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 **NORTON ROSE FULBRIGHT**

## **Hydraulic Fracturing: Lessons Learned from Shale Gas and Tight Oil Operations in the U.S. and Their Application to CBM**

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January 2014

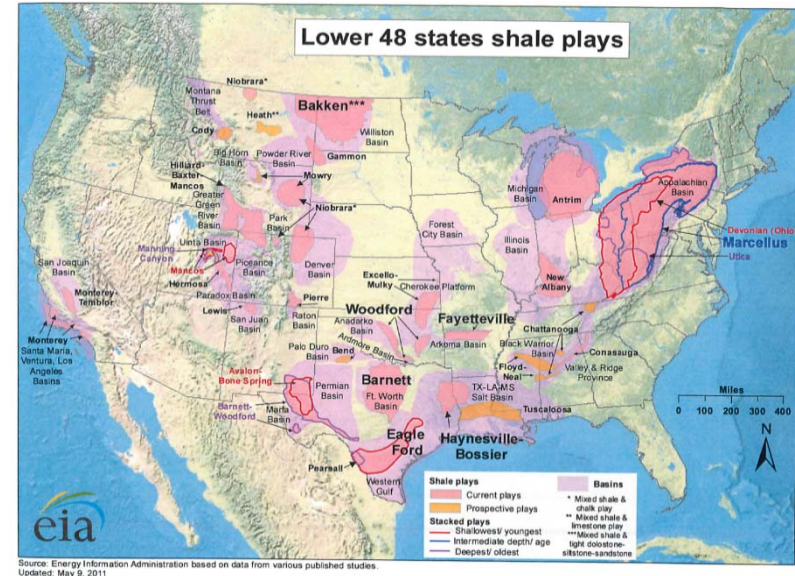


# Shale Gas Plays - Lower 48 States

May 28, 2009

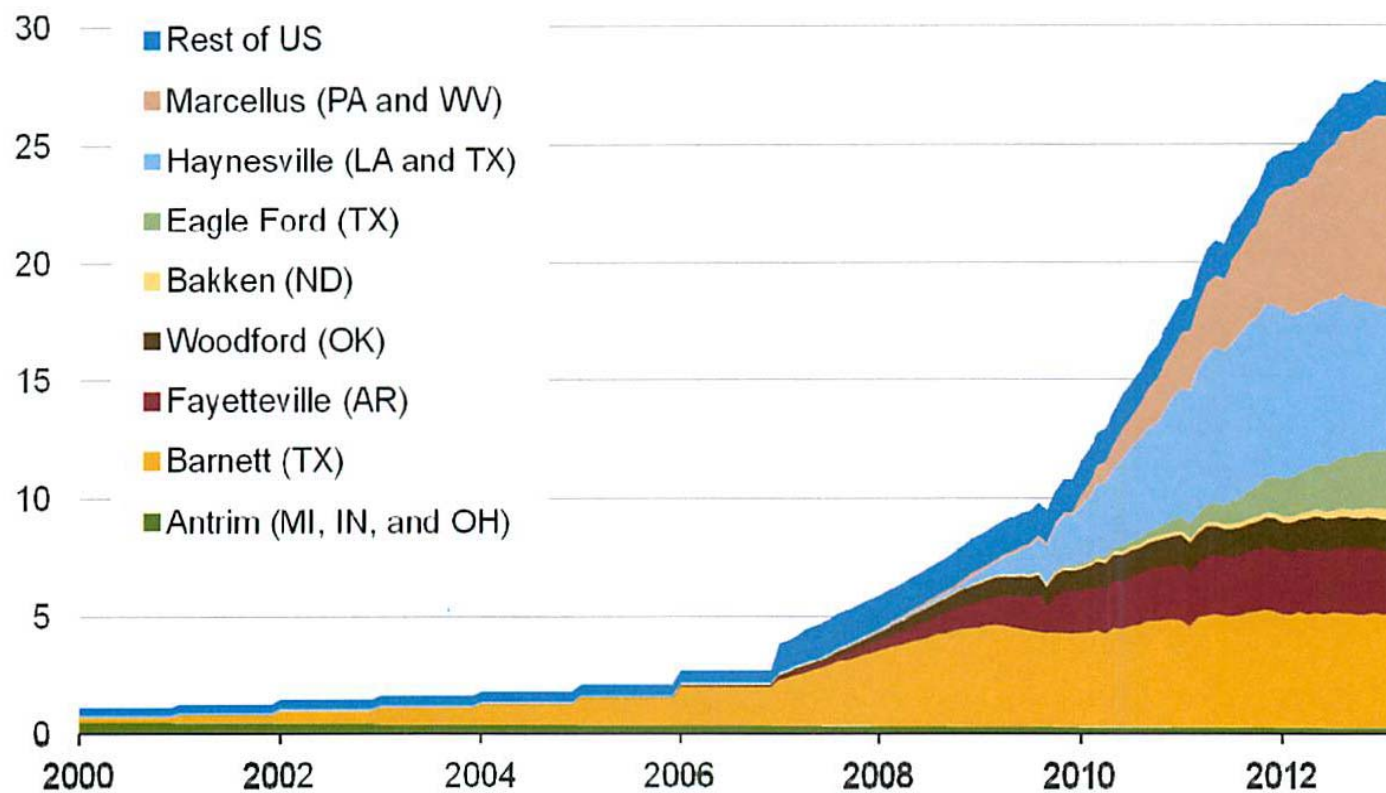


May 9, 2011



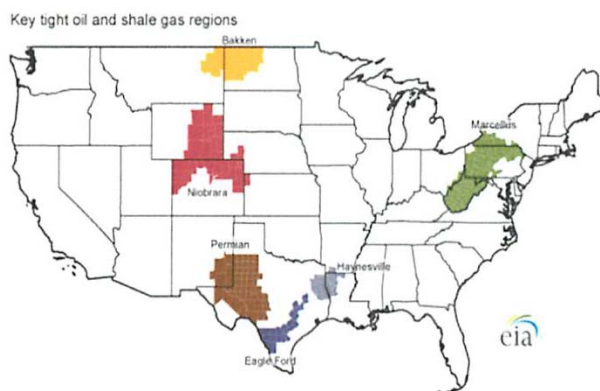
- Shale Gas adds 40% to the world's technically recoverable natural gas reserves.
- U.S. may have up to 100 years' worth of gas reserves based on current consumption.
- 98% of natural gas consumed in the U.S. comes from domestic sources.

# Gas Production History for Selected Shale Gas Plays, Dry Gas in Billion Cubic Feet per Day (3/2013)



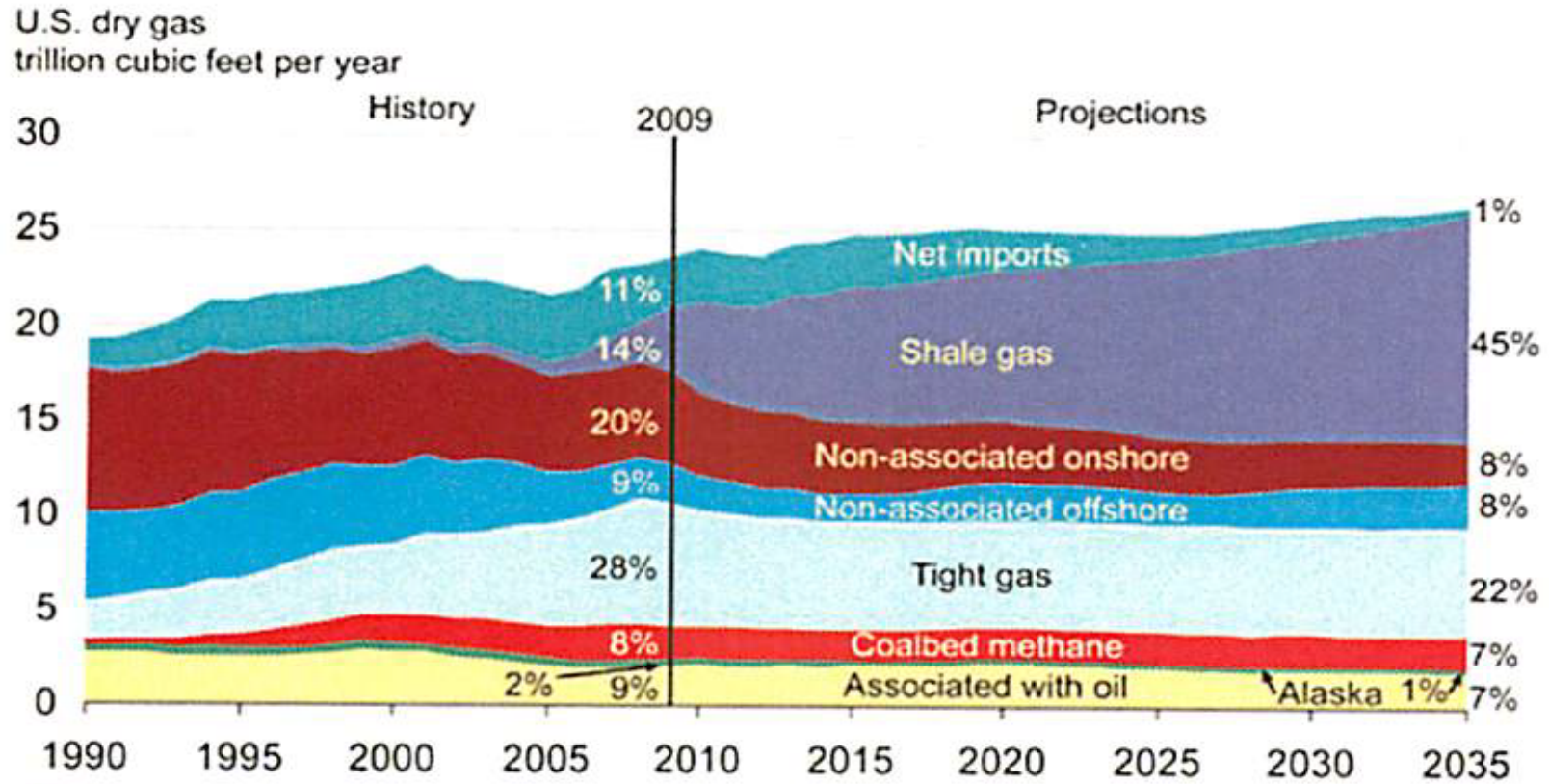
# Six Shale Plays Fuel U.S. Oil and Gas Production

According to the Energy Information Administration (EIA), six U.S. shale plays accounted for nearly 90% of domestic oil production growth and virtually all domestic natural gas production growth during 2011-2012.



