RAILROAD COMMISSION OF TEXAS

WORKSHOP

PRODUCED WATER MANAGEMENT IN SHELBY, PANOLA, AND HARRISON COUNTIES

PETROLEUM-ENGINEERING STUDY OF THE CARTHAGE GAS FIELD, PANOLA COUNTY, TEX.

BY C. J. WILHELM, H. M. HARRIS, AND M. N. HARLIN

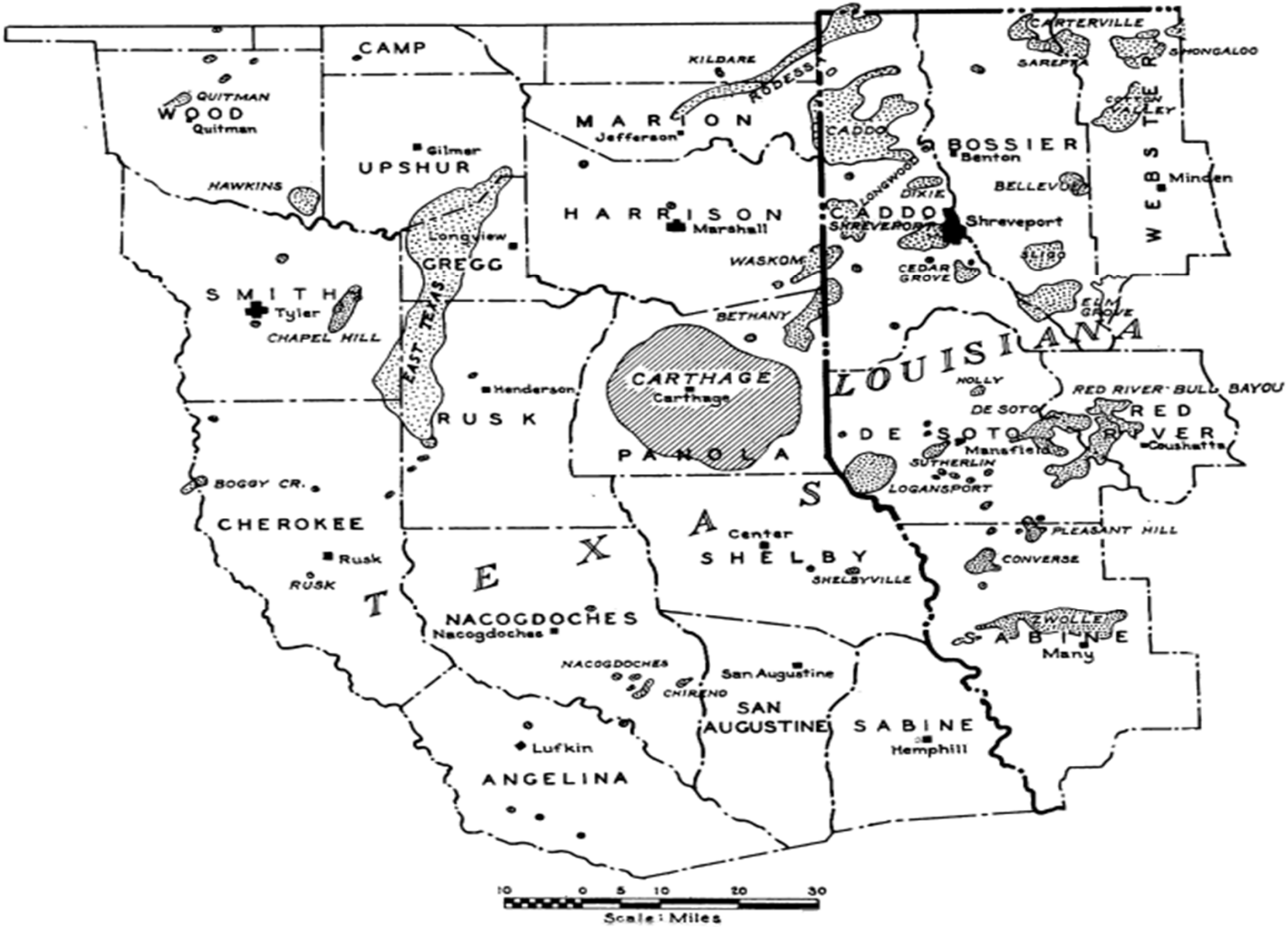
* * * * * * * * * **Report of Investigations 4698**

UNITED STATES DEPARTMENT OF THE INTERIOR
Oscar L. Chapman, Secretary
BUREAU OF MINES
James Boyd, Director

Work on manuscript completed January 1950 . The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is made: "Reprinted from Bureau of Mines Report of Investigations 4698."

August 1950

East Texas and Northwest Louisiana Oil and Gas Fields



An engineering study has been made by Bureau of Mines engineers, with the ultimate objective of arriving at an estimate of the gas reserves, by application of the data made available by the operators in the Carthage field. During World War II the Bureau of Mines submitted a restricted petroleum-engineering report on the Carthage field to the Petroleum Administration for War, at which time (March 1944) the development consisted of only 19 producing wells, 7 of which were dual completions. Because of the restricted nature of the first report and the limited development at the time of writing, a more complete investigation and subsequent publication was considered advisable.

The Carthage field can be considered the fourth largest gas reserve in the United States, insofar as reserves developed to January 1, 1948, are concerned. An estimate of the original gas reserves of the Carthage reservoirs considered in this report and measured at 14.4 p.s.i.a. and 60° F. are:

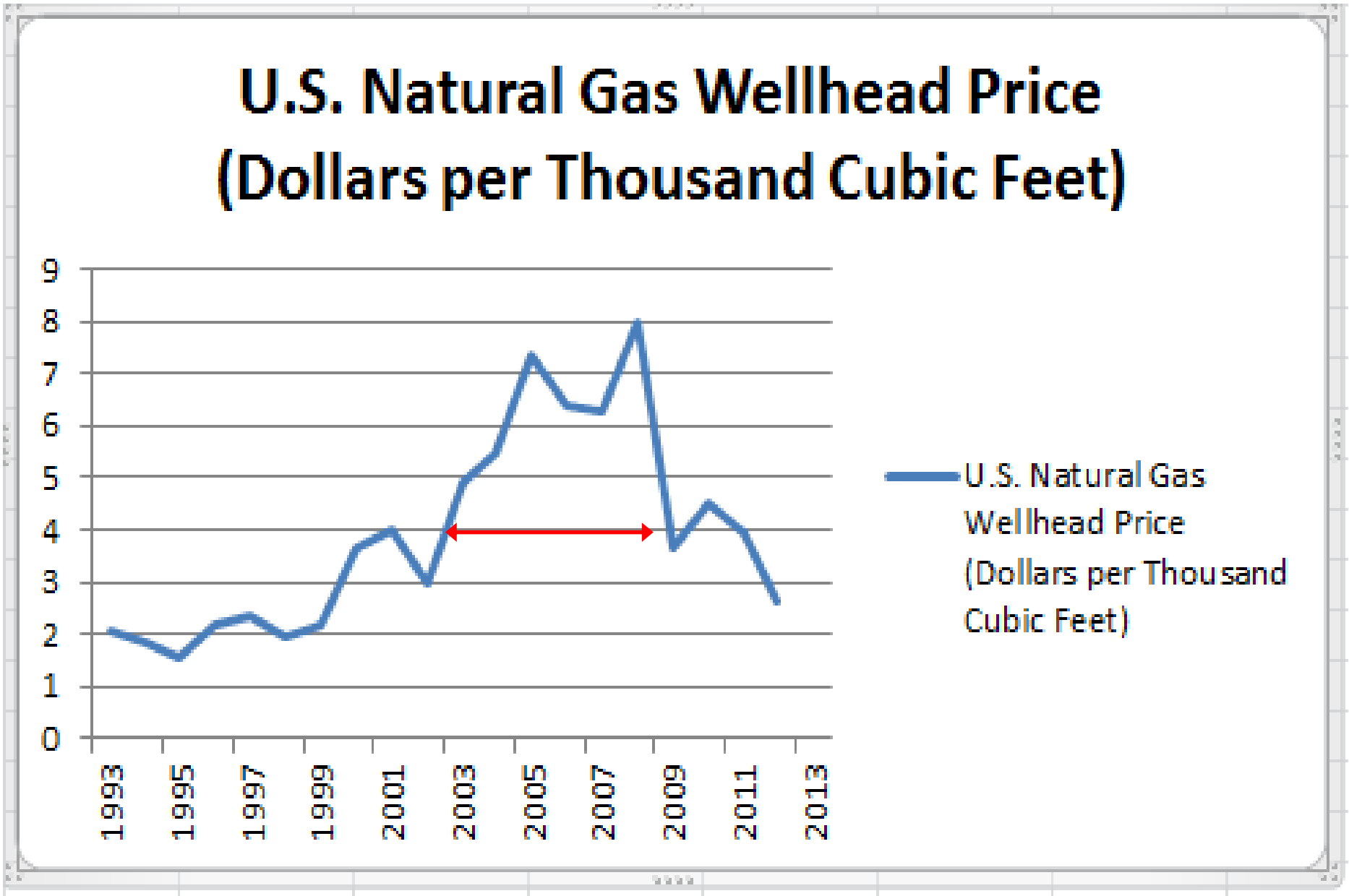
0.165 trillion cubic foot in the Hill reservoir.

2.395 trillion cubic foot in the Upper Pettit reservoir.

5.044 trillion cubic foot in the Lower Pettit reservoir.

The total estimated gas reserve of the Carthage field is 7.604 trillion cubic foot.

The above estimates do not include the reserves available in the Travis Peak zone or the southern Hill reservoir, as these reservoirs were not included in this study; the Travis Peak and southern Hill reserves are small in comparison with the other three.


U.S. Natural Gas Wellhead Price
(Dollars per Thousand Cubic Feet)
9
8
7
6
5
4
3
2
1
0
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
U.S. Natural Gas Wellhead Price (Dollars per Thousand Cubic Feet)

Timeline Carthage Field

- Over 12,000 wells drilled in Panola County
- Over 7,000 wells currently on schedule
- 821 mi.^{2} – over 14 wells/mi.^{2}
- Pettit – 1942; 5,628’; over 250 BCF
- Travis Peak – 1943; 6,243’; over 450 BCF
- Cotton Valley – 1960; 9509’, over 5 TCF
- Haynesville – 2009; 10,529’, over 1.5 TCF

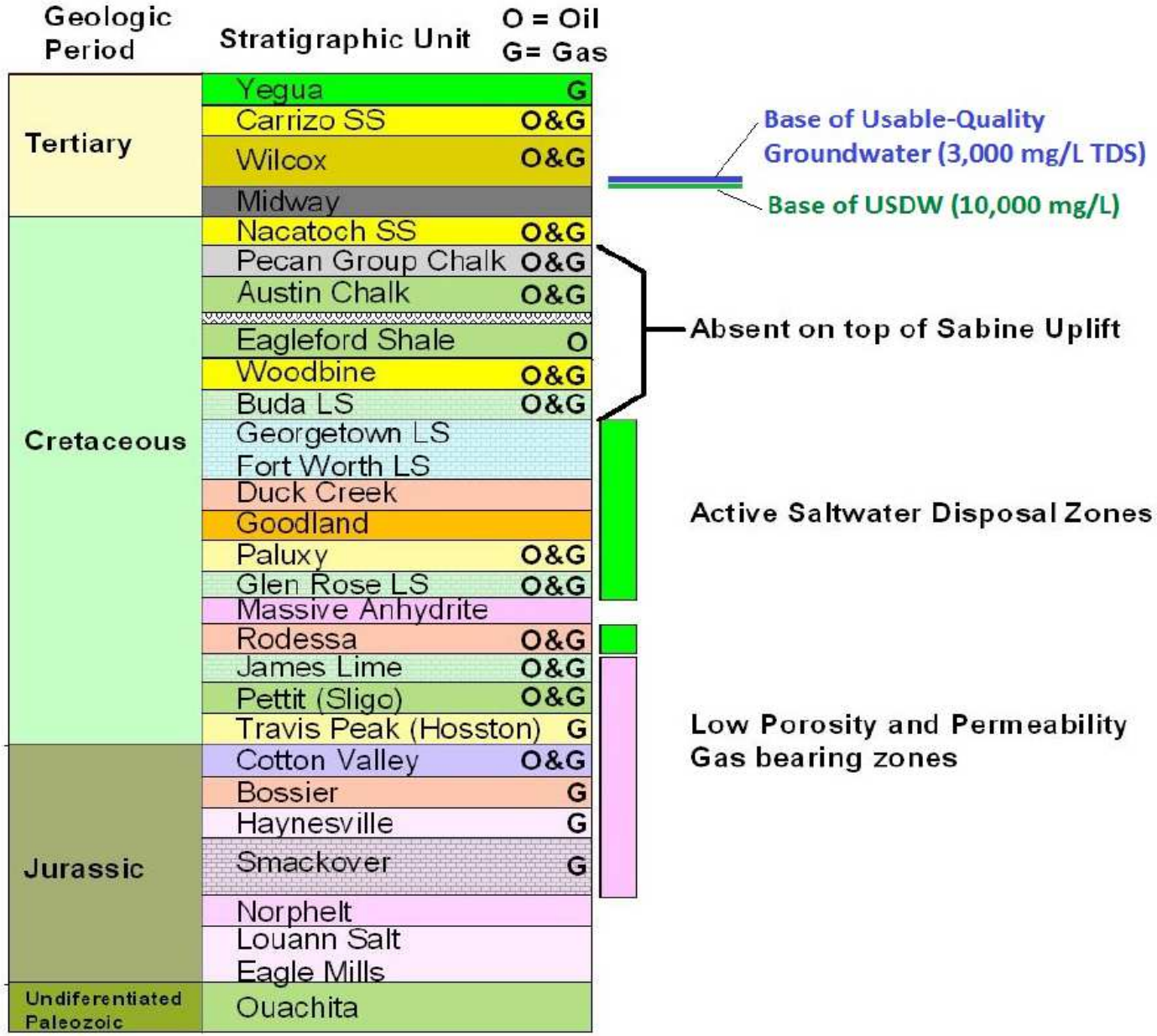
Regulatory Concerns

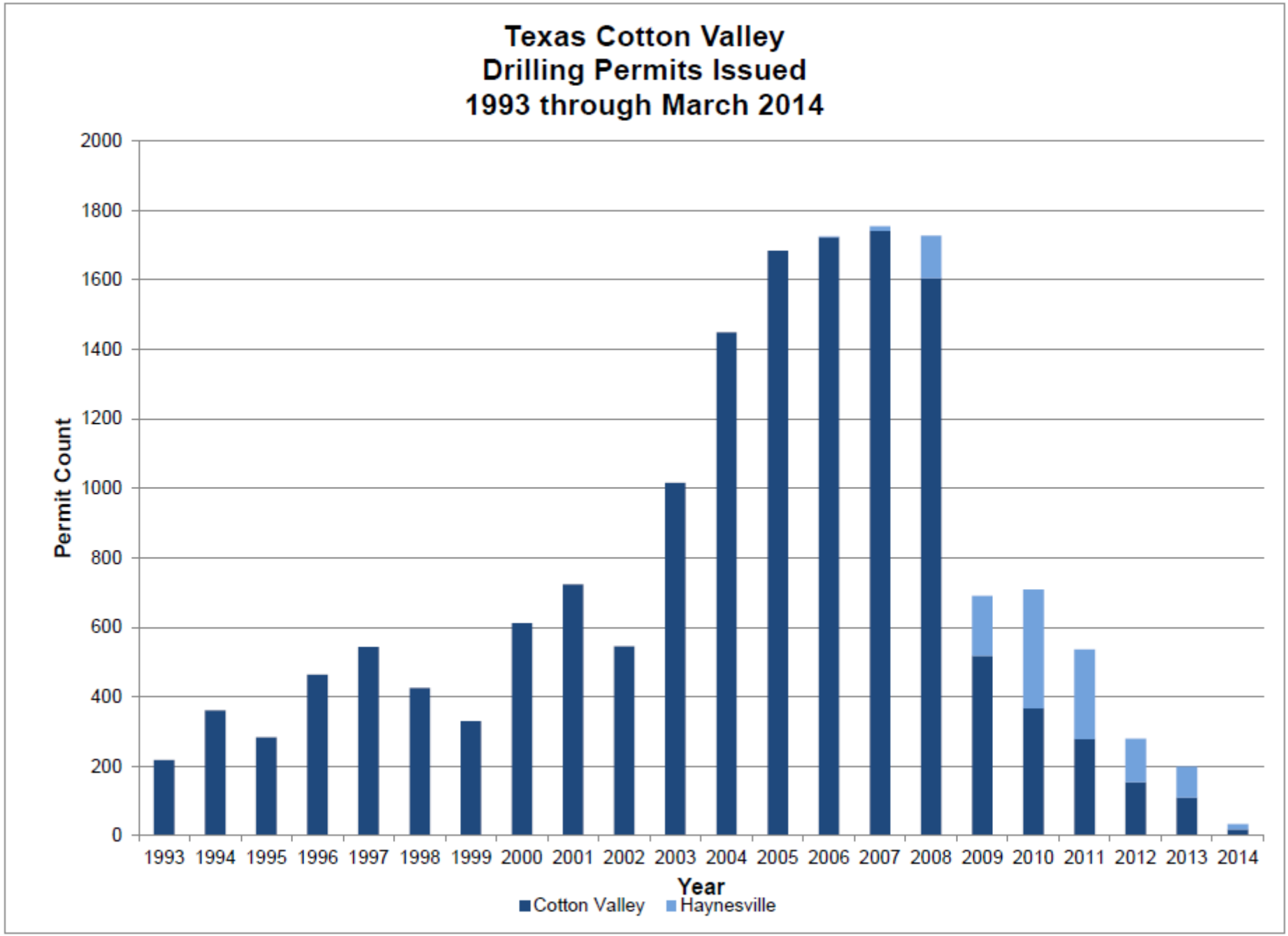
- Problem Statement:

