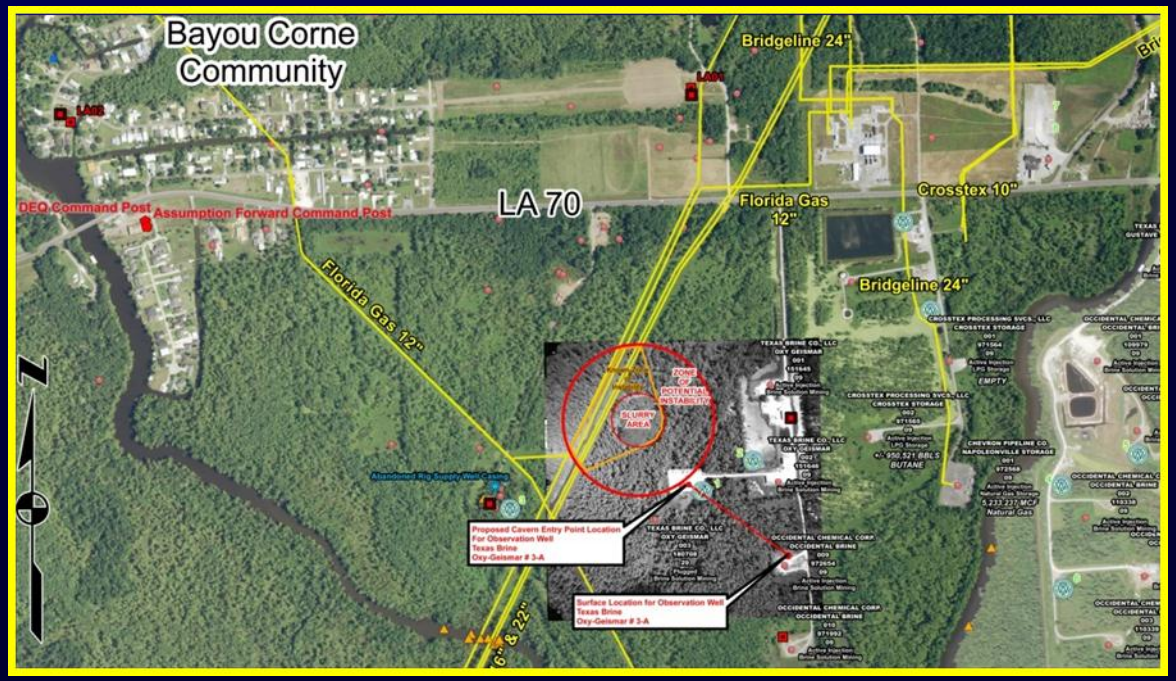
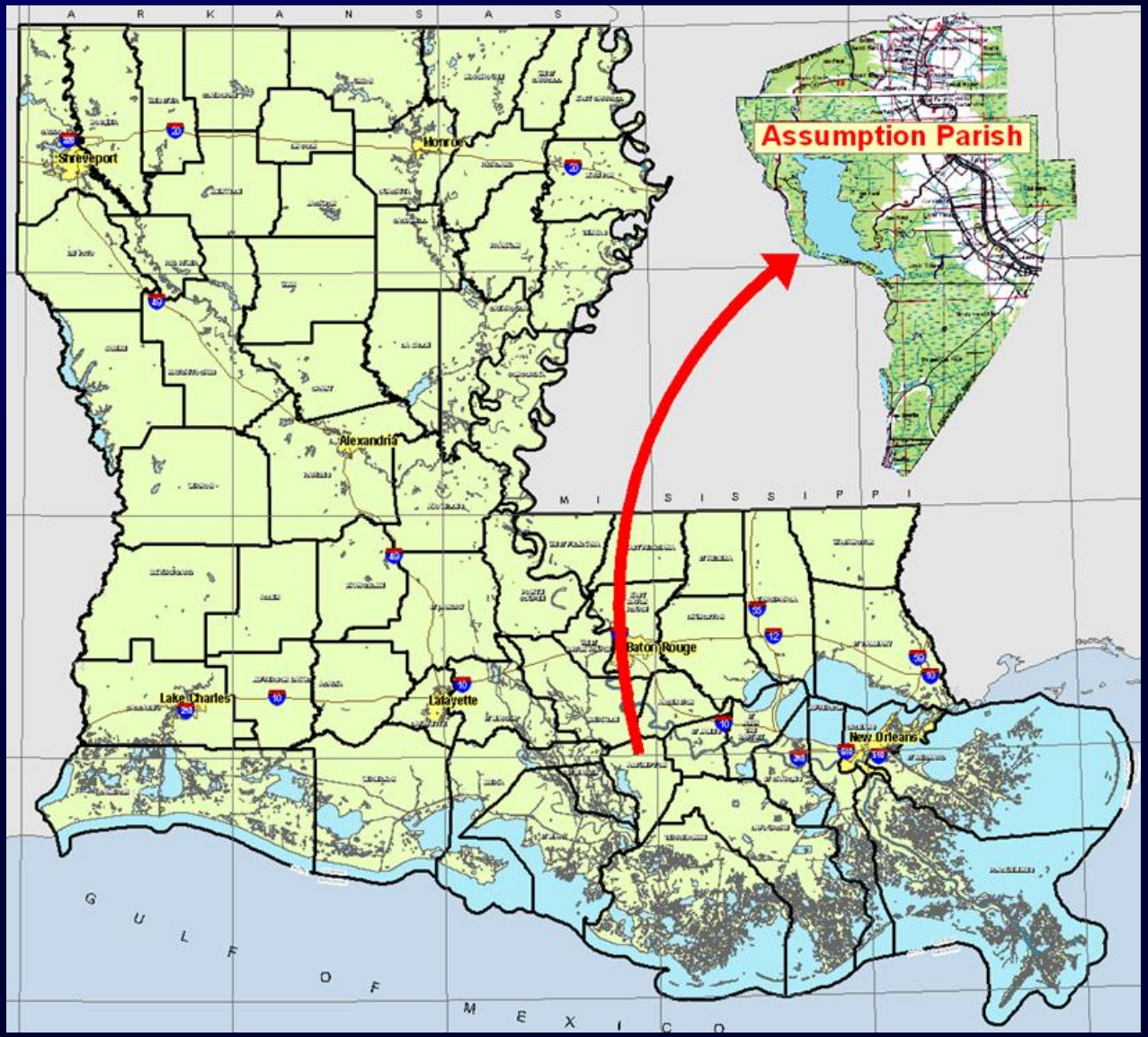
Louisiana DNR
Office of Conservation

