

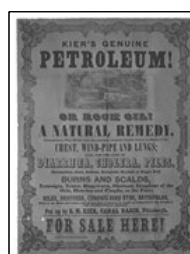
## Hydraulic Fracturing

Mike Watts  
January 12<sup>th</sup> 2012

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### Northeast - Birthplace of U.S. Natural Gas

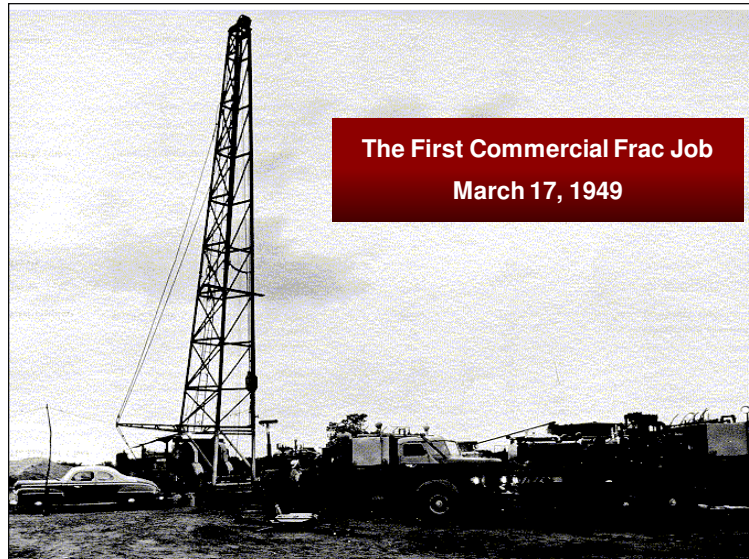
- First natural gas well
  - William Hart – 1821
  - Fredonia, New York
- First natural gas pipeline
  - E. L. Drake – 1859
  - Titusville, Pennsylvania
- Early challenges
  - Funding
  - Commercial quantities
  - Storage and transport
  - Technology



**Natural Gas Evolution Underway**

**HALLIBURTON**

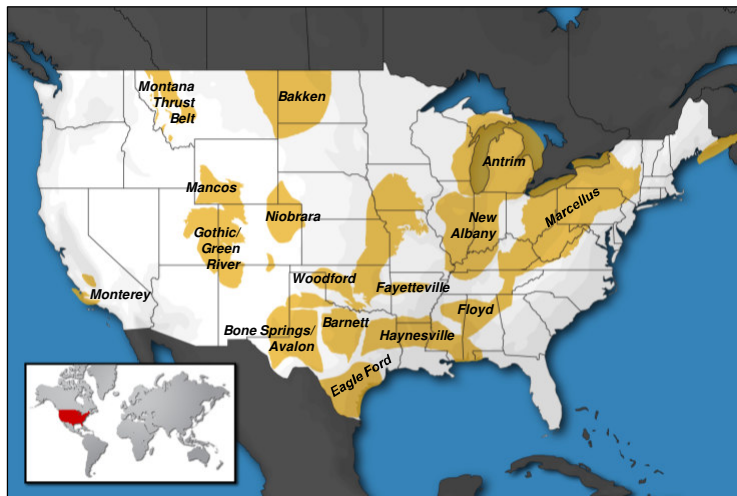
## Velma, Oklahoma



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## Expanding US Shale Development

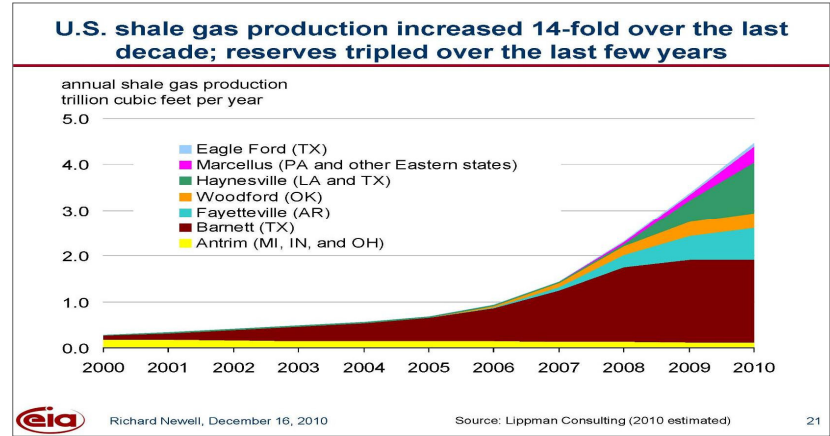


[http://www.eia.gov/oil\\_gas/rpd/shale\\_gas.jpg](http://www.eia.gov/oil_gas/rpd/shale_gas.jpg)

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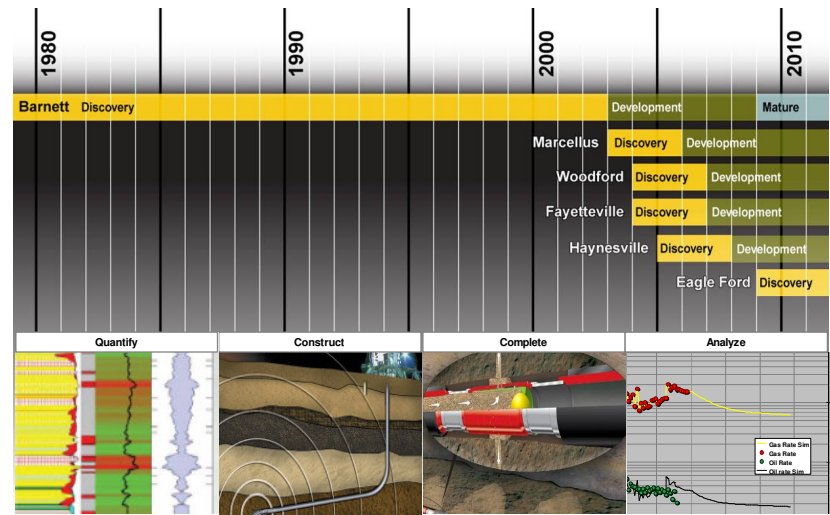
# Why HF Is Important To Energy Development



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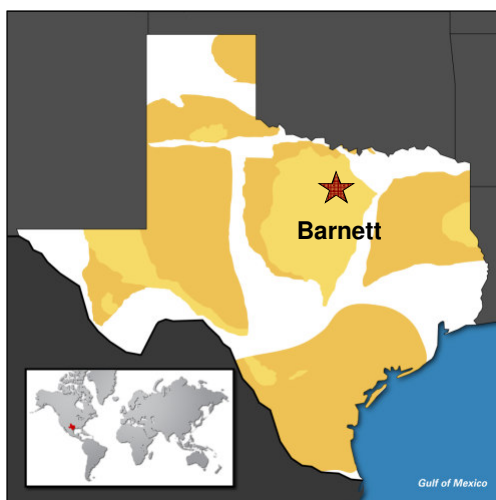
# Decades of Technology Development



