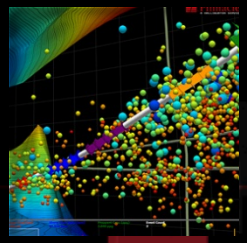
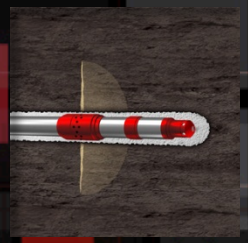
2013 TECHNOLOGY





Hydraulic Fracturing
The Power of Technology

MR. MIKE WATTS
Director Stimulation Affairs

Solving challenges.™

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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

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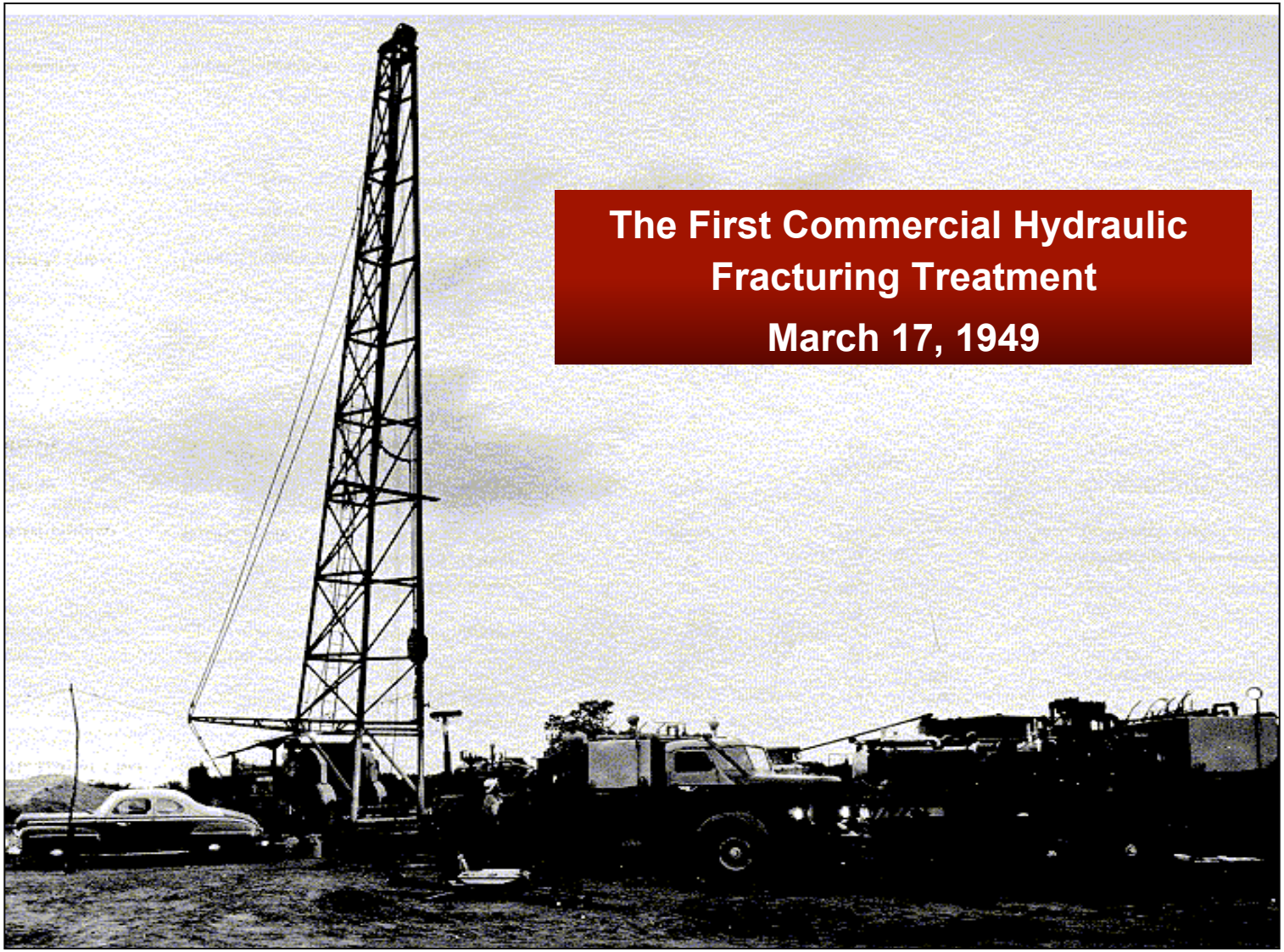
Velma, Oklahoma



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Overarching US Debate - Federal Versus State Oversight

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

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State Regulation - Under Review

Wyoming	Chapter 3 regulations address well construction and completions – Lawsuit over disclosure
Pennsylvania	Chapter 78 regulations address well construction and completions activities
Colorado	Rule 205-A ruling sets the standard for HF chemical disclosure through FracFocus
Texas	HB 3328 regulation expands guidelines for HF chemical disclosure through FracFocus
California	SB 4 enacts new requirements for well stimulation in oil and gas activities across the state
Alaska	The Alaska Oil and Gas Conservation Commission (AOGCC) proposes regulations governing hydraulic fracturing activities