Bayou Corne

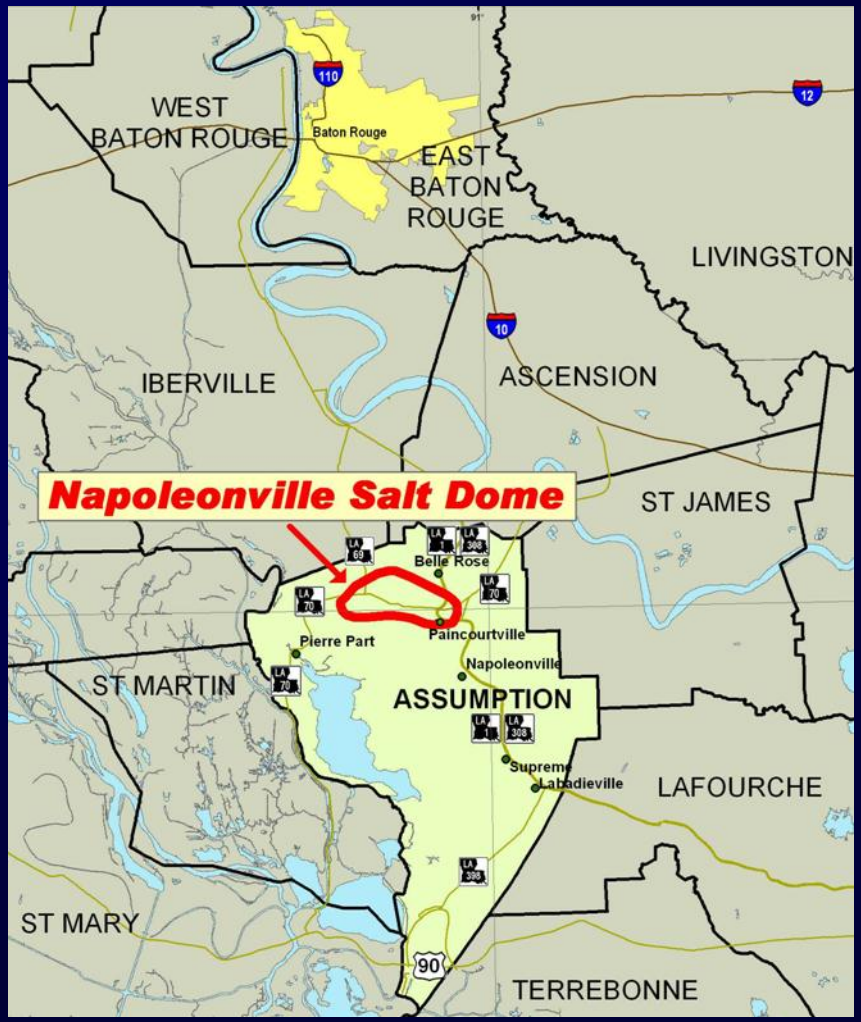
Ongoing Investigation and Response



Assumption Parish



