Fracking in Kentucky

Brandon C. Nuttall

Kentucky Geological Survey

UK
UNIVERSITY OF
KENTUCKY

Reporting on Fracking Conference
Berea College, Berea, Kentucky, 6-Nov-2015

WWW.UKY.EDU/KGS

- Water wells & springs
- Earthquakes
- Coal
- Minerals
- Mapping
- Karst

UK UNIVERSITY OF KENTUCKY

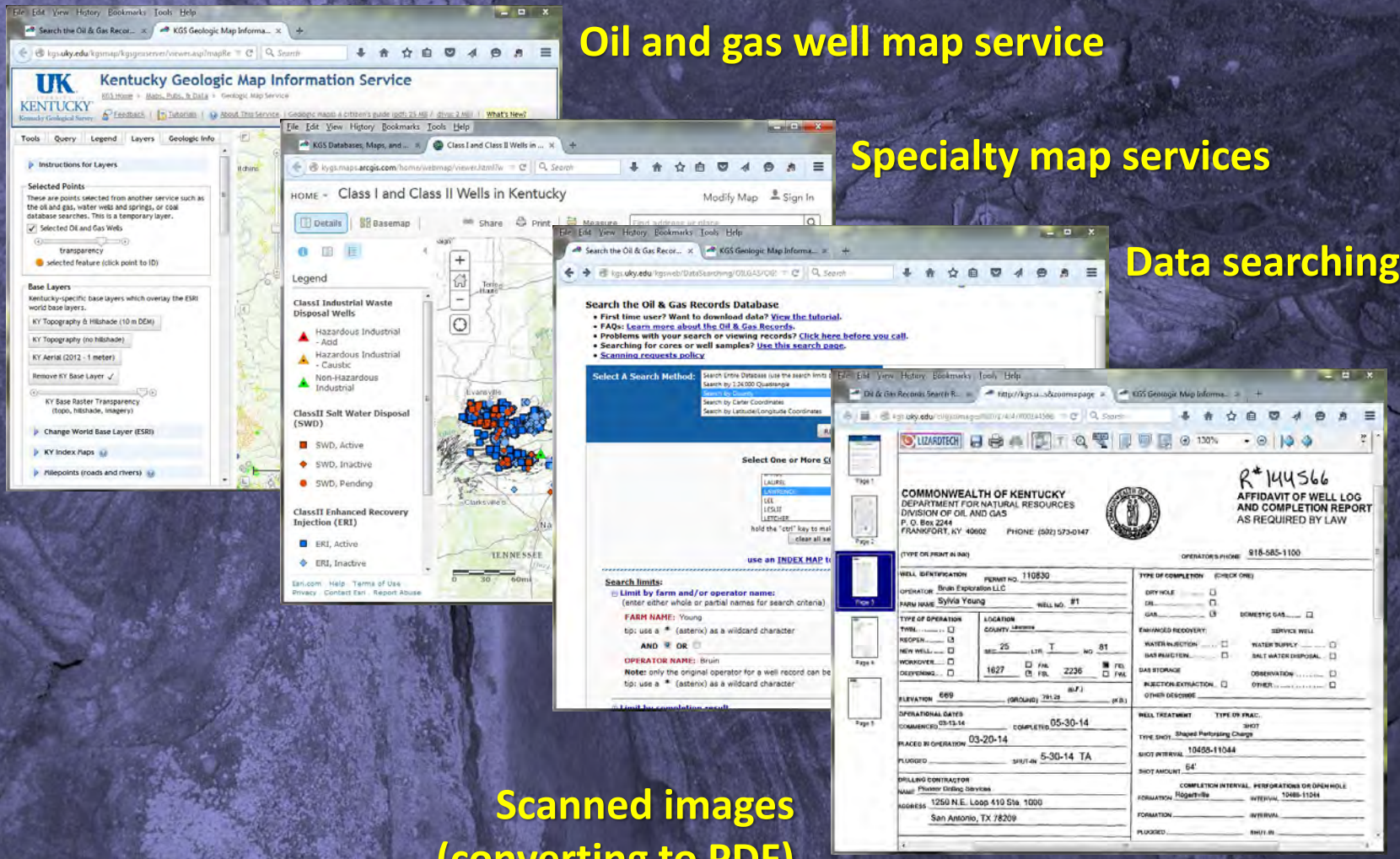
Energy & Minerals

Oil and gas well map service

Specialty map services

Data searching

Scanned images
(converting to PDF)



To Frack or Not to Frac

- Frac – no “k”, industry shorthand for hydraulic fracture stimulation
- But without the k
  - Fraced, fracing rhymes with braced, bracing
- So
  - Fracked and fracking
- But not “frack” – euphemism for an expletive

To ~~Frack or Not to~~ Frac

- **Frac** – no "k", industry shorthand for hydraulic fracture stimulation
- But without the k
  - Fraced, fracing rhymes with braced, bracing
- So
  - **Fracked** and **fracking**
- But not "~~frack~~" – euphemism for an expletive

Plural: "fracks," not fracs or fraces

UK UNIVERSITY OF KENTUCKY

Drilling (not Fracking)

UK
UNIVERSITY OF
KENTUCKY

What is Fracking?

- Inject high–pressure fluids underground
- Induce new fractures
- Connect to existing natural fractures
- Create
  - A larger stimulated reservoir volume
  - Permeable pathways for oil and gas to flow into the well bore

EPA 2015: Fracking in the U.S.

- Water (68% to 99%, median 88%)*
  - <30,000 gal. to >8,000,000 gal.
- Chemicals (2% or less, median 0.43%)
  - Control fluid properties
  - Maintain well integrity
- Sand (2.4% to 24%, median 11%)

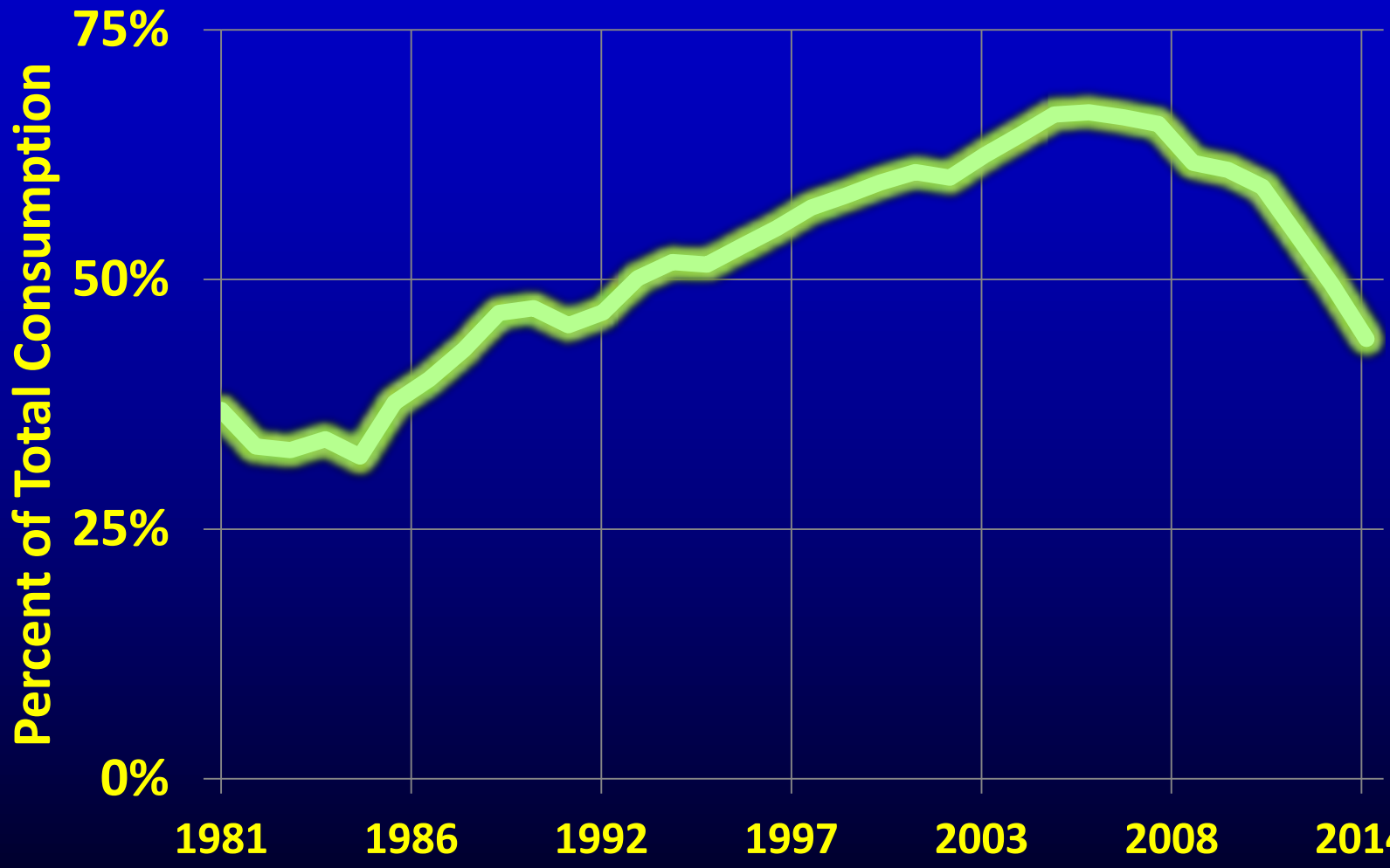
** Composition by mass, data from 2015 EPA analysis of frac fluid data from FracFocus 1.0*

UK UNIVERSITY OF KENTUCKY

Why Frac?

- **Energy security**
  - Imported more than 60% of oil, ≈$1 billion/day
  - "Saudi Arabia of shale" (NG, NGL, oil)
  - Net energy exporter by 2015-2020 (EIA, IEA)
- **Jobs**
- **Reduce CO_2 emissions**

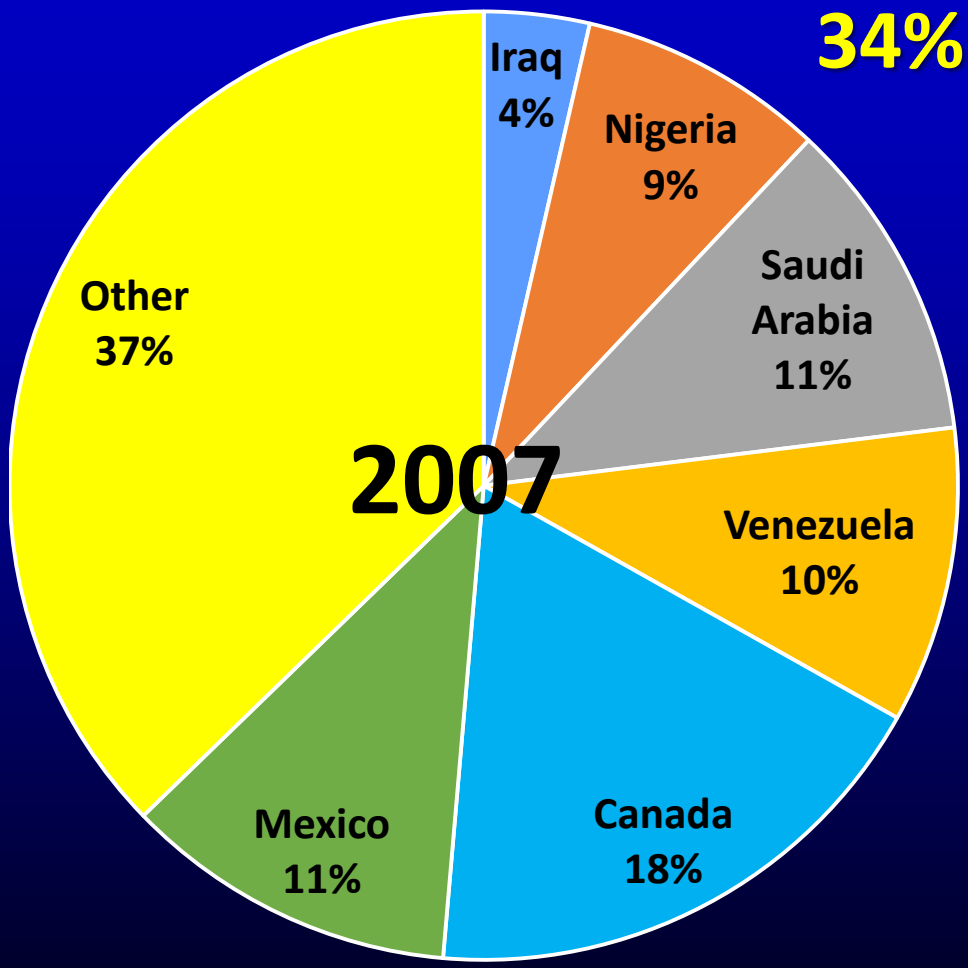
U.S. Crude Oil Imports



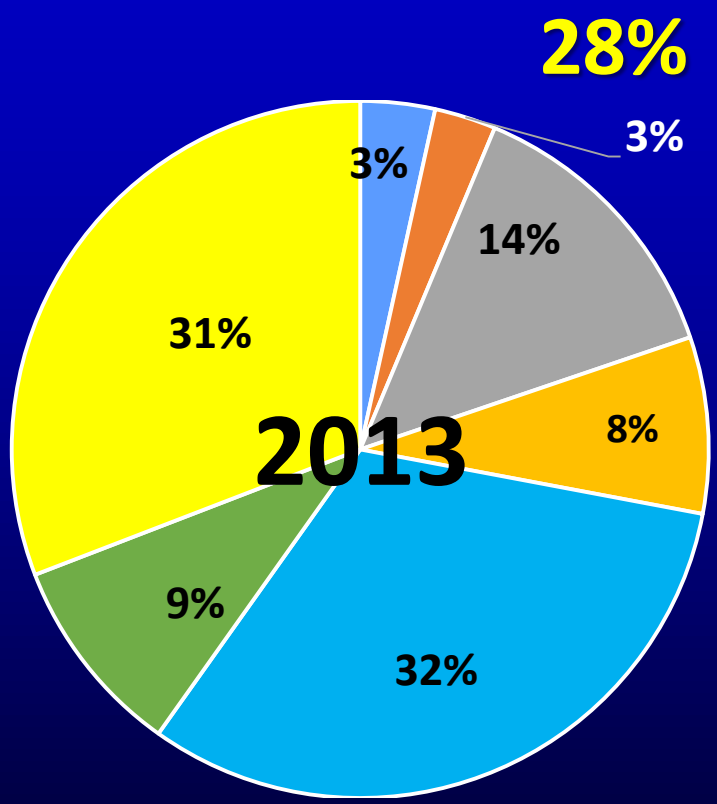
www.eia.gov/dnav/pet/pet_sum_snd_d_nus_mbbl_a_cur.htm

