Shale Resource Development in the U.S.: Part I. History and Issues of Concern

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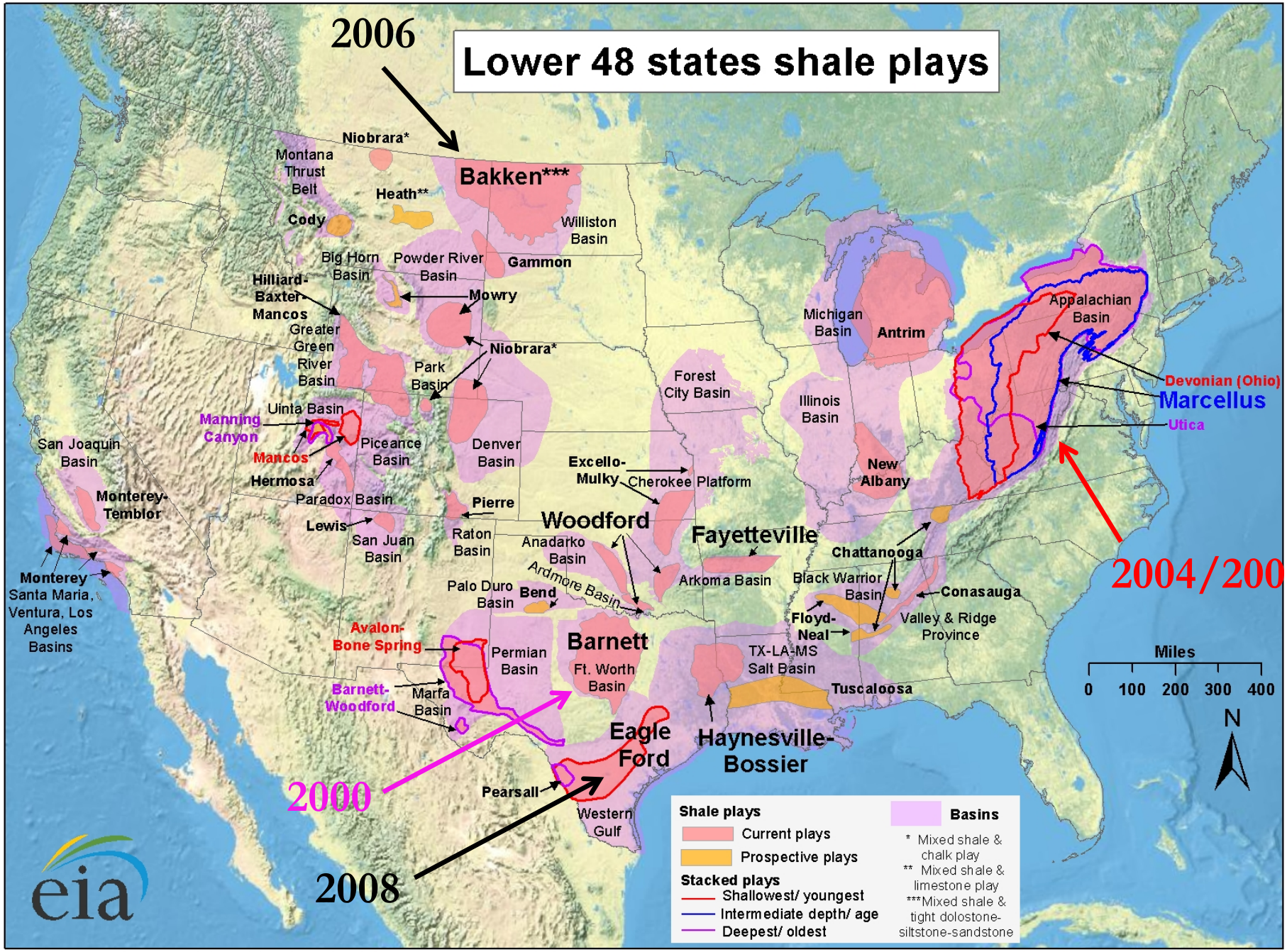
UT ARLINGTON™

Outline

- Shale gas development history in the U.S.
- Field trip of shale development sites
- Various issues related to hydraulic fracturing
- Ongoing major shale resource developments in the U.S.
- Summary



Source: Energy Information Administration based on data from various published studies.
Updated: May 9, 2011

http://www.eia.gov/pub/oil_gas/natural_gas/analysis_publications/maps/maps.htm

Brief Overview of Shale Resources Development

- 1821: 1st shale well (27 ft deep) in Fredonia, NY to provide the light equivalent of "two good candles"
- 1858: North America's first gas company (Fredonia Gas Light Company) founded; two gas wells 200 ft deep to supply gas for 30–35 yrs
- Late 1970s to early 1980s: DOE funded Eastern Gas Shales Project to study Devonian shale in eastern US
- 2000: mature hydraulic fracturing technologies at the Barnett Shale (George Mitchell of Mitchell Energy)
- 2004: Marcellus Shale at the Appalachian Basin
- 2008: Eagle Ford Shale with both oil and gas

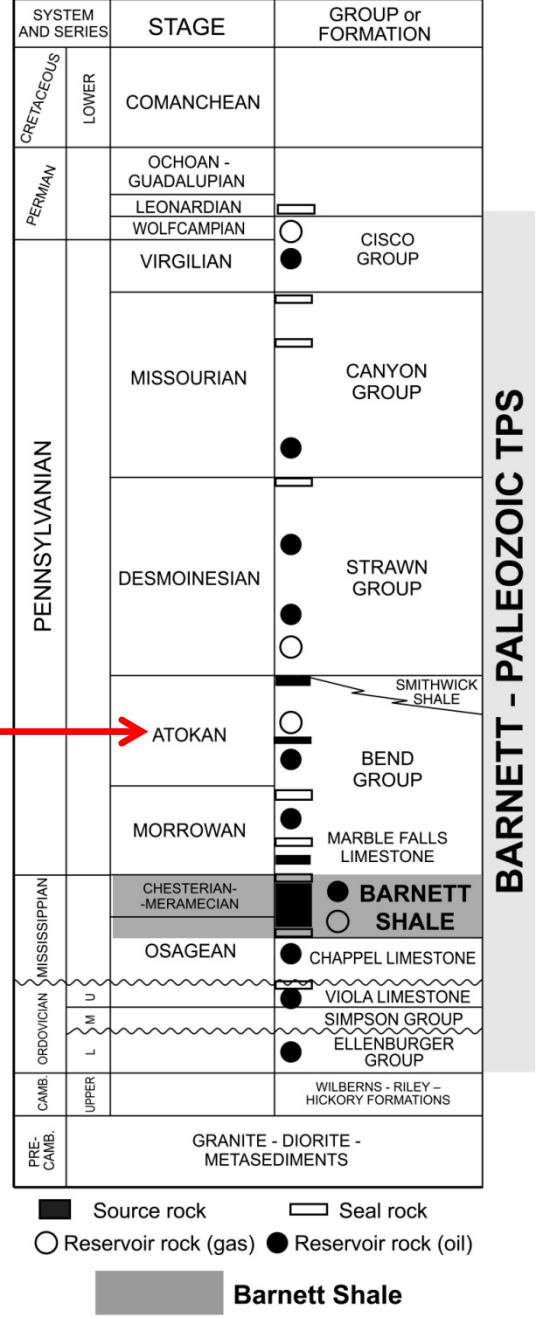


Figure 3. Generalized subsurface stratigraphic section of the Bend arch–Fort Worth Basin province showing the distribution of source rocks, reservoir rocks, and seal rocks of the Barnett-Paleozoic TPS. Modified from Pollastro (2003).

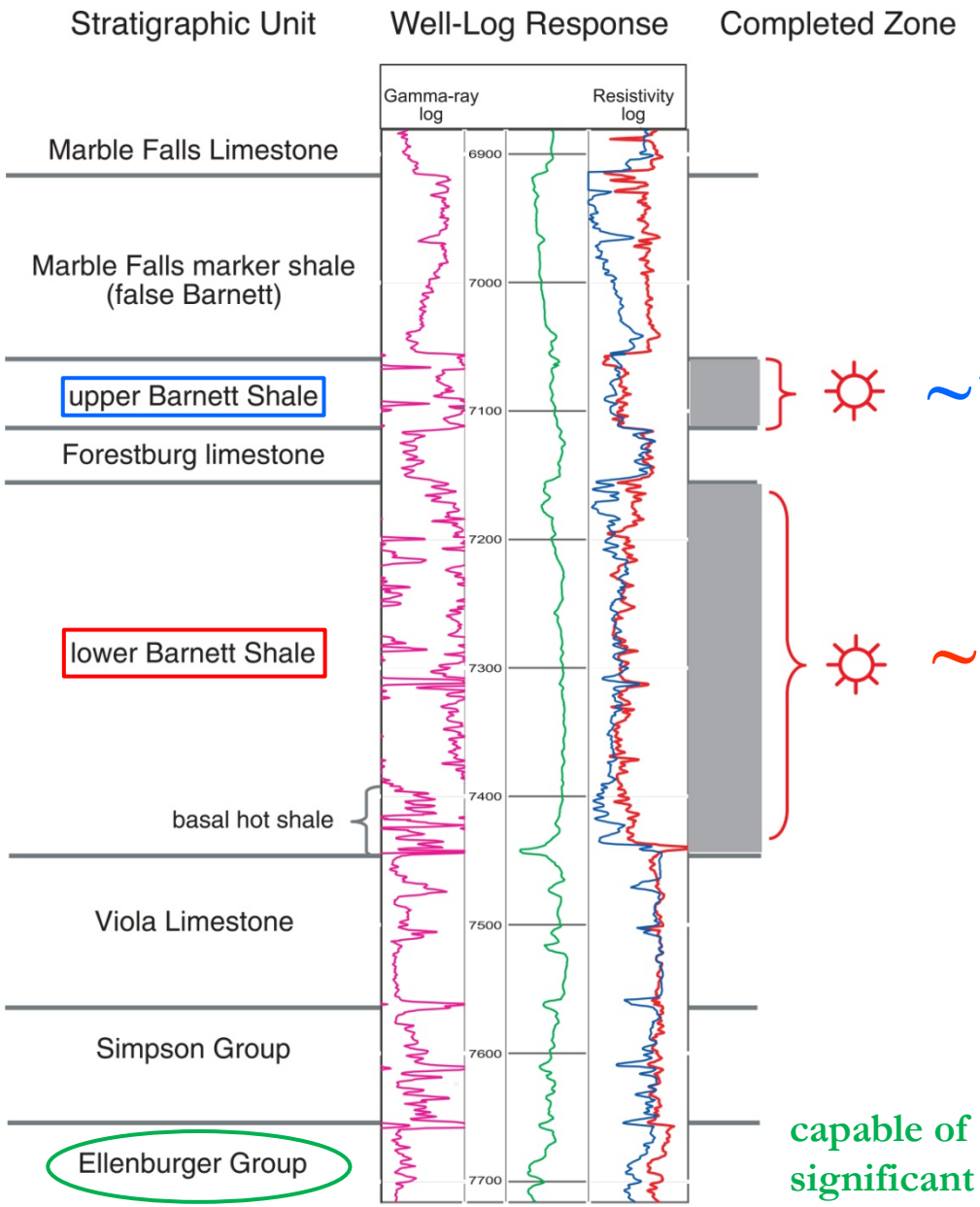
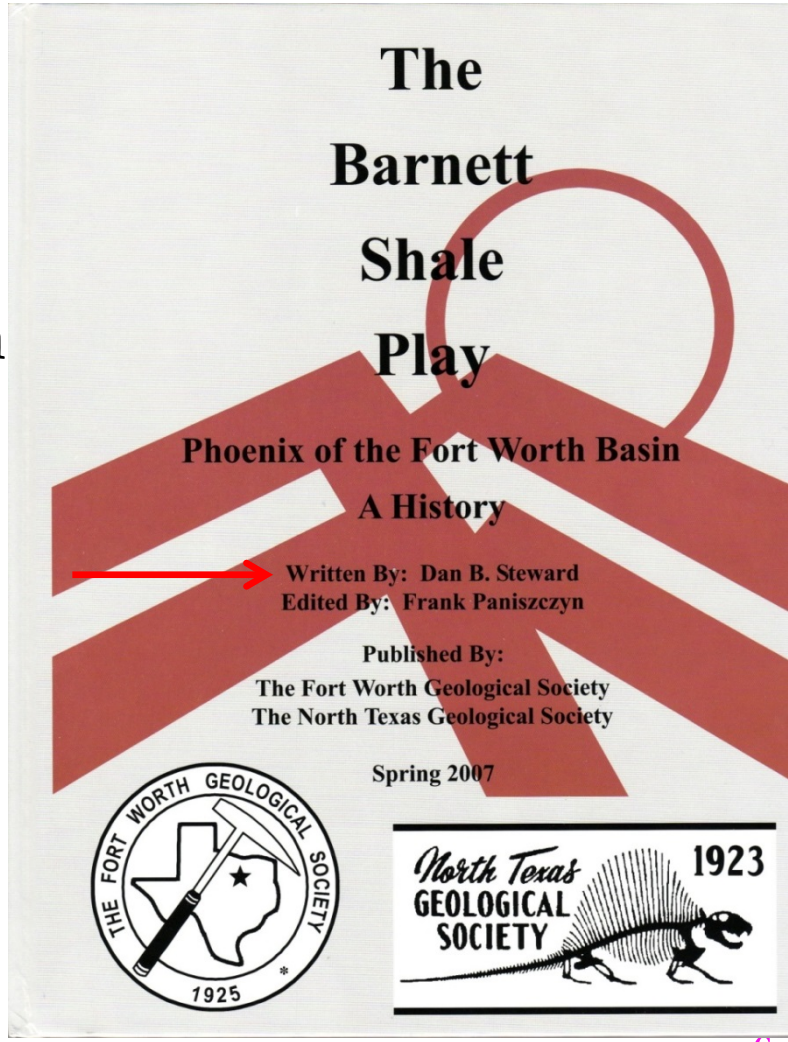


Figure 8. Typical well-log stratigraphic section showing gamma-ray and resistivity logs through the Barnett Shale and overlying and underlying units. Depth in feet.

George Mitchell's Entrance into North Texas

- **Mid–1940's to 1951**: gas production first recognized in the **Bend Conglomerates in the Wise County area**
- **Mitchell started a consulting firm in 1946**, and helped establish Oil Drilling Inc. with H. Merlyn Christie and Johnny Mitchell
- Drilled a dozen successful Bend Conglomerate gas wells
- Began to work with Natural Gas Pipeline (NGPL) to move gas to Chicago market (1953–1995)



George Mitchell during 1957 – 1981

- Began delivering gas to NGPL on Dec. 17, 1957
- 1962: company name changed to Mitchell & Mitchell Gas and Oil Corp. (buy–out of Christie's interest), and to George Mitchell & Associates (buyout of Johnny's 1/3 interest)
- 1963: acquired Southwestern Gas Pipeline to expand its gas processing business
- 1964: $6.25M purchase of 50,000 acres north of Houston
- 1968: started to drill in South and East Texas
- 1972: town of Woodlands started to be constructed

George Mitchell during 1957 – 1981

- By mid–1970's: offices in TX, OH, CO, OK; LA; and CA
- 1972: name changed to Mitchell Energy & Development Corp. and as a public company (George had 70% of the voting stock)
- 1973: the Arab Oil Embargo; demand for oil and gas production
- 1979: 1st largest massive hydraulic frac stimulation (a gelled water frac consisting of one million gallons of fluid and 2.8 million pounds of sand); opening up a new niche, unconventional, tight–gas reservoirs

George Mitchell during 1981 – 1985

- **Early 1981: the C.W. Slay No. 1 discovery well of Barnett shale to the depth of 7,856'; shut–in for evaluation in early June**
- **Decided to frac the perforated interval with nitrogen, with 250 ft theoretical frac half length (TFHL); assumed the shale has fracture network**
- **Late Sep. 1981: well treated and produced 246 Mcf; shut in for pipeline connection (not enough production for NGPL)**
- **June 1982: came on production at 120 Mcf/d; about 8 months after well completion**
- **1982–1985: filed a name Newark East (wells near the community of Newark in Wise County) for the new field discovery in the Barnett Shale**

George Mitchell during 1986 – 1997

- 1986: oil price crash
- 1986–1995: contract with NGPL renegotiated and buy–out on July 1, 1995 (have to use spot market pricing)
- 1987–1997: examined the production history
- 1987–1990: approached Gas Research Institute (GRI) for cash and technology infusion
- 1995: Sandia technology of micro seismic frac mapping, assisted by GRI; used at the Barnett, with initial failures
- 1990–1997: 3D seismic; improved economics (TFHL, tube string, down hole drilling motors)

George Mitchell during 1997 – 2001

- 1997: initial application of the light sand fracs (LSF)
- 1997: the sale of the real estate arm of the company, with $460M net proceeds; $200M used to pay for debt in shale gas
- Had so far invested about $250M in the Barnett play
- 1997: Chevron disbanded the unconventional group and leave the Barnett play; Kent Bowker joined Mitchell
- 1998–2001: expansion phase of the Barnett
- Prior to 2000: the Barnett play was dominated by Mitchell
- Sep. 28, 2000: the Barnett Shale Symposium by the Oil Information Library of Fort Worth
- Aug. 14, 2001: Devon Energy and Mitchell Energy merged; Devon paid $60.40/share for 51.7 million shares

George Mitchell (1919 - 2013)

- A native of Galveston, Texas
- Graduated from Texas A&M University with a degree in petroleum engineering (No. 1 in the class) and geology (waited tables in the residence halls; sold candy; built bookcases); the school's largest benefactor with donations topping $95 million
- Brought 300,000 lease acres in north of Fort Worth known as "The Wildcatters' Graveyard"
- By 1964, Mitchell & Mitchell owned over 1,000 producing wells, and George and Cynthia Mitchell had 10 children
- In 1960's, to develop a real estate project; The Woodlands, a 25,000-acre planned community opened late 1974
- Mitchell Energy & Development Corp. went public in 1972 (60% stocks); merger in January 2002 with Devon Energy for $3.1B
- A testament to intellect, optimism, and perseverance, persisted through 17 yrs of failures and incremental successes (Father of Fracking)
- During his career, participated in about 10,000 wells, including more than 1,000 wildcats
- In 2013, the annual Forbes list of wealthiest Americans ranked him 239th with a net worth of $2 billion