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## Barnett Shale

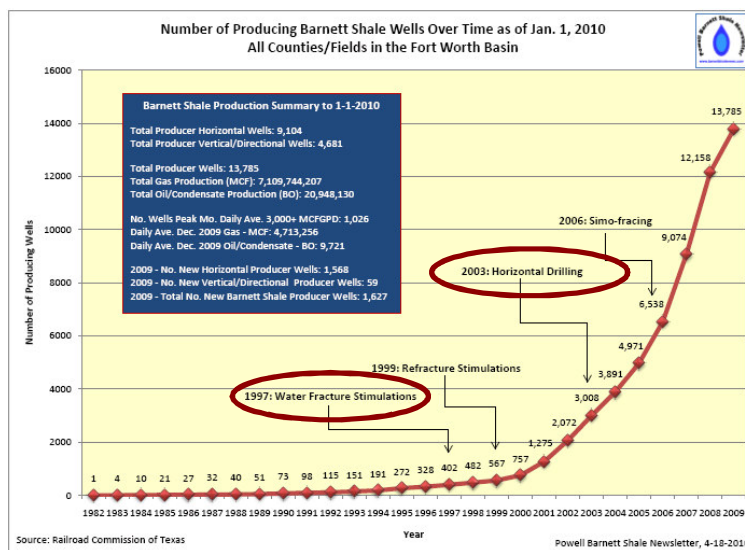


- Set the stage for modern shale gas development
- Learnings leveraged into future operations
- Over 15,000 producing wells today

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## Barnett Milestones



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## Austin Chalk

### Horizontal Drilling and Hydraulic Fracturing



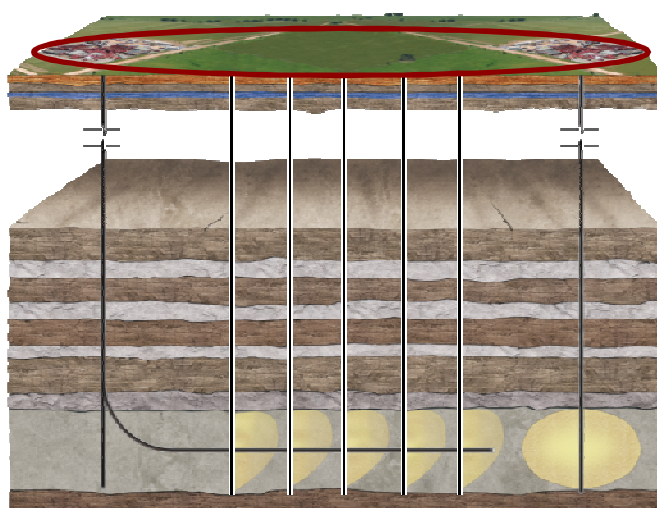
- Extensive use of horizontal drilling and hydraulic fracturing since 1985
- Long laterals and large volume fracturing safely utilized
- Processes are proven and well understood

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## Overview

### Horizontal versus Vertical



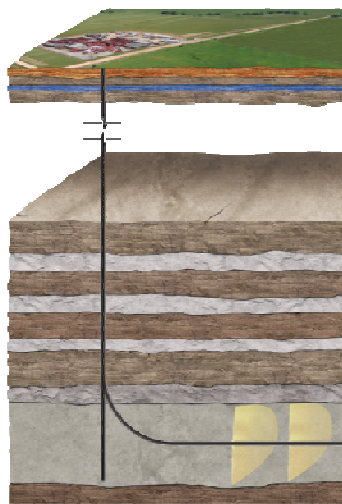
#### Horizontals

- Improve efficiency
- Reduce surface footprint

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## What is “Hydraulic Fracturing?”



### Hydraulic Fracturing:

- The use of fluids to create a pathway to the wellbore
- The placement of small granular solids into the pathway to ensure that it remains open after the hydraulic pressure is removed

### Objective:

- Increase the rate at which the well is capable of producing oil or gas
- Increase the economically recoverable reserves for a well

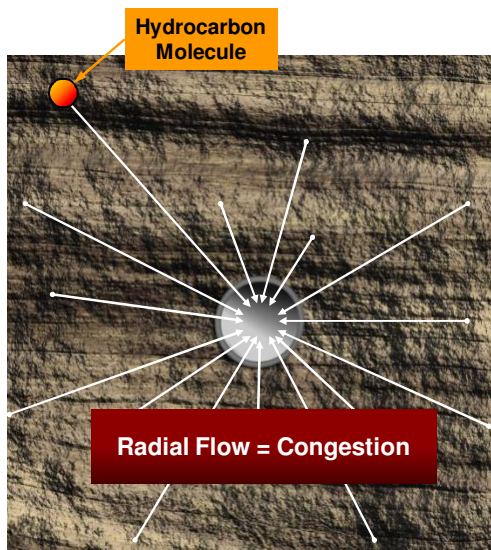
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## Why We Frac *Radial Flow*



Hydrocarbon  
Molecule

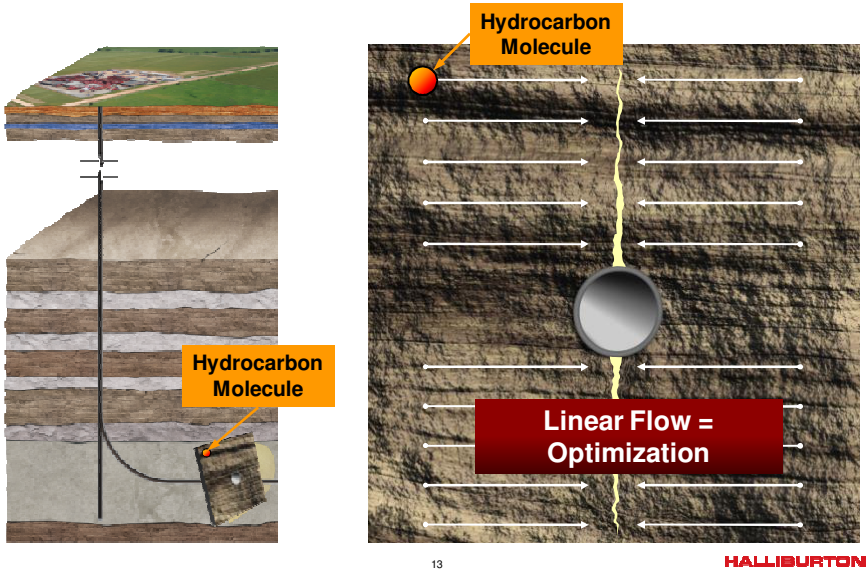


Radial Flow = Congestion

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**Why We Frac**  
*Linear Flow*