Shale Play	Oil Produced Nov. 2013	Gas Produced Nov. 2013
Eagle Ford	1.2 million barrels/day	6 billion cubic feet/day
Bakken	976,000 barrels/day	1 billion cubic feet/day
Niobrara	280,000 barrels/day	4.63 billion cubic feet/day
Marcellus	44,000 barrels/day	12.5 billion cubic feet/day
Haynesville	57,000 barrels/day	6.7 billion cubic feet/day
Permian	1.3 million barrels/day	5 billion cubic feet/day

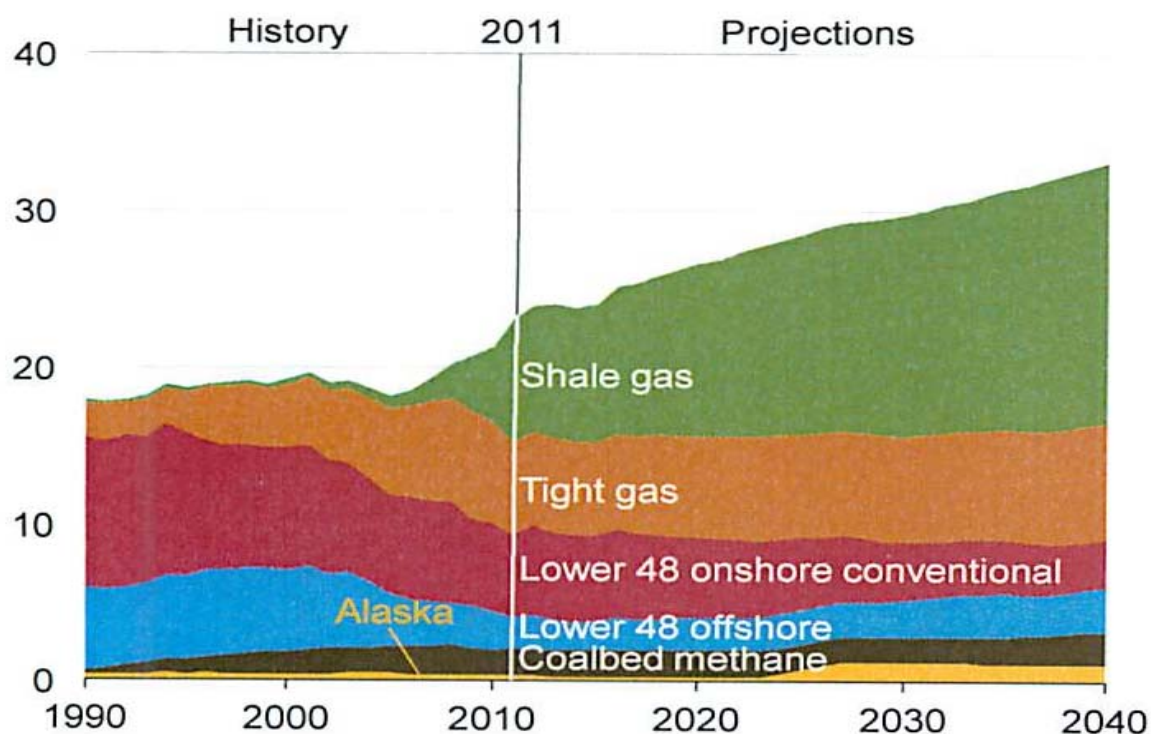
# Predicted Sources of Natural Gas Consumed in the United States through 2035



Source: EIA, Annual Energy Outlook 2011

# Natural Gas Production by Source, 1990-2040 (tcf)

44% increase in total natural gas production from 2011 through 2040 results from the increased development of shale gas, tight gas, and coalbed methane resources  
34 percent in 2011 to 50 percent in 2040.



Source: EIA Annual Energy Outlook 2013

# Hydraulic Fracturing

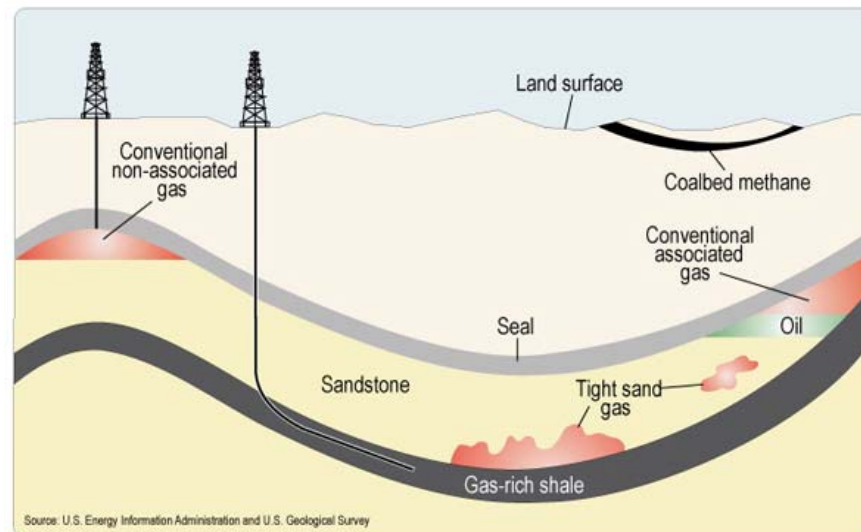
# The Fracing Controversy

- Within the past few years hydraulic fracturing (“fracing” or “fracking”) and its alleged impact on water quality has received increasing attention from the media, the EPA, Congress, and state and federal regulatory agencies.
- Focus Areas:
  - Regulation or Lack Thereof – National Regulations and Hearings
  - Water Supply and Disposal—Utilizes large volumes of water. Produces large volumes of fluids called “flowback” or “produced water”, which is either injected into a Class II Well, treated and disposed of, or treated and recycled.
  - Patents – Technology Disputes
  - State Disclosure Laws

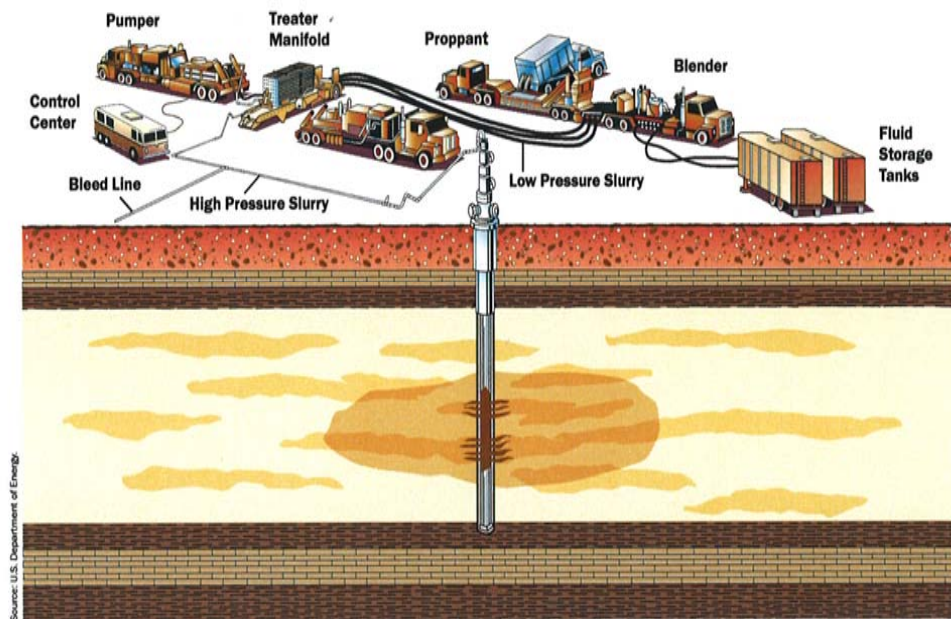
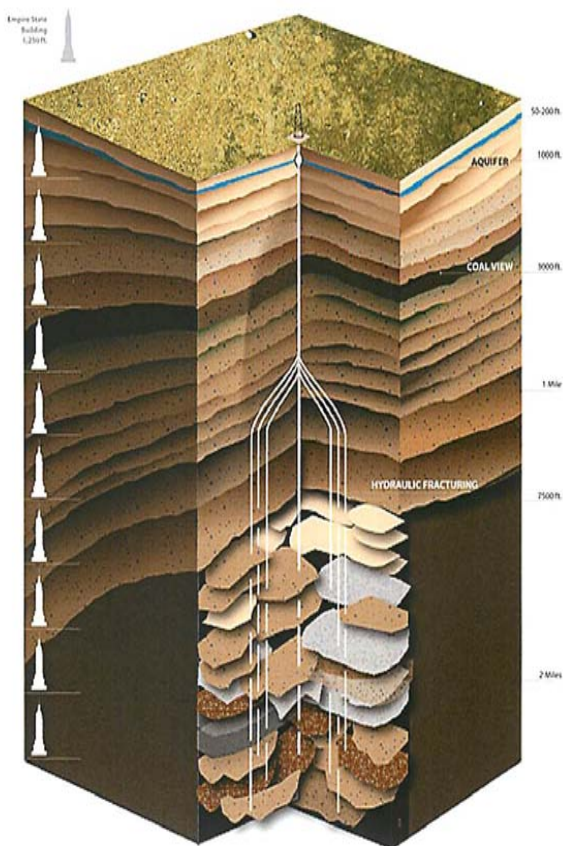


# Hydraulic Fracturing

- Hydraulic fracturing is the injection of highly pressurized fluids and proppants into shale or other non-porous hydrocarbon formations to increase production of oil and natural gas wells.
- Hydraulic fracturing has been utilized in the oil and gas industry for many decades (commercially developed in the late 1940s).
- Hydraulic fracturing and horizontal drilling make shale gas accessible.