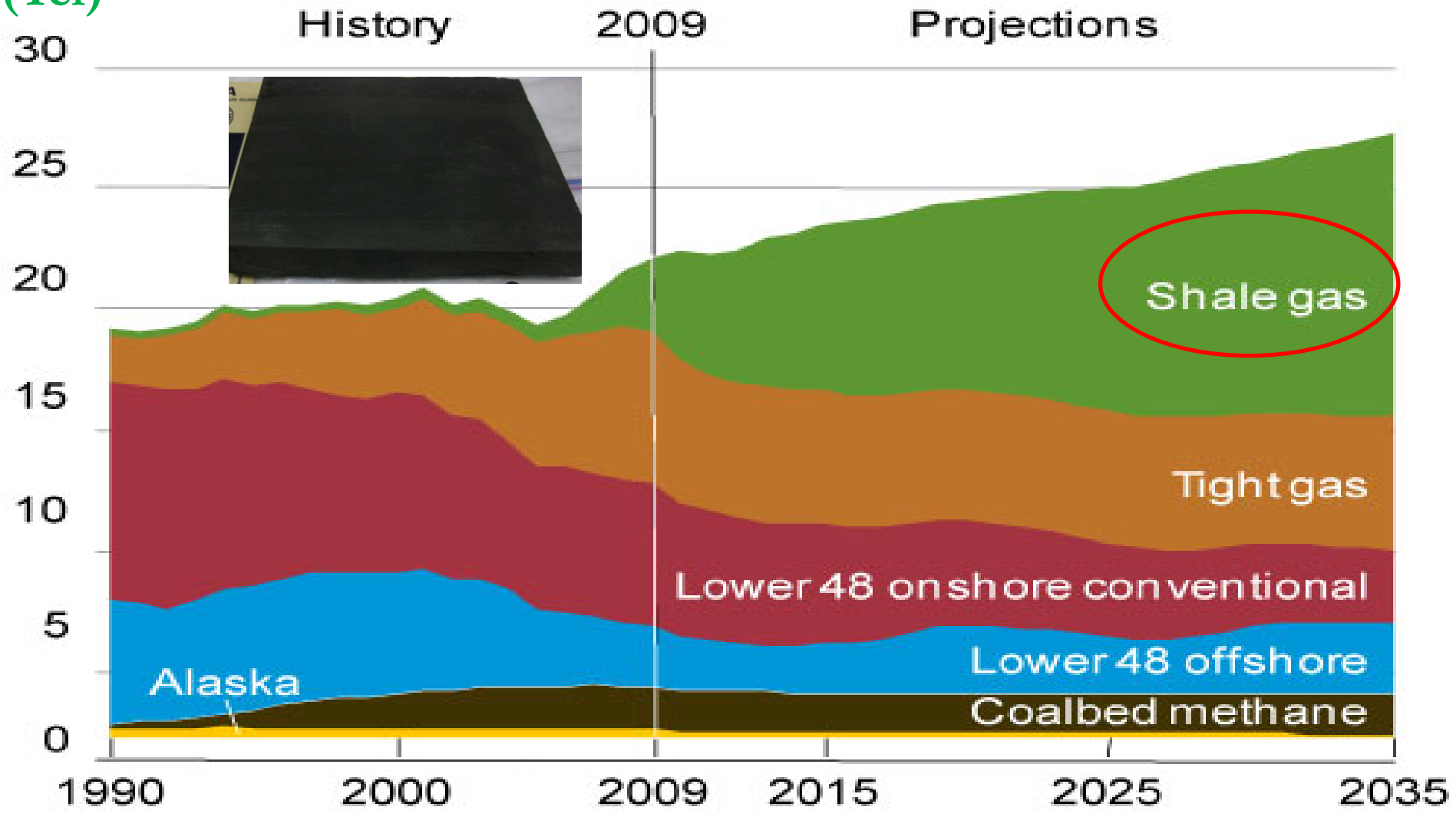
http://cgmf.org/index.php

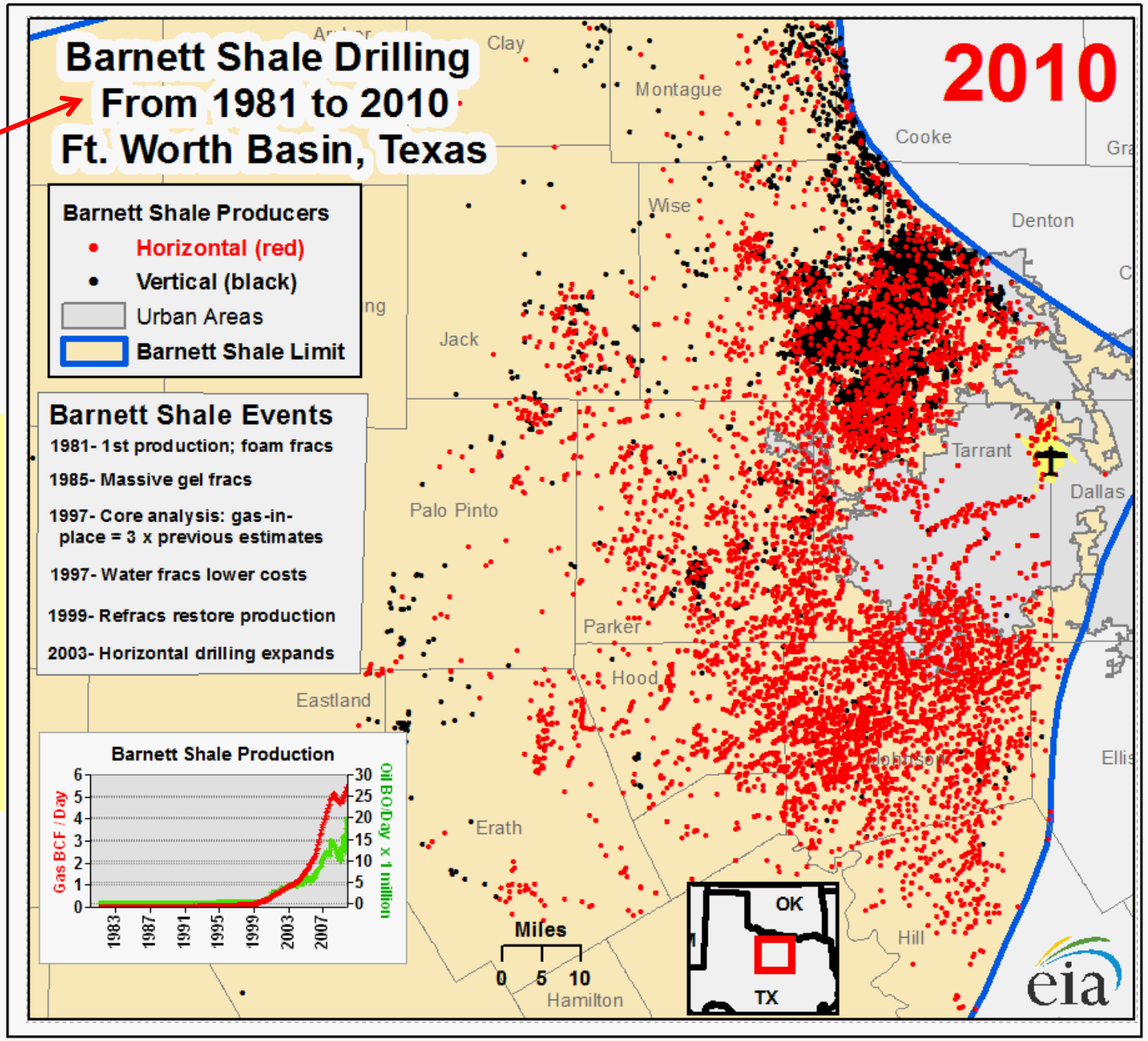
History of MEC C.W. Slay No. 1 (Barnett Discovery Well)

- Drilled in early 1981 by Mitchell Energy
- Fractured with nitrogen foam; produced 212 MMcf (million cubic feet) in 12 years
- Shut–in for almost 2 years
- Re–fractured using large gel fracturing: produced another 29 MMcf in 2.5 years
- Shut-in for another 2–yr period
- Fractured with large water (light sand): produced another 1,007 MMcf
- Currently producing 6.3 MMcf gas/month
- To date, has produced 1,348 MMcf gas

U.S. Shale Gas Production

- 1.0 Tcf (28.3 Bcm) in 2006
- 4.8 Tcf in 2010 (23% of total gas supply; expected to be 46% by 2035)





http://www.eia.gov/todayinenergy/detail.cfm?id=2170

Updated June 1, 2011

What is horizontal drilling and hydraulic fracturing?

http://www.hydraulicfracturing.com/Process/Pages/information.aspx

Pressures at 480 to 850 bars to open existing fractures or initiate new fractures

Carrizo Oil and Gas Com.

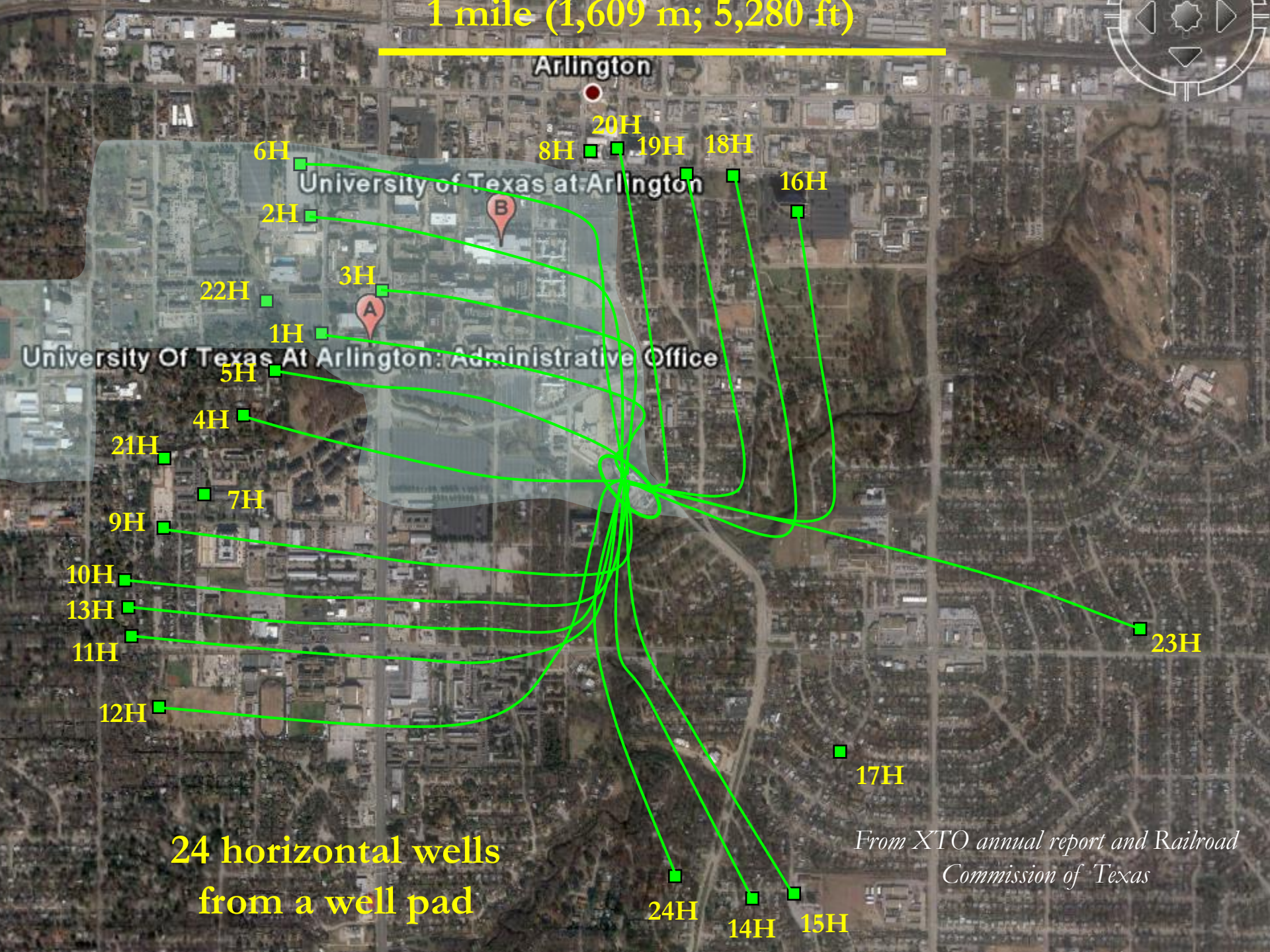
$400,000 one–time donation

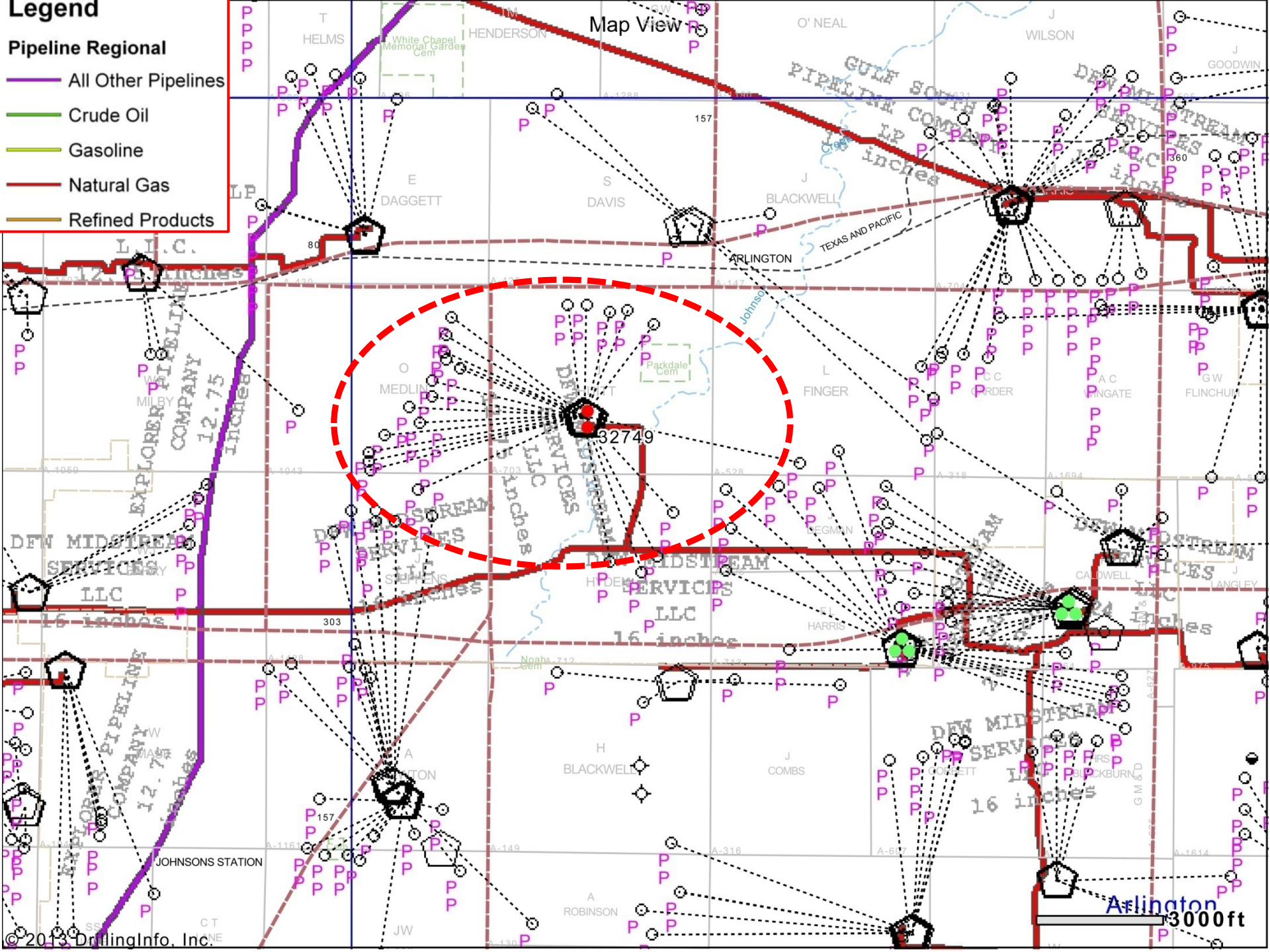
$391,000 ($1,000 per acre) for the right

27% royalty

Barnett drilling location at 2008
University of Texas at Arlington

http://www.star-telegram.com/2010/09/30/2510136/ut-arlington-pad-site-exemplifies.html


1 mile (1,609 m; 5,280 ft)
Arlington
University of Texas at Arlington
University Of Texas At Arlington: Administrative Office
A
B
6H
8H
20H
19H
18H
16H
2H
3H
22H
1H
5H
4H
21H
7H
9H
10H
13H
11H
12H
23H
17H
24H
14H
15H
24 horizontal wells
from a well pad
From XTO annual report and Railroad
Commission of Texas


Legend
Pipeline Regional
All Other Pipelines
Crude Oil
Gasoline
Natural Gas
Refined Products
Map View
32749
ARLINGTON
JOHNSONS STATION
TEXAS AND PACIFIC
DFW MIDSTREAM SERVICES LLC
16 inches
EXPLORER PIPELINE COMPANY
12.75 inches
GULF SOUTH PIPELINE COMPANY LP
Arlington
3000ft
© 2013 DrillingInfo, Inc.

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- Various issues related to hydraulic fracturing
- Ongoing major shale resource developments in the U.S.
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1105
S. PECAN
DANGER
NO SMOKING
PELIGRO
NO FUMAR
CARRIZO
CARRIZO
CARRIZO
DANGER NO SMOKING ALLOWED
(911) CARRIZO OIL & GAS, INC.
EMERGENCY NUMBER 866-515-1998
FIRE LANE
NO PARKING
P
Continuing Ed/
WFDC
Visitor Parking
Lot 46
TOBACCO-FREE CAMPUS
April 2013


WOODLAND FENCE
817-851-9420
1105 PECAN
DANGER NO SMOKING
PELIGRO NO FUMAR
Carrizo Oil & Gas, Inc.
613 South 4th Avenue
Mansfield, Texas 76063
Emergency Response Plan - City of Arlington
24 Hour Emergency Number 1-866-515-1998
817-477-9955
ARRIZO
CARRIZO
CARRIZO
TA A UNIT
.94 ACRES
Emergencies Call:
1-866-515-1998
UTA C UNIT
407.61 ACRES
For Emergencies Call:
1-866-515-1998
UTA B UNIT
295.8 ACRES
For Emergencies Call:
1-866-515-1998
DANGER NO SMOKING ALLOWED
(911) CARRIZO OIL & GAS, INC.
EMERGENCY NUMBER 866-515-1998