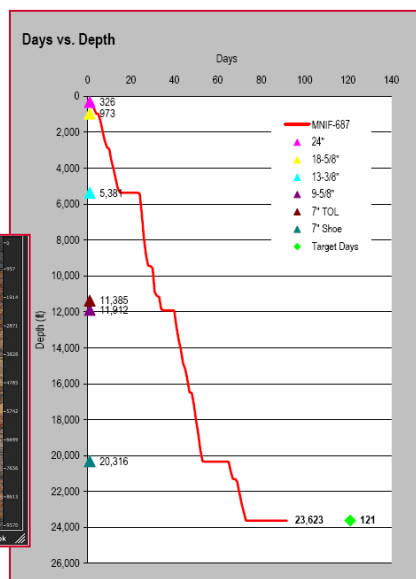
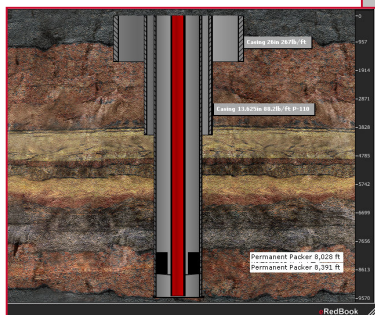
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**Well Construction**  
**Protecting Ground Water**

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## Casing Points

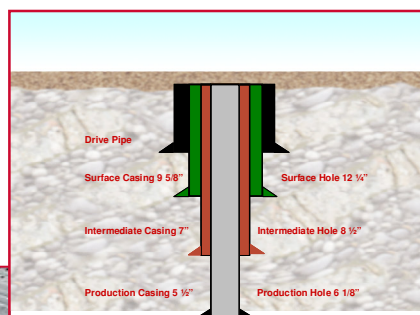


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## Steel Casing

- Casing Objectives
  - Hole Stability
  - Well Control
  - Pressure Containment
- Casing Specifications
  - API Standards
  - Life Cycle

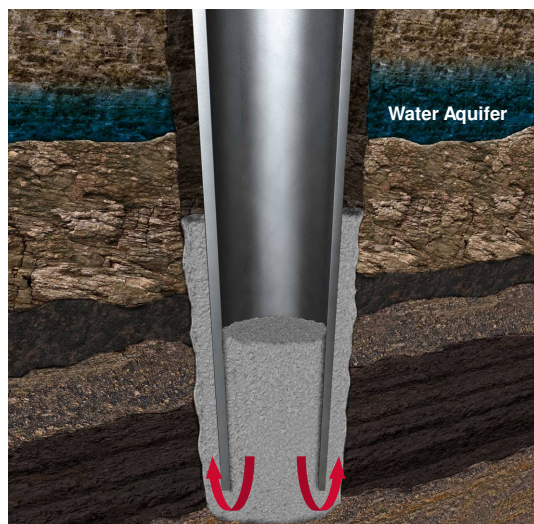


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## Cementing Operation



Society of Petroleum Engineers, Cementing Monograph Volume 4, 1990

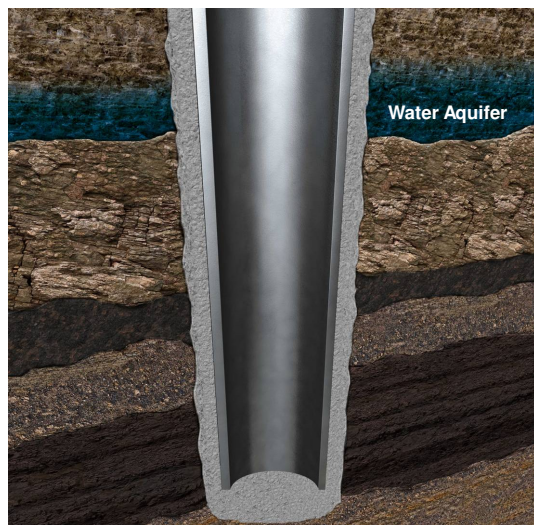
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### Well Cementing :

- The process of designing & mixing a slurry of cement, water and additives.
- Then pumping the slurry down through steel casing to critical points in the annulus between the casing and in the open hole.

## Why Oil and Gas Wells Are Cemented



Society of Petroleum Engineers, Cementing Monograph Volume 4, 1990

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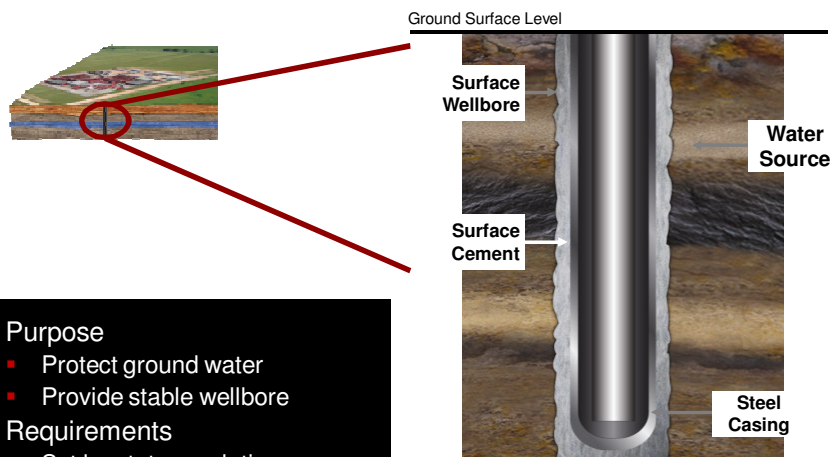
### Purpose of Cementing

- Protects ground water
- Bonds and supports the casing
- Restricts fluid movement between formations



## Surface Casing

### Isolating Wellbore and Formation



#### Purpose

- Protect ground water
- Provide stable wellbore

#### Requirements

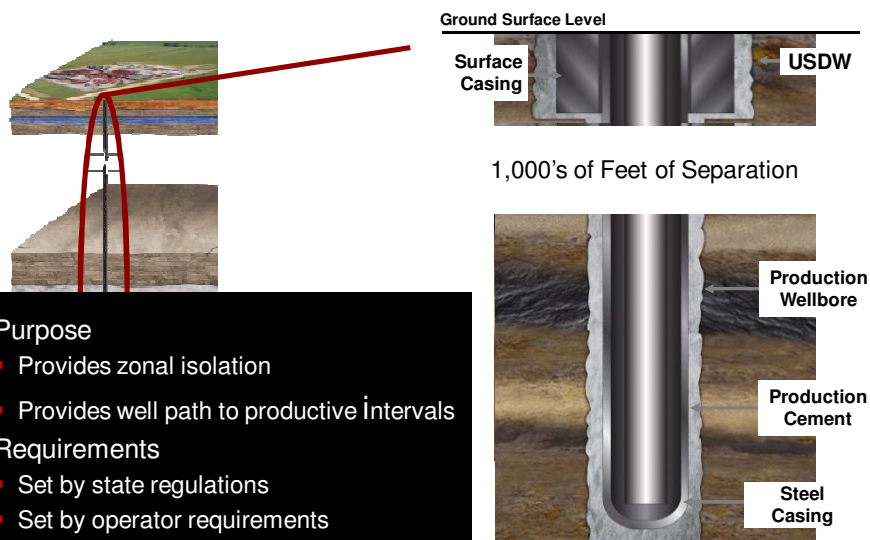
- Set by state regulations
- Typically 500 to 1,500 ft