UK UNIVERSITY OF KENTUCKY

Changes in U.S. Crude Imports



4.9 billion barrels

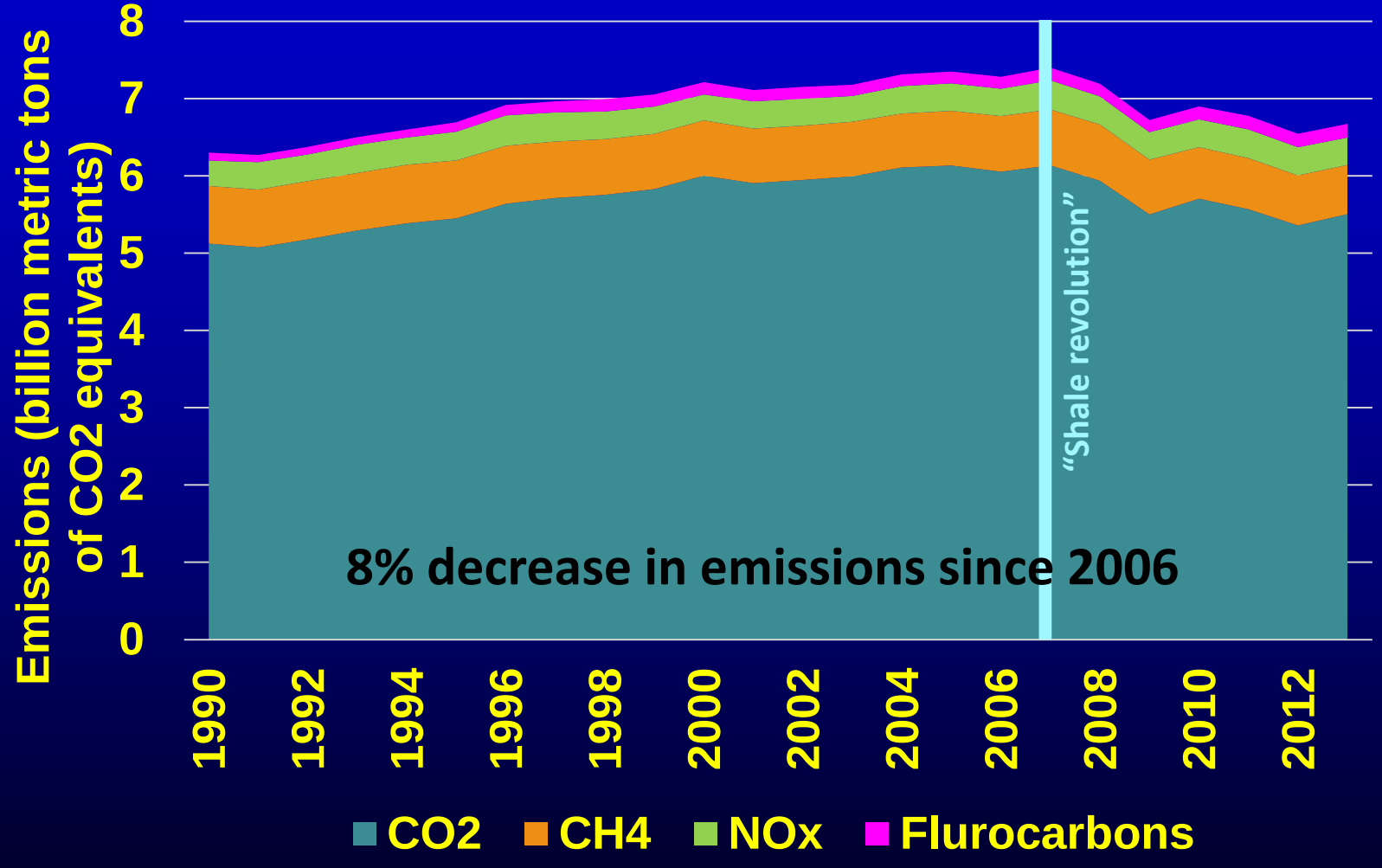


3.6 billion barrels

www.eia.gov

UK UNIVERSITY OF KENTUCKY

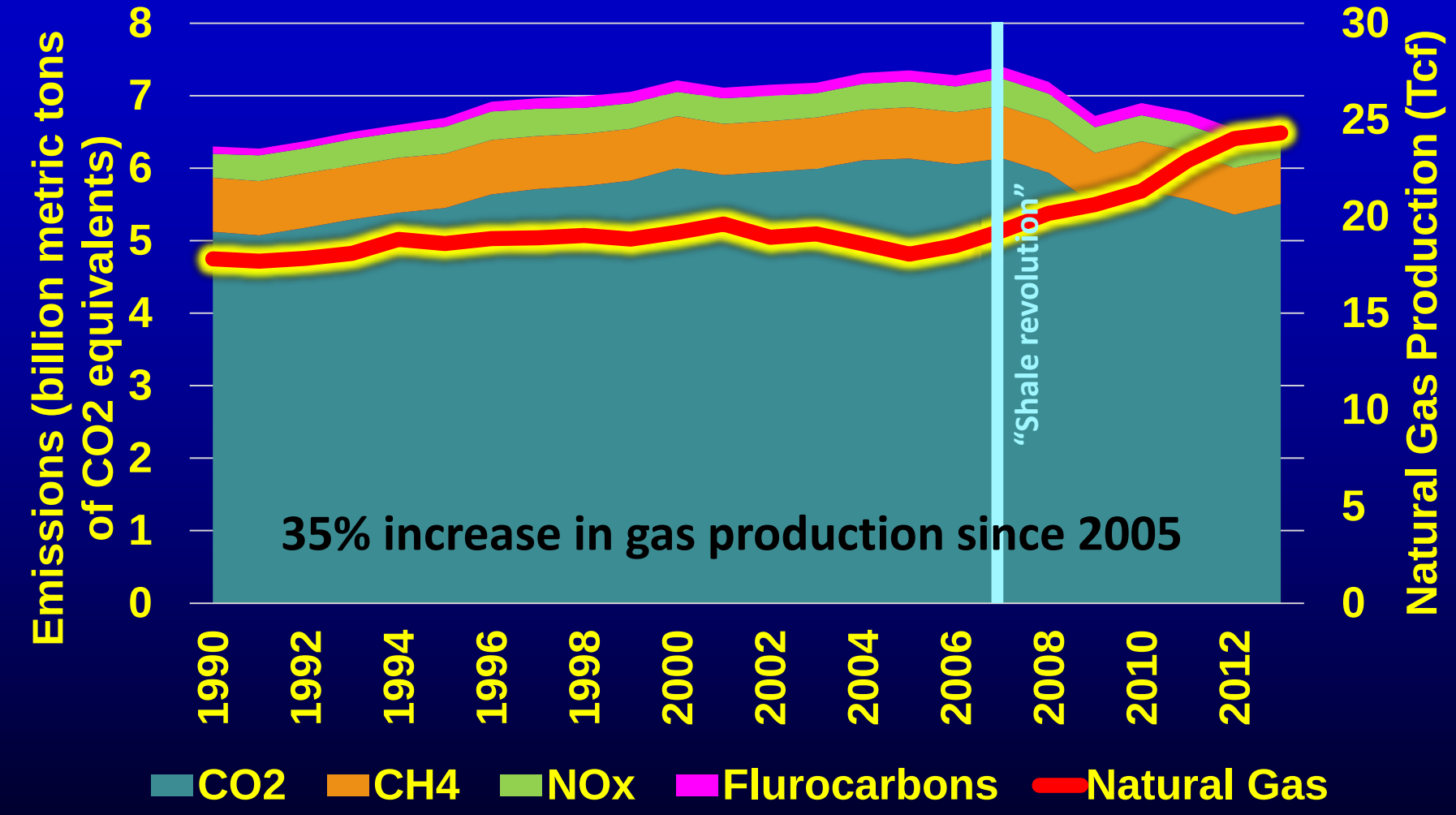
U.S. Greenhouse Gas Emissions



www3.epa.gov/climatechange/science/indicators/ghg/us-ghg-emissions.html

UK UNIVERSITY OF KENTUCKY

U.S. Greenhouse Gas Emissions

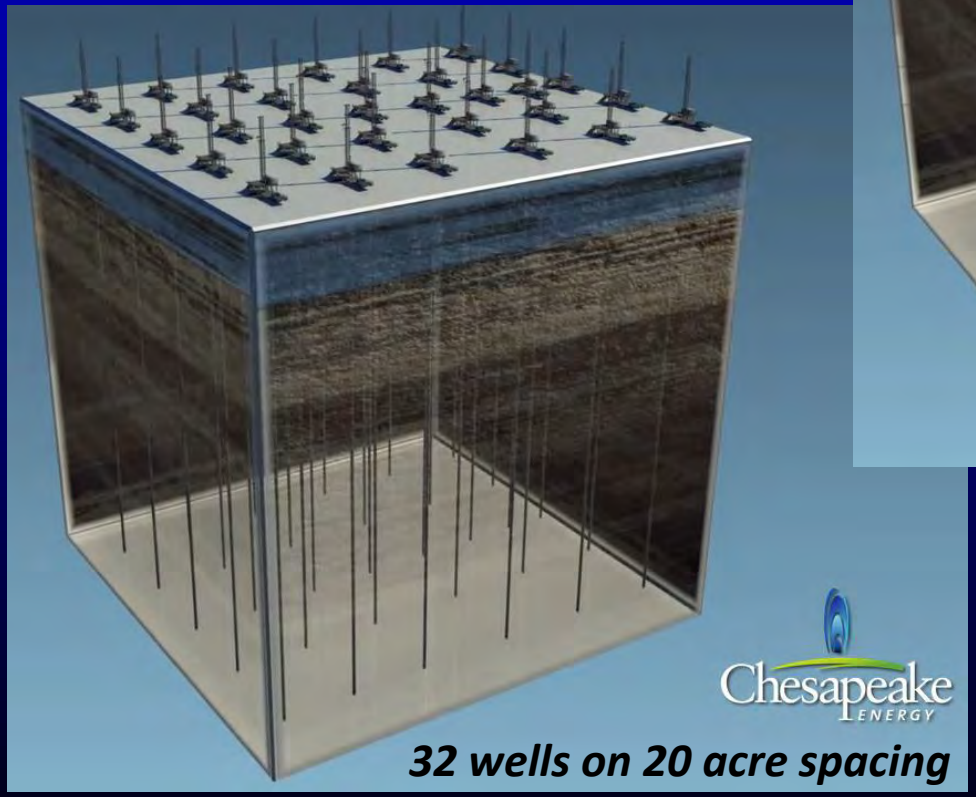


www3.epa.gov/climatechange/science/indicators/ghg/us-ghg-emissions.html
www.eia.gov/dnav/ng/hist/n9070us2a.htm

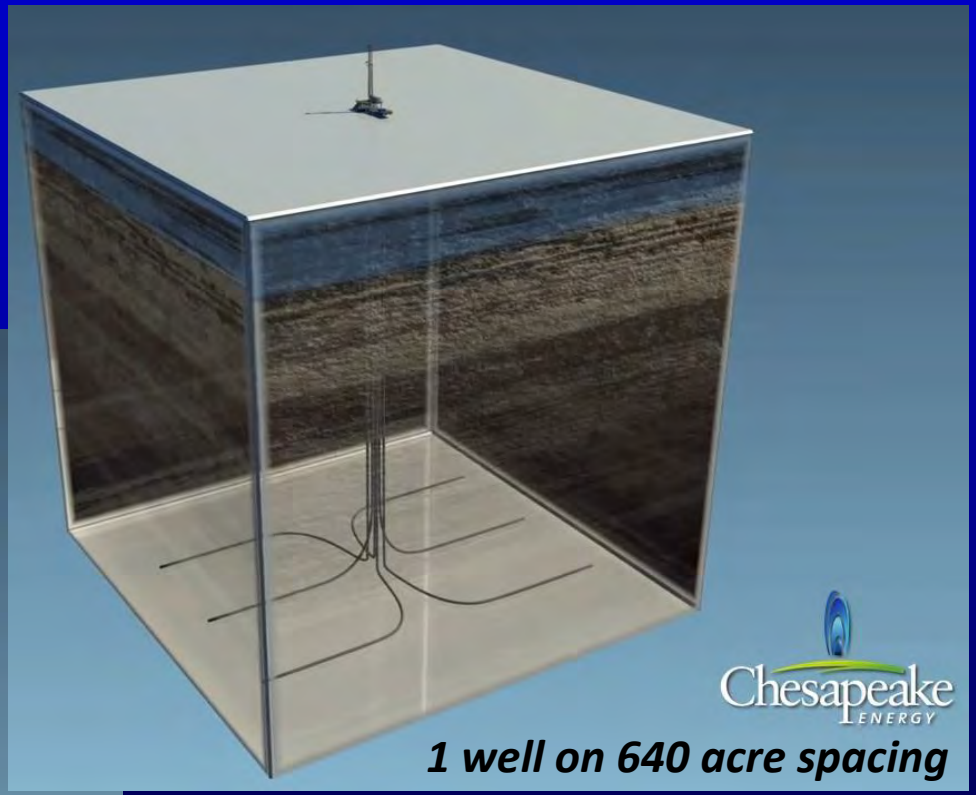
UK UNIVERSITY OF KENTUCKY

Horizontal wells minimize surface impact of drilling.