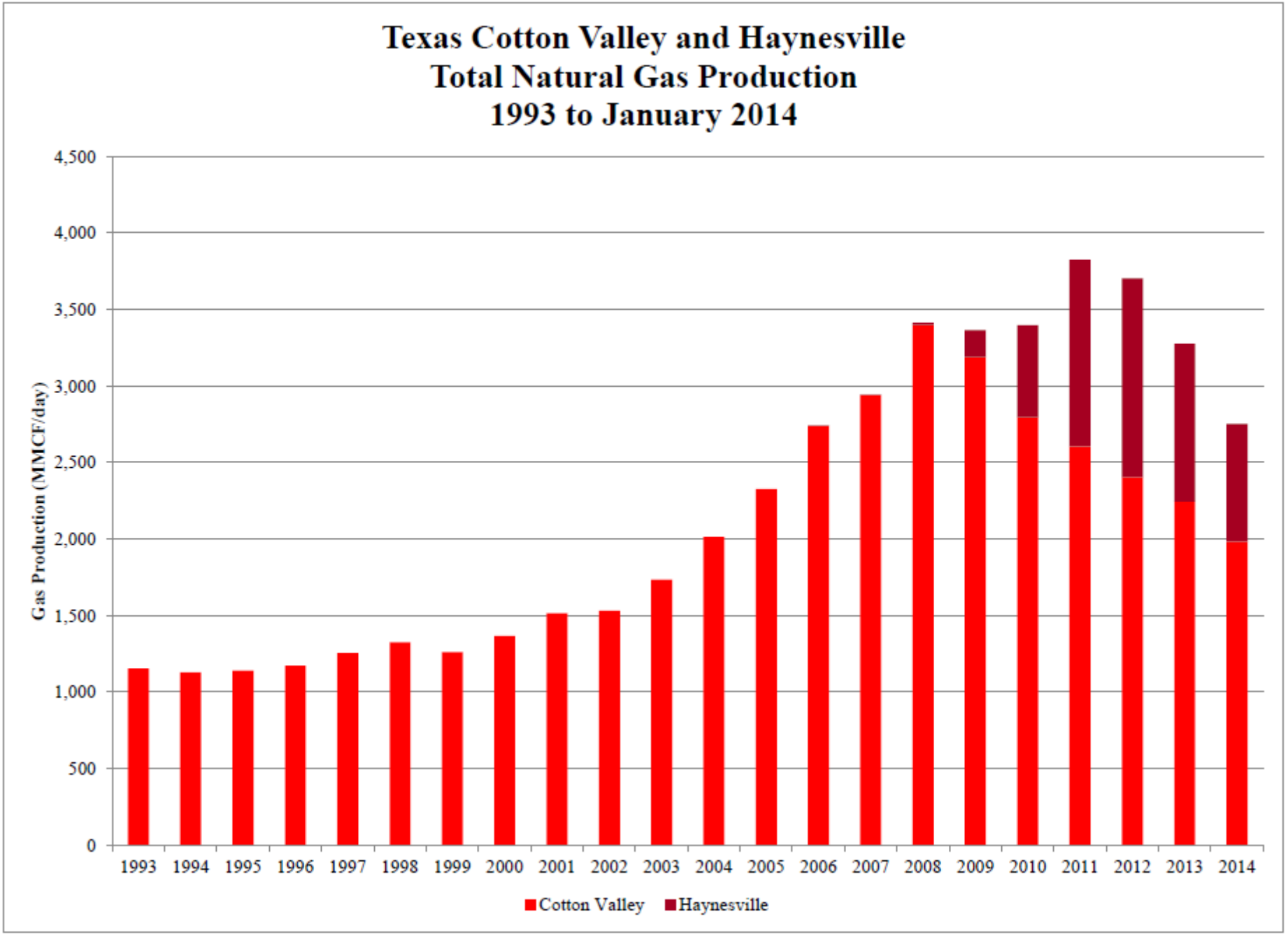
  There has been a stark increase in demand for disposal capacity beginning around 2003. There is a need to evaluate wastewater disposal alternatives to ensure ongoing groundwater protection.

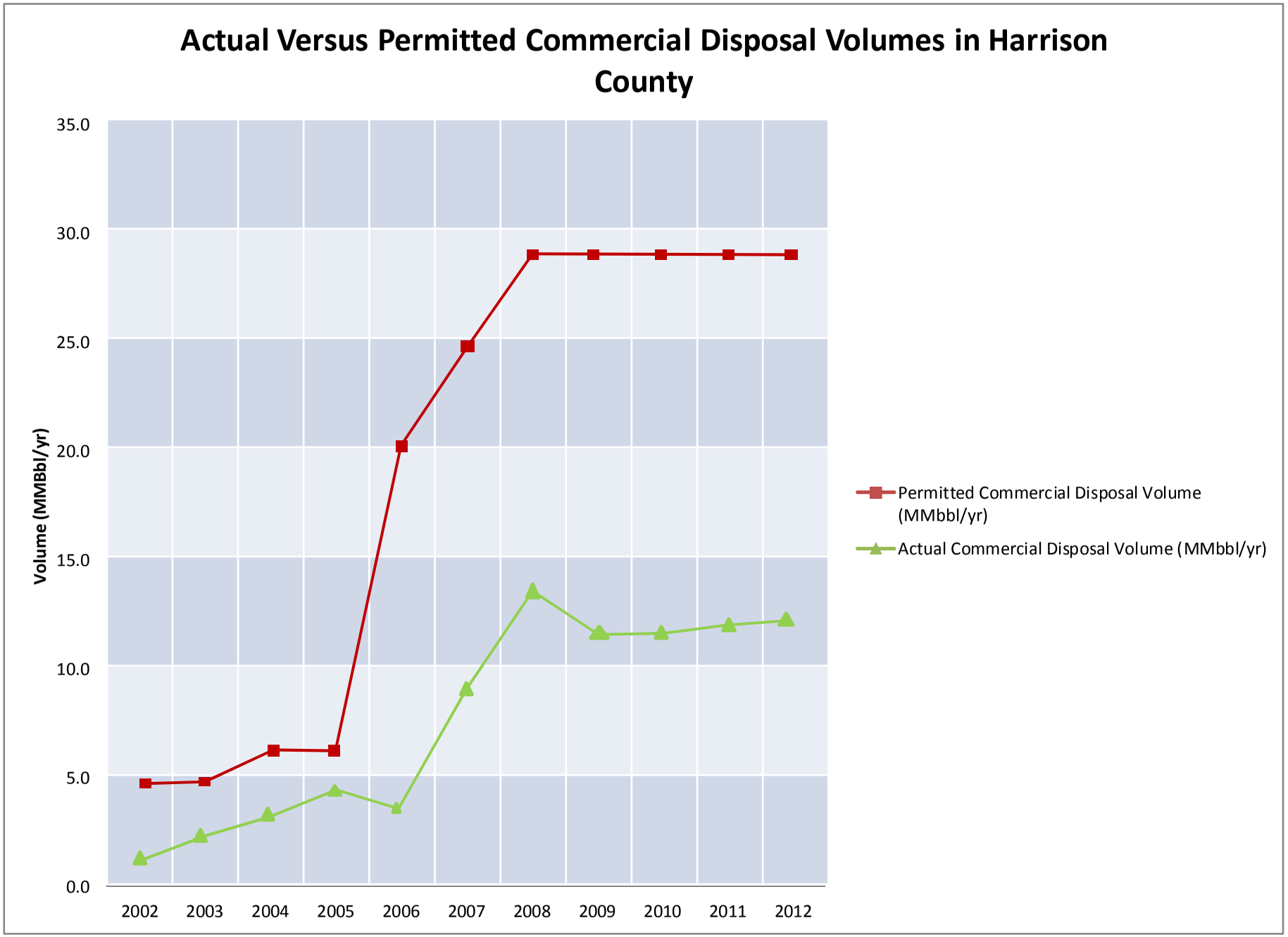
- Geologic Setting:
  - Brief development history
    - Pettit
    - Travis Peak
    - Cotton Valley
    - Haynesville/Bossier
  - Geologic data
    - Sabine Uplift
    - East Texas Basin

