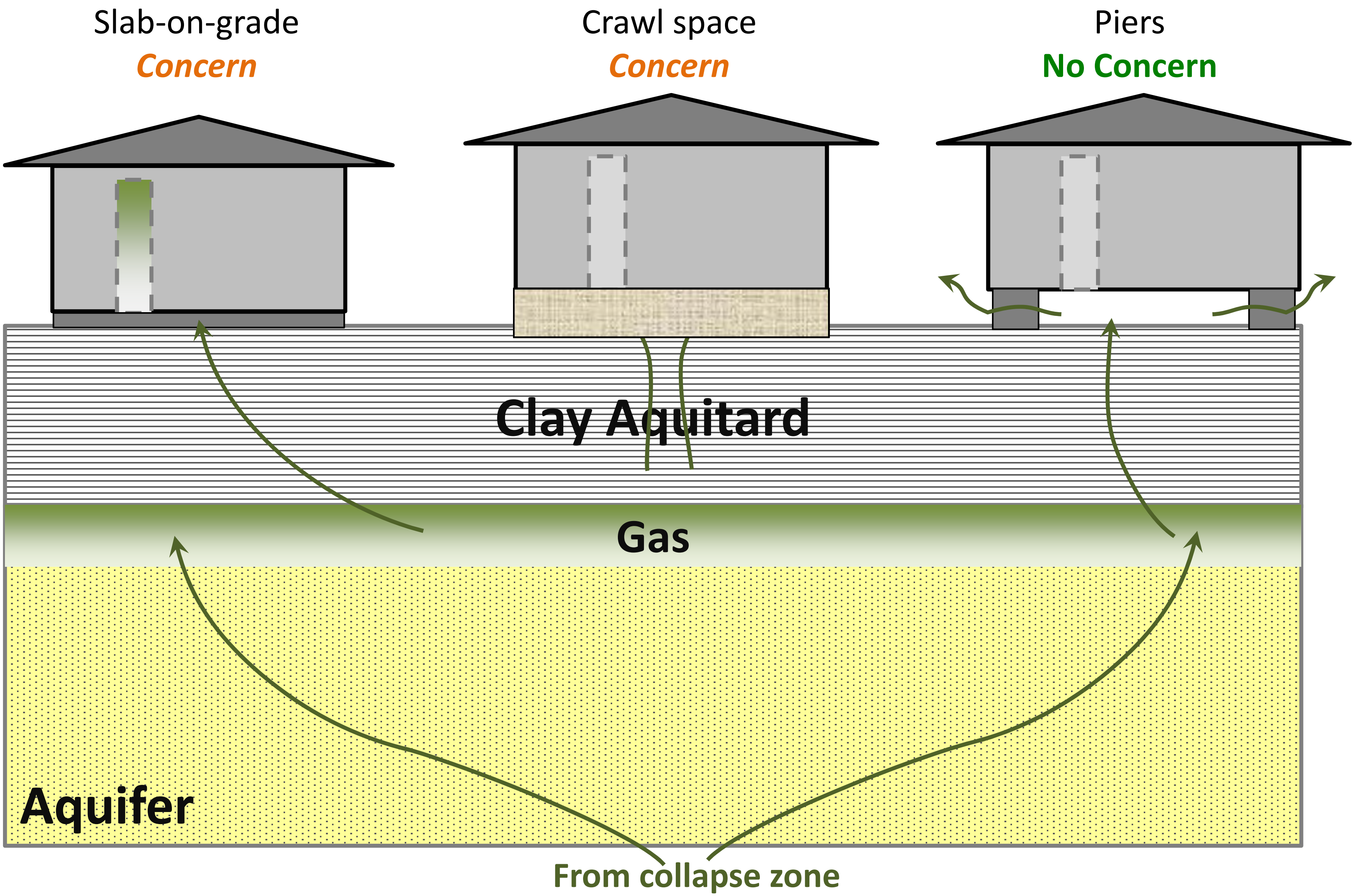
Conceptual Shallow Gas Model



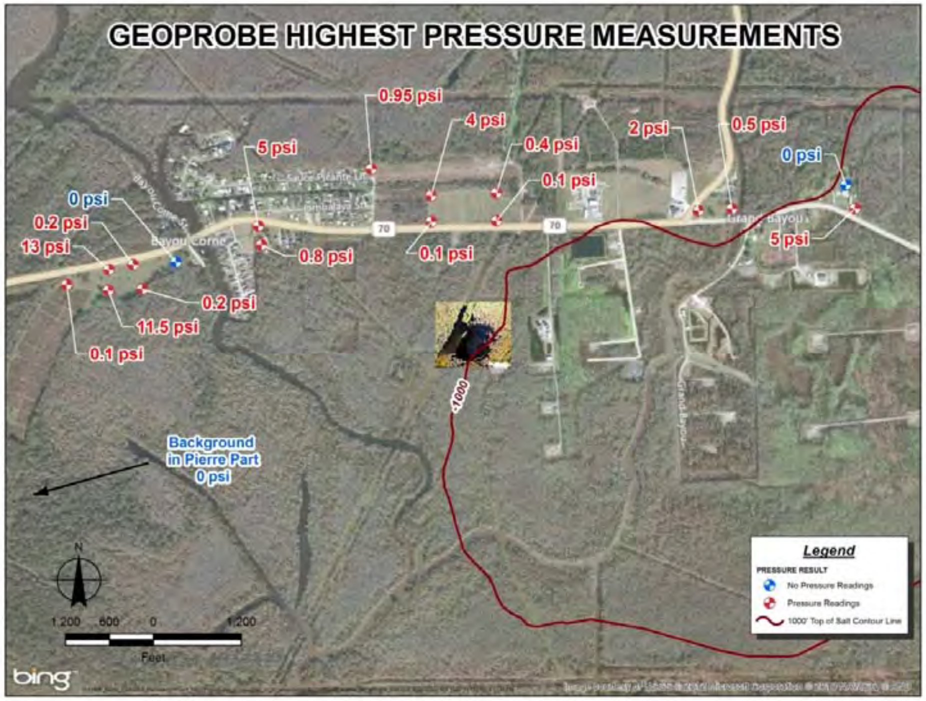
Barometric pressure changes can affect pressures day to day