Many surface locations



32 wells on 20 acre spacing



1 well on 640 acre spacing

Many underground laterals

UK
UNIVERSITY OF
KENTUCKY

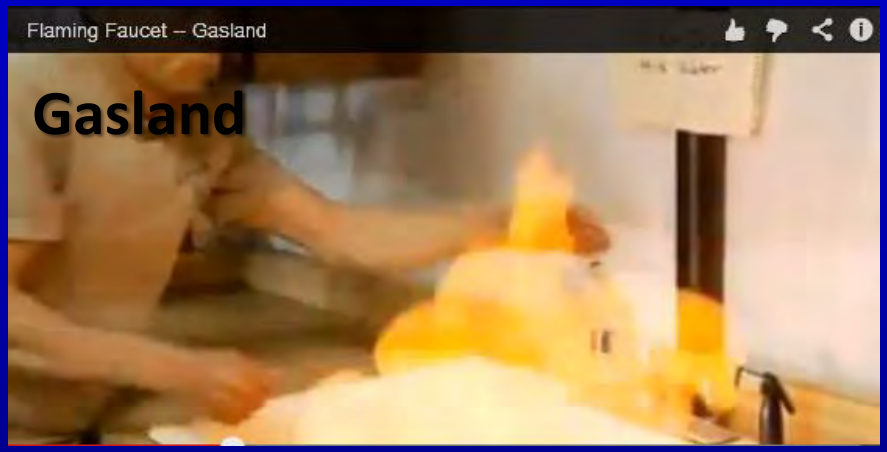
Potential Hazards (not Risks)

- Flaming water
- Secret toxic chemical mix
- Earthquakes
- Poisoned water
- Radon
- STDs
- Traffic accidents
- Noise

Social issues

Call for ban or moratorium "until they do the science."

Burning Tap Water

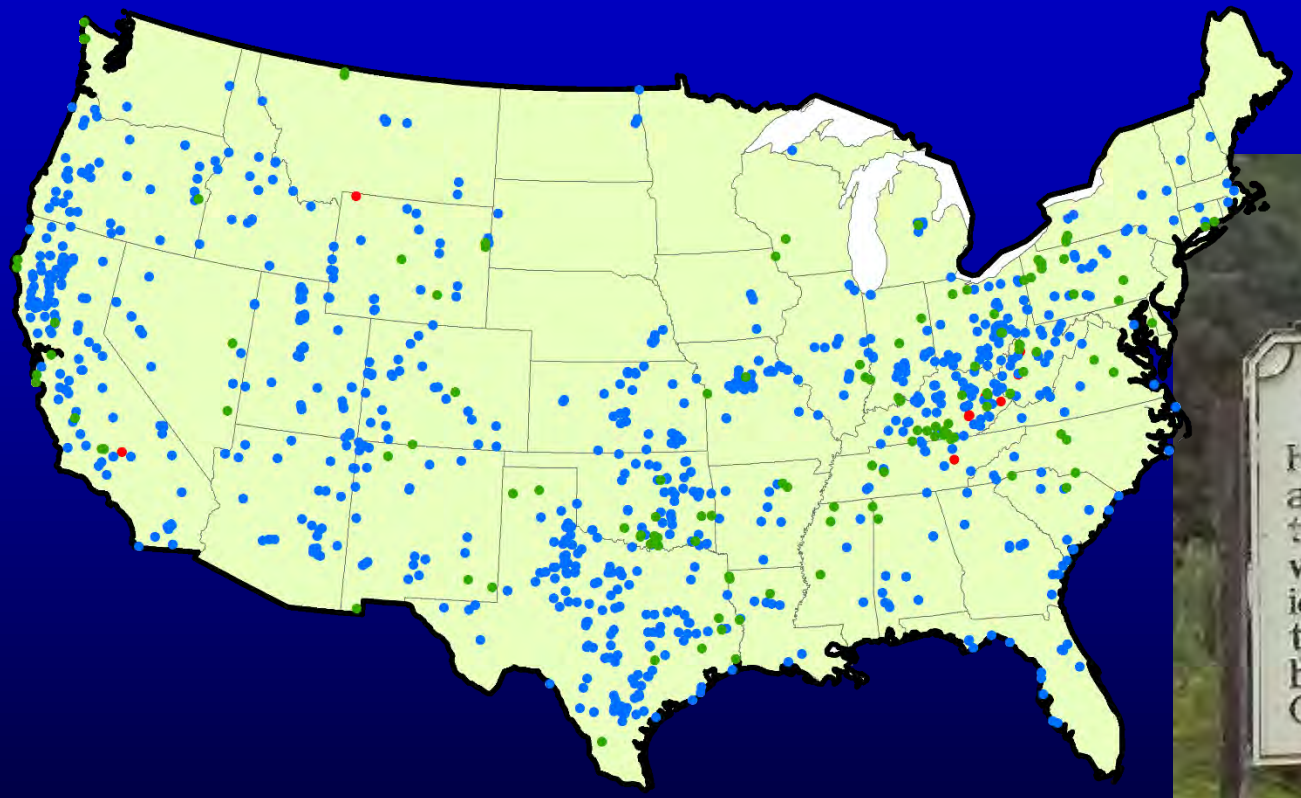


Weld County, CO: Investigated and not due to fracking or shale gas drilling.

Parker Co, TX: Staged, not hooked to a water supply, leaking from shallow natural sources into water

UK UNIVERSITY OF KENTUCKY

Salt, Burning, and Oil Springs



Does not include places like Big Bone Lick, Ky

Does indicate naturally "impaired" groundwater

UK UNIVERSITY OF KENTUCKY

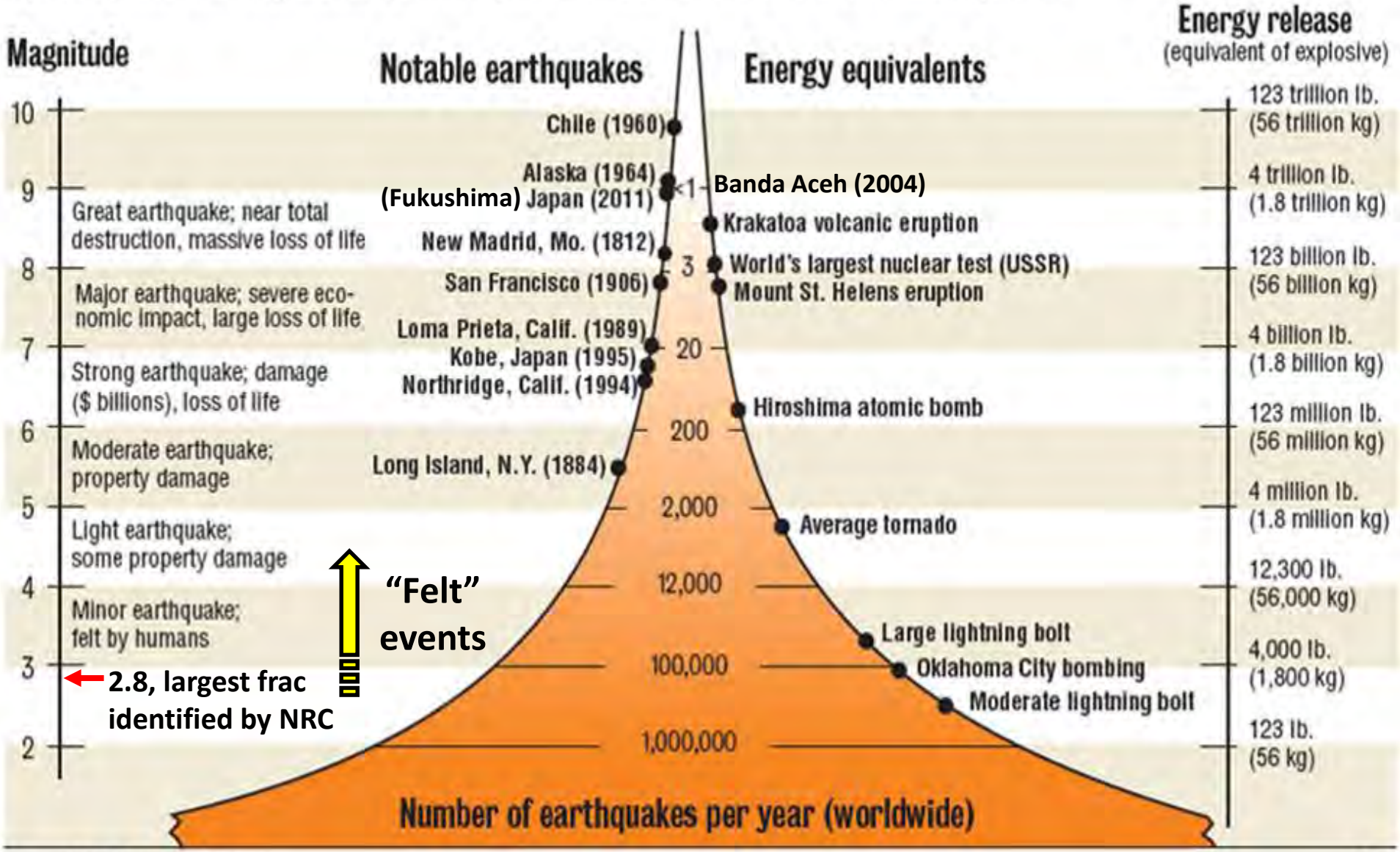
Does Fracking Cause Earthquakes?

Loma Prieta Earthquake, San Francisco Mission District, 1989 (photo by USGS)

Maybe

Earthquake frequency and destructive power

The left side of the chart shows the magnitude of the earthquake and the right side represents the amount of high explosive required to produce the energy released by the earthquake. The middle of the chart shows the relative frequencies.



Source: U.S. Geological Survey

MCT

Factors Needed for Felt Earthquake

- Fault large enough to produce a felt event
- Stress in rocks large enough to produce earthquakes
- Presence of fluid path between injection point and fault
- Fluid pressure changes large enough to induce an earthquake

Adapted from:
Rubinstein & Mahani, 2015, Seismic Research Letters, v. 86, n. 4
IOGCC/GWPC, 2015, Potential Injection-Induced Seismicity Associated with Oil & Gas Development
NSF, 2013, Induced Seismicity Potential in Energy Technologies

UK UNIVERSITY OF KENTUCKY

What the Science Says

"The process of hydraulic fracturing a well as presently implemented for shale gas recovery does not pose a high risk for inducing felt seismic events."

"Injection for disposal of wastewater … into the subsurface does pose some risk." And, "Reducing injection volumes, rates, and pressures has been successful in decreasing rates of felt seismicity."