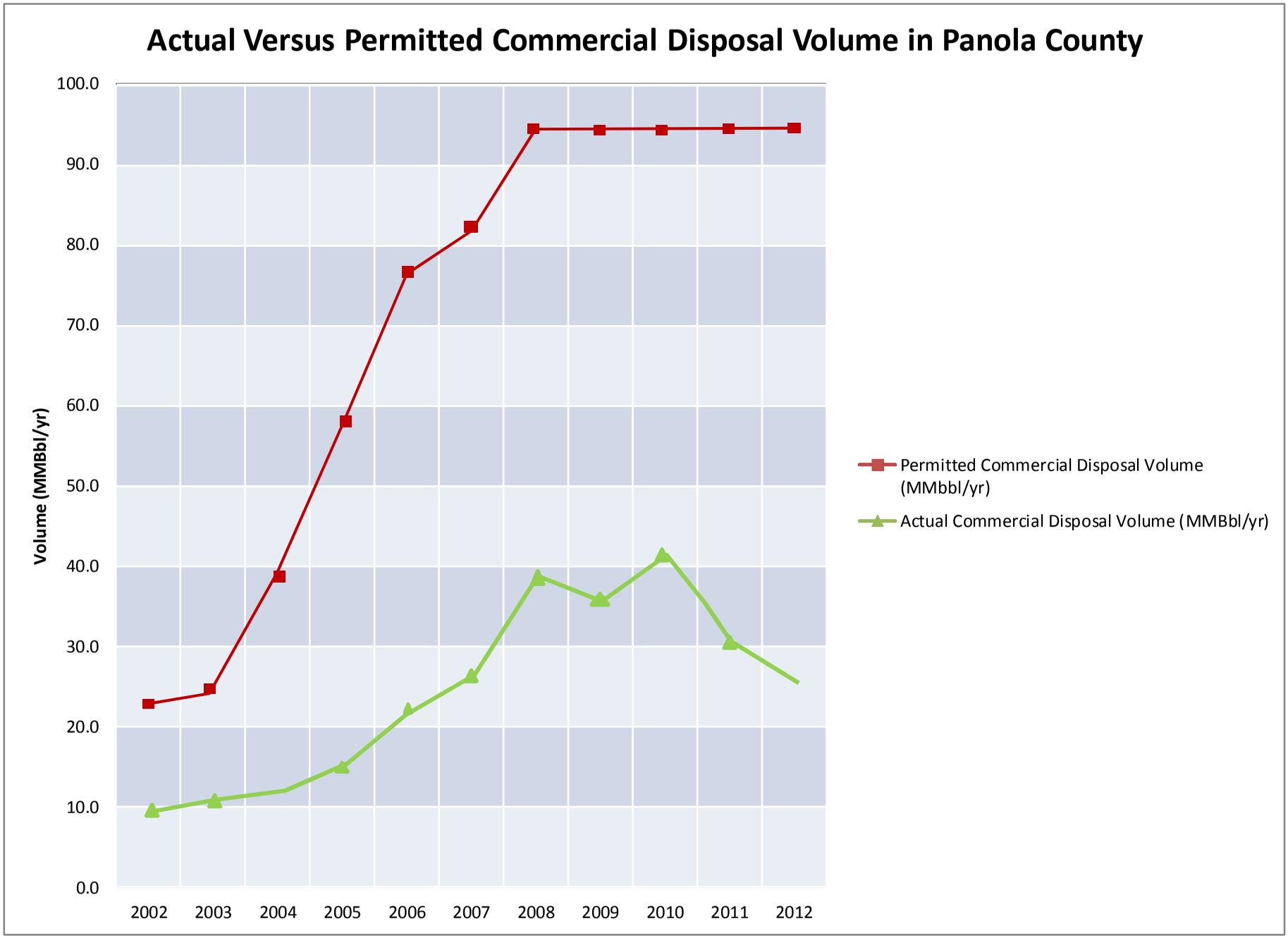
EAST TEXAS BASIN STRATIGRAPHY

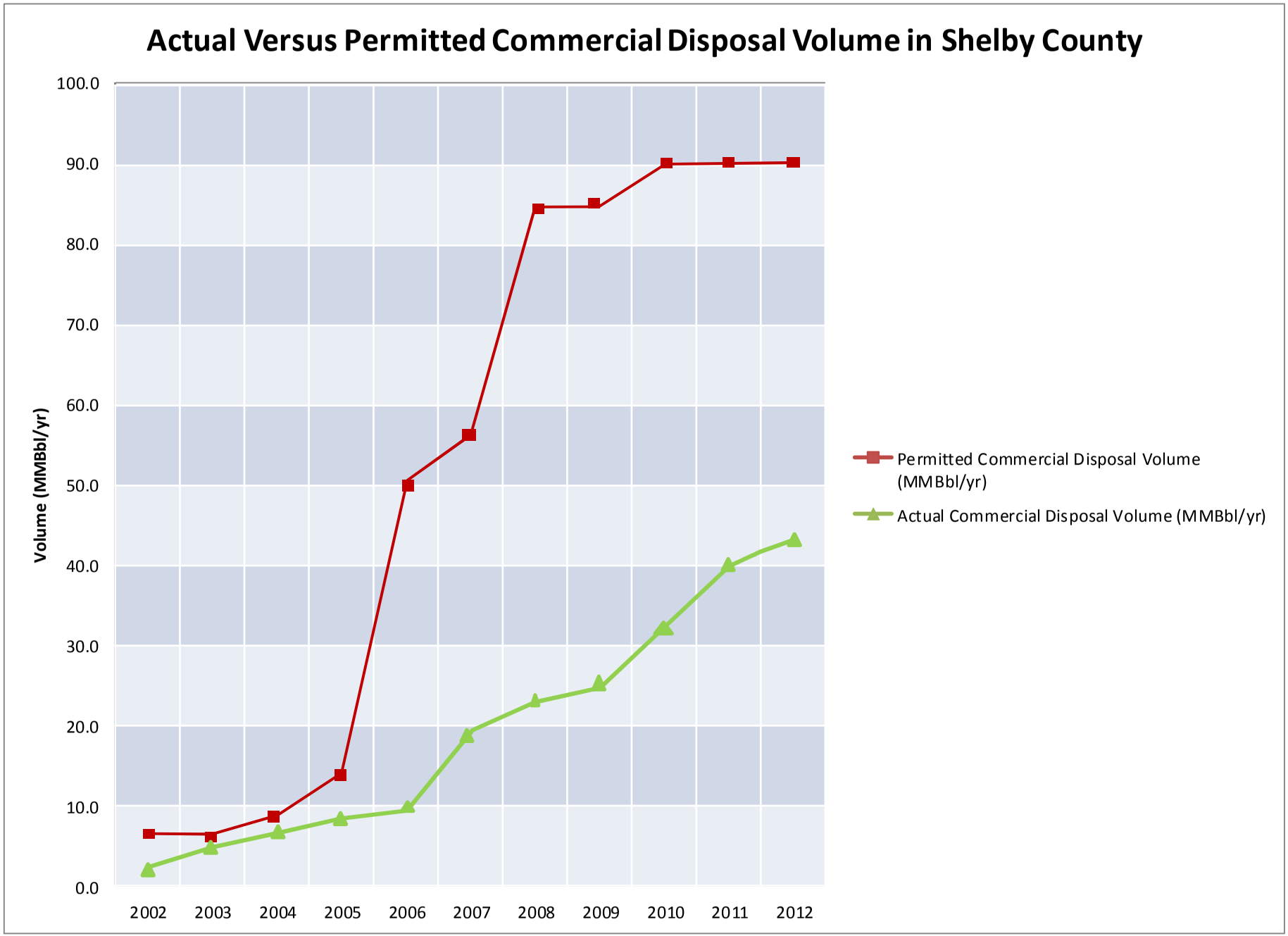


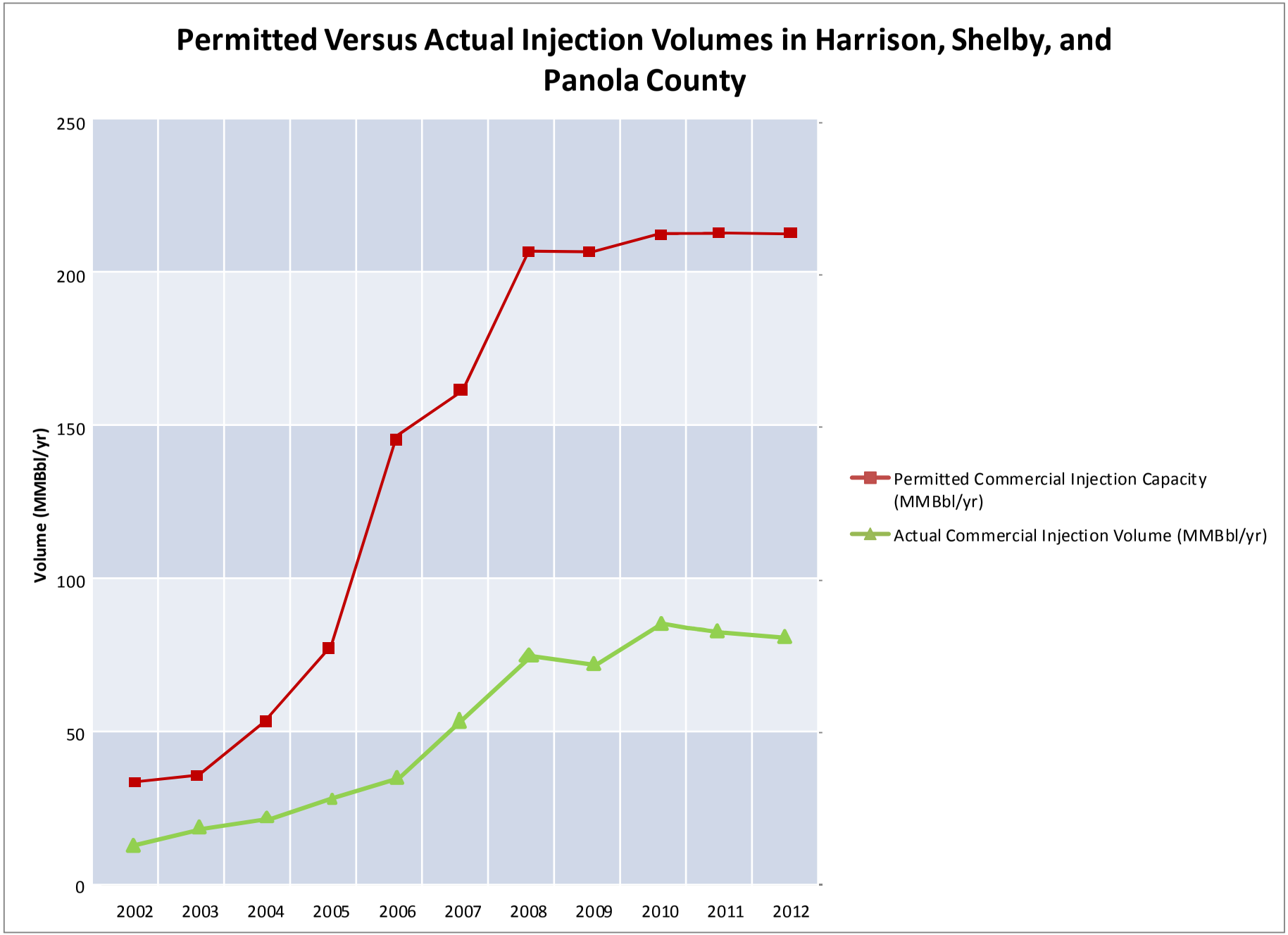

Texas Cotton Valley
Drilling Permits Issued
1993 through March 2014
Permit Count
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014
Year
Cotton Valley
Haynesville

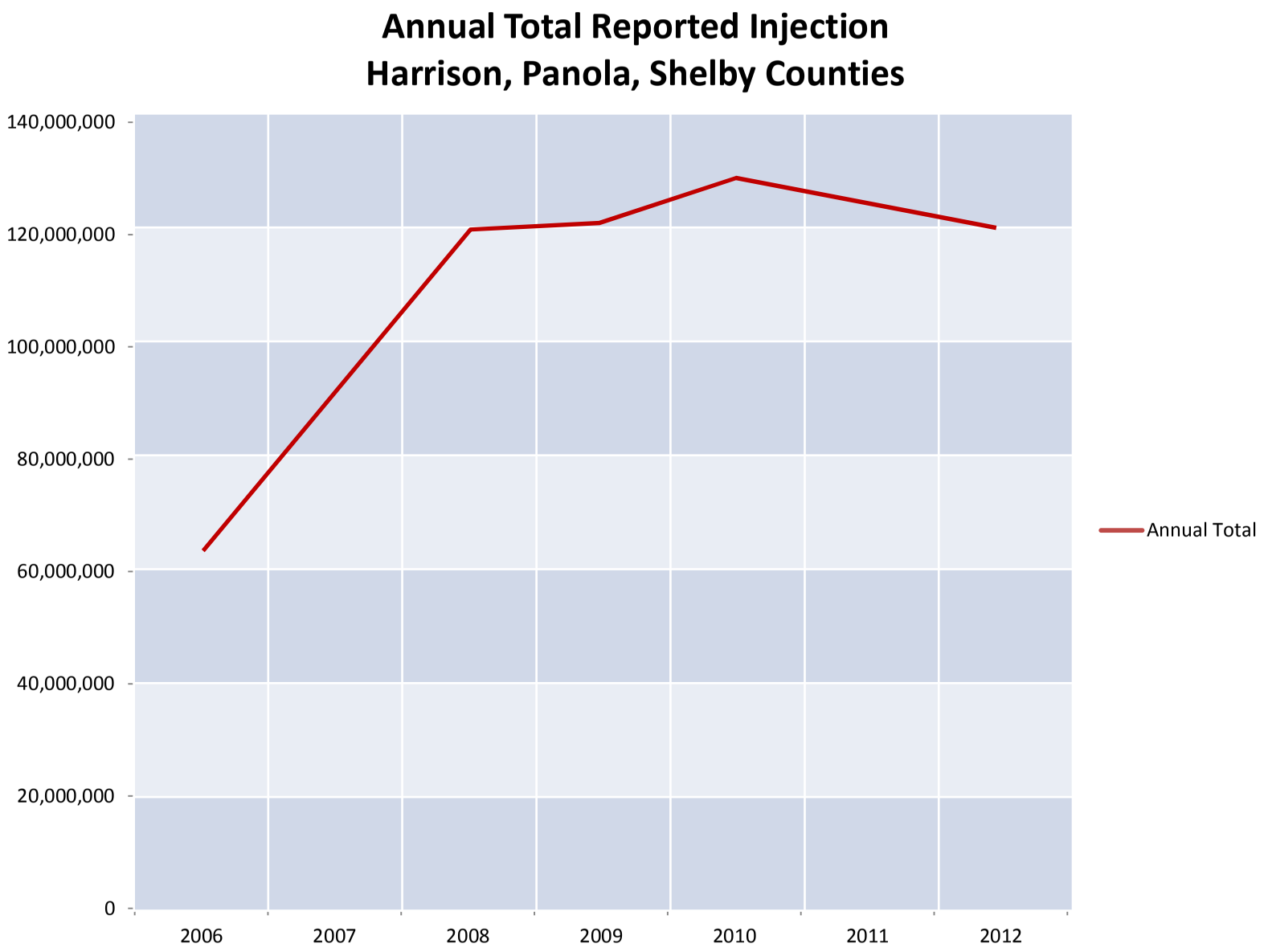

Texas Cotton Valley and Haynesville
Total Natural Gas Production
1993 to January 2014
Gas Production (MMCF/day)
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
Cotton Valley
Haynesville

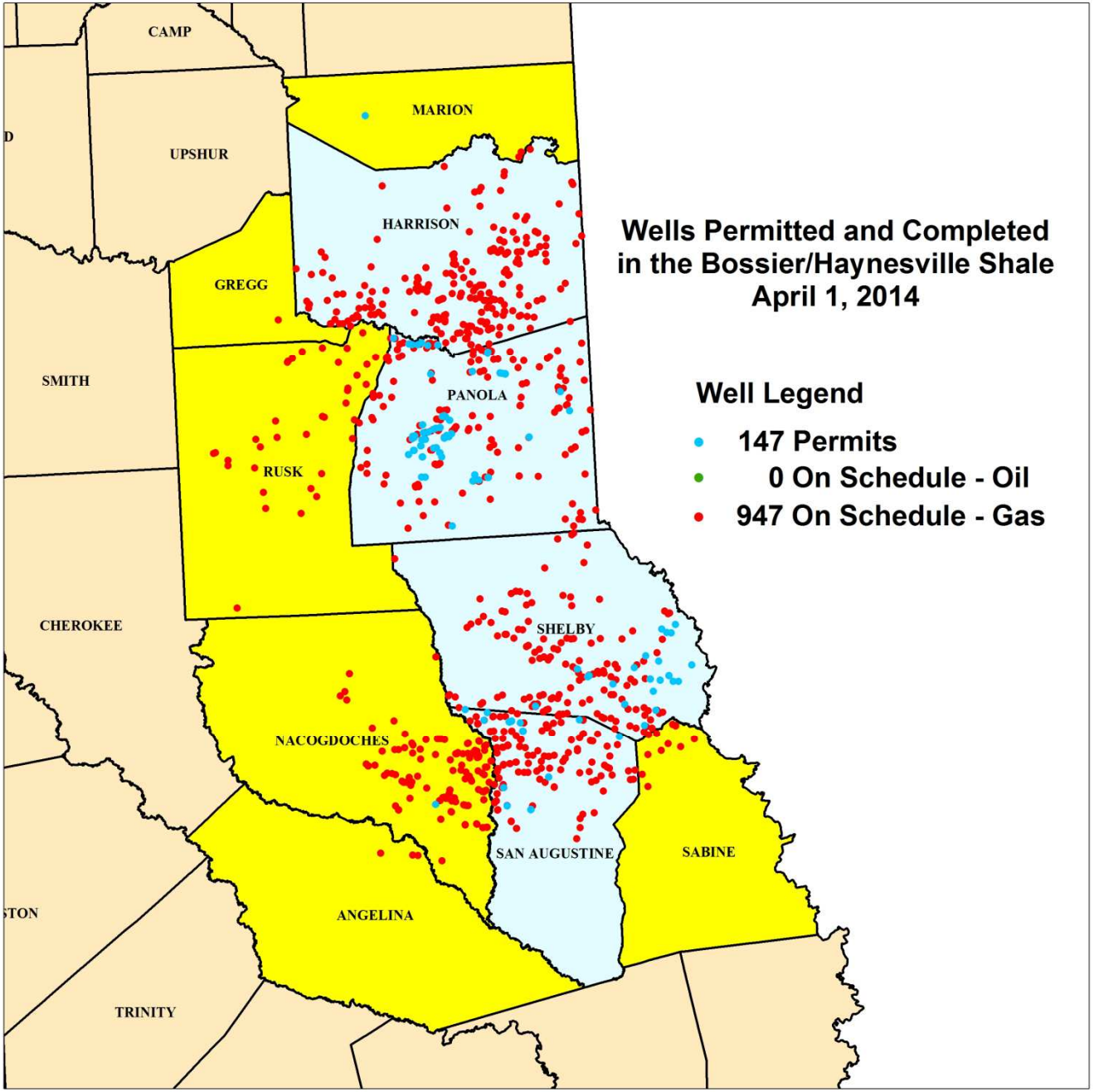

Actual Versus Permitted Commercial Disposal Volumes in Harrison County
Volume (MMBbl/yr)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Permitted Commercial Disposal Volume (MMbbl/yr)
Actual Commercial Disposal Volume (MMbbl/yr)


Actual Versus Permitted Commercial Disposal Volume in Panola County
Volume (MMBbl/yr)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Permitted Commercial Disposal Volume (MMbbl/yr)
Actual Commercial Disposal Volume (MMBbl/yr)

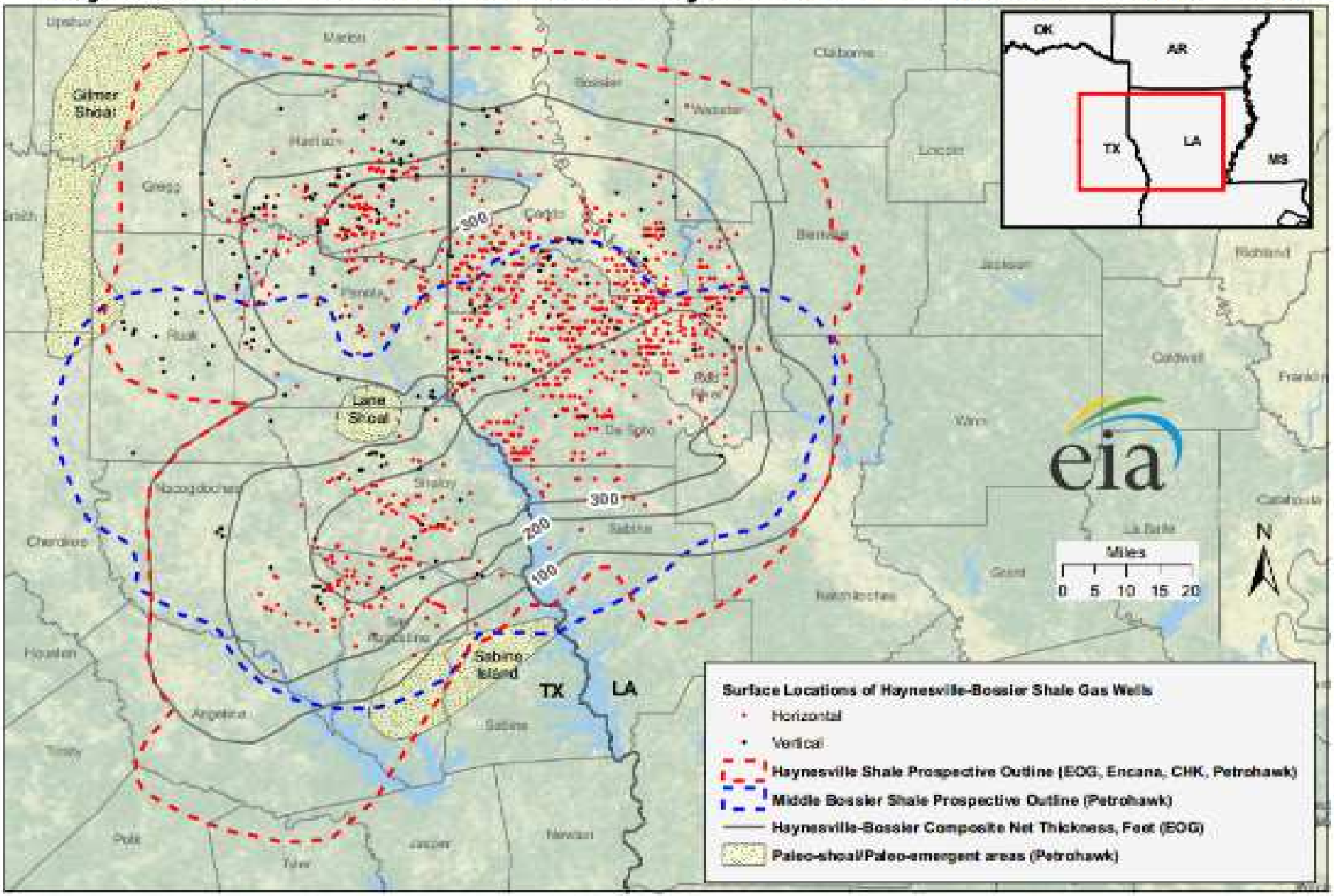

Actual Versus Permitted Commercial Disposal Volume in Shelby County
Volume (MMBbl/yr)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Permitted Commercial Disposal Volume (MMBbl/yr)
Actual Commercial Disposal Volume (MMBbl/yr)


