Shale Gas Production via Hydraulic Fracturing

AOSC 433/633 & CHEM 433

Ross Salawitch

Class Web Site: http://www.atmos.umd.edu/~rjs/class/spr2017

- Overview of shale gas production via horizontal drilling and hydraulic fracturing (aka fracking)
- Concerns about shale gas production:
  - Earthquakes
  - Contamination of ground water
  - Air quality (surface O_3 precursors)
  - Climate (fugitive release of CH_4)

Lecture 21

2 May 2017

Annoucements

1) Course evaluation page is open https://www.courseevalum.umd.edu until 12 May

Course Evaluations Currently Open*	Evaluation Start Date	Deadline	#
201701-AOSC433-0101-ATMSPHRC CHEM & CLIMATE	April 30, 2017	May 12, 2017	14
201701-AOSC633-0101-ATMSPHRC CHEM & CLIMATE	April 30, 2017	May 12, 2017	6
201701-CHEM433-0101-ATMSPHRC CHEM & CLIMATE	April 30, 2017	May 12, 2017	1

Algae as a Biofuel

Pros:

- High oil content
- Absorbs atmospheric CO_2
- Can use waste as fertilizer
- Not a food staple

Cons:

- Need sunny, warm conditions; certain areas preferred
- Growth limited by “self shading” effect; challenge to exploit entire volume of pond
- Water intensive (rules out many warm, sunny environs for large scale production)
- Efficient processing method still being researched
- Fertilizer intensive
- Water intensive

The promise of algae as an economically viable clean source of fuel is leading many groups to research the large scale viability of this potential resource.

http://stateimpact.npr.org/texas/2012/12/17/the-downside-of-using-algae-as-a-biofue l

Algae as a Biofuel

Wigmosta *et al*., *Water Resources Res*, 13 April 2011 conclude:

Using current technology, 48% of petroleum needed for US transportation can be produced using:

- 5.5% of U.S. land area (lower 48)
- 3 times the total amount of water used for irrigation

Optimal placement of algae production facility in the humid Gulf Coast, southeastern seaboard, and Great Lakes regions would considerably reduce the water needed

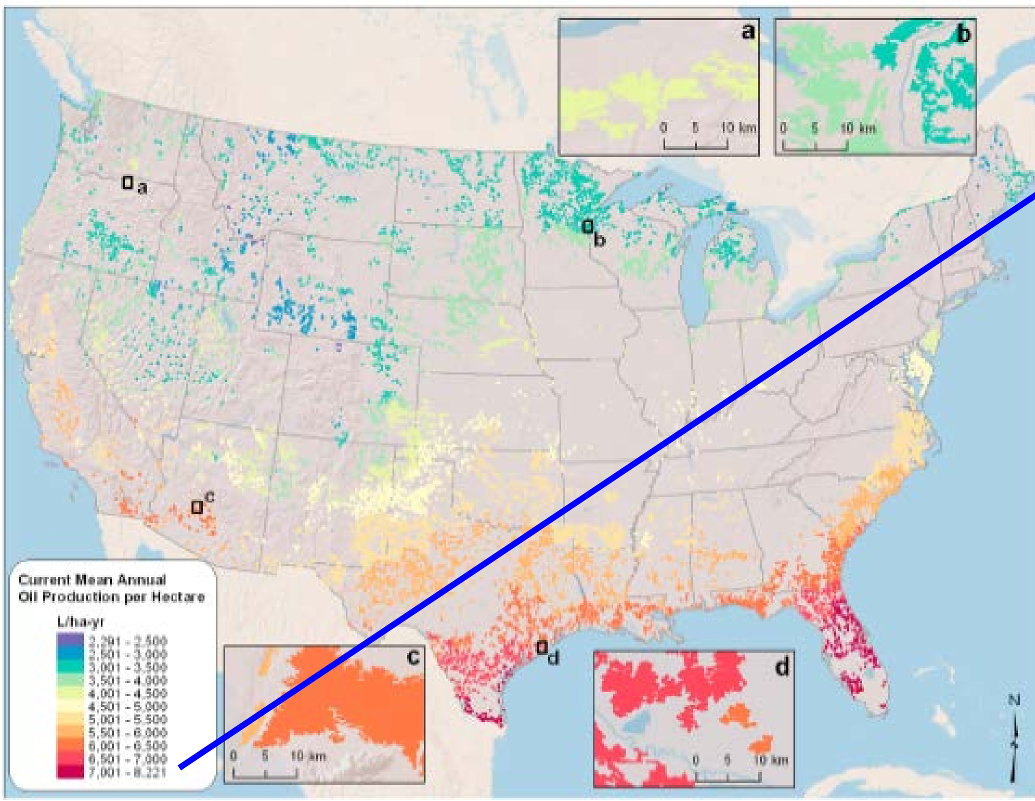


Figure 3. Mean annual biofuel production (L ha^{-1} yr^{-1}) under current technology plotted at the centroid of each pond facility.

High yield: 8000 L/ha/year:

U.S. uses $5.4{\times}10^{11}$ L/year of gasoline

Hence, need 6.8×10^7 ha
or 2.6×10^5 mi^2

510 x 510 miles
(7% land area, lower 48)
☹

http://www.eia.gov/tools/faqs/faq.cfm?id=23&t=10

Hydraulic Fracturing

- Pumping of chemical brine to loosen deposits of natural gas from shale
- Extraction of CH_4 from shale gas became commercially viable in 2002/2003 when two mature technologies were combined: horizontal drilling and hydraulic fracturing
- High-pressure fluid is injected into bore of the well at a pressure that fractures the rock

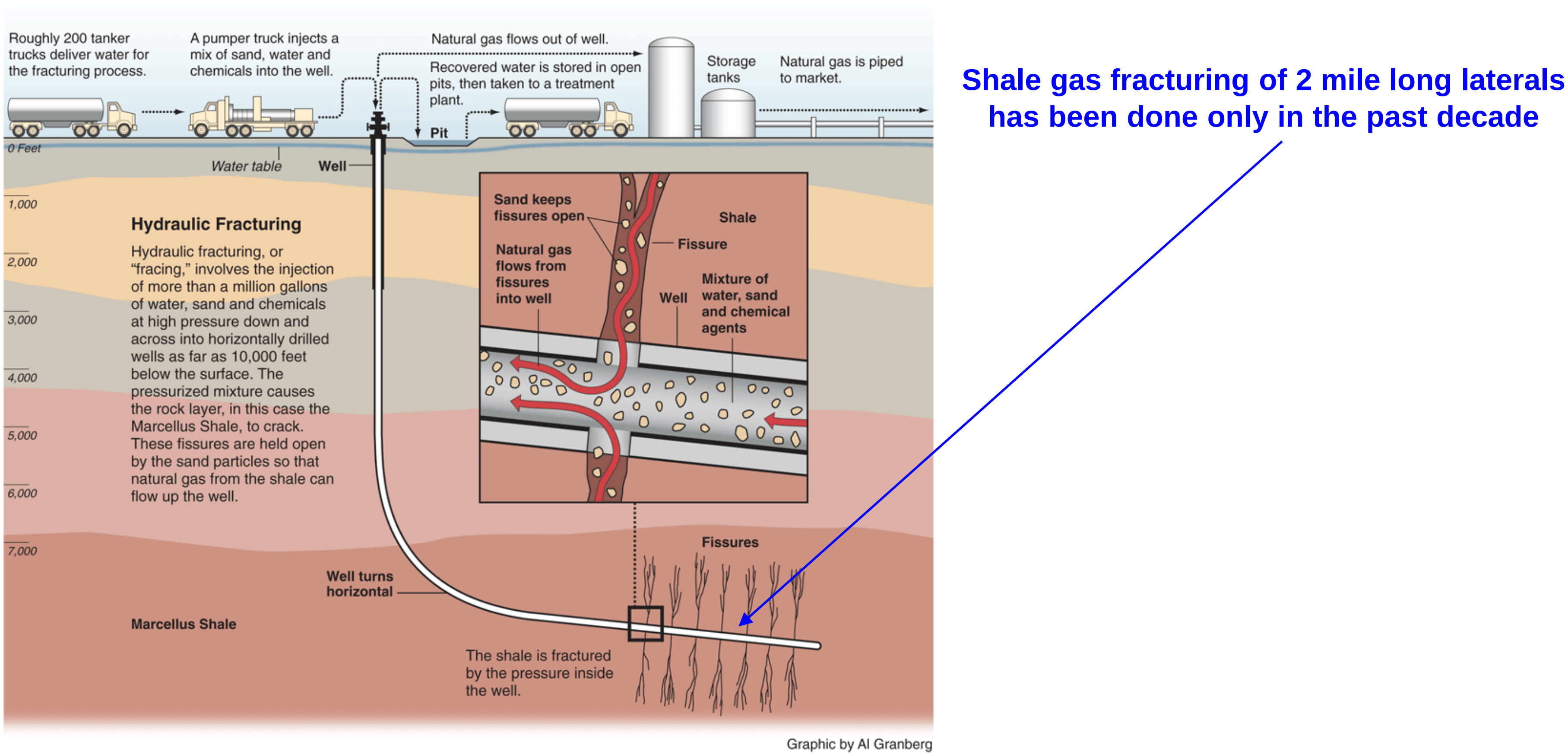
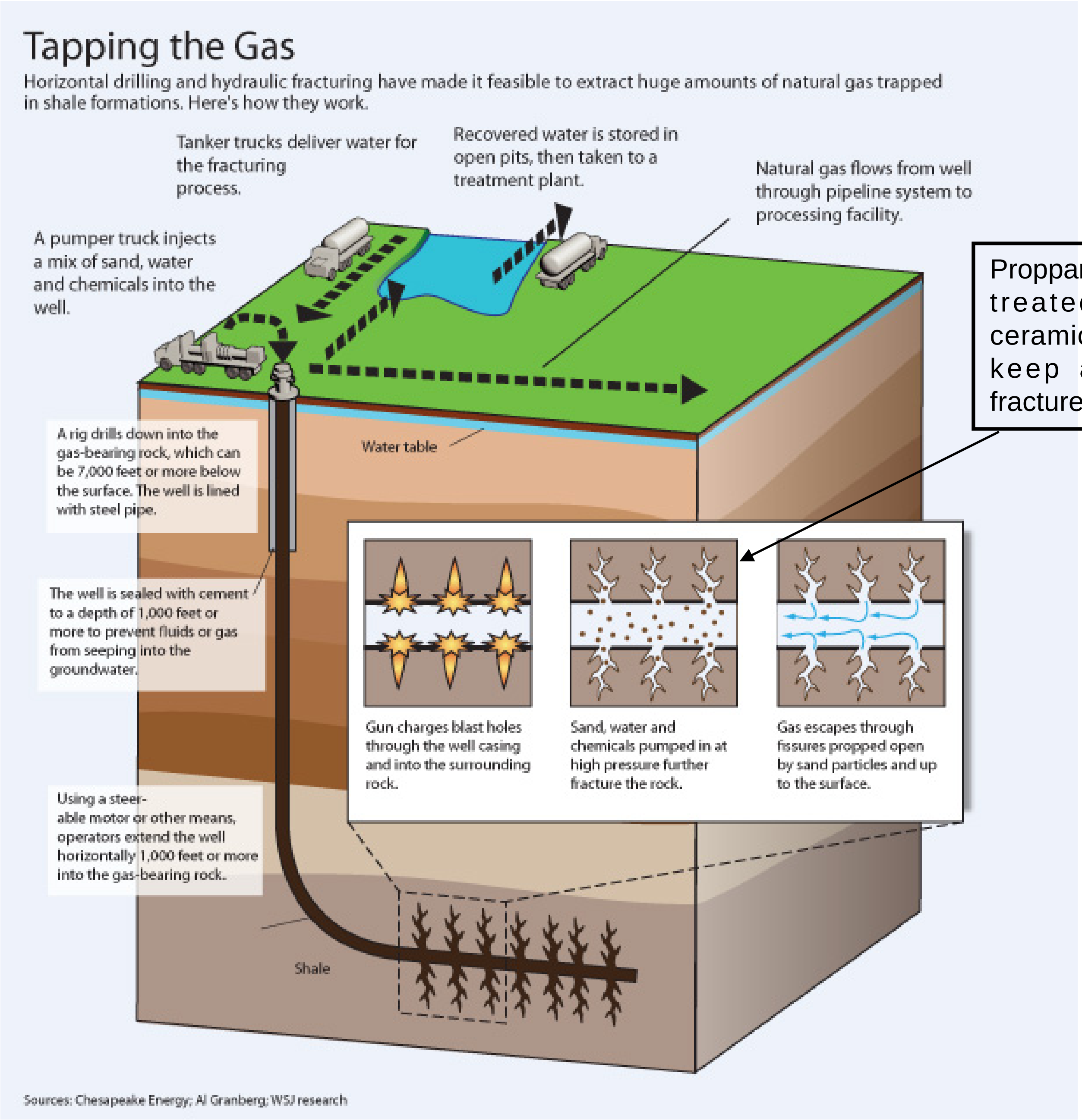
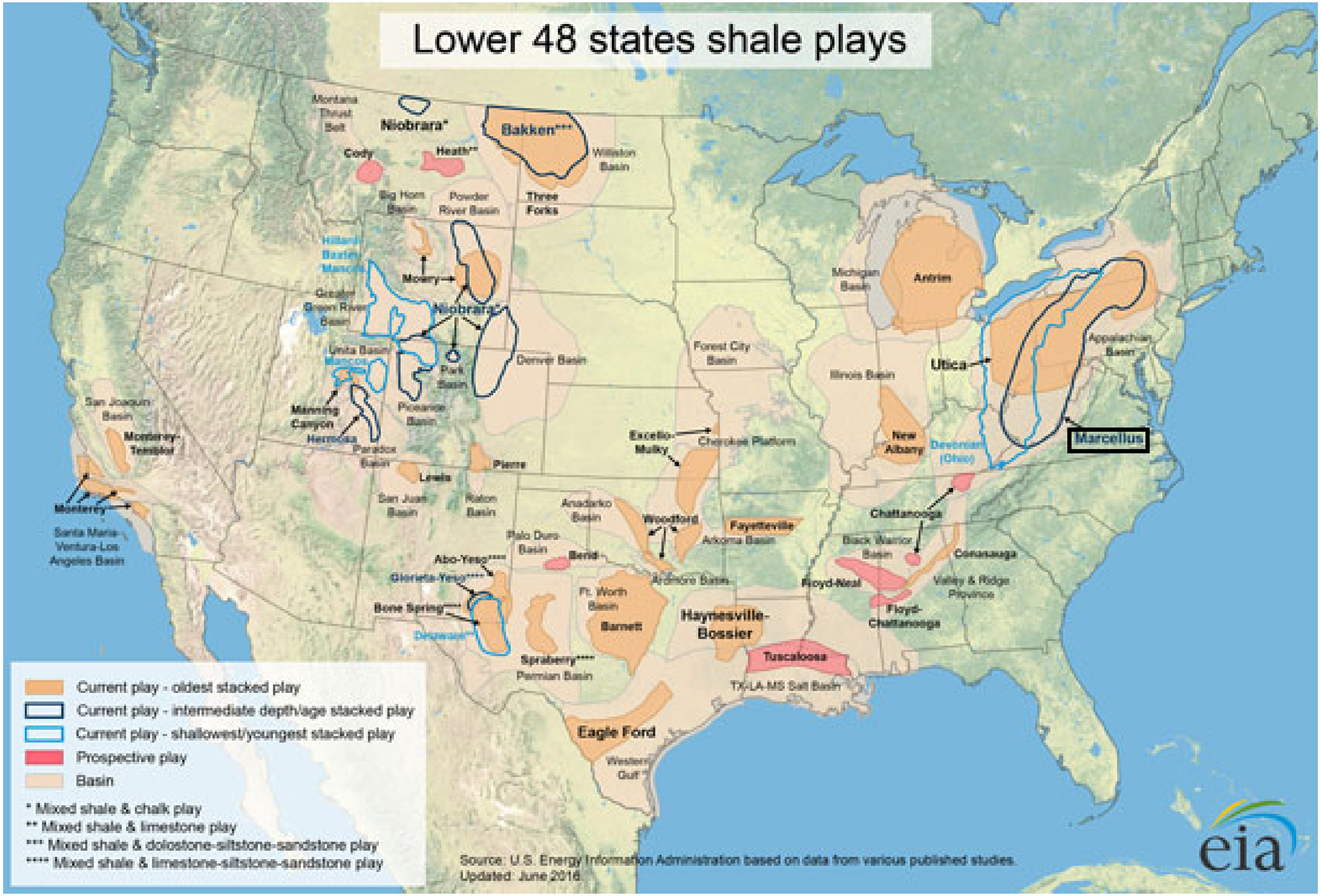