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## Production Casing

### Well Construction



#### Purpose

- Provides zonal isolation
- Provides well path to productive intervals

#### Requirements

- Set by state regulations
- Set by operator requirements


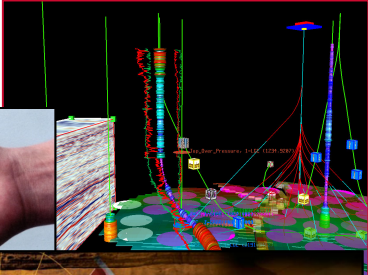

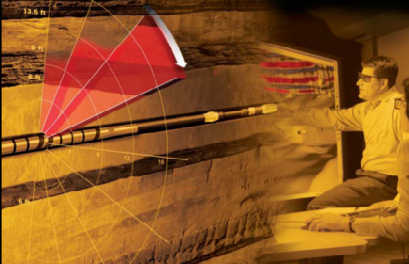
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### Geologic Location Methods

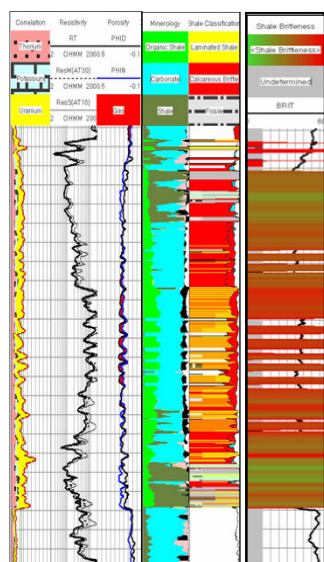
- Logging While Drilling
- Mud Logging
- Wireline
- Coring

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## Shale Brittleness Index



Shale brittleness index – Ease at which the formation will fracture.

Shale Brittleness  
 <Shale Brittleness>

Brittle Shale - Red (easier to frac)  
 Ductile Shale - Green (hard to frac)

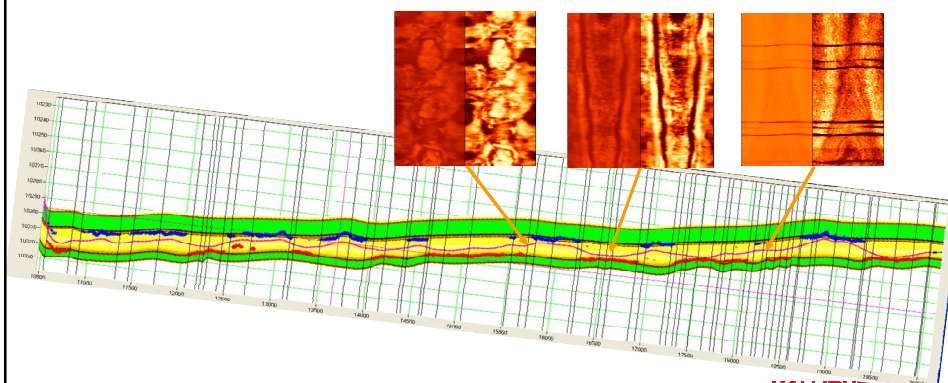
- Completion design
  - Frac Fluid Type
  - Frac Barriers
  - Frac Geometry
  - Packer Placement
  - Perforation Selection
  - Proppant Type

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## Optimized Wellbore Placement

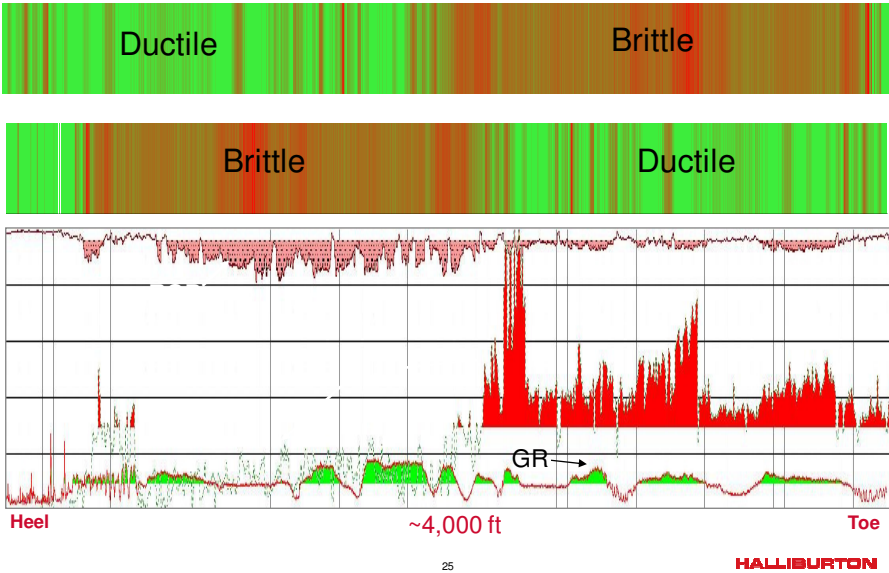
- Locating “Sweet Spot”
- Proper Placement of Completion
- Maximizing Production



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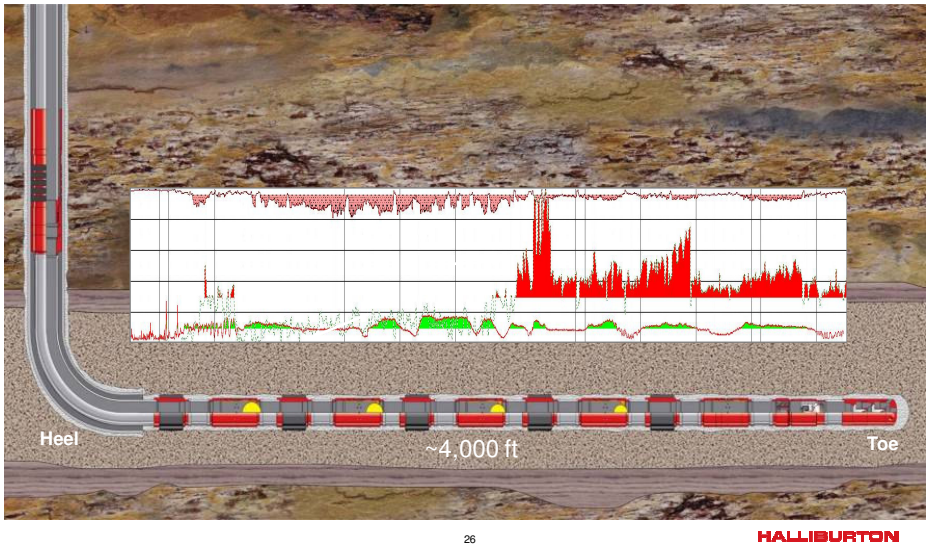
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Horizontal Design