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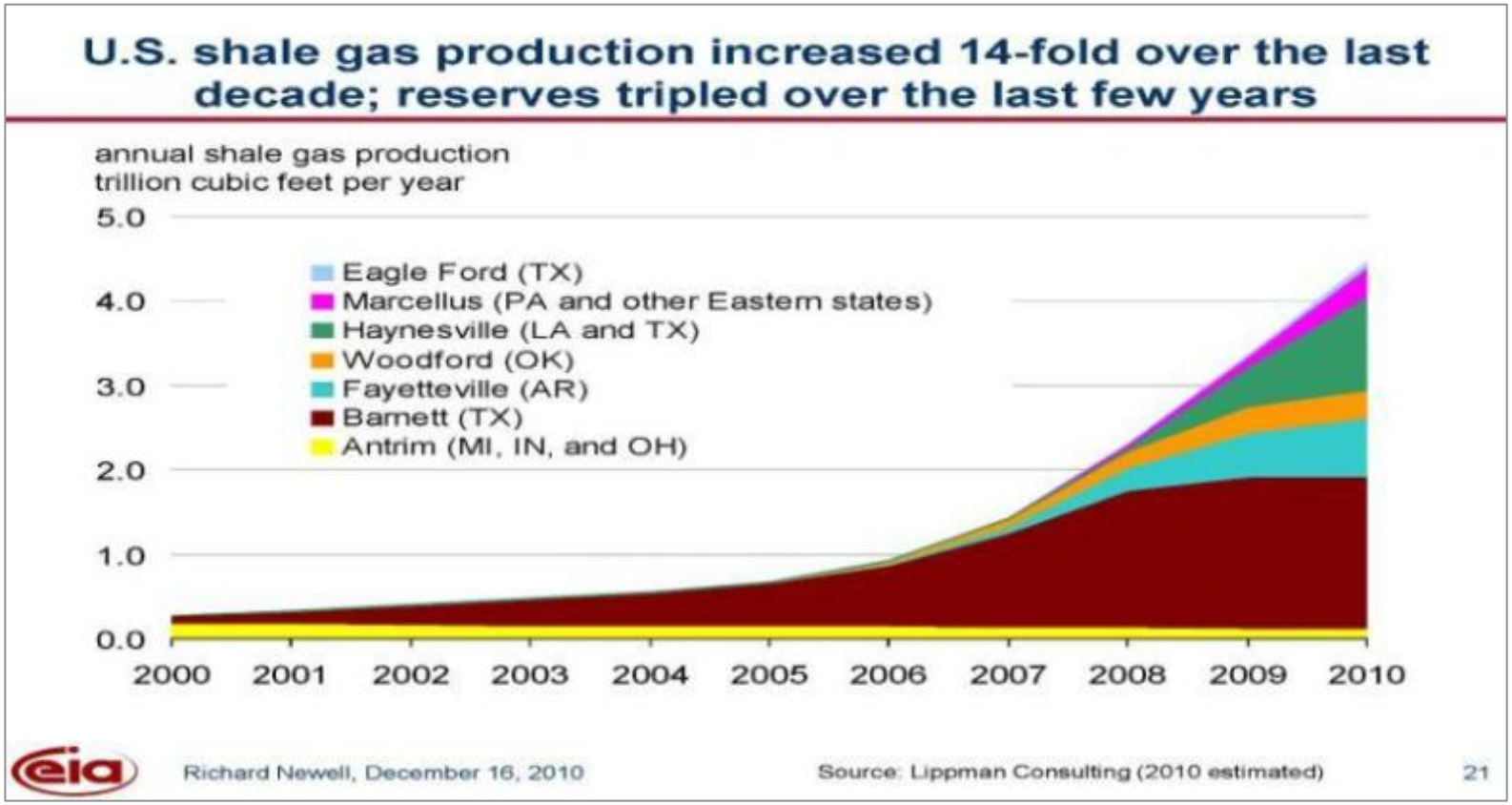
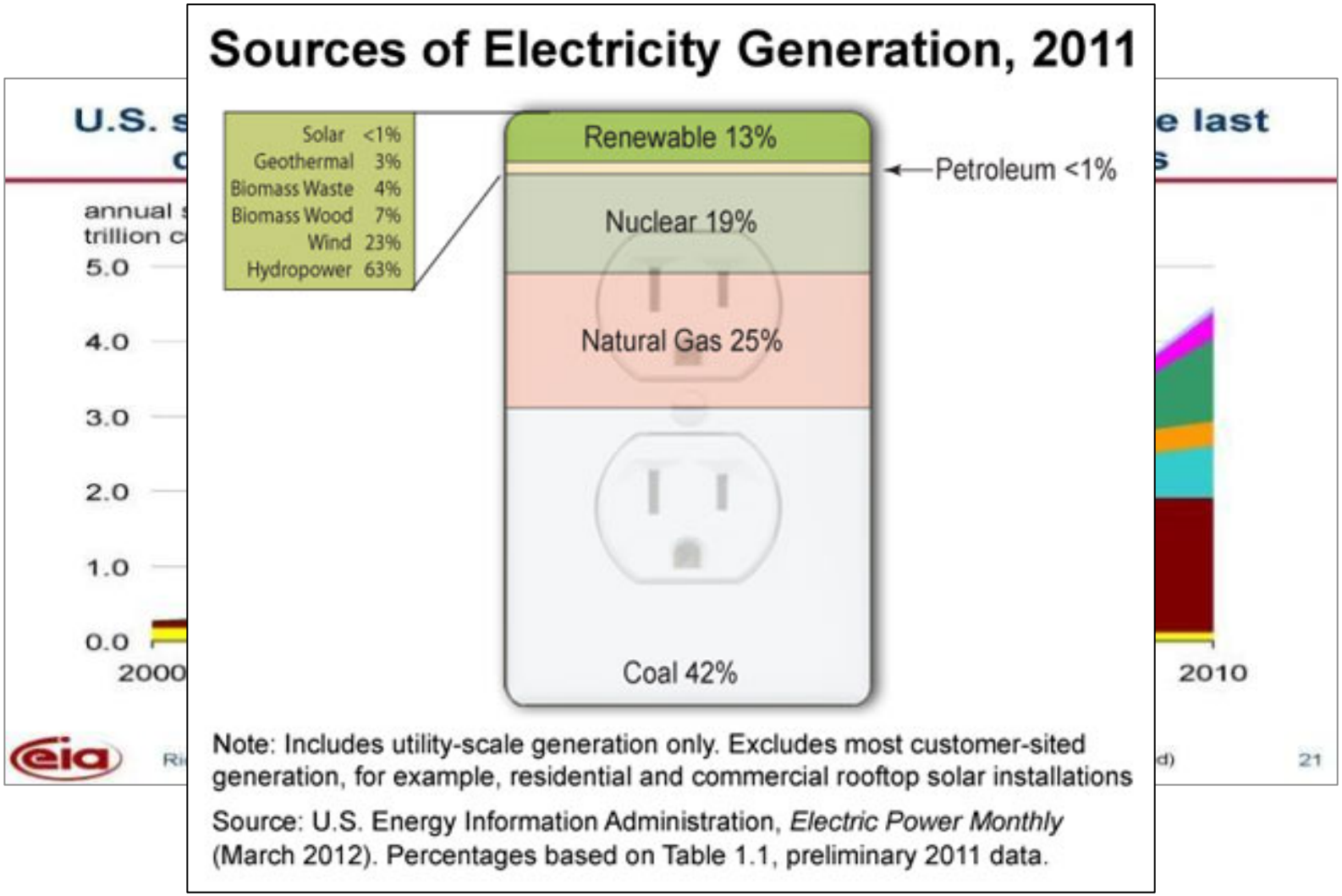
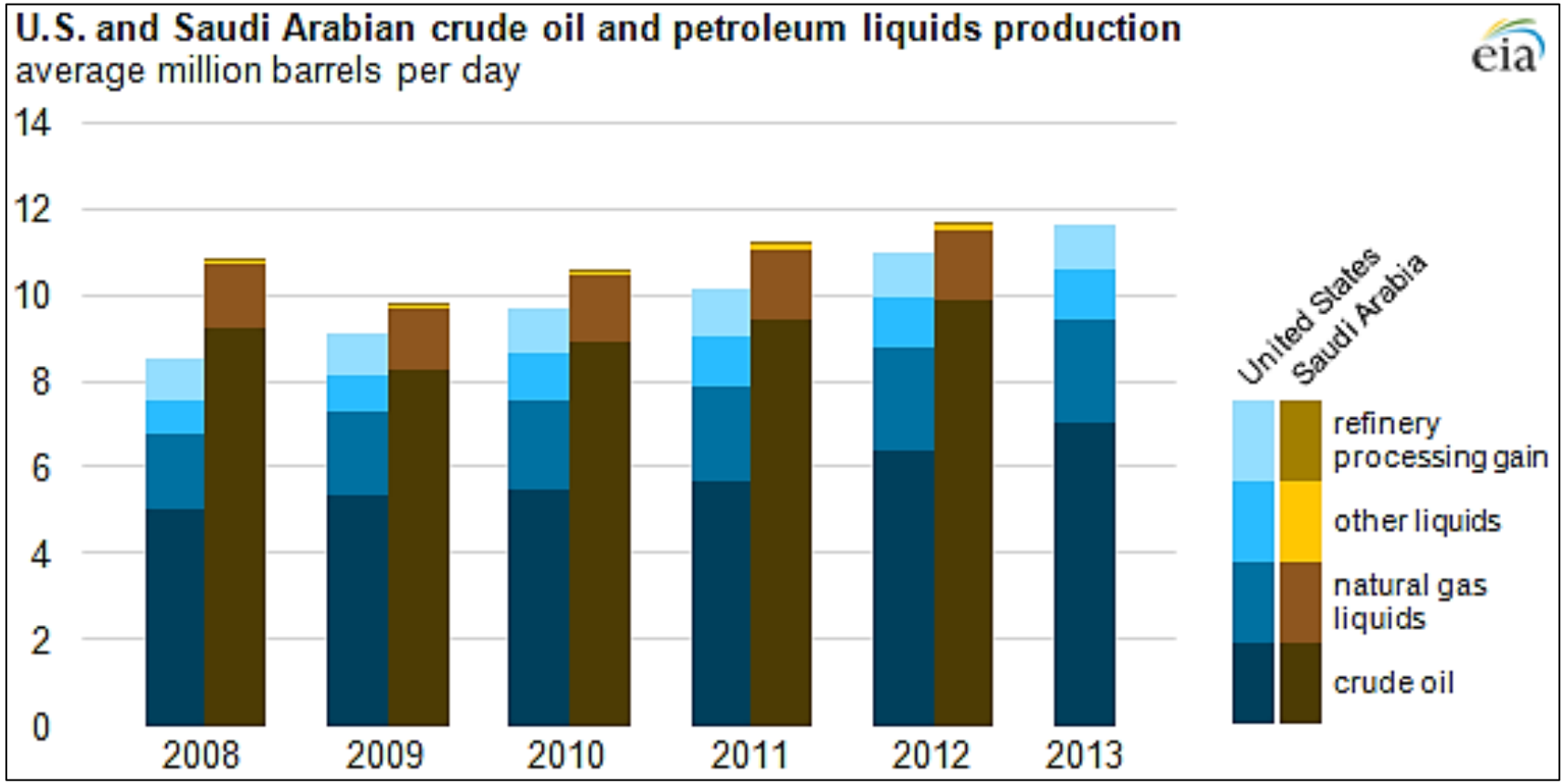
Shale Gas – Game Changer