Image: http://www.propublica.org/images/articles/natural_gas/marcellus_hydraulic_graphic_090514.gif



Proppant: solid material, typically treated sand or man-made ceramic materials, designed to keep an induced hydraulic fracture open

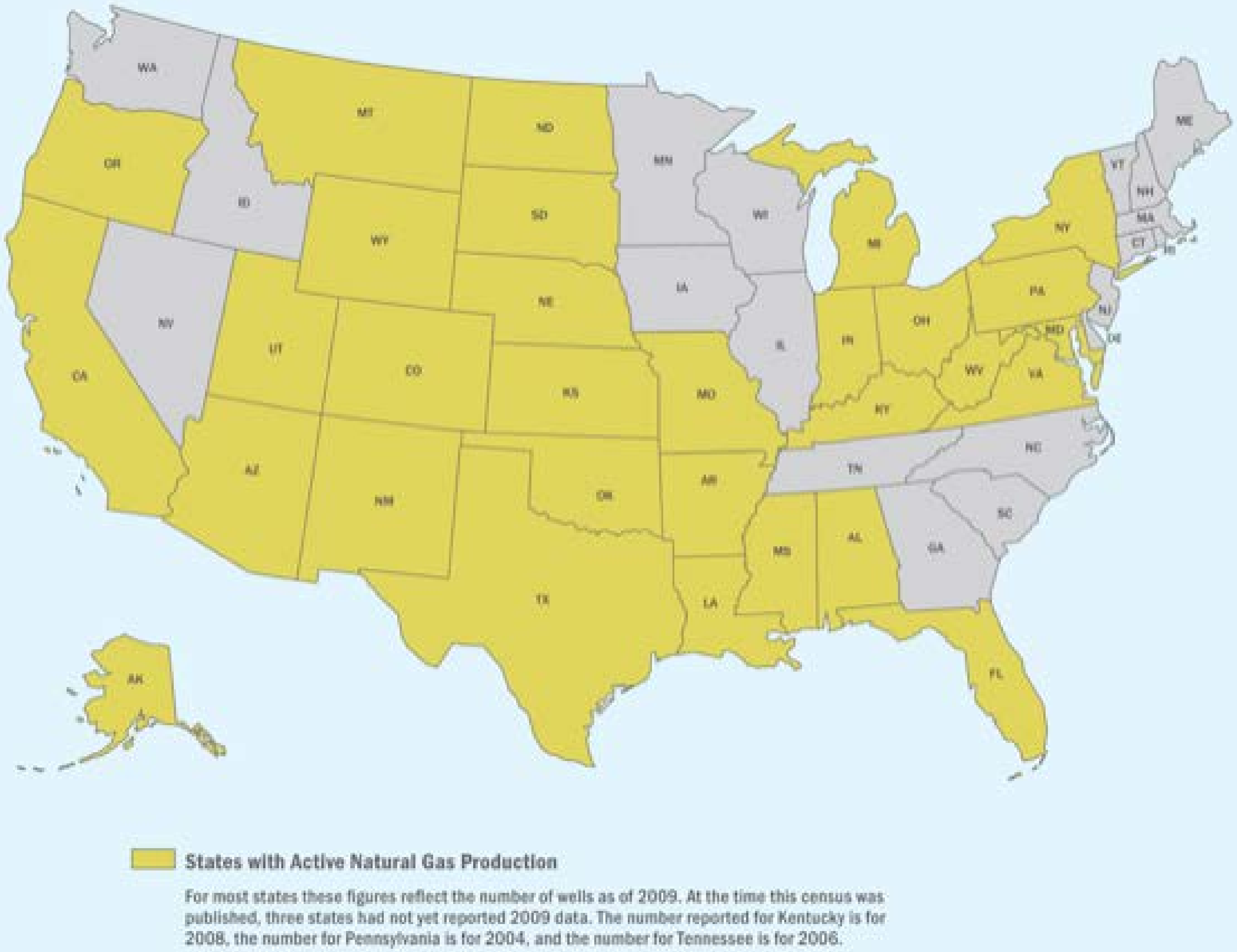
Image: http://online.wsj.com/article/SB10001424052702303491304575187880596301668.html



https://www.eia.gov/energyexplained/index.cfm?page=natural_gas_where

States with Active Natural Gas Production

as of 2009 (most states)

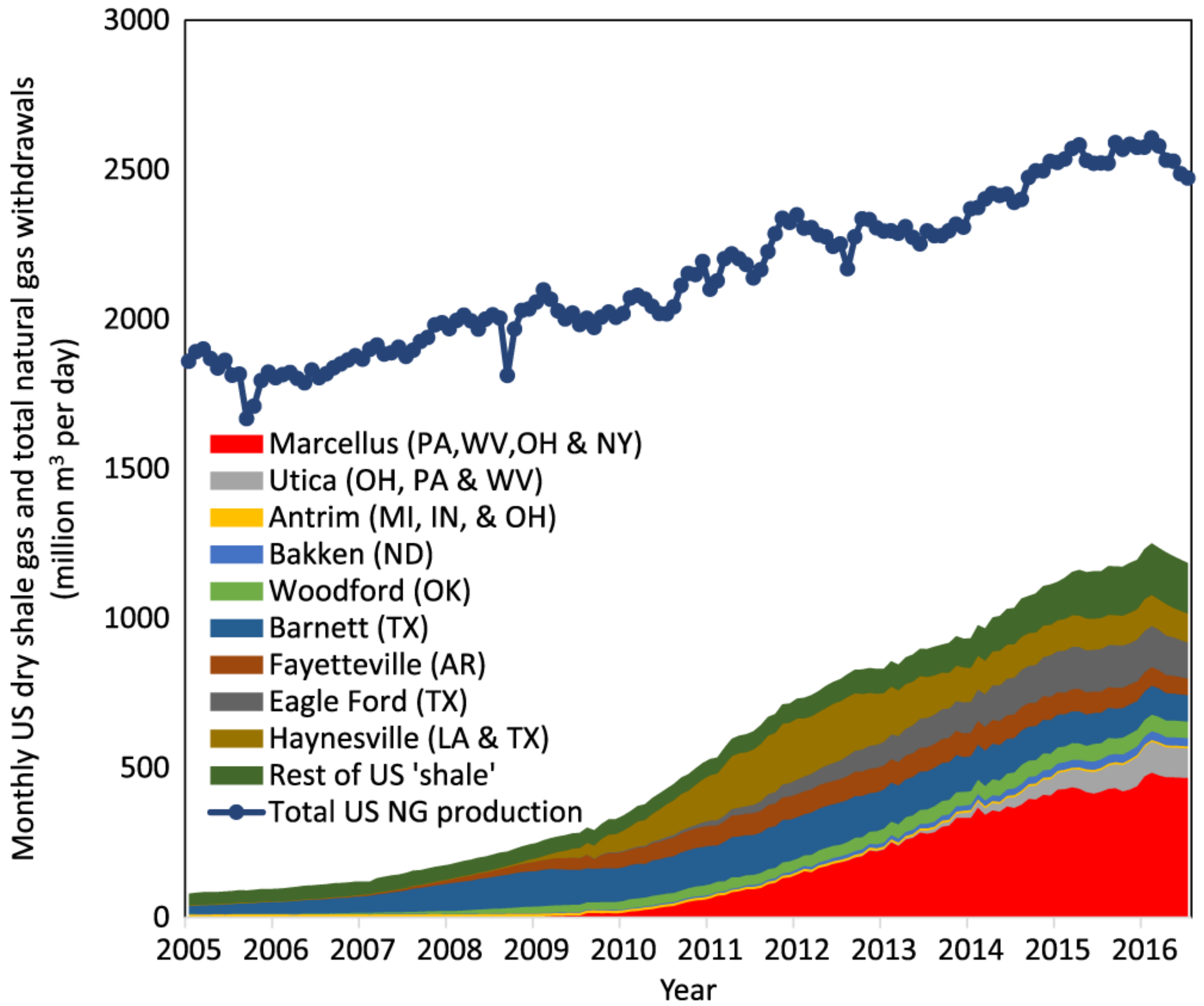


States	No. of Wells
Texas	121,534
Oklahoma	52,287
West Virginia	42,645
New Mexico	39,497
Colorado	38,278
Pennsylvania	35,928
Wyoming	32,617
Ohio	28,181
Kansas	26,025
Louisiana	18,519
Kentucky	13,330
Michigan	10,462
Virginia	7,078
New York	6,995
Utah	6,860
Arkansas	6,859
Montana	6,760
Alabama	6,157
California	4,142
Mississippi	1,734
Alaska	1,046
Indiana	620
North Dakota	509
Nebraska	354
South Dakota	137
Oregon	23
Arizona	6
Maryland	4
Florida	4
Missouri	2

Source: U.S. Energy Information Administration[32]

Weinhold, Envir. Health Perspective, 2012: http://ehp.niehs.nih.gov/120-a272/

Monthly US natural gas production



Year	% of US Total CH_4 Production Via Fracking
2001	**2**
2006	**6**
2008	**12**
2011	**29**
2013	**40**
2016	**48**

Figure: Ren et al., JGR, 2017
Table: http://www.shalegas.energy.gov/resources/081811_90_day_report_final.pdf (2001) & this figure (2006 to 2016)