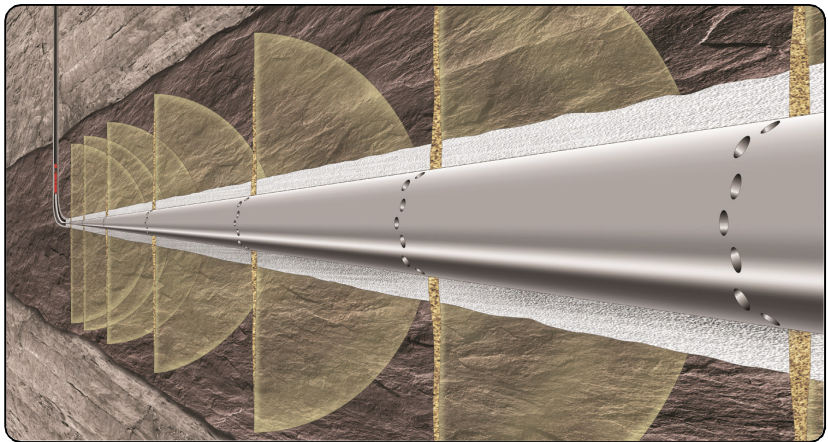
Completion Design

DELTA STIM SHALE VIDEO





Hydraulic Fractures  
*Precisely Placed*

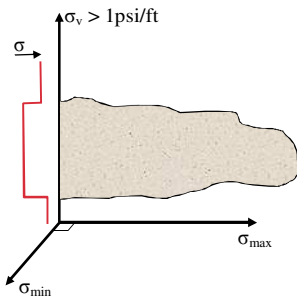


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Hydraulic Fracturing  
*An Engineered Process*

Hydraulic Fracturing  
Equation



$$\sigma_{\min} = \left[ \begin{matrix} \nu \\ 1 - \nu \end{matrix} \right] \left[ \sigma_z - \alpha_1 P_R \right] + \alpha_2 P_R + \sigma_{Tec}$$

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Fracture Design  
Pump Schedule

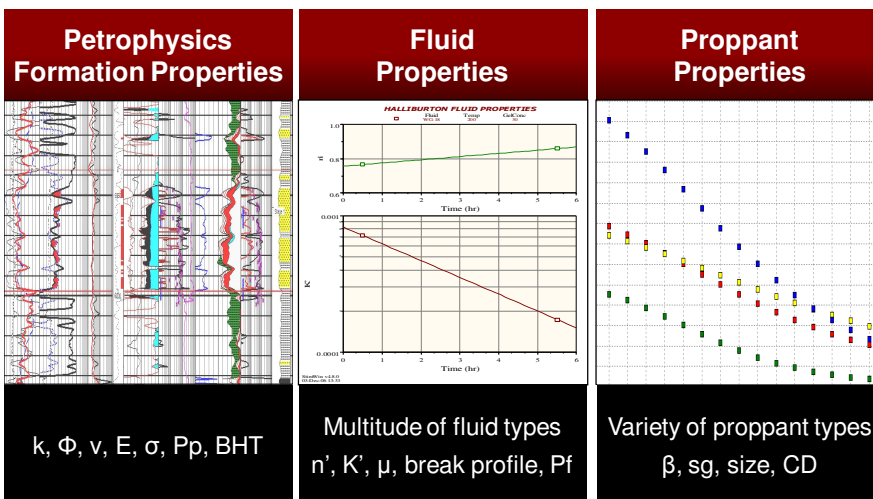
Stage #	Flow Path	Fluid System	Prop Type	Stage Time (min)
1 - 1	Shut-in			0
1 - 2	In	20# Water Frac G		39.3
1 - 3	In	20# Water Frac G	SAND - PREMIUM - 20/40, BULK, SK (100003678)	17.82
1 - 4	In	20# Water Frac G		6.39
1 - 5	In	15% Hydrochloric Acid		1.06
1 - 6	In	20# Water Frac G		16.46
1 - 7	In	20# Water Frac G	SAND-CRC PREMIUM- 20/40, BULK (101357961)	7.02
1 - 8	In	20# Water Frac G	SAND-CRC PREMIUM- 20/40, BULK (101357961)	10.32
1 - 9	In	20# Water Frac G	SAND-CRC PREMIUM- 20/40, BULK (101357961)	8.96
1 - 10	In	20# Water Frac G	SAND-CRC PREMIUM- 20/40, BULK (101357961)	6.31
1 - 11	In	20# Water Frac G		10.37
1 - 12	Shut-in			0

Total 124.01  
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## Fracture Design

### Data Required




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## Fracturing Fluids

### Technical Demands



Specific additives are used based on the requirements of the frac fluid

• Polymers	• Clay Control
• Crosslinkers	• Biocides
• pH Control	• Conductivity Enhancers
• Gel Breakers	• Fluid Loss Additives
• Surfactants	• Proppants

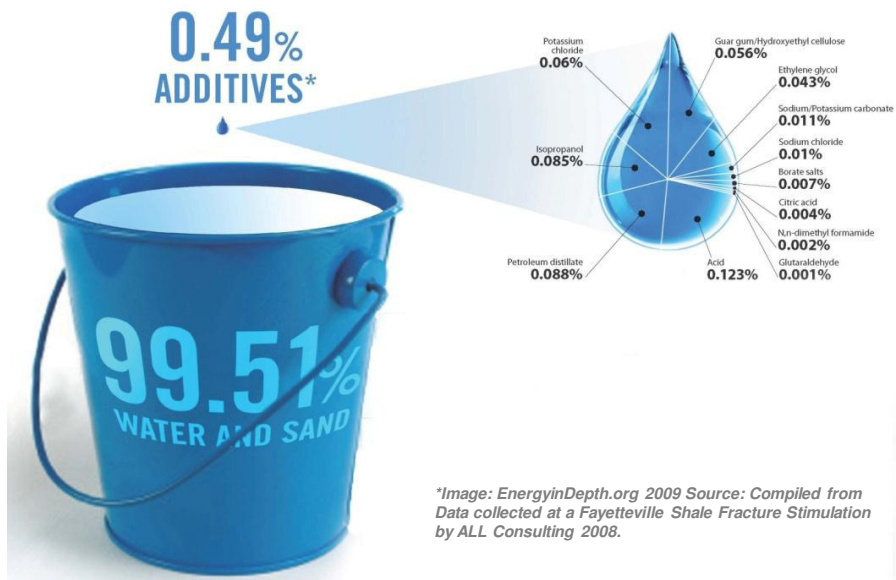
- All additive injection rates are controlled by advanced metering systems
- The purpose of any additive is to improve the overall effectiveness of the resulting fracture (i.e. productivity of the well)