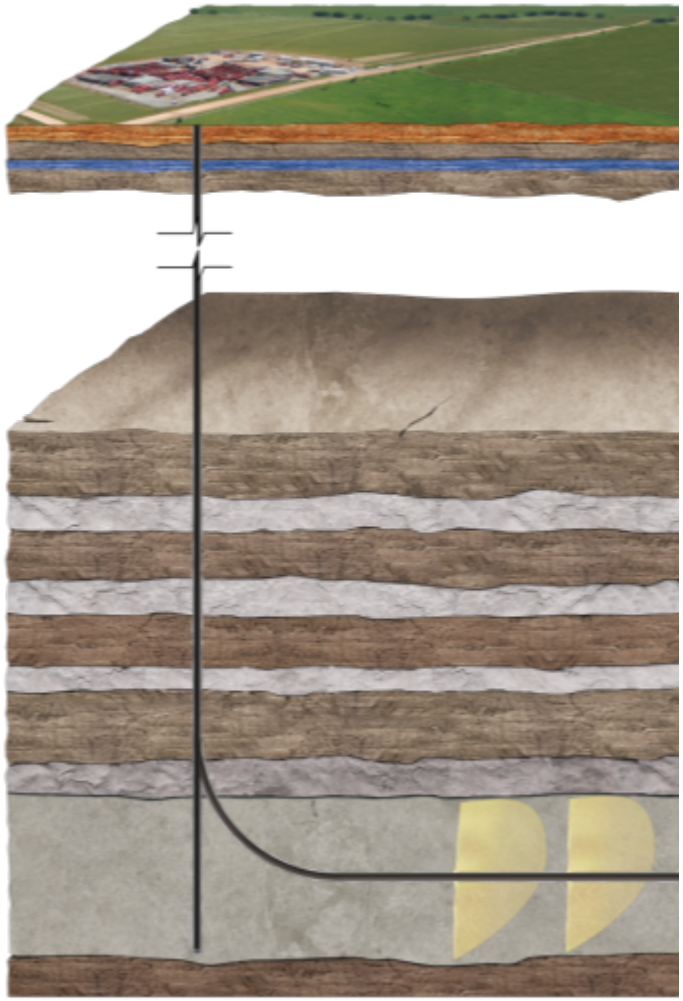
Shale Gas – Benefits



Oil Development – Equally Compelling

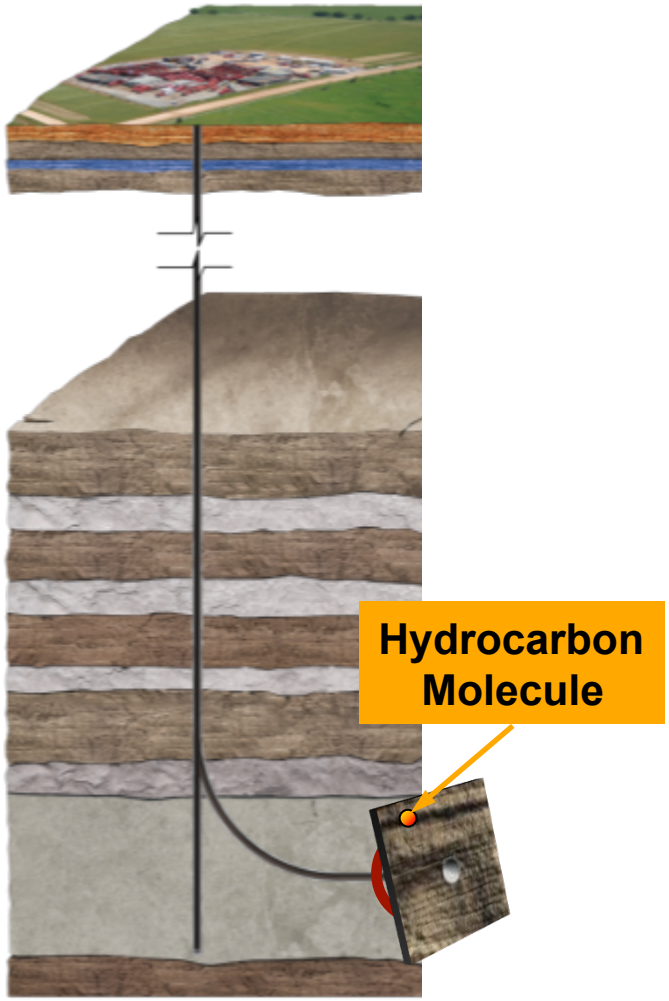


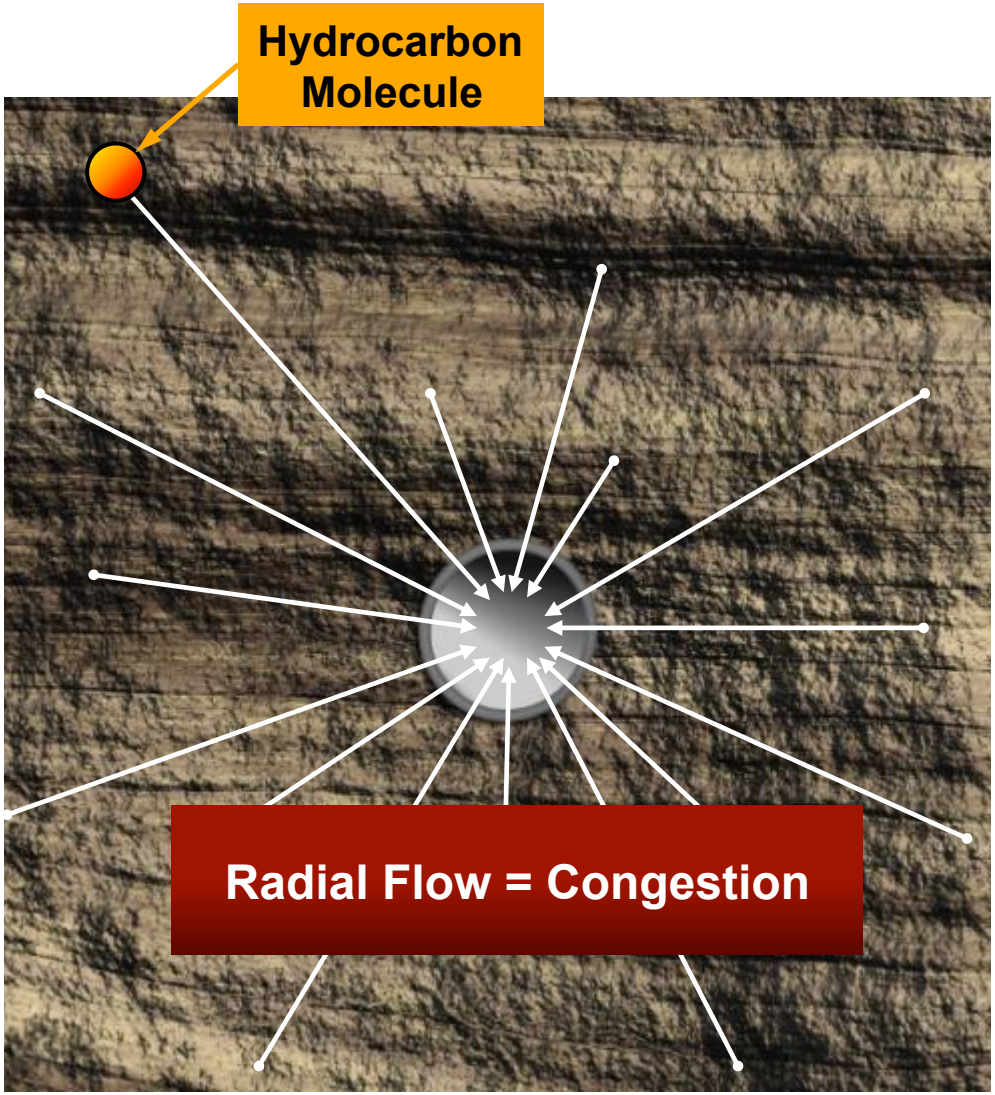
What is “Hydraulic Fracturing?”



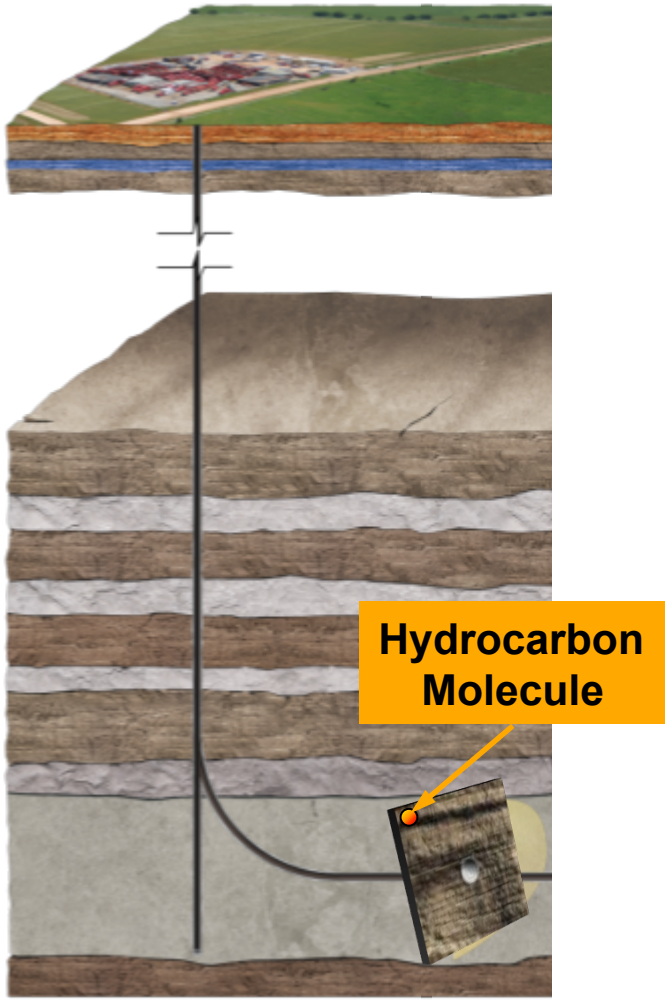
- Hydraulic Fracturing:
  - The use of fluids to create a pathway to the wellbore
  - The placement of small granular solids into the pathway to ensure that it remains open after the hydraulic pressure is removed
- Objective:
  - Increase the rate at which the well is capable of producing oil or gas
  - Increase the economically recoverable reserves for a well