Permitted Versus Actual Injection Volumes in Harrison, Shelby, and Panola County
Volume (MMBbl/yr)
250
200
150
100
50
0
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Permitted Commercial Injection Capacity (MMBbl/yr)
Actual Commercial Injection Volume (MMBbl/yr)

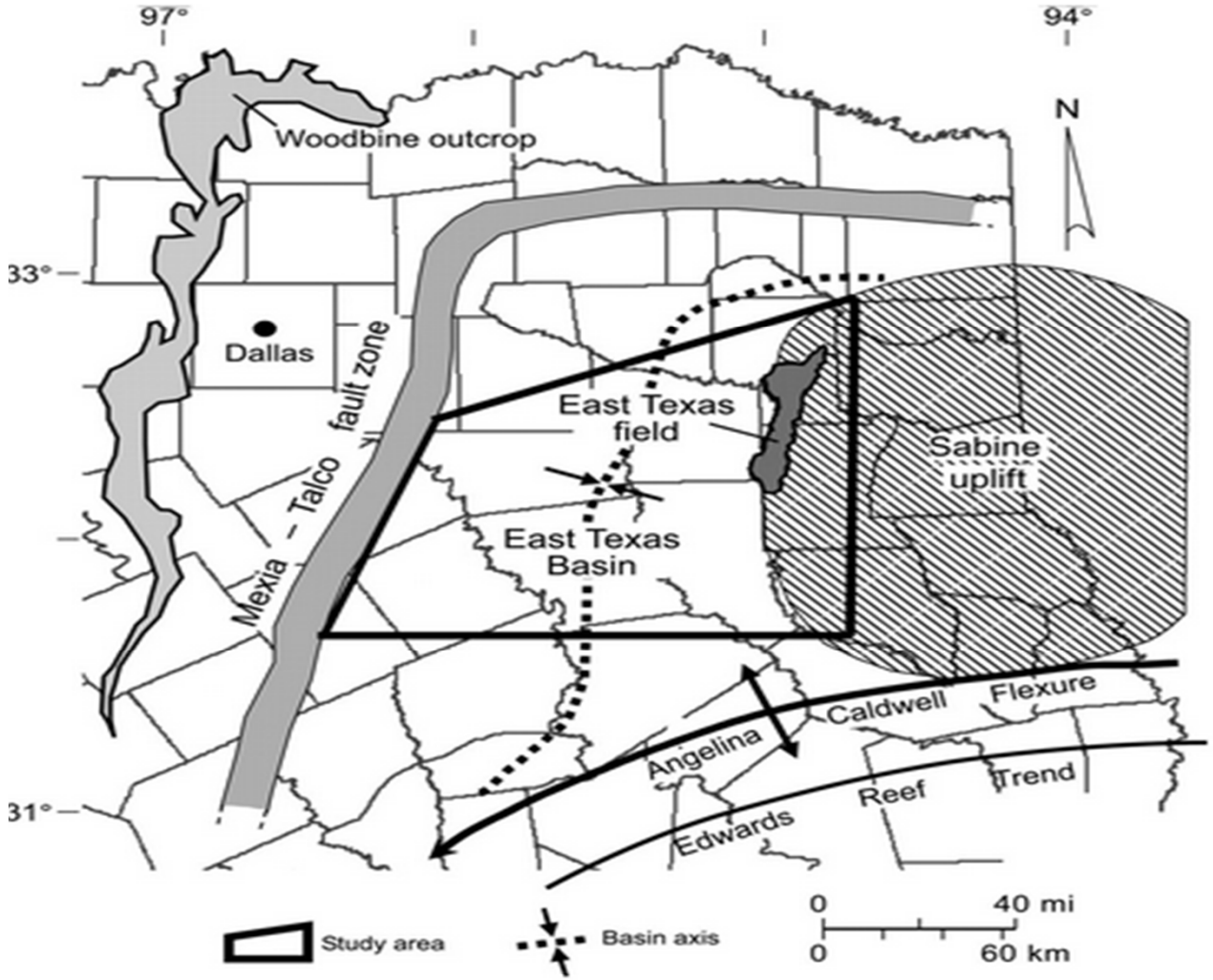

Annual Total Reported Injection
Harrison, Panola, Shelby Counties
140,000,000
120,000,000
100,000,000
80,000,000
60,000,000
40,000,000
20,000,000
0
2006
2007
2008
2009
2010
2011
2012
Annual Total

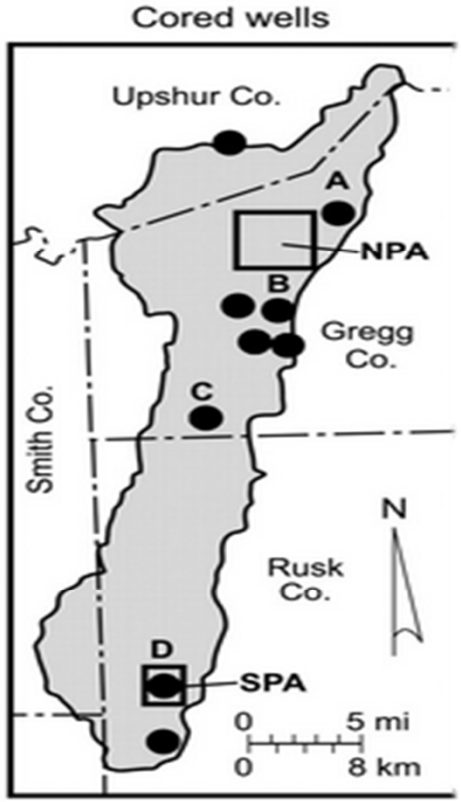

Wells Permitted and Completed
in the Bossier/Haynesville Shale
April 1, 2014
Well Legend
147 Permits
0 On Schedule - Oil
947 On Schedule - Gas
CAMP
MARION
UPSHUR
HARRISON
GREGG
SMITH
PANOLA
RUSK
CHEROKEE
SHELBY
NACOGDOCHES
SAN AUGUSTINE
SABINE
ANGELINA
TRINITY

Haynesville-Bossier Shale Play, Texas-Louisiana Salt Basin



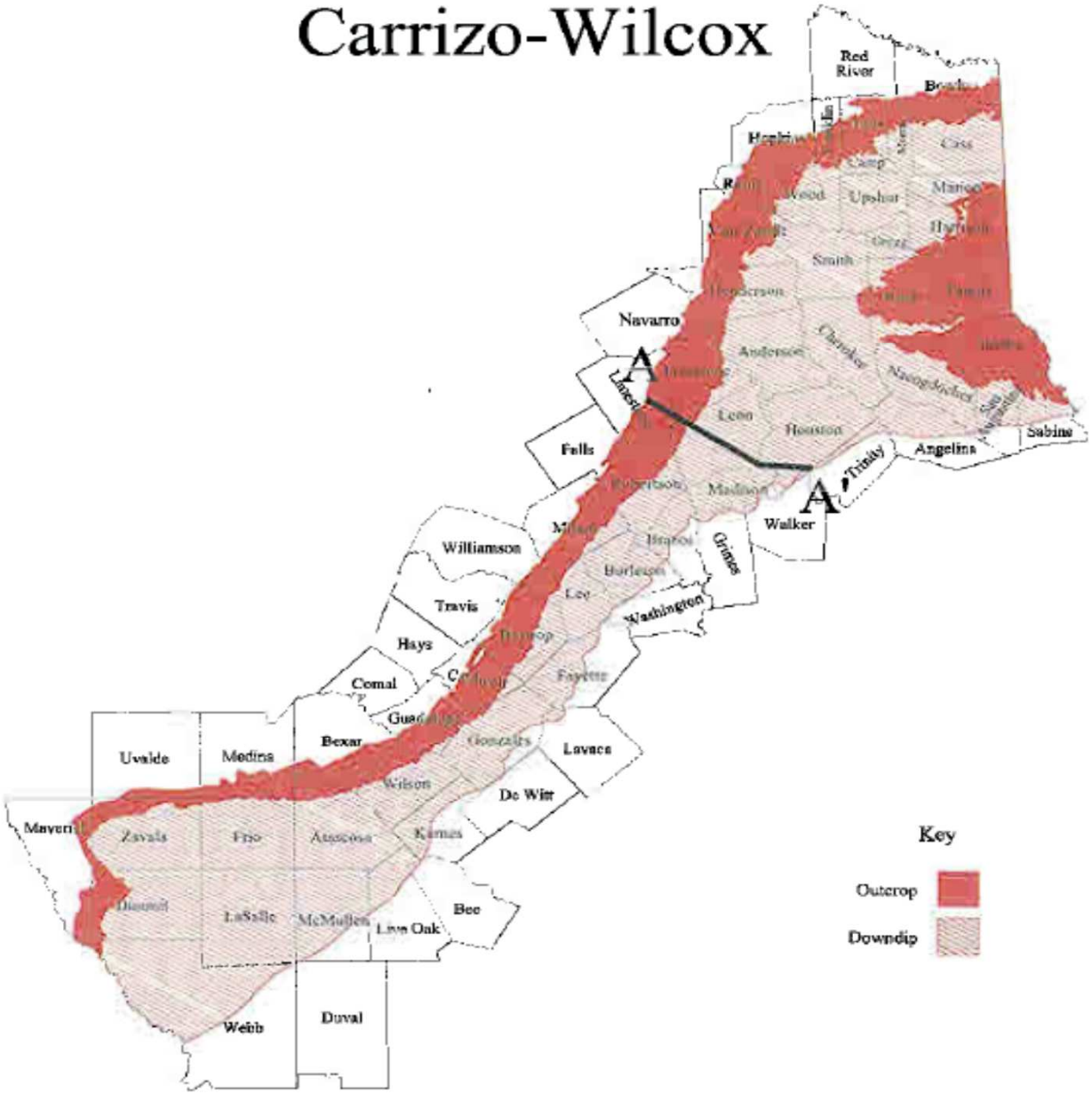
Source: Energy Information Administration based on data from HPDI, TX Railroad Commission, LA Dept. of Natural Resources, Operators.
Updated May 26, 2011