Shale Gas Production

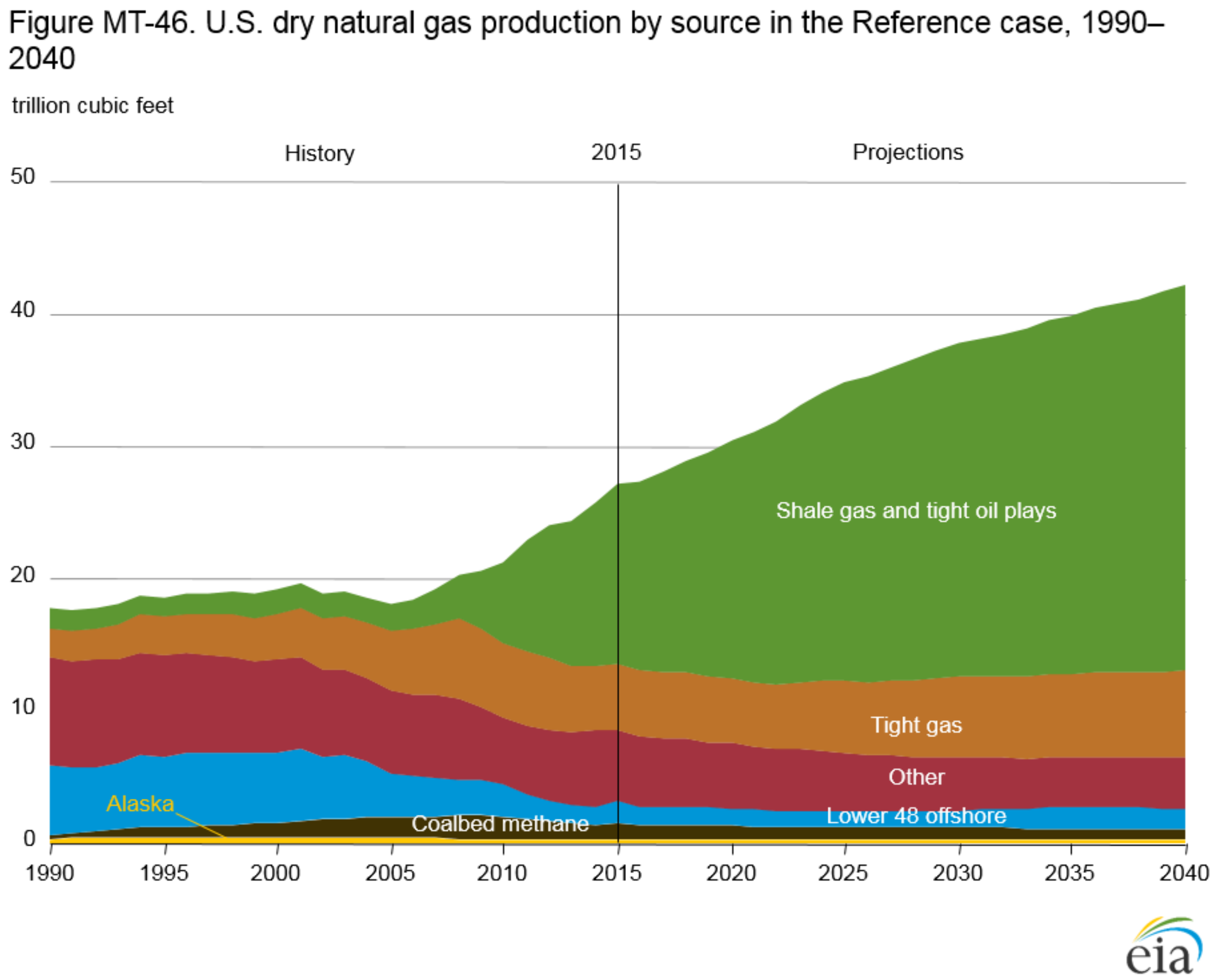


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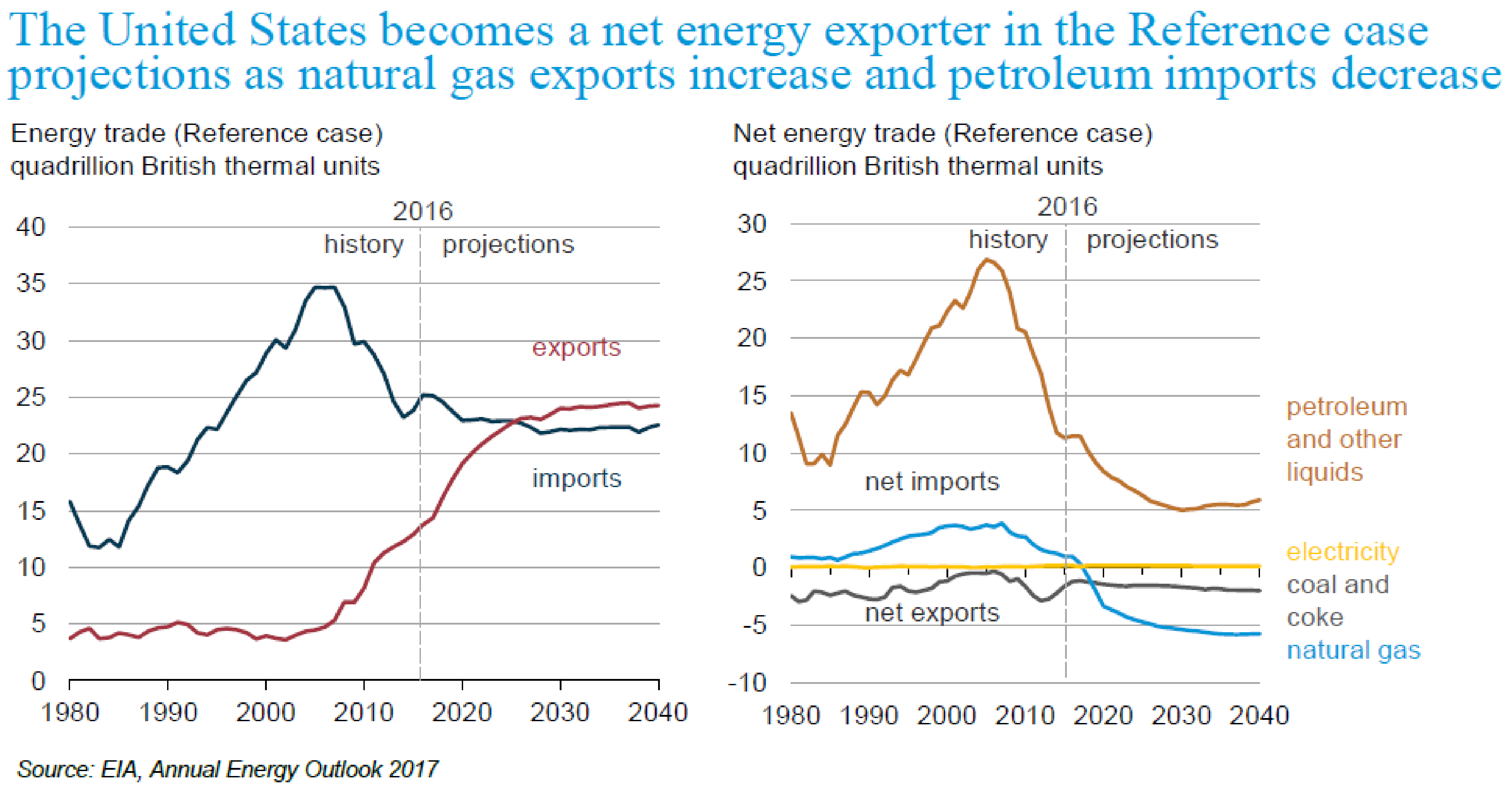
Figure: https://www.eia.gov/outlooks/archive/aeo16/images/fig_mt-46.png
Table: http://www.shalegas.energy.gov/resources/081811_90_day_report_final.pdf (2001) & this figure (2006 to 2016)

Shale Gas provides domestic source to meet U.S. consumer needs



https://www.eia.gov/pressroom/presentations/sieminski_01052017.pdf

Tight Gas and Shale Gas

Tight gas: CH_4 dispersed within low porosity silt or sand that create "tight fitting" environment; has been extracted for many years using hydraulic fracturing

Shale gas: CH_4 accumulated in small bubble like pockets within layers sedimentary rock such as shale, like tiny air pockets trapped in baked bread

Image:
http://www.wintershall.com/en/different-types-of-reserves-tight-gas-and-shale-gas.html

Shale Gas Production & Public Policy

- U.S. imports very little CH_4 (some imports from Canada)
- Price of CH_4 has fallen by a factor of 2 since 2008
- Concerns about shale gas production fall into four categories:
  - **Earthquakes**
  - **Contamination of ground water**
  - **Air quality (surface O_3 precursors)**
  - **Climate (fugitive release of CH_4)**
- Former U.S. Dept of Energy Secretary David Chu (served 21 Jan 2009 to 22 April 2013) commissioned two reports from the Shale Gas Subcommittee of the Secretary of Energy Advisory Board (SEAB) to "identify measures that can be taken to reduce the environmental impact and to help assure the safety of shale gas production"
- First report (11 Aug 2011) identified 20 action items (see table, next slide)
- Second report (18 Nov 2011) outlined recommendations for implementation of action items
- EPA issued new standards for the oil and natural gas industry on 14 Jan 2015
- Notably absent is extended discussion of earthquake issue

https://www.epa.gov/controlling-air-pollution-oil-and-natural-gas-industry

Shale Gas Production & Public Policy

- First report (11 Aug 2011) identified 20 action items

1. Improve public information about shale gas operations
2. Improve communication among state and federal regulators
3. Improve air quality: 4. Industry to measure CH_4 & other air pollutants 5. Launch federal interagency effort to establish GHG footprint over shale gas extraction life cycle 6. Encourage companies & regulators to reduce emissions using proven technologies & best practices
7. Protect water quality: 8. Measure and report composition of water stock 9. Manifest all transfers of water among different locations 10. Adopt best practices for well casing, cementing, etc & conduct micro-seismic surveys to "assure that hydraulic growth is limited to gas producing formations" 11. Field studies of possible CH4 leakage from shale gas wells to water reservoirs 12. Obtain background water quality measurements (i.e., CH_4 levels in nearby waters prior to drilling)

Protect water quality (cont.): 13. Measure and report composition of water stock
14. Disclosure of fracking fluid composition
15. Reduce use of diesel fuel for surface power
16. Manage short-term & cumulative impacts on communities & wild life: sensitive areas can be deemed off-limit to drilling and support infrastructure through an appropriate science based process
17. Create shale gas industry organiz. to promote best practice, giving priority attention to: 18. Air: emission measurement & reporting at various points in production chain 19. Water: Pressure testing of cement casing & state-of-the-art technology to confirm formation isolation
20. Increase R & D support from Administration & Congress to promote technical advances such as the move from single well to multiple-well pad drilling

https://www.edf.org/sites/default/files/11903_Embargoed_Final_90_day_Report%20.pdf

Concern #1: Earthquakes

2012 Seismological Society of America meeting

ARE SEISMICITY RATE CHANGES IN THE MIDCONTINENT NATURAL OR MANMADE?

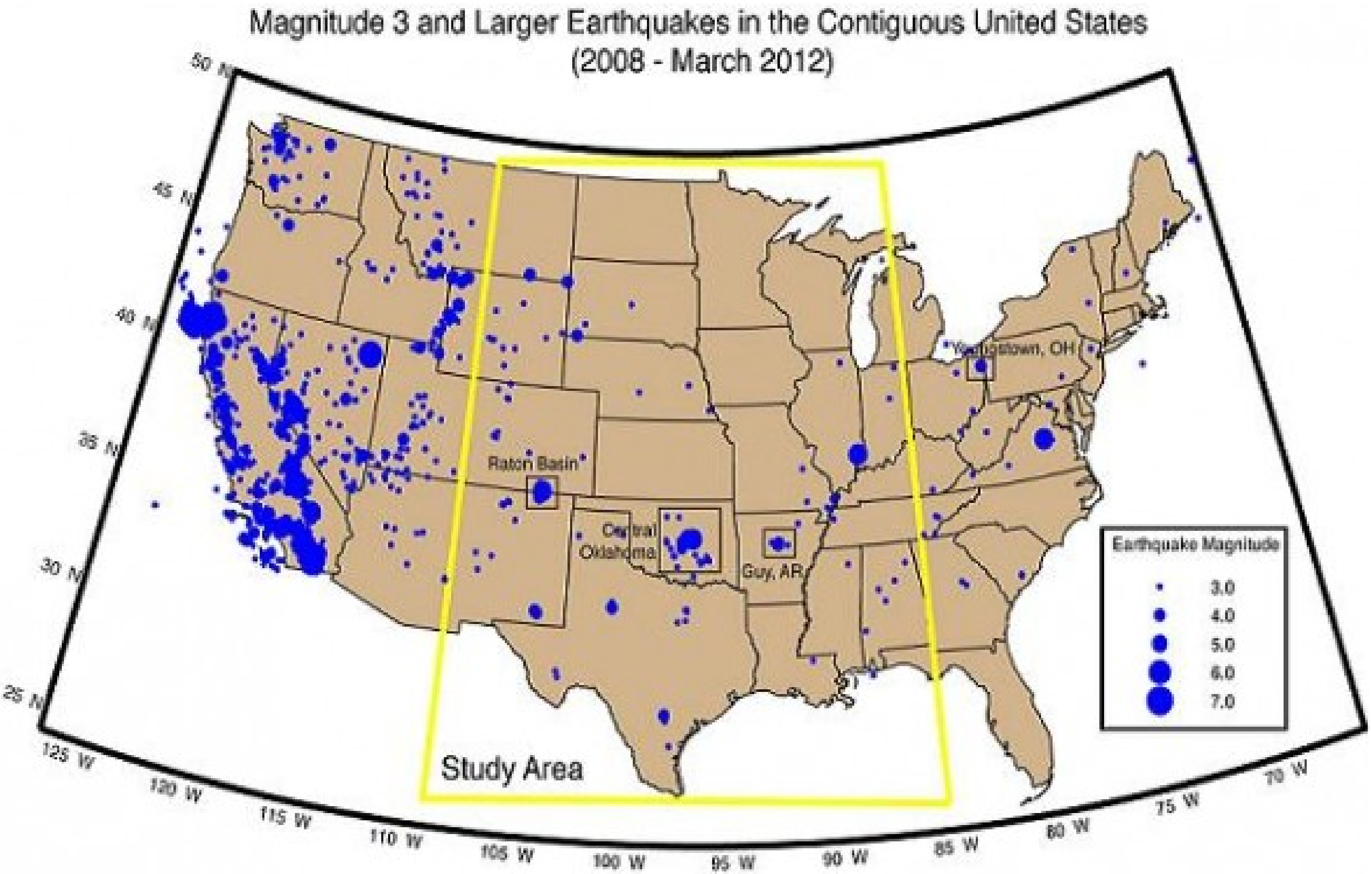
ELLSWORTH, W. L., US Geological Survey, Menlo Park, CA; HICKMAN, S. H., US Geological Survey, Menlo Park, CA; LLEONS, A. L., US Geological Survey, Menlo Park, CA; MCGARR, A., US Geological Survey, Menlo Park, CA; MICHAEL, A. J., US Geological Survey, Menlo Park, CA; RUBINSTEIN, J. L., US Geological Survey, Menlo Park, CA

A remarkable increase in the rate of M 3 and greater earthquakes is currently in progress in the US midcontinent. The average number of M >= 3 earthquakes/year increased starting in 2001, culminating in a six-fold increase over 20th century levels in 2011. Is this increase natural or manmade? To address this question, we take a regional approach to explore changes in the rate of earthquake occurrence in the midcontinent (defined here as 85° to 108° West, 25° to 50° North) using the USGS Preliminary Determination of Epicenters and National Seismic Hazard Map catalogs. These catalogs appear to be complete for M >= 3 since 1970. From 1970 through 2000, the rate of M >= 3 events averaged 21 +- 7.6/year in the entire region. This rate increased to 29 +- 3.5 from 2001 through 2008. In 2009, 2010 and 2011, 50, 87 and 134 events occurred, respectively. The modest increase that began in 2001 is due to increased seismicity in the coal bed methane field of the Raton Basin along the Colorado-New Mexico border west of Trinidad, CO. The acceleration in activity that began in 2009 appears to involve a combination of source regions of oil and gas production, including the Guy, Arkansas region, and in central and southern Oklahoma. Horton, et al. (2012) provided strong evidence linking the Guy, AR activity to deep waste water injection wells. In Oklahoma, the rate of M >= 3 events abruptly increased in 2009 from 1.2/year in the previous half-century to over 25/year. This rate increase is exclusive of the November 2011 M 5.6 earthquake and its aftershocks. A naturally-occurring rate change of this magnitude is unprecedented outside of volcanic settings or in the absence of a main shock, of which there were neither in this region. While the seismicity rate changes described here are almost certainly manmade, it remains to be determined how they are related to either changes in extraction methodologies or the rate of oil and gas production.

Wednesday, April 18th / 3:45 PM Oral / Pacific Salon 4 & 5

Concern #1: Earthquakes

Ellsworth's study area:



http://www.esa.org/esablog/ecology-in-the-news/increase-in-magnitude-3-earthquakes-likely-caused-by-oil-and-gas-production-but-not-fracking

Concern #1: Earthquakes

Ellsworth's study suggests:

- Deep waste water injection wells are the culprit, especially if in the vicinity of a fault
- Increased fluid pressure in pores of the rock can reduce the slippage strain between rock layers
- Speed of pumping is important (slow better than fast)

USGS testimony:

- On 19 June 2012, Dr. William Leath of the U.S. Geological Survey testified before the U.S. Senate Committee on Energy and Natural Resources, stating:

> The injection and production practices employed in these technologies have, to varying degrees, the potential to introduce earthquake hazards
>
> Since the beginning of 2011 the central and eastern portions of the United States have experienced a number of moderately strong earthquakes in areas of historically low earthquake hazard. These include M4.7 in central Arkansas on Feb27, 2011; M5.3 near Trinidad, Colorado on Aug 23, 2011; M5.8 in central Virginia also on Aug 23, 2011; … M5.6 in central Oklahoma on Nov 6, 2011 … and M4.8 in east Texas on May 17, 2012. Of these *only the central Virginia earthquake is unequivocally a natural tectonic earthquake.*
>
> In all other cases, there is scientific evidence to at least raise the possibility that the earthquakes were induced by wastewater disposal or other oil- and gas-related activities.
>
> USGS scientists documented a seven-fold increase since 2008 in the seismicity of the central U.S., an increase largely associated with areas of wastewater disposal from oil, gas & coalbed methane production

First three bullets:
http://www.esa.org/esablog/ecology-in-the-news/increase-in-magnitude-3-earthquakes-likely-caused-by-oil-and-gas-production-but-not-fracking
USGS testimony:
http://www.usgs.gov/congressional/hearings/docs/leith_19june2012.DOCX

Concern #1: Earthquakes

28 Jan 2015 Washington Post

The Washington Post

Search

Economy

Oklahoma worries over swarm of earthquakes and connection to oil industry

GUTHRIE, Okla. – The earthquakes come nearly every day now, cracking drywall, popping floor tiles and rattling kitchen cabinets. On Monday, three quakes hit this historic land-rush town in 24 hours, booming and rumbling like the end of the world.