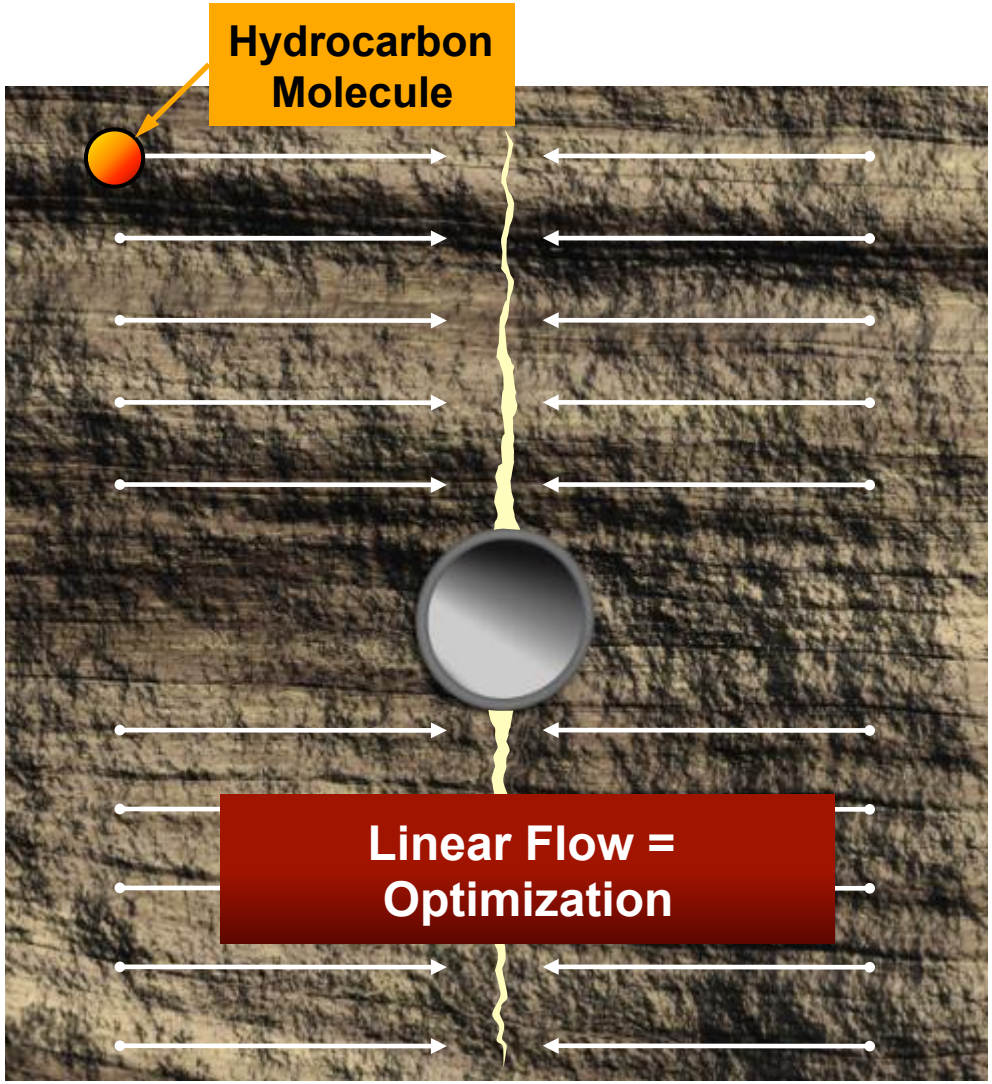
Why We Use HF - Radial Flow



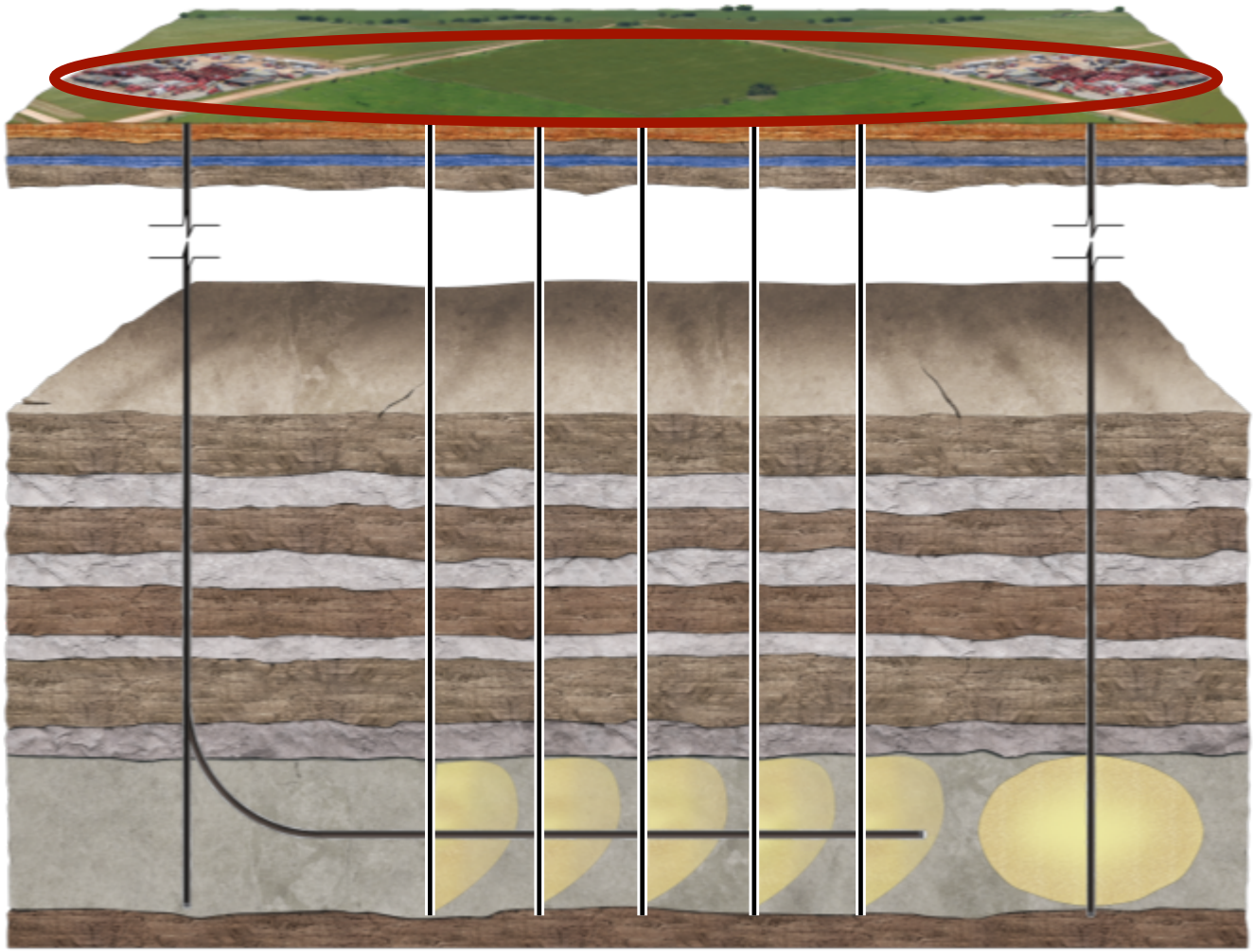


Why We Use HF - Linear Flow





Benefits – Vertical Versus Horizontal Wells

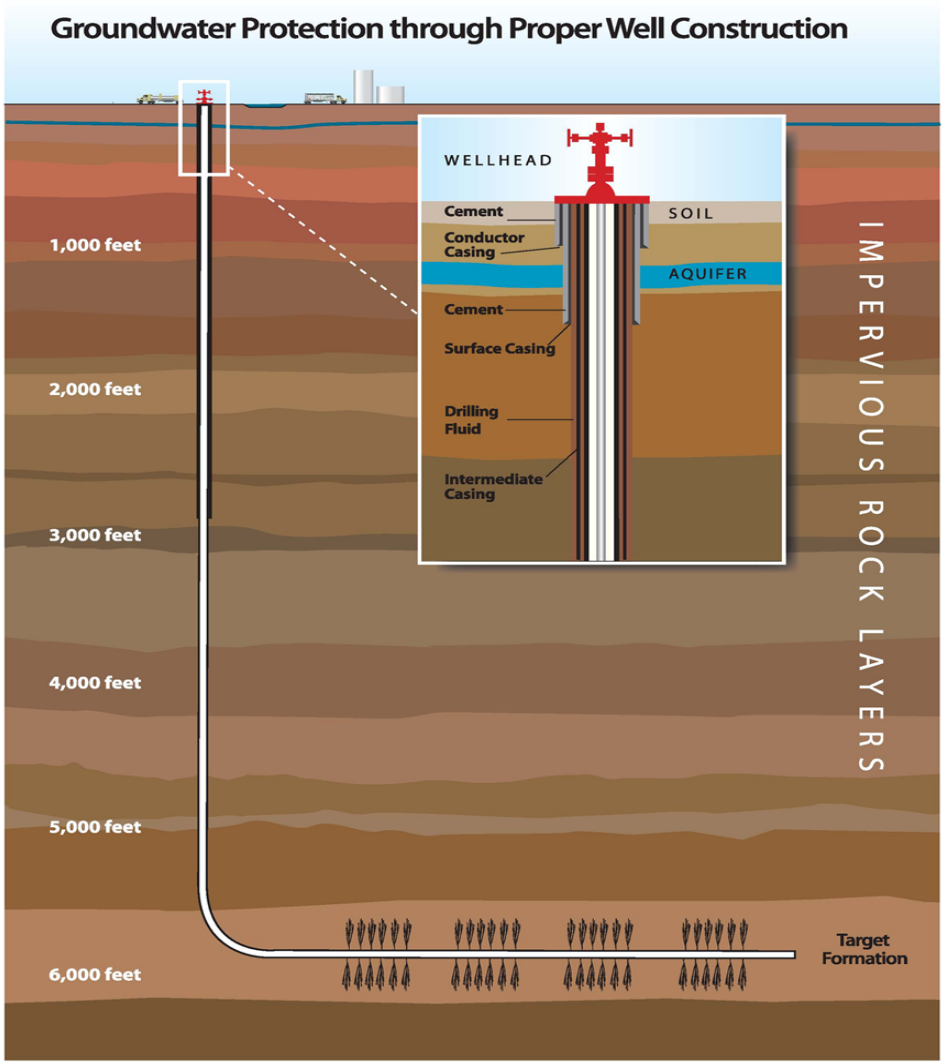


- Increase contact area of formation
- Improve efficiency and economic viability
- Reduce surface footprint

Well Construction – Protecting Ground Water

Multiple layers of cement and steel casing

- Isolate and protect ground water
- Bond and support casing strings
- Restrict fluid movement between formations



FracFocus – Chemical Disclosure Registry

- Publicly available information on a well by well basis
- Standardizes reporting for all fracturing operations
- Supports multiple state disclosure efforts
- Provides information on state regulations and educational material

www.FracFocus.org

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FracFocus – Deeper Look

Hydraulic Fracturing Fluid Product Component Information Disclosure

Job Start Date:	12/3/2012
Job End Date:	12/6/2012
State:	Pennsylvania
County:	Bradford
API Number:	37-015-22148
Operator Name:	VE Producer
Well Name and Number:	Test Well #1
Longitude:	-76.22389500
Latitude:	41.80361300
Datum:	NAD27
Federal Well:	NO
Total Base Water Volume (gal):	6,290,802
Total Base Non Water Volume:	

Chemical Description

Maximum Concentration

Hydraulic Fracturing Fluid Composition:

Trade Name	Supplier	Purpose	Ingredients	Chemical Abstract Service Number (CAS #)	Maximum Ingredient Concentration in Additive (% by mass)**	Maximum Ingredient Concentration in HF Fluid (% by mass)**
water	VE Chem	carrier				
			H20	7732-18-5	100.00	90.59700
sand	VE Chem	proppant				
			crystalline silica	14808-60-7	100.00	8.48850