# Hydraulic Fracturing - Well Stimulation Technology Deployed Thousands of Feet Below the Water Table



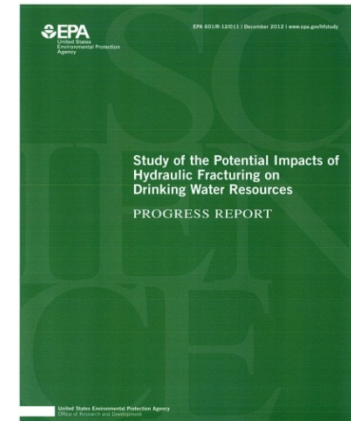
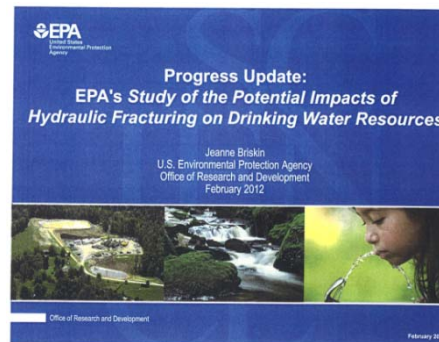
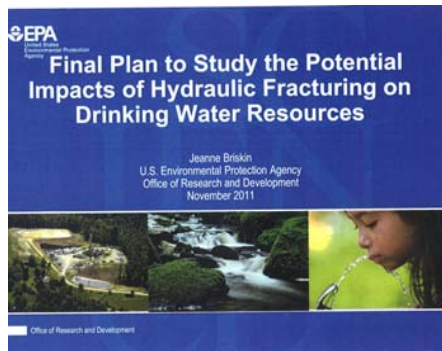
# U.S. Regulation

- In the U.S., there are multi-levels of government (federal, state, county, and municipality) affecting when, where, how, and what to drill. The rules include permit applications, completion and production reports, disclosure requirements, casing and cementing standards, and zoning restrictions.
- Federal
  - Land use plans are the principal documents used to govern the development of mineral extraction on federal lands. Opening areas to activities addressed in the plans requires an Environmental Assessment or Environmental Impact Statement.
  - Leases issued on federal land are competitively bid.
  - Submission of an Application for Permit to Drill with a Plan of Development
  - Laws governing water, air, endangered species, antiquities, and other resources.
    - Safe Drinking Water Act, National Pollution Discharge Elimination System, Underground Injection Control Program, Resource Conservation and Recovery Act, and Comprehensive Environmental Response, Compensation, and Liability Act
- State
  - State oil and gas commissions and boards established to oversee oil and gas operations by establishing well integrity requirements, drilling units, and well permit and operations regulations.
  - Water laws, including acquisition, use and disposal

# **EPA - Potential Impacts of Hydraulic Fracturing on Drinking Water**

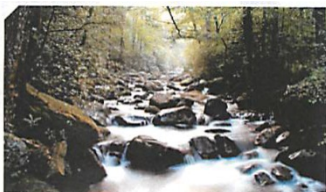
# EPA – National Regulatory Landscape

- Hydraulic fracturing is not regulated by the Safe Drinking Water Act
  - 2004 EPA Study found that fracturing of coal bed methane reservoirs posed “little or no threat” to drinking water.
  - The Energy Policy Act of 2005 granted a statutory exemption to hydraulic fracturing.
- In 2010, the EPA began a congressionally mandated study to examine the impact of hydraulic fracturing on drinking water. Final results are due the end of 2014.

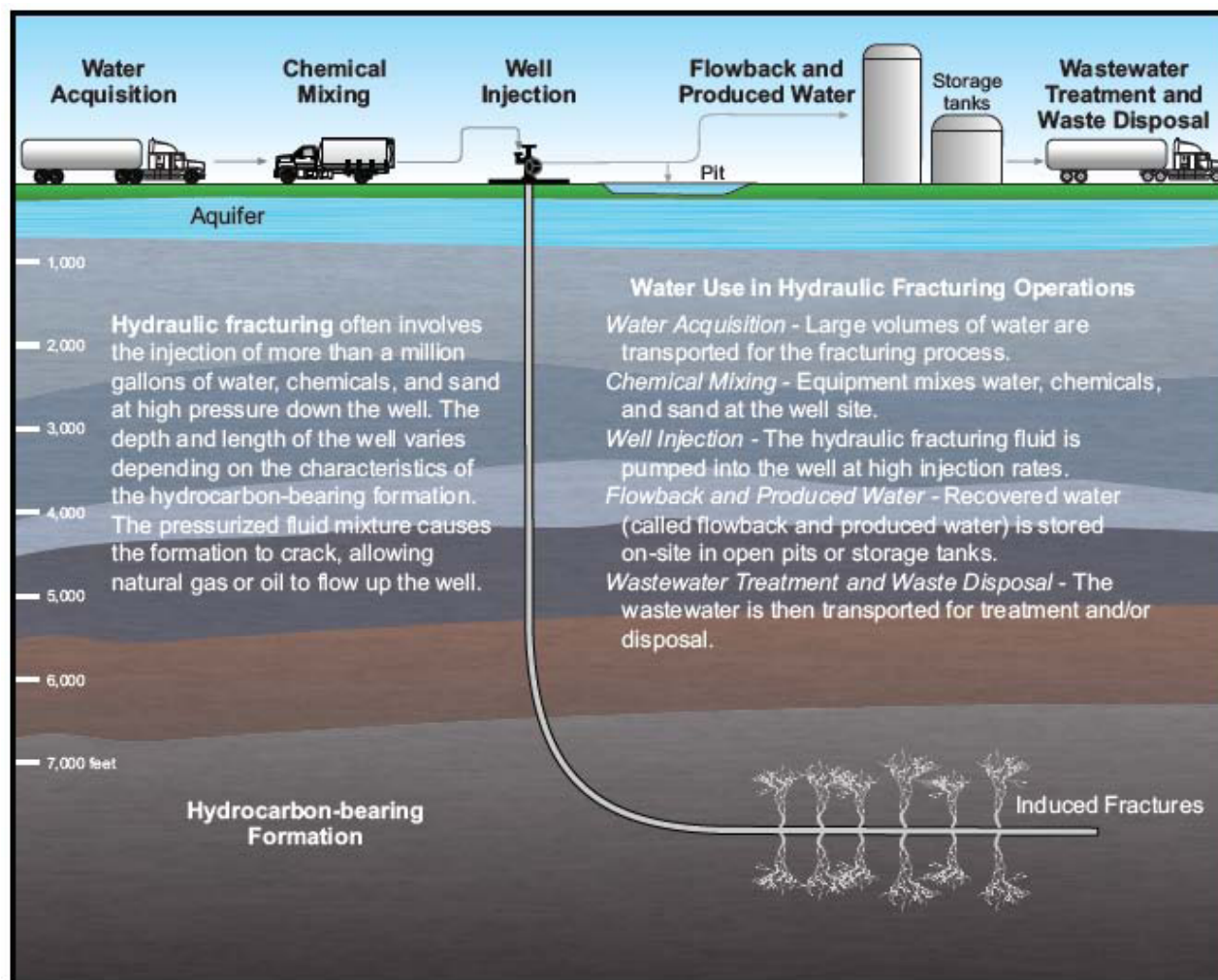


# EPA Study to Assess the Potential Impacts of Hydraulic Fracturing on Drinking Water

- Sites Selected
  - Texas, Louisiana, North Dakota, Colorado, Pennsylvania
- Purposes
  - To assess whether hydraulic fracturing can impact drinking water resources
  - To identify driving factors that affect the severity and frequency of any impacts
- Research questions and technical workshops focusing on the water cycle in hydraulic fracturing: Water resources management, well construction and operation, chemical and analytical methods, fate and transport.
- On September 12, 2013, during a web conference summary on the Technical Workshop on Case Studies to Assess Potential Impacts of Hydraulic Fracturing on Drinking Water Resources, an anticipated timeline showed that it would take at least two years to monitor water quality and flow indicators for the prospective case studies.



# Why is Water Important? Water Cycle

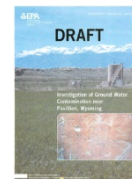


# **EPA – Water Study in Pavillion, Wyoming**



# EPA - Pavillion, Wyoming

- Well owners in Pavillion, Wyoming complained of objectionable taste and odor in their water. In 2010, the EPA tested the water wells and found that 11 out of 39 wells were polluted with 2-butoxyethanol phosphate which is contained in some drilling fluids.
  - Residents were advised to use alternative sources of water for drinking and cooking.
- EPA's December 2011 report – Found that constituents associated with hydraulic fracturing had been released into the Wind River aquifer at depths above the production zone.
  - Criticism of EPA report: Based on limited and questionable data; dismissed reports of historical problems with groundwater quality; and examined fracking as the only contamination source.
- U.S. Geological Survey report released in October 2012: Groundwater near two deep monitoring wells contains synthetic chemical (glycols and alcohols) and high levels of methane linked to hydraulic fracturing.
- Criticism of the EPA and USGS reports continued.
  - Wyoming Department of Environmental Quality (DEQ) complained that the results of the reports had not been vetted by state agencies and the research was conducted without transparency.
  - Encana who has wells in the area stated that the EPA provided no evidence that fracking or any drilling activity was the direct cause of any contamination.
- On June 20, 2013, the EPA announced that, while standing behind its research, it would not seek peer review of the report or finalize it or use the report's conclusions in any rulemaking. The EPA turned the investigation over to Wyoming state officials who plan to have a final report in the fall of 2014.