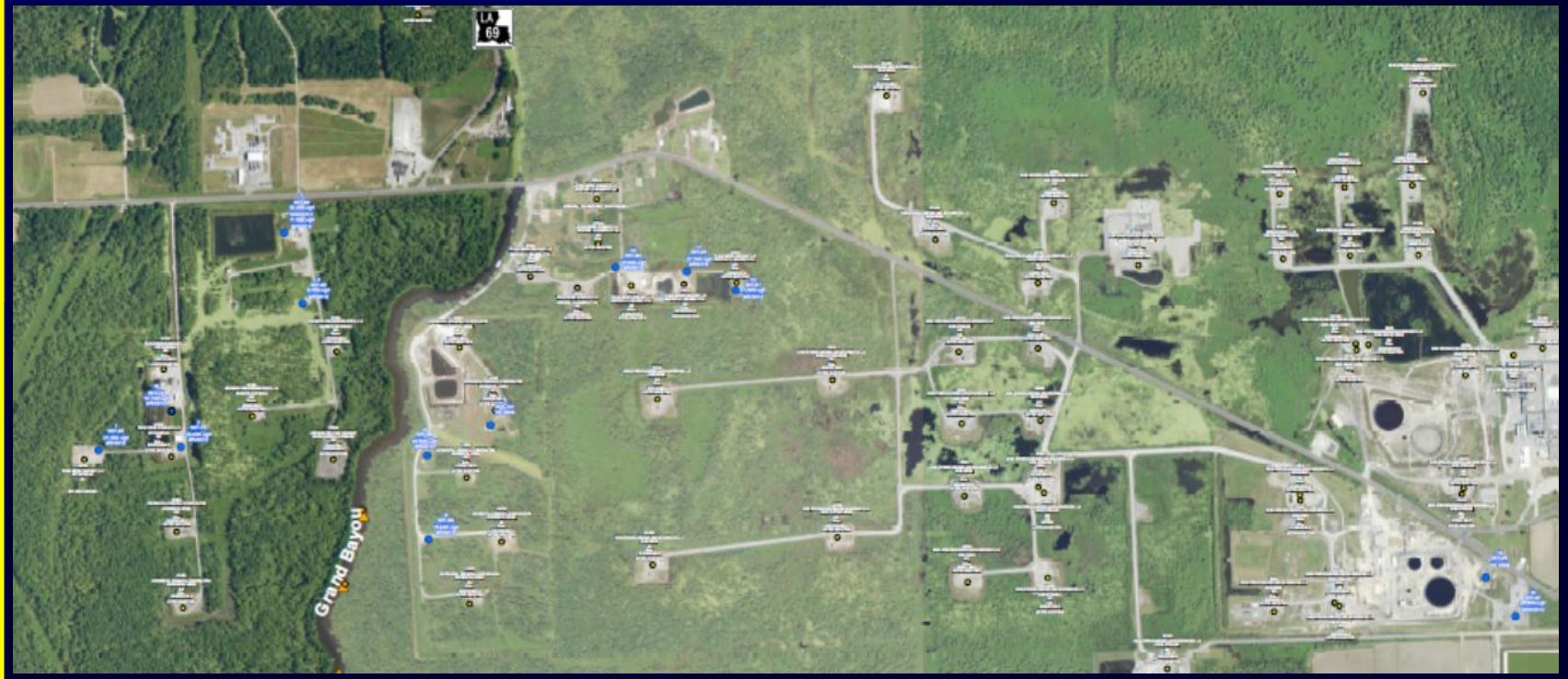
Napoleonville Salt Dome



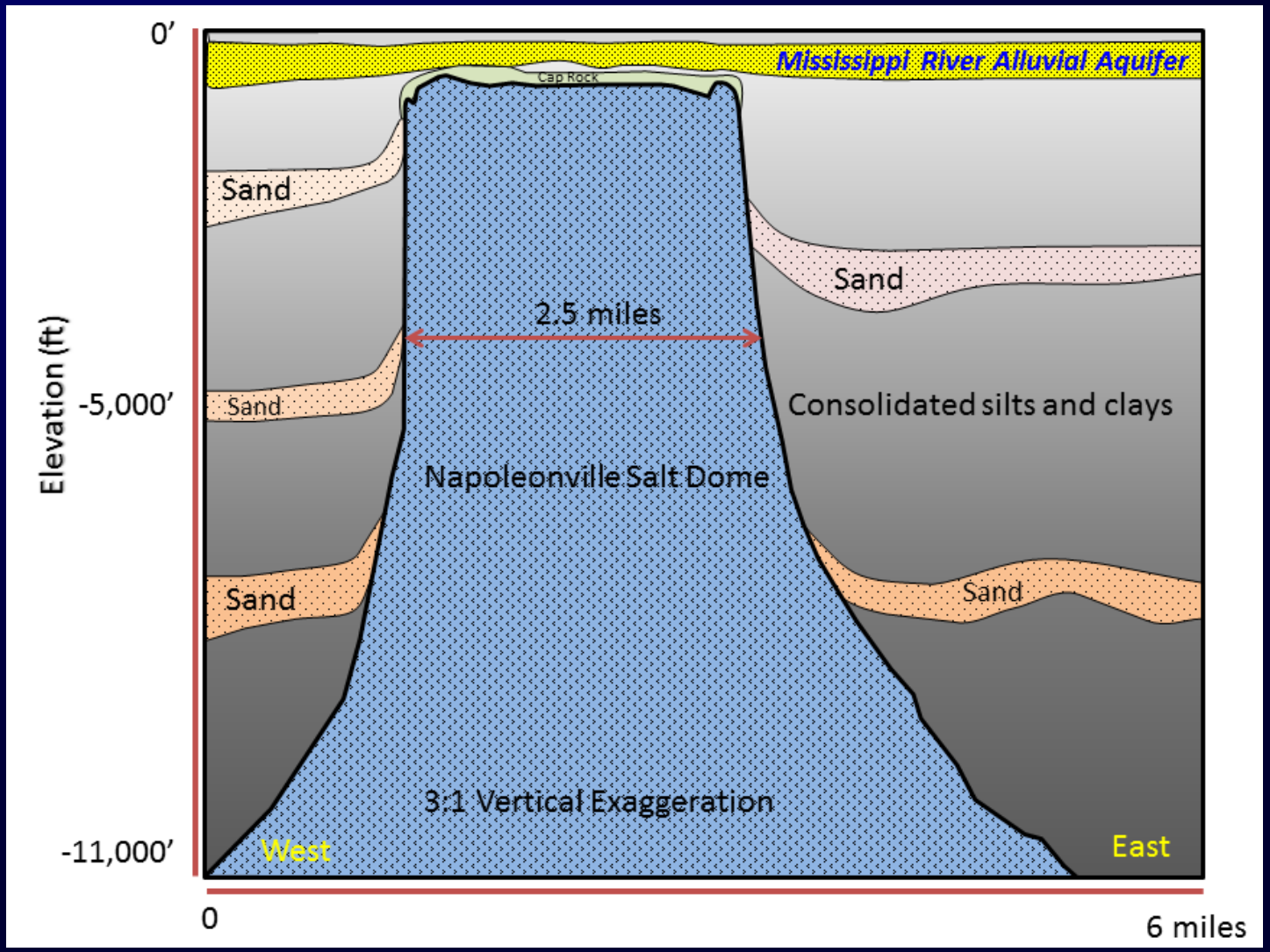
32 miles due south of downtown Baton Rouge