15% HCl	Veil Chem	acid				
			hydrochloric acid	7647-01-0	15.00	0.13219
FRA-405	Clearwater	Friction reducer				
			petroleum distillates	64742-47-8	27.50	0.02385
			sodium chloride	7647-14-5	7.50	0.00651
			ammonium chloride	12125-02-9	5.00	0.00434

FracFocus
Chemical Disclosure Registry

Environmentally Focused Energy Development

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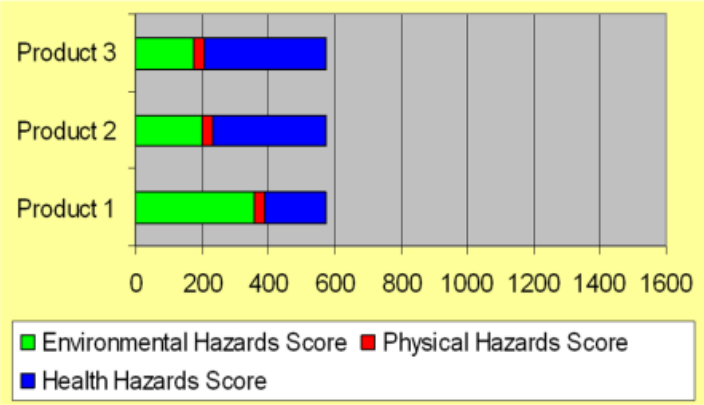
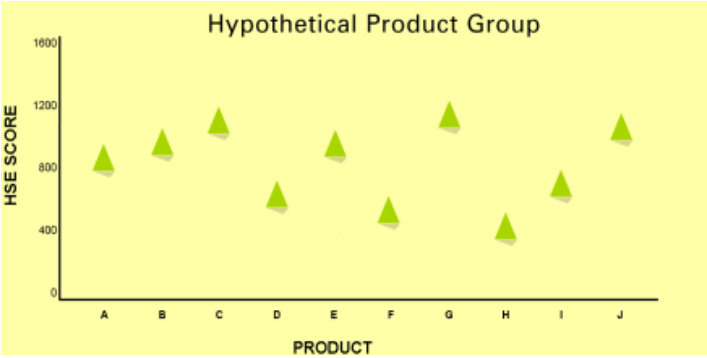
Environmental Advancements In Fracturing

Chemistry Scoring Index (CSI)

- Assess Health, Safety and Environmental hazards of products
- Considers relative hazards in formulating new products
- Can be adopted by entire industry





Health → Safety → Environmental

Environmental Advancements In Fracturing

CleanStim™ Formulation

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

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Environmental Advancements In Fracturing

CleanStream® Service

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

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Environmental Advancements In Fracturing

CleanWave® Service

- Electrocoagulation process
- Minimizes chemical usage
- Reduces the volume of fresh water for fracturing treatments

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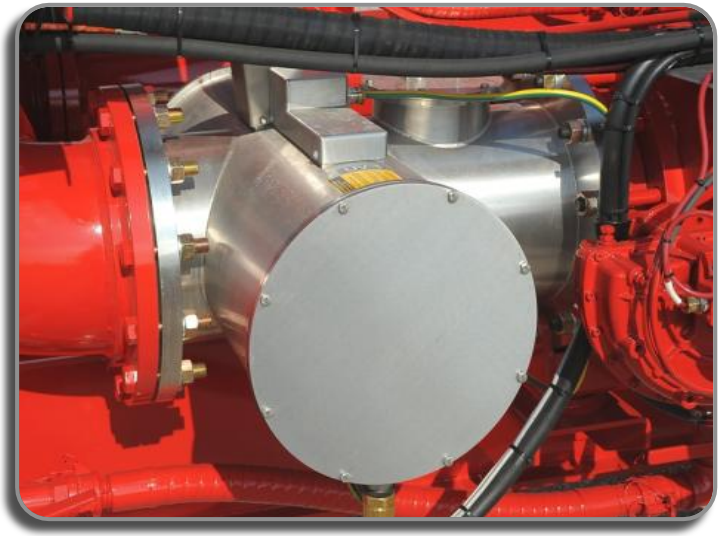
Advancing Water Life Cycle Management

H2OForward℠ Service

- Effective Water Treatment
- Effective Biocide
- State of the Art Fluid Formulation (High TDS)
- Enhanced Scale Modeling

Benefits

- Reduces Fresh Water Demand
- Increases Produced Water Recycling
- Reduces Volume of Fluids for Disposal
- Reduces Trucking Across the Water Life Cycle