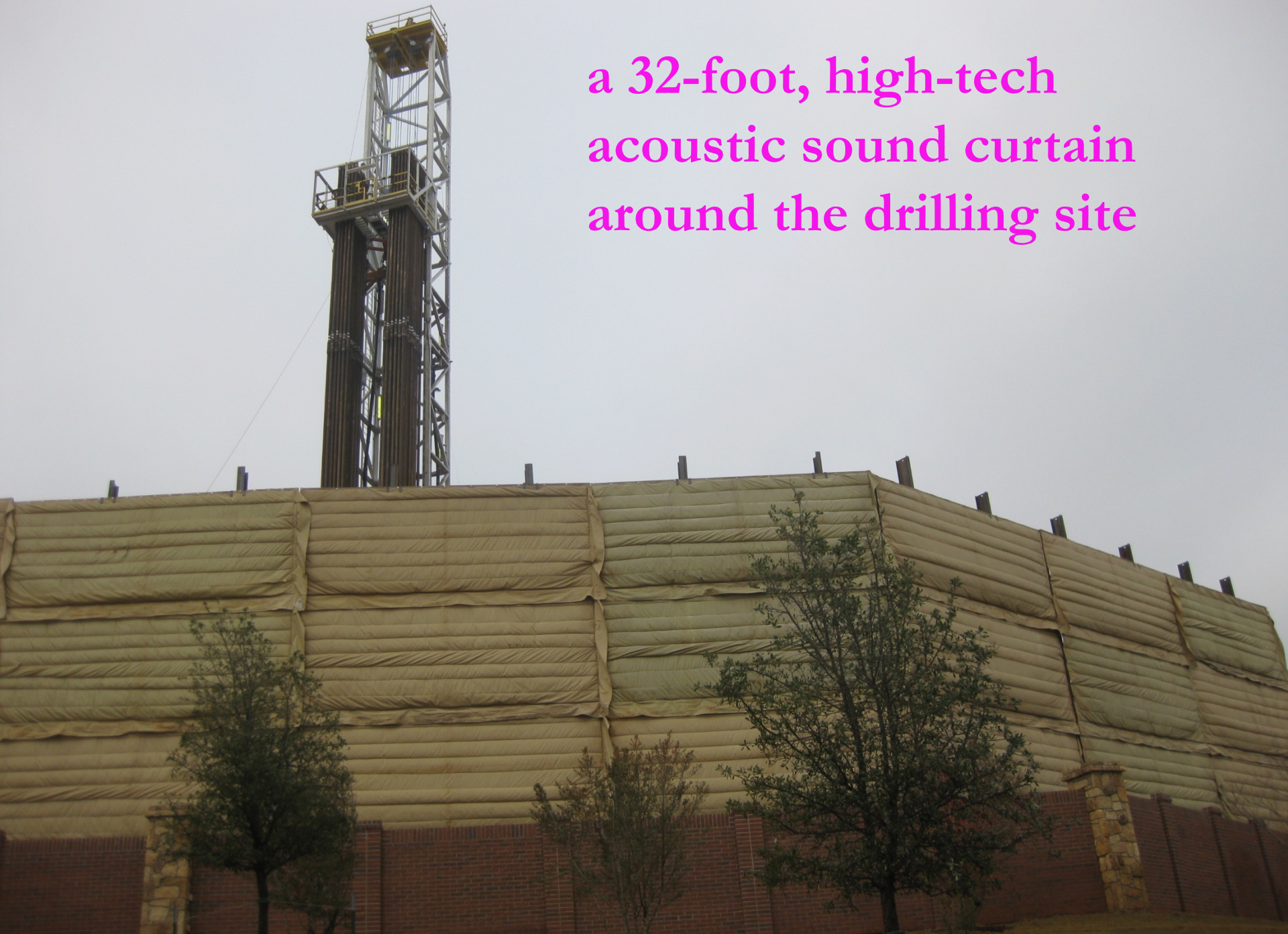
April 2013


April 2013


Air
monitoring
station
April 2013


November, 2010
Cooper Street near
Green Oaks,
Arlington, TX
4 miles away from
UT Arlington


November, 2010
Cooper Street near Green Oaks,
Arlington, TX
4 miles away from UT Arlington


a 32-foot, high-tech
acoustic sound curtain
around the drilling site


“fracturing fleet”
2 weeks for drilling
2 weeks for completion
STOP

Field trip (April 2009)


XTO
ENERG
PATTERSON-UTI
DRILLING COMPANY LLC
RIG 310


Drill rig and pipe

Pressure pump


10-million gallons fracturing pond


XTO ENERGY
Fracturing trailer

Gas gathering and processing station

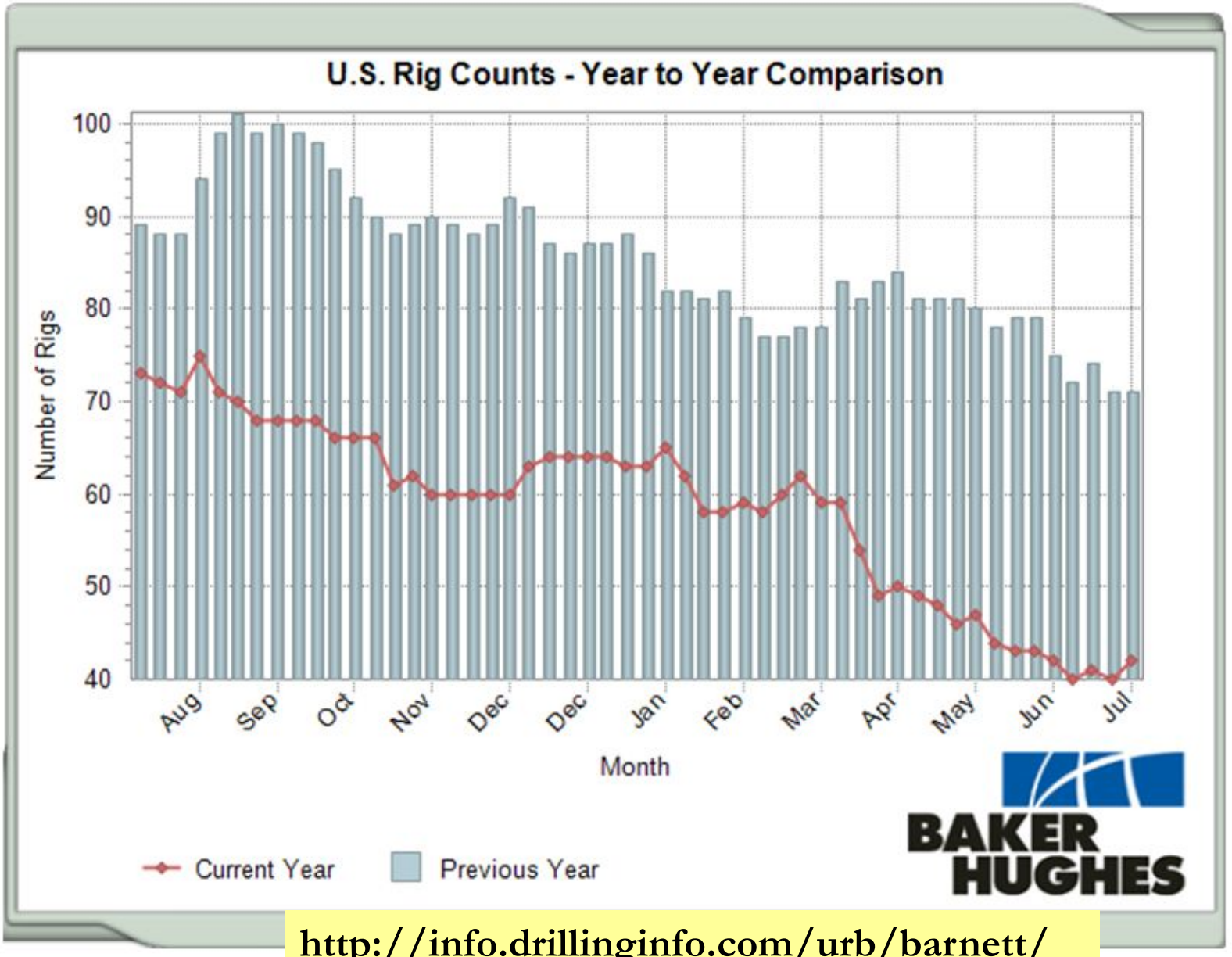
U.S. Natural Gas Wellhead Price

$3.35 mcf (7/18/2013)

http://www.eia.gov/dnav/ng/hist/n9190us3m.htm

EnergyStrategyPartners

Barnett Shale Rig Count as of 7/13/2012



http://info.drillinginfo.com/urb/barnett/

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Concerns about Shale Resources Development

- Water availability and consumption
- Ground water contamination
- Fracturing fluid and flowback fluid management
- Seismic activity
- Air emission
- Noise
- Land use and surface disturbance
- Naturally Occurring Radioactive Material (NORM)
- Sand mining (silica in the dust)

Kargbo, D.M., R.G. Wilhelm and D.J. Campbell. 2010. Natural gas plays in the Marcellus Shale: Challenges and potential opportunities. *Environmental Science and Technology*, 44(15): 5679-5684.


Pennsylvanians for NATURAL GAS
SAY YES TO MARCELLUS
Will Frac For Clean Energy
Pennsylvanians for NATURAL GAS
I SUPPORT RESPONSIBLE DRILLING
DRILLING = JOBS, STRONG ECONOMY & CLEAN ENVIRONMENT

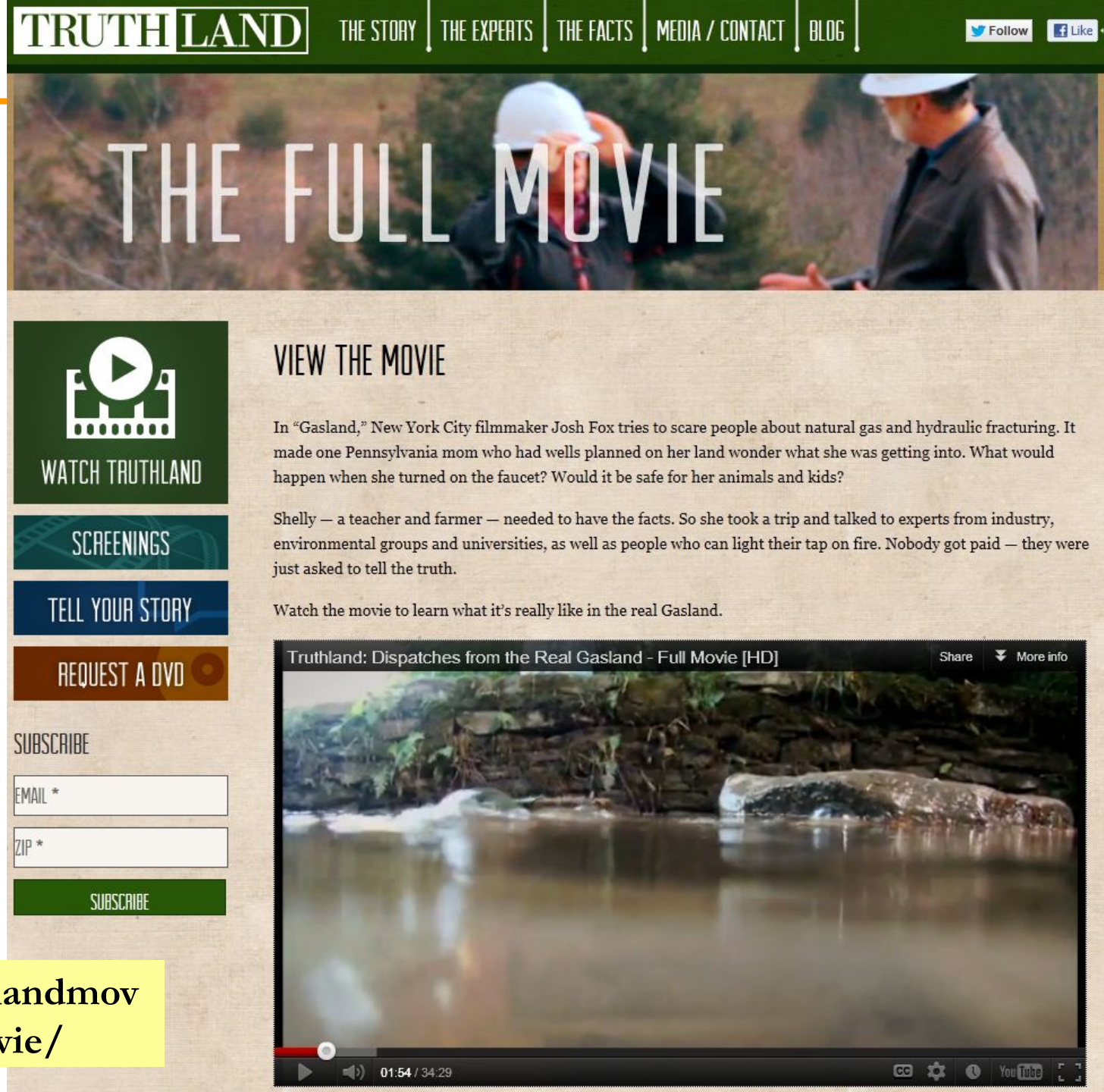
September 20, 2012 in Philadelphia

GASLAND: A Film by Josh Fox (Premier on HBO on June 21, 2010)

DVD available in Dec. 2010

http://gaslandthemovie.com/

Copyright: Energy In Depth, a project of the Independent Petroleum Association of America (IPAA)



http://www.truthlandmovie.com/watch-movie/

EXHIBIT 37: ESTIMATED WATER NEEDS FOR DRILLING AND FRACTURING WELLS IN SELECT SHALE GAS PLAYS

Shale Gas Play	Volume of Drilling Water per well (gal)	Volume of Fracturing Water per well (gal)	Total Volumes of Water per well (gal)
Barnett Shale	400,000	2,300,000	2,700,000
Fayetteville Shale	60,000*	2,900,000	3,060,000
Haynesville Shale	1,000,000	2,700,000	3,700,000
Marcellus Shale	80,000*	3,800,000	3,880,000

* Drilling performed with an air "mist" and/or water-based or oil-based muds for deep horizontal well completions.

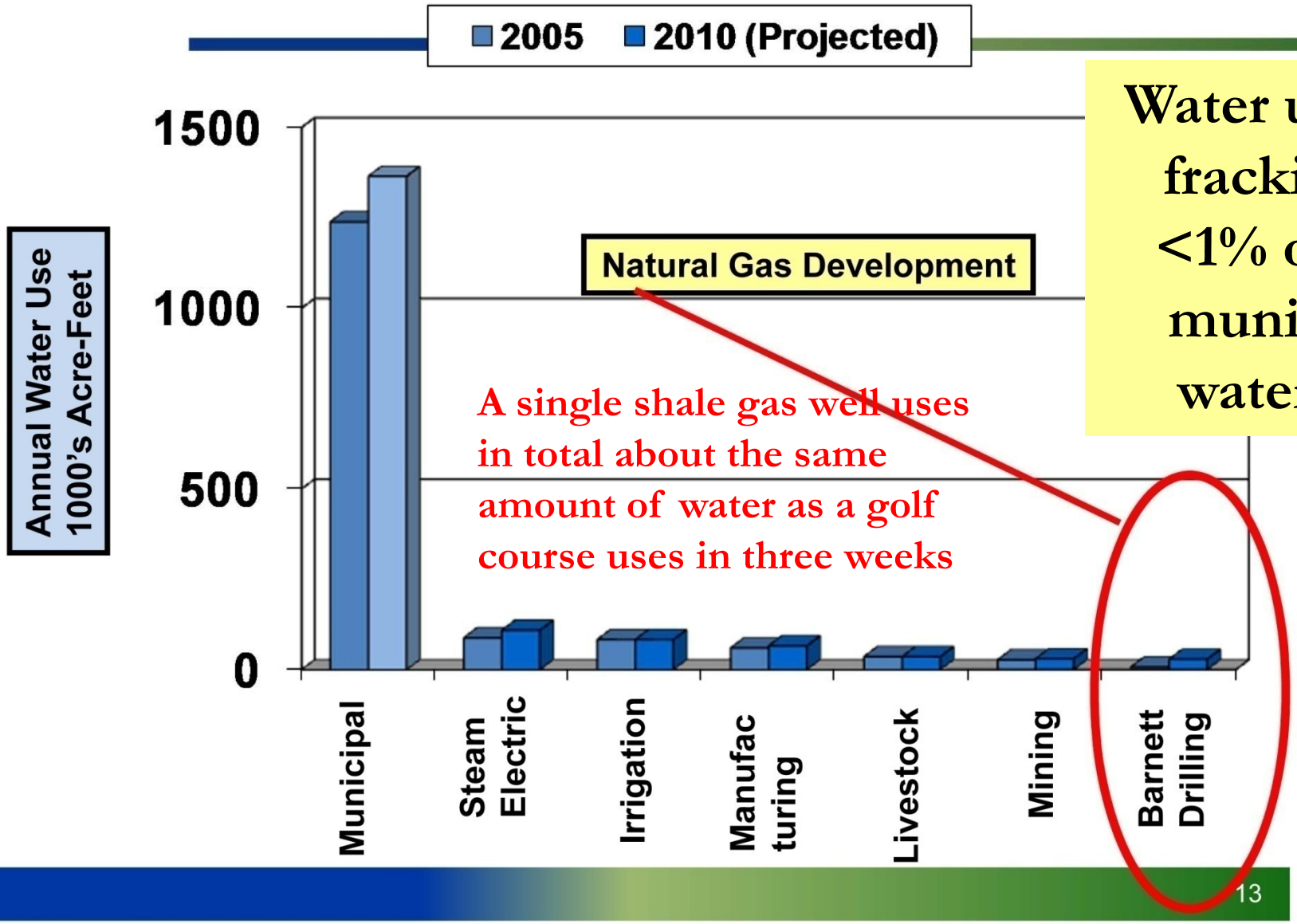
Note: These volumes are approximate and may vary substantially between wells.

Source: ALL Consulting from discussions with various operators, 2008

DOE (2009)

A gallon = 3.7854 liters

Freshwater Users in the Barnett Shale Region



Water used in fracking is <1% of the municipal water use

gti

Public Concerns

- Water availability and consumption
- **Ground water contamination**
- Fracturing fluid and flowback water management
- Seismic activities
- Air emission
- Noise
- Land use and surface disturbance
- Naturally Occurring Radioactive Material (NORM)
- Sand mining (silica in the dust)

Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing

8172–8176 | PNAS | May 17, 2011 | vol. 108 | no. 20

Stephen G. Osborn[a], Avner Vengosh[b], Nathaniel R. Warner[b], and Robert B. Jackson[a,b,c,1]

[a]Center on Global Change, Nicholas School of the Environment, [b]Division of Earth and Ocean Sciences, Nicholas School of the Environment, and [c]Biology Department, Duke University, Durham, NC 27708

Schon, S.C. 2011. Hydraulic fracturing not responsible for methane migration. *PNAS,* 108(37): E664-E664.

Saba, T. and M. Orzechowski. 2011. Lack of data to support a relationship between methane contamination of drinking water wells and hydraulic fracturing. *PNAS*, 108(37): E663-E663.

Davies, R.J. 2011. Methane contamination of drinking water caused by hydraulic fracturing remains unproven. *PNAS*, 108(43): E871-E871.

Osborn, S.G., A. Vengosh, N.R. Warner and R.B. Jackson. 2011. Reply to Saba and Orzechowski and Schon: Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing. *PNAS,* 108(37): E665-E666.

Jackson, R.B., S.G. Osborn, A. Vengosh and N.R. Warner. 2011. Reply to Davies: Hydraulic fracturing remains a possible mechanism for observed methane contamination of drinking water. *PNAS,* 108(43): E872-E872.