Napoleonville Salt Dome

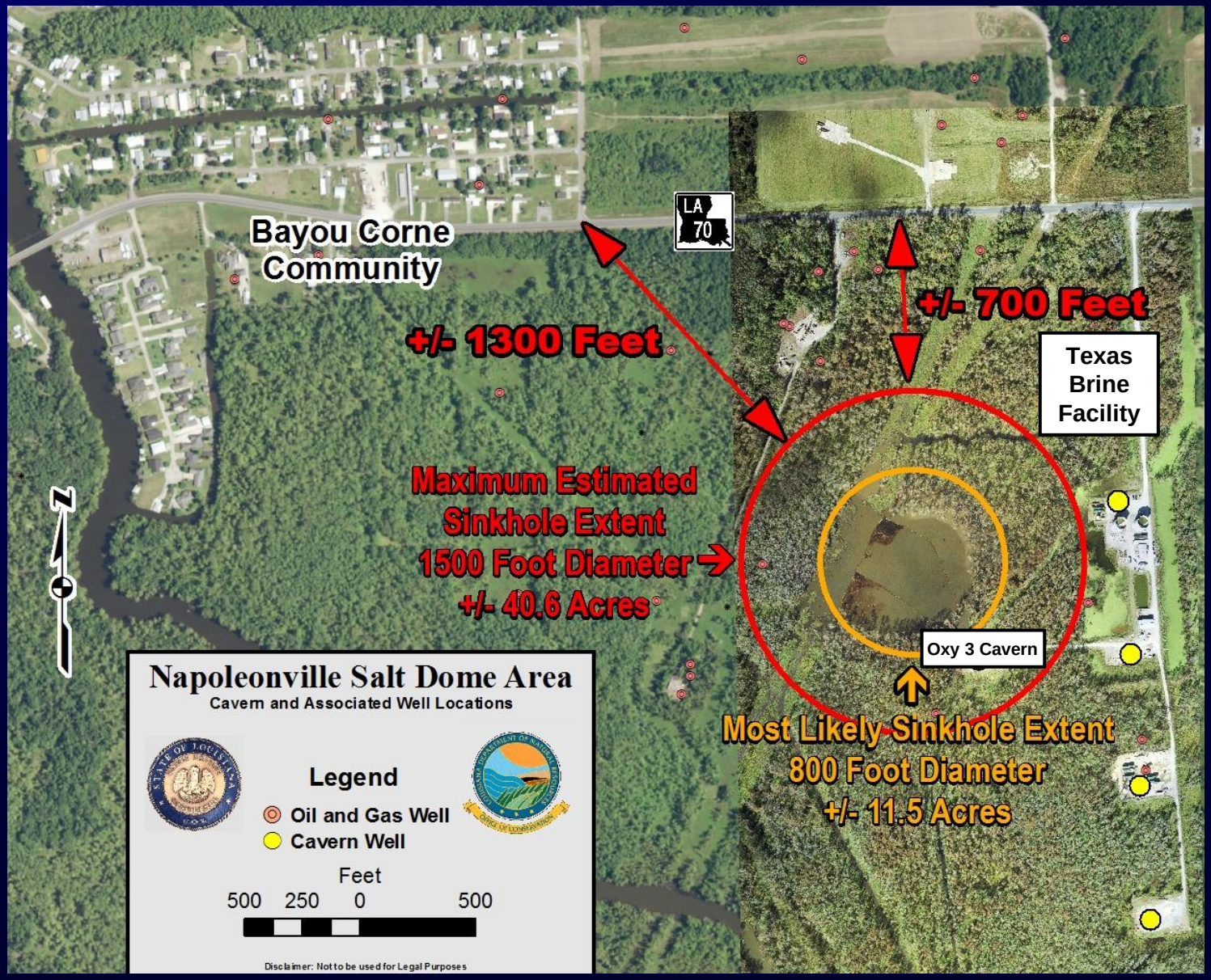
Salt dome operated in area of 1 mile (North-South) by 3 miles (East-West)



Generalized Geology of Napoleonville Salt Dome



Texas Brine Facility/Bayou Corne

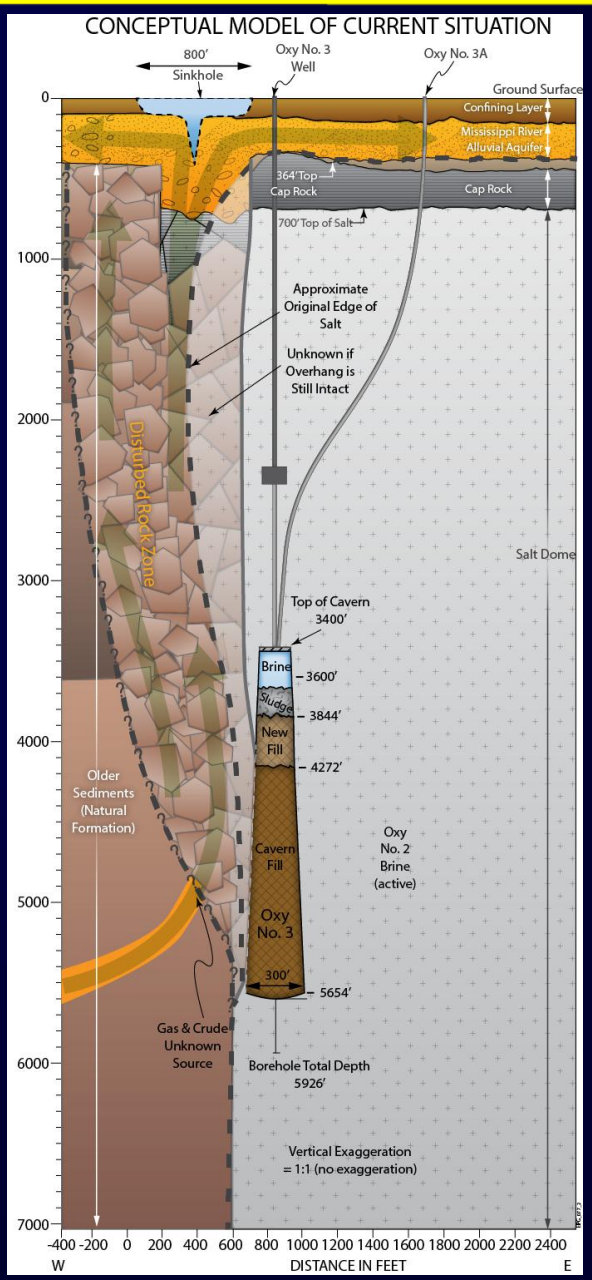


Situation Summary

- Sinkhole – ~ 9 acres – estimated maximum potential size 40 acres
  - Closest potential approach to community estimated at 1,300+ feet
  - Current depth 220 feet – varies over time
- Crude oil on sinkhole surface, coming up from deep formation(s)
- Natural gas in sinkhole, aquifer, shallow soils – 2 sq. miles
- Mandatory evacuation ordered by Assumption Parish still in effect
  - Approx. 150 homes, 350 people affected by order

What Happened?