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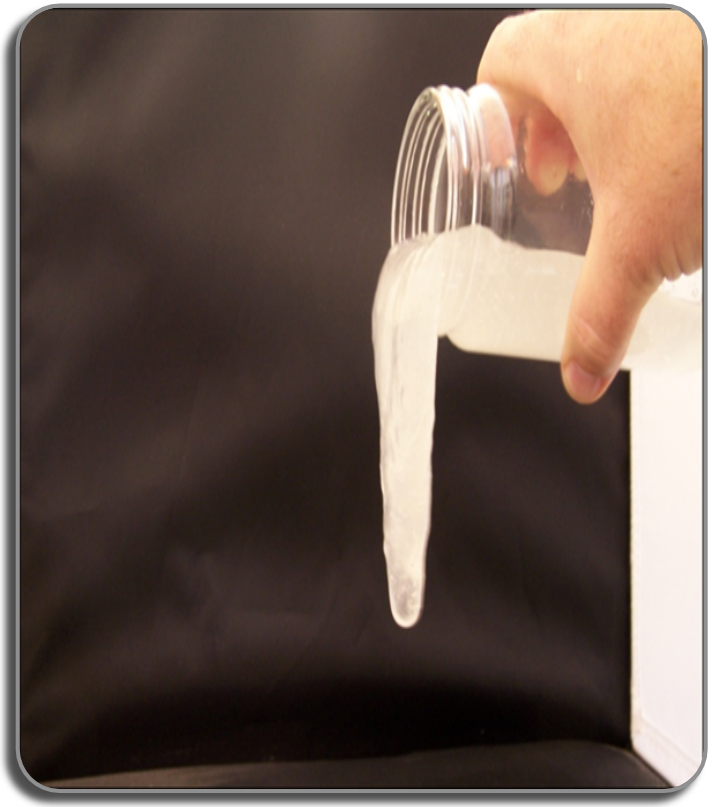
UniStim™ Fracturing Fluid Service

UniStim™ Service

- High performance fluid system that enables the use of 100% produced or flowback water
- Crosslinked gelled system that tolerates salt concentrations in excess of 300,000 ppm



2013 Papers on High TDS Recycle Produced Water

- SPE #163824

  "Development and use of High TDS Recycled Produced Water for Crosslink-Gel Based Hydraulic Fracturing"

- SPE #165085

  "Effects of Total Suspended Solids on Permeability of Proppant Pack"

- JPT Magazine Technology Update, June 2013

  "Treatment Enables High-TDS Water Use as Base Fluid for Hydraulic Fracturing"

- SPE # 165641

  "Recycling Water: Case Studies in Designing Fracturing Fluids Using Flowback, Produced, and Nontraditional Water Sources"

Tomorrow's Fracturing Location

- ✓ Industry leading reliability
- ✓ Highly efficient operations
- ✓ Safe and easy to the wellhead
- ✓ Effective land usage
- ✓ Environmental responsibility
- ✓ Remotely operable

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Environmental Advancements In Fracturing

ADP™ Advanced Dry Polymer Blender

- Introduces gelling agent in dry powder form into fracturing fluids
- Eliminates the large volumes of carrier fluids

Environmental Advancements In Fracturing

SandCastle™ Storage Bins

- Solar power
- Gravity feed
- Smart inventory control
- Reduces location size
- Eliminates diesel power pack

Frac of the Future – Alaska Today

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Remote Operations Centers Drive Efficiency

- Successfully overcoming the challenge of distance
- Reduces manpower and vehicles at wellsite
- Provides rapid access to technical expertise
- Improves repeatability and training

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Comprehensive Environmental Stewardship

CleanStream®

Ultra-violet light to control bacteria

Treated > 860 million gallons of water eliminating 129,000 gallons of biocide

CleanWave™

Electrocoagulation to recycle water for fracturing process

Recycled > 31 million gallons water saving 7,400 truck loads

ADP™ Blender

Dry powder gelling agent to eliminate carrier fluids

Eliminated > 30 million gallons of mineral oil from fracturing operations

SandCastle®

Solar energy and gravity rather than diesel power

Saved > 1.4 million gallons of diesel and avoided 31 million pounds of CO_2

Dual fuel technology

Powering equipment with a blend of diesel and natural gas

2012 Statistics

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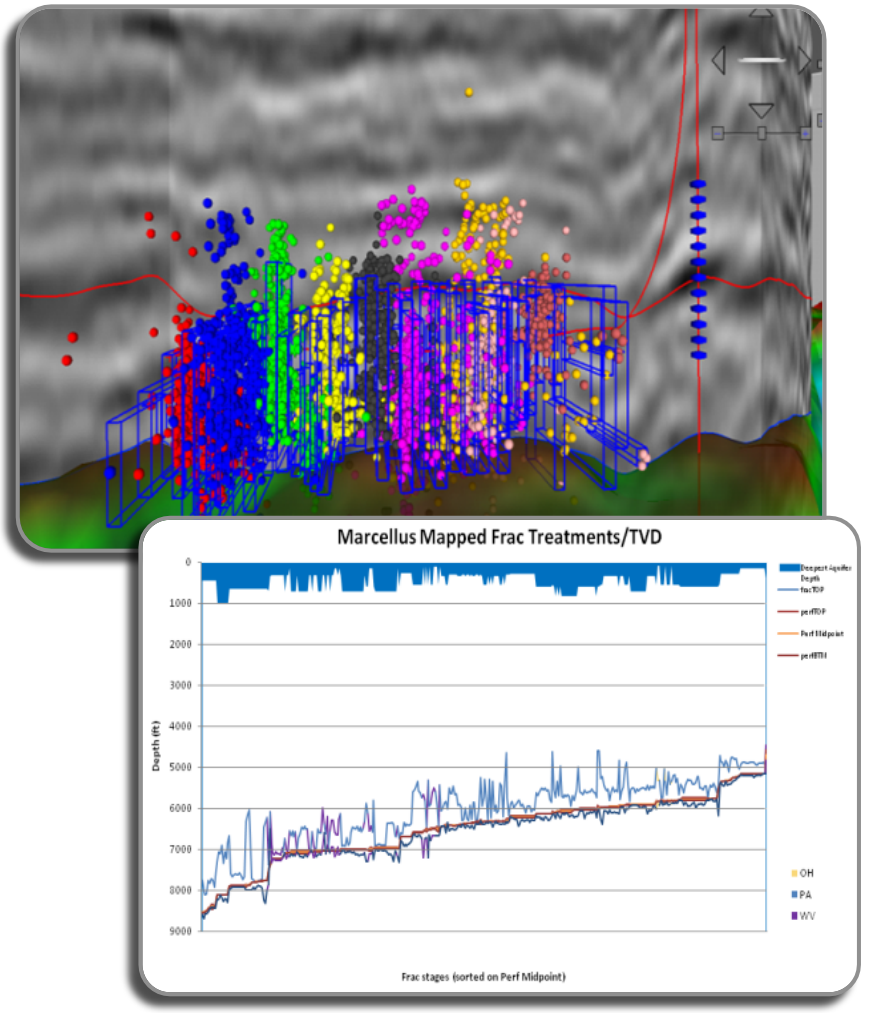
Environmental Advancements In Fracturing

Microseismic Fracture Mapping

- Enables understanding and controlling where the fractures are located
- Helps maximize stimulated reservoir volume