East Texas Field
Sabine Uplift

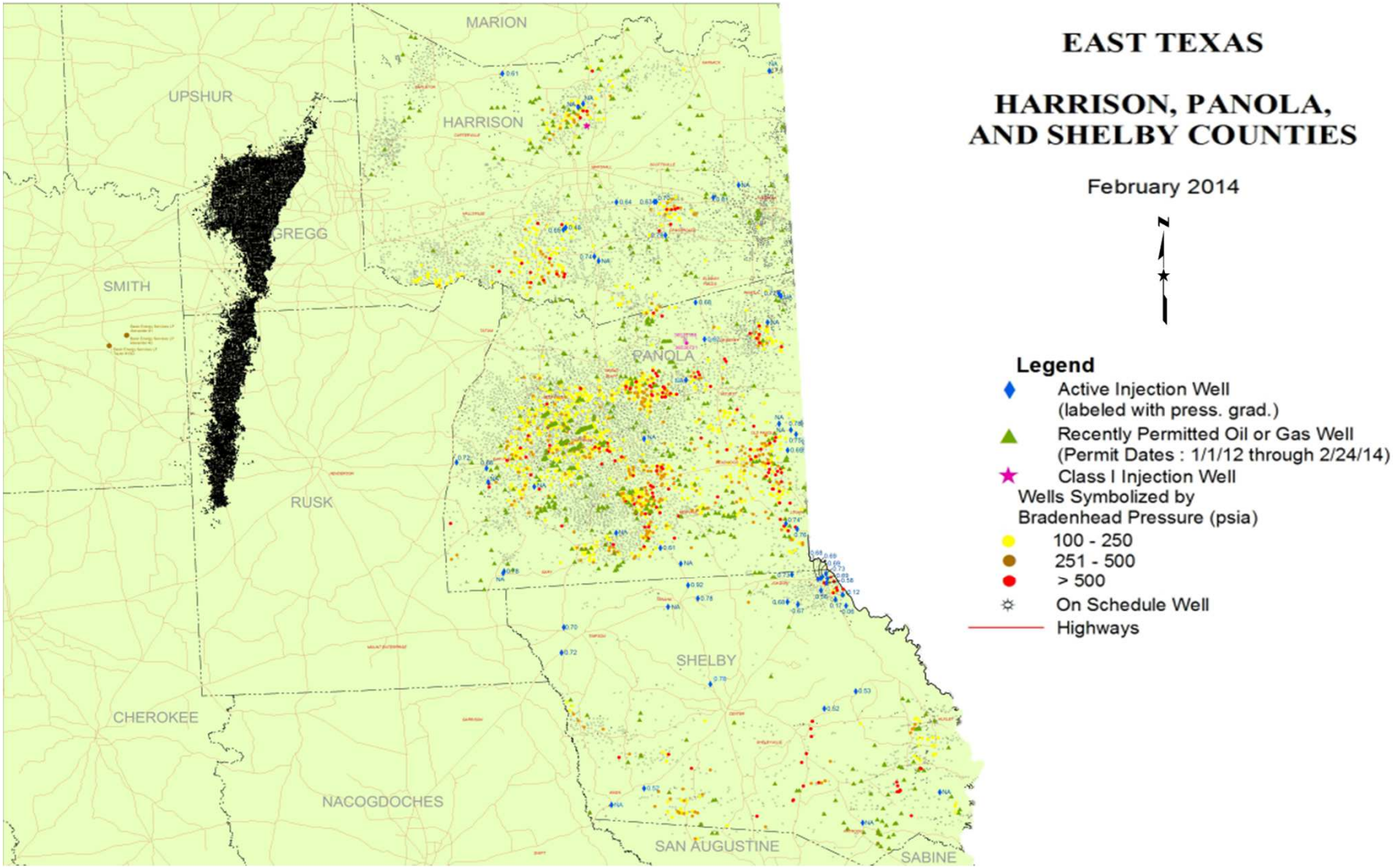
Carrizo-Wilcox

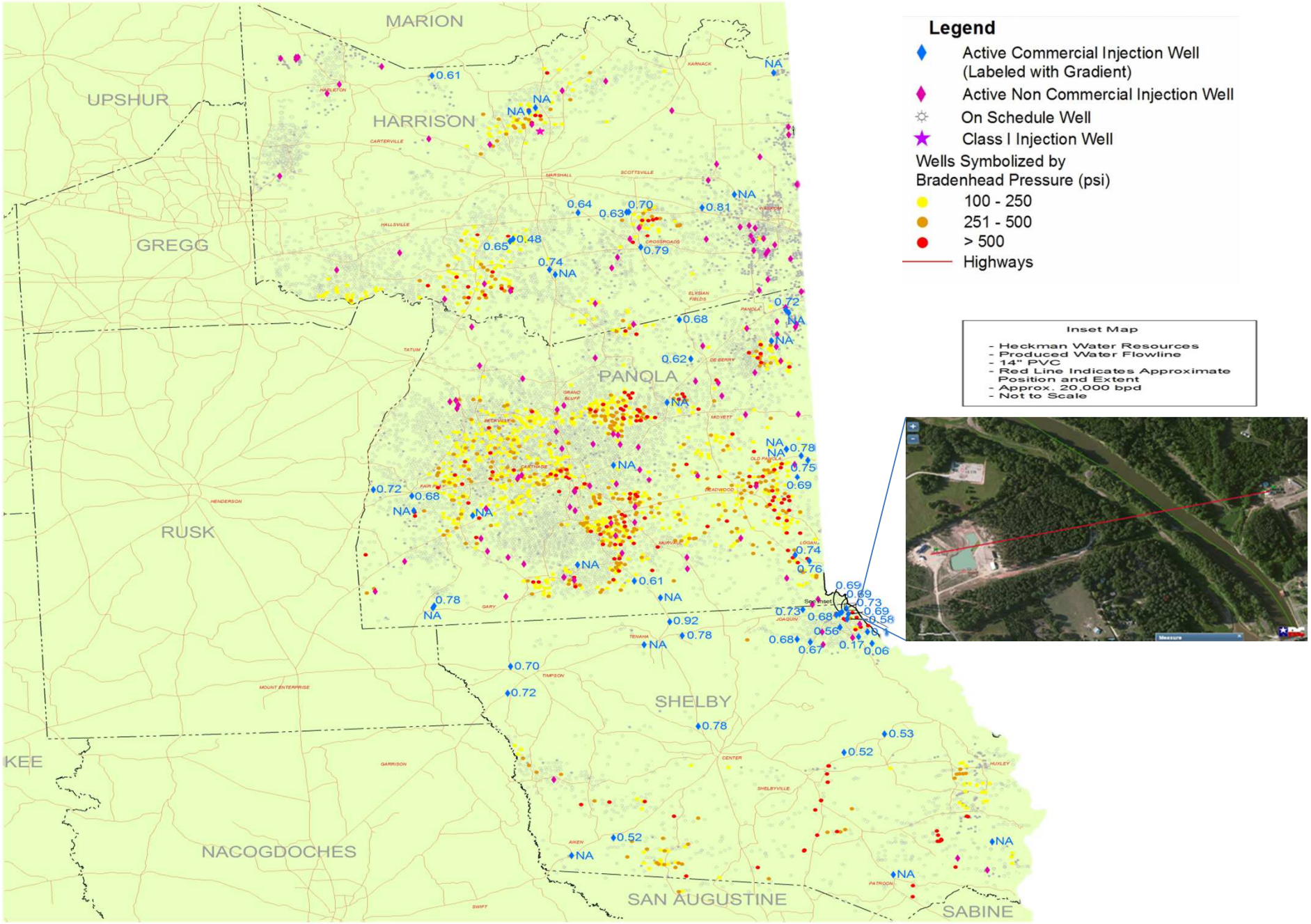


Timeline

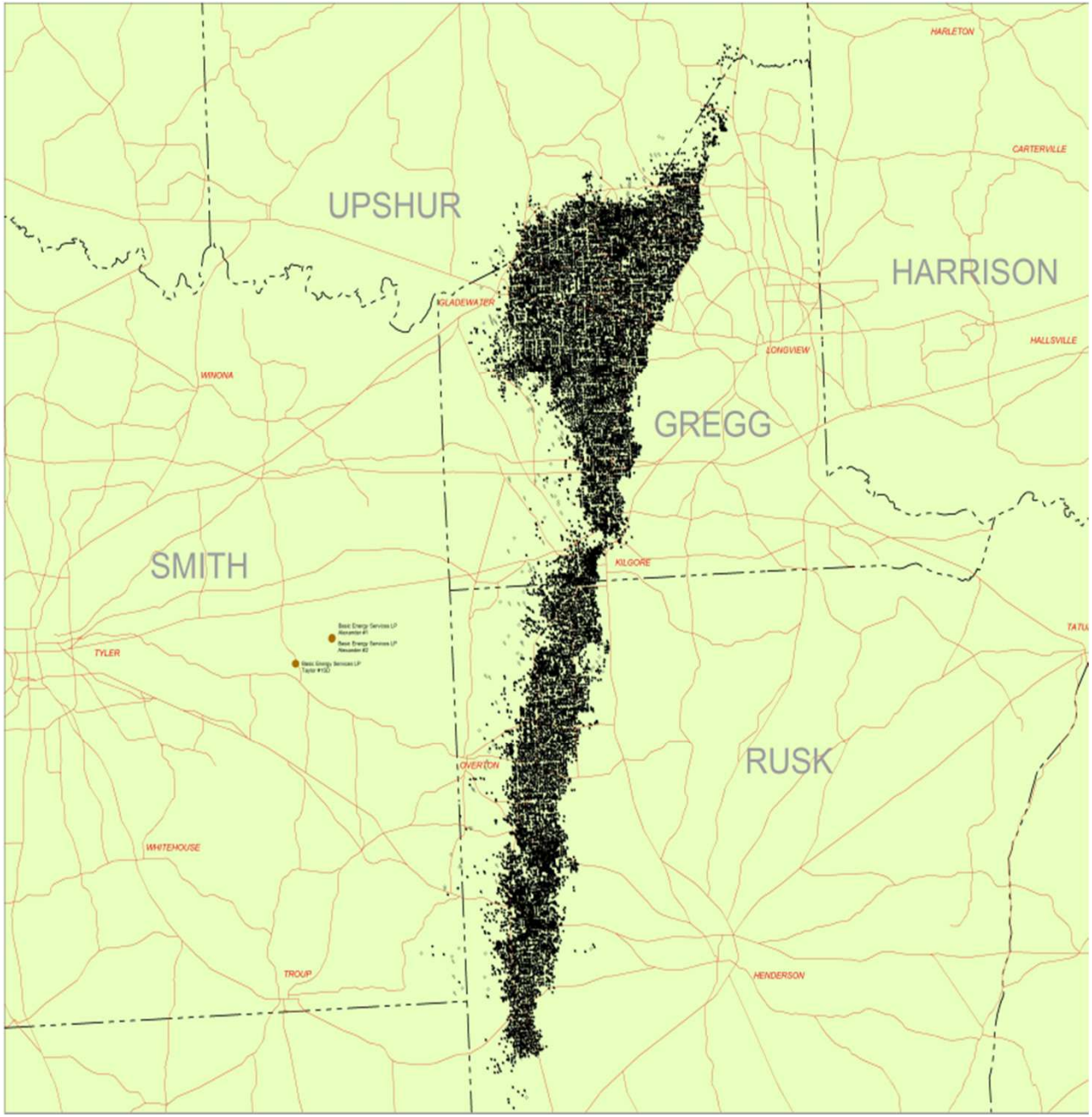
- Drilling stats related to CV and Haynesville
- Production stats
- Injection stats
- Hearing & other RRC information
  - Grayward Complaint – surface breakout, 2009
  - Greer/Heckman – 2009-2010
  - AADE paper – 2005

East Texas


EAST TEXAS
HARRISON, PANOLA, AND SHELBY COUNTIES
February 2014
N
Legend
Active Injection Well (labeled with press. grad.)
Recently Permitted Oil or Gas Well (Permit Dates : 1/1/12 through 2/24/14)
Class I Injection Well
Wells Symbolized by Bradenhead Pressure (psia)
100 - 250
251 - 500
> 500
On Schedule Well
Highways
MARION
UPSHUR
HARRISON
GREGG
SMITH
PANOLA
RUSK
SHELBY
CHEROKEE
NACOGDOCHES
SAN AUGUSTINE
SABINE


MARION
UPSHUR
HARRISON
GREGG
PANOLA
RUSK
SHELBY
KEE
NACOGDOCHES
SAN AUGUSTINE
SABINE
Legend
Active Commercial Injection Well (Labeled with Gradient)
Active Non Commercial Injection Well
On Schedule Well
Class I Injection Well
Wells Symbolized by Bradenhead Pressure (psi)
100 - 250
251 - 500
> 500
Highways
Inset Map
- Heckman Water Resources
- Produced Water Flowline
- 14" PVC
- Red Line Indicates Approximate Position and Extent
- Approx. 20,000 bpd
- Not to Scale

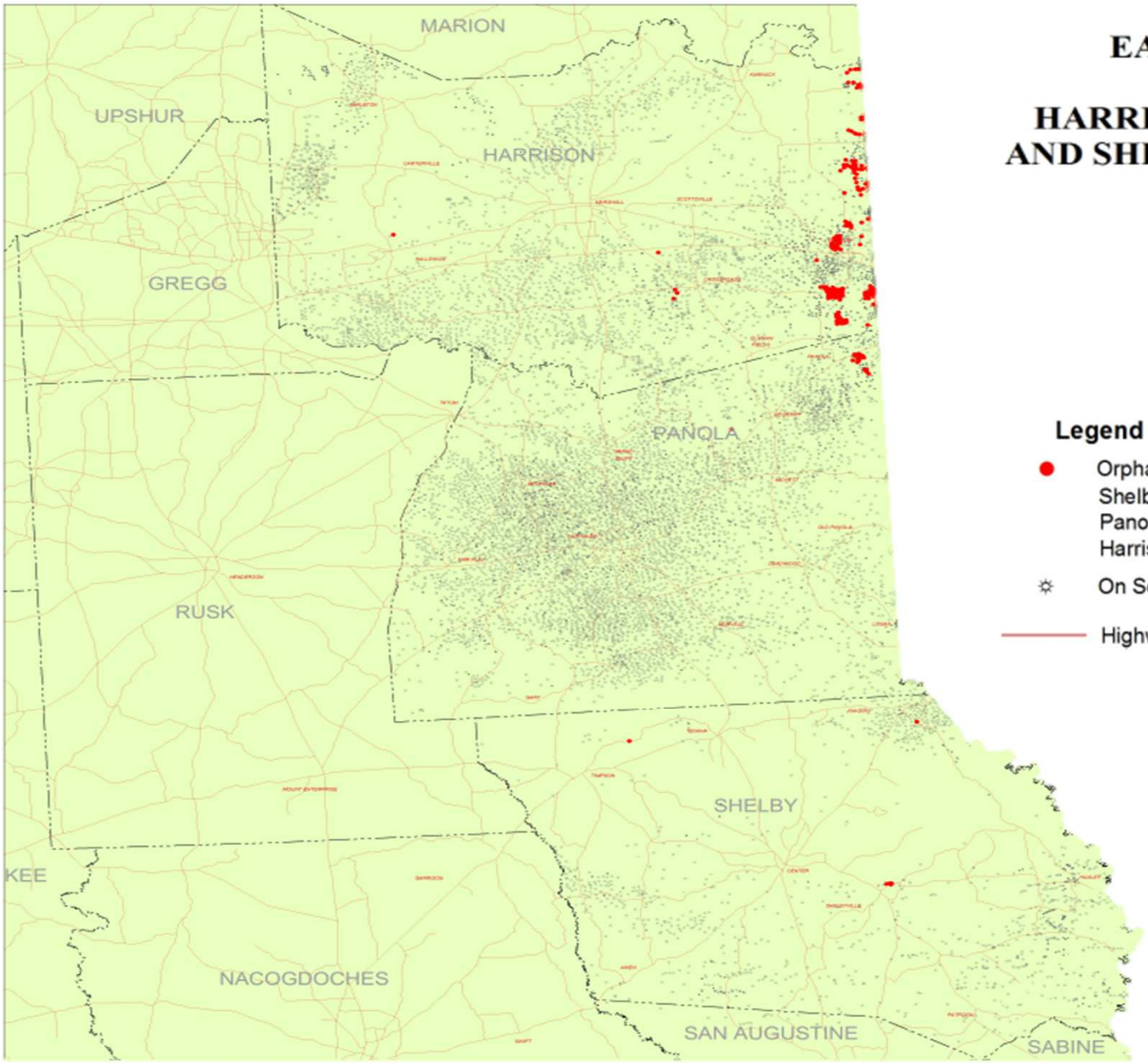
EAST TEXAS FIELD AREA



N

Legend

- Basic Energy Services Injection Well
- East Texas Field Well
- Highways



EAST TEXAS

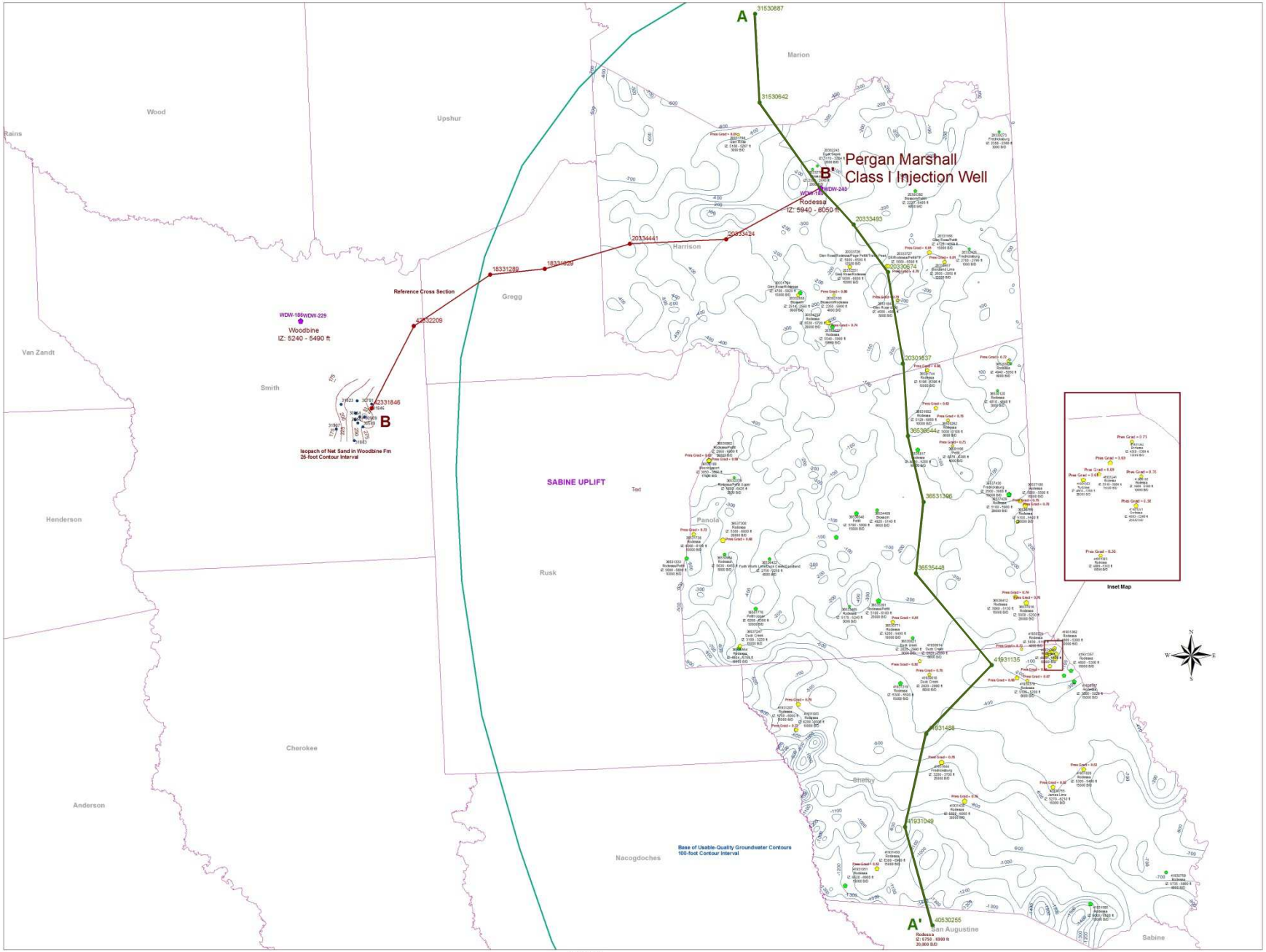
HARRISON, PANOLA, AND SHELBY COUNTIES

N

Legend

- Orphan Well
  Shelby Co. - 6 orphan wells
  Panola Co. - 18 orphan wells
  Harrison Co. - 147 orphan wells
- On Schedule Well
- Highways