Methane in Pennsylvania water wells unrelated to Marcellus shale fracturing

Oil & Gas Journal | Dec. 5, 2011

Lisa J. Molofsky
John A. Connor
Shahla K. Farhat
GSI Environmental Inc.
Houston

Albert S. Wylie Jr.
Tom Wagner
Cabot Oil & Gas Corp.
Pittsburgh

Acknowledgments

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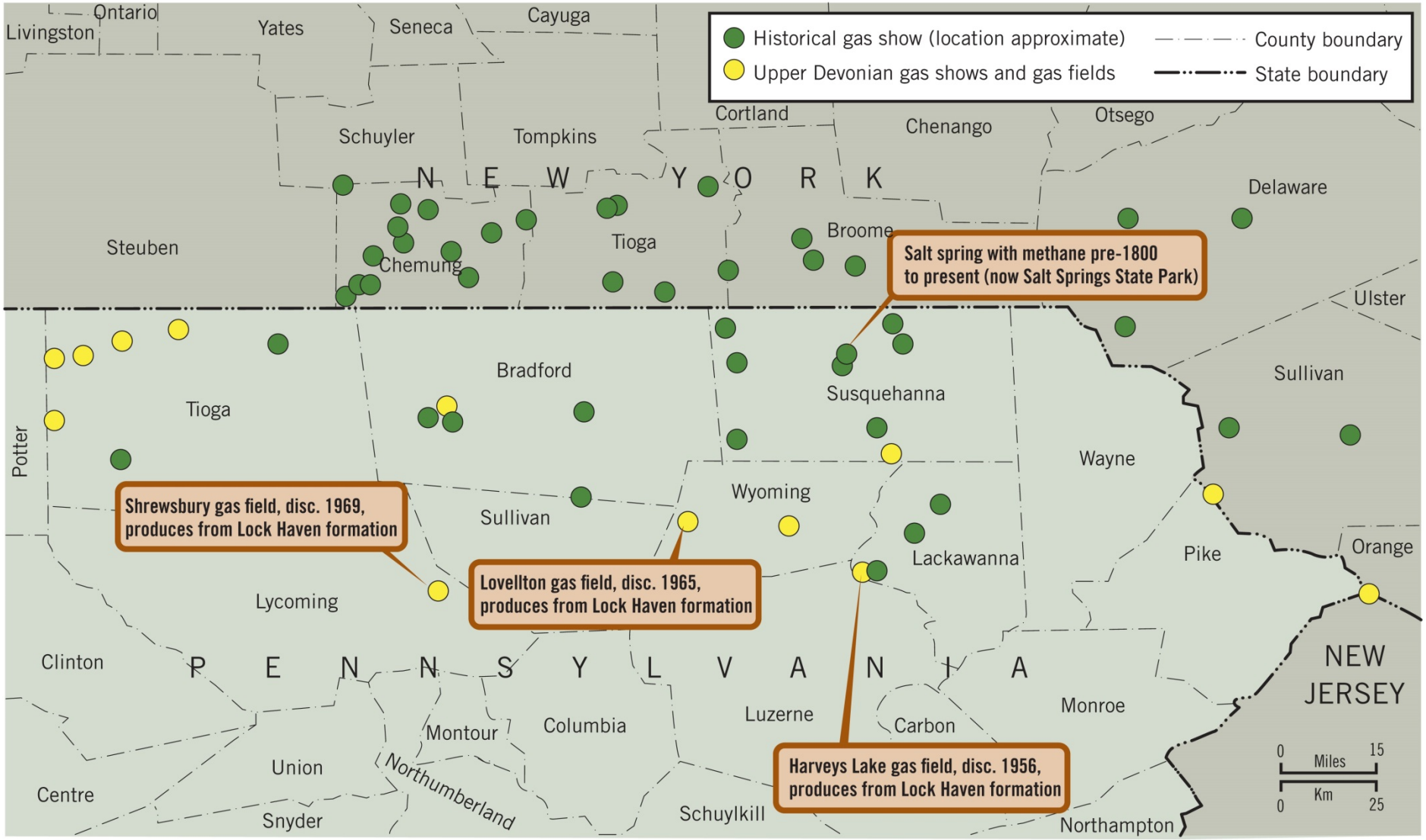
HISTORIC LOCATIONS OF GAS SHOWS AND GAS FIELDS IN NORTHEASTERN PENNSYLVANIA

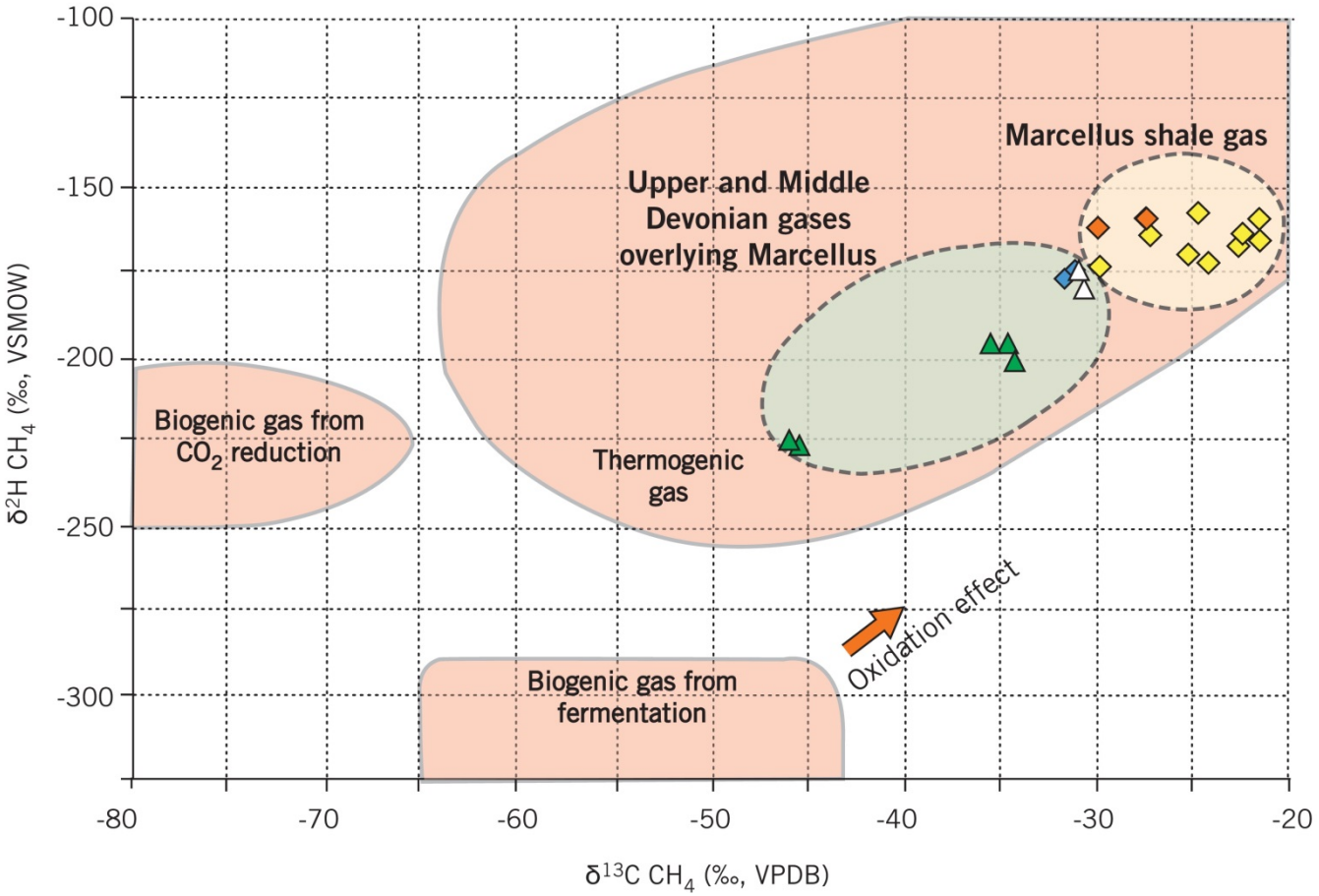
FIG. 3



Molofsky et al. (2011)

COMPARISON OF SUSQUEHANNA COUNTY METHANE ISOTOPIC SIGNATURES

FIG. 6



Gas well samples

- Middle/Upper Devonian formation gases overlying the Marcellus (collected by Pa. DEP)
- Marcellus shale gas (collected by Cabot)
- Marcellus shale gas (collected by Pa. DEP)

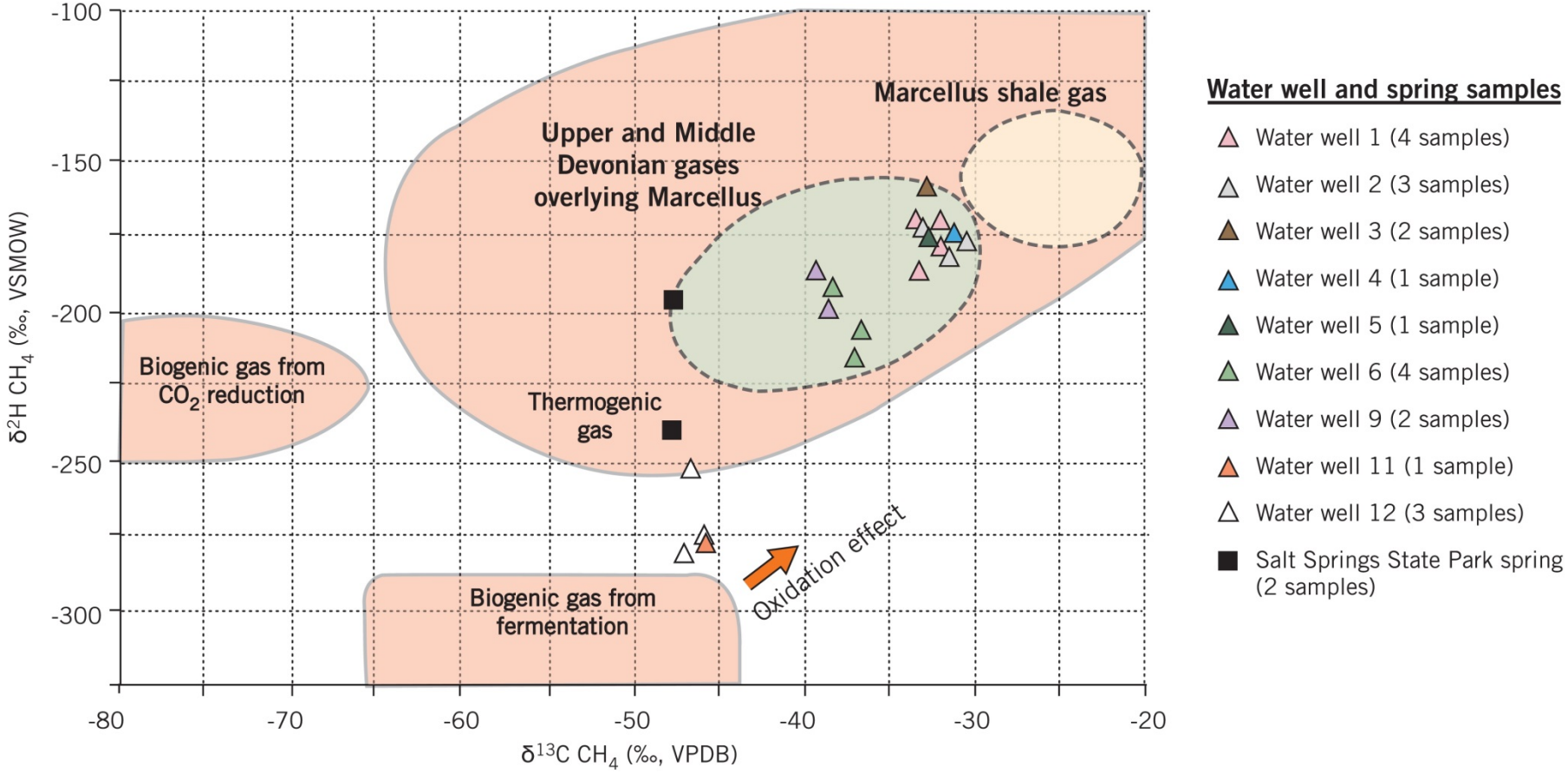
Water well samples

- Dissolved methane classified as Middle/Upper Devonian gases overlying the Marcellus by Pa. DEP (water wells 7 and 8: 1 & 2 samples, respectively)
- Dissolved methane classified as Upper Devonian gases overlying the Marcellus by Pa. DEP (water wells 10, 13, and 14: 2, 2, & 1 sample(s), respectively)

Molofsky et al. (2011)

ISOTOPIC SIGNATURES OF DISSOLVED METHANE FROM ADDITIONAL WATER WELLS AND A SALT SPRING

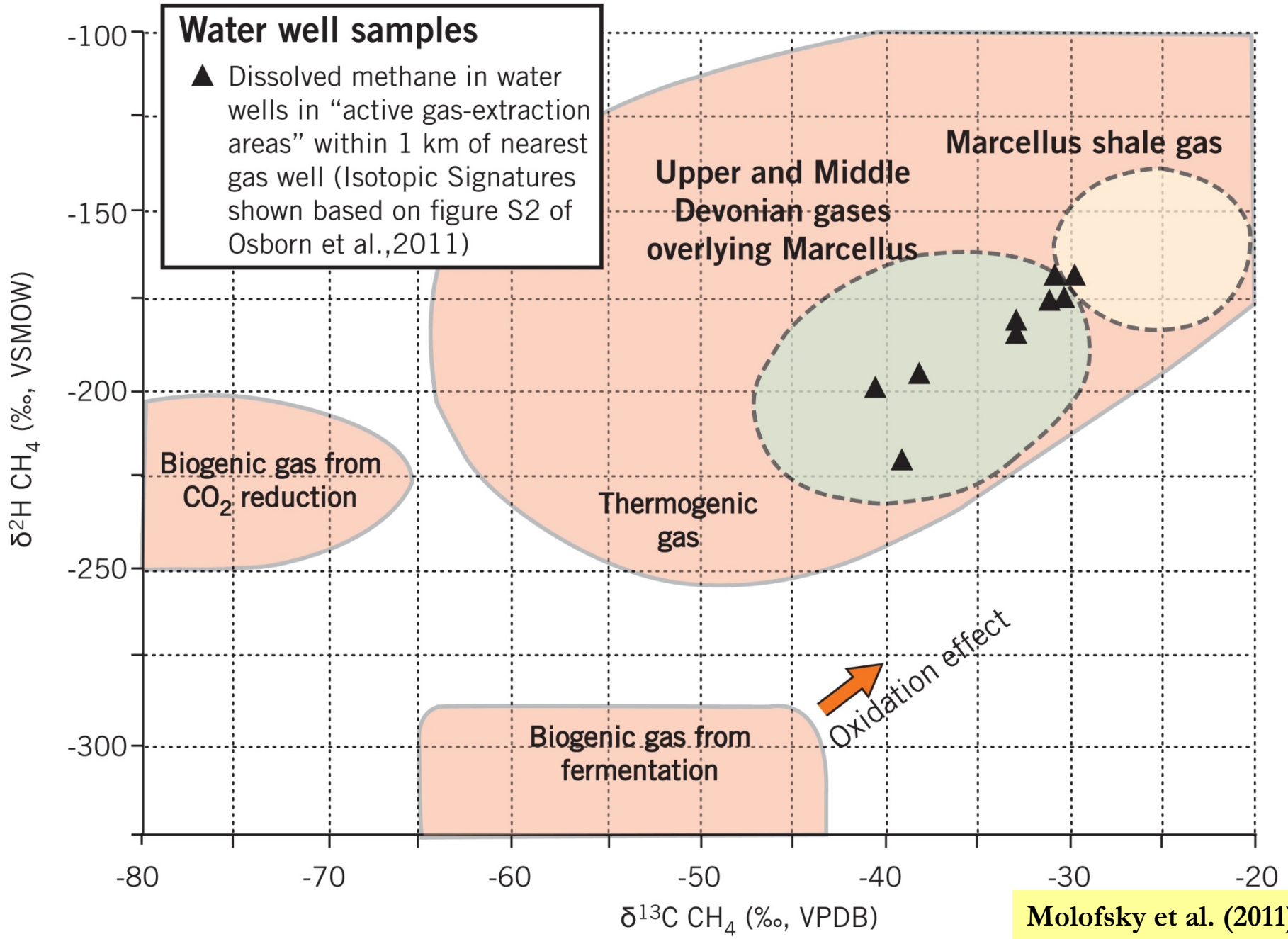
FIG. 7



Molofsky et al. (2011)

DUKE 2010 STUDY IN SUSQUEHANNA COUNTY

FIG. 9



Molofsky et al. (2011)

Geochemical evidence for possible natural migration of Marcellus Formation brine to shallow aquifers in Pennsylvania

Nathaniel R. Warner[a], Robert B. Jackson[a,b], Thomas H. Darrah[a], Stephen G. Osborn[c], Adrian Down[b], Kaiguang Zhao[b], Alissa White[a], and Avner Vengosh[a,1]

[a]Division of Earth and Ocean Sciences, Nicholas School of the Environment, Duke University, Durham, NC 27708; [b]Center on Global Change, Nicholas School of the Environment, Duke University, Durham, NC 27708; and [c]Geological Sciences Department, California State Polytechnic University, Pomona, CA 91768

Edited by Karl K. Turekian, Yale University, North Haven, CT, and approved May 10, 2012 (received for review January 5, 2012)

PNAS | July 24, 2012 | vol. 109 | no. 30 | 11961–11966

Engelder, T. 2012. Capillary tension and imbibition sequester frack fluid in Marcellus gas shale. *PNAS*, 109(52): E3625-E3625.

Warner, N.R., R.B. Jackson, T.H. Darrah, S.G. Osborn, A. Down, K. Zhao, A. White and A. Vengosh 2012. Reply to Engelder: Potential for fluid migration from the Marcellus Formation remains possible. *PNAS*, 109(52): E3626-E3626.

Terry Engelder is in the department of geosciences at Pennsylvania State University, University Park, Pennsylvania 16802, USA.

Competing financial interests

Over more than 40 years, T.E.'s research on fracking has been supported by US government agencies including the NSF, DOE, RPSEA, NETL, NYSERDA, EPRI, GRI, NRC, USGS, and PA-DCNR. Industry support has come from Royal Dutch Shell, Total, Elf, Agip, Texaco, Shell USA, Exxon, ARCO, Mobil, Chevron, Chesapeake, Range Resources, CNX, Talisman, Samson, Southwestern, Encana, Hess and Schlumberger. He has also consulted for industry nationally and internationally.

Applied Geochemistry xxx (2013) xxx–xxx

May 2013

Contents lists available at SciVerse ScienceDirect

Applied Geochemistry

journal homepage: www.elsevier.com/locate/apgeochem

Geochemical and isotopic variations in shallow groundwater in areas of the Fayetteville Shale development, north-central Arkansas ☆

Nathaniel R. Warner [a], Timothy M. Kresse [b], Phillip D. Hays [c], Adrian Down [a], Jonathan D. Karr [d], Robert B. Jackson [a], Avner Vengosh [a,*]

[a] Division of Earth and Ocean Sciences, Nicholas School of the Environment, Duke University, Durham, NC 27708, USA
[b] U.S. Geological Survey, Arkansas Water Science Center, Little Rock, AR 72211, USA
[c] U.S. Geological Survey, Arkansas Water Science Center, Fayetteville, AR 72701, USA
[d] Duke Environmental Stable Isotope Laboratory, Duke University, Durham, NC 27708, USA

Acknowledgments

Funding for this study was provided by the Nicholas School of the Environment and the Center on Global Change at Duke University and by funding to the Nicholas School from Fred and Alice Stanback. Field sampling activities were funded by Shirley Community Development Corporation and Faulkner County, Arkansas. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the US Government.