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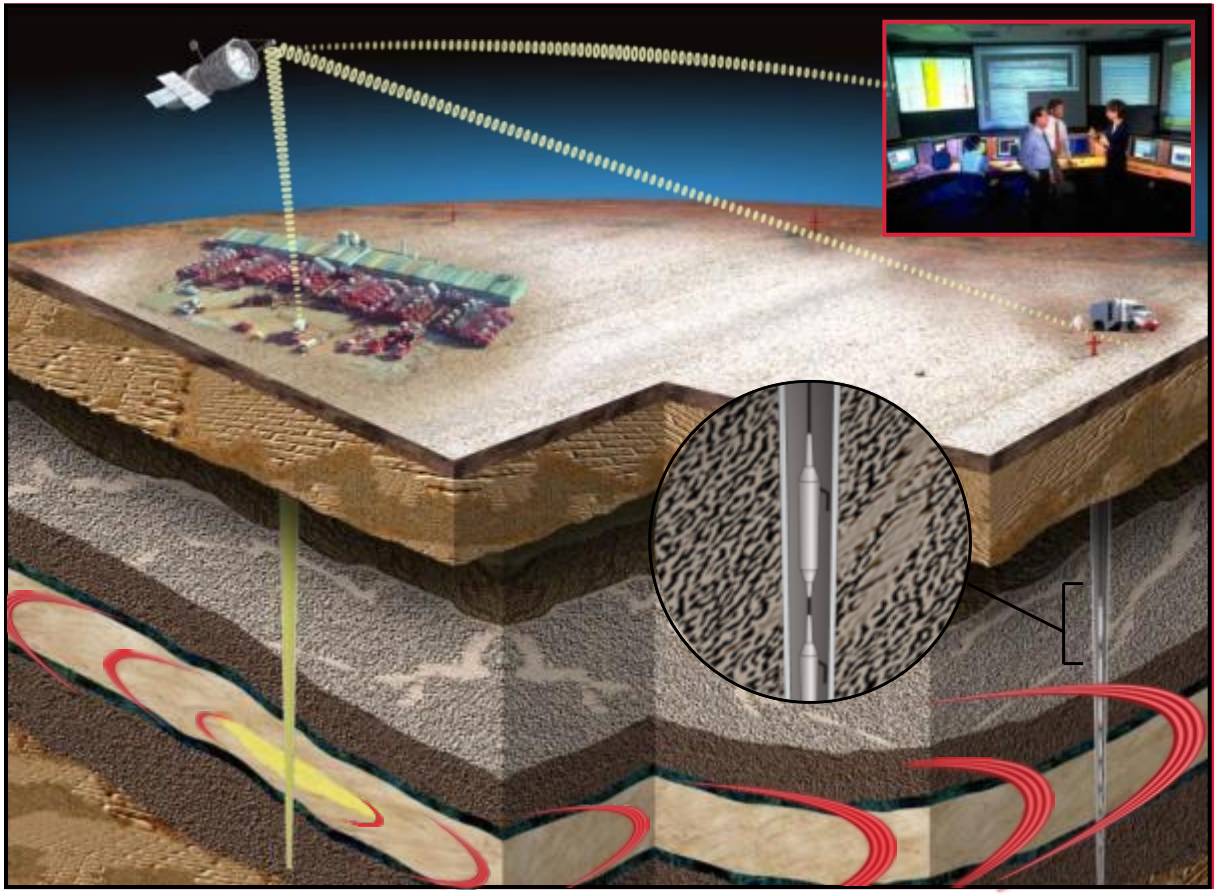
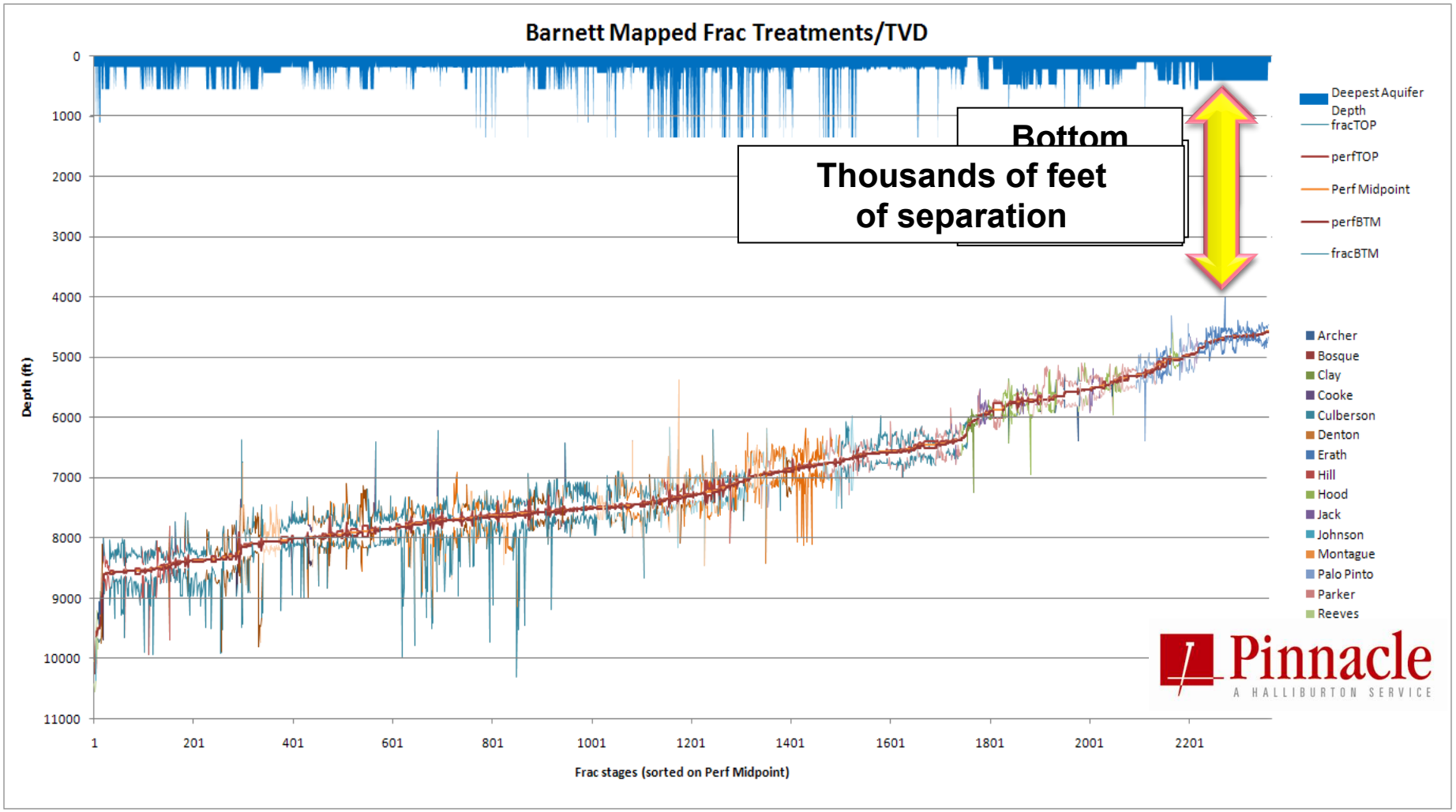
Fracture Evaluation - Microseismic Monitoring

- Fracturing process generates “nano” level microseismic events
- Geophones in monitor well identify and map location of events