# Water Contamination Studies

# University Studies Concerning Water Contamination

- Duke University—overall positive report finding no evidence of contamination from the chemicals used in the fracturing process, but found high levels of methane.
  - “We found no evidence of contamination of drinking-water samples with deep saline brines or fracturing fluids.”
- Pennsylvania State University monitored more than 200 drinking water wells near Marcellus Shale gas drilling sites in 20 counties for an 18-month period. Research did not show a statistically significant link between shale gas drilling and methane contamination.
- Duke University and U.S. Geological Society (May 2013)
  - Sampled 127 shallow drinking water wells in areas overlying the gas-producing Fayetteville Shale formation.
  - No evidence of groundwater contamination from shale gas drilling operations.
  - Variations in local and regional geology as well as human factors, such as drilling techniques and the integrity of the well bore, play major roles in determining the possible risk of groundwater impacts from shale gas development and in preventing or allowing gas leakage from drilling sites to shallow aquifers.

## Study in the U.K. Regarding Water Contamination

- UK Energy Committee concluded that “fracturing itself does not pose a direct risk to water aquifers, provided the well-casing is intact before this commences. Rather, any risks that do arise are related to the integrity of the well, and are no different to issues encountered when exploring for hydrocarbons in conventional geological formations.”
  - “There is no evidence that the hydraulic fracturing process itself poses a direct risk to underground water aquifers. That hypothetical and unproven risk must be balanced against the energy security benefits that shale gas could provide to the UK.”
- In a report dated April 23, 2013, Britain’s House of Commons Energy and Climate Change Committee indicated that “ the current regulatory framework is sufficient to allow exploration [for gas] to proceed.” It points to the US experience as a “useful case study” from which the UK can develop its own regulations.

# Hydraulic Fracturing Regulations on Federal Lands

## Department of Interior - Bureau of Land Management Proposed Rules for Federal and Indian Lands Issued on May 4, 2012

- On May 4, 2012, the BLM issued its proposed new rules that set new standards for fractured wells on roughly 700 million acres of public land as well as 56 million acres of Indian lands.
  - All chemicals used in hydraulic fracturing must be publicly disclosed following the completion of fracking.
  - New guidelines for how drillers case drilled wells, which must be approved prior to drilling the well.
  - Drillers must submit and have approved water management plans prior to drilling, plans that must include how wastewater will be disposed.
- Operators would be required to:
  - Get prior approval before beginning fracking operations as a part of the application for a permit to drill.
  - Submit additional information on the geological formations they are operating within and the specifications of the wells being drilled to ensure that water sources are protected.
  - Conduct mechanical integrity tests to ensure that wells can sustain the pressures expected during fracking.
  - Store recovered fluids in tanks or lined pits, as the current industry recommended practice.
  - After fracking, submit actual totals of fracking fluids used and the composition of fluids to the Bureau of Land Management.
  - Chemical name, purpose, and amount would be posted to a public website, i.e., [FracFocus.org](http://FracFocus.org).

## BLM Publishes Revised Proposed Hydraulic Fracturing Rules

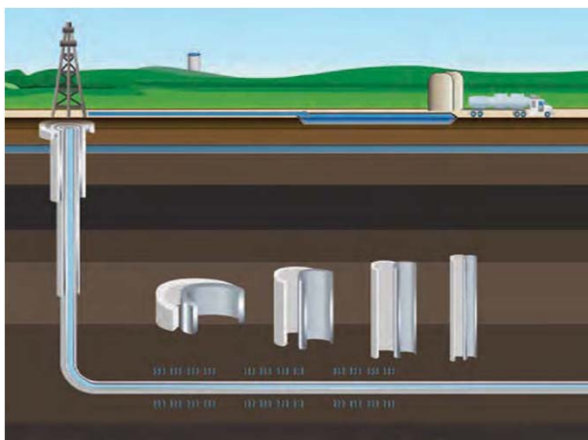
- On January 19, 2013, the BLM announced that it would replace its May 2012 proposed rules to accommodate more than 170,000 comments from stakeholders and the public.
  - The revised rules maintain the components of the initial proposal – including mandatory disclosure by operators of the fluids used in the fracturing process.
- The proposed revised rules were published in the Federal Register on May 24, 2013, with a public comment period that was extended to August 23, 2013.
  - Anti-fracking groups claim that the BLM watered down the original rules by allowing operators to expedite permit reviews for “type wells” (a different but similar well nearby), and giving BLM the discretion to grant variances.
  - Pro-fracking groups complain that the regulations impose a “one-size-fits-all” set of rules that are a roadblock to job creation, lower energy prices and American energy security.
    - BLM requirements could duplicate and perhaps contradict state regulations.
      - If the state regulation is more protective, then the state rule will remain in effect. If it is the other way around, the BLM rule will apply
  - Drilling on federal lands will take longer and cost more as the regulatory hurdles increase.

# **Possible Sources of Contamination: Well Construction, Transportation, and Flooding**



## Possible Avenues for Impacts to Groundwater and Drinking Water

- Improper well construction (e.g., damaged casing, poor cementing), including improper sealing of abandoned wells.



- Increased use of freshwater, especially in areas with water constraints.
- Improper wastewater management and disposal
- Accidents during the transport or storage and use of oil and gas and or materials used in the drilling process.

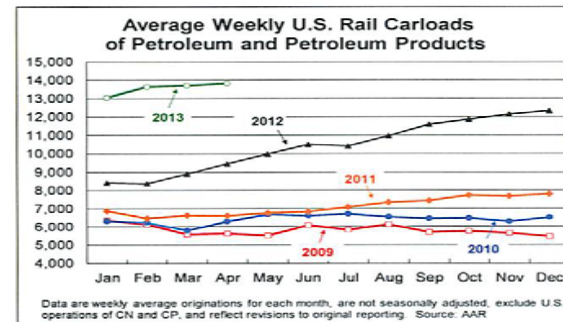
# Protecting Groundwater: Casing and Cementing

- Surface water and aquifer protection.
  - How a state deals with water acquisition and its use for fracking is dependent on the way the state deals with water rights in general.
    - Generally fee mineral owners and their lessees can use a reasonable amount of water from a tract for use on that tract.
    - Under the riparian system, all landowners whose property is adjacent to a body of surface water have the right to make reasonable use of it.
    - Groundwater may be treated differently. For example, in Texas, groundwater rights can be used for oil and gas exploration and development off the tract of its origination without the requirement of permitting from local conservancy districts.
- Casing, cementing, drilling, and completion requirements.
  - Bad cement jobs and leaky casing can, if unchecked, cause contamination.
  - Old and forgotten unplugged wells can possibly provide contamination routes.
    - Texas rules:
      - All casing cemented in any well must be steel casing that has been hydrostatically pressure tested with an applied pressure at least equal to the maximum pressure to which the pipe will be subjected in the well.
      - Casing shall be cemented across and above all formations permitted for injection.
      - Any proposal to set surface casing to a depth of 3,500 feet or greater requires prior approval. Operator must specify plans on preventing upward migration of deeper formation fluids into protected water.
      - Minimum separation wells (where vertical distance between the case of usable quality water and the top of the formation to be stimulated is less than 1,000 feet) are subject to more rigorous cementing and pressure testing limitations and requirements.

# Transport of Oil Products by Truck and Rail

- With the increased development and production of shale resources and the need for more pipelines, there has been an increased use of trucks and rail to bring in needed materials, equipment, and chemicals to a well site and to remove waste water and oil or gas product from the well.

EIA estimates that 1.37 million barrels per day of oil and petroleum products were shipped during the first six months of 2013.



- Increased risk of accidents
- Train derailments involving oil industry related shipments since April 2013 – Lac-Mégantic, Quebec; Baltimore; Minnesota; Casselton, ND.
  - In Lac-Mégantic, an unattended 73 car freight train wrecked in the center of town, rupturing many of the tanker cars and creating a fire and explosion which killed 47 people.




# Transport of Oil Products by Truck and Rail

- The federal Hazardous Materials Transportation Act regulates transportation of crude oil and also may regulate the transportation to and from the well site of any hazardous chemicals that make up fracking fluid.
- The Department of Transportation has proposed new safety regulations (thicker shell and installation of pressure relief valves) for the DOT-111 tankers used to transport some hazardous materials.



- The federal government regulates rail transportation.
- Each state regulates trucking within its borders.

# PHMSA Safety Alert Relating to Flammability of Bakken Crude



The Pipeline and Hazardous Materials Safety Administration  
1200 New Jersey Avenue, SE  
Washington, DC 20590  
[www.phmsa.dot.gov](http://www.phmsa.dot.gov)

**Safety Alert -- January 2, 2014**

**Preliminary Guidance from OPERATION CLASSIFICATION**

The Pipeline and Hazardous Materials Safety Administration (PHMSA) is issuing this safety alert to notify the general public, emergency responders and shippers and carriers that recent derailments and resulting fires indicate that the type of crude oil being transported from the Bakken region may be more flammable than traditional heavy crude oil.

Based upon preliminary inspections conducted after recent rail derailments in North Dakota, Alabama and Lac-Mégantic, Quebec involving Bakken crude oil, PHMSA is reinforcing the requirement to properly test, characterize, classify, and where appropriate sufficiently degasify hazardous materials prior to and during transportation. This advisory is a follow-up to the PHMSA and Federal Railroad Administration (FRA) [joint safety advisory](#) published November 20, 2013 [78 FR 69745]. As stated in the November Safety Advisory, it is imperative that offerors properly classify and describe hazardous materials being offered for transportation. 49 CFR 173.22. As part of this process, offerors must ensure that all potential hazards of the materials are properly characterized.