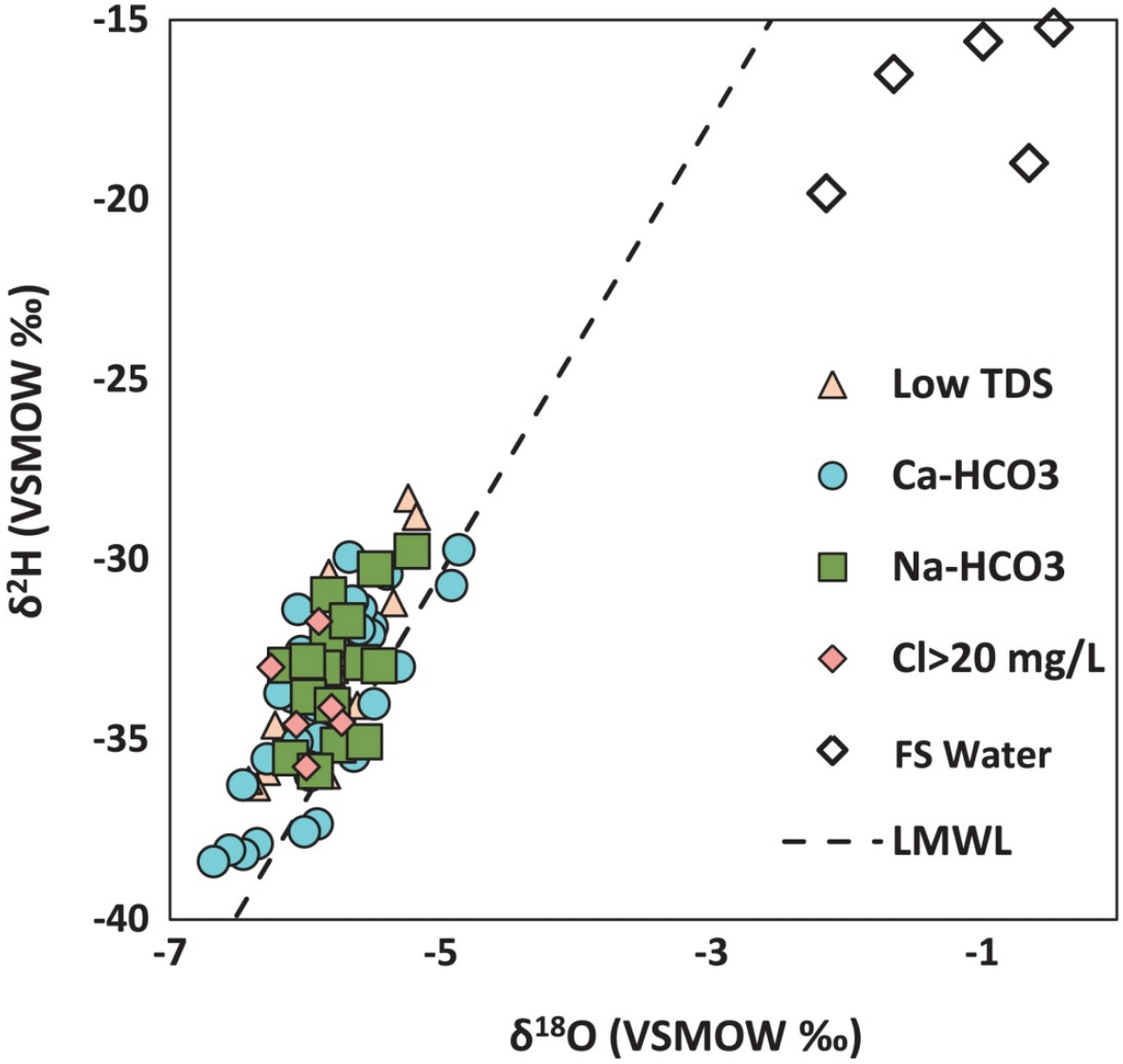


Fig. 12. δ^2H versus $\delta^{18}O$ values in shallow groundwater and the Fayetteville Shale brines. The relationship between $\delta^{18}O$ and δ^2H in shallow groundwater is consistent with the local meteoric water line (LMWL) while the Fayetteville Shale brines plot to the right of the LMWL and could reflect mixing between depleted $\delta^{18}O$ and δ^2H low-saline water and $\delta^{18}O$ and δ^2H-enriched brines.

Warner et al. (2013)

"Impact of Shale Gas Development on Regional Water Quality"

REVIEW SUMMARY

Impact of Shale Gas Development on Regional Water Quality

R. D. Vidic,[1]* S. L. Brantley,[2] J. M. Vandenbossche,[1] D. Yoxtheimer,[2] J. D. Abad[1]

READ THE FULL ARTICLE ONLINE
http://dx.doi.org/10.1126/science.1235009

Cite this article as R. Vidic *et al.*, *Science* **340**, 1235009 (2013). DOI: 10.1126/science.1235009

Table 1. Common chemical additives for hydraulic fracturing.

Additive type	Example compounds	Purpose
Acid	Hydrochloric acid	Clean out the wellbore, dissolve minerals, and initiate cracks in rock
Friction reducer	Polyacrylamide, petroleum distillate	Minimize friction between the fluid and the pipe
Corrosion inhibitor	Isopropanol, acetaldehyde	Prevent corrosion of pipe by diluted acid
Iron control	Citric acid, thioglycolic acid	Prevent precipitation of metal oxides
Biocide	Glutaraldehyde, 2,2-dibromo-3-nitrilopropionamide (DBNPA)	Bacterial control
Gelling agent	Guar/xantham gum or hydroxyethyl cellulose	Thicken water to suspend the sand
Crosslinker	Borate salts	Maximize fluid viscosity at high temperatures
Breaker	Ammonium persulfate, magnesium peroxide	Promote breakdown of gel polymers
Oxygen scavenger	Ammonium bisulfite	Remove oxygen from fluid to reduce pipe corrosion
pH adjustment	Potassium or sodium hydroxide or carbonate	Maintain effectiveness of other compounds (such as crosslinker)
Proppant	Silica quartz sand	Keep fractures open
Scale inhibitor	Ethylene glycol	Reduce deposition on pipes
Surfactant	Ethanol, isopropyl alcohol, 2-butoxyethanol	Decrease surface tension to allow water recovery

- Environmental risks to regional water quality: gas emission; contaminant transport through induced and natural fractures; wastewater discharge; accidental spills
- Accidental rate of seal problems in unconventional gas wells is relatively low (1 to 3%)
- "Multiple lines of evidence approach"

Source: Science Review/Summary May 2013

"Gas drilling taints groundwater"

- Shale-gas extraction has transformed the US energy landscape, but its environmental effects are unclear
- Fears about the potential impact on ground-water resources have taken center stage in a number of high-profile disputes between scientists, regulators and industry

Source: Nature News, June 25 2013

- The PNAS (June 24, 2013) paper of Rob Jackson at the Center on Global Change of Duke University in Durham, North Carolina, on Marcellus shale
- Jackson stresses that the contamination is probably due to poor well construction, rather than hydraulic fracturing itself
- Jackson's team found methane in 115 of the 141 shallow drinking-water wells that it sampled; carbon-isotope ratios of the methane molecules, and ethane, propane and helium are also analyzed
- But the team did not find evidence that chemicals used in fracking migrated from depth to contaminate aquifers
- Jackson says that his results do not necessarily mean that all drilling operations will have problems. More importantly, he says, the results suggest that the problem (well integrity) is relatively simple to fix

Increased stray gas abundance in a subset of drinking water wells near Marcellus shale gas extraction

Robert B. Jackson[a,b,1], Avner Vengosh[a], Thomas H. Darrah[a], Nathaniel R. Warner[a], Adrian Down[a,b], Robert J. Poreda[c], Stephen G. Osborn[d], Kaiguang Zhao[a,b], and Jonathan D. Karr[a,b]

[a]Division of Earth and Ocean Sciences, Nicholas School of the Environment and [b]Center on Global Change, Duke University, Durham, NC 27708; [c]Department of Earth and Environmental Sciences, University of Rochester, Rochester, NY 14627; and [d]Geological Sciences Department, California State Polytechnic University, Pomona, CA 91768

Edited by Susan E. Trumbore, Max Planck Institute for Biogeochemistry, Jena, Germany, and approved June 3, 2013 (received for review December 17, 2012)

Author contributions: R.B.J., A.V., T.H.D., N.R.W., and A.D. designed research; R.B.J., A.V., T.H.D., N.R.W., A.D., R.J.P., S.G.O., K.Z., and J.D.K. performed research; R.B.J., A.V., T.H.D., N.R.W., A.D., R.J.P., K.Z., and J.D.K. analyzed data; and R.B.J., A.V., T.H.D., N.R.W., and A.D. wrote the paper.

The authors declare no conflict of interest.

This article is a PNAS Direct Submission.

Freely available online through the PNAS open access option.

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This article contains supporting information online at www.pnas.org/lookup/suppl/doi:10.1073/pnas.1221635110/-/DCSupplemental.

ACKNOWLEDGMENTS. W. Chameides, the Jackson laboratory, and anonymous reviewers provided helpful suggestions on the work. We acknowledge financial support from the Nicholas School of the Environment and Center on Global Change and Fred and Alice Stanback to the Nicholas School. We thank William Chameides, Dean of the Nicholas School, for supporting this research.

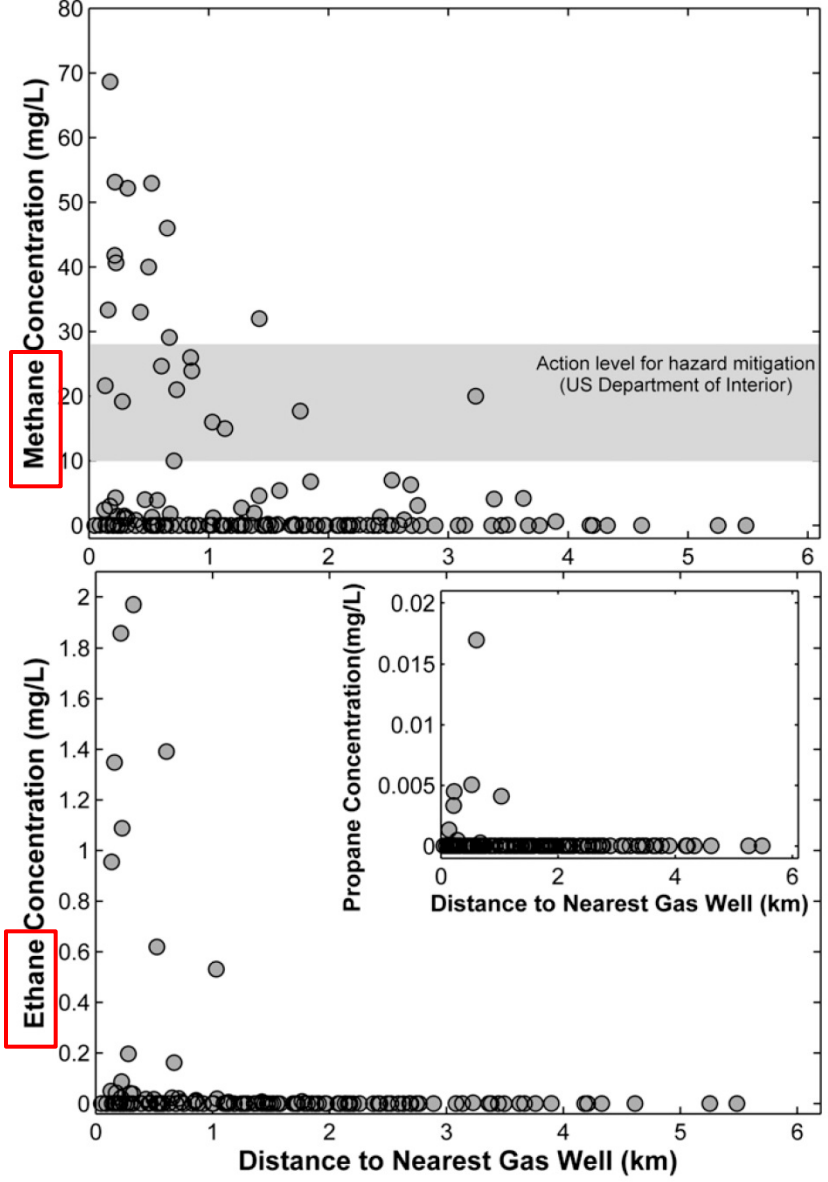

Fig. 1. Concentrations of (*Upper*) methane, (*Lower*) ethane, and (*Lower Inset*) propane (milligrams liter^{-1}) in drinking water wells vs. distance to natural gas wells (kilometers). The locations of natural gas wells were obtained from the Pennsylvania DEP and Pennsylvania Spatial Data Access databases (54). The gray band in *Upper* is the range for considering hazard mitigation recommended by the US Department of the Interior (10–28 mg CH_4/L); the department recommends immediate remediation for any value >28 mg CH_4/L.

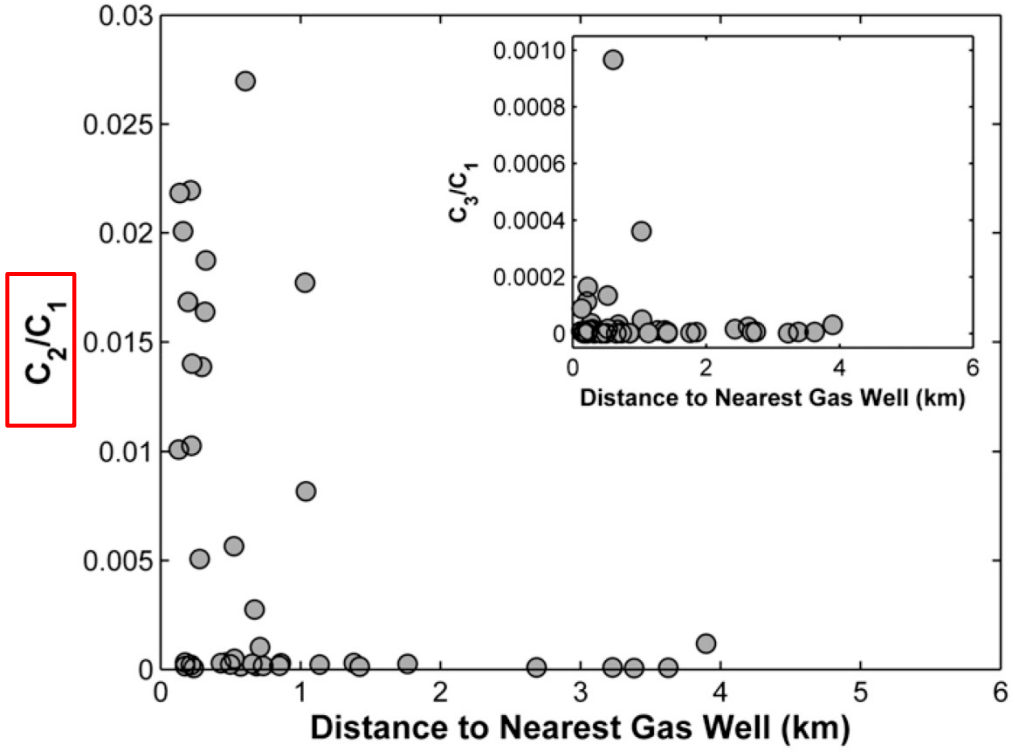

Fig. 2. The ratio of ethane to methane (C_2/C_1) and (*Inset*) propane to methane (C_3/C_1) concentrations in drinking water wells as a function of distance to natural gas wells (kilometers). The data are plotted for all cases where [CH_4], [C_2H_6], and [C_3H_8] were above detection limits or [CH_4] was >0.5 mg/L but [C_2H_6] or [C_3H_8] was below detection limits using the detection limits of 0.0005 and 0.0001 mg/L for [C_2H_6] and [C_3H_8], respectively.

Jackson et al. (2013)

Environmental Science & Technology

Article

An evaluation
near natural ga

Brian E Fontenot, Laura R
L Walton, Dan Hopkins,

Environ. Sci. Technol., **Just**

Author contributions: BEF
HO, JLW, DH, and AO perfor
machines, and field sampling
DDC, LRH, and QHH wrote t

Disclaimer: This work is no
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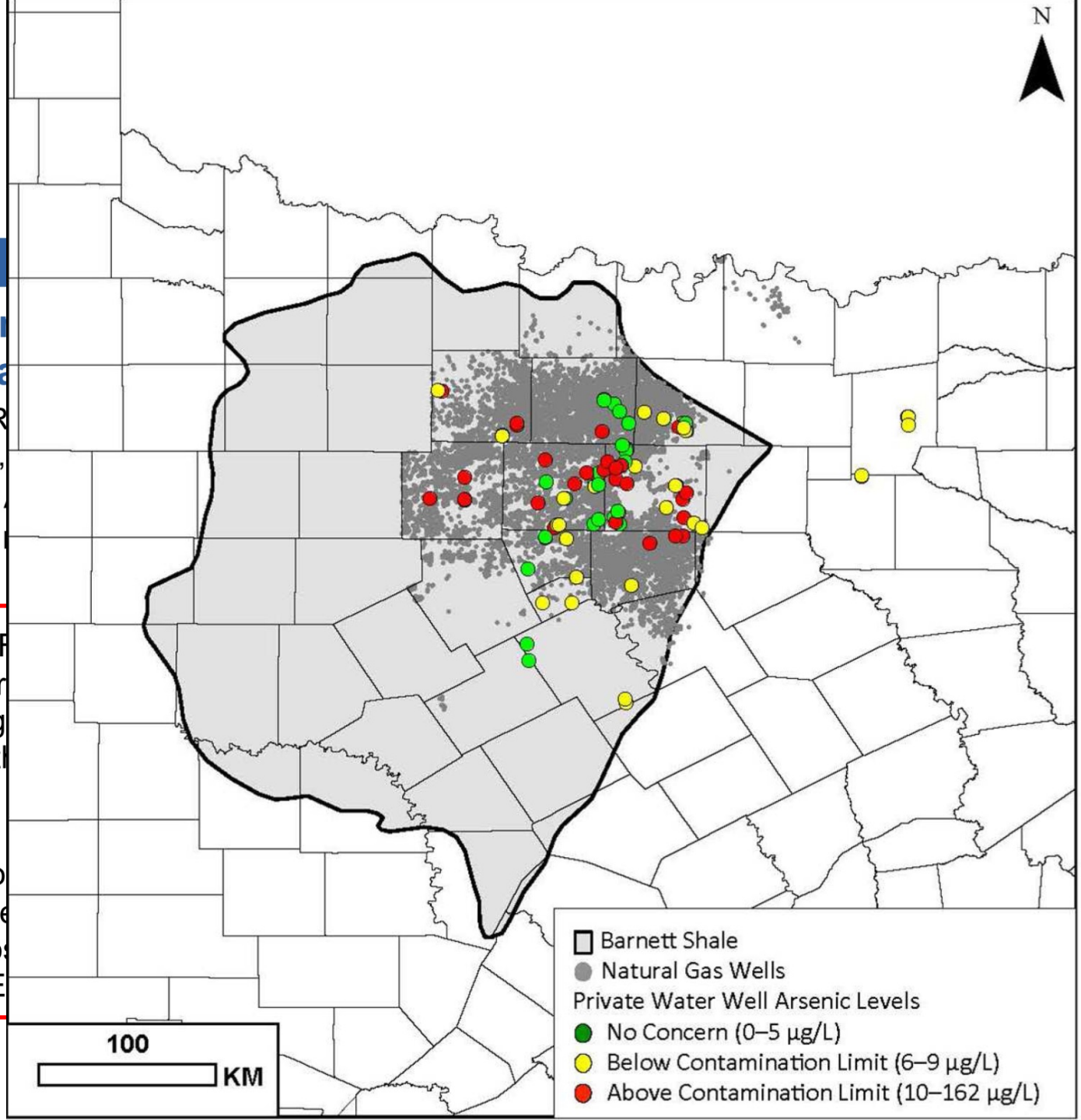
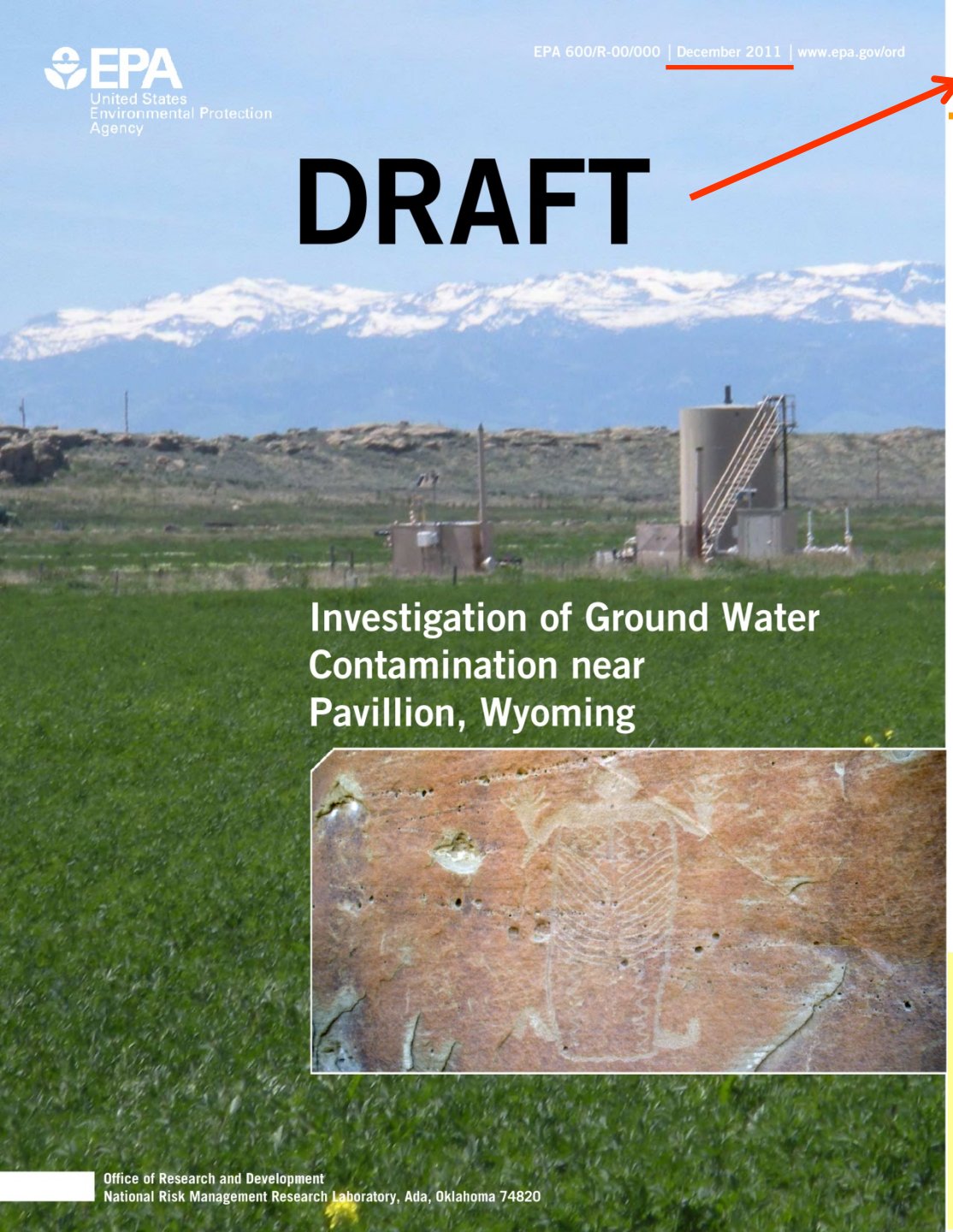