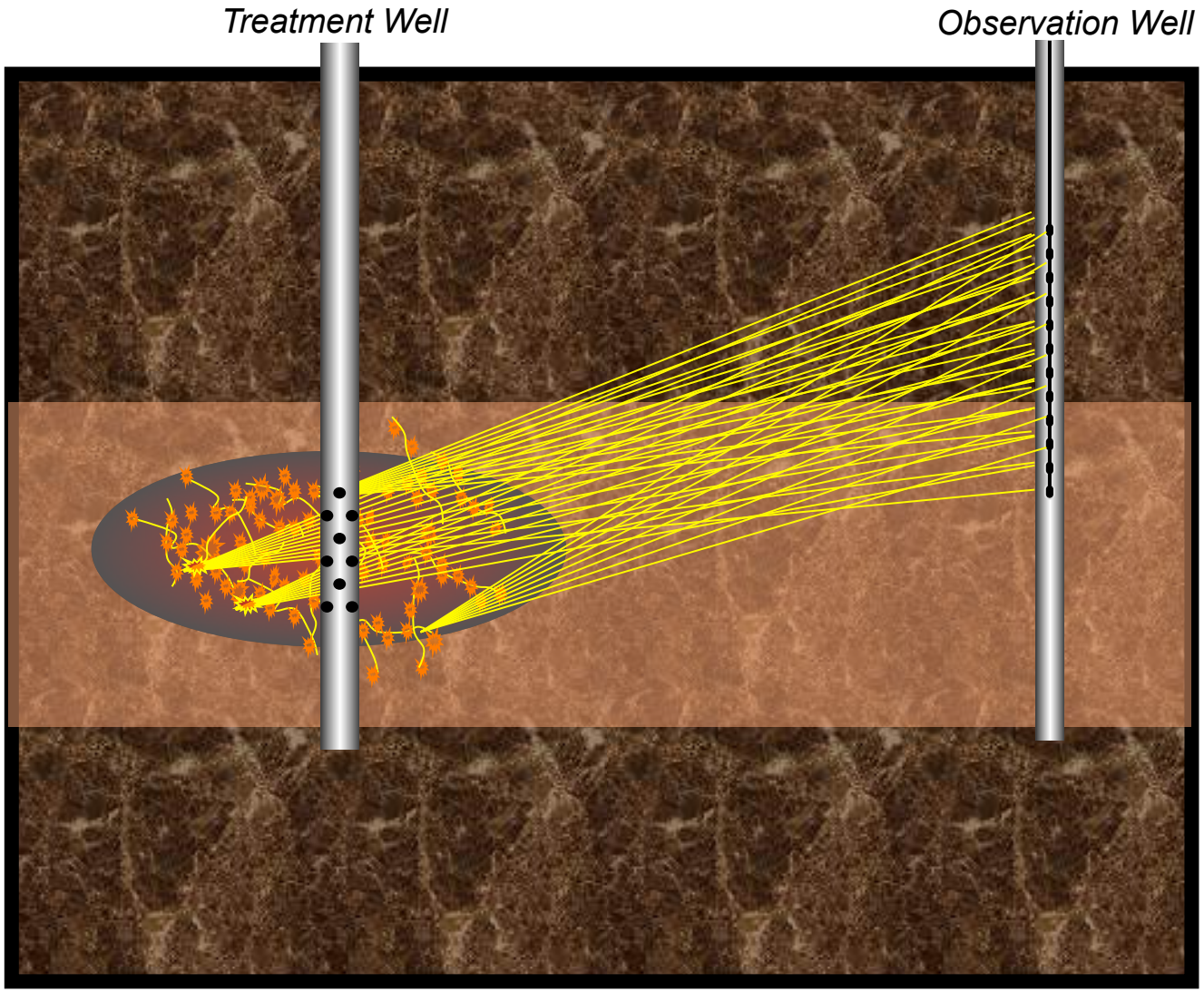


Fracture Location Determination - Barnett Study

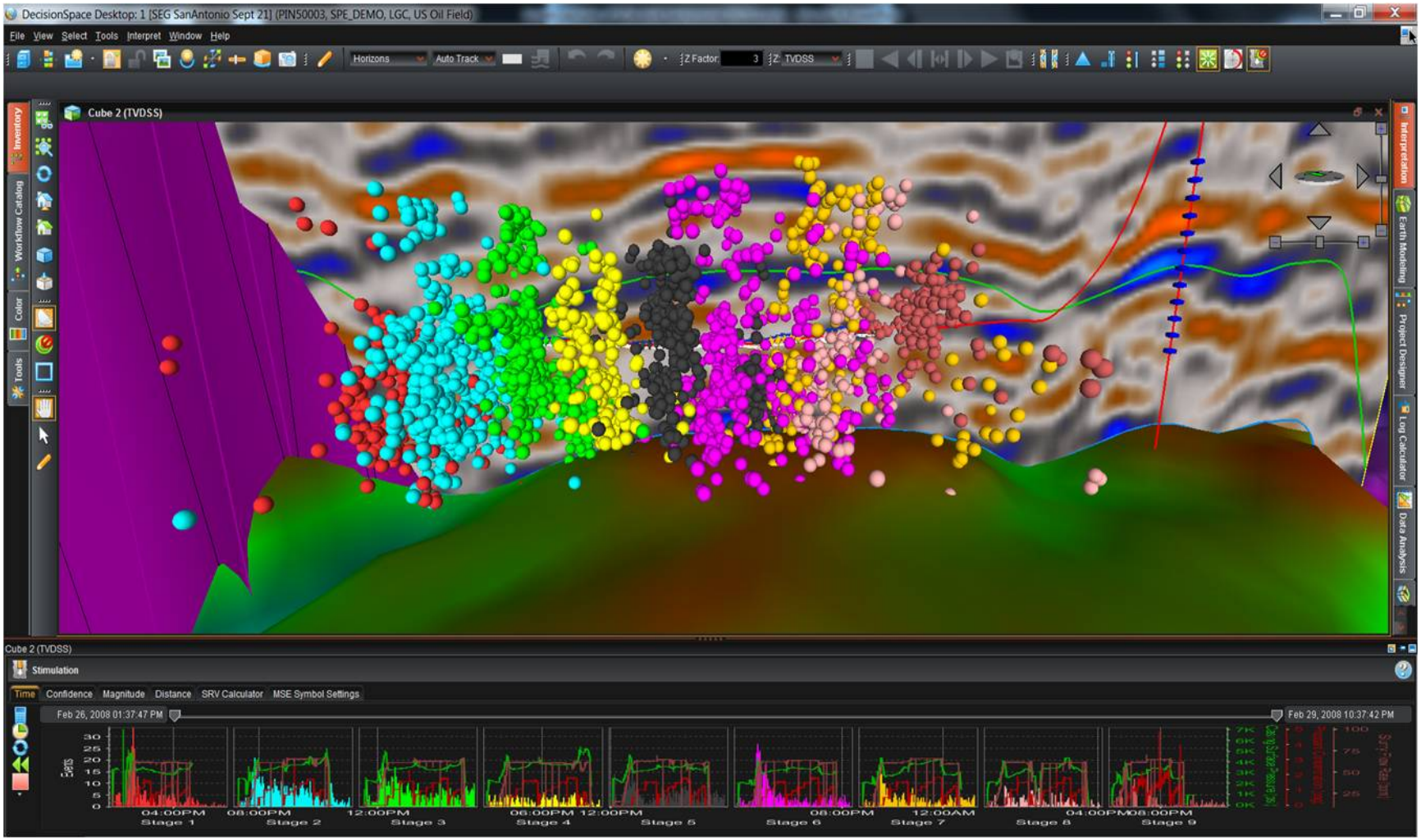


Kevin Fisher, "Data Confirm Safety of Well Fracturing,"
The American Oil & Gas Reporter – July 2010

Closer Look - Microseismic Monitoring



Fracture Location



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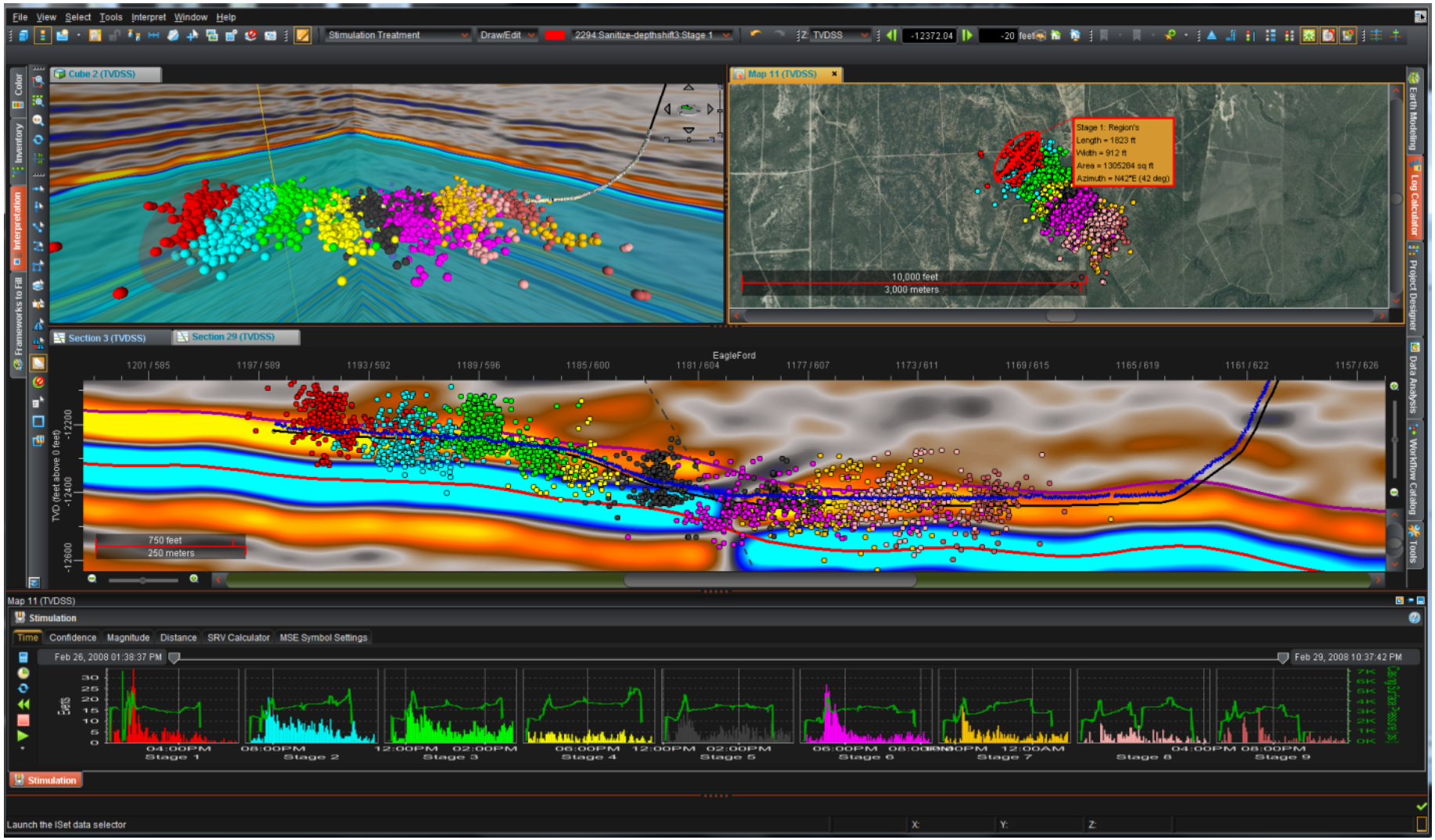
Subsurface Mapping



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