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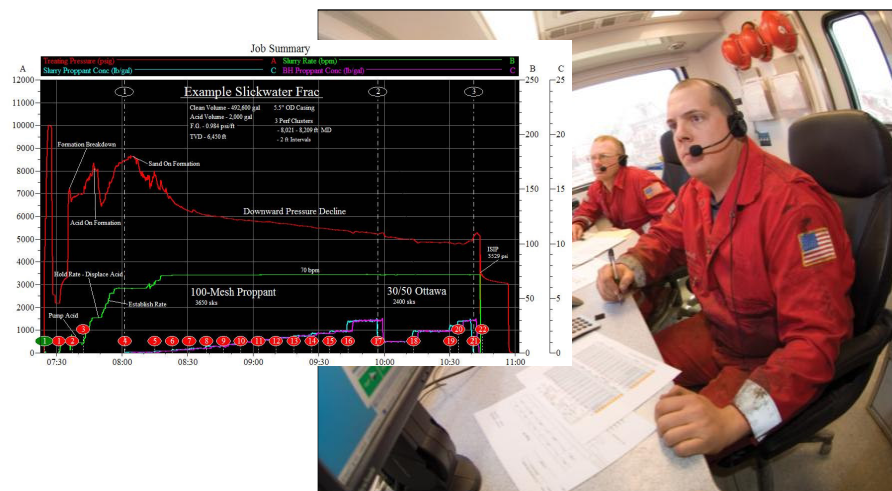
## Frac Fluid Composition



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## Fracture Treatment A Managed Process

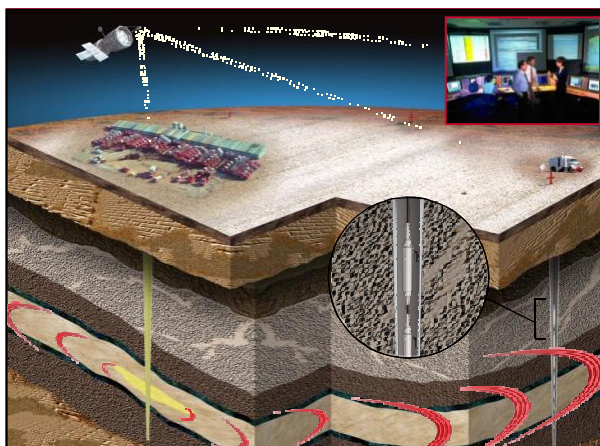


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## Fracture Evaluation *Microseismic Monitoring*

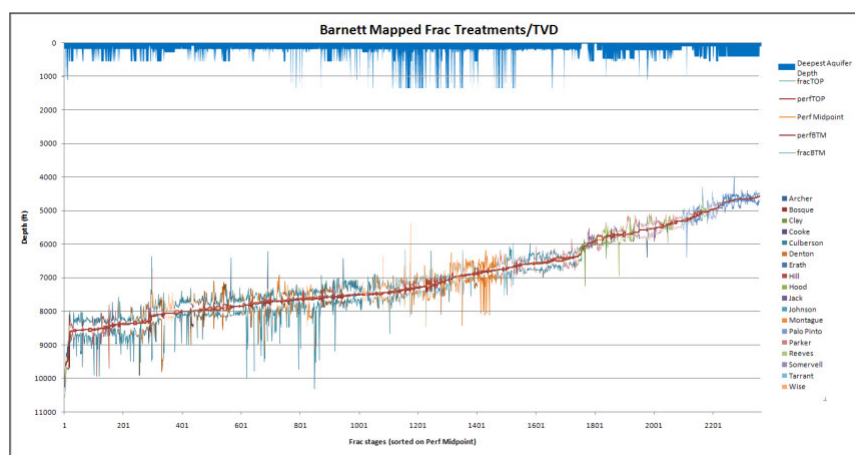
- Fracing process generates nano level microseismic events
- Geophones in monitor well identify and map precise location of events



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## Fracture Height Determination *Barnett*



Kevin Fisher, "Data Confirm Safety of Well Fracturing" *The American Oil & Gas Reporter* – July 2010







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




## Overarching US Debate

### *Federal Versus State Oversight*

<b>Federal</b>	Through bills such as the FRAC Act, legislators vie to regulate HF at the federal level	
<b>Diesel Regulation</b>	Waxman inquiry prompts EPA to expand regulatory guidance on diesel use in frac fluids	
<b>Federal Lands</b>	BLM reviewing operations and revising oil and gas regulations on federal lands	
<b>EPA Study</b>	EPA HF study to include water withdrawals, storage, treatment, disposal and recycling	
<b>SEAB</b>	Natural Gas Subcommittee recommendations on improved safety & environment in shale development	
<b>State</b>	State regulators are seeking to maintain primacy over Oil & Gas regulation	

## State Regulation

### *Under Review*





New York	De facto moratorium awaiting final SGEIS ruling in the Spring of 2012?	
Wyoming	Chapter 3 regulations address well construction and completions	
Pennsylvania	Chapter 78 regulations address well construction and completions	
Arkansas	Rule B-19 regulations address well construction and completions	
Texas	HB 3328 proposes new standards for disclosure	
California	AB 591 proposes new legislation on upstream activities including HF disclosure	

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## International Arena

### *Challenges and Opportunities*

France	Legislation recently enacted to ban the use of hydraulic fracturing & possibly all E&P activities.	
Poland	Adopted legislation regarding the issuance of permits to drill which should facilitate shale gas development.	
European Union	EU reviewing position on unconventional E&P activities including HF.	
Australia	Queensland, WA and New South Wales introducing legislation regulating oil and gas activities.	

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## Support and Information

### STRONGER

In-depth peer review of the HF regulatory programs in OH, PA, OK, LA and CO



### API

Hydraulic Fracturing microsite contains detailed fluid information and educational material



### IOGCC/GWPC

FracFocus website operational & making well by well information available to the public



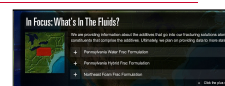
### Energy In Depth

Energy In Depth launches new grassroots initiatives in northeast PA, southern NY and eastern Ohio



### Halliburton

Hydraulic Fracturing microsite contains detailed fluid information and educational material



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## State Review of Oil and Natural Gas Environmental Regulations



- A non-profit corporation established to educate regulators and members of the public as to the appropriate elements of state oil and gas environmental regulatory programs.
- Administers the State Review Process - an open, multiple stakeholder process that reviews state oil and gas regulatory programs against national guidelines and makes recommendations for program improvements.
- Ohio, Pennsylvania, Louisiana, Oklahoma and Colorado have recently been reviewed by STRONGER.