National Research Council (2013) Induced Seismicity Potential in Energy Technologies, nap.edu

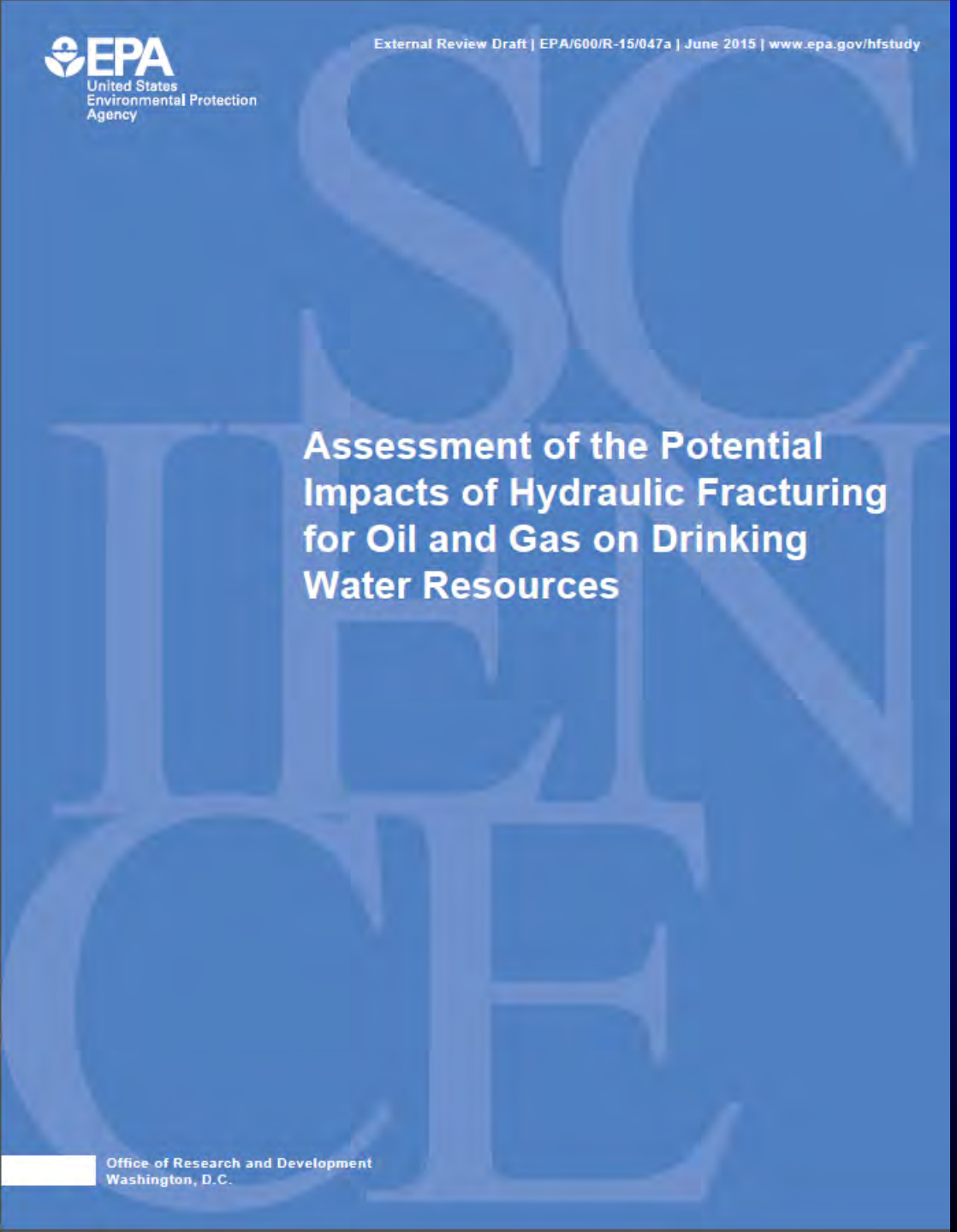
UK UNIVERSITY OF KENTUCKY

IOGCC and GWPC Report

- Understanding induced seismicity
- Assessing potentially injection-induced seismicity
- Risk management and mitigation strategies
- Focus
  - Hazards – what can go wrong
  - Risk – likelihood of consequences to people and property
  - State-level regulation

iogcc.publishpath.com/Websites/iogcc/images/2015OKC/ISWG_Primer_Final-Web.pdf

UK UNIVERSITY OF KENTUCKY



U.S. EPA Review Draft

- 5-year study
- 998 pages

www.epa.gov/hfstudy

UK
UNIVERSITY OF
KENTUCKY

The EPA Followed the Water

- Withdrawal
- Mixing of water, chemicals, proppant
- Injection of fracturing fluids
- Management of flowback and produced water
- Reuse, treatment and discharge, or disposal of wastewater

EPA Identified Potential Pathways

- Water withdrawal (supply)
- Spills
  - Hydraulic fracturing fluids
  - Produced water
- Fracturing directly into USDW
- Below ground migration of fluids and gas
- Inadequate treatment and discharge of wastewater

U.S. EPA External Review Draft EPA/600/R-15/047a, June 2015

UK UNIVERSITY OF KENTUCKY

EPA Finding

"We did not find evidence that these mechanisms have led to widespread, systemic impacts on drinking water resources in the United States. … [W]e found specific instances where one or more mechanisms led to impacts on drinking water resources, including contamination of drinking water wells. The number of identified cases, however, was small compared to the number of hydraulically fractured wells."

U.S. EPA says: "DRAFT—DO NOT CITE OR QUOTE" at bottom of every page.

UK UNIVERSITY OF KENTUCKY


How is water protected?

A well is constructed using nested pipe, "casing", that is cemented into place.

Soil

Relative widths exaggerated

USDW

Typical Well Construction (not to scale)

1,000s of ft.

Reservoir

UK UNIVERSITY OF KENTUCKY

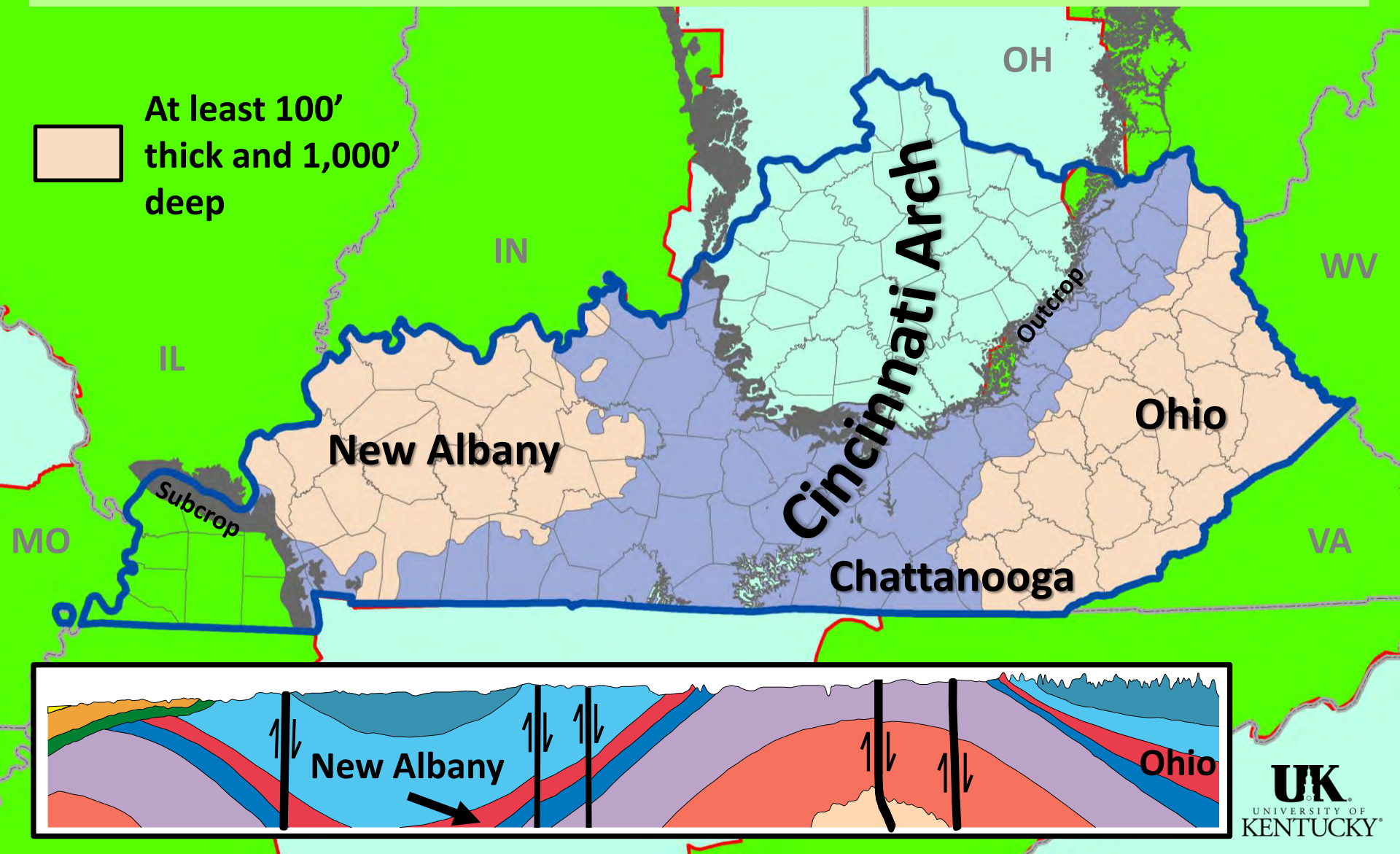
Spill Prevention Control and Counter Measures (SPCC)

www.epa.gov/osweroe1/content/spcc/index.htm

UK UNIVERSITY OF KENTUCKY

What's happening in Kentucky?

At least 100' thick and 1,000' deep



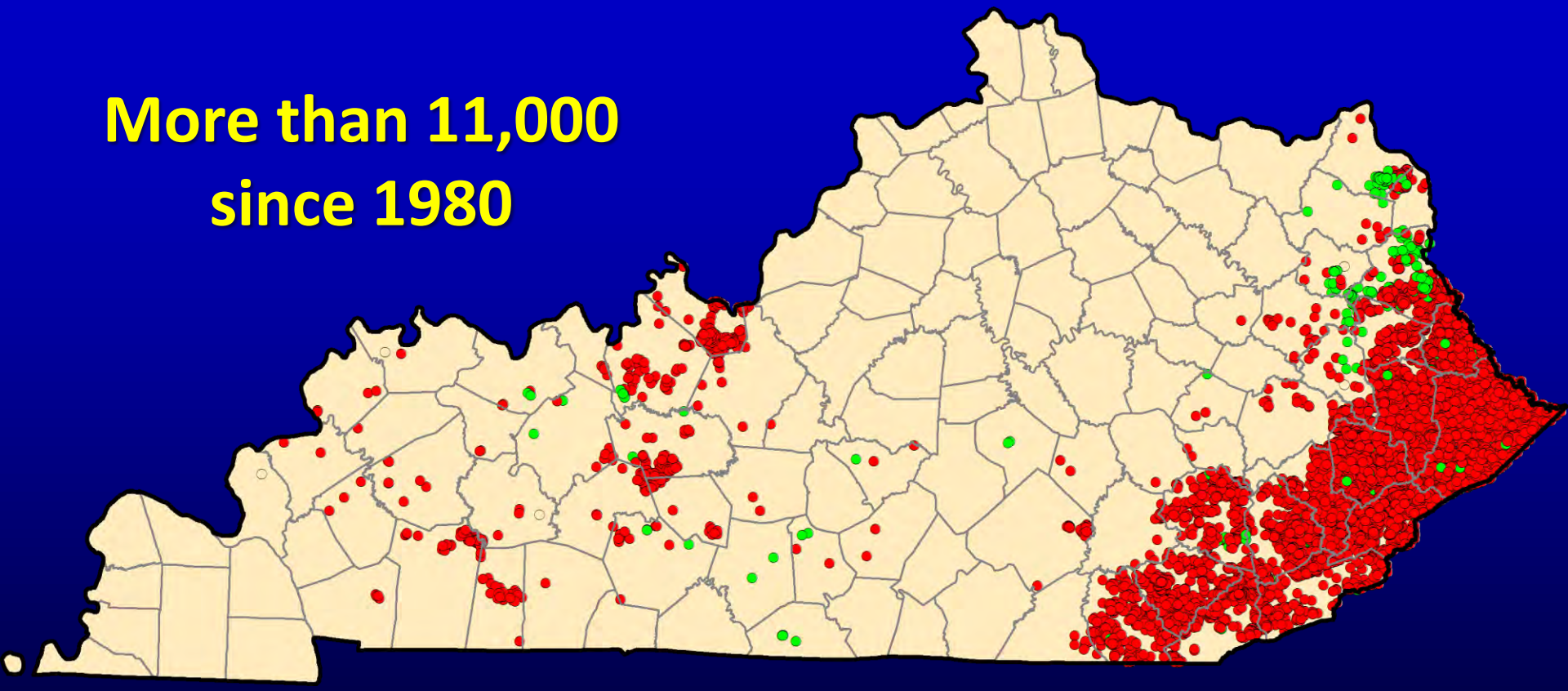
UK UNIVERSITY OF KENTUCKY

History of Fracture Stimulation in Kentucky

- 1806: Explosives to improve water wells
- 1888: 1st Kentucky oil well to be "shot"
- 1950s: Hydraulic fracturing
  - 1946: 1st in U.S. (Kansas)
- 1972: Nitrogen (and foam) frac
- Shale gas wells in Kentucky are nitrogen fracks
- Hydraulic fracks
  - Berea (Lawrence and Greenup Counties)
  - New Albany shale (Breckinridge County)
  - Rogersville (HVHF)