"After a while, you can't even tell what's a pre-shock or an after-shock. The ground just keeps moving," said Jason Murphey, 37, a Web developer who represents Guthrie in the state legislature. "People are so frustrated and scared. They want to know the state is doing something."

What to do about the plague of earthquakes is, however, very much an open question in Oklahoma. Last year, 567 quakes of at least 3.0 magnitude rocked a swath of counties from the state capital to the Kansas line, alarming a populace long accustomed to fewer than two quakes a year.

Scientists implicated the oil and gas industry — in particular, the deep wastewater disposal wells that have been linked to a dramatic increase in seismic activity across the central United States. But in a state founded on oil wealth, officials have been reluctant to crack down on an industry that accounts for a third of the economy and one in five jobs.

Concern #1: Earthquakes

28 Jan 2015 Washington Post

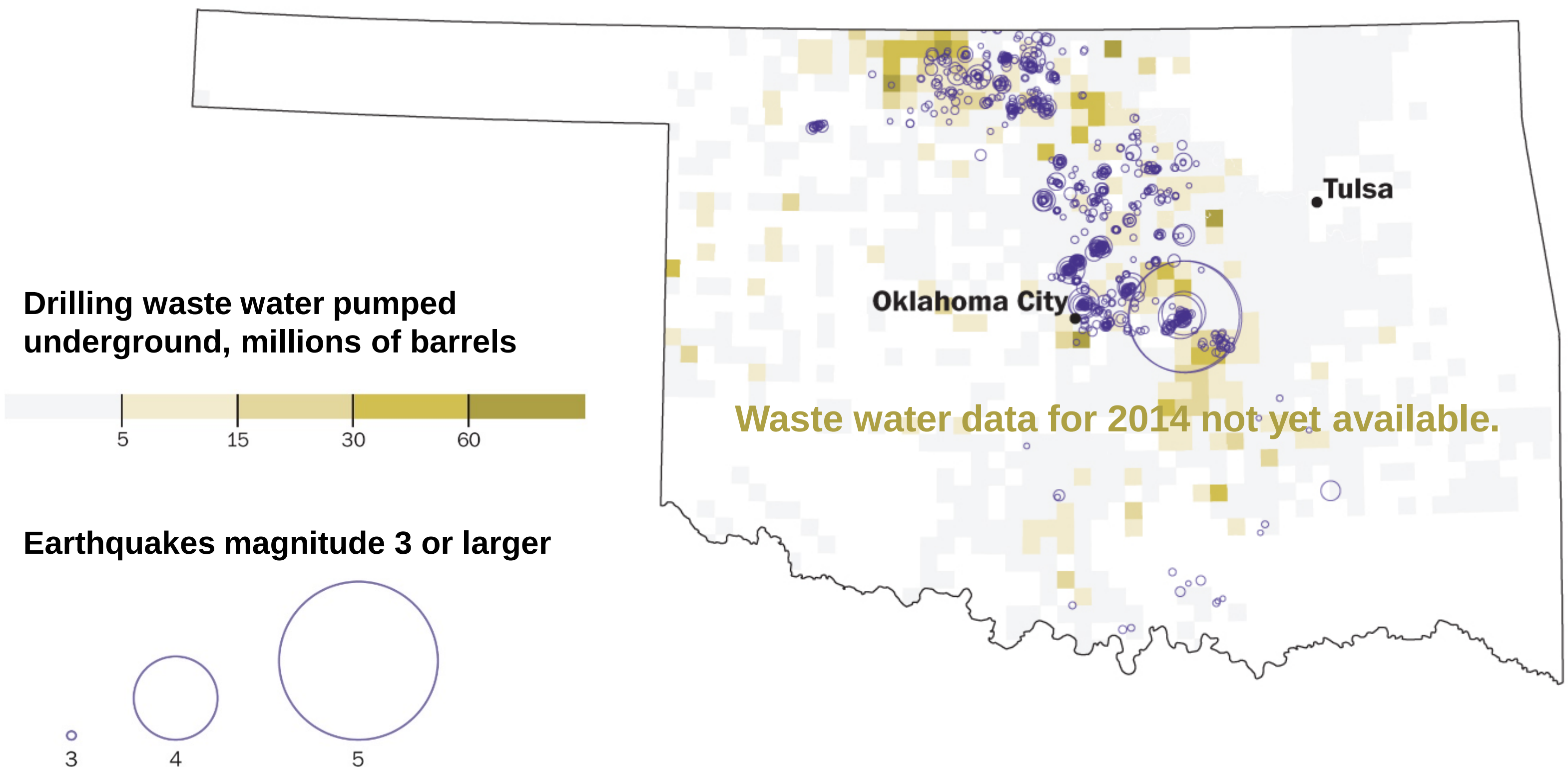
The Washington Post

Search

Economy

Oklahoma worries over swarm of earthquakes and connection to oil industry

2014



http://www.washingtonpost.com/graphics/national/oklahoma-earthquakes/

Concern #1: Earthquakes

7 Nov 2016 USA Today

USA TODAY

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Oklahoma earthquake reignites concerns that fracking wells may be the cause

Rick Jervis , USA TODAY 5:34 p.m. ET Nov. 7, 2016

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(Photo: Jim Beckel, AP)

A 5.0 magnitude earthquake that rattled north-central Oklahoma Sunday was only the sixth of that strength in state history and has reawakened concerns that oil and gas activity could be causing the tremors.

The temblor, which occurred around 7:44 p.m. Sunday about a mile west of Cushing, Okla., sheared bricks off buildings, caused structural damage to homes and forced local schools to close Monday. Around 40 residents were evacuated from a retirement home and sheltered at a local gymnasium.

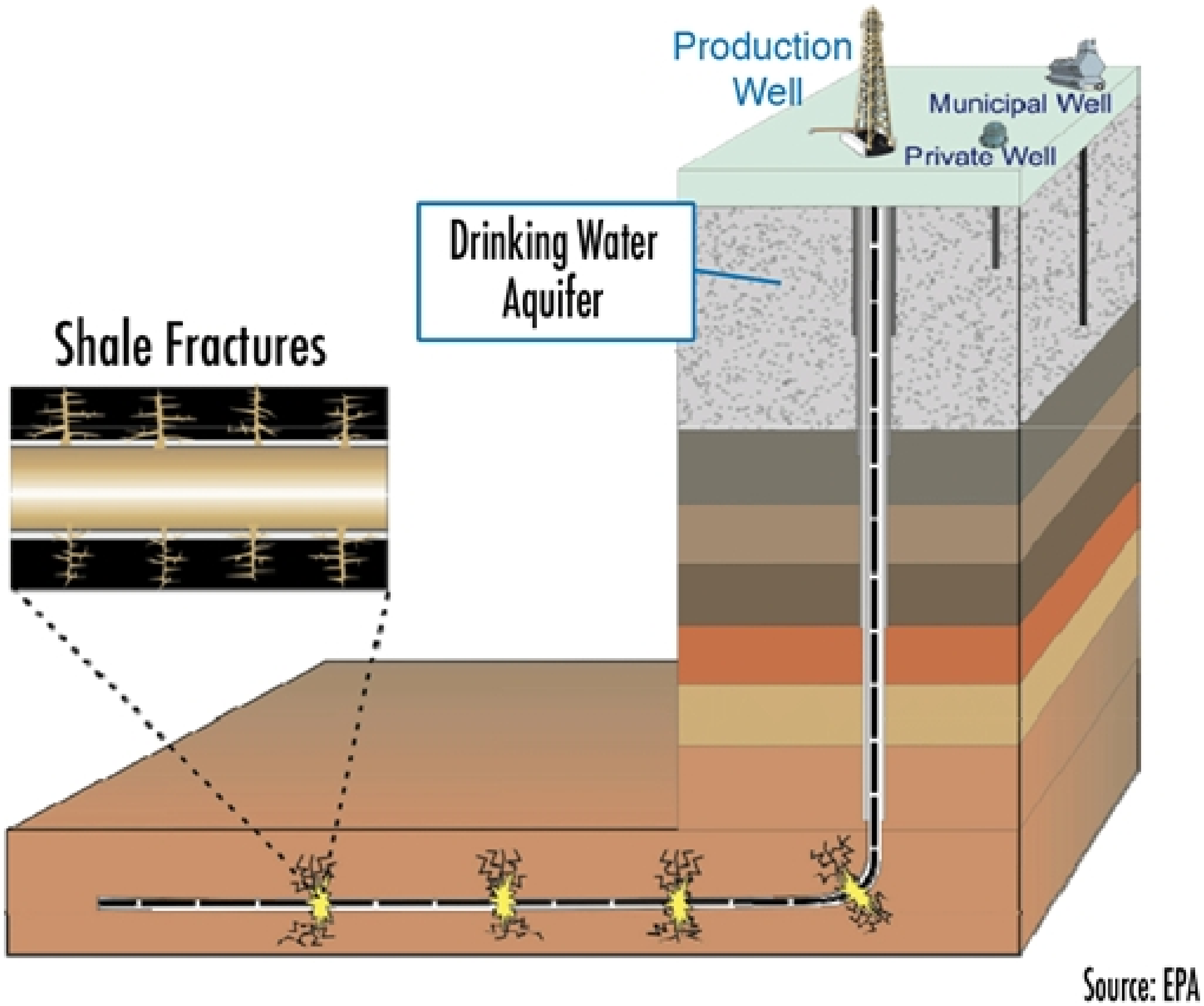
It was only the sixth 5.0 magnitude or higher to strike Oklahoma since 1882, said George Choy, a geophysicist with the U.S. Geological Survey in Boulder, Colo. Three of those larger quakes occurred this year. The strongest ever recorded in Oklahoma

Concern #1: Earthquakes

23 April 2015, Daily Show

http://www.businessinsider.com/jon-stewart-fracking-causes-earthquakes-2015-4

Concern #2: Water Quality



http://savethewater.org/wp-content/uploads/2013/02/Stock-Save-the-water-New-Study-Predicts-Fracking-Fluids-Will-Seep-Into-Aquifers-Within-Years.jpg

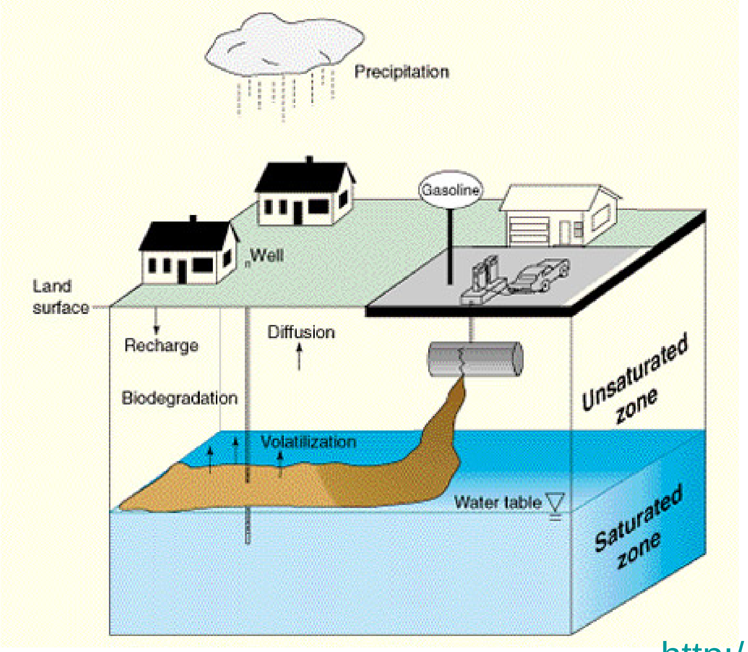
Concern #2: Water Quality

Spread of contaminants in ground water determined by

Dispersion – differential flow of water through small openings (pores) in soil

Diffusion – random molecular (Brownian) motion of molecules in water

Sorption – some chemicals may be *absorbed by soil* while others are *adsorbed* (adhere to surfaces)



Highly diffusive chemicals (e.g. MTBE) can spread very quickly even though ground water is relatively motionless.

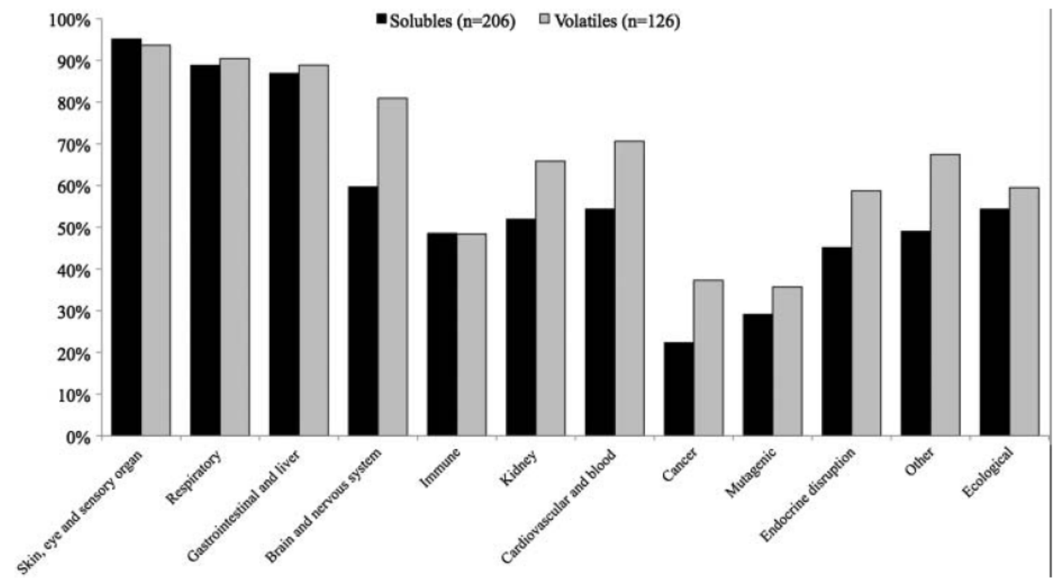
http://toxics.usgs.gov/topics/gwcontam_transport.html

Concern #2: Water Quality

Typical Chemical Additives Used in Frac Water

Compound	Purpose	Common application
Acids	Helps dissolve minerals and initiate fissure in rock (pre-fracture)	Swimming pool cleaner
Sodium Chloride	Allows a delayed breakdown of the gel polymer chains	Table salt
Polyacrylamide	Minimizes the friction between fluid and pipe	Water treatment, soil conditioner
Ethylene Glycol	Prevents scale deposits in the pipe	Automotive anti-freeze, deicing agent, household cleaners
Borate Salts	Maintains fluid viscosity as temperature increases	Laundry detergent, hand soap, cosmetics
Sodium/Potassium Carbonate	Maintains effectiveness of other components, such as crosslinkers	Washing soda, detergent, soap, water softener, glass, ceramics
Glutaraldehyde	Eliminates bacteria in the water	Disinfectant, sterilization of medical and dental equipment
Guar Gum	Thickens the water to suspend the sand	Thickener in cosmetics, baked goods, ice cream, toothpaste, sauces
Citric Acid	Prevents precipitation of metal oxides	Food additive; food and beverages; lemon juice
Isopropanol	Used to increase the viscosity of the fracture fluid	Glass cleaner, antiperspirant, hair coloring

Source: DOE, GWPC: Modern Gas Shale Development in the United States: A Primer (2009).