Pavillion, WY



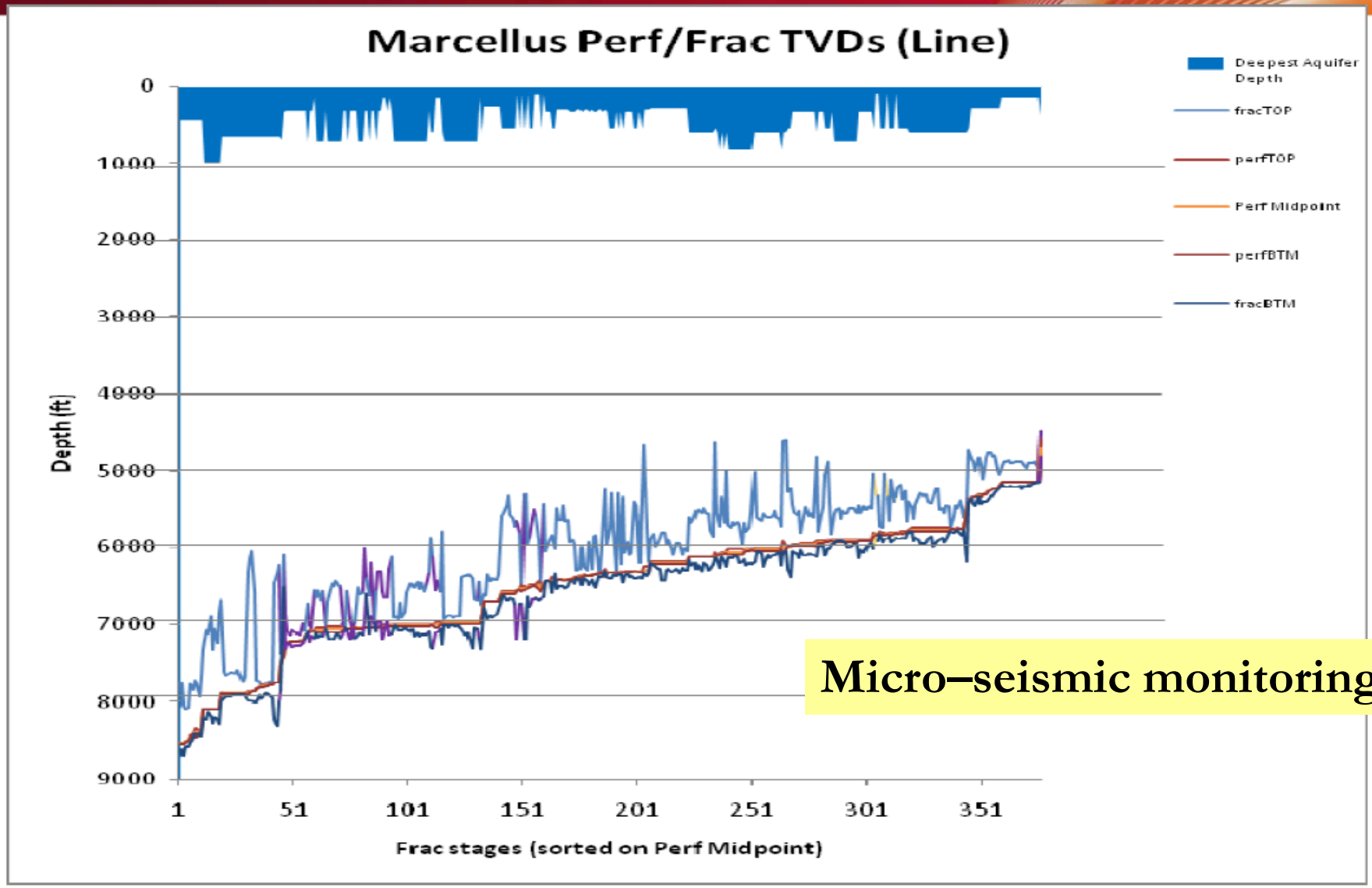
- Public comment extended to Sep. 2013
- EPA's studies cancelled on June 20, 2013

Dominic C. DiGiulio
Richard T. Wilkin
Carlyle Miller
U.S. Environmental Protection Agency
Office of Research and Development
National Risk Management Research Laboratory
919 Kerr Research Drive
Ada, OK 74820

Gregory Oberley
U.S. Environmental Protection Agency
Region 8
1595 Wynkoop Street
Denver, CO 80202

- Five municipal wells screened at depths ranging from 122 to 158 m bgs
- Domestic wells screened as deep as 245 m bgs
- Hydraulic fracturing in gas production wells occurred as shallow as 372 m bgs to about 900 m bgs

Marcellus shale – frac height vs aquifer depth



Micro–seismic monitoring

Drawbacks to Natural Gas | Science Comments

Science 12 April 2013:
Vol. 340 no. 6129 pp. 141-141
DOI:10.1126/science.340.6129.141-a

LETTER

Drawbacks to Natural Gas

Sara Souther | 2 Comments

http://comments.sciencemag.org/content/10.1126/science.340.6129.141-a

Qinhong Hu

There are valid environmental concerns (e.g., methane emissions, freshwater contamination from poor wellbore management or waste storage/disposal) about hydrocarbon exploitation by hydraulic fracturing (1), but Souther's comment about groundwater contamination at the Pavilion site requires clarification. The Pavilion site in Wyoming is unique, in that the shale formations being fractured were only 372 to 900 meters below ground surface (bgs), with domestic wells in the area screened as deep as 245 m bgs. In contrast, hydraulic fracturing in major U.S. shale plays occurs from 2,000 to 6,000 m bgs (2), 1,000 m or more below any aquifers being used. So long as shale-gas extraction occurs many hundreds of meters below any aquifers being used, and wellbore integrity is sound, the risk of fracturing fluids reaching those overlying aquifers is very low (3).

The EPA, USGS, NSF, and DOE's Research Partnership to Secure Energy for America (RPSEA) and National Energy Technology Laboratory (NETL) support research to provide timely science and tools to protect the environment, support sound policy, allow for informed decisions at many levels regarding development of unconventional resources, and advance technologies that will maximize benefits to the nation. During March-April 2013, RPSEA and NETL issued solicitations, backed by $28M in new funding, aimed at improving the environmental performance of unconventional resource development.

The public and the scientific community have raised concerns about hydraulic fracturing, and government and industry are moving to address them. We scientists must inform our opinions with the scientific facts in this rapidly evolving field, rather than over-generalizing from an exceptional case. By implementing best practices, and by continuing to improve technologies, regulations, and monitoring systems, the environmental risks associated with hydraulic fracturing can be effectively managed.

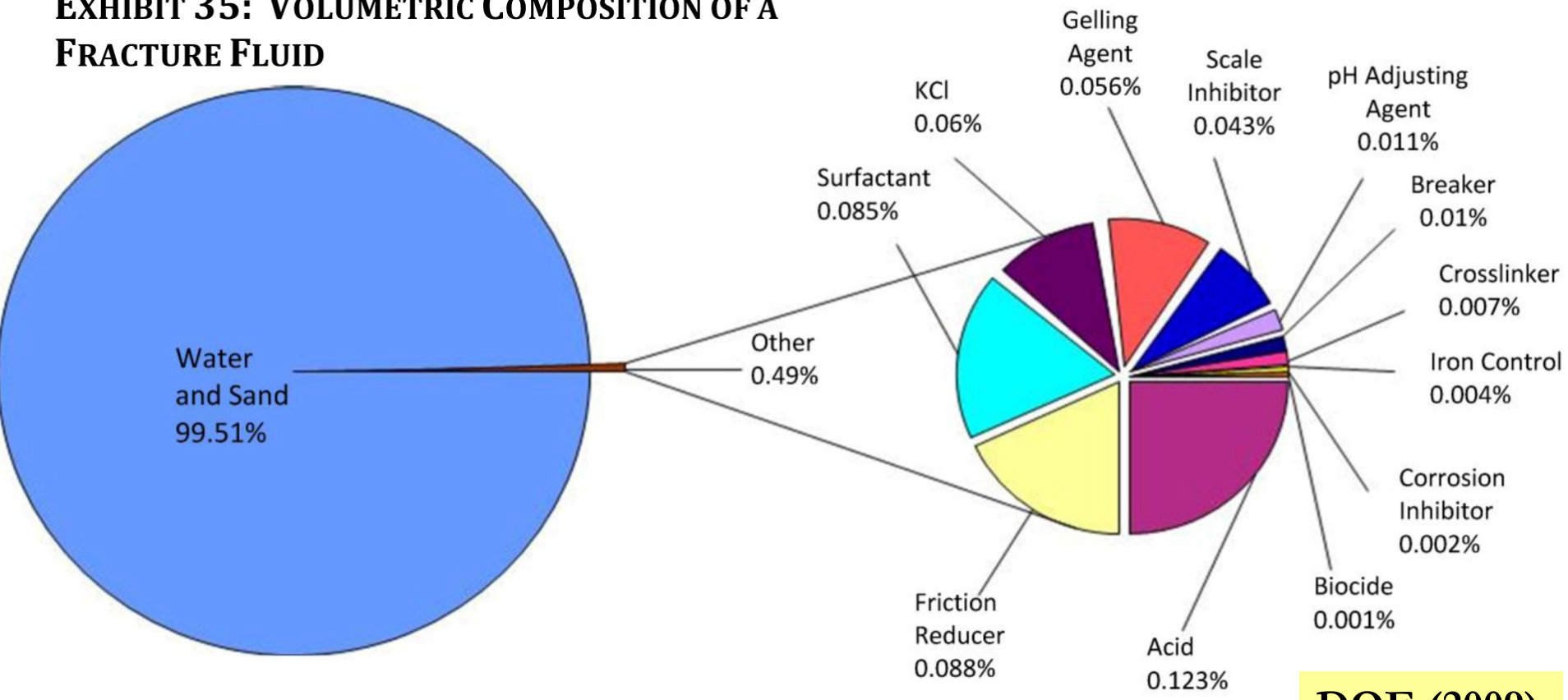
References: 1. R.W. Howarth, and T. Engelder, Should fracking stop? Nature, 477: 271-275 (2011). 2. D.M. Jarvie, Shale resource systems for oil and gas: Part 1—Shale-gas resource systems, in J. A. Breyer, ed., Shale reservoirs—Giant resources for the 21st century: AAPG Memoir 97, pp. 69–87 (2012). 3. The Royal Society and The Royal Academy of Engineering. Shale gas extraction in the UK: a review of hydraulic fracturing. (2012). http://royalsociety.org/policy/projects/shale-gas-extraction/report/.hyd...

Submitted on Sat, 04/27/2013 - 01:53

Public Concerns

- Water availability and consumption
- Ground water contamination
- **Fracturing fluid and flowback water management**
- Seismic activities
- Air emission
- Noise
- Land use and surface disturbance
- Naturally Occurring Radioactive Material (NORM)
- Sand mining (silica in the dust)

EXHIBIT 35: VOLUMETRIC COMPOSITION OF A FRACTURE FLUID



DOE (2009)

Source: ALL Consulting based on data from a fracture operation in the Fayetteville Shale, 2008

Chemical additives in a typical hydrofrac fluid is commonly <0.5% by volume

The additives in a 3 million gallon hydrofrac job, for example, would result in about 15,000 gallons of chemicals in the waste

TABLE 1 VOLUMETRIC COMPOSITION AND PURPOSES OF THE TYPICAL CONSTITUENTS OF HYDRAULIC FRACTURING FLUID.

DATA COMPILED FROM VARIOUS SOURCES (EPA 2004; API 2009)

Constituent	Composition (% by vol)	Example	Purpose
Water and sand	99.50	Sand suspension	"Proppant" sand grains hold microfractures open
Acid	0.123	Hydrochloric or muriatic acid	Dissolves minerals and initiates cracks in the rock
Friction reducer	0.088	Polyacrylamide or mineral oil	Minimizes friction between the fluid and the pipe
Surfactant	0.085	Isopropanol	Increases the viscosity of the fracture fluid
Salt	0.06	Potassium chloride	Creates a brine carrier fluid
Scale inhibitor	0.043	Ethylene glycol	Prevents scale deposits in pipes
pH-adjusting agent	0.011	Sodium or potassium carbonate	Maintains effectiveness of chemical additives
Iron control	0.004	Citric acid	Prevents precipitation of metal oxides
Corrosion inhibitor	0.002	n,n-dimethyl formamide	Prevents pipe corrosion
Biocide	0.001	Glutaraldehyde	Minimizes growth of bacteria that produce corrosive and toxic by-products

About 750 chemicals or other components are used, and 29 of them are hazardous (Vidic et al., 2013)

DOE (2009)

Table 2 TYPICAL RANGE OF CONCENTRATIONS FOR SOME COMMON CONSTITUENTS OF FLOWBACK WATER FROM NATURAL GAS DEVELOPMENT IN THE MARCELLUS SHALE. THE DATA WERE OBTAINED FROM FLOWBACK WATER FROM SEVERAL PRODUCTION SITES IN WESTERN PENNSYLVANIA[1].

Constituent	Low[2] (mg/L)	Medium[2] (mg/L)	High[3] (mg/L)
Total dissolved solids	66,000	150,000	261,000
Total suspended solids	27	380	3200
Hardness (as $CaCO_3$)	9100	29,000	55,000
Alkalinity (as $CaCO_3$)	200	200	1100
Chloride	32,000	76,000	148,000
Sulfate	ND[5]	7	500
Sodium	18,000	33,000	44,000
Calcium, total[4]	3000	9800	31,000
Strontium, total	1400	2100	6800
Barium, total	2300	3300	4700
Bromide	720	1200	1600
Iron, total	25	48	55
Manganese, total	3	7	7
Oil and grease	10	18	260
Total radioactivity	ND[5]	ND	ND

1 Data compiled by Elise Barbot, University of Pittsburgh, and Juan Peng, Carnegie Mellon University

2 "Low" concentrations are from early flowback at one well. "Medium" concentrations are from late flowback at the same well for which the "low" concentrations are reported.

3 "High" concentrations are the highest concentrations observed in late flowback from several wells with similar reported TDS concentrations.

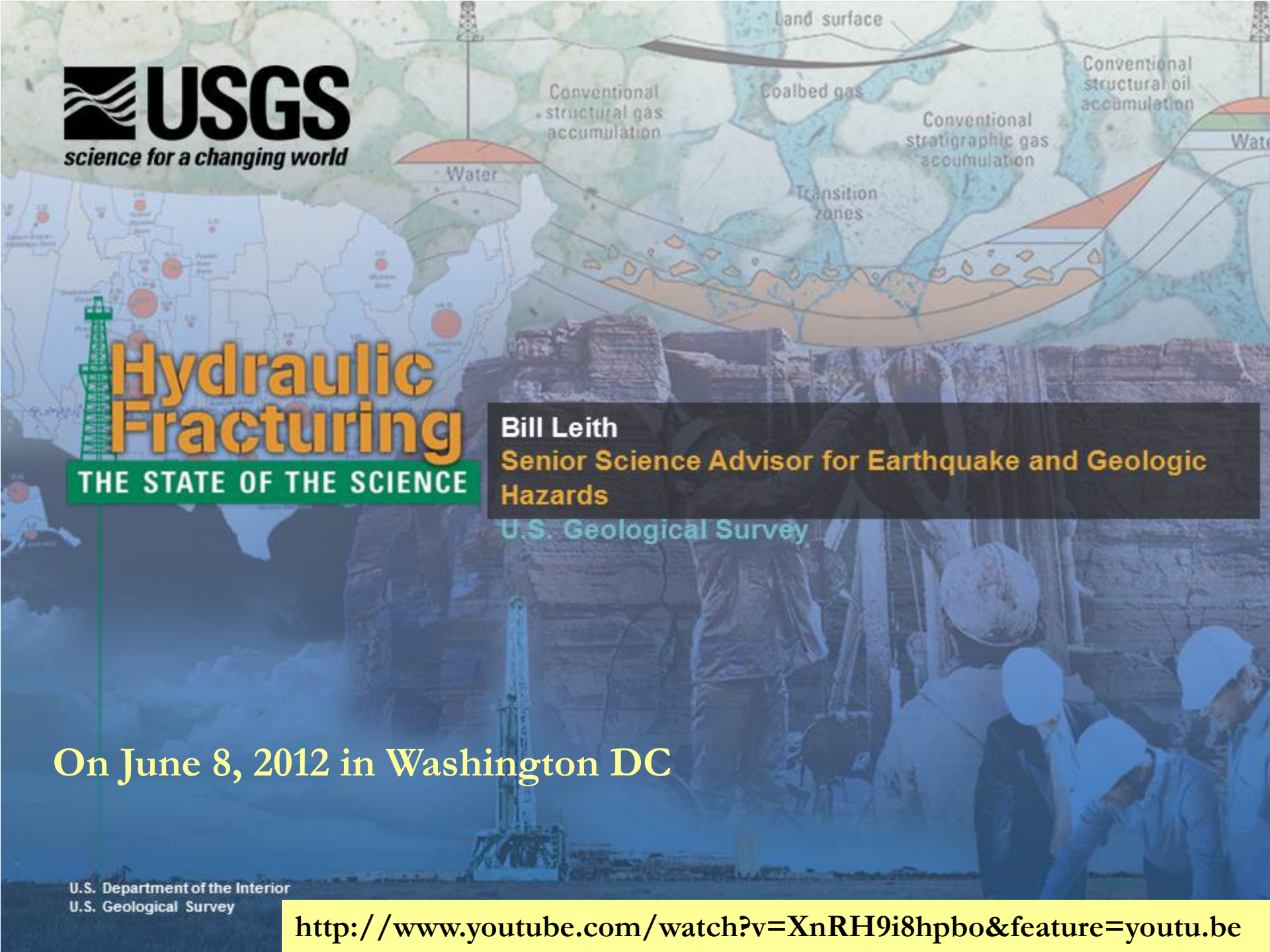
4 Total concentration = dissolved phase + suspended solid phase concentrations.