Proper characterization will identify properties that could affect the integrity of the packaging or present additional hazards, such as corrosivity, sulfur content, and dissolved gas content. These characteristics may also affect classification. PHMSA stresses to offerors the importance of appropriate classification and packing group (PG) assignment of crude oil shipments, whether the shipment is in a cargo tank, rail tank car or other mode of transportation. Emergency responders should remember that light sweet crude oil, such as that coming from the Bakken region, is typically assigned a packing group I or II. The PGs mean that the material's flashpoint is below 73 degrees Fahrenheit and, for packing group I materials, the boiling point is below 95 degrees Fahrenheit. This means the materials pose significant fire risk if released from the package in an accident.

As part of ongoing investigative efforts, PHMSA and FRA initiated "Operation Classification," a compliance initiative involving unannounced inspections and testing of crude oil samples to verify that offerors of the materials have been properly classified and describe the hazardous materials. Preliminary testing has focused on the classification and packing group assignments that have been selected and certified by offerors of crude oil. These tests measure some of the inherent chemical properties of the crude oil collected. Nonetheless, the agencies have found it necessary to expand the scope of their testing to measure other factors that would affect the proper characterization and classification of the materials. PHMSA expects to have final test

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For additional information regarding this safety alert, please contact Rick Raksnis, PHMSA Field Services Division, (202) 366-4455 or E-mail: [Richard.Raksnis@dot.gov](mailto:Richard.Raksnis@dot.gov). For general information and assistance regarding the safe transport of hazardous materials, contact PHMSA's Information Center at 1-800-467-4922 or [phmsa.hm-infocenter@dot.gov](mailto:phmsa.hm-infocenter@dot.gov).

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## Recent Flooding in Colorado

- As of October 1, 2013, the Colorado Oil and Gas Conservation Commission (COGCC) was tracking 14 “notable releases” of oil and 12 releases of produced water related to the September floods that closed approximately 2,000 oil and gas wells north of Denver.
  - A total of 1,042 barrels, or 42,764 gallons of oil, was spilled from tanks or equipment damaged by flood waters. This is equivalent to 3 conventional storage tanks.
  - A total of 413 barrels, or 17,350 gallons, of produced water was spilled from damaged equipment.
  - There are 16 locations with evidence of minor releases, i.e. sheen.
- One energy company closed 758 oil and gas wells during the floods.
  - Reported 4 flood-related spills, totaling about 212 barrels of oil and 30 barrels of produced water.
  - Estimated damage to equipment estimated between \$7 million and \$17 million.

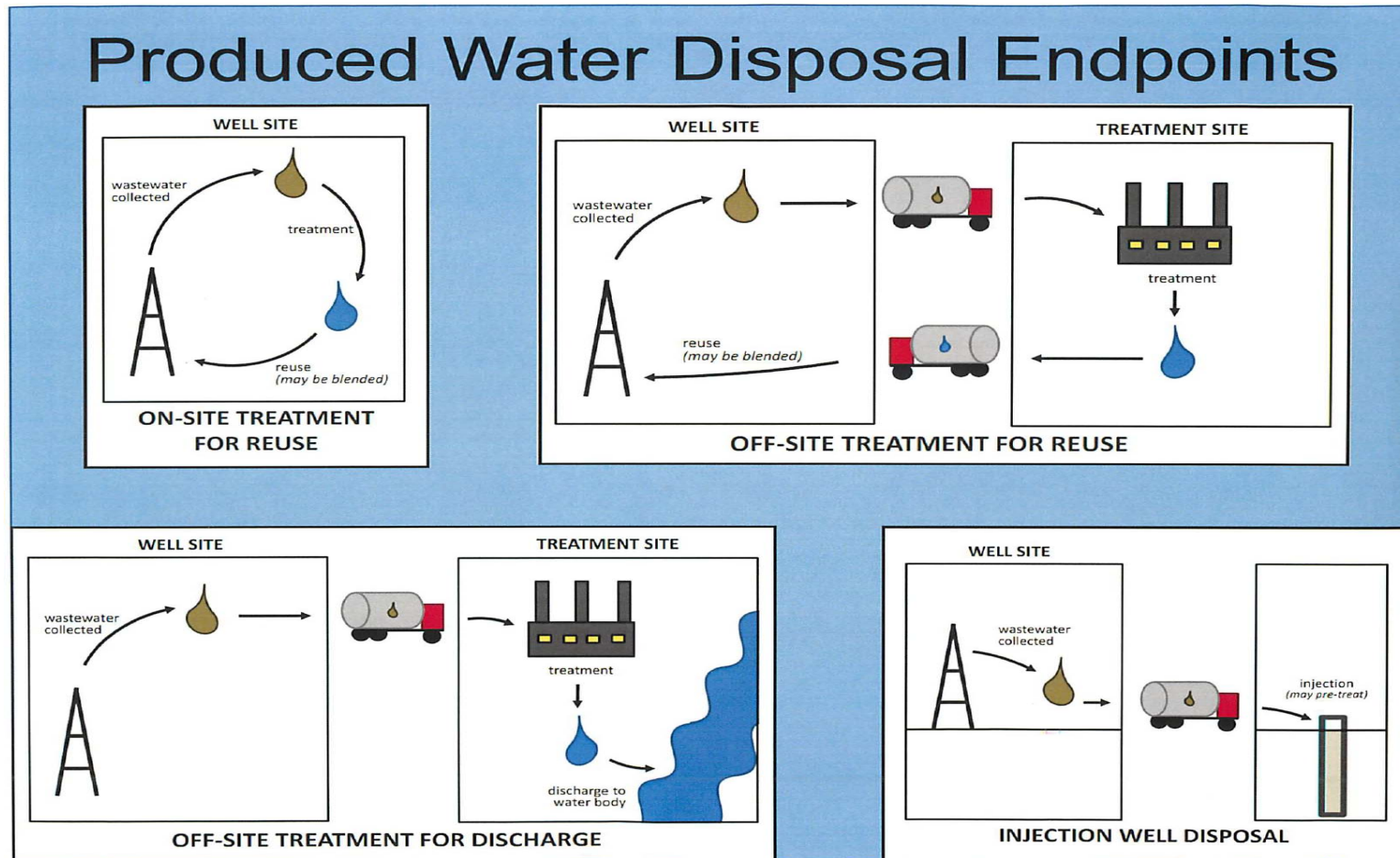
# Colorado Flooding



# Disposal of Wastewater



# Disposal of Wastewater



# Recycling Wastewater

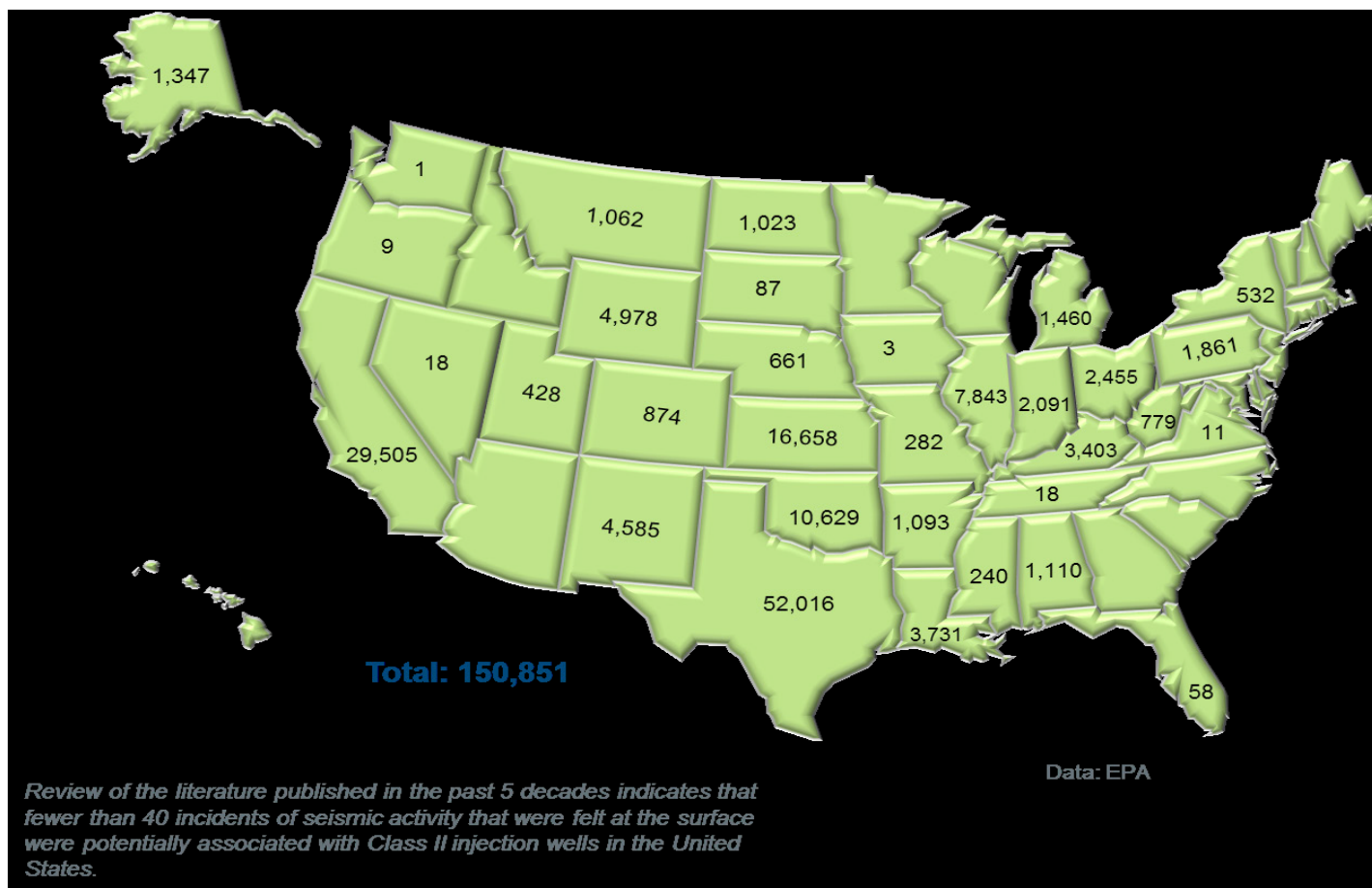
- Recover and re-use flowback
  - Reduces water demand and disposal requirements
  - Pilot programs: Devon, Texas A&M, Fountain Quail
- Challenges
  - High TDS and other constituents
  - Expensive - Devon abandoned its project because recycling cost 40% more than underground injection.
  - BUT, Fountain Quail used mobile evaporators (NOMADS) to process 14 million barrels of frac flowback from 2005 to 2009.
- Texas – New rules adopted March 26, 2013
  - RRC permit is required to operate a commercial recycling facility.
  - Operators can recycle flowback fluids to use in the hydraulic fracturing process without obtaining a permit, whether the recycling process is conducted on lease or off-site, so long as the recycling location is non-commercial.