Calculated gas flow rate very low

Potential Gas Migration Into Homes

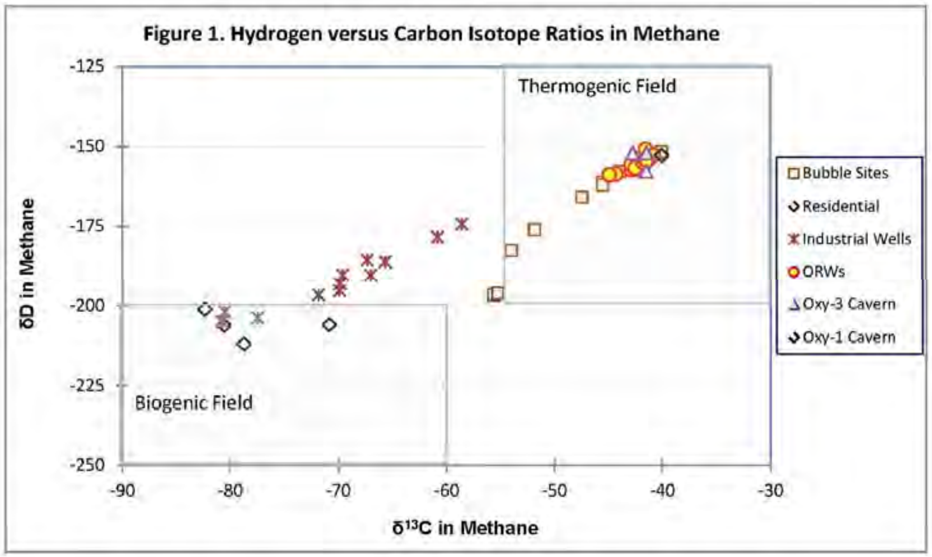


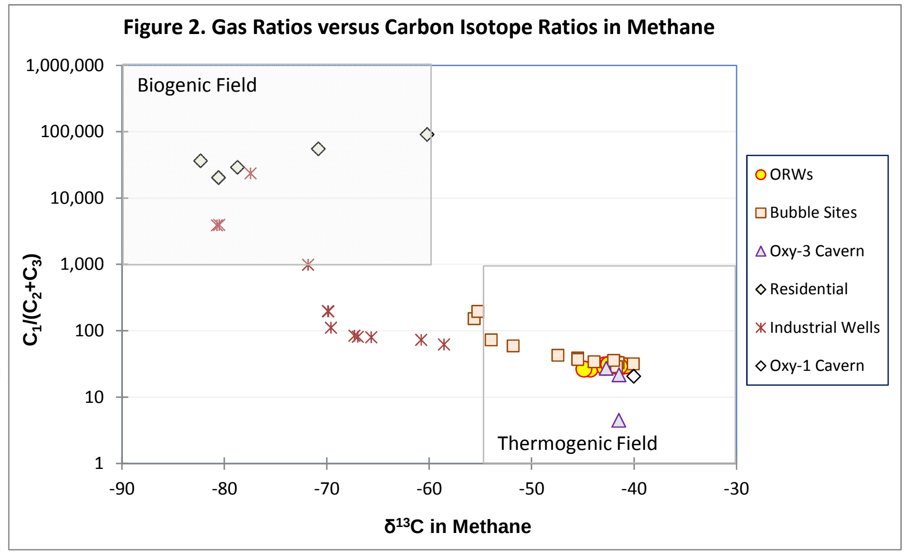
Shallow Geoprobe Wells Monitor Pressure



- 24 Geoprobe wells at depths of 20-40 feet
- Positive pressures over monitoring area
- Bubbling observed in some wells
- Some wells self purge—lift water column when wellhead valve opened
- Low pressures (< ½ psi)are likely result of barometric pressure changes
- Formation pressures are about the same across Bayou Corne area when water levels and depths are accounted for