- Apparent sidewall collapse with pressure from hydrocarbons outside salt dome
- Sidewall collapse of a brine cavern/release of oil and gas to surface unprecedented
- Brine mining cavern was operated near western edge of salt dome – never used for gas storage
- 1 previous brine cavern collapse in state history (1954) – none in modern regulatory era

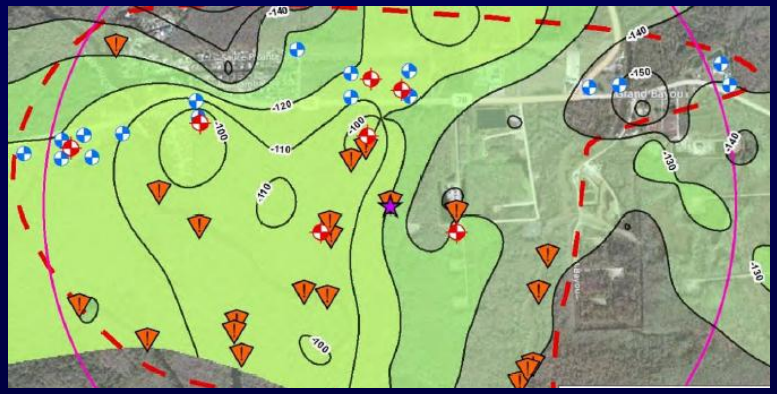


Key Public Safety Issues in Response

Natural gas in aquifer

- Natural gas at pressure in groundwater working up through weak spots to shallow subsurface and surface near community

- Even shallow surface penetrations provide pathway



Key Public Safety Issues in Response

Further extent of subsidence/potential for large gas release

- Possibility of void spaces holding natural gas
- Potential for further subsidence in area

Key Public Safety Issues in Response

Crude oil/contaminants in sinkhole

- Ensuring crude oil or other contaminants do not impact nearby waterways

Key Public Safety Issues in Response

Stability of western side of salt dome

- Determining effect of Texas Brine Oxy 3 cavern failure and damaged rock zone on edge of salt and surrounding caverns

State/Local Agencies Involved

Federal Agencies Involved

- **EPA –provided contaminant detection overflight, site visits, oversight of treatment plans**
- **DOI – provided monitoring equipment and expertise through U.S. Geological Survey**
- **DOE – provided scientific expertise on salt domes and cavern through Sandia National Laboratories, allocated funding to its experts to dedicate effort to Bayou Corne**

Conservation Contractors/Experts

CB&I

ITASCA™

MiSS
Measurement, Pipeline and Storage Solutions, LLC

WHE
WALKER-HILL ENVIRONMENTAL

Shaw

DON J. MARLIN
GEOPHYSICAL
CONSULTANT

PRO-TECH
ENVIRONMENTAL SERVICES

FRANK'S

ISOTECH®
ISOTECH LABORATORIES INC

OGEC
Oil & Gas Evaluations and Consulting, LLC

LSU

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Louisiana Geological Survey
1934

Science Work Group

State and Local Government Participants

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Madhurendu Kumar, PhD	DNR	James Smith	GOHSEP
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Gary Ross, PE	DNR	Jake Causey	DHH
Chris Sandoz, PE	DNR	John Boudreaux	APPJ
Donald Haydel	DNR	Norman Mabile	APPJ
Joe Ball	DNR	John Johnston III	LGS
Laurence Bland	DNR	Chacko John, PhD	LGS
Gary Snellgrove	DNR	Warren Schulingcamp	LGS
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Celeste Bonnecaze	DEQ	Donald Goddard, PhD	LSU
Dutch Donlon	DEQ	Allan Pulsipher, PhD	LSU
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Kevin Davis	GOHSEP	Jeff Nunn, PhD	LSU
Pat Santos	GOHSEP		

Science Work Group

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Jon Kolak	USGS
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Michael LeBlanc	CrossTex Energy
Bobby McDonald	Florida Gas Pipeline
Bob Thoms, PhD	Texas Brine consultant
Joe Ratigan, PhD	Consultant to Oxy
Bill Goodman	Respec
Ted Bourgoyne. PhD	BEI
Boyce Clark, PhD	Arcadis
Brad Barre’	CB&I
Gary Hecox	CB&I
Deborah Saxton	CB&I
Calvin Wiggs	CB&I
Will Pettit	Itasca
Branko Damjanac	Itasca

Contracted by Texas Brine to Meet Conservation Requirements

TETRA TECH

Boone Exploration, Inc.

PRO-TECH ENVIRONMENTAL SERVICES

Michael Pisani & Associates, Inc.
Environmental Consulting Services

GCAL

MEQGeo
Microseismic Consulting and Services

ISOTECH®
ISOTECH LABORATORIES INC

KB Wellbore Solutions, LLC

BAKER HUGHES

Hill Geophysical Consulting
H.G.C.
Integrating Geophysical Technology with Geology

SAGE environmental

RESPEC
CONSULTING & SERVICES

Initial Reporting

- June 11, 2012 – Parish officials and legislators contact Conservation to report bubbling in bayous
  - Officials specifically raise concern about pipelines
  - June 24, Conservation receives reports of tremors in area

Natural Gas Release Triage

Conservation initiates "triage" approach

- Identify highest risk to public safety
  - Proximity and potential impact

- Identify most likely sources
  - Capable of feeding wide range of sites continuously

- Concurrent investigations
  1. Pipelines
  2. Gas Storage Caverns
  3. Active/Inactive Oil and Gas Production Wells

Natural Gas Triage – Pipelines

High volume sources with close proximity to inhabited areas and bubbling sites

Initiated June 11

- Major pipelines identified
- Operators instructed to report status
- Crosstex 36” pipeline excavated
- Pipeline operators de-pressurized to test
- Bubbling sampled for comparison to pipeline gas

No evidence of connection to natural gas bubbling

Natural Gas Triage – Gas Storage Caverns

High volume sources with recent history of 2003 casing pipe leak

Initiated June 12

- Gas storage cavern operations identified
- Operators notified and instructed to report status
- Staff reviewed gas storage cavern integrity tests
- Bubbling sampled for comparison to cavern gas