Sabine Uplift Region East Texas Basin



RAILROAD COMMISSION OF TEXAS
OIL AND GAS DIVISION
GROUNDWATER ADVISORY UNIT
John D. Estepp, P.G.
March 28, 2014

DRAFT WORK MAP

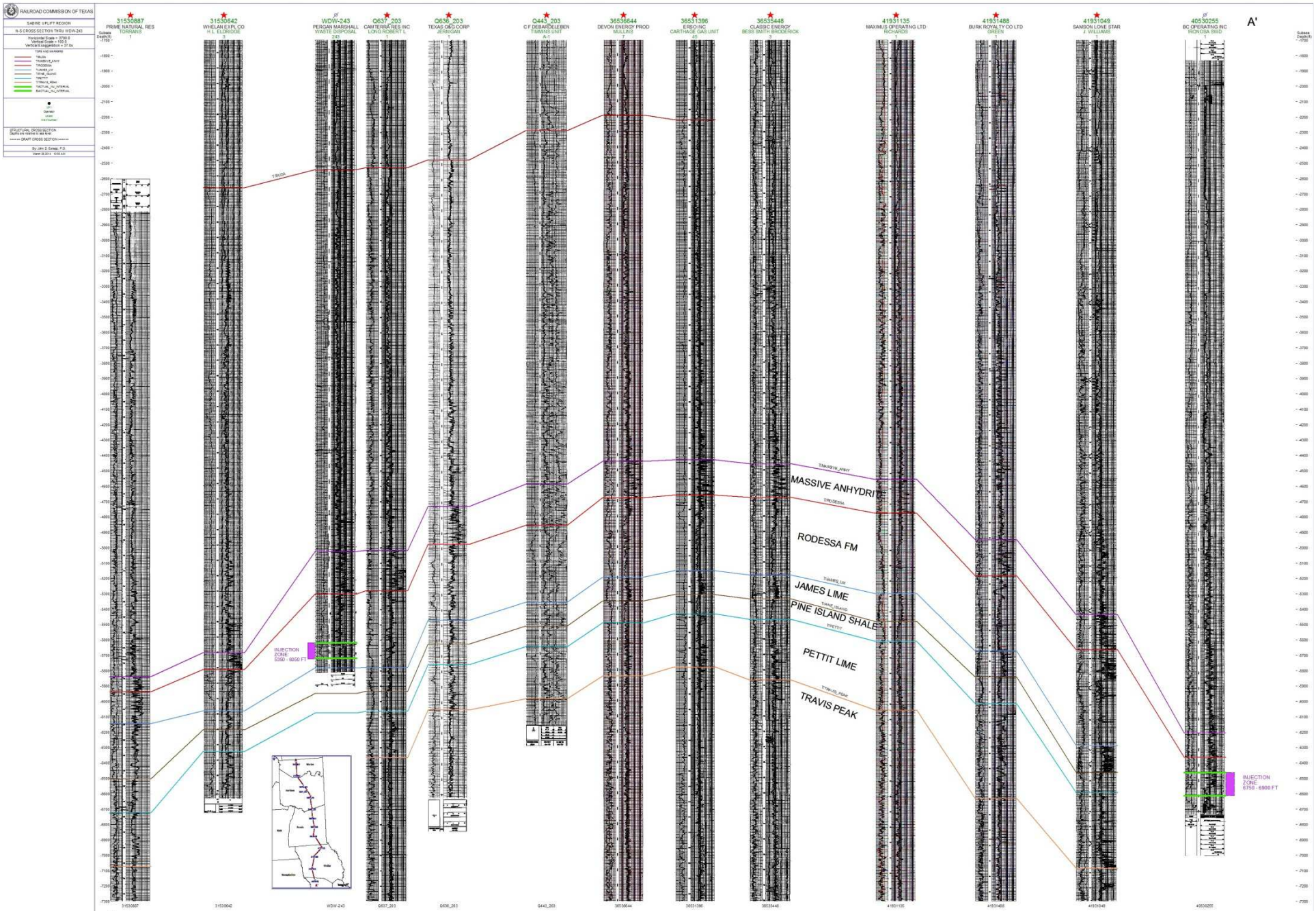
Explanation

Permitted Daily Injection Volume Rate
- 1000 - 4000 B/D
- 4000 - 8500 B/D
- 8501 - 12,500 B/D
- 12,501 - 17,500 B/D
- 17,501 - 20,000 B/D

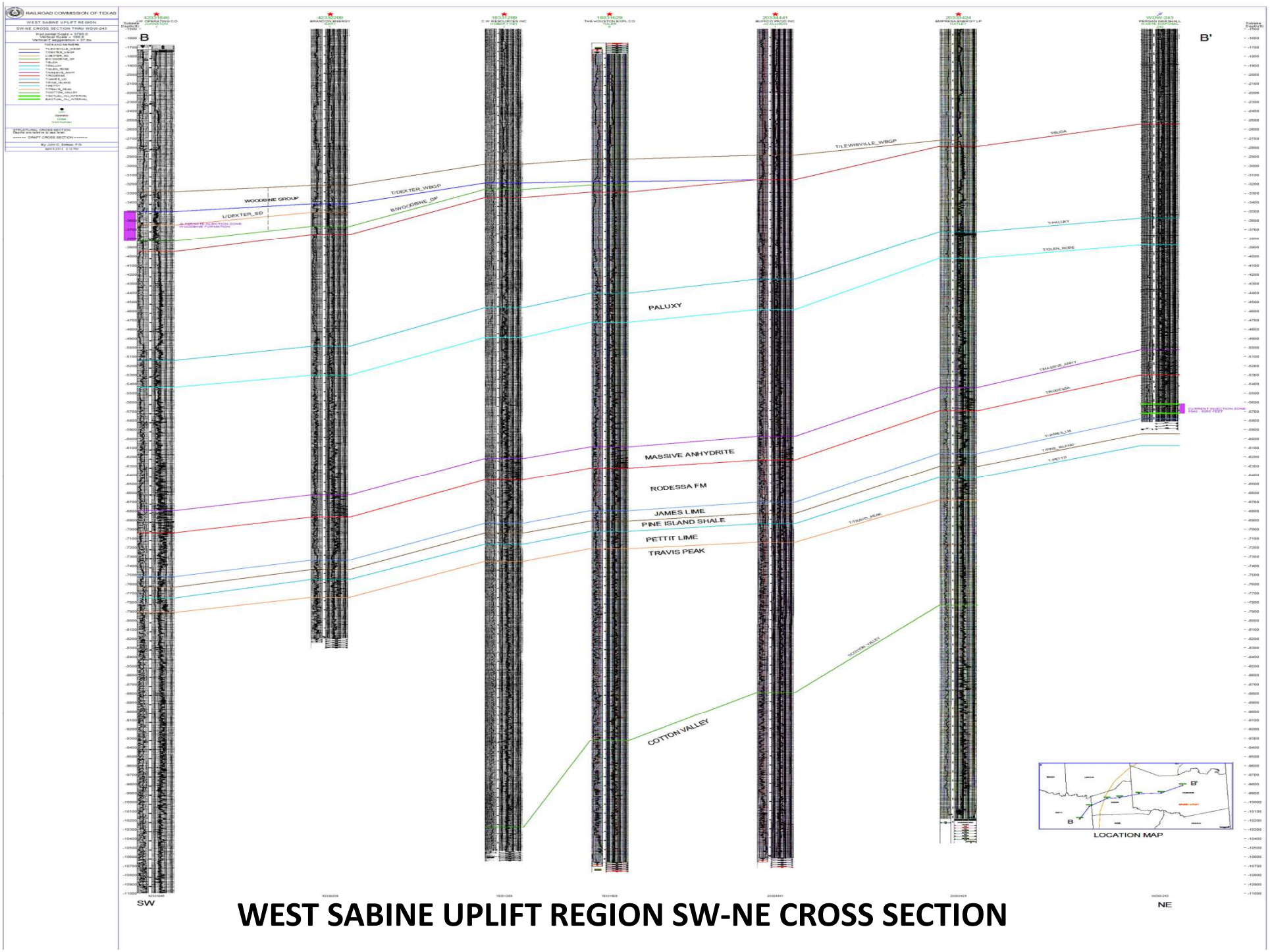
Class 2 Injection Well
Pressure gradient (pounds per foot of depth)
Press Grad = 0.91
36530771
Rodessa
IZ: 5300 - 5400 ft
15000 B/D
API number
Injection Formation
Injection zone interval
Permitted daily injection rate (Barrels/Day)
(Yellow: high-light identifies pressure gradient exceeds 0.5 pounds/foot)