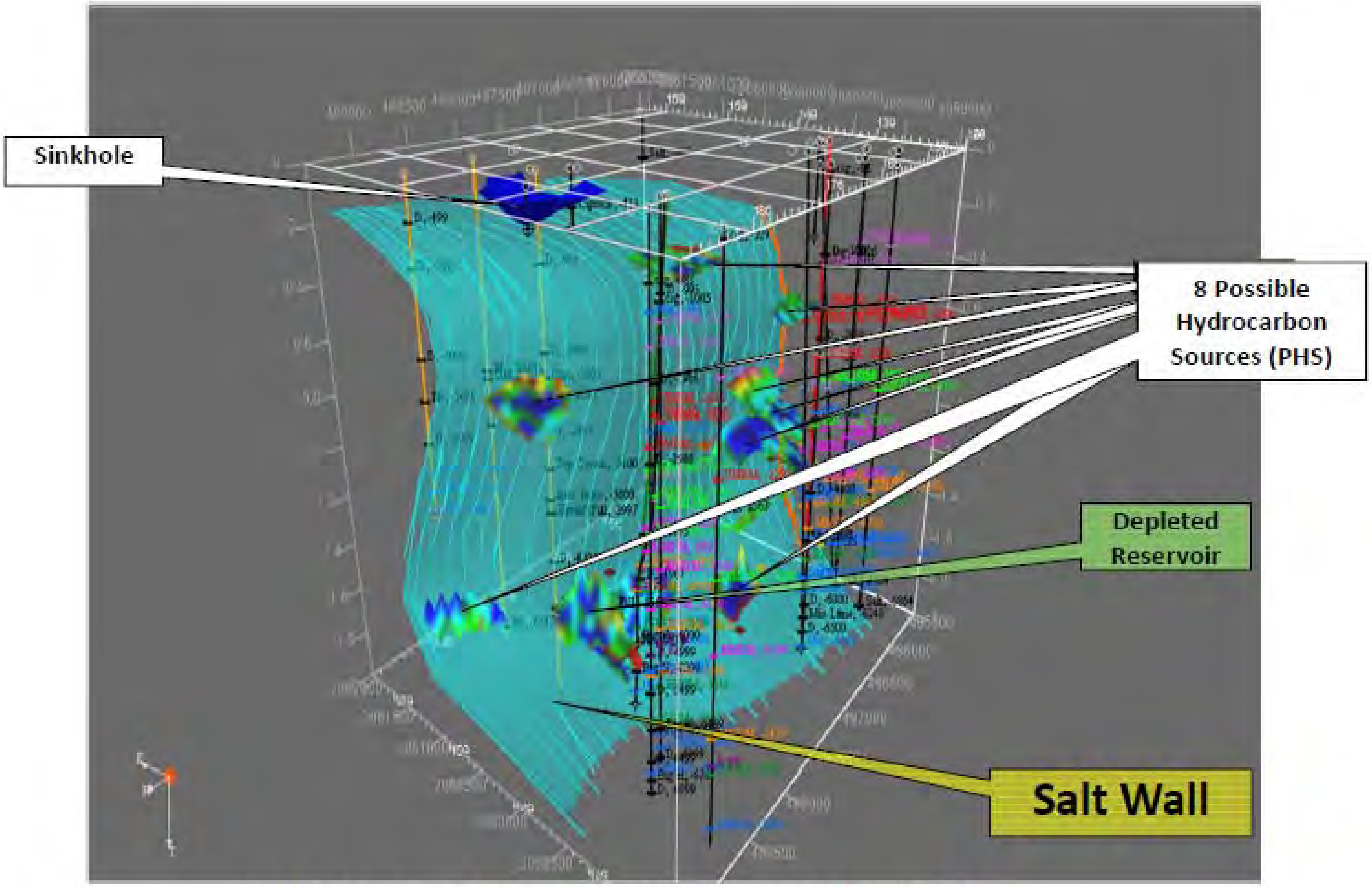
Gas Isotope Evaluation





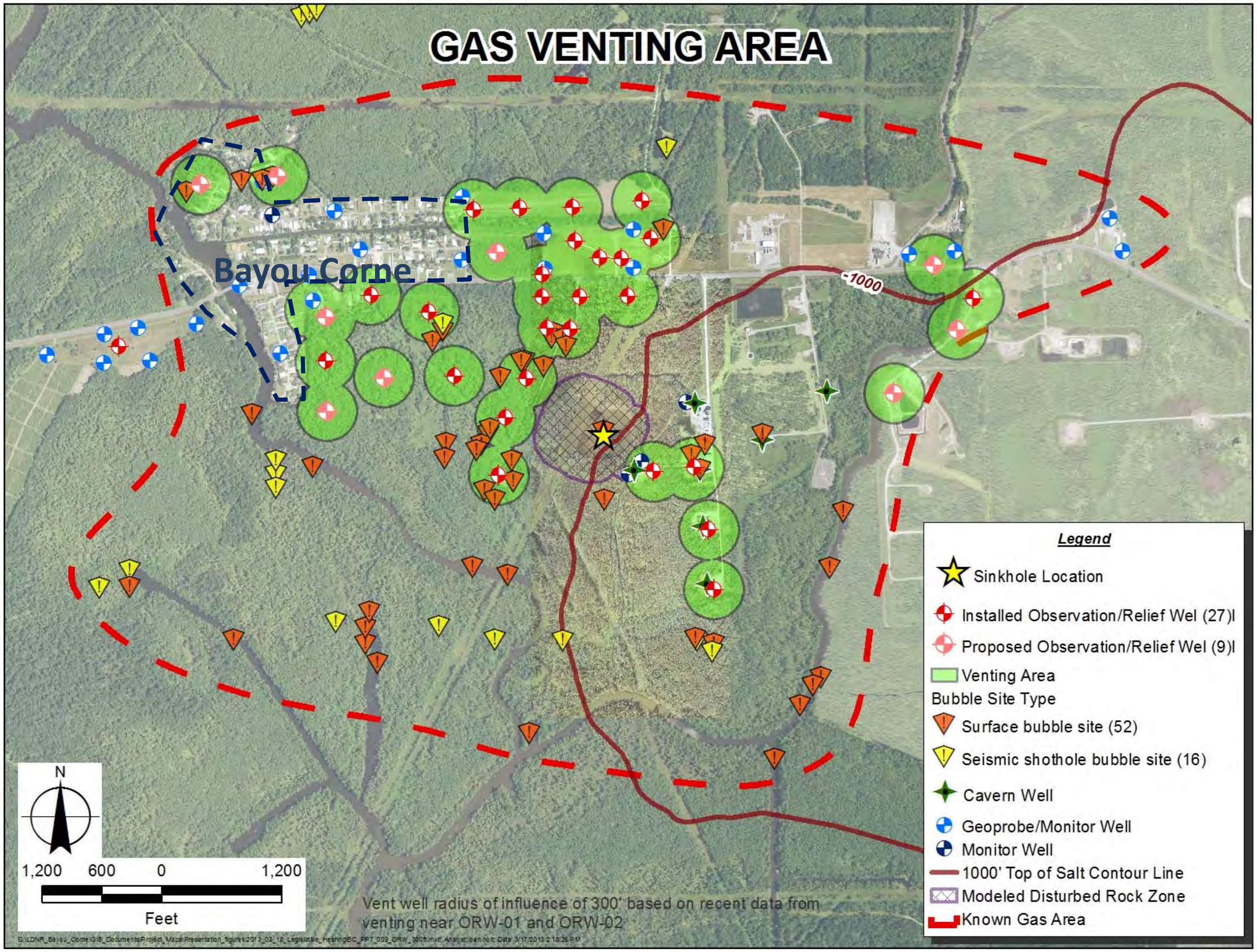
Evaluation by Dr. Jonathan Myers, CB&I

Source Horizons for Gas

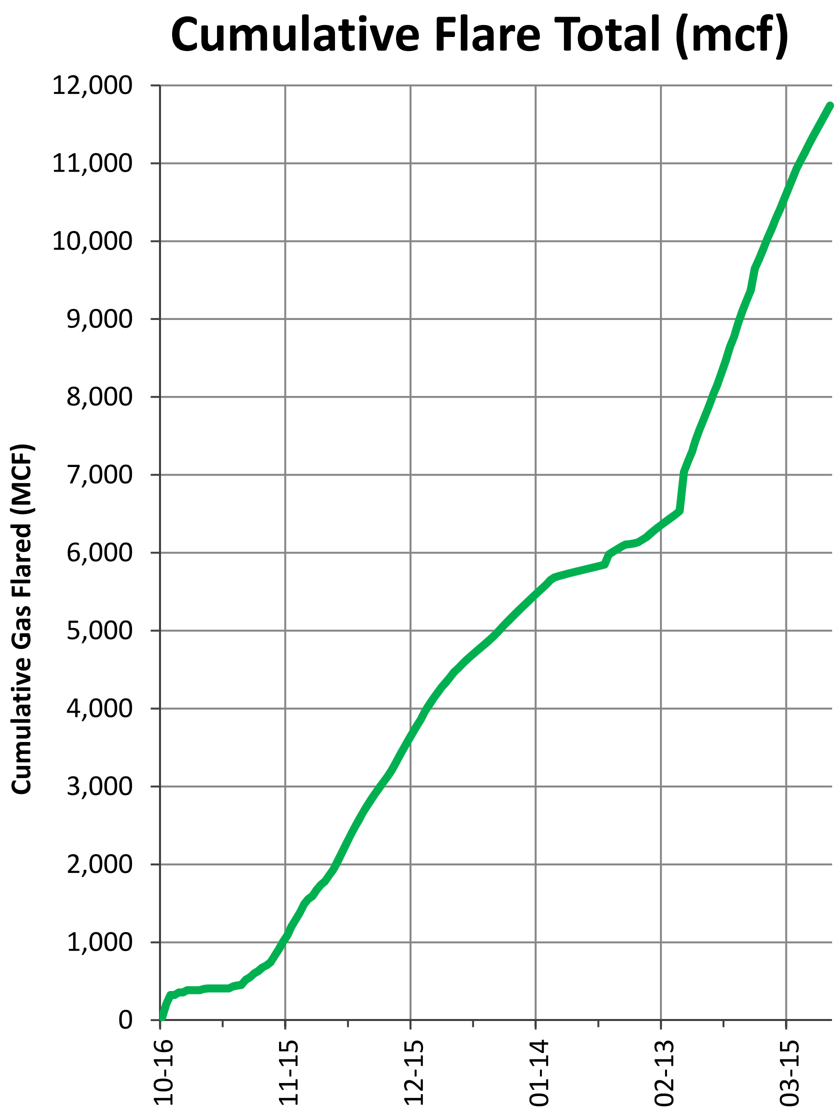


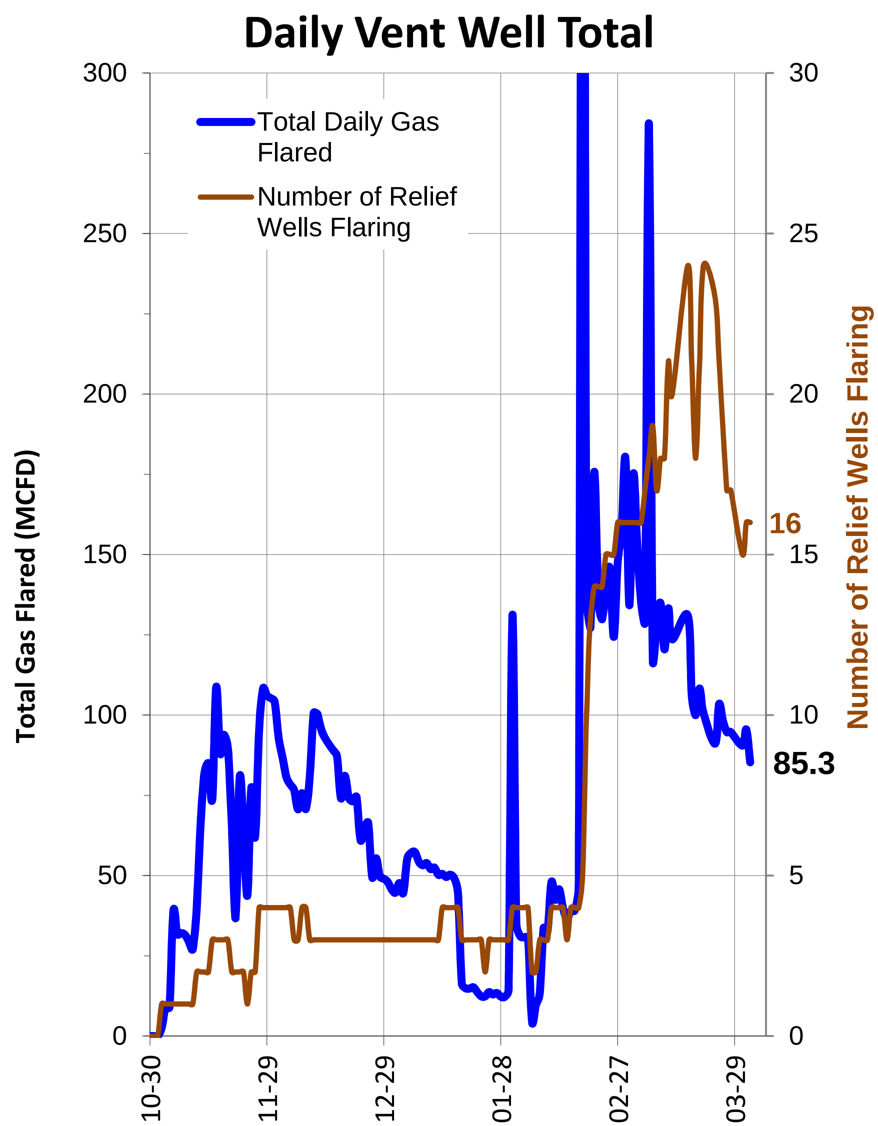
2007 3D seismic interpretation by Don Marlin, CPG

Vent Wells


GAS VENTING AREA
Bayou Corne
-1000
Legend
Sinkhole Location
Installed Observation/Relief Wel (27)l
Proposed Observation/Relief Wel (9)l
Venting Area
Bubble Site Type
Surface bubble site (52)
Seismic shothole bubble site (16)
Cavern Well