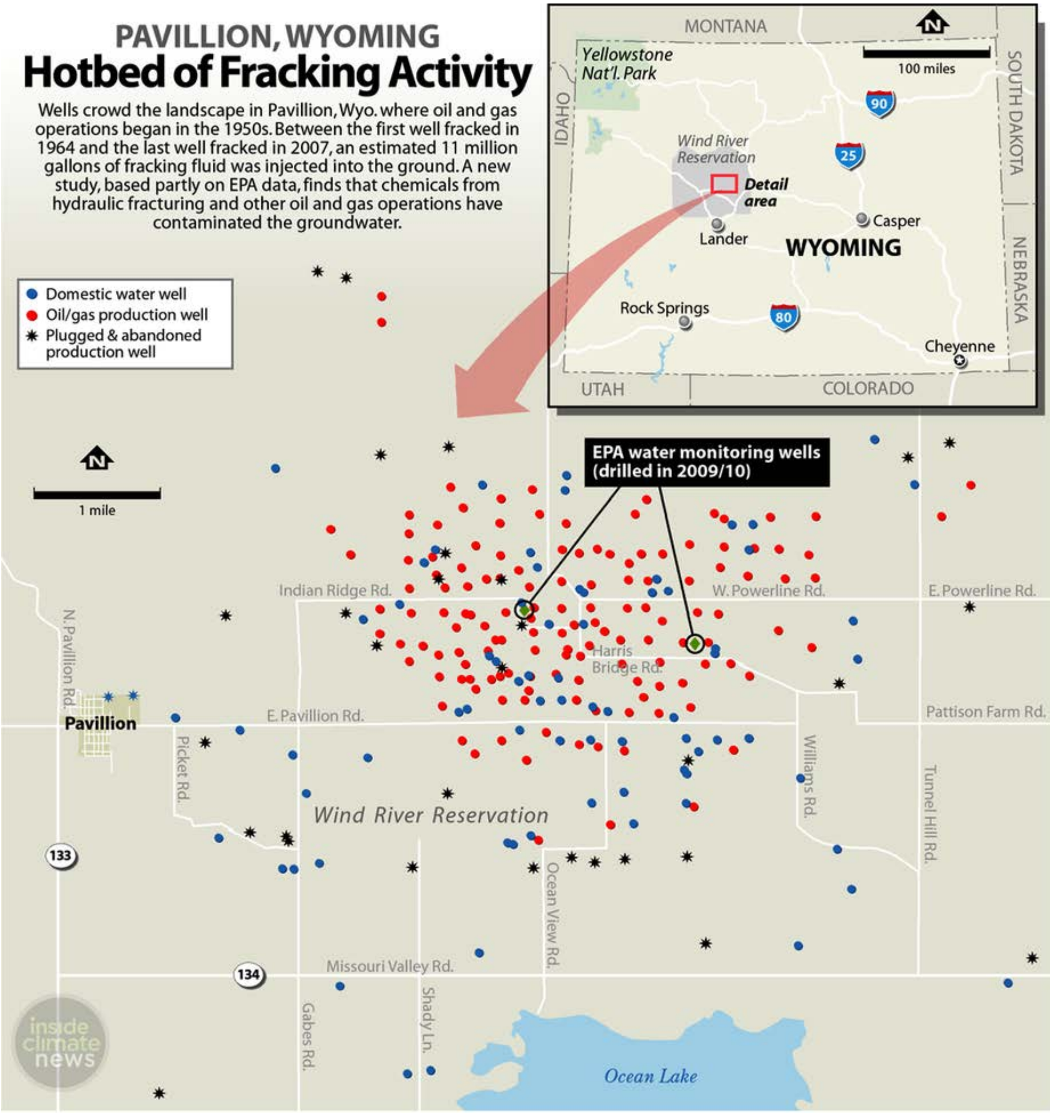
http://www.exxonmobilperspectives.com/2011/08/25/fracking-fluid-disclosure-why-its-important/

http://www.tandfonline.com/doi/pdf/10.1080/10807039.2011.605662

Many chemicals used in fracking have "everyday" uses …

We control how chemicals are used in homes, not the case for fracking

Concern #2: Water Quality



SOURCE: *Environmental Science & Technology*, March 18, 2016 PAUL HORN / InsideClimate News

Wyoming:

25000 wells

Study area:

11 million gallons of various fluids including hydrochloric acid and methanol, many of which are neurotoxins and carcinogens, pumped into the ground

Companies frequently fracked at much shallower depths than previously thought, sometimes very close to wells

High levels of diesel-related organic compounds & acids were found...
“it seems implausible this is due to natural conditions," DiGiulio said. “When you look at the compounds, it's a virtual fingerprint of chemicals used in the field."

https://insideclimatenews.org/news/29032016/fracking-study-pavillion-wyoming-drinking-water-contamination-epa

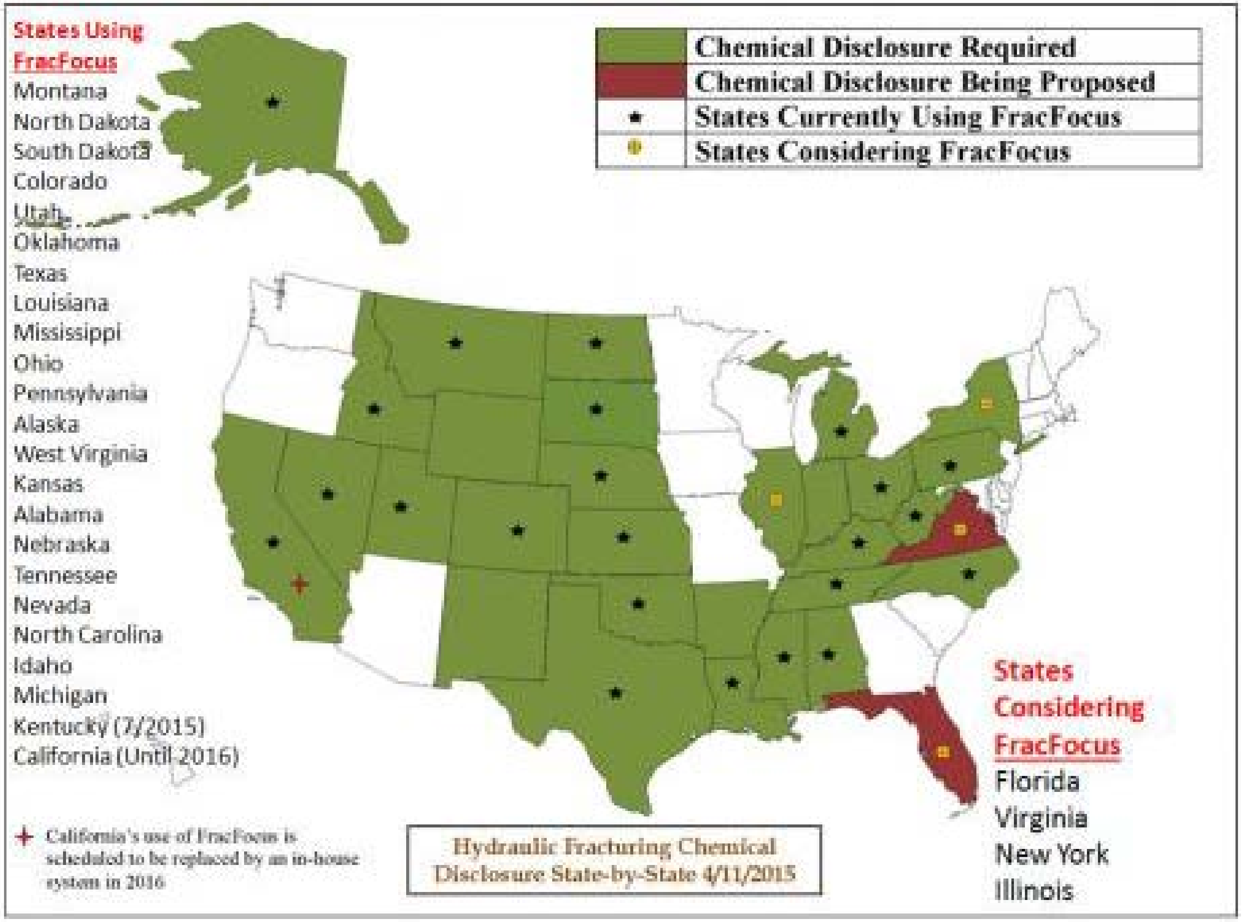
Concern #2: Water Quality

Fluid composition:

April 2011: www.fracfocus.org created as central disclosure registry for industry use

As of January 2016, 28 states require the disclosure of some, but not all, chemicals used during fracking & 23 use Frac Focus

Searchable database & Google map interface allow user to obtain info for individual wells



http://fracfocus.org/welcome

Concern #2: Water Quality

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Harvard Law School study highlights flaws in this system:

1) **Timing of Disclosures: Site does not notify States if company submits late**

2) **Substance of Disclosure: Site does not provide state specific forms, no minimum reporting standards**

3) **Nondisclosures: Companies not required to disclose chemicals if they are considered a "trade secret"**

~20% of all chemicals not reported.

http://www.eenews.net/assets/2013/04/23/document_ew_01.pdf

See also http://www.factcheck.org/2017/04/facts-fracking-chemical-disclosure

Concern #2: Water Quality

Fluid composition:

ECONOMY

March 15, 2017 9:55 PM

Associated Press

Trump Administration Halts Obama-Era Rule on Fracking on Public Land

WASHINGTON — The Trump administration is rolling back an Obama administration rule requiring companies that drill for oil and natural gas on federal lands to disclose chemicals used in hydraulic fracturing, better known as fracking.

The administration said in court papers Wednesday that it is withdrawing from a lawsuit challenging the Obama-era rule and will begin a new rule-making process later this year.

The Interior Department issued the rule in March 2015, the first major federal regulation of fracking, the controversial drilling technique that has sparked an ongoing boom in natural gas production but raised widespread concerns about possible groundwater contamination and even earthquakes.

The rule has been on hold since last year after a judge in Wyoming ruled that federal regulators lack congressional authority to set rules for fracking.

A worker helps monitor water pumping pressure and temperature, at a hydraulic fracturing and extraction site, outside Rifle, in western Colorado, March 29, 2013.

http://www.voanews.com/a/trump-administration-halts-obama-era-rule-on-racking-on-public-land/3768474.html

Fluid composition:

Concern #2: Water Quality

search text ...

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ECONOMY

March 15, 2017 9:55 PM

Associated Press

Trump Administration Halts Obama-Era Rule on Fracking on Public Land

Interior Department confirms intent

A spokeswoman for Interior Secretary Ryan Zinke confirmed the administration's intent to submit a new rule but did not add further comment late Wednesday. Zinke took office March 1 and has promised to review a slew of department rules and policies.

Michael Saul, an attorney with the Center for Biological Diversity, an environmental group, called the Trump administration's decision to withdraw the fracking rule “disturbing” and said it “highlights Trump's desire to leave our beautiful public lands utterly unprotected from oil industry exploitation.”

Backing away from what he called modest rules “is doubly dangerous, given the administration's reckless plans to ramp up fracking and drilling on public lands across America,” Saul said.

The Obama-era rule came after three years of consideration, drawing criticism from the oil and gas industry as unnecessary and duplicative of state efforts to regulate drilling. Some environmental groups worried that the rules were too lenient and could allow unsafe drilling techniques to pollute groundwater.

FracFocus.org started in 2011

The rule relies on an online database used by at least 16 states to track the chemicals used in fracking operations. The website, FracFocus.org, was formed by industry and intergovernmental groups in 2011 and allows users to gather well-specific data on tens of thousands of drilling sites across the country.

Companies would have had to disclose the chemicals they use within 30 days of the fracking operation.

Fracking involves pumping huge volumes of water, sand and chemicals underground to split open rocks to allow oil and gas to flow.

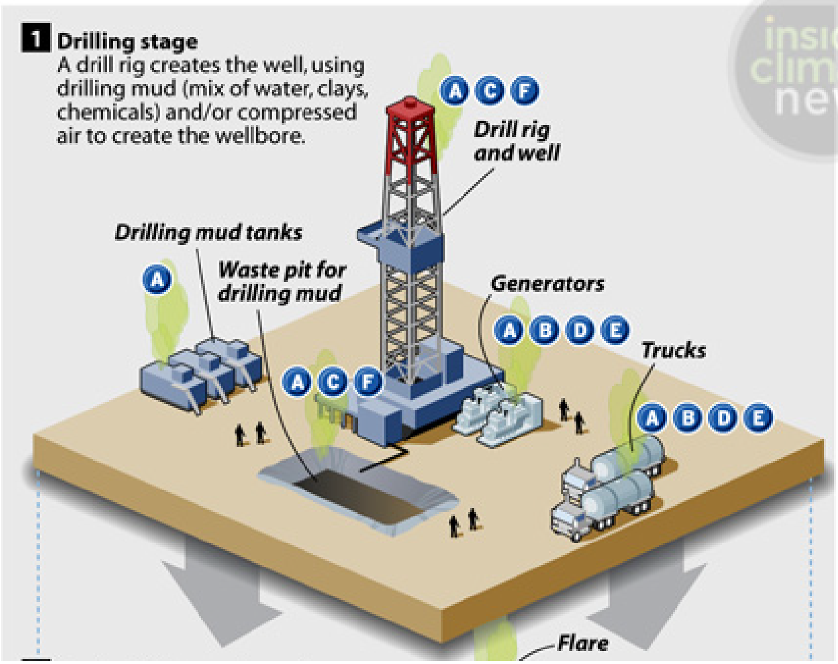
http://www.voanews.com/a/trump-administration-halts-obama-era-rule-on-racking-on-public-land/3768474.html

Concern #3: Air Quality

- Fracking releases a lovely mixture of air pollutants

Air Emissions from Oil and Gas Development in the Eagle Ford

There are more than 7,000 oil and gas wells in the Eagle Ford Shale, and Texas regulators have approved another 5,500. Most of them, like the one shown here, are oil wells that also produce condensate and natural gas. Developing these resources releases various air pollutants, some of which are shown in this simplified diagram.