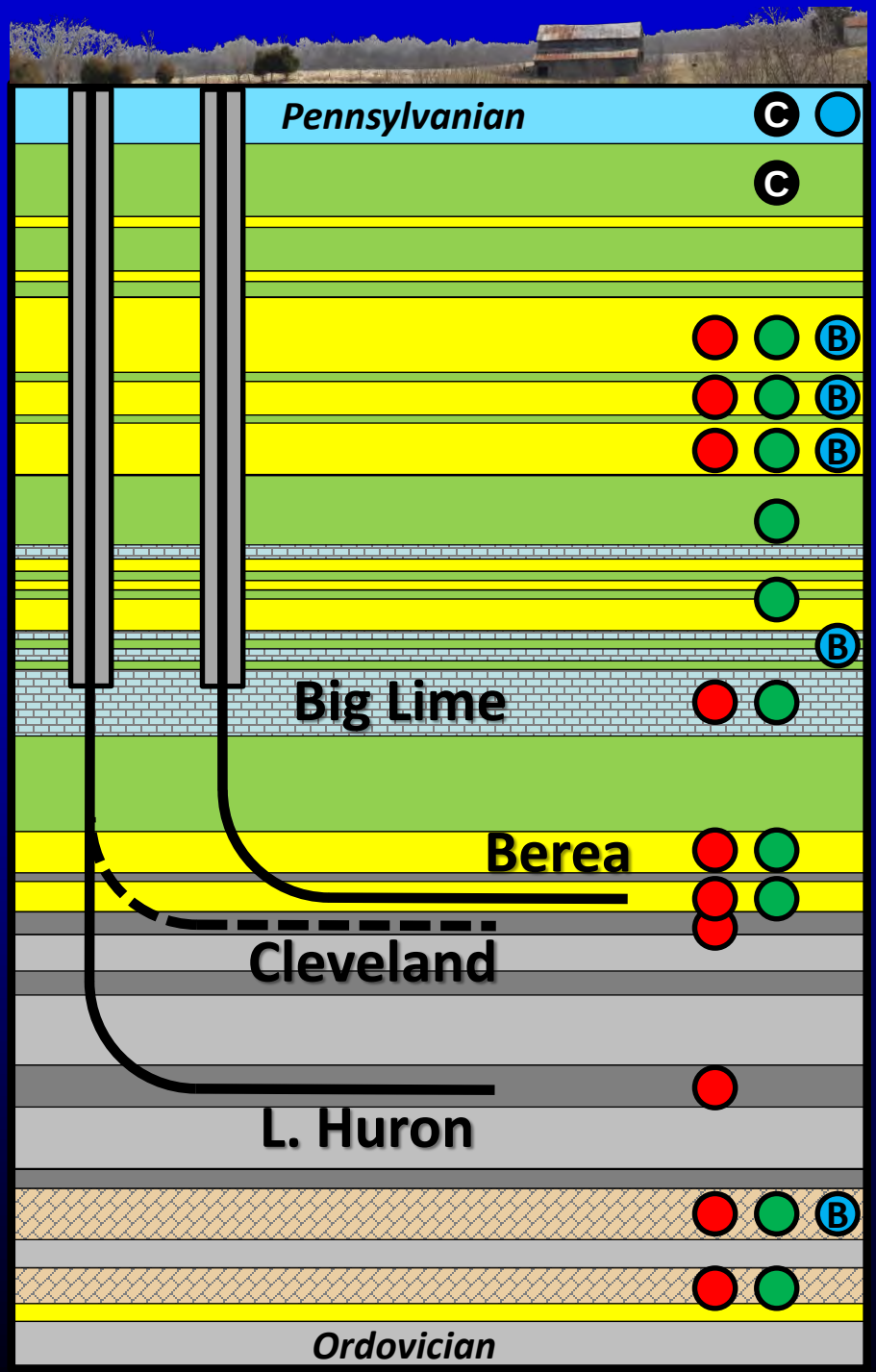
Fracked Wells in Kentucky

More than 11,000 since 1980



UK UNIVERSITY OF KENTUCKY

Typical Completions



Lawrence & Greenup
1,200 ft to 1,800 ft

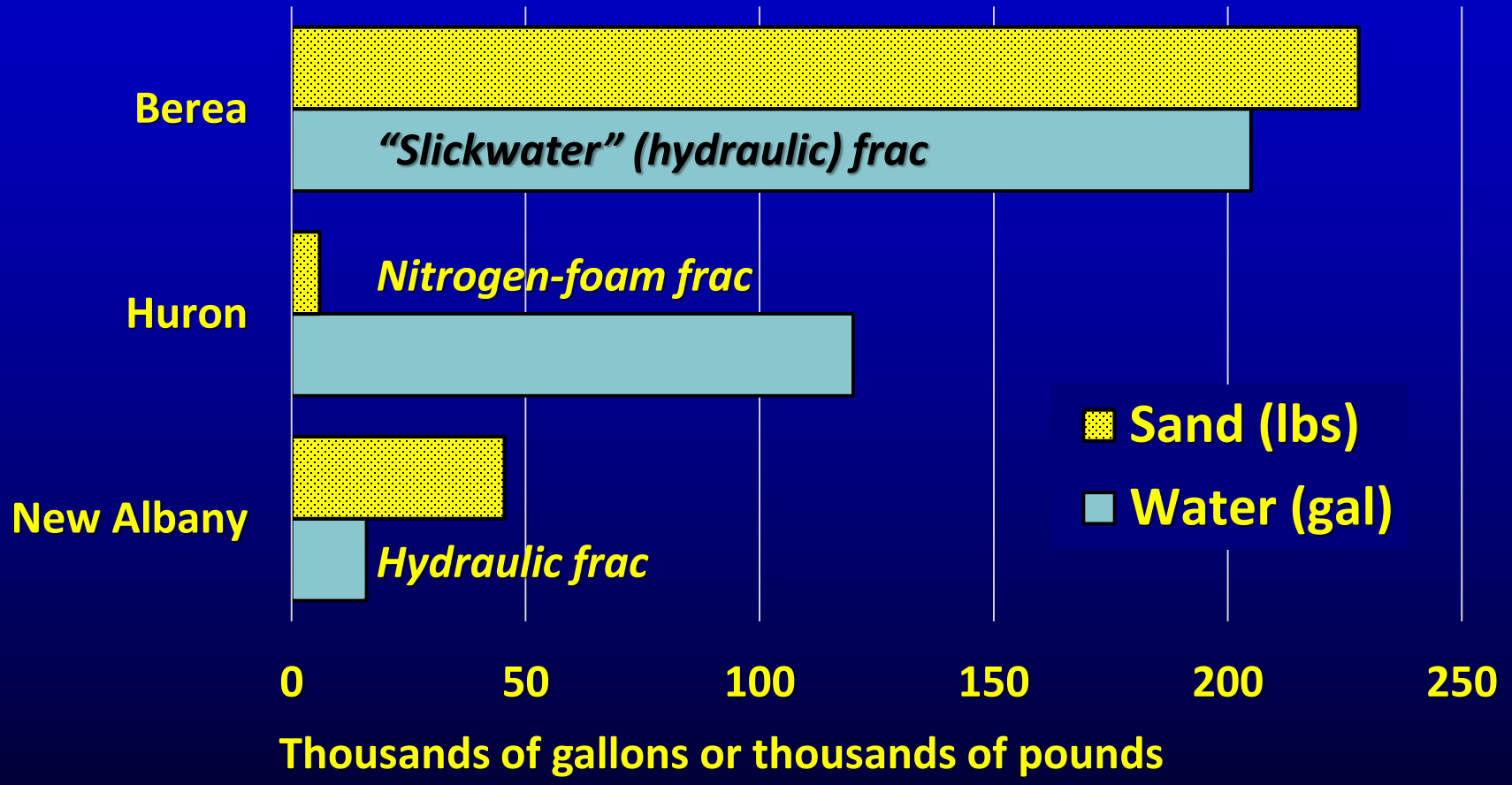
East Kentucky
2,000 ft to 5,000 ft

- C Coal
- Water
- Oil
- Gas
- B Brine

Depth and thickness varies across Kentucky

UK UNIVERSITY OF KENTUCKY

Water Use in Kentucky Fracks



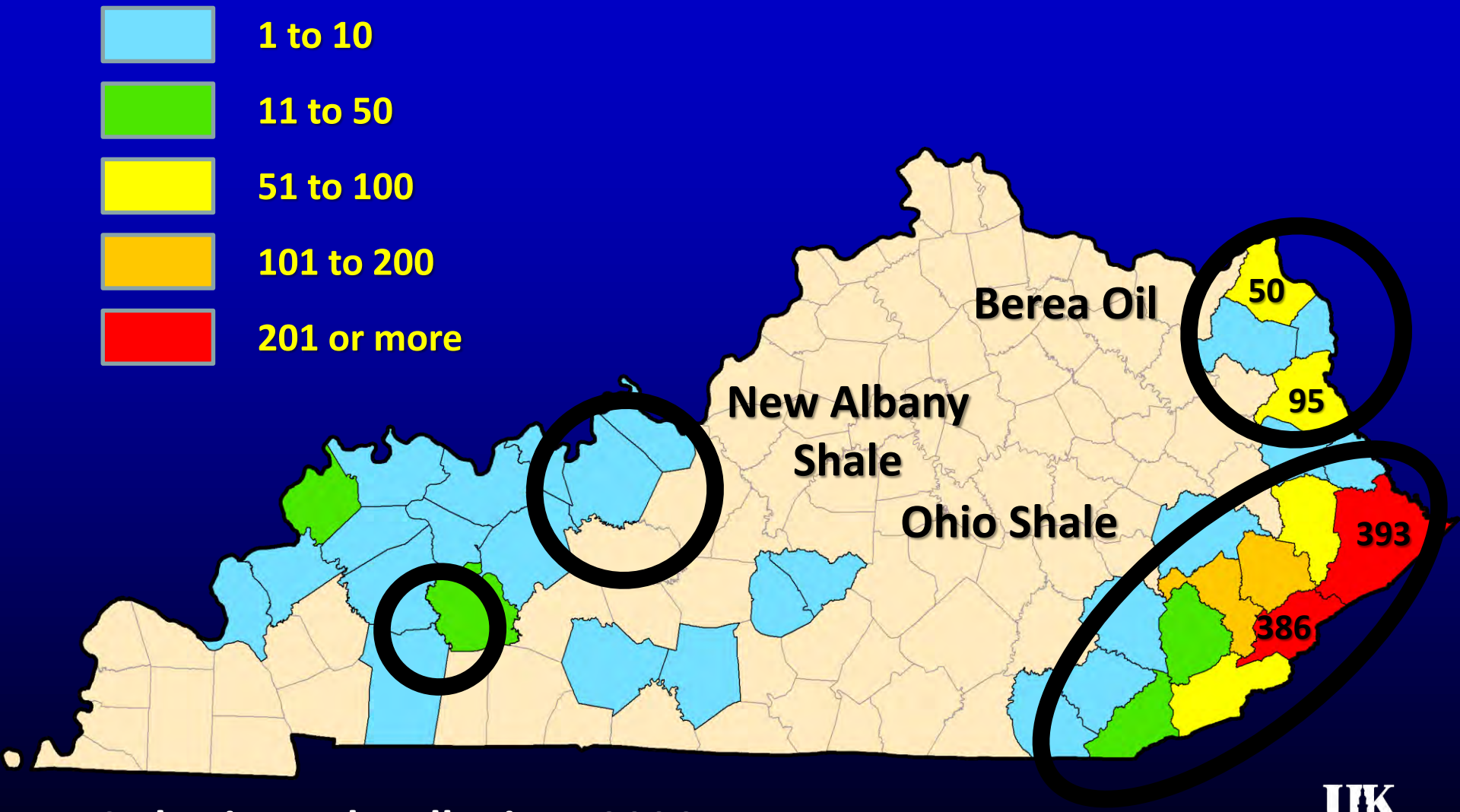
UK
UNIVERSITY OF KENTUCKY

Nitrogen Frac, Eastern KY

Courtesy Brint Camp, NGAS

UK
UNIVERSITY OF
KENTUCKY

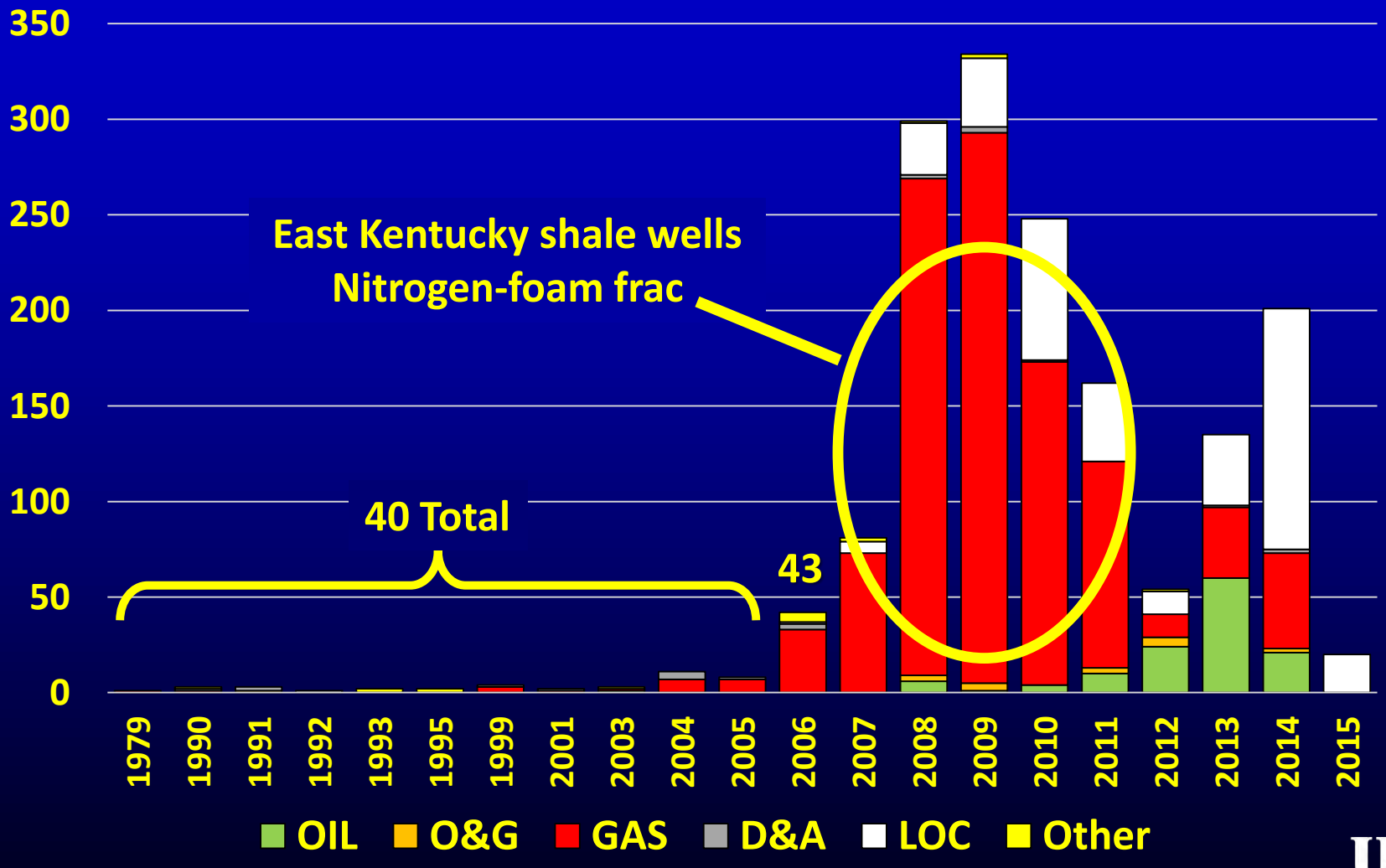
Horizontal Wells since 2006



1,464 horizontal wells since 2006