No evidence of connection to natural gas bubbling

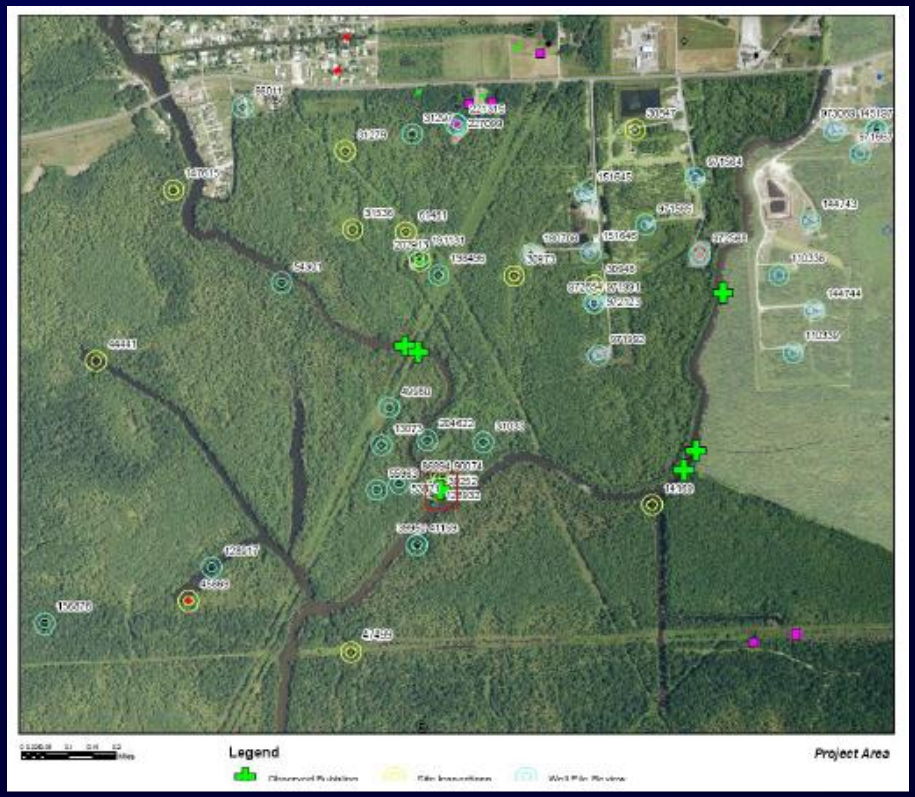
Natural Gas Triage – Oil and Gas Wells

Potential for high volume release – wide geographic spread of potential sources

Initiated June 11

- **Active/inactive wells identified and located**
- **Reviewed records of identified wells**
- **June 28 - Conservation, OEP and DEQ agents inspected well sites**

No evidence of connection to natural gas bubbling



Further Analysis of Available Evidence

Alternative potential sources explored based on available evidence –

- Ongoing bubbling across the area
- Reports of tremors
- Salt formations known to trap oil and natural gas working its way up from deeper formations
- Napoleonville Salt Dome known to release some natural gas during active salt brining

Gathering Data

- July 5 – Conservation contacted USGS on installation of seismic equipment, shared data on local geology and mechanics of salt dome

- July 24 – first land location of bubbling, abandoned rig supply well venting natural gas
  - Top of aquifer in well 107’
  - Agents investigated – contractor hired to excavate

- July 27 – Initiated isotopic (fingerprint) gas analysis plan

Following the Seismic Clues

July 26 – USGS Seismic Points to Western Side of Salt Dome

- All operators on western side notified and advised to take precautions
  - Natural Gas Storage (Chevron)
  - LPG Storage (Crosstex)
  - Brine solution mining operations
- August 1st – Conservation met with Texas Brine (western-most operator) on abandoned cavern "Oxy 3"
  - Texas Brine salt dome expert consultant assessed cavern collapse probability as "exceptionally low"
  - Mechanical integrity sound through productive history
  - Cavern 3,400' feet deep (deeper than any known cavern failure impacting surface in international record)
  - VSP indicated possible sidewall proximity to edge – no previous guidance identifying sidewall as collapse threat
  - Cavern never used for natural gas storage – considered unlikely source to feed widespread bubbling sites

Sinkhole – Immediate Response/Orders

Received report of sinkhole/slurry in early hours of Aug. 3 – by end of day, DNR/Conservation had:

- Issued emergency order to Texas Brine to evaluate Oxy 3 cavern integrity and abate
- Issued orders to pipelines to empty and shut in
- Issued notice to cavern gas storage operators to take precautions
- Formalized Science Work Group and set up meeting at LSU
- Made initial determination of potential area of instability

Emergency declarations by Governor, Conservation and Assumption Parish all still in effect

Continuing Response – Public Safety

- Ongoing testing of ground water (aquifer in area is not potable without treatment, primarily used by industry)
- DEQ testing of air quality in community and around sinkhole – continues to date
- DOTD monitoring Hwy 70 for subsidence – continues to date
- Coordinated with EPA and DEQ on use of EPA plane equipped to detect natural gas and other releases
  - Flight runs on Aug. 25 detected no significant concentrations

EPA's ASPECT contaminant detection plane

Continuing Response - Assistance

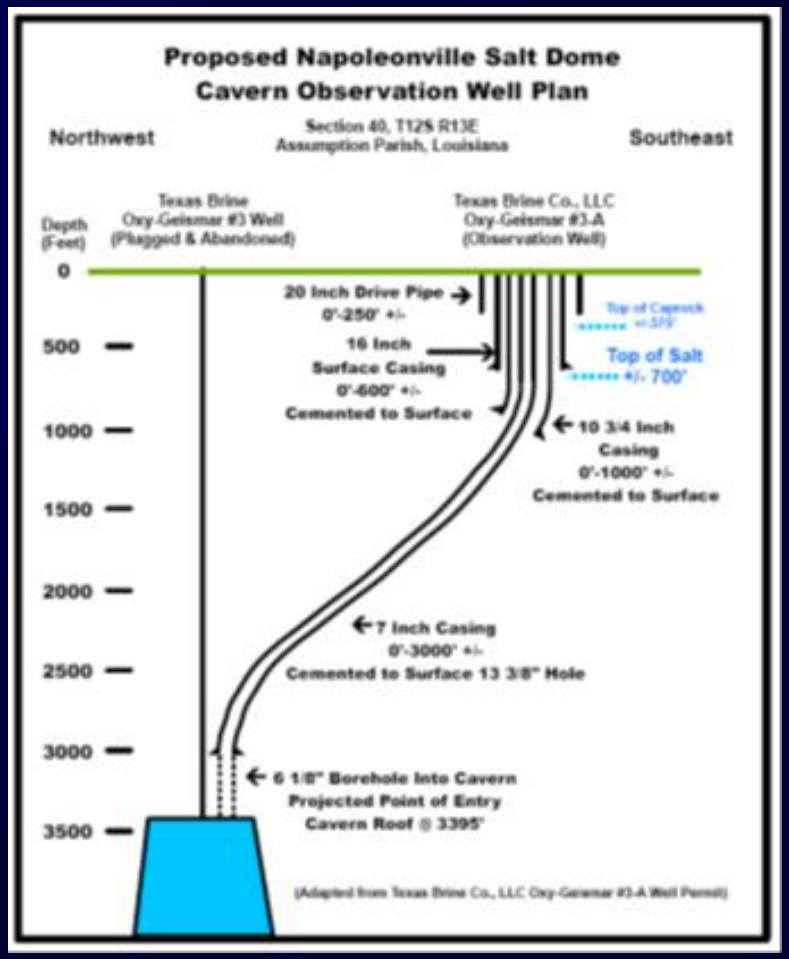
Conservation advised Texas Brine of permit requirement to provide public assistance to residents in the event a sinkhole formed