Emission Sources

The pollutants come from a number of sources, including the diesel- or natural gas-fueled equipment, the oil and gas itself, and leaks from storage devices. The emissions' actual and relative amounts vary widely based on operator practices and local geology. The emissions occur regularly in some cases, but are intermittent in others.

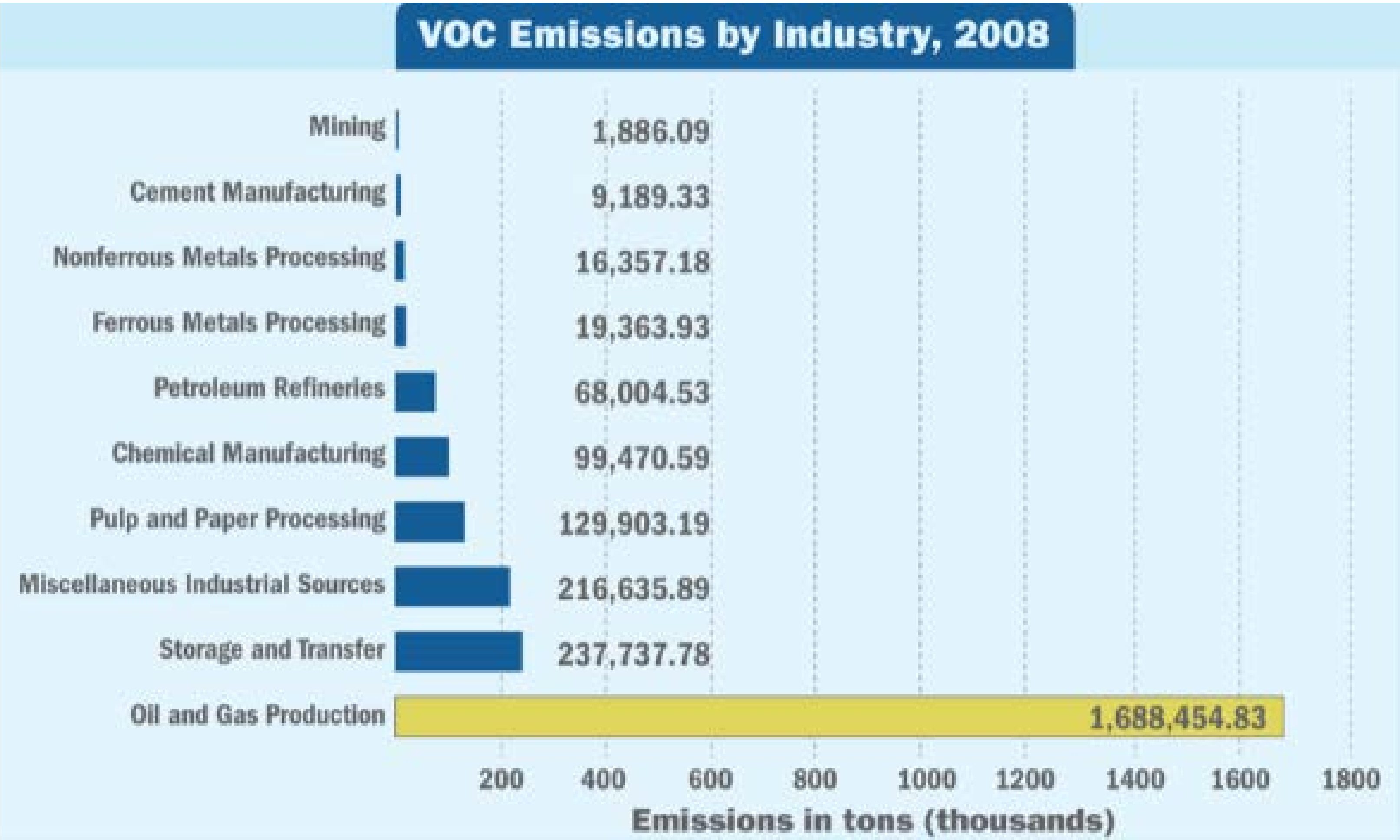
CHEMICAL	WHAT IT IS	WHAT IT DOES
A VOCs	Volatile organic compounds including benzene, formaldehyde	There are dozens of VOCs that make people sick. Some can cause cancer. VOCs react with NOx to form ozone, a respiratory irritant and greenhouse gas.
B PM	Particulate matter	Affects the heart and lungs.
C CH_4	Methane	Main component of natural gas. Much more powerful than CO_2 as a greenhouse gas.
D CO_2	Carbon dioxide	Major greenhouse gas.
E NOx	Nitrogen oxides	Reacts with VOCs to create ozone.
F H_2S	Hydrogen sulfide	Toxic gas found in some gas fields. Causes illness and death at certain concentrations.

Fugitive emissions: pipelines, valves, pneumatic devices etc. leak methane, VOCs, H_2S and CO_2 throughout the entire process.

https://insideclimatenews.org/infographics?topic=All&project=&keywords=&page=16

Concern #3: Air Quality

- Fracking is a major contributor to anthropogenic VOCs



https://ehp.niehs.nih.gov/120-a272/

Tropospheric Ozone Production

$$CO + OH \rightarrow CO_2 + H$$
$$H + O_2 + M \rightarrow HO_2 + M$$
$$HO_2 + NO \rightarrow OH + NO_2$$
$$NO_2 + h\nu \rightarrow NO + O$$
$$O + O_2 + M \rightarrow O_3 + M$$

Net: $CO + 2\,O_2 \rightarrow CO_2 + O_3$

$$RH + OH \rightarrow R + H_2O$$
$$R + O_2 + M \rightarrow RO_2 + M$$
$$RO_2 + NO \rightarrow RO + NO_2$$
$$RO + O_2 \rightarrow HO_2 + R'CHO$$
$$HO_2 + NO \rightarrow OH + NO_2$$
$$2\times \quad NO_2 + h\nu \rightarrow NO + O$$
$$2\times \quad O + O_2 + M \rightarrow O_3 + M$$

Net: $RH + 4O_2 \rightarrow R'CHO + H_2O + 2\,O_3$

VOC: Volatile Organic Compounds

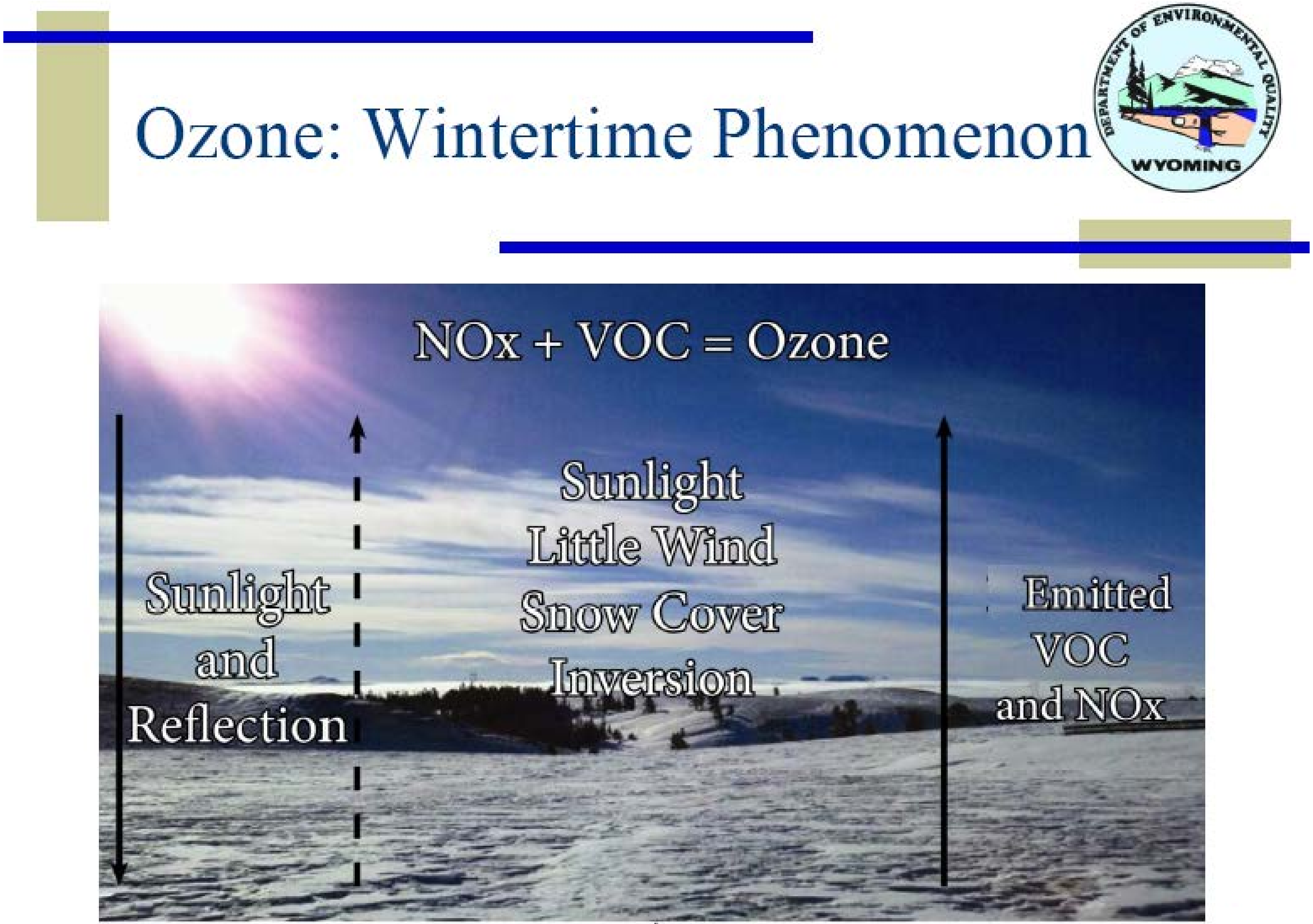
Produced by trees and fossil fuel vapor

Strong source of HO_x (OH & HO_2) & O_3 (depending on NO_x levels)

Examples of RH and R'CHO : CH_4 (methane) $\rightarrow$ CH_2O (formaldehyde)
: C_2H_6 (ethane) $\rightarrow$ CH_3CHO (acetaledhyde)
: C_3H_8 (propane) $\rightarrow$ CH_3COCH_3 (acetone)

Ozone Production "limited" by $k[HO_2][NO] + \Sigma\, k_i\, [RO_2]_i\, [NO]$

Concern #3: Air Quality (Case Study: Wyoming)



http://deq.state.wy.us/out/downloads/UGRBTaskForce02212012WDEQAQD.pdf

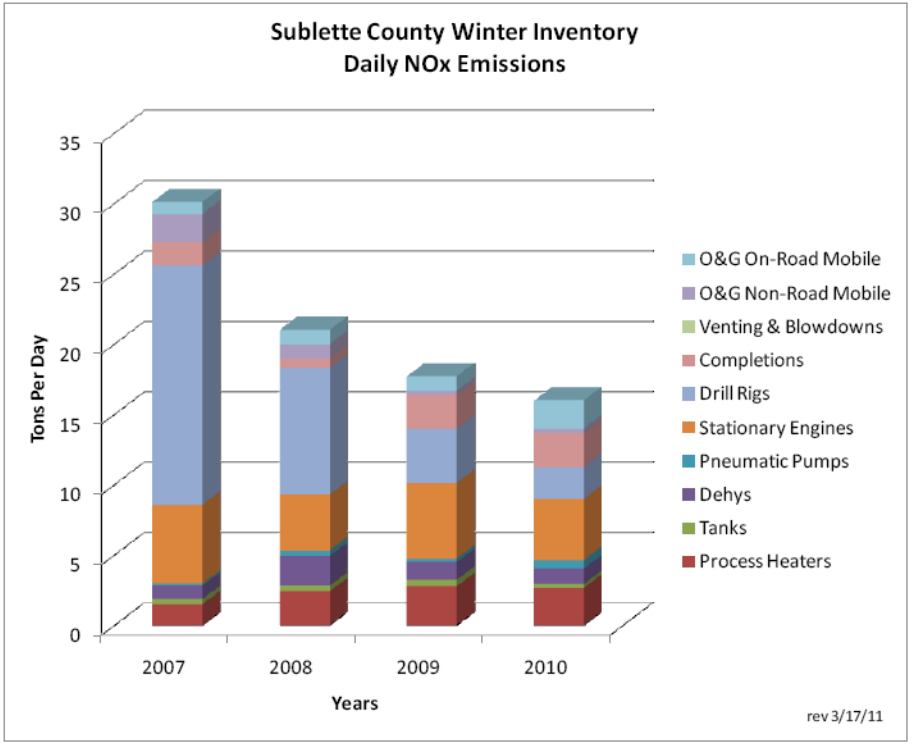
Concern #3: Air Quality (Case Study: Wyoming)

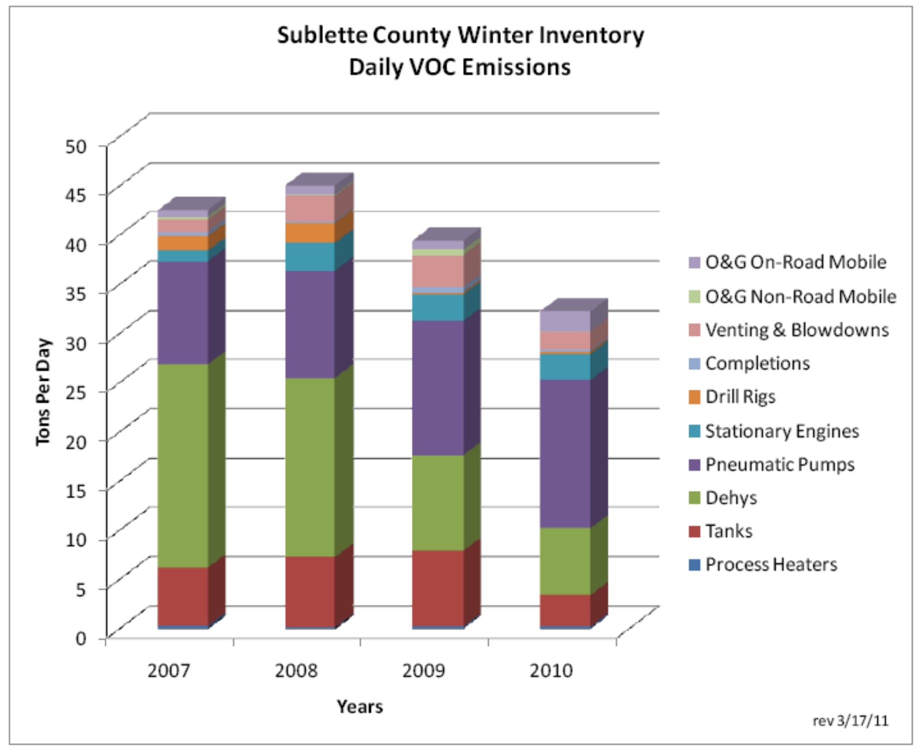
Sublette County Ozone & Weather History (2005 – 2011)