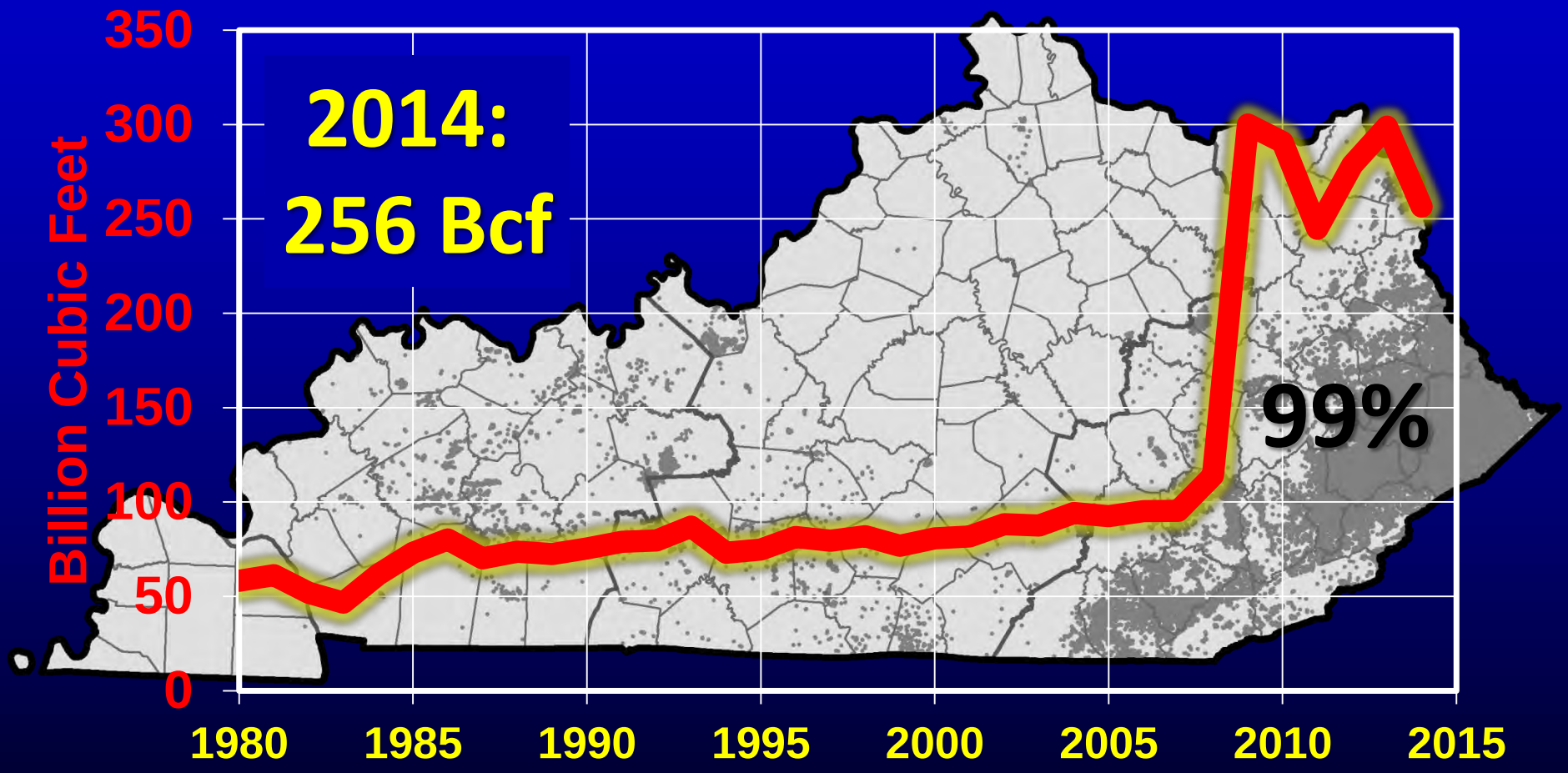
UK UNIVERSITY OF KENTUCKY

Horizontal Wells By Year



UK UNIVERSITY OF KENTUCKY

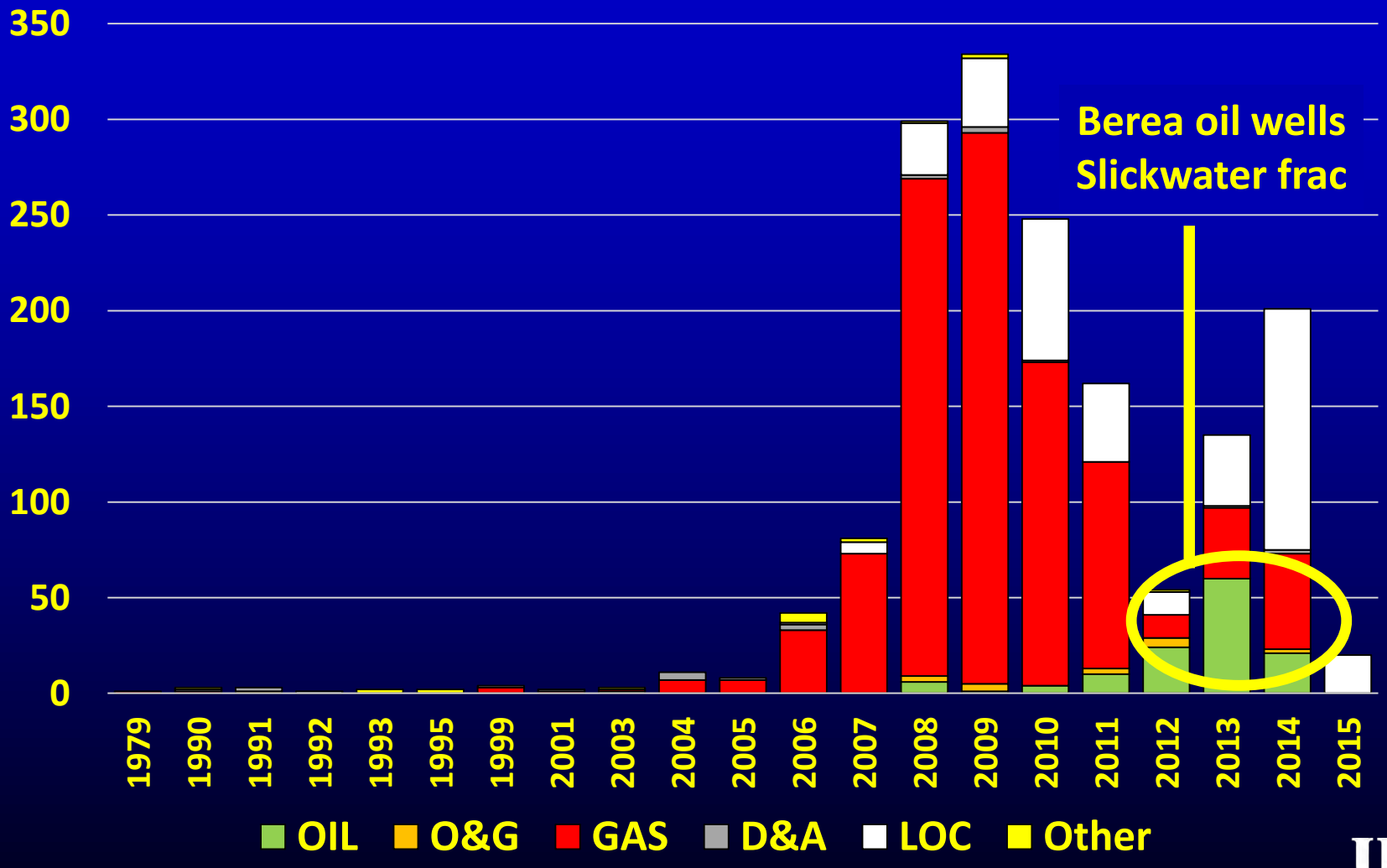
Kentucky Natural Gas Production



34 Kentucky counties

UK UNIVERSITY OF KENTUCKY

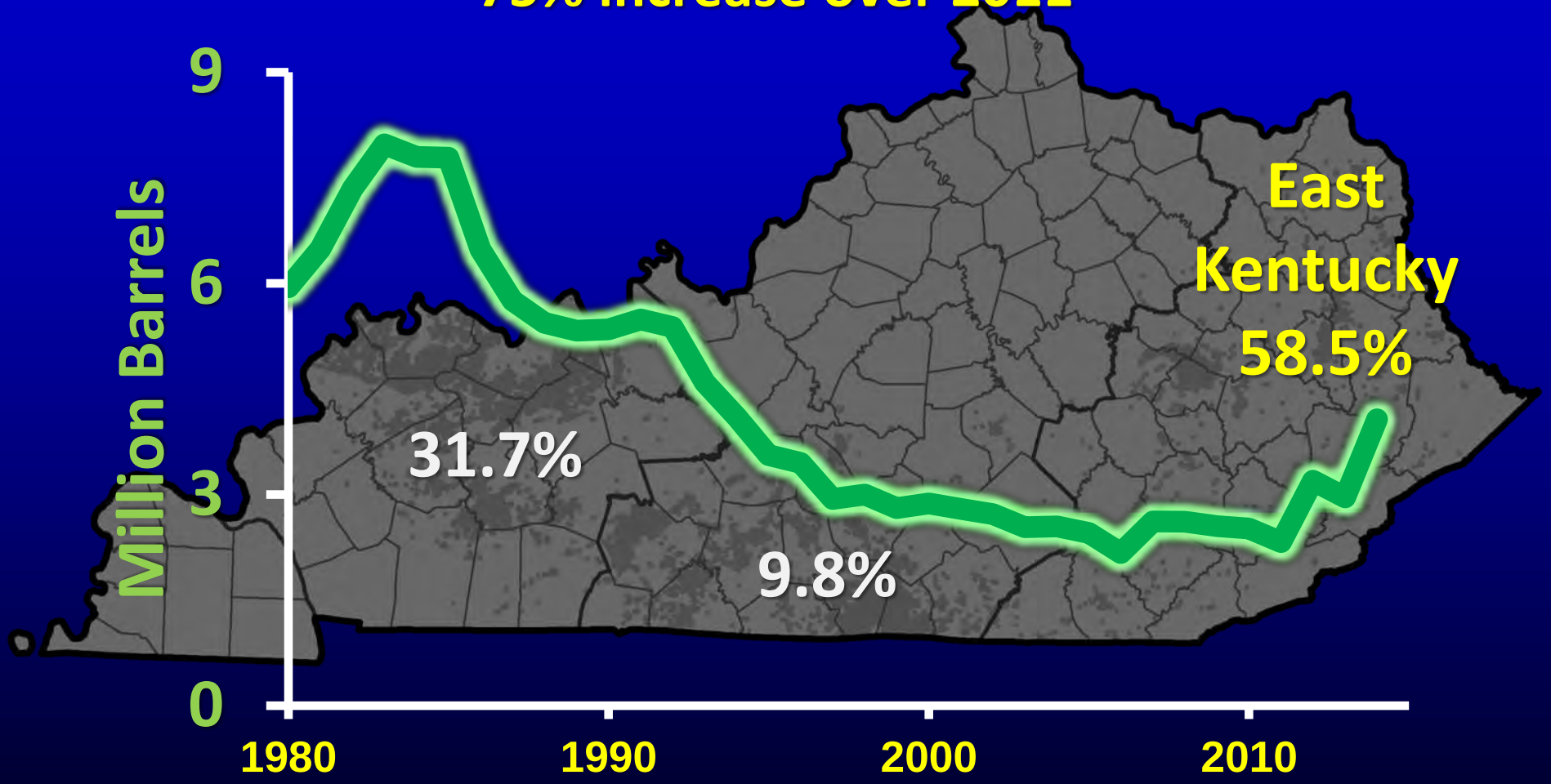
Horizontal Wells By Year



UK UNIVERSITY OF KENTUCKY

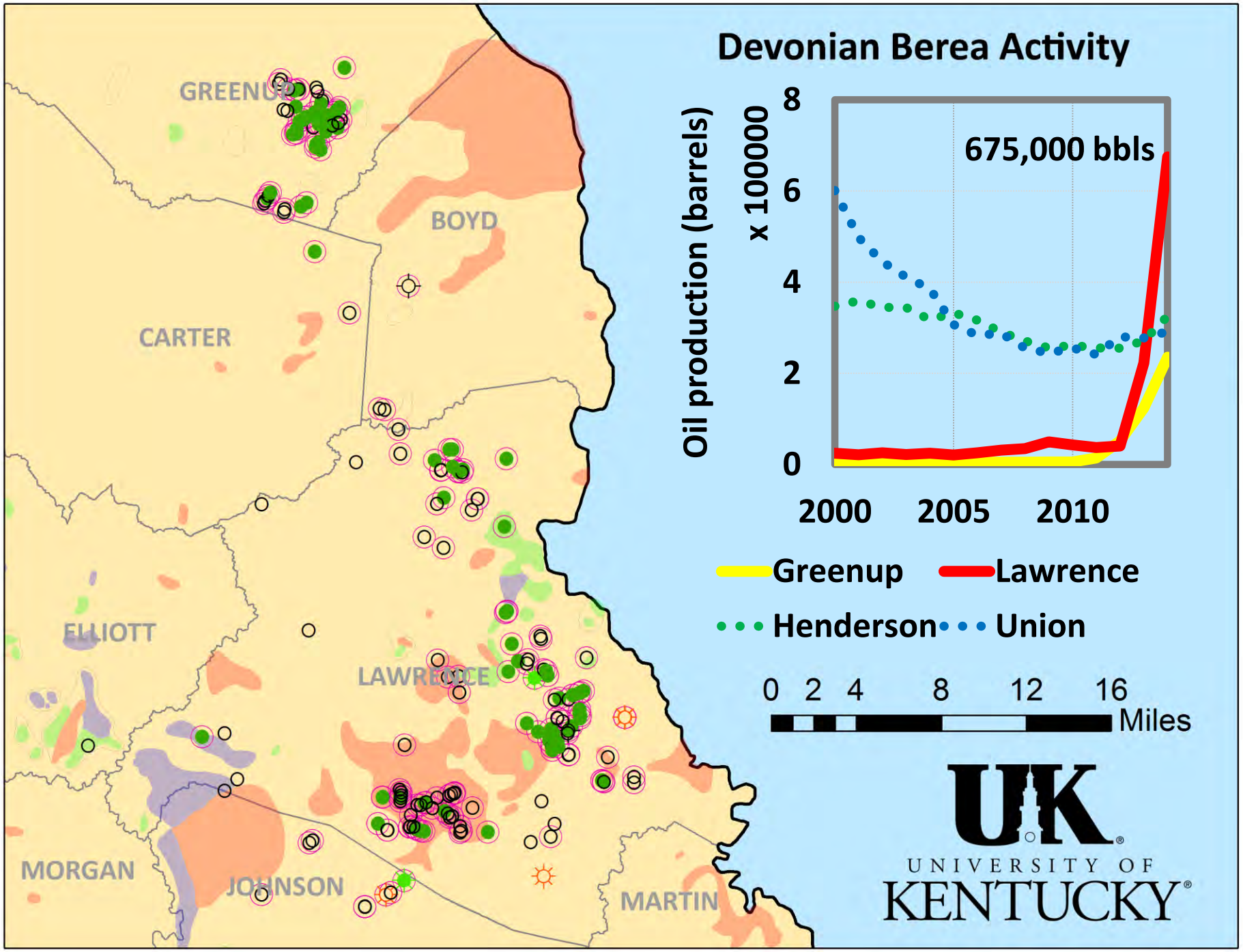
2014 Oil Production: 4.1 MMbo

75% increase over 2011

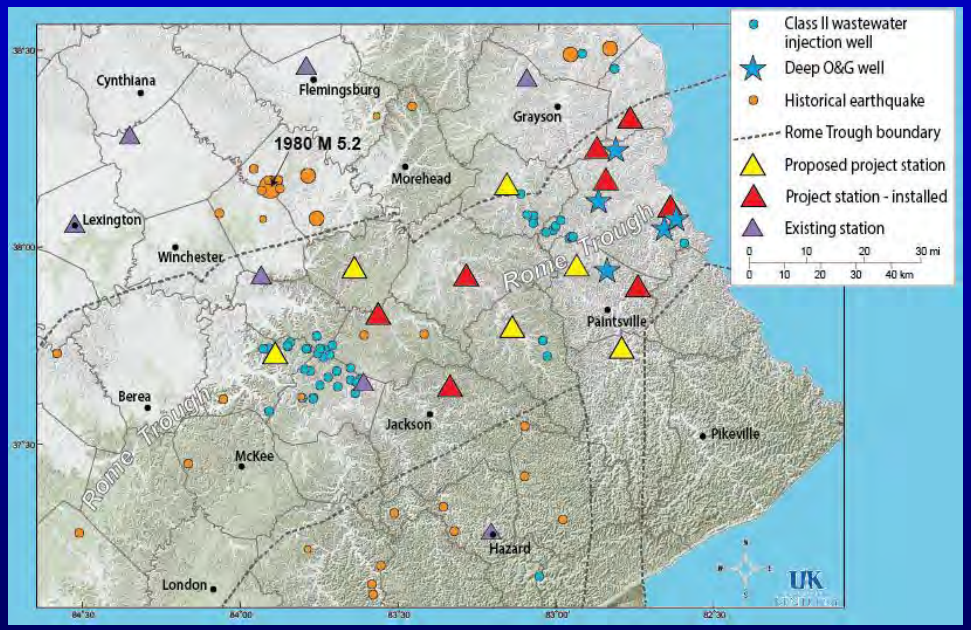


63 Kentucky counties

UK UNIVERSITY OF KENTUCKY


Devonian Berea Activity
Oil production (barrels)
x 100000
8
6
4
2
0
675,000 bbls
2000
2005
2010
Greenup