- **Permit language ties assistance to evacuation order**
- **Formally ordered Texas Brine to provide assistance retroactive to date of evacuation order**
- **Commissioner announces potential penalties for failure to comply with assistance order**

New Stage of Response

Conservation orders Texas Brine to drill investigatory well to determine status of abandoned cavern

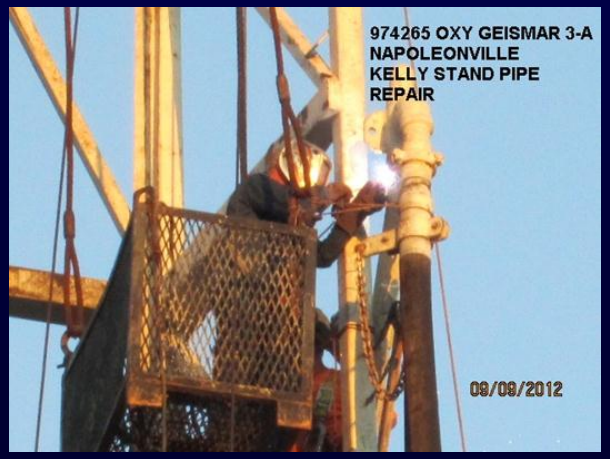
- Science Work Group concurs with need for investigatory well
- Drilling from nearby cavern pad
- S-Curve directional drilling to intersect cavern at top



Drilling the Investigatory Well

Commenced Drilling Aug. 19 – Reached Cavern Sept. 22

- Drilling activity interrupted by Hurricane Isaac Aug. 27-31
- Conservation agents on site 24/7 to ensure safety and efficient operations
- Conservation contractors on site to oversee testing activities



Concurrent Actions

Mid-August:

Pending cavern entry, responsible party, cavern status and links to sinkhole/natural gas release not yet determined

Addressing potential threat to public safety cannot wait

- **Conservation takes direct action to assess natural gas extent and begin venting effort**
- **Mapped top of aquifer to identify gas gathering points**
- **Contracted drillers to assess natural gas near community**

Observation/Vent Wells

Aug. 24 – 1st site identified and driller under contract to drill initial observation well

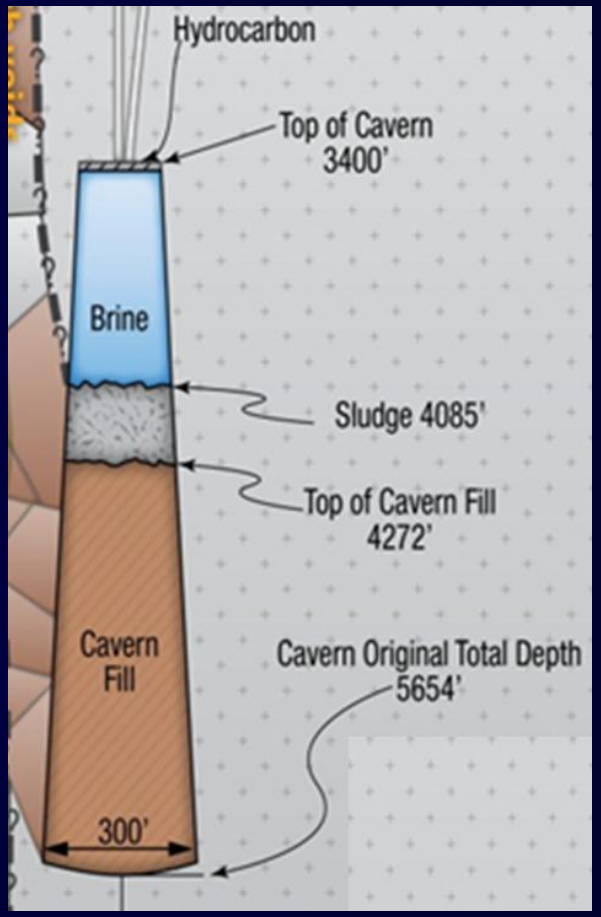
- Delayed by Hurricane Isaac and awaiting landowner access
- Landowner access granted week of Sept. 3, initial test wells drilled the following week
- Shaw E&I contracted to install further observation/vent wells and assist in overall response
- Installed four vent wells with flare systems and 18 shallow monitoring wells

Vent Well Challenges Overcome

- Methane concentrated in top of aquifer silt/clay medium
- Vent well perforations clogged initially, tended to clog again over time
- Landowner access a recurring issue, creates unpredictable periods of delay
- Few contractors respond to RFP – liability concerns due to litigation already initiated
- Wetland environment creates difficulties in reaching key areas, delays due to additional site preparation
- PDK log difficulties

What Was Learned After Cavern Entry

- **Cavern collapsed from side**
  - ¾ filled by outside material
  - Top of cavern intact
- **Natural gas/crude oil found in cavern**
  - Analysis established links to crude oil in sinkhole/natural gas bubbling sites
- **Cavern collapse led to sinkhole and created path for natural gas/crude oil to surface**
  - Analysis of crude oil/natural gas samples
  - USGS reports cavern collapse caused seismic activity



Conservation Orders Following Cavern Entry

Six further amendments/revisions issued, increasing in complexity and specificity required to achieve results, along with two notices of civil penalty totaling $260,000 – *Sense of urgency needed!*

Aug. 9, 2012 – Drill re-entry well, associated sampling of cavern contents

Sept. 25, 2012 – Provide all data/samples collected from cavern/sinkhole/bubbling

Oct. 11, 2012 – Install vent and monitor wells, upgrade seismic array, assess geophysical conditions using 3D seismic or other means

Nov. 12, 2012 – Home monitoring & ventilation, additional vent and monitor wells, sinkhole containment