[www.strongerinc.org](http://www.strongerinc.org)

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**American Petroleum Institute**  
**HF Guidance Documents**



- **HF 1 – Hydraulic Fracturing Operations – Well Construction and Integrity Guidelines**
  - Highlights industry practices for well construction and integrity for wells that will be hydraulically fractured.
  - The guidance identifies actions to protect shallow groundwater aquifers.
- **HF 2 – Water Management Associated with Hydraulic Fracturing**
  - Identifies best practices used to minimize environmental impacts associated with the acquisition, use, management, treatment and disposal of water and other fluids associated with the process of hydraulic fracturing.
  - Focuses primarily on issues associated with hydraulic fracturing pursued in deep shale gas development, but also describes the important distinctions related to hydraulic fracturing in other applications.

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**American Petroleum Institute**  
**HF Guidance Documents**



- **HF 3 – Practices for Mitigating Surface Impacts Associated with Hydraulic Fracturing**
  - Identifies the best practices for minimizing surface environmental impacts associated with hydraulic fracturing operations.
  - Focuses on protecting surface water, soils, wildlife, other surface ecosystems, and nearby communities.
- **RP 51R - Environmental Protection for Onshore Oil and Gas Production Operations and Leases**
  - Provides environmentally sound practices and reclamation guidelines for all domestic onshore oil and gas production operations.
  - Begins with the design and construction of access roads and well locations prior to drilling, and extends to reclamation, abandonment, and restoration operations.
  - The guidance applies to all production facilities including produced water handling and gas compression facilities.

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**GWPC/IOGCC Chemical Registry**  
*FracFocus*



- Publicly available frac data on a well by well basis
- Supports States in disclosure discussions
- Standardized format for all operators
- Provides information on state regulations and educational material

As of January 5<sup>th</sup>, 2012 there were over 9,300 records in the system and 100 participating companies.

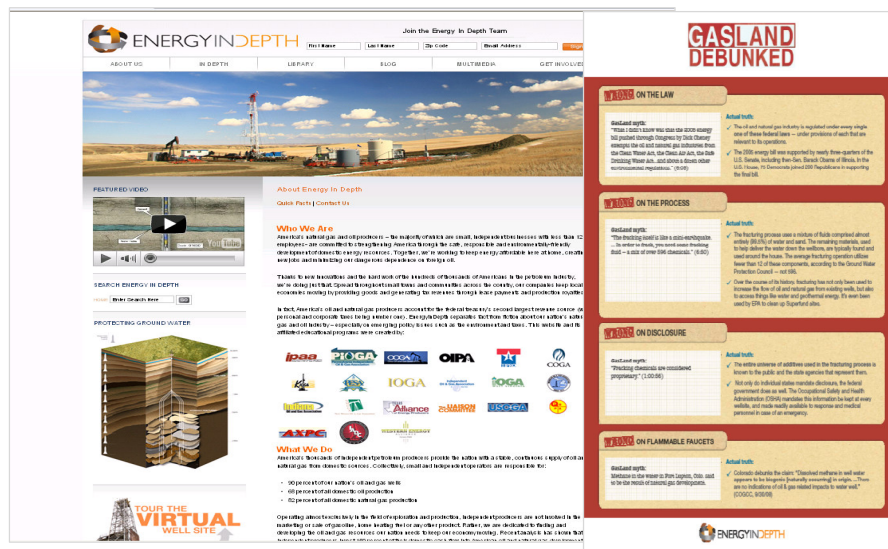
[www.FracFocus.org](http://www.FracFocus.org)

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## Energy in Depth

### *Resource for Information*



[www.Energyindepth.org](http://www.Energyindepth.org)

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## Halliburton Outreach HF Microsite

**Hydraulic Fracturing**

An “overnight” triumph of science and engineering, 60-plus years in the making. Today, it’s being used to redefine what’s possible in accessing clean-burning energy resources deep underground. What will it help us do tomorrow? Click around to find out.

**Hydraulic Fracturing 101**

Sand, water and pressure: the basic components of building a great sandcastle, and the same ones being used today to spur a revolution in the way Americans access and utilize clean-burning energy resources confined deep underground.

At the forefront of this revolution is a technology known as hydraulic fracturing, a well stimulation practice first pioneered by Halliburton in the 1940s –

**In-Focus: What’s in the Fluids?**

Even though sand and water typically comprise more than 99.5 percent of the fluid system used in fracturing, getting that fluid to formations thousands of feet underground requires advanced chemistry and engineering to do things like:

- Fight the growth and buildup of bacteria in the fluid and the wellbore.

**CleanSuite™ Technologies**

Halliburton invests considerable time, energy and resources in engineering solutions that set new standards for environmental safety – all while helping our customers do more by using less.

- CleanStim™ Formulation, a fracture fluid system comprised of materials sourced entirely from the food industry.

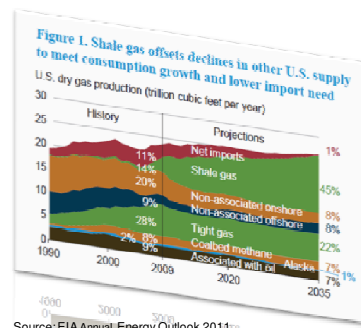
[www.Halliburton.com/HydraulicFracturing](http://www.Halliburton.com/HydraulicFracturing)

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## Conclusion

- Across the US, abundant natural gas is being enabled by hydraulic fracturing and other technologies
- Hydraulic fracturing is a safe and well understood process with a long and proven track record
- Well construction and sound engineering practices are the keys to protecting ground water
- Technological advancements are making real impacts in reducing the industry’s overall footprint
- With scientifically based and balanced regulations shales can be developed in an environmentally sensitive and cost effective manner



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Thank You!

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Public Debate

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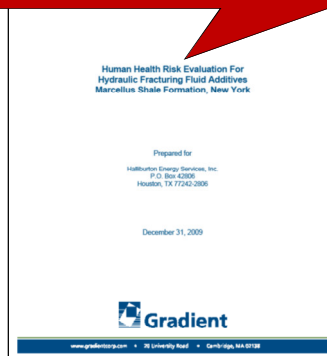


## Studies Show No Plausible Risk From Subsurface Migration of Frac Fluids



"Based on the information collected and reviewed, EPA has determined that the injection of hydraulic fracturing fluids into CBM wells poses little or no threat to USDWs."

The migration of hydraulic fracturing fluids from the Marcellus Shale to an overlying groundwater aquifer is "an implausible contamination pathway."



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## HF Process Is Not Polluting Drinking Water

- HF has been used for over 60 years with no confirmed instances of contamination
  - Numerous U.S. state regulators and USEPA have repeatedly affirmed that they are not aware of any instances of HF resulting in contamination of drinking water aquifers
  - EPA studies have shown no adverse impacts

Lisa Jackson

"I'm not aware of any proven case where the fracking process itself has affected water, although there are investigations ongoing."

**American Thinker**  
*Editor: Dr. Andrew*

May 26, 2011

### EPA Administrator confirms no water contamination from fracking

Steve Schwert and Thomas Lifson  
It is close to an article of faith on the left that any hydrocarbon-based source of energy must cause severe pollution problems. The extraordinary benefits to America from cheap natural gas released by the fracking technique have been fought with ground-up propaganda about purported water pollution.