5 Not detected

- **Flowback can be 3% – 80% of the total amount of water and other material used to fracture the well**
- **Flowback fluids contains high TDS, not treatable by wastewater treatment plants**
- **Most flowback fluids are disposed of in underground injection wells, a Class II injection well, regulated by EPA**

Water Treatment Technology

- **Core technologies currently in use for the removal and concentration of dissolved solids vary and depend on the concentration of the TDS**
  - ✓ **ion exchange is used in low–TDS waters and for the removal of sodium (Na^+) in high bicarbonate/carbonate (HCO_3^- water)**
  - ✓ **For TDS concentrations of up to 20,000 mg/L, reverse osmosis has been the preferred method**
  - ✓ **Thermal distillation and evaporation is used for waters with TDS concentrations of 40,000 – 100,000 mg/L**
  - ✓ **New and cost–effective technologies that treat wastewaters with TDS exceeding 200,000 mg/L are needed**


USGS
science for a changing world
Land surface
Conventional structural gas accumulation
Coalbed gas
Conventional structural oil accumulation
Conventional stratigraphic gas accumulation
Water
Transition zones
Hydraulic Fracturing
THE STATE OF THE SCIENCE
Bill Leith
Senior Science Advisor for Earthquake and Geologic Hazards
U.S. Geological Survey
On June 8, 2012 in Washington DC
U.S. Department of the Interior
U.S. Geological Survey
http://www.youtube.com/watch?v=XnRH9i8hpbo&feature=youtu.be

Key Points

Seismic Activities

Injection or extraction of fluid at depth carries a risk of inducing earthquakes.

Hydrofracking, by itself, rarely triggers small earthquakes, and has not caused earthquakes large enough to be a safety concern.

The rate of earthquakes in the U.S. midcontinent has increased significantly in recent years, but few injection wells are triggering earthquakes.

The risk can be managed.

USGS

Leith (2012)

Injection-Induced Earthquakes

William L. Ellsworth

READ THE FULL ARTICLE ONLINE
http://dx.doi.org/10.1126/science.1225942

Cite this article as W. L. Ellsworth, *Science* **341**, 1225942 (2013).
DOI: 10.1126/science.1225942

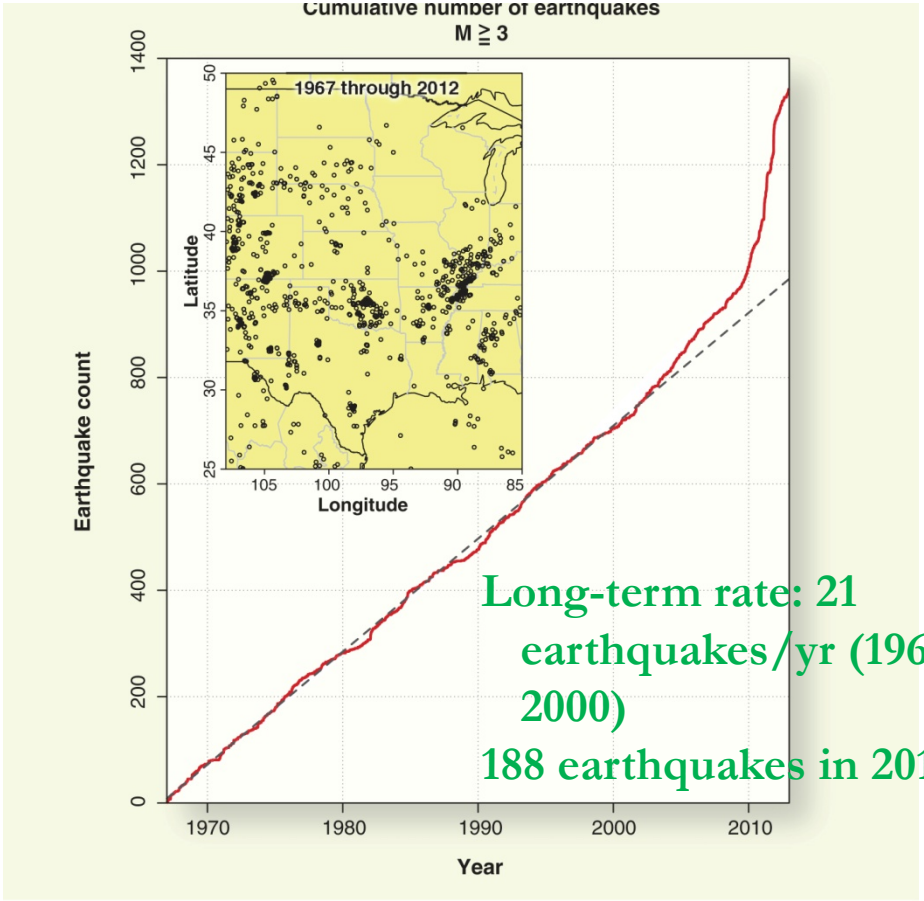


Fig. 2. Cumulative count of earthquakes with $M \geq 3$ in the central and eastern United States, 1967–2012. The dashed line corresponds to the long-term rate of 21.2 earthquakes/year. (**Inset**) Distribution of epicenters in the region considered here.

- Fracking produces micro-earthquakes (magnitude <2)
- The largest induced earthquake from fracking of >100,000 wells is magnitude 3.6
- Wastewater disposal into deep wells poses a higher risk (e.g., magnitude 5.7 event in central OK on Nov. 6, 2011)
- Only a small fraction of >30,000 wastewater disposal wells appears to be problematic

Source: Science Review/Summary July 2013

Climatic Change
DOI 10.1007/s10584-011-0061-5

Air Emission

LETTER

Methane and the greenhouse-gas footprint of natural gas from shale formations

A letter

Robert W. Howarth · Renee Santoro · Anthony Ingraffea

Howarth, R.W., R. Santoro, and A. Ingraffea. 2011. Methane and the greenhouse-gas footprint of natural gas from shale formations. Climate Change, DOI 10.1007/s10584-011-0061-5.

Received: 12 November 2010 / Accepted: 13 March 2011

"Natural gas greenhouse emissions study draws fire"

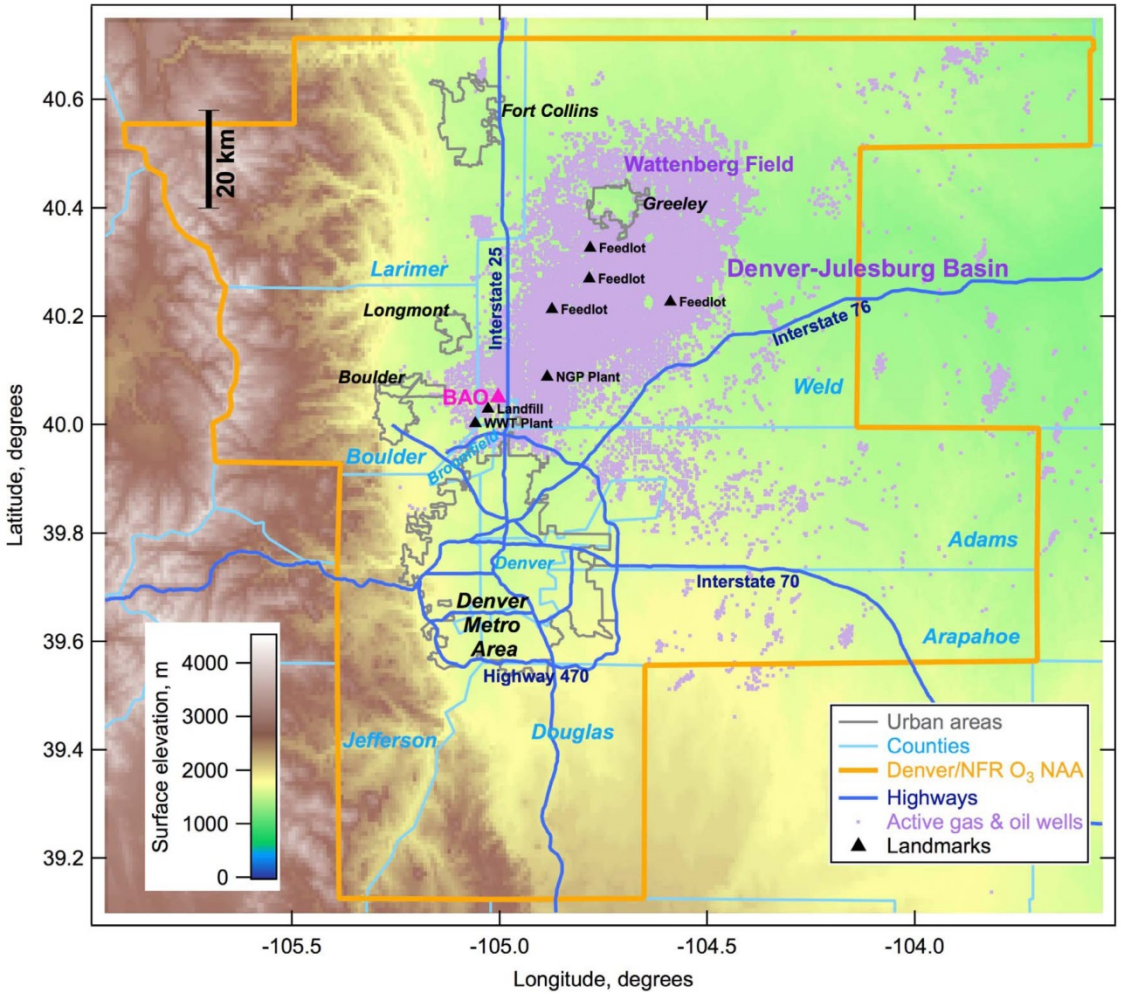
Research suggetst that leaks of methane gas from shale gas extraction make it worse for the climate than burning coal. *Jim Olive / Photolibrary*

Source: Nature April 2011

- On a per-joule basis, burning methane produces less carbon dioxide than burning coal
- Howarth et al. (2011) estimated methane release from gas production and transportation over a 20–yr period; they reported between 0.6 and 3.2% of the gas can escape to the atmosphere
- "The main author is an evolutionary biologist and an anti–natural gas activist who is not credentialed to do this kind of chemical analysis."
- Methane is 70 times more powerful at heating the atmosphere than CO_2 over 20–yr period, and 25 times more tent after 100 yrs
- Counter argument: comparison based on emissions per kilowatt–hour of electricity; data quality and availability from the industry

"Methane leaks erode green credentials of natural gas"

20,000 oil and gas wells drilled over the past 4 decades in the Basin



- Up to 4% of the methane produced at Denver–Julesburg Basin near Denver escape into the atmosphere
- 2012 AGU presentation showed 9% leakage from a field in the Uinta Basin of Utah
- 2009 EPA report suggested 2.4% leakage of total natural gas production
- 2012 PNAS paper showed shifting to natural gas from coal-fired generators has immediate climatic benefits as long as the cumulative leakage rate is below 3.2%

Source: Nature News Jan. 2013

Outline

- Shale gas development history in the U.S.
- Field trip of shale development sites
- Various issues related to hydraulic fracturing
- **Ongoing major shale resource developments in the U.S.**
- Summary

FEBRUARY 2012

Fact-Based Regulation for Environmental Protection in Shale Gas Development

Charles G. Groat, Ph.D.
Principal Investigator

Thomas W. Grimshaw, Ph.D.
Co-Principal Investigator

- Associate Director of Energy Institute
- USGS Director (1998–2005)

The Energy Institute
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Austin, TX 78712

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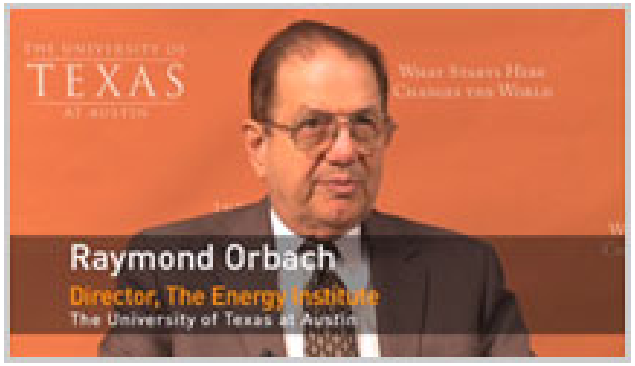
512.475.8822



1st Under Secretary for Science at DOE (2006–2009)

A REPORT BY

energy institute
The University of Texas at Austin

Table of Contents

Groat and Grimshaw (Feb. 2012, UT report)

Groundwater Contamination and Other Environmental Impacts

- Researchers found no evidence of aquifer contamination from hydraulic fracturing chemicals in the subsurface by fracturing operations, and observed no leakage from hydraulic fracturing at depth
- Many reports of groundwater contamination occur in conventional oil and gas operations (e.g., failure of well-bore casing and cementing) and are not unique to hydraulic fracturing
- Methane found in water wells within some shale gas areas (e.g., Marcellus) can most likely be traced to natural sources, and likely was present before the onset of shale gas operations
- Surface spills of fracturing fluids appear to pose greater risks to groundwater sources than from hydraulic fracturing itself
- Blowouts — uncontrolled fluid releases during construction or operation — are a rare occurrence, but subsurface blowouts appear to be under-reported

Groat and Grimshaw (Feb. 2012, UT report)

Regulation of Shale Gas Development

- Primary regulatory authority for shale gas is at the state level, and many federal requirements have been delegated to the states
- Most state oil and gas regulations were written well before shale gas development became widespread
- Some states have revised regulations specifically for shale gas development, with particular focus on three areas of concern:
  - ✓ Disclosure of hydraulic fracturing chemicals
  - ✓ Proper casing of wells to prevent aquifer contamination
  - ✓ Management of wastewater from flowback and produced water
- Gaps remain in the regulation of well casing & cementing, water withdrawal and usage, and waste storage and disposal
- Regulations should focus on the most urgent issues, such as spill prevention–which may pose greater risk than hydraulic fracturing itself

Groat and Grimshaw, Feb. 2012, UT report.

Tone of Media Coverage about Shale Gas Development

Media	Negative	Neutral	Positive	Scientific research mentioned
National Newspapes	64%	25%	12%	<20%
Local newspapers	65%	23%	12%	
National TV and radio	64%	19%	18%	<25%
Local TV	70%	27%	3%	
Online News	63%	30%	7%	<33%

Groat and Grimshaw, Feb. 2012, UT report.

A REVIEW OF THE PROCESSES

OF PREPARATION AND DISTRIBUTION

OF THE REPORT

"FACT-BASED REGULATION FOR ENVIRONMENTAL PROTECTION IN SHALE GAS DEVELOPMENT"

CAVEAT

The review documented herein was performed at the request of the University of Texas, Austin, to address the *process* of preparing and distributing the report, "Fact-Based Regulation for Environmental Protection in Shale Gas Development." As such, the authors of the review take no position herein with regard to the merits or liabilities of hydraulic fracturing.

REVIEW PARTICIPANTS:

NORMAN R. AUGUSTINE (CHAIR) | RITA R. COLWELL | JAMES J. DUDERSTADT

"Chip Groat failed to disclose his material financial relationship as a member of the Board of Directors of the Plains Exploration and Production"

Review Prepared at the Request of the University of Texas at Austin

Note

Dr Colwell holds stock in several firms involved in oil exploration and in a variety of natural gas exploration products and transportation activities. She receives an honorarium as chair of the Research Board of the Gulf of Mexico Research Initiative funded by BP to address scientific issues associated with the Deep Horizon Oil Spill.

November 30, 2012

- In Dec. 2012, Chip Groat was fired from UT
- Ray Orbach removed from the Energy Institute Director position

Obama Administration Announces New Partnership on Unconventional Natural Gas and Oil Research (*April 13, 2012*)

Chris Smith

Deputy Assistant Secretary for Oil and Natural Gas in the Office of Fossil Energy of DOE

- **Administer domestic and international oil and gas programs, including research and development, policy analysis, and LNG import and export licensing**
- **Currently chairs the steering team that will lead efforts to coordinate research on shale gas and tight oil resources**

HF meeting

Perry, Kent [kperry@rpsea.org]

Sent: Tuesday, June 12, 2012 5:09 PM

To: ian palmer [ian@higgs-palmer.com]; Hu, Qinhong; Mukul Sharma (msharma@mail.ut

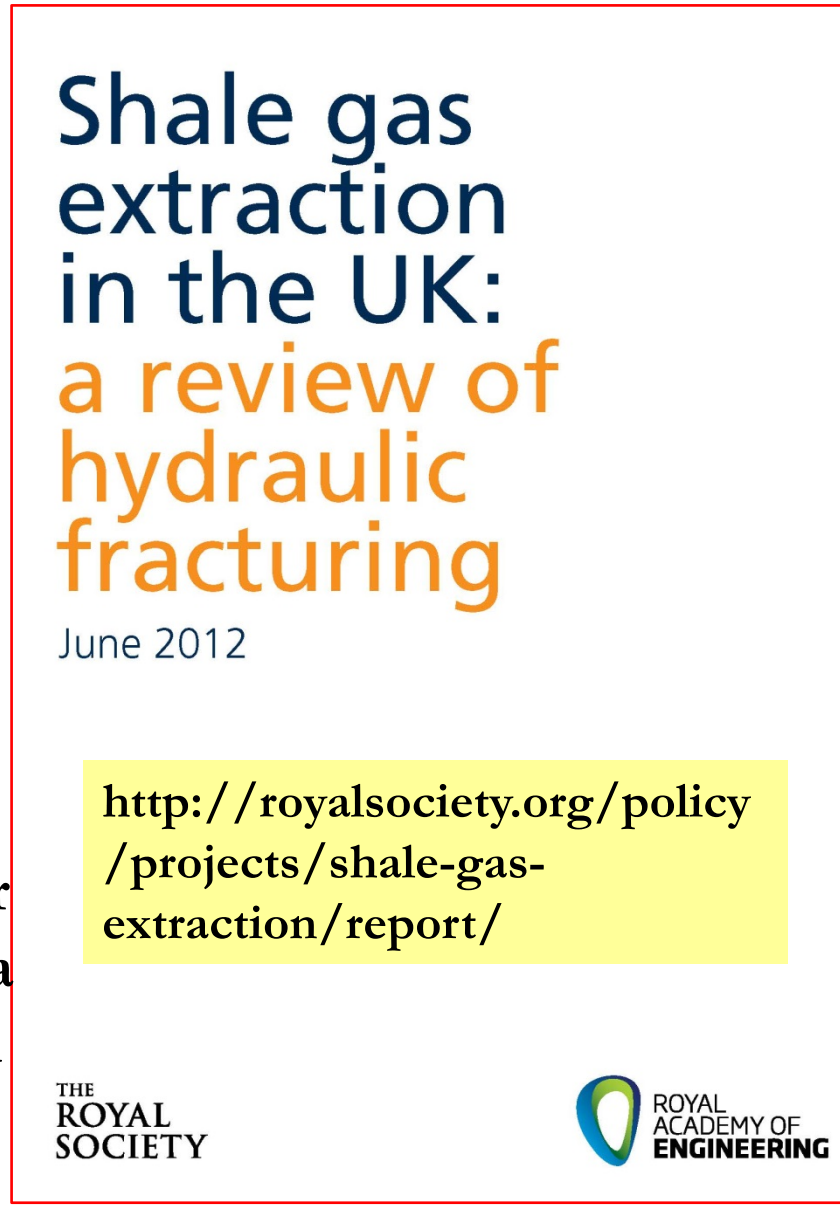
Cc: Siegfried, Bob [bob.siegfried@rpsea.org]; Roy Long (Roy.Long@netl.doe.gov)

We gave confirmed the morning of July 25th for the meeting with Chris Smith. It will be held in Houston most likely at the DOE offices near Sugar Land. Please mark your calendars and we will send more information at a later date. Thanks, KP

Kent F. Perry
Vice President, Onshore Programs
Research Partnership to Secure Energy for America

Shale Gas Extraction: Final Report

- **Released on June 29, 2012**
- **By the Royal Society and the Royal Academy of Engineering**
- **To review the scientific and engineering evidence and consider whether the risks associated with hydraulic fracturing as a means to extract shale gas could be managed effectively in the UK**
- **Chaired by Prof. Robert Mair (CBE, FREng, FRS); a civil engineer who advised on the construction of a London Underground extension and the construction of the Channel Tunnel**



Shale Gas Extraction: Key Findings

- The health, safety and environmental risks can be managed effectively in the UK
- Fracture propagation is an unlikely cause of contamination
- Well integrity is the highest priority
- Robust monitoring is vital
- An Environmental Risk Assessment should be mandatory
- Seismic risks are low
- Water requirements can be managed sustainably
- Regulation must be fit for purpose: regulatory coordination
- Policymaking would benefit from further research: carbon footprint

http://royalsociety.org/policy/projects/shale-gas-extraction/report/

The Marcellus Shale Research Network

- Funded by the National Science Foundation in October 2011 ($750K) to put together the database and to run annual workshops between 2012 and 2015
- Vision: create a central and accessible repository for geochemistry and hydrology data collected by watershed groups, government agencies, industry stakeholders, and universities working together to document natural variability and potential environmental impacts of shale gas extraction activities
- The Steering Committee of the ShaleNetwork derive from Dickinson College, Pitt University, Penn State (Sue Brantley, PI), and the Consortium of Universities for the Advancement of Hydrologic Sciences, Inc. (CUAHSI)

http://www.shalenetwork.org/

Shale Network

A Network of Shale Water Researchers

Shale Network Members

The Shale Network is open to any individual or organization interested in sharing data related to water quality in areas experiencing shale gas resource development. If you have data to share and are interested in joining the Shale Network please apply for membership.

Name	Postion	Institution/Organization
Jorge Abad	Assistant Professor	University of Pittsburgh
Chuck Anderson	Visualization and Outreach Specialist	Penn State University
Sina Arjmand	Graduate Assistant	University of Pittsburgh
Tom Barnard	Research Scientist	Wilkes University
Susan Brantley	Professor of Geosciences	Penn State University
Kathy Brasier		Penn State University
Anne Danahy	writer	Penn State
Kristin Dauer		University of Pittsburgh
Brian Ellis	Assistant Professor	University of Michigan
Paul Grieve	Graduate Student	Penn State University
Nell Herrmann	Learning Enrichment and Gifted Support Specialist	State College Area High School
Brian Hone	researcher	University of Pittsburgh
Richard Hooper	Director	CUAHSI
Qinhong (Max) Hu	Associate Professor	University of Texas at Arlington
Robert Hughes	Executive Director	EPCAMR
Krissy Kasserman	Youghiogheny Riverkeeper/Assistant Executive Director	Mountain Watershed Association
Wendy Kedzierski	Program Manager	Creek Connections - Allegheny College
Tom Kulakowski	Hydrogeologist	PA Fish & Boat Commission
Debbie Lambert	staff assistant	Penn State University
Colleen McLean	Assistant Professor	Youngstown State University
Greg O'Toole	Web Developer & Researcher	The Pennsylvania State University
Karl Oetjen	graduate student	Syracuse University
Maggie Peacock	Data Coordinator	Penn State University
Jon Pollak	User Support Specialist	CUAHSI
Elisabeth Rowan	Research Geologist	USGS
Cesar Simon	Graduate Assistant	University of Pittsburgh
Ryan Szuch		PA Bureau of Forestry
Julie Vastine	Director	Dickinson College
Radisav Vidic	Professor	University of Pittsburgh
Bob Volkmar	Volunteer stream steward	Trout Unlimited
Candie Wilderman	Professor	Dickinson College
Jennifer Williams	SSHCZO Program and Data coordinator	PSU
Dave Yoxtheimer	Extension Associate/Hydrogeologist	Penn State University

July 28, 2012 in DC

"We can handle the truth. We just need someone to tell us the truth"

September 20, 2012 in Philadelphia

"NSF awards CU-Boulder-led team $12 million to study effects of natural gas development" (10/2/2012)

- To explore ways to maximize the benefits of natural gas development while minimizing negative impacts on ecosystems and communities
- Lead PI: Joe Ryan of CU-Boulder; over 5 years
- The team will examine social, ecological and economic aspects of the development of natural gas resources and the protection of air and water resources
- A part of NSF's Sustainability Research Network initiative, or SRN, the project will focus on the Rocky Mountain region
- Two grants (along with Penn State) chosen from more than 200 SRN proposals by the NSF as part of its Science, Engineering and Education for Sustainability program
- Partners on the project include the Colorado School of Mines, Colorado State University, University Corporation for Atmospheric Research, National Renewable Energy Laboratory, National Oceanic and Atmospheric Administration, University of Michigan, Colorado School of Public Health, and California State Polytechnic University Pomona (hydrogeologist Stephen Osborn)

http://www.nsf.gov/news/news_summ.jsp?cntn_id=125599

DOE–RPSEA Funding in Nov. 2012

- "Research Projects Addressing Technical Challenges to Environmentally Acceptable Shale Gas Development Selected by DOE"
- Fifteen research projects for a total of $28 million (additional $8.6 million in cost-share) in funding from the U.S. DOE's Office of Fossil Energy (FE), managed by RPSEA
- Address research needs primarily in four categories:
  - ✓ Reduced environmental impacts
  - ✓ Improved water handling and treating methods
  - ✓ Enhanced characterization of shales
  - ✓ Improved understanding of the hydraulic fracturing process

http://www.netl.doe.gov/publications/press/2012/121128_research_projects.html

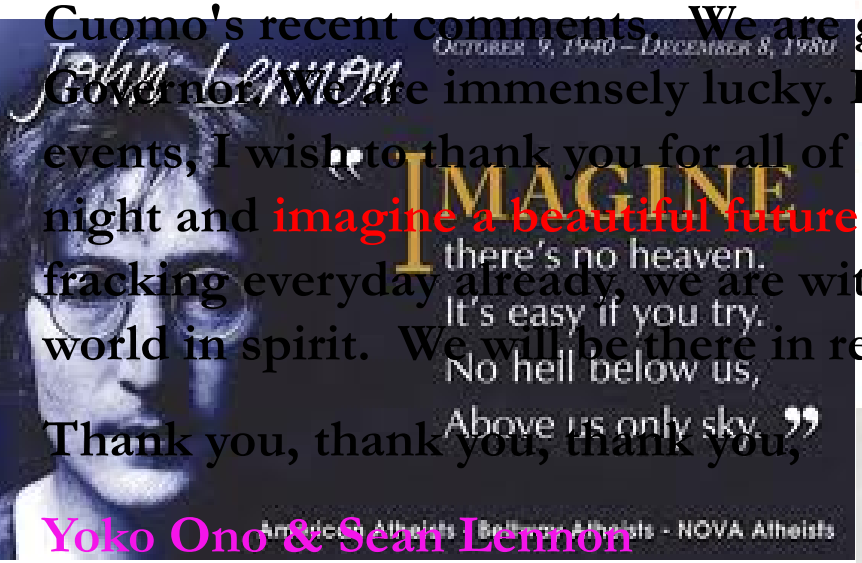
Gas Land E–Mail (11/22/12)

Dear All,

I truly believe that all of your work against tracking had an effect on Governor Cuomo's recent comments. We are glad that we have a wise and courageous Governor. We are immensely lucky. In celebration of this amazing turn of events, I wish to thank you for all of your incredible efforts in working day and night and imagine a beautiful future for all of us. For those of us living with fracking everyday already, we are with you. I know we are already in a frack free world in spirit. We will be there in reality very, very soon!

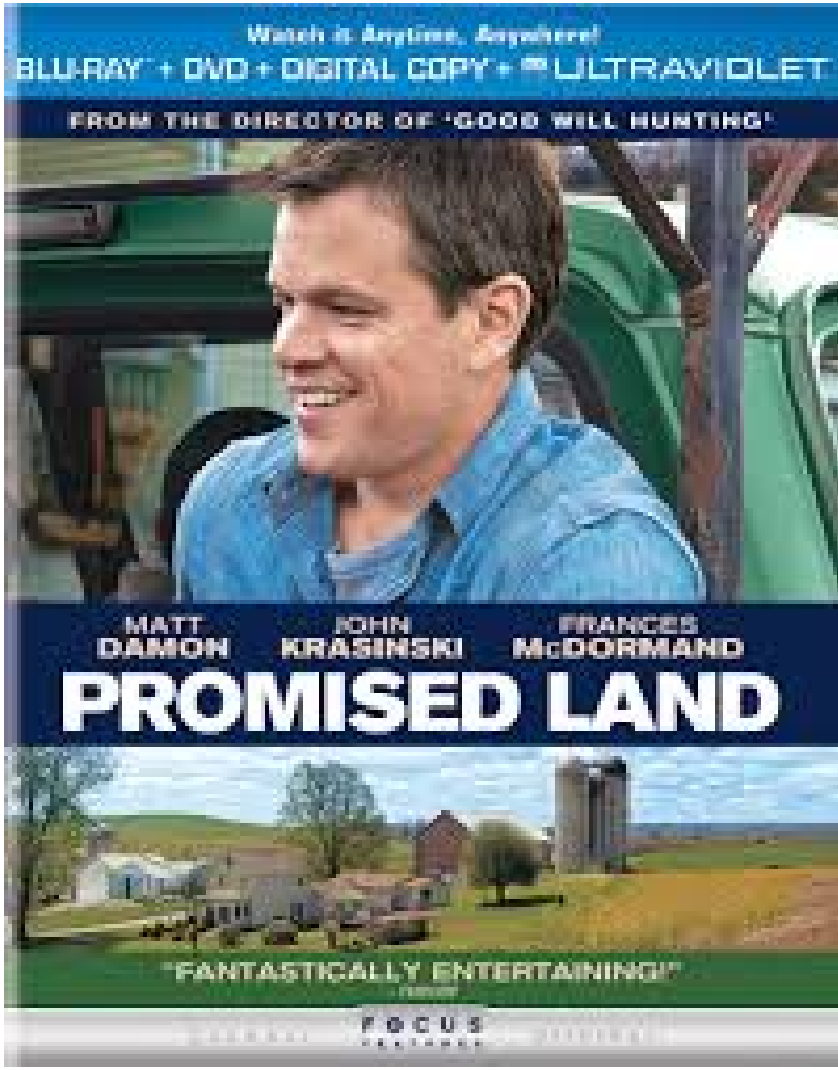
Thank you, thank you, thank you,

Yoko Ono & Sean Lennon



Promised Land (2012 Film)

- A 2012 American drama film directed by Gus Van Sant and starring Matt Damon, John Krasinski, Frances McDormand, and Hal Holbrook
- *Promised Land* follows two corporate salespeople who visit a rural town in an attempt to buy drilling rights from the local residents
- Had a limited release in the United States on December 28, 2012



http://www.youtube.com/watch?v=AHQt1NAkhIo

EPA Technical Workshops

- **EPA held four technical workshops from February through March 2011 to explore the following focus areas:**
  - ✓ **Chemical & Analytical Methods, February 24-25;**
  - ✓ **Well Construction & Operations, March 10-11;**
  - ✓ **Fate & Transport, March 28-29; and**
  - ✓ **Water Resource Management, March 29-30.**
- **The goal of the technical workshops was three-fold:**
  - ✓ **Inform EPA of the current technology and practices being used in hydraulic fracturing,**
  - ✓ **Identify research related to the potential impacts of hydraulic fracturing on drinking water resources, and**
  - ✓ **Provide an opportunity for EPA scientists to interact with technical experts. EPA invited technical experts from the oil and natural gas industry, consulting firms, laboratories, state and federal agencies, and environmental organizations to participate in the workshops**

EPA's Science Advisory Board Announces Independent Panel to Peer Review Agency's Hydraulic Fracturing Research

- Announced on March 25, 2013
- Will peer review EPA's 2014 draft report of results for its national study on any potential impacts of hydraulic fracturing on drinking water resources
- The SAB sought public nominations of nationally and internationally recognized scientists and engineers in an August 2012 Federal Register notice
- The SAB initially identified and sought public comment on 144 potential candidates
- After reviewing public comments, confidential financial disclosure forms and additional information submitted by prospective candidates, the SAB identified the panel of 31 experts
- Has at least three experts in each of the following nine areas of expertise that were sought for the panel: Petroleum/Natural Gas Engineering; Petroleum/Natural Gas Well Drilling; Hydrology/Hydrogeology; Geology /Geophysics; Groundwater Chemistry/Geochemistry; Toxicology/Biology; Statistics; Civil Engineering; and Waste Water and Drinking Water Treatment

Gas Land Part II

- Premiere at Tribeca Film Fest on April 21, 2013
- Gasland inspired the world to take a closer look at the dangers of fracking, but it's been supporters like you who have kept it at the forefront of the national debate
- In GASLAND Part II, we have undertaken an unflinching, fearless investigation of the toxic influences polluting our democracy
- GASLAND Part II delves even deeper into the corrupt and poisonous world of hydraulic fracturing, exposing the forces desperately working to keep us addicted to the shrinking resources of the fossil fuel industries
- Ultimately, GASLAND Part II calls us to action, demanding that We The People do "The most we can do", and that we command our elected officials to pursue a future we can all live in
- You can answer that call right now

Love,
Josh and The *GASLAND* Team

NRC Workshop on HF

- Organized by the Board of Environmental Change and Society (BECS) of National Research Council
- A public Webcast workshop on May 30-31, 2013
- "Workshop on Risks of Unconventional Shale Gas Development"
- Seeks a broad and balanced assessment of the issues surrounding fracking with presentations by invited experts, discussant comments from contrasting perspectives, and open discussion on each topic
- During the workshop, online viewers may submit questions or comments to the presenters and discussants by e-mail to BECS@NAS.EDU; a selection of these contributions will be read during relevant discussion sessions

http://sites.nationalacademies.org/DBASSE/BECS/DBASSE_083187#.UaoDDL6wrrd

Gasland The Movie

On July 8th the truth comes out. Again.

That's the day HBO will premiere Gasland Part II. Although the frackers would prefer otherwise, millions of Americans will soon learn about the dangers fracking poses to our water, our air, our climate.

And the simple truth is this: once people understand what fracking is, and what it does, they make the right choice. That is how we (and you are a BIG part of that "we") put a stop to fracking in the Delaware River Basin. That is why there is no fracking in New York today.

The lesson is that we can stop the drills if we can get enough people to listen. So here is the part of the email where we need to ask something of you:

Go to gaslandthemovie.com and sign-up to host a watch party on July 8th.

Hold your own movie premiere, invite your friends, pop some popcorn and get ready to see the truth.

And check this out: right after the movie I will be holding a live national Q&A. You can dial in and ask a question

By getting your family, friends, neighbors, work colleagues,"plus ones," and anyone else you can grab to watch this movie, you make the movement to end fracking that much stronger.

So go to gaslandthemovie.com right now sign up to host a watch party on July 8th.

Because the more people that see this movie, the more people will us fight to stop fracking.

Josh Fox, Director of *GASLAND Part II*

NAE Shale Gas Promises and Challenges Topical Meeting

- The meeting (6/18-19/2013), sponsored by the National Academy of Engineering and hosted by Case Western Reserve University
- Keynote talks and three panel discussions with leaders in the energy field on
  - ✓ Science and Technology Challenges
  - ✓ Impact on the Economy and Energy Security
  - ✓ Environmental, Health, Safety, and Societal Impact

http://naeshalegas.com/

- There will be substantial time allocated to discussion in moderated panels to address the critical issues facing the fast evolving shale gas activity throughout all of North America
- The panels will recommend potential solutions to the posed challenges
- Appropriate roles for academia, industry, and government will be highlighted

Host and co-sponsor → Case Western Reserve University EST. 1826; Cleveland State University; Kent State University Excellence in Action

Contributors → Cleveland Clinic; Cleveland Foundation; Dominion; GenerationFoundation; The Kelvin & Eleanor Smith Foundation; ulmer berne llp ATTORNEYS

Supporters → Monte Ahuja College of Business, Cleveland State University; Drs. Glenn & Jeannette Brown; Bulk Trading & Transportation Company; Cleveland Museum of Natural History; Fairmount Minerals; FirstEnergy; Ruth Swetland Eppig Great Lakes Energy Institute; KeyBank; Lorain County Community College; NorTech; Ohio Fuel Cell Coalition; S. Livingston Mather Charitable Trust; Case Western Reserve University, School of Engineering; Weatherhead School of Management, Case Western Reserve University

DOE Study: Fracking Chemicals Didn't Taint Water

Kevin Begos 7/19/2013

URL:
http://www.rigzone.com/news/oil_gas/a/127864/DOE_Study_Fracking_Chemicals_Didnt_Taint_Water

PITTSBURGH - A landmark federal study on hydraulic fracturing, or fracking, shows no evidence that chemicals from the natural gas drilling process moved up to contaminate drinking water aquifers at a western Pennsylvania drilling site, the Department of Energy told The Associated Press.

After a year of monitoring, the researchers found that the chemical-laced fluids used to free gas trapped deep below the surface stayed thousands of feet below the shallower areas that supply drinking water, geologist Richard Hammack said.

Summary

- Horizontal drilling and hydraulic fracturing make the shale hydrocarbon production feasible
- Shale hydrocarbon production will continue to be a controversial issue
- Water resources availability, groundwater contamination (wellbore seal integrity, surface spills) flow back and produced water management and treatment, and gas emission are issues of particular concerns
- More federal and state oversight and regulation of the oil/gas industry is key to sound development of shale hydrocarbon resources