Lawrence
Henderson
Union
0 2 4 8 12 16
Miles
GREENUP
BOYD
CARTER
ELLIOTT
LAWRENCE
MORGAN
JOHNSON
MARTIN
UK
UNIVERSITY OF
KENTUCKY

East Kentucky Microseismic Monitoring Project

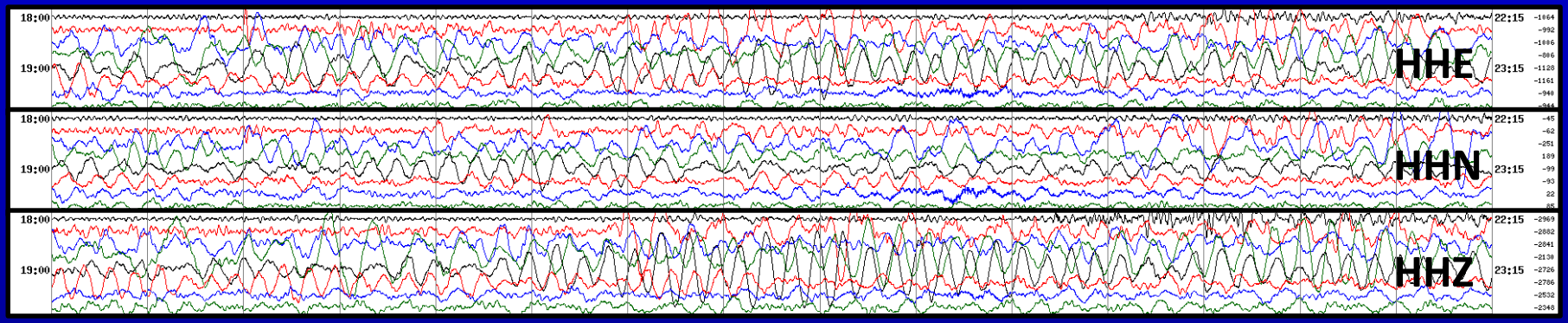


- What type of events can be detected?
- What is the frequency of natural microseismic events?

Real-time events:
www.uky.edu/KGS/geologichazards/equake_eky.htm

UK UNIVERSITY OF KENTUCKY

Microseismic Monitoring Network



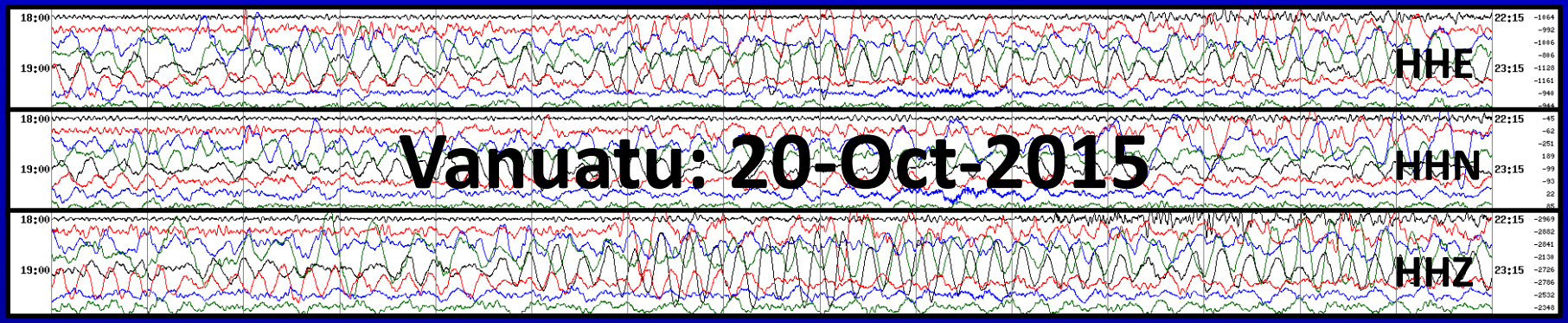
Separate records are recorded for each axis of motion

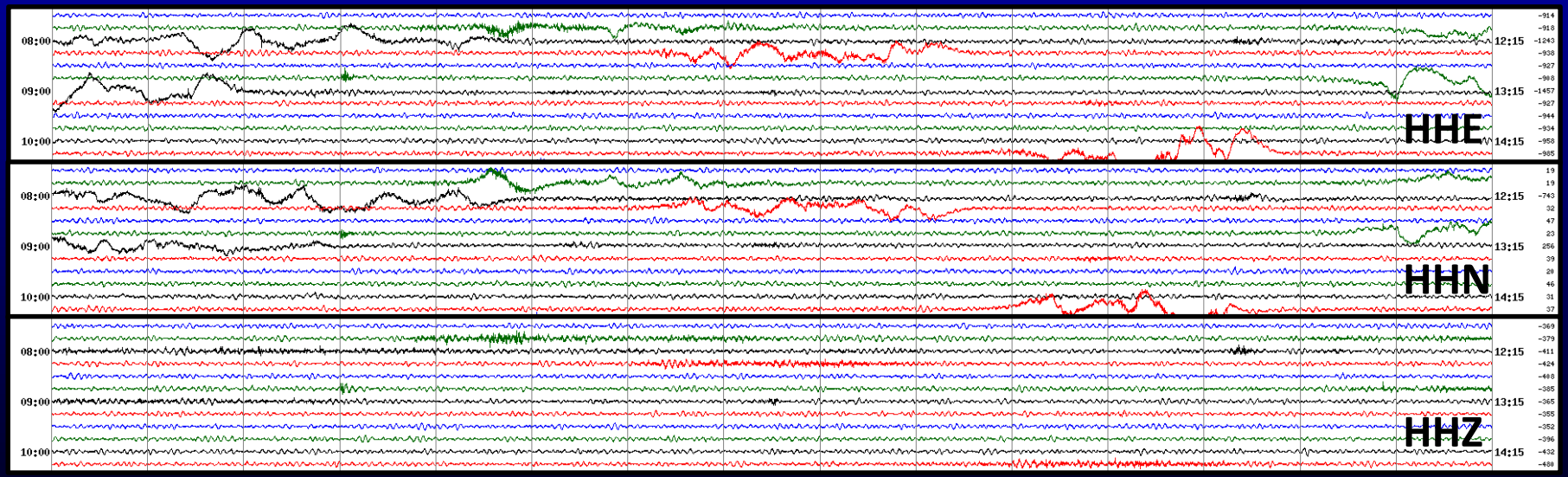
Vanuatu M 7.1 event recorded 20-Oct by instrument EK13 in Lawrence County.