# Injection or Disposal Well



- Using wells to place the wastewater thousands of feet underground in porous rock formations that are separated from treatable groundwater.
  - The fluid pressure, fracture pressure, and geological characteristics of the injection zone must be considered when evaluating a zone that may be suitable for injection.
- UIC Class II Wells – Oil and Gas Related Injection Wells
  - Regulated by federal and state Underground Injection Control (UIC) programs.
- Texas regulations
  - Application, notice and hearing process
    - Must demonstrate that injection formations are separated from fresh water formations by impervious geology that will provide adequate protection.
    - Wells must be securely cased, with the casing securely anchored.
    - Requires records maintenance, monitoring, reporting, testing, and plugging.

# Class II Injection Wells



# Induced Seismicity: Hydraulic Fracturing and Injection Wells

# Earthquakes, Injection, Fracking – Oh My!

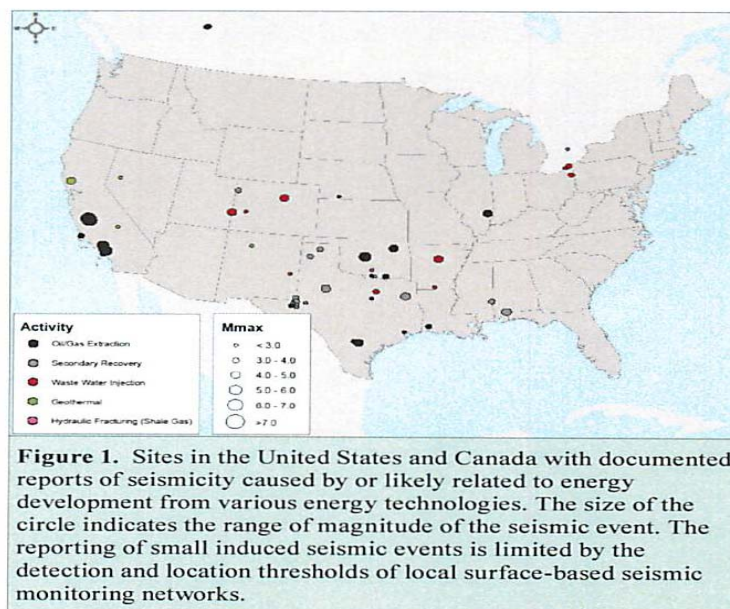
- Earthquake activity has occurred in Arkansas, Ohio, Oklahoma, Texas and West Virginia near drilling and/or hydraulic fracturing operations and near disposal and/or injection wells.
- Arkansas – eight pending lawsuits
  - Arkansas Geological Survey monitored 599 seismic events in Guy, Arkansas between September 20, 2010 and March 23, 2011. The largest in 35 years occurred on February 28, 2011 and measured 4.7 in magnitude.
  - Arkansas Oil & Gas Commission established a moratorium on disposal wells.
- Texas – one pending class action lawsuit in Johnson County against several oil and gas companies with wells in the area, filed on July 30, 2013
  - Claim that each defendant caused destructive “earthquakes, ground subsidence and other seismic activity’ on their property by fracking and injection well operations at nearby natural gas formations.
  - Allege that the injection of drilling wastewater into underground disposal wells can enter a fault, causing slippage and earthquakes.
  - Causes of action: negligence, nuisance, and strict liability
  - Undisclosed amount of damages – Market value of their property has declined and will continue to drop.
  - Difficult to prove without establishing that earthquakes will occur constantly over the next 10 years.

# Shale and Earthquakes: What's Shaking And Why

- U.S. Geological Survey, 1990
  - Report for EPA – “Earthquake Hazard Associated with Deep Well Injection”
  - Recommendation - Care should be taken in selecting locations for deep injection wells, namely “the desirability of high permeability and porosity in the injection zone and a site situated away from known fault structures,” which would make the possibility of “induced earthquakes...less likely.”
- Oklahoma Geological Survey, August 2011
  - “[D]etermining whether or not earthquakes have been induced [by drilling]...is problematic, because of our poor knowledge of historical earthquakes, earthquake process and the long recurrence intervals in the stable continent... The number of historical earthquakes in the [Eola] area and uncertainties in hypocenter locations make it impossible to determine with a high degree of certainty whether or not hydraulic fracturing induced these earthquakes.”
- Cuadrilla Resources Ltd., November 2011
  - “[S]eismic events [in Lancashire UK] were due to an unusual combination of geology at the well site coupled with the pressure exerted by water injection as part of operations.”
- U.S. Geological Survey, April 2012
  - “While the seismicity rate changes described [in Arkansas and Oklahoma]...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.”
- University of Memphis, April 2012
  - Build-up of seismic activity in Oklahoma was probably triggered by fluid injection into the subsurface.

# Shale and Earthquakes: What's Shaking And Why

- National Research Council, “Induced Seismicity Potential in Energy Technologies,” June 2012
  - The process of hydraulic fracturing as presently implemented does not pose a high risk for inducing seismic events.
  - Injection for disposal of waste water in the subsurface does “pose some risk for induced seismicity, but very few events have been documented over the past several decades relative to the large number of disposal wells in operation.”





# Shale and Earthquakes: What's Shaking And Why

- University of Oklahoma, March 2013
  - Oklahoma 5.7 earthquake in November 2011 – “Subsurface data indicate that fluid was injected into effectively sealed compartments, and we interpret that a net fluid volume increase after 18 yr of injection lowered effective stress on reservoir-bounding faults. Significantly, this case indicates that decades-long lags between the commencement of fluid injection and the onset of induced earthquakes are possible.”
- University of Texas Studies
  - Dallas-Fort Worth earthquakes (Barnett Shale) from October 2008 to May 2009, December 2010 – DFW earthquakes appear to be induced by disposal of produced brines, possibly interacting with a subsurface fault. The earthquakes appear not to be induced by drilling, fracking or gas production.
  - Barnett Shale earthquakes, using information from temporary seismograph stations set up from November 2009 to September 2011, July 2012 – “Injection only triggers earthquakes if injected fluids reach and relieve friction on a suitably oriented, nearby fault that is experiencing regional tectonic stress.”
    - 67 probable earthquakes. “All 24 of the most reliably located epicenters occurred in eight groups within 3.2 km of one or more injection wells.”
  - Eagle Ford Shale earthquakes, using information from 25 temporary seismograph stations set up from November 2009 to September 2011, September 2013 - “While the majority of small earthquakes may be triggered/induced by human activity, they are more often associated both with fluid extraction than with injection.”
    - 62 probable earthquakes: 2 near wells injecting increased volumes of water; 8 near wells extracting recently increased volumes of oil and/or water; 4 wells not located near wells reporting significant injection/extraction increases.
- **BOTTOM LINE:** Lack of scientific consensus makes it difficult to establish causal connection between fracking and earthquakes. Although minor seismic activity is an inevitable part of the fracking process, most tremors are so small that they are never felt on the ground. Even when detected, tying them to fracking will be difficult without comparable data dating back before the fracking started.

# Silica Regulations

# OSHA – Notice of Proposed Rule – Crystalline Silica

- Respirable crystalline silica – very small particles at least 100 times smaller than ordinary sand you might encounter on beaches and playgrounds – is created during work operations involving stone, rock, concrete, brick, block, mortar, and industrial sand. Exposures to respirable crystalline silica are common in brick, concrete, and pottery manufacturing operations, as well as during operations using industrial sand products, such as in foundries, sand blasting, and hydraulic fracturing (fracking) operations in the oil and gas industry.
- Proposed rule would reduce the current PEL (Permissible Exposure Limit) by 50%.
- The proposed rules were published in the Federal Register on September 12, 2013. The public comment period ends on December 11, 2013
- OSHA plans to have public hearings on silica rulemaking on March 4, 2014.
- Close-up view of frac sand (on the right) and a typical sand of similar grain size (on the left). Notice how the frac sand has a very uniform grain size, nicely rounded grain shapes and a uniform composition. It is also a very tough material that is highly resistant to fracturing.



# OSHA InfoSheet and NIOSH Study

- In cooperation with oil and gas industry partners, NIOSH collected 116 full shift air samples at 11 hydraulic fracturing sites in five states (Arkansas, Colorado, North Dakota, Pennsylvania, and Texas) to determine the levels of worker exposure to silica at various jobs at the worksites.
  - Many air samples showed silica levels for workers in and around the dust generation points above-defined occupational exposure limits.
    - 47% Silica exposures greater than the calculated OSHA PEL
    - 79% Silica exposures greater than the NIOSH REL of 0.05 mg per cubic meter
    - 9% Silica exposures 10 or more times the PEL, with one sample more than 25 times the PEL
    - 31% Silica exposures 10 or more times the REL, with one sample more than 100 times the REL
- REL = Recommended Exposure Limits  
 PEL = Permissible Exposure Limits

**OSHA INFOSHEET**

**Silica Exposure during Hydraulic Fracturing**

The National Institute for Occupational Safety and Health (NIOSH) identified exposure to airborne silica as a health hazard to workers conducting some hydraulic fracturing operations. This INFOSHEET discusses the hazards of silica, how you can be exposed, what safety employers must take to reduce exposures, and your rights as a worker.