Geoprobe/Monitor Well
Monitor Well
1000' Top of Salt Contour Line
Modeled Disturbed Rock Zone
Known Gas Area
N
1,200 600 0 1,200
Feet
Vent well radius of influence of 300' based on recent data from venting near ORW-01 and ORW-02

Vent Well Performance





Next Steps

Ongoing Data Collection/Modeling Activities

1. 2013 3D seismic survey to 7000 feet to image collapse zone and determine potential gas production zones
2. Oxy 3 bottom tag and sonar
3. Final geotechnical analysis of core from 1,000-foot well
4. 3D geomechanical modeling of cavern stability and Oxy 3 collapse
5. Replacement of deep salt seismic array originally installed in Oxy 1
   a) Oxy 1 array had noise issues
   b) TBC with MEQGeo and Magnitude (France) looking at various options for monitoring salt volume between Oxy 1, 2, and 3 caverns
   c) Results of monitoring modeling—mid-April
6. Aquifer test data from new MRAA monitoring wells
7. New sinkhole water quality depth survey
8. Extent of gas investigation
9. Radius of influence testing of ORW wells
10. Basic gas migration model from Dr. Faust (Tetra-Tech)
11. TBC re-logging ORW wells with PDK logs (issue with PDK not showing low gas saturations)
12. Shallow Geoprobe monitoring wells near ORW wells

Known Data Gaps with Ongoing Work in Progress

- Full extent of gas in aquifer being defined
- Rate and mechanics of gas migration from aquifer to shallow subsurface not yet fully understood
- Permeability of aquifer
- Locations of seismic events

Three-Day Workshop

- Late April/early May 2013
- Site visit
- Define technical scope
- Define schedule—will be very aggressive

Bayou Corne Cavern Collapse—An Unprecedented Event