Dec. 1, 2012 – $100,000 in fines issued for failure to comply with home monitoring/ventilation, vent well, containment directives

Dec. 7, 2012 – Two 6,000-foot wells for geophysical assessment by August 2013, seismic array near Oxy 3, chloride monitoring wells for middle and base of aquifer, assess and monitor Oxy 1 & 2 stability

Dec. 17 – $160,000 in fines issued for failure to comply with home monitoring/ventilation, containment directives

Jan. 14, 2013 – Revise means of geophysical assessment to 3D seismic delivered by April 21, addition of one 1,000-foot seismic monitoring well outside salt

Where The Effort Stands Today

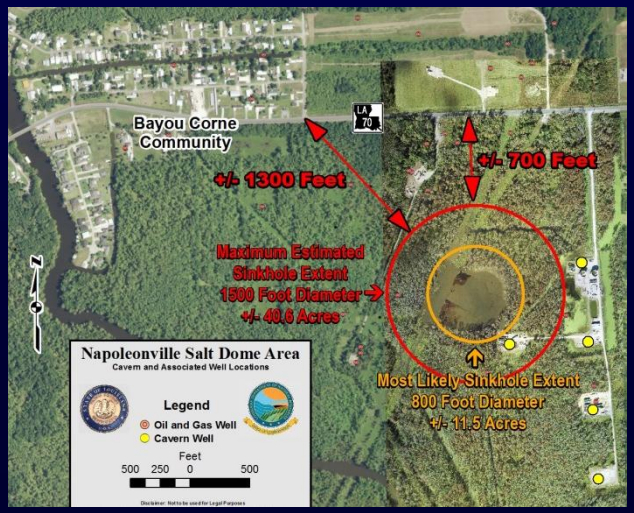
Remove methane from aquifer/ensure community safety

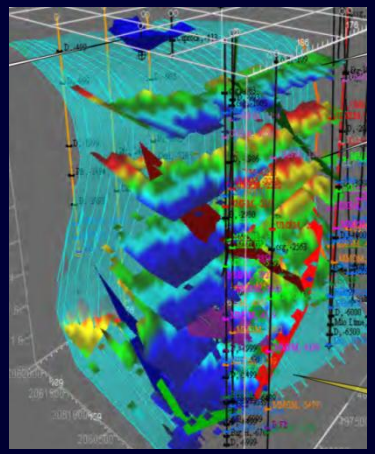
- 15 vent wells installed to flare natural gas from aquifer
- 11 additional vent wells planned
- 27 pressure monitoring wells installed
- 53 indoor methane/H2S monitors installed in 21 structures in community

Where The Effort Stands Today

Determine potential for further subsidence and gas release

- CB&I and Itasca modeling of disturbed rock zone
- 3-D seismic to provide source of gas/image of potential void spaces that could contain gas
- Ongoing monitoring of dimensions and growth of sinkhole
- Collection of core samples from 1,000-foot geophysical well to inform rock modeling





Where The Effort Stands Today

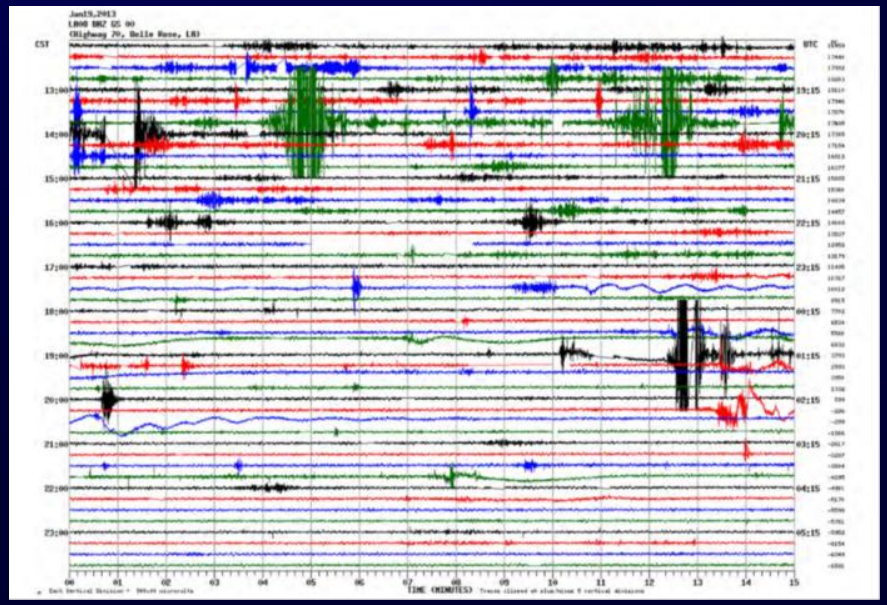
Contain crude oil in sinkhole

- Boom in place around sinkhole
- Containment berm south and west boundaries 90 percent complete, north boundary 60 percent complete, east boundary is Texas Brine facility road
- Monitoring changes in sinkhole walls and subsidence area

Where The Effort Stands Today

Evaluate stability of western side of salt dome

- 3-D seismic to aid in assessment of stability
- Vertical seismic profiles of nearby caverns
- Ongoing seismic monitoring and subsidence study
- Continuous pressure monitoring of caverns on west side of dome



Activity Since Fines and Revised Directive

Installed 11 vent wells and begun flaring 9 wells

Provided plans for 15 more vent wells (total of 26 installed/proposed to date)

Installed 53 indoor monitoring sets

Established initial berms for sinkhole containment

Begun surveying for 3D seismic

Public Awareness and Involvement

- Participated in 14 public meetings in Assumption
- Provided responses to more than 250 questions submitted by citizens
- Established web site to provide reports and data to inform on all aspects of response
- Providing field updates through Assumption Parish blog
- Daily presence at worksites in and near community

Path Forward

- Continue effort to expedite property access and vent well installation
- Collection of 3D seismic data to inform subsurface modeling and direct further response action
- Completion of permanent sinkhole containment structure
- Continue monitoring of seismic arrays and nearby cavern conditions
- Continue to make information on developments and response available to the public

Continuing Commitment

- DNR/Office of Conservation is committed to providing all necessary staff and resources to this situation until problems resolved
- You are always welcome to contact us with concerns and questions
- Information is made available on our website

http://dnr.louisiana.gov/