In May 2012, NIOSH reported that workers may be exposed to dust with high levels of respirable crystalline silica during hydraulic fracturing. Silica is a common mineral found in the earth's crust. It occurs primarily as quartz and is a major component of the sand, clay and stone materials used to make energy products such as concrete, brick and glass. Large amounts of sand are frequently used in hydraulic fracturing operations ("fracking").

**What are the health hazards of silica?**

- Silicosis is a lung disease caused by breathing in very small particles of silica that cause inflammation and scarring in the lungs and reduce the lungs' ability to take oxygen. Workers who breathe silica dust day after day are at greater risk of developing silicosis.
- Breathing in silica also increases the risk of lung cancer and other diseases, such as tuberculosis, chronic obstructive pulmonary disease, and kidney and autoimmune diseases.

**How are workers exposed to silica on hydraulic fracturing sites?**

Dust containing silica can be released when sand is off-loaded from transport trucks and transported through movers, along transfer belts, and into blender hoppers. You are exposed to silica if you breathe the dust.

**Primary sources where dust can be released include:**

- Dust transfer between points on top of the sand mover with the machinery is running during refilling hot loading.
- Open side lift parts on the sand mover during lifting operations.
- On-site vehicle traffic, such as sand trucks.
- Transfer belts under the sand movers.
- Sand poured into, or mixed by, the blender hopper and on transfer belts.
- Operation of transfer belts between the sand mover and the blender.
- End of the sand transfer belt (transfer belt) on sand movers.

**How do you know if silica is being released into the air?**

To determine silica exposure levels, your employer should collect air samples using devices that measure the amount of silica in a worker's breathing zone. This enables employers to determine whether they may expose workers to silica and the levels of silica in the air. The OSHA permissible exposure limit for worker exposure to silica is approximately 0.1 mg/m<sup>3</sup> for pure quartz silica.



Silicon dioxide bag photo credit CDC



Airborne silica dust in sand mover and transfer systems photo credit NIOSH



**How can worker exposures to silica in the air be reduced?**

- Reduce the amount of silica dust.
- Work practices that can be used now:
  - Close-coupled lift parts on sides of sand movers.
  - Reduce distance that sand falls (e.g., between the end of the dragger's tail and T-belt).
  - Limit the number of workers and the time that workers must spend in areas where silica dust is in the air.
  - Conduct maintenance to equipment so that dust operations can be performed remotely.
  - Apply water-based products to roads and around the well site to reduce the amount of airborne dust.
- Work practices that require equipment modification:
  - Enclose points where dust is released (e.g., starting around bottom/side of sand movers, discharging around and at the end of the dragger's tail).
  - Use dust masks and HEPA filtration on enclosed operator cabs or booths where possible.
  - Use local exhaust ventilation on machines or equipment to collect dust.
  - Replace transfer belts with screw augers on sand movers in new designs or retrofits.
- Use respirators when required.

When respirators are required, your employer must have a respiratory protection program that meets the requirements of OSHA's Respiratory Protection standard (29 CFR 1910.134). This program must include proper respirator selection, fit testing, medical evaluations, and training. All respirators need to be NIOSH approved.

**Inform and train workers on the hazards of silica and other chemicals.**

OSHA's Hazard Communication standard requires your employer to provide workers training and access to safety data sheets (SDS) on silica sand and other hazardous chemicals used or produced during hydraulic fracturing operations.

This infographic is always in color and informational in content. It is not a standard or regulation, and it neither creates nor enforces any new safety obligations created by OSHA. It is available on the Occupational Safety and Health website at [www.osha-slc.gov](http://www.osha-slc.gov). For more information, contact OSHA at 1-800-368-5888. OSHA is an Equal Opportunity Employer. In addition, the Air Quality Criteria Document, Respiratory Protection, and other documents are available on the OSHA website at [www.osha-slc.gov](http://www.osha-slc.gov). For more information, contact OSHA at 1-800-368-5888. OSHA is an Equal Opportunity Employer. In addition, the Air Quality Criteria Document, Respiratory Protection, and other documents are available on the OSHA website at [www.osha-slc.gov](http://www.osha-slc.gov).

**WORKER RIGHTS**

Under OSHA law, employers have the responsibility to provide a safe workplace. Workers must receive information and training (in a language and vocabulary they can understand) about workplace hazards, methods to prevent them, and the OSHA standards that apply. Workers can review records of work-related injuries and illnesses as well as get copies of test results that find and measure hazards. Workers may confidentially ask OSHA to inspect their workplace if they believe that their employer is not following OSHA standards or that there are serious hazards. Workers have the right to use their rights under the law, including their right to report a work-related injury or illness, free from discrimination or retaliation. For more information, to ask a question, or to file a complaint, visit [www.OSHA.gov](http://www.OSHA.gov) or call 1-800-368-5888. OSHA 162421. It is confidential.

**NIOSH FACT SHEET**



**NIOSH FIELD EFFORT TO ASSESS CHEMICAL EXPOSURE RISKS TO GAS AND OIL WORKERS**

**BACKGROUND**

There is a lack of existing information regarding the variety and magnitude of chemical exposure risks to oil and gas extraction workers. To determine if risks are present, NIOSH wants to develop partnerships with the oil and gas extraction industry to identify, characterize and (if needed) control workplace chemical exposures. This work will occur as part of the NIOSH Oil and Gas Extraction Safety and Health Program, which seeks to prevent injuries and illnesses among oil and gas extraction workers. Strategic objectives include identifying possible exposures, determining risk, and preventing chemical exposures to workers involved in oil and gas extraction industry.

**PURPOSE**

The goals of this NIOSH field effort include: 1) identifying processes and activities where chemical exposures could occur; 2) characterizing potential exposures to vapors, gases, particulates and fumes (e.g., solvents, diesel particulate, crystalline silica, acids, metals, aldehydes, and possibly other chemicals identified during the study); 3) depending on results of the field effort, recommending safe work practices and/or engineering and evaluating exposure controls (to include engineering controls, substitution, and personal protective equipment).

Department of Health and Human Services  
 Center for Disease Control and Prevention  
 National Institute for Occupational Safety and Health

OSHA  
 Occupational Safety and Health

CDC  
 NIOSH

**WHO CAN PARTICIPATE**

Workers, managers, supervisors, and health and safety professionals involved in oil and gas drilling and servicing operations are encouraged to participate in the field effort.

**BENEFITS OF PARTICIPATION**

Companies can leverage the industrial hygiene expertise of a NIOSH field research team to help identify if chemical exposure risks are present or absent, and based on results of field studies, prioritize and control potential workplace chemical exposures at their worksites. Data and results collected by NIOSH in the field effort will be communicated to the company in letter format. Become involved with NIOSH and be seen as a leader in occupational safety and health in the gas and oil industry.

**Note:** This Field Research Effort will be fully funded by NIOSH; there is no cost to participate. NIOSH is a part of the Centers for Disease Control and Prevention (CDC). NIOSH is federal agency responsible for conducting research and providing guidance related to occupational health and safety. NIOSH is not a regulatory agency. Federal regulations provide for trade secret protection for participating companies.





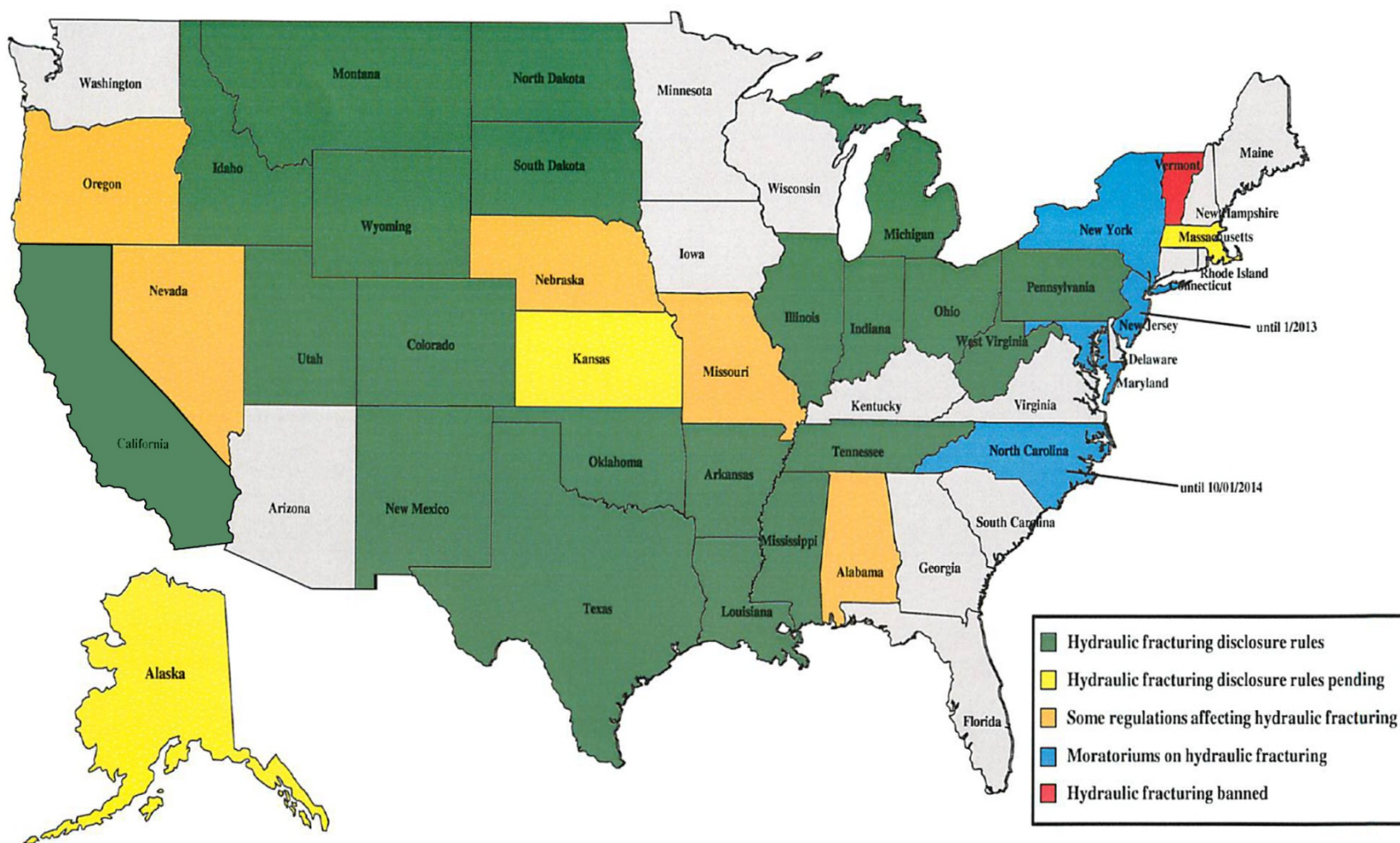
Photo credit: Eric Esswein, NIOSH



Sand truck operator at hydraulic fracturing operations. Image courtesy of Eric Esswein, NIOSH.