Class 1 Injection Well
WDW-243
Rodessa
IZ: 5940 - 6050 ft

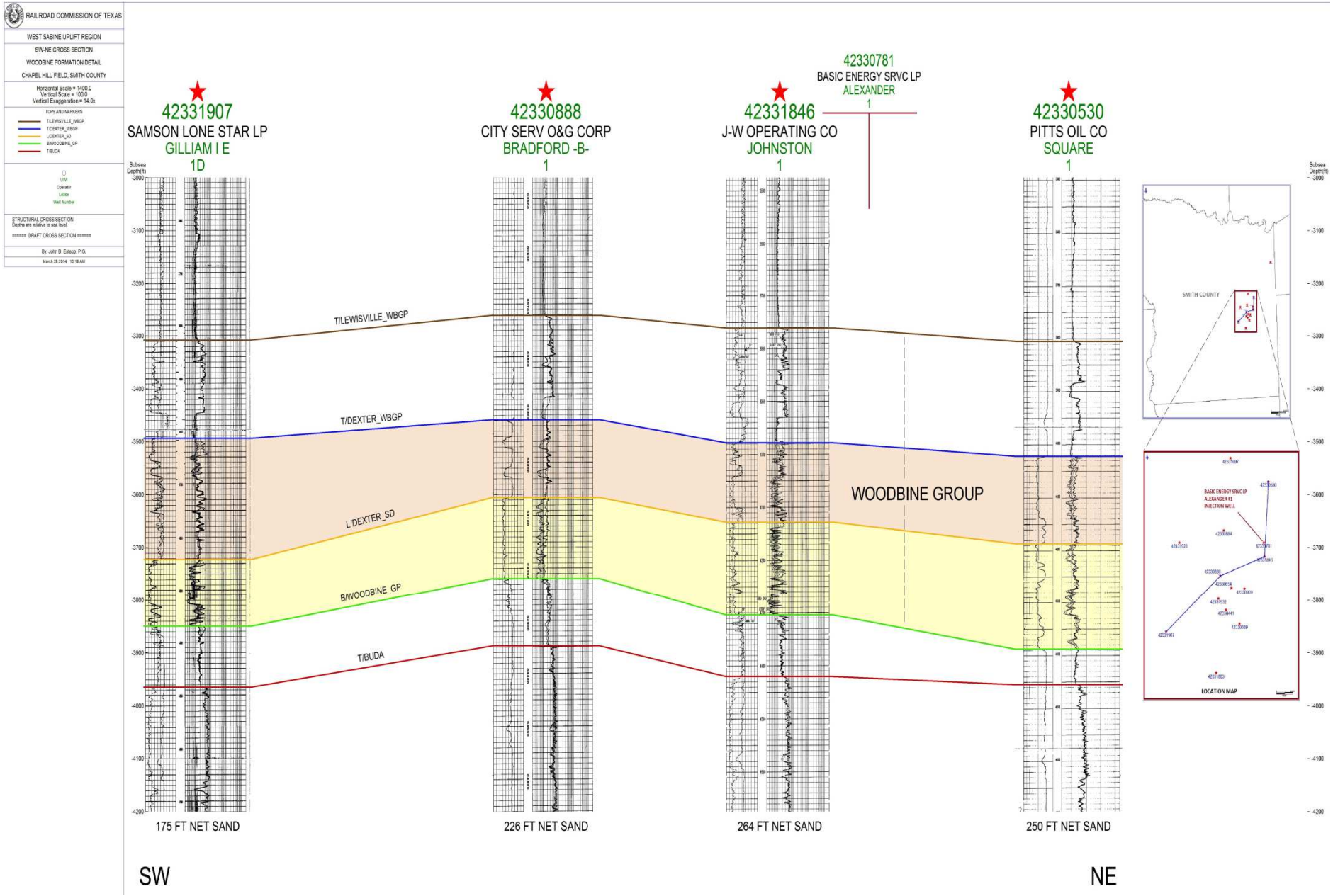
Scale: 1:180,000
0 5 10 20 30 Miles



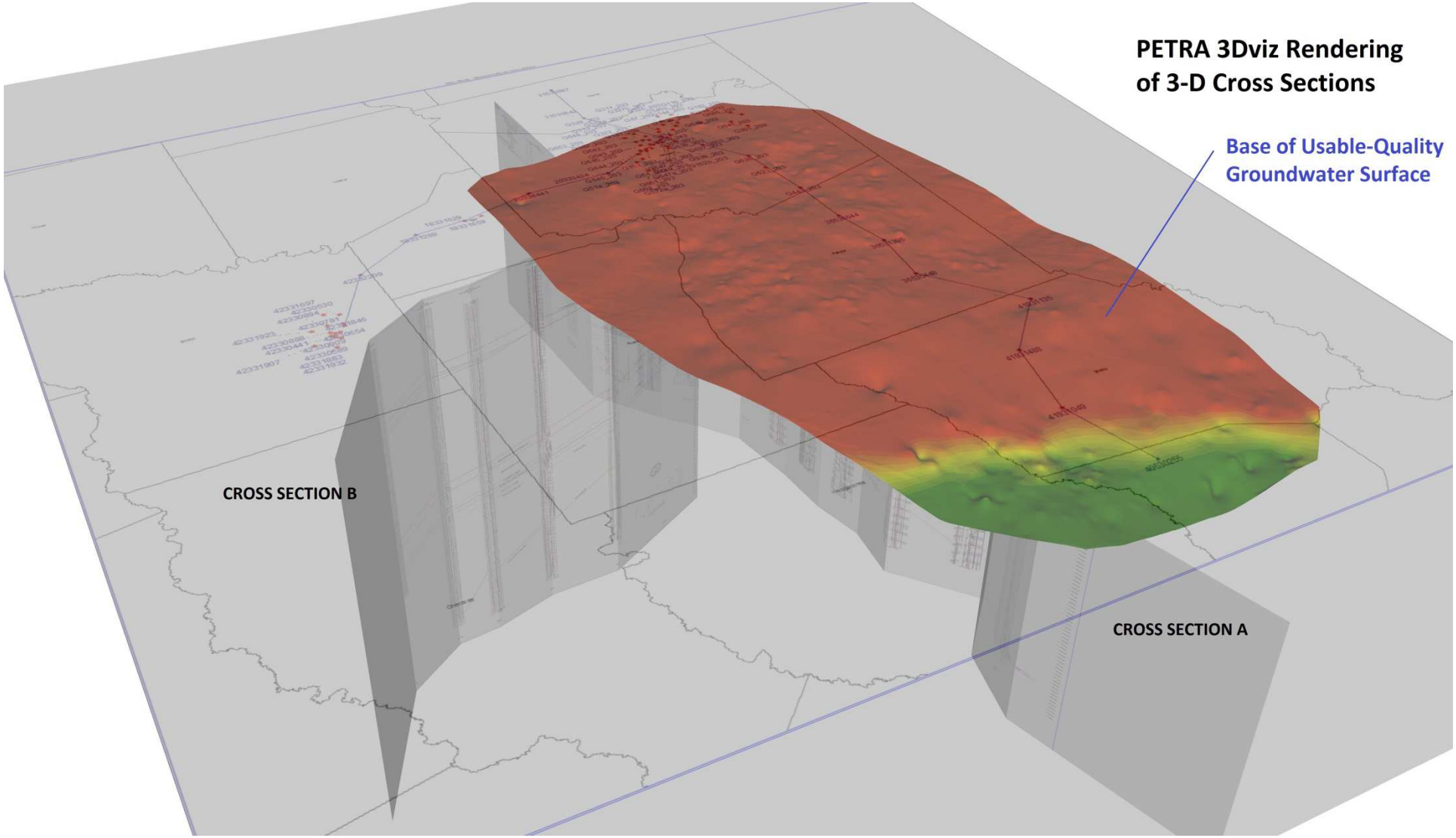
SABINE UPLIFT REGION N-S CROSS SECTION

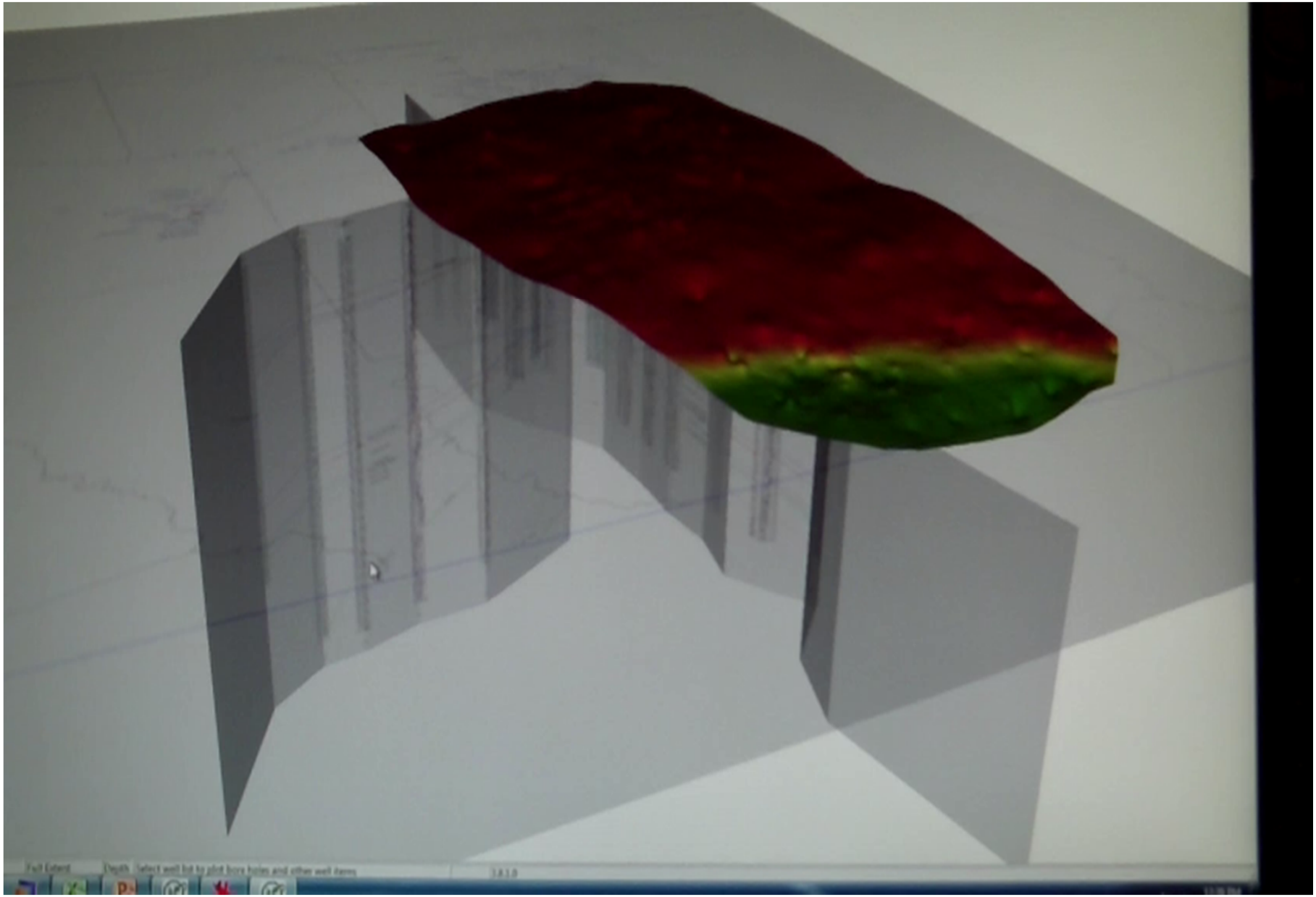


WEST SABINE UPLIFT REGION SW-NE CROSS SECTION



WEST SABINE UPLIFT REGION SW-NE CROSS SECTION
WOODBINE FORMATION DETAIL CHAPEL HILL FIELD, SMITH COUNTY


PETRA 3Dviz Rendering
of 3-D Cross Sections
Base of Usable-Quality
Groundwater Surface
CROSS SECTION B
CROSS SECTION A


Full Extent
Depth
Select well list to plot bore holes and other well items

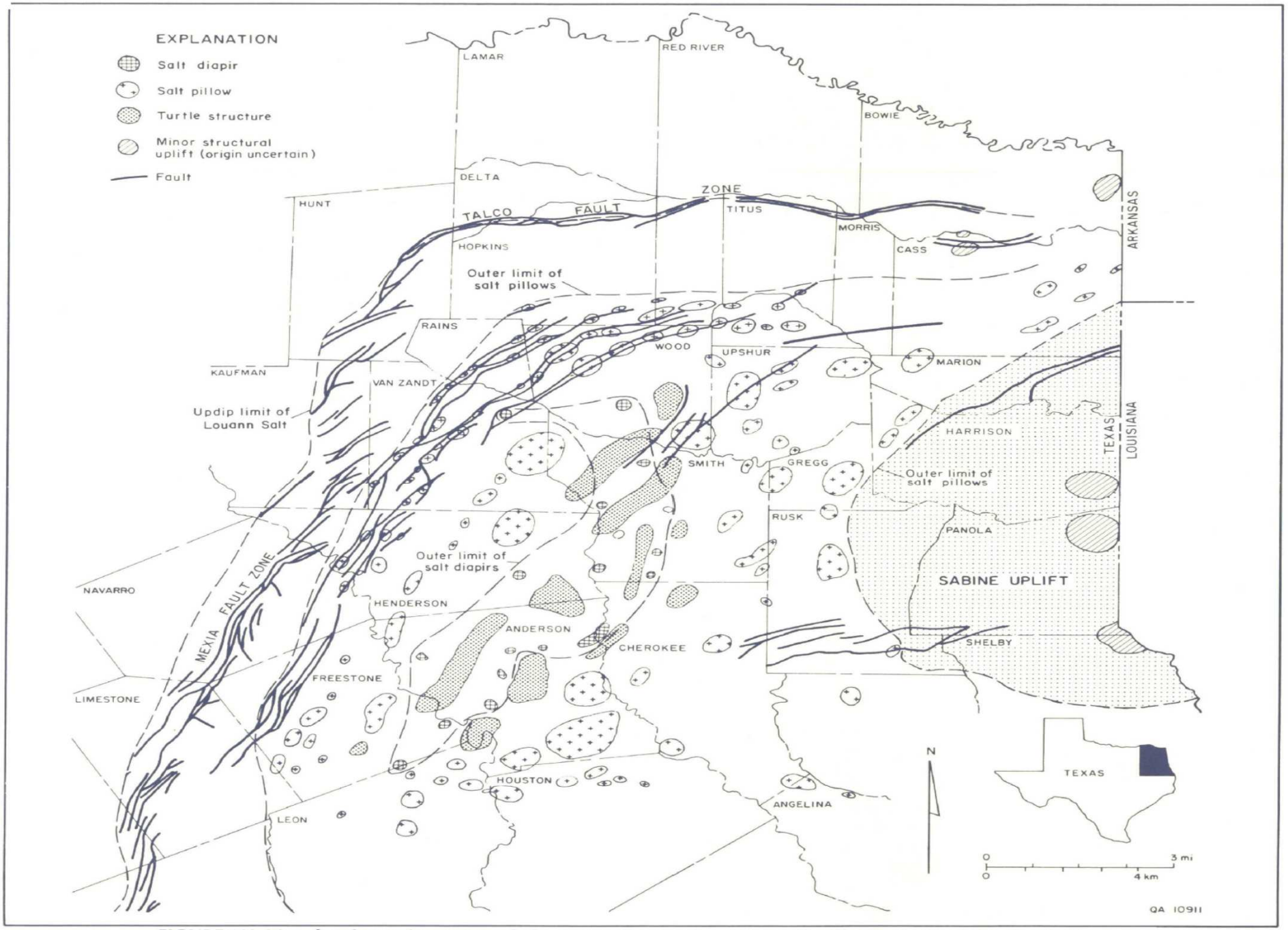
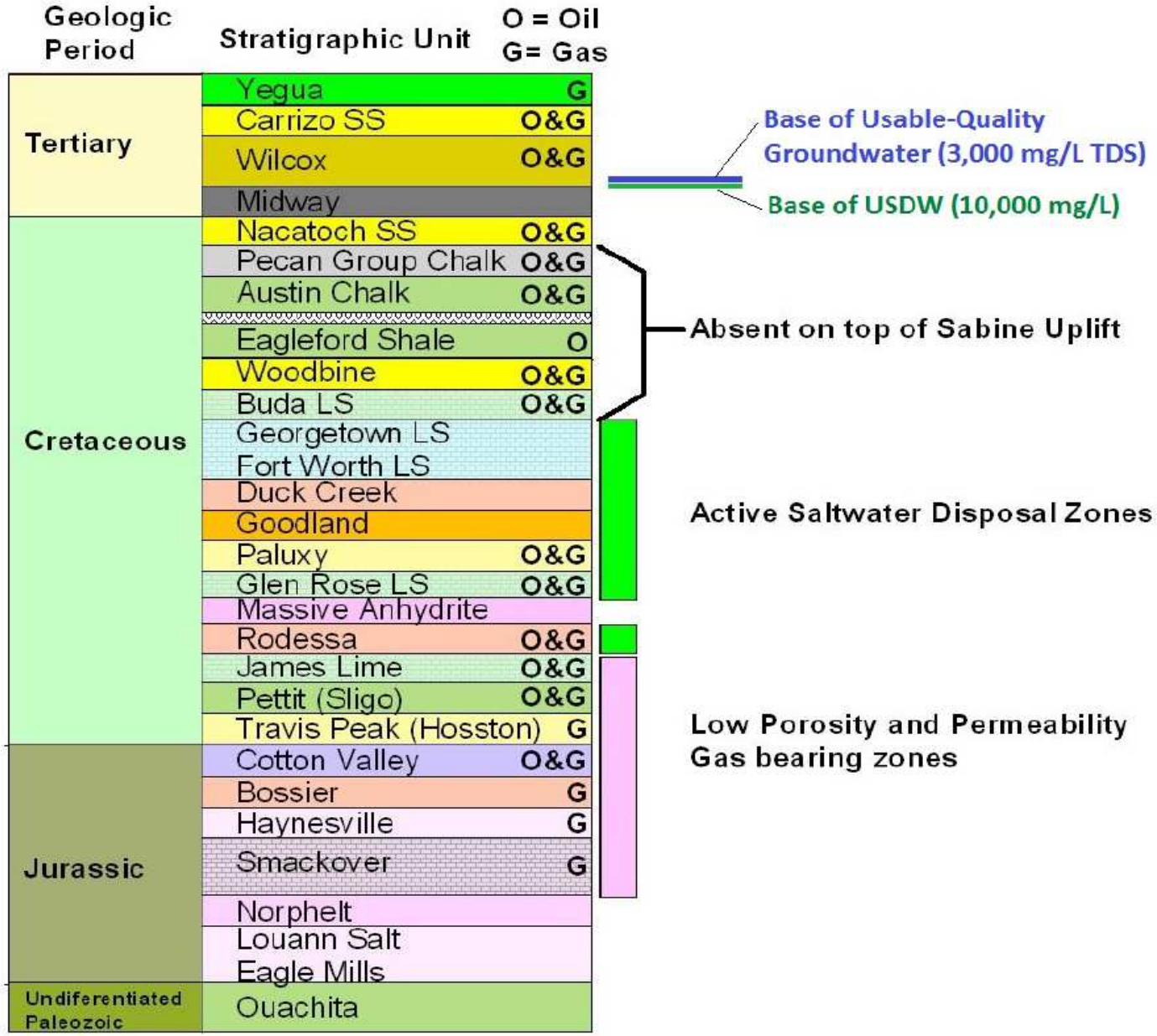


FIGURE 146. Map showing major structural elements in the East Texas Basin. The distribution and size of salt pillows are the primary control on the distribution of Smackover fields. Modified from Jackson (1982).

("ATLAS OF MAJOR TEXAS GAS RESERVOIRS", Kosters, E.C.; et al., University of Texas Bureau of Economic Geology, 1989, page

EAST TEXAS BASIN STRATIGRAPHY



Main Issues

- Bradenhead pressures
- Drilling problems
- Plugging problems
- Pergan Class I Wells

Information Resources

Hearing & Other RRC Records

- Peoples' Pollard #2 - 2007
- Graward Complaint - 2009
  - Order No. 06-0262483
  - Permit No. 12794 cancelled
  - Breakout outside surface casing
- Talco Midstream vs. Pergan 06-0272897 - 2012

Other Data Sources

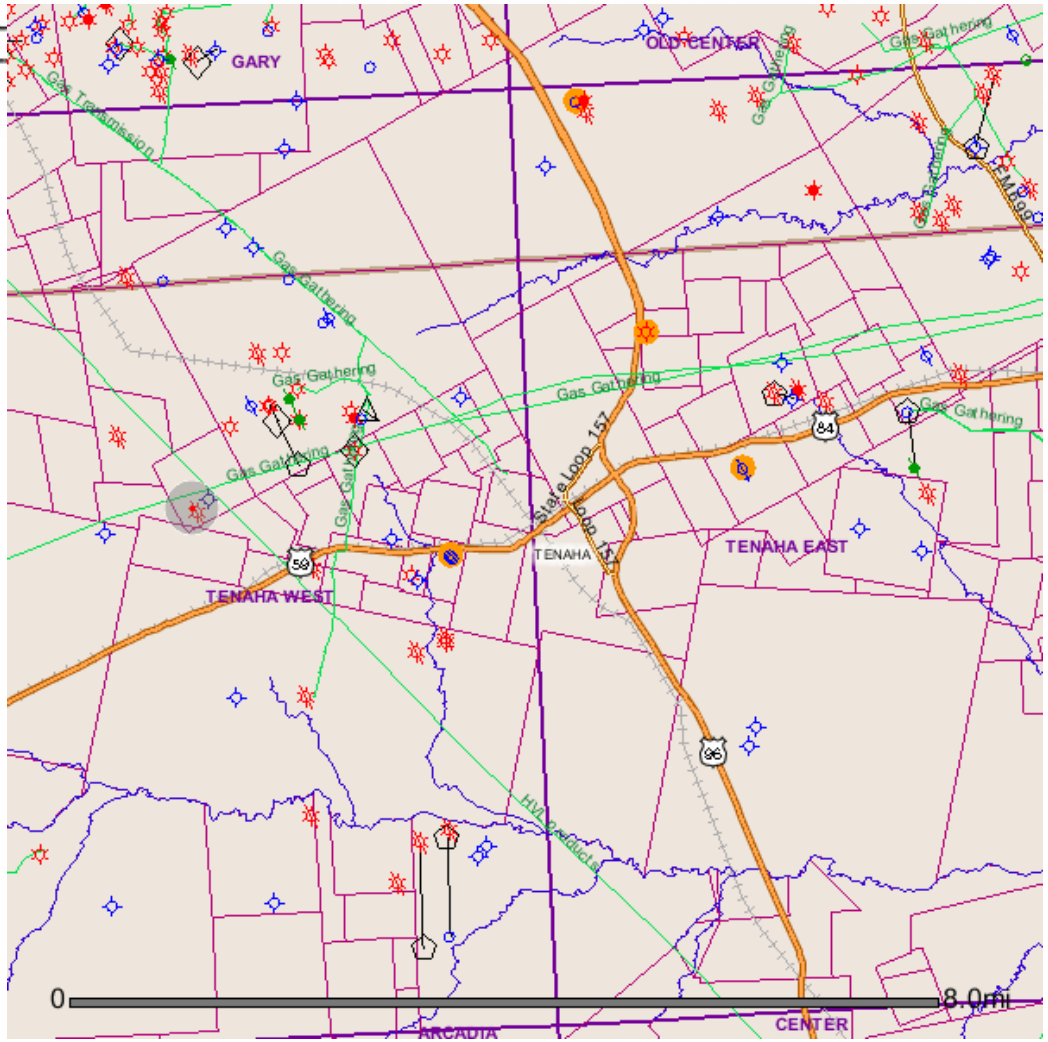
- AADE Article - 2005
- Lack of info from LaDNR
- Study to be Funded in 2014 by Ground Water Research & Education Foundation

Peoples' Pollard #2

REMARKS Encountered possible pressured salt water disposal / injection zone at 3025'. Lost circulation, unable to regain. TA'd well. Currently evaluating for possible sidetrack.