But yesterday, under oath, EPA Administrator Lisa Jackson admitted that there have been no (in 2011) instances of ground water contamination from fracking, despite the propaganda that has convinced many progressives that fracking is a devil's bargain. Watch the video in which Jackson states: "The last source of any proven case where the fracking process itself has affected water, although there are investigations ongoing."

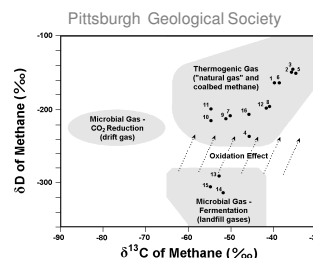


If energy has become the focus, shared against cheap natural gas. The global economy cannot rely on oil and coal against natural gas, which does produce CO2 (and as we all do when we breathe). But other than CO2, combustion of natural gas produces water vapor, but no SO2, no mercury, really no pollution to speak of at all. And America has centuries' worth of natural gas, easily accessed. It is one economic act in the hole, a resource lacking in China, Japan, Europe, and one other economic crisis.

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## Naturally Occurring Methane

- Methane is *naturally* present in up to 30% of all drinking water wells in the US
- USGS - naturally occurring methane is present in over 75% of water wells in West Virginia
- Images of "flaming faucets" from naturally occurring methane found in shallow formations

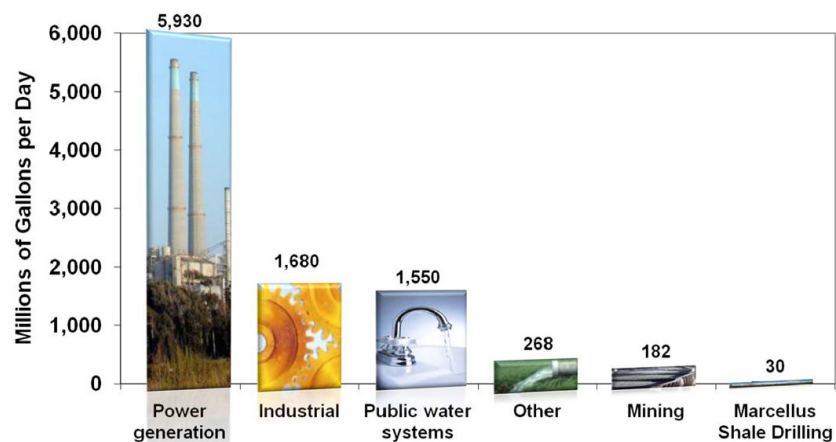


"The documentary Gasland has attracted wide attention. The Colorado Oil and Gas Conservation Commission (COGCC) would like to correct several errors in the film's portrayal of the Colorado incidents."

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## Water Use Comparison Shale Gas Development < 1%

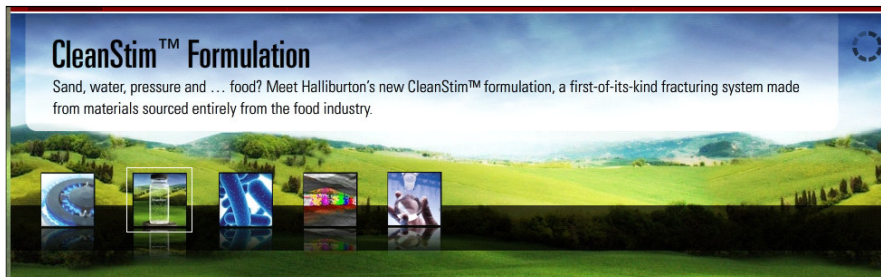


Source: USGS

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## Fluid Technology

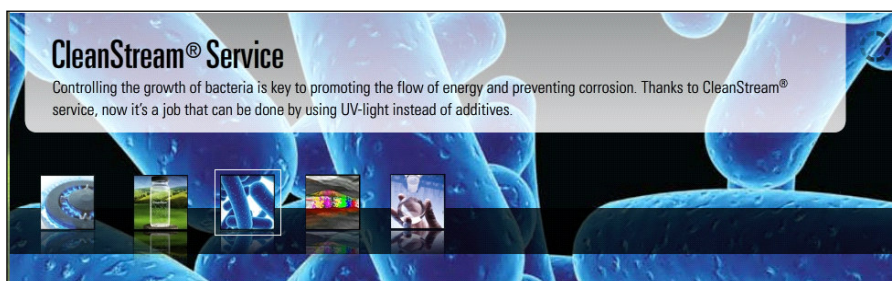


- A clean, low-impact fracturing fluid system
- All ingredients sourced from the food industry

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## Mechanical Solutions

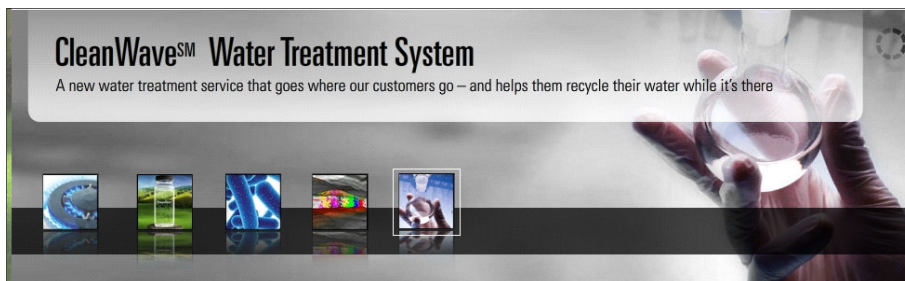


- Uses ultraviolet light to control bacteria in fracturing fluid
- Minimizes or even eliminates biocides

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## Water Management

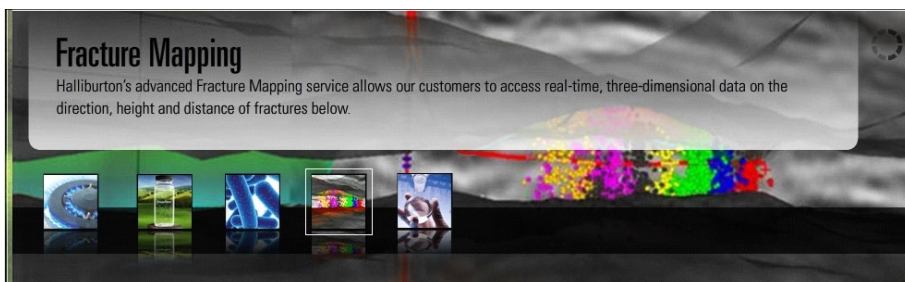


- Electrocoagulation process increases recycling and re-use
- Reduces volume of fresh water required for fracs

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## Fracture Optimization



- Enhances understanding of fracture location
- Assists in maximizing stimulated reservoir volume

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