# Disclosures

# Hydraulic Fracturing Disclosures as of January 1, 2014



# Disclosure Regulations

## Proposed Legislation:

Alaska

Kansas

Nebraska

New York

North Carolina

## New Regulations Effective 2010-2013

Arkansas

California

Colorado

Idaho

Illinois

Indiana

Louisiana

Michigan

Mississippi

Montana

New Mexico

North Dakota

Ohio

Oklahoma

Pennsylvania

South Dakota

Tennessee

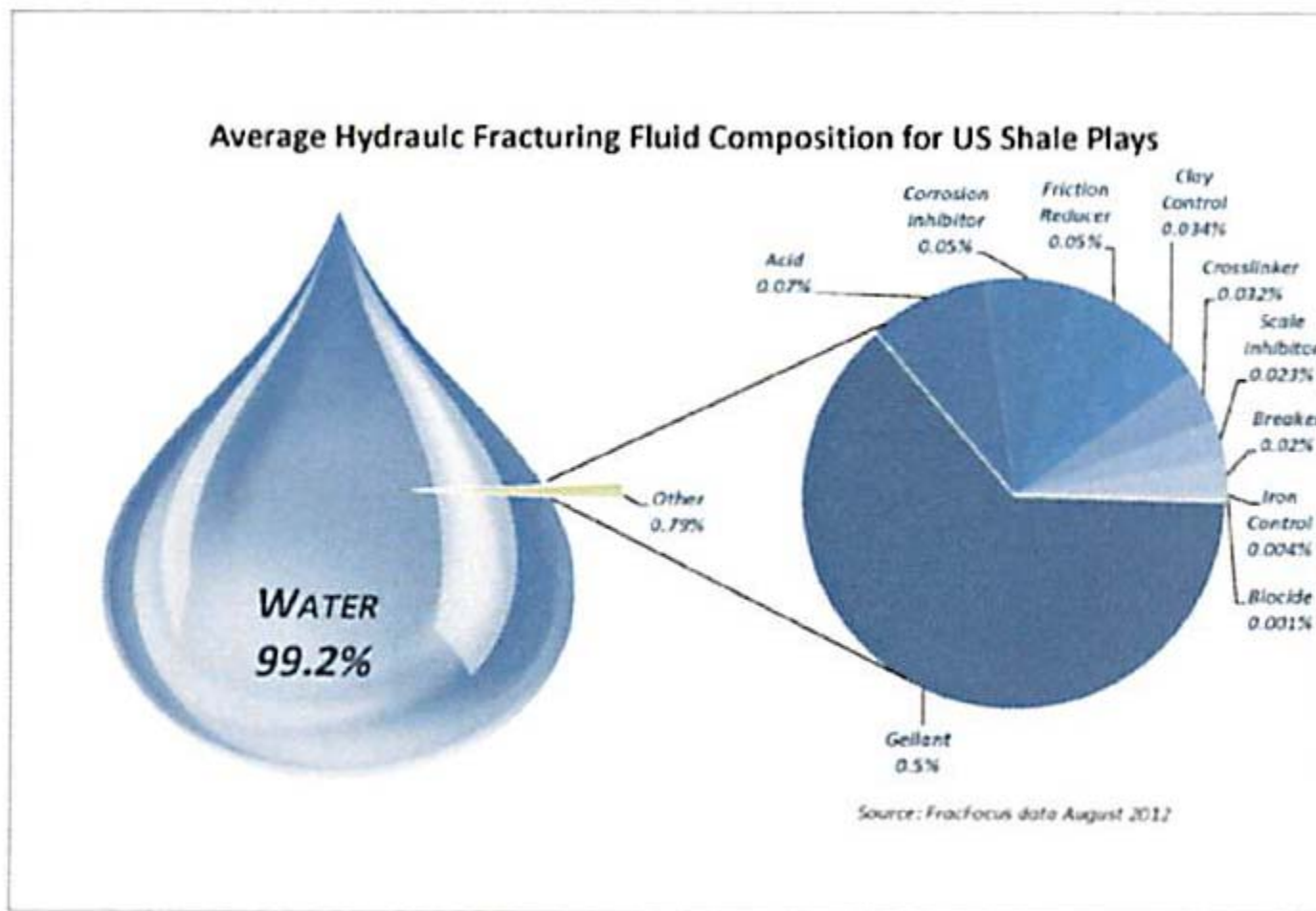
Texas

Utah

West Virginia

Wyoming

# Hydraulic Fracturing Fluid Composition





## Overview of State Disclosure Rules

- Several states require that the disclosures be made public at the FracFocus.org website; others require disclosure to state agencies.
- Level of disclosure often depends on the extent to which the state allows trade secret protections.
- Some states allow the company to withhold information at its discretion or to submit fewer details about propriety chemicals, except in emergencies.
- A few states require the submission of Material Safety Data Sheets for certain chemicals.
- Some states require some disclosure before fracking begins; others require disclosure within so many days after well completion (e.g., Texas, within 30 days); and five states require disclosure both before and after.

# Coal Bed Methane – Potential and Concerns

- Methane from coal is an attractive resource.
  - Coal can store large volumes of methane-rich gas – 6 or 7 times as much gas as a conventional natural gas reservoir of equal rock volume can hold.
  - Much of the coal and its methane lies at shallow depths, making wells easy to drill and inexpensive to complete.
  - Exploration costs for CBM are low, and the wells are cost effective to drill.
- Technological and environmental difficulties and costs
  - Water permeates coal beds, and its pressure traps methane within the coal. To produce methane from coal beds, water must be drawn off first, lowering the pressure so methane can flow out of the coal and to the well bore. This water, which is commonly saline or in some areas potable, must be disposed of in an environmentally acceptable manner.

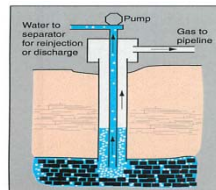


Figure 3. Diagram showing the production scheme of gas and water for a typical coal-bed methane well.

- Surface disposal of large volumes of potable water can affect streams, groundwater sources, and other habitats. Subsurface re-injection adds to the cost of production.
- Methane is a greenhouse gas, which in the atmosphere, can trap heat and contribute to global warming.

# Coal Bed Methane

# CBM Characteristics and Challenges

- CBM projects raise many of the same issues as shale gas.
  - Additional CBM challenges
    - Large volumes of water production
    - Co-existence with coal development
- Evaluating a CBM prospect
  - Gas in place
    - Gas content: Coal rank, composition of the coal, burial history
    - Total coal in place: Extent of coal in the area, net coal seam thickness
    - Storage capacity: Saturation indicates recoverable gas
  - Economic gas deliverability determined by
    - Thickness of coal seams, permeability, spacing of coal seams, depth of coal seams, hydrology, depositional environment, saturation, geologic structure, reservoir pressure
- Challenges
  - Significant technology needs, higher capital requirements, longer development times, higher production costs, reservoir management complexities
  - Gathering, transportation and marketing challenges
  - Environmental challenges
  - Development plans and coordination with transportation infrastructure

# Best Management Practices for CBM

- Planning and Permitting
  - Identify land ownership, existing and expected surface uses (spacing of wells, roads, pipelines, water disposal facilities, processing units, etc.)
- Water management planning
  - Produced water options
    - Lining holding ponds and pits, recycling, and use of injection wells
  - Water quality
    - Prevent surface and groundwater contamination - Establish a baseline (water testing before, during and after drilling), monitor data, understand hydrology of the basin, disclosure of all hydraulic fracturing fluids, and use water-based fracturing fluids rather than diesel fuel
- Communicating with landowners
  - Surface use agreements
  - Water well mitigation
- Infrastructure considerations
  - Roads, transportation, and pipelines
  - Wells – location, surface disturbance, equipment removal, reclamation
  - Gas gathering treatment, compression, and other processing facilities
  - Noise
  - Air quality
  - Public safety

## What It Takes to Succeed

- Evidence of sizeable resources to attract interest in CBM development
- Economic and fiscal incentives
- Extend exploration and development times
- Block extensions
- Access to domestic markets
- Availability of infrastructure
- Promotion of natural gas utilization
- Participation of specialized players to ensure that experiences developed elsewhere are utilized
- Government sponsored R&D funding
- Critical attention to environmental challenges (carbon footprint, air quality, water management, land disturbance, waste disposal)

The logo for Norton Rose Fulbright, featuring a gold chevron icon above the text "NORTON ROSE FULBRIGHT" in red, uppercase, sans-serif font.

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