- Mid-January – March 2005
  - 8 Elevated 8-Hour O_3 Days > 75 ppb
- Mid-January – March 2006
  - 2 Elevated 8-Hour O_3 Days > 75 ppb
- Mid-January – March 2007
  - 0 Elevated 8-Hour O_3 Days > 75 ppb
  - Meteorological conditions not conducive to formation of elevated ozone levels.
- Mid-January – March 2008
  - 14 Elevated 8-Hour O_3 Days > 75 ppb
  - Higher magnitude than previous years
  - Met. conditions conducive to formation of elevated ozone levels.
- Mid-January – March 2009
  - 0 Elevated 8-Hour O_3 Days > 75 ppb
  - Limited met. conditions conducive to formation of elevated ozone levels.
- Mid-January – March 2010
  - 0 Elevated 8-Hour O_3 Days > 75 ppb
  - Met. conditions not conducive to formation of elevated ozone levels.
- Mid-January – March 2011
  - 13 Elevated 8-Hour O_3 Days > 75 ppb
  - Higher magnitude than previous years
  - Met. conditions conducive to formation of elevated ozone levels.

http://deq.state.wy.us/out/downloads/March22PublicMtg_2011Ozone_WDEQ.pdf

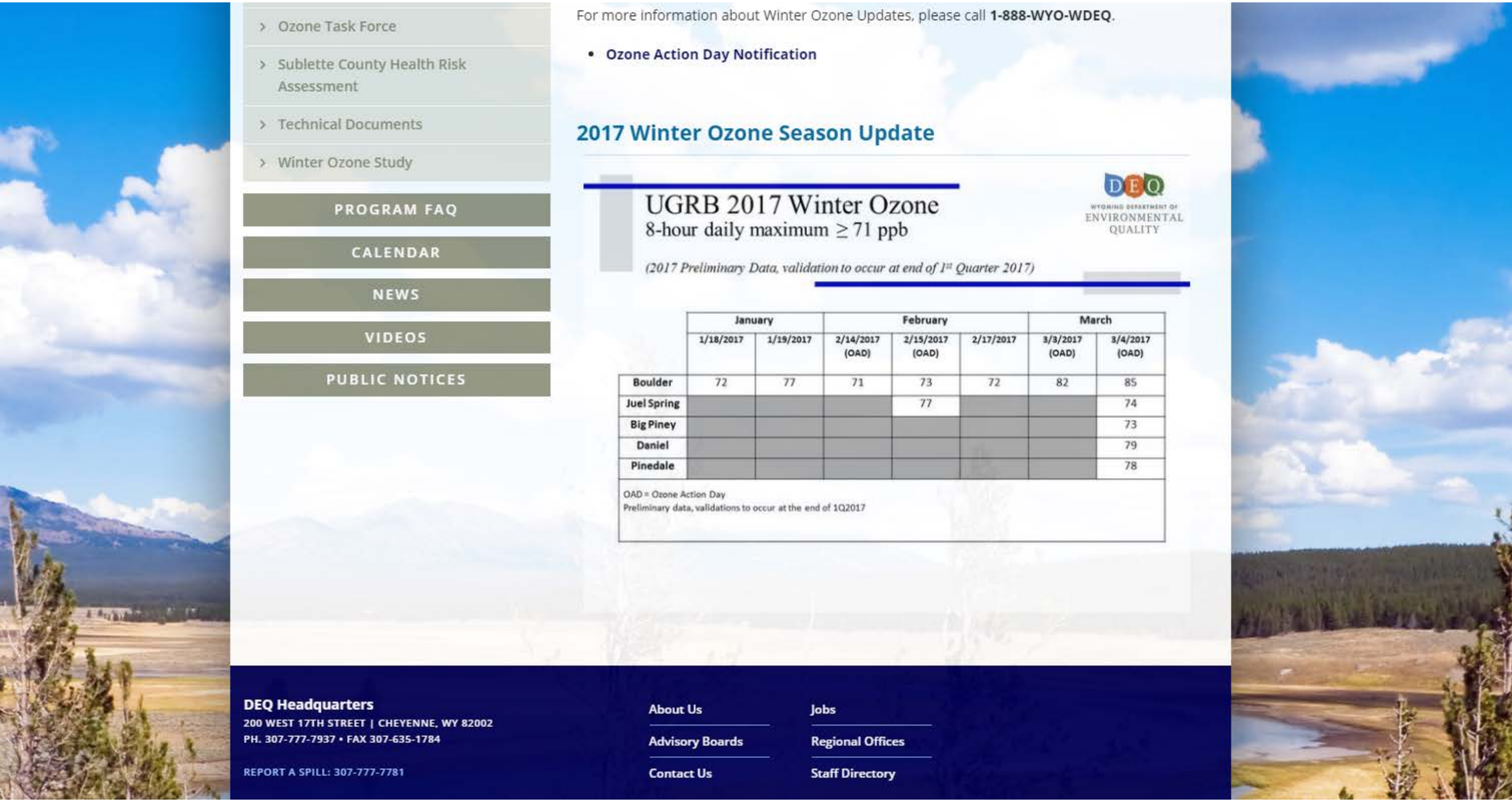
Concern #3: Air Quality (Case Study: Wyoming)





http://www.shalegas.energy.gov/resources/071311_corra.pdf

Concern #3: Air Quality (Case Study: Wyoming)



- Ozone Task Force
- Sublette County Health Risk Assessment
- Technical Documents
- Winter Ozone Study

PROGRAM FAQ

CALENDAR

NEWS

VIDEOS

PUBLIC NOTICES

For more information about Winter Ozone Updates, please call **1-888-WYO-WDEQ**.

- **Ozone Action Day Notification**

2017 Winter Ozone Season Update

DEQ
WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY

UGRB 2017 Winter Ozone
8-hour daily maximum ≥ 71 ppb

(2017 Preliminary Data, validation to occur at end of 1st Quarter 2017)

	January		February			March	
	1/18/2017	1/19/2017	2/14/2017 (OAD)	2/15/2017 (OAD)	2/17/2017	3/3/2017 (OAD)	3/4/2017 (OAD)
Boulder	72	77	71	73	72	82	85
Juel Spring				77			74
Big Piney							73
Daniel							79
Pinedale							78

OAD = Ozone Action Day
Preliminary data, validations to occur at the end of 1Q2017

DEQ Headquarters
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PH. 307-777-7937 • FAX 307-635-1784

REPORT A SPILL: 307-777-7781

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http://deq.wyoming.gov/aqd/winter-ozone

Concern #3: Air Quality (Case Study: Wyoming)

Statement on Winter Ozone Levels in the Upper Green River Basin

Wyoming Department of Environmental Quality sent this bulletin at 03/09/2017 09:56 AM MST

Having trouble viewing this email? View it as a Web page. SHARE

WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY

Statement on Winter Ozone Levels in the Upper Green River Basin

03/09/2017 12:00 AM MST

We - Government, Industry, and the Public - have worked hard and made significant progress but we are not yet there. While we have significantly reduced NOx and VOC emissions from a variety of sources, it is clear that we have more to do to achieve our ultimate goal.

https://content.govdelivery.com/accounts/WYDEQ/bulletins/18c490a

2017 Winter Ozone Forecasting Season Has Come to an End

Wyoming Department of Environmental Quality sent this bulletin at 04/03/2017 06:06 PM MDT

Wyoming Department of Environmental Quality | view as a webpage

WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY

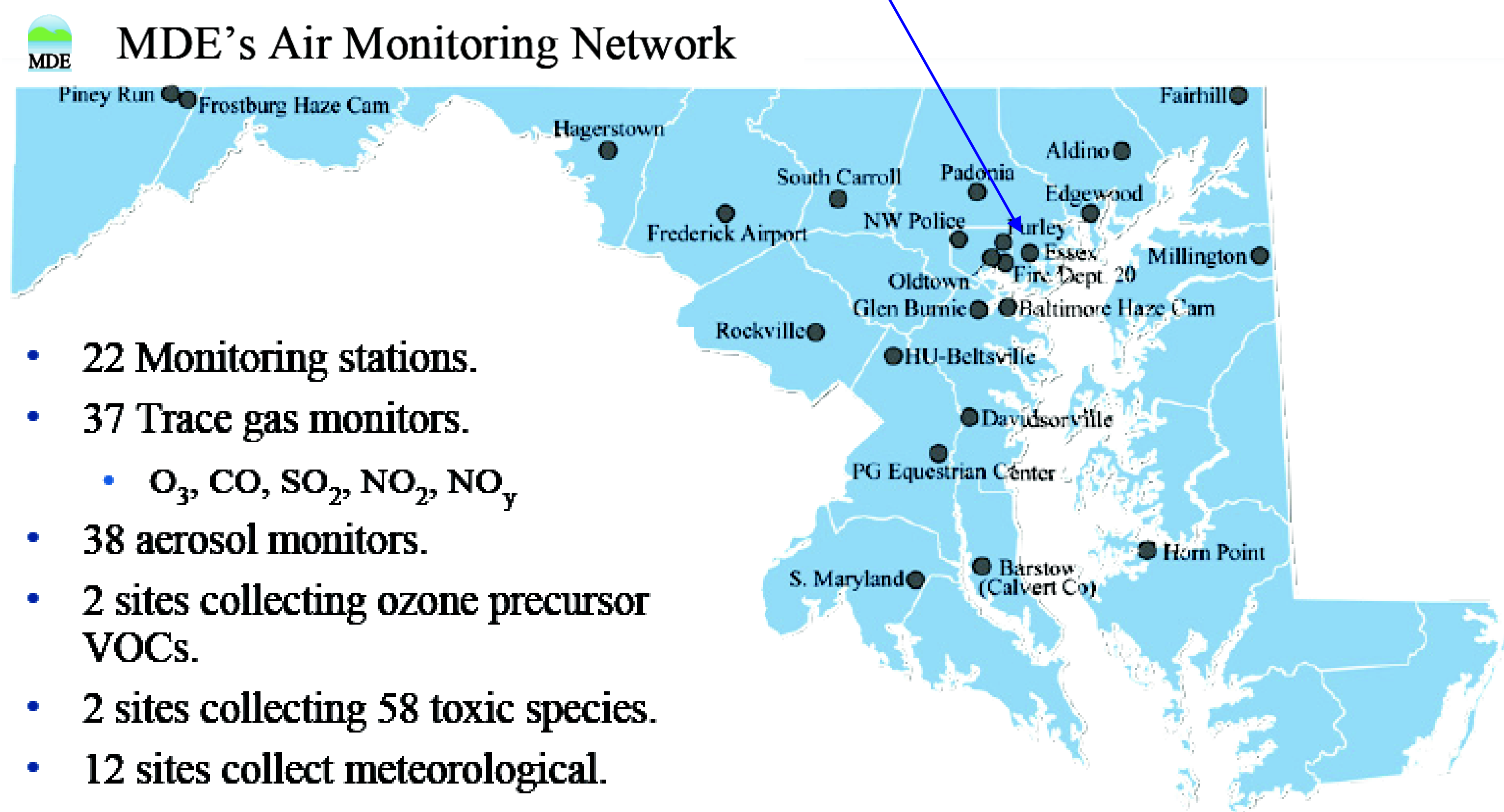
2017 Winter Ozone Forecasting Season Has Come to an End

The 2017 Winter Ozone Forecasting season has officially come to an end. The 2017 Winter Ozone Forecasting season for the Upper Green River Basin (UGRB) began on Tuesday, January 3rd and ended on Friday, March 31st. Preliminary monitoring data for the 2017 Winter Ozone Season can be found at winterozone.org for the Upper Green River Basin.

https://content.govdelivery.com/accounts/WYDEQ/bulletins/191f6c8

Concern #3: Air Quality (Case Study: Maryland)

- Air mass trajectories (meteorological modeling) show air parcels affected by fracking can reach the Baltimore/DC region
- Fracking releases a stew of VOCs, including ethane (C_2H_6)
- Ethane and other VOCs measured at **Essex** MDE site



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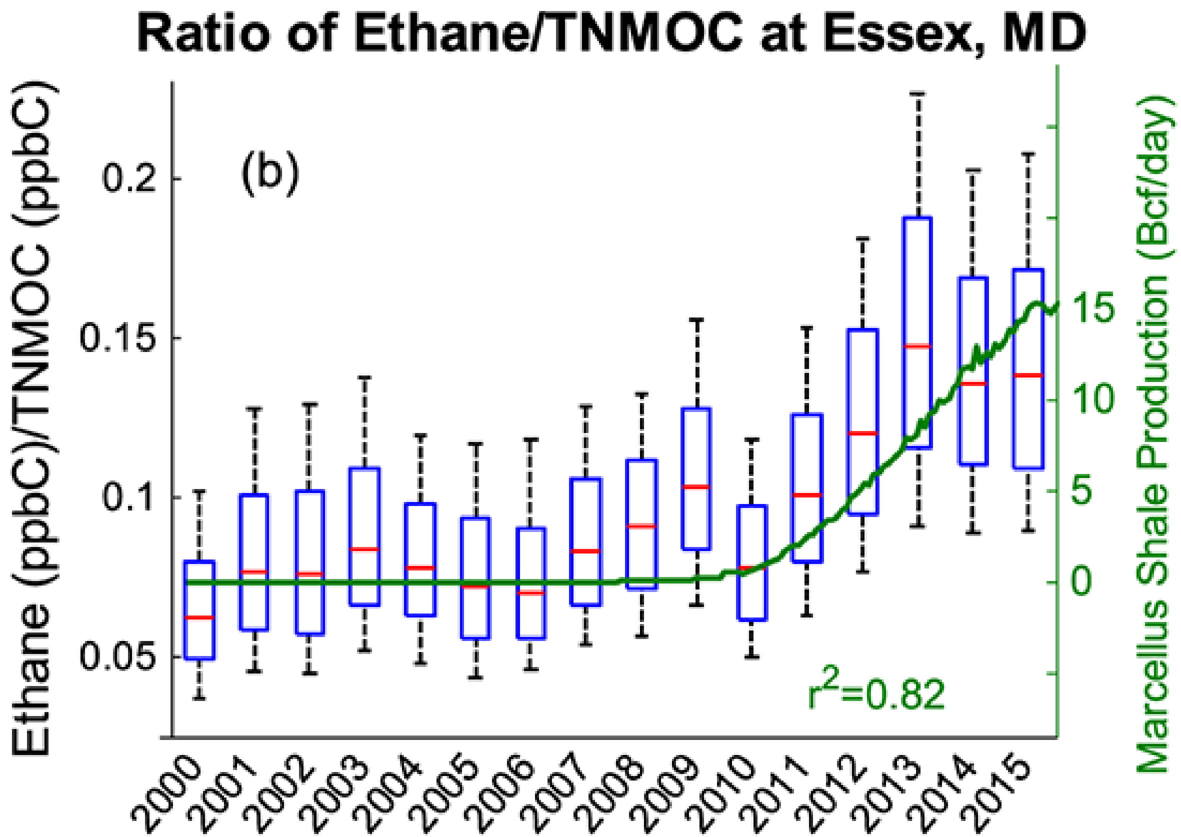