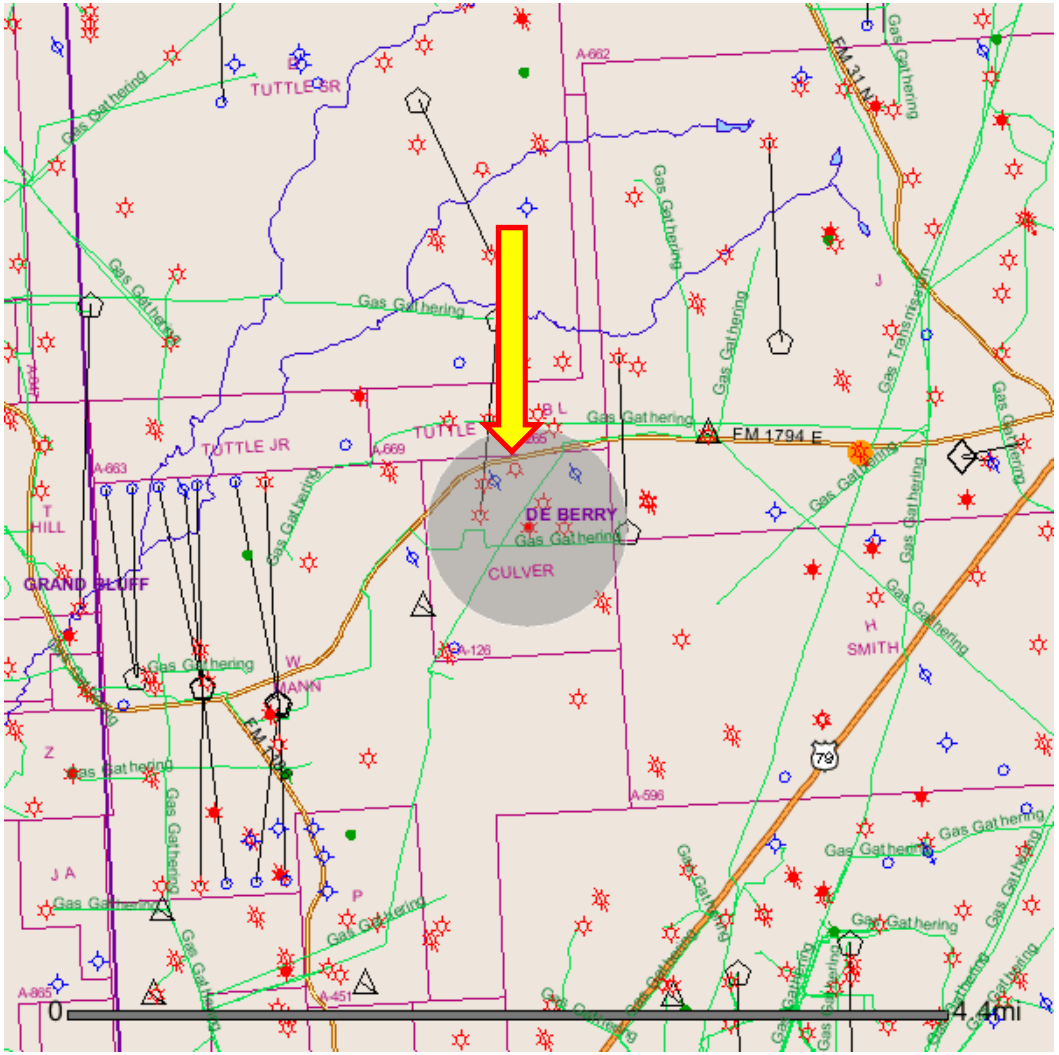
VALID PERMIT 619083 FEB 02 2007

The Pollard #2, west of Tenaha in north Shelby County, was drilled in June 2006 and eventually plugged in August 2008. The State spent over $77,000 from April 2007 – March 2008 hauling water from a nearby unidentified well before it could be plugged.



Graward's Jernigan-Evans #1

Graward's well, in north-central Panola County, is at the center of half-mile circle. Complete's well shown at the tip of the arrow. Breakout around Graward's well occurred within a couple of months from initial injection into Complete's well.



AADE-05-NTCE-33

AADE-05-NTCE-33

Case History: Updated Drilling Practices for the Carthage (Cotton Valley) Field

Fred McDougal, Anadarko Petroleum

This paper was prepared for presentation at the AADE 2005 National Technical Conference and Exhibition, held at the Wyndam Greenspoint in Houston, Texas, April 5-7, 2005. This conference was sponsored by the Houston Chapter of the American Association of Drilling Engineers. The information presented in this paper does not reflect any position, claim or endorsement made or implied by the American Association of Drilling Engineers, their officers or members. Questions concerning the content of this paper should be directed to the individuals listed as author/s of this work.

Abstract

Aggressive use of new technology and an overhaul of drilling practices have reduced drill times and resulted in production friendly wellbores for Anadarko in the Carthage (Cotton Valley) field. This paper describes some of the challenges faced by Operators in the mature Carthage (Cotton Valley) field and changes in drilling practices Anadarko has made over the last 3 years which have cut drill time by a third and improved

producing interval is the Pettit at 5900'. The Pettit was responsible for the bulk of the 7.7 TCF produced by the Lower Cretaceous carbonates. At the base of the Pettit, the lithology changes from predominately carbonate to sandstones and shale from the Travis Peak (6100') through the Cotton Valley (8300'). APC's Cotton Valley wells typically reach total depth (9700') in the Bossier shale.

Conditions have changed significantly since the

AADE-05-NTCE-33

- "Maintaining sufficient mud weight to control the SWD zones can induce massive mud losses to the 3 deeper producing intervals. This situation can quickly become unmanageable and require intermediate casing in severe cases."

- "The production string must be insulated from the corrosive waters in the Duck Creek and Rodessa SWD zones. However circulation is easily lost in the Pettit, Travis Peak and Cotton Valley during cement work"

AADE-05-NTCE-33 Cont.

- "Between 2000 and 2001, lost circulation during displacement of the production string cement job was reported on over 50% of APC's wells."

- "While the average cost to repair a casing leak is substantial at $90,000, the larger financial loss is impaired production."

AADE-05-NTCE-33 Cont.

- "Ninety casing leaks starting in the mid-1980s to present [2005] were investigated in detail. At least 70% of the leaks occurred from 2000' to 6500', which is the interval of most intense SWD activity."

- "Casing leaks were not showing until 2 to 3 years after spud before 1997. From 1997 to 2001 many of the leaks were detected a year or less after spud."

Drilling Problems

- Several operators encountering problems in Panola and Shelby Counties when drilling new wells
- Lost circulation during drilling operations (especially problematic in the Rodessa)
- Saltwater flows and differential sticking are contributing to the difficulty in successful drilling and completion operations

Top of Cement Issues

- Graward hearing in 2009 (Docket No. 06-0262483) found unreliable top of cement data in Panola County.
- Top of cement, as verified by cement bond logs, in producing wells was up to 1,000 feet below the calculated top of cement.
- As a result, the Commission found that the Rodessa is exposed in wells in proximity to the disposal well.
- Fluid from disposal well caused a breakout in outside of the surface casing of the nearby producing well.
- Hearing resulted in cancellation of disposal well permit.

Top of Cement Issues (cont.)

- Graward PFD found that:
  - Childress Well No. 1D
    - Calculated TOC would be at surface
    - CBL shows TOC at 3,060 feet
  - G. H. Stephens Well No. 6
    - W-15 shows TOC to surface
    - CBL shows TOC at 4,260 feet

Plugging Problems

- District has received several reports of operators encountering problems in plugging wells:
  - BP example
  - Saltwater flow during plugging
  - Pressure on surface casing

Snubbing unit needed by BP to successfully plug its Beckworth #2, a “shut-in” gas well.

Bradenhead Pressure

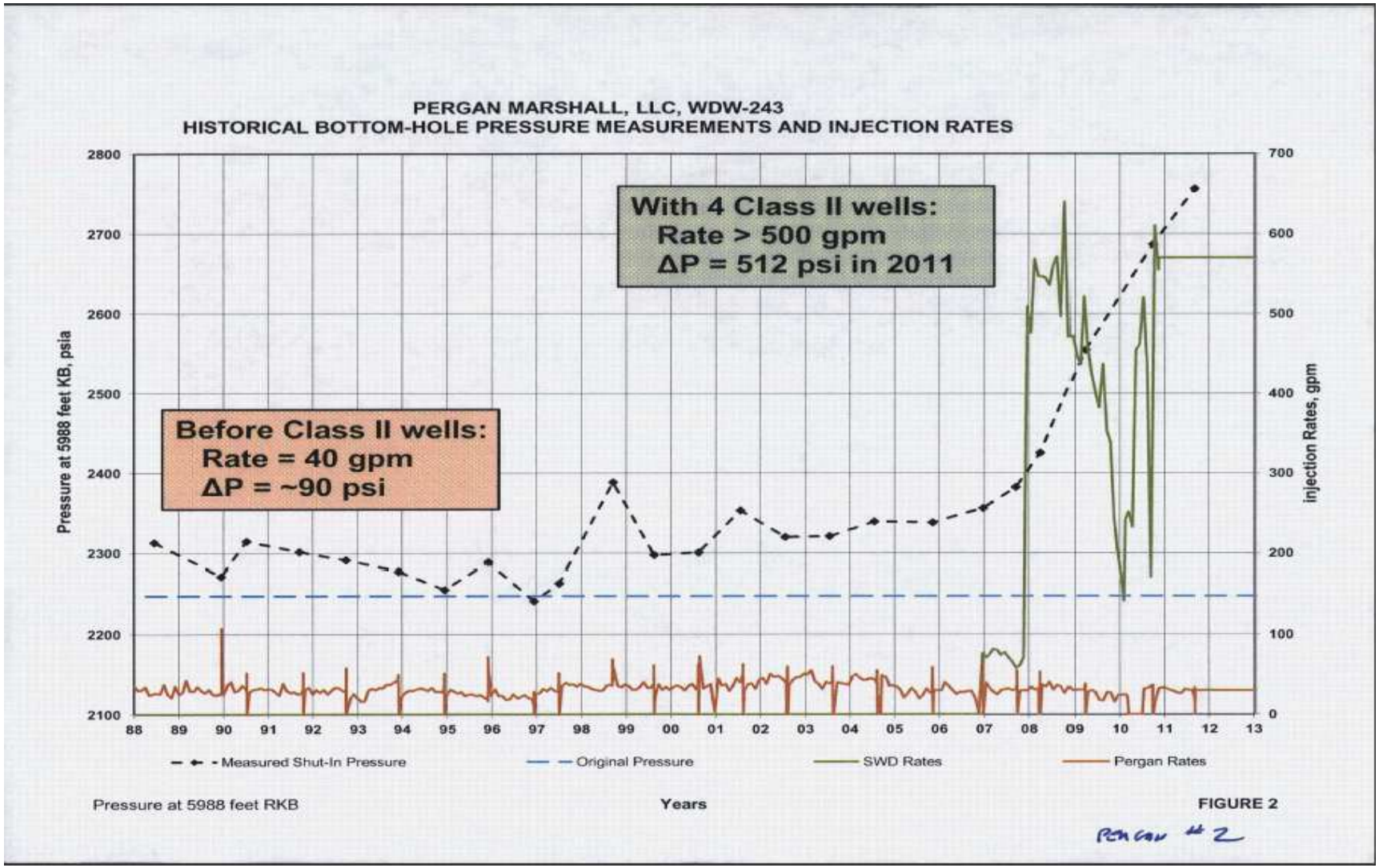
- Multitude of wells in area showing elevated bradenhead pressure.

- Many with pressures exceeding 500 psi and sustained water flows with elevated chloride concentrations

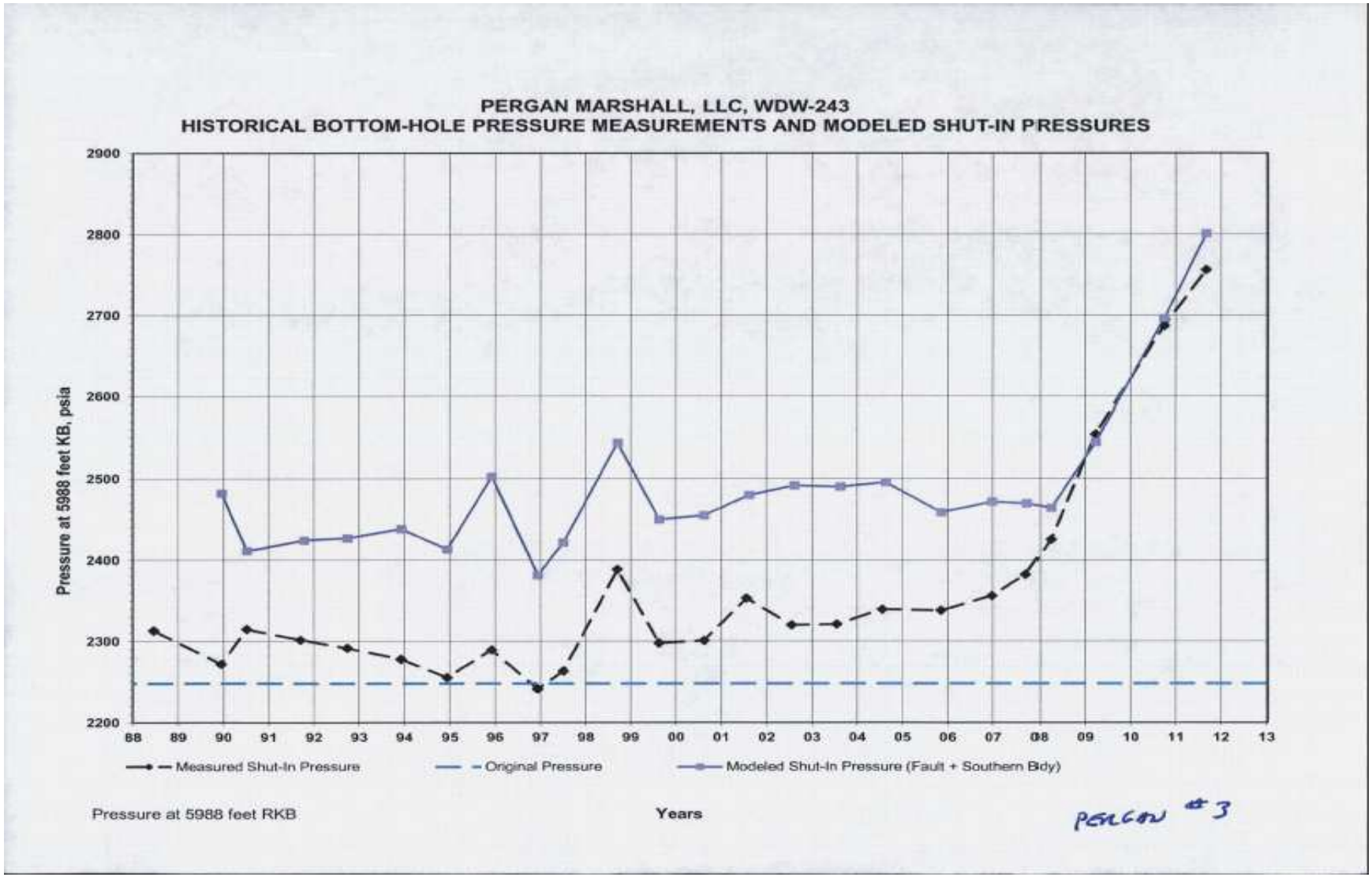
Pergan Marshall Class I Wells

- Two Class I hazardous waste disposal wells located outside city of Marshall (Harrison County)
- Class I Well operators must:
  - Demonstrate hazardous waste plume will not migrate into USDW for 10,000 years (EPA approval required)
  - Perform annual pressure falloff tests
  - Obtain permit renewal every 10 years

Pergan Marshall



Pergan Marshall



Responses to date:

- Discontinued permitting new injection wells in three county area beginning in 2008 and 2009
- Data acquisition:
  - Bottom Hole Pressure Measurements
  - Bradenhead Pressure Observations
- Rulemaking:
  - Rule 13 – Effective 1/1/2014: Require isolation of disposal interval in all new producing wells within AOR of existing or permitted injection wells.
  - Draft Rules 9 and 46 – Published for informal comment: Prove isolation of proposed disposal interval in all producing wells within AOR.

Additional Permit Conditions

INITIAL TESTING

- Perform an initial static bottom hole pressure test.
- Permit will be cancelled if initial pressure exceeds 250 psig or pressure gradient exceeds 0.465 psi/ft.

ONGOING TESTING

- After six months, one year, and annually thereafter, conduct a pressure fall off test.
- Permit will be cancelled if average reservoir pressure exceeds 250 psig or pressure gradient exceeds 0.465 psi/ft.

Rule 13 Provisions

"Casing shall be cemented across and above all formations permitted for injection under §3.9 of this title (relating to Disposal Wells) at the time the well is completed, or cemented immediately above all formations permitted for injection under §3.46 of this title (relating to Fluid Injection into Productive Reservoirs) at the time the well is completed, in a well within one-quarter mile of the proposed well location…"

Draft Rule 9 and 46 Provisions:

(F) A table of all wells of public record that penetrate the top of the proposed disposal interval and that are within a one-quarter mile radius of the proposed disposal well. The table shall include the well identification, date drilled, total depth, current status, and the plugging dates of those wells that are plugged. The table shall identify any wells that are not adequately cased and/or cemented, and that are unplugged, improperly plugged, or orphaned, and that penetrate the top of the proposed injection interval. In addition, the table shall identify any wells within the one-quarter mile radius that lack cement behind the casing through the proposed disposal interval. Alternatively, an applicant may request a variance under subsection (g)(2) of this section.

Possible Options

- Modify permits to:
  - Reduce injection rates and/or pressures
  - Pressure monitoring conditions
  - Establish term limits
  - Establish that bradenhead pressure buildup is NOT an indication that fluids are unconfined to the Rodessa
- SB 514 – Use of TxDot ROW