Raw data recordings are being analyzed

UK UNIVERSITY OF KENTUCKY

EK13 HVHF Record: 21-Oct-2015

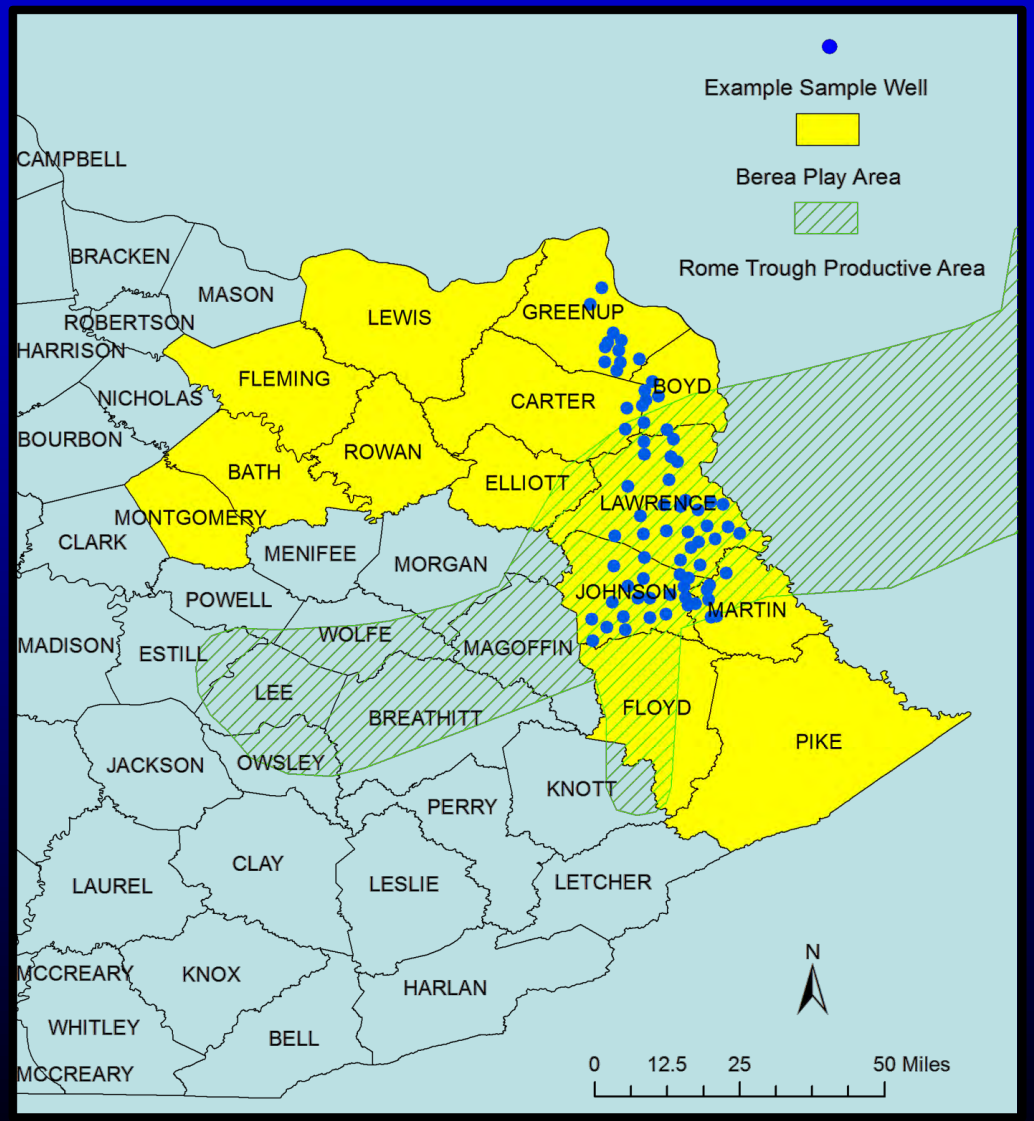




Raw data recordings are being analyzed

UK UNIVERSITY OF KENTUCKY

Baseline Groundwater Geochemistry



- Berea & Rogersville
- 50 candidate well sites
- Water quality data
- Isotopes of dissolved methane (origin)
- Continuous monitoring of selected sites

UK UNIVERSITY OF KENTUCKY

Energy and Environment Cabinet
Department for Natural Resources

Home | Agencies | Online Services | Resources | Programs | Open Records | About Us

Division of Oil and Gas

eec.ky.gov | Search

oilandgas.ky.gov
KRS 353
805 KAR 1:020-200

Division of Oil and Gas

The mission of the Division of Oil and Gas is to regulate the crude oil and natural gas industry in the Commonwealth; protect the correlative rights of mineral owners, fresh water zones and minable coal seams; and conserve and protect oil and gas reserves in Kentucky.

The Division of Oil and Gas maintains a well history database for each well containing data relative to the permit, operator, well location, pertinent dates and well completion. Currently, there are 136,286 wells stored online. This information is shared with the Kentucky Geological Survey (KGS) to assist in the compilation of oil and gas data.

DIVISION OF OIL & GAS

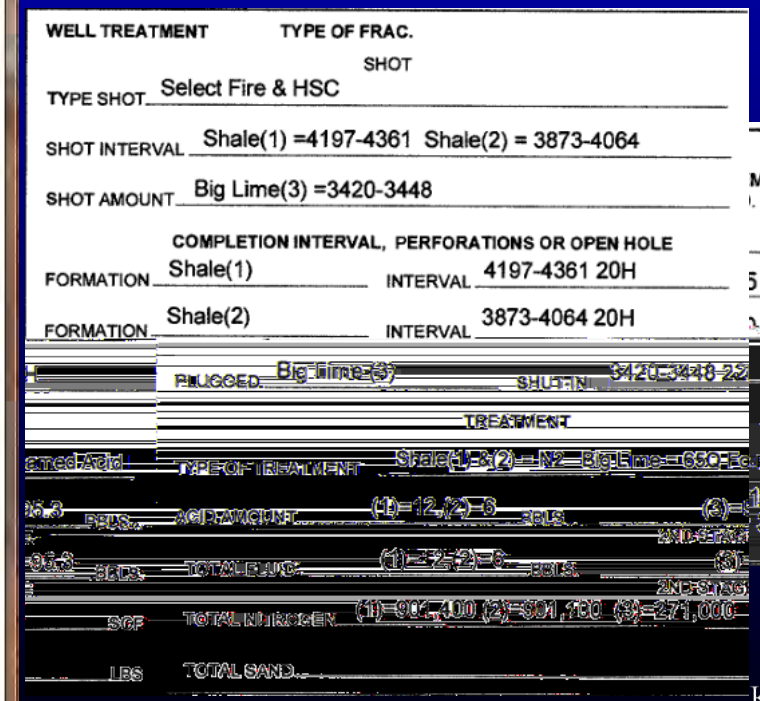
Quick Links

- Kentucky Geological Survey

Public records

Scanned documents are available for browsing, printing, or downloading.

Completion and stimulation



WELL TREATMENT TYPE OF FRAC.
SHOT
TYPE SHOT Select Fire & HSC
SHOT INTERVAL Shale(1) =4197-4361 Shale(2) = 3873-4064
SHOT AMOUNT Big Lime(3) =3420-3448
COMPLETION INTERVAL, PERFORATIONS OR OPEN HOLE
FORMATION Shale(1) INTERVAL 4197-4361 20H
FORMATION Shale(2) INTERVAL 3873-4064 20H
PLUGGED Big Lime(3) SHUT-IN 3420-3448 22H
TREATMENT
TYPE OF TREATMENT Shale(1) &(2) = N2 Big Lime = 65Q Foamed Acid
ACID AMOUNT (1)=12,(2)=6 BBLS (3)=95.3 BBLS 2ND STAGE
TOTAL FLUID (1)=12,(2)=6 BBLS (3)=95.3 BBLS 2ND STAGE
TOTAL NITROGEN (1)=901,400 (2)=901,100 (3)=271,000 SCF
TOTAL SAND LBS

Summary

- Fracking
  - Used for decades
  - Unlikely to cause felt earthquakes
  - No systematic, widespread impact on drinking water
  - Horizontal wells
    - Ohio Shale (natural gas)
    - Berea Sand (oil)
    - Rogersville (?)
- HVHF regulations (KRS 353)
  - Notification
  - Water testing
  - Mandatory disclosure
  - Reclamation

UK UNIVERSITY OF KENTUCKY

Take Aways

- Fracking is a hazardous industrial activity
  - Risk of affecting people or property is small
  - Energy benefits are large
- Oil and gas development and fracking are regulated
- Kentucky has updated KRS 353 to address HVHF issues
  - Regulatory review and modernization continue

UK UNIVERSITY OF KENTUCKY

Thank you

- bnuttall@uky.edu
- (859) 323-0544
- www.uky.edu/KGS

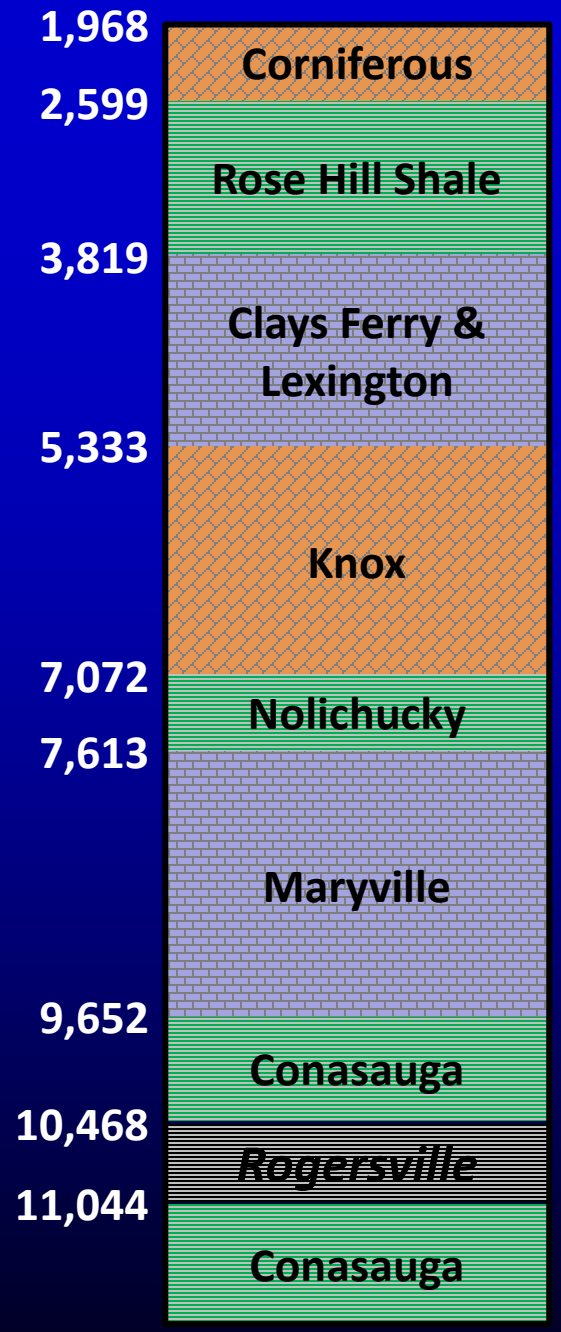
Scan these tags with your smart phone

Rogersville Activity

COUNTY	WELL	TYPE	STATUS
Lawrence (KY)	Bruin #1 Young	V (H)	Gas Well
Lawrence (KY)	Bruin #1 Walbridge	H	Re-permitted
Putnam (WV)	Cabot #50 Amherst	V	Drilled (Gas)
Johnson (KY)	Horizontal Tech #572360 EQT	H	Drilled
Lawrence (KY)	Strat test permit 111649	?	?
Lawrence (KY)	Strat test permit 111720	?	?
Lawrence (KY)	Strat test permit 111721	?	?
Lawrence (KY)	Strat test permit 111757	?	?

One of these drilled and evaluated for HVHF

UK UNIVERSITY OF KENTUCKY



Bruin #1 Young

- Cased hole to TD
- Perforated 10,468 to 11,044
- Slickwater frac
- Tested 115 Mcf (5/6/2014)
- Shut-in 5/30/2014
- SIP 2,599 psi after 24 hours
  - Below expected hydrostatic pressure

UK UNIVERSITY OF KENTUCKY

Return

Rogers -ville Play Area

2+ million acres

1.5-1.6 million acres

Bruin #1 Young

(Based on data available in 2004)

Courtesy Dave Harris, KGS

UK UNIVERSITY OF KENTUCKY