Ren *et al.*, JGR, 2017

Concern #4: Climate

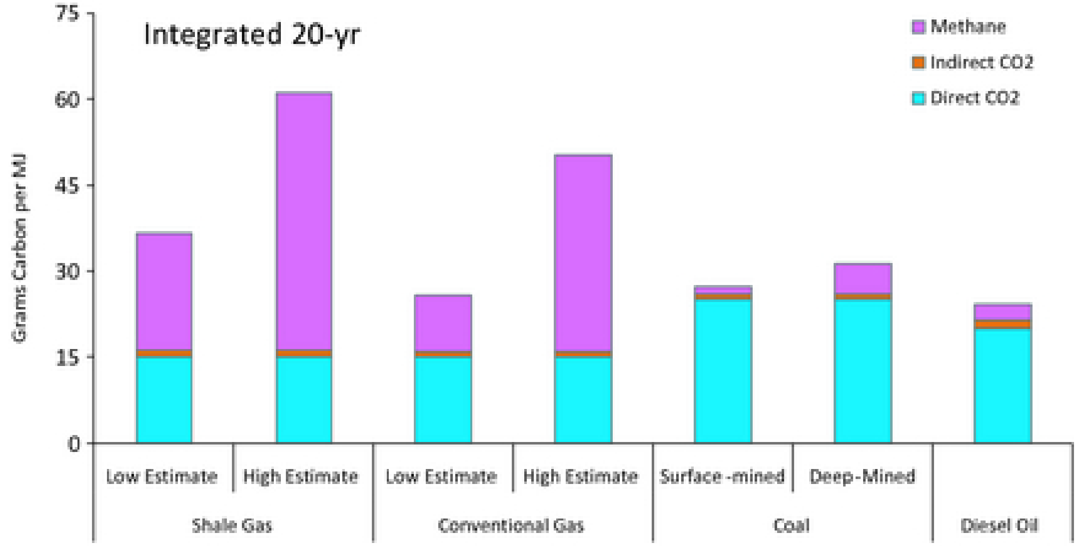
As shown in Lecture 17, under normal operating conditions w/ no leaks, less CO_2 is released to the atmosphere per kWh of electricity upon combustion of CH_4 than upon combustion of coal to generate the same amount of electricity

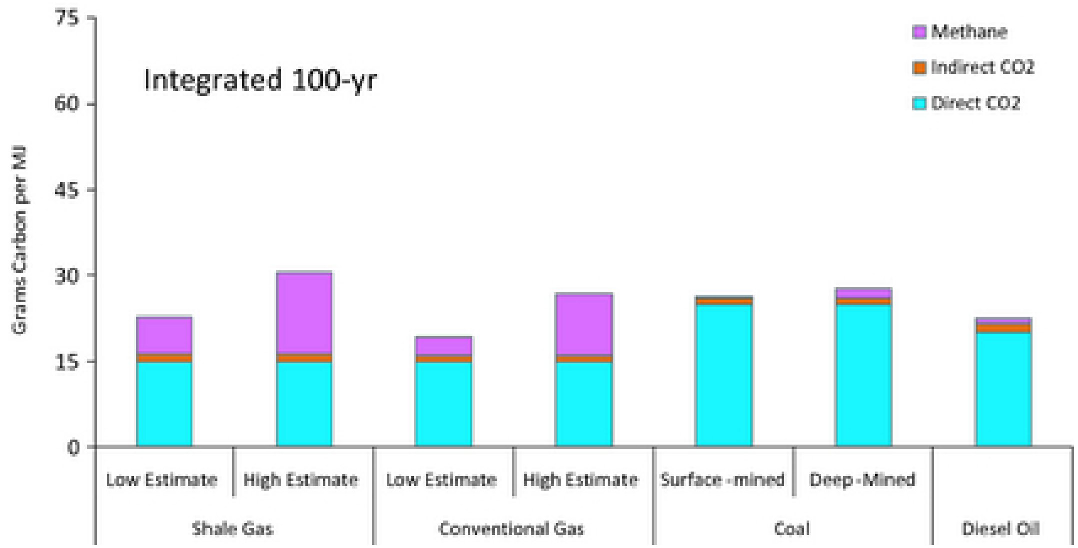
Fossil Fuel	GHG Output (pounds CO_2 per kWh)
Oil Sands	**5.6**
Coal	**2.1**
Oil	**1.9**
Gas	**1.3**

Since CH_4 has a larger GWP than CO_2, if CH_4 escapes via leakage rather than being oxidized via combustion, the **net GWP** of the sum of rising atmospheric CH_4 due to leakage plus rising CO_2 following combustion of natural gas can exceed the GWP of CO_2 from the combustion of fossil fuel.

http://www.eia.gov/cneaf/electricity/page/co2_report/co2emiss.pdf
http://www.iop.org/EJ/abstract/1748-9326/4/1/014005

Concern #4: Climate

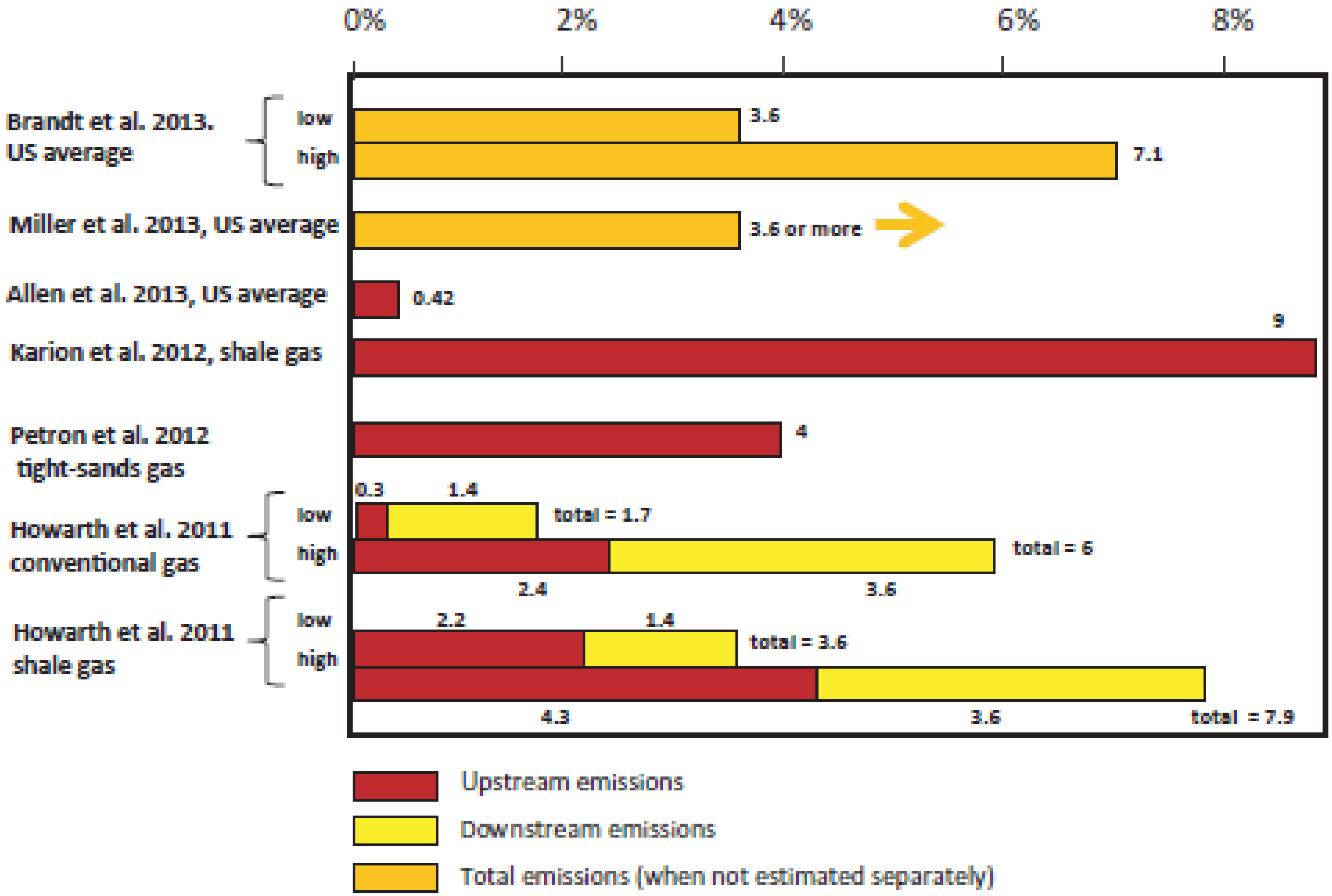




Howarth, *ESE*, 2014

Concern #4: Climate

Observed fugitive CH_4 emissions

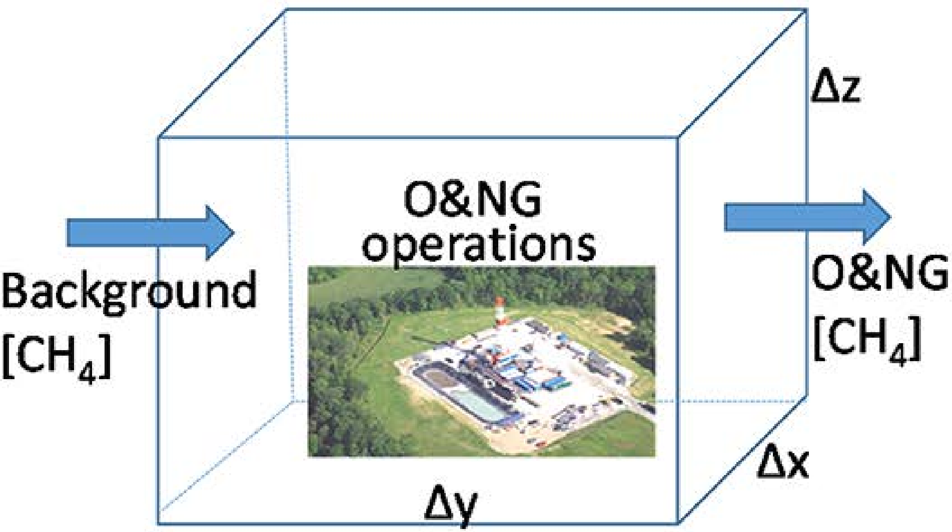


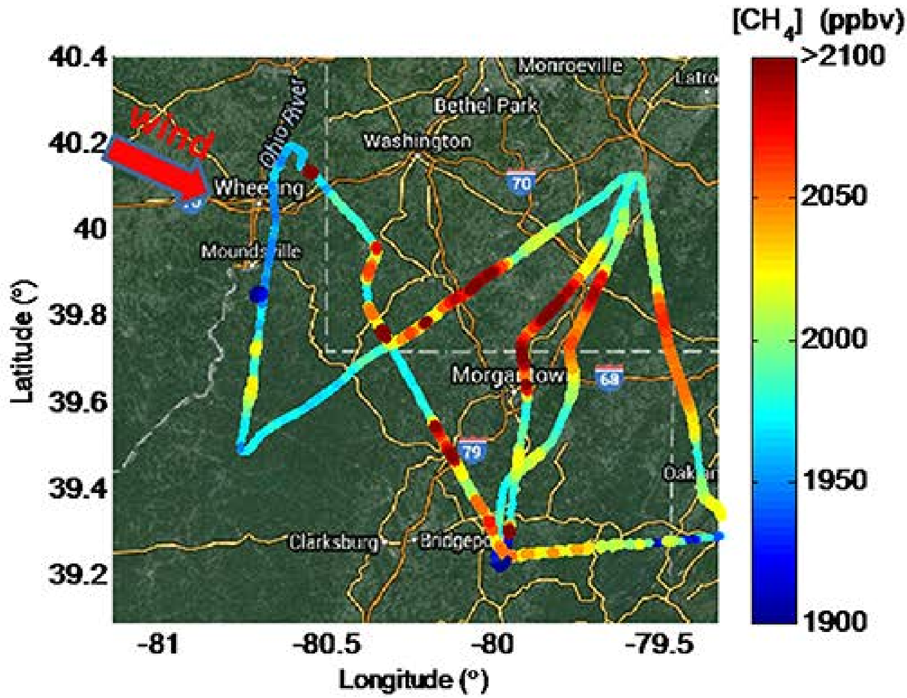
Howarth, *ESE*, 2014

Concern #4: Climate

Observed fugitive CH_4 emissions

Ren *et* al. *JGR* 2017 report a leakage of 3.9% (1.5 to 6.3% range) of CH_4 from oil and gas operations (O&NG) at the Marcellus Shale in southwestern U.S.





Left: Conceptual model of mass balance approach to quantify methane emissions from an O&NG operation area.

Right: CH_4 mixing ratio measured along the flight track on 14 September 2015. An enhancement was clearly observed along the transects downwind of O&NG operations.

Lots of U.S. Fracking Regulation Are Now Uncertain

Regulatory Actions

EPA to Reconsider Aspects of the 2016 New Source Performance Standards (NSPS), Stay Compliance Date for Fugitive Emissions Monitoring Requirements

April 18, 2017 – EPA intends to reconsider certain aspects of the 2016 NSPS for the oil and natural gas industry, in response to several administrative reconsideration petitions. In a letter to the petitioners, the agency said it also intends to issue a 90-day stay of the June 3, 2017 compliance date for the fugitive emissions monitoring requirements in the rule.

Read the letter

EPA Updates New Source Performance Standards (NSPS), permitting rules

May 12, 2016 - EPA has issued three final rules that together will curb emissions of methane, smog-forming volatile organic compounds (VOCs) and toxic air pollutants such as benzene from new, reconstructed and modified oil and gas sources, while providing greater certainty about Clean Air Act permitting requirements for the industry.

- Learn More

Proposed measures to cut methane and VOC emissions from the oil and natural gas industry and clarify permitting requirements

August 18, 2015 - EPA has proposed a suite of commonsense requirements that together will help combat climate change, reduce air pollution that harms public health, and provide greater certainty about Clean Air Act permitting requirements for the oil and natural gas industry

- Learn More

https://www.epa.gov/controlling-air-pollution-oil-and-natural-gas-industry/actions-and-notices-about-oil-and-natural-gas
https://www.epa.gov/sites/production/files/2017-04/documents/oil_and_gas_fugitive_emissions_monitoring_reconsideration_4_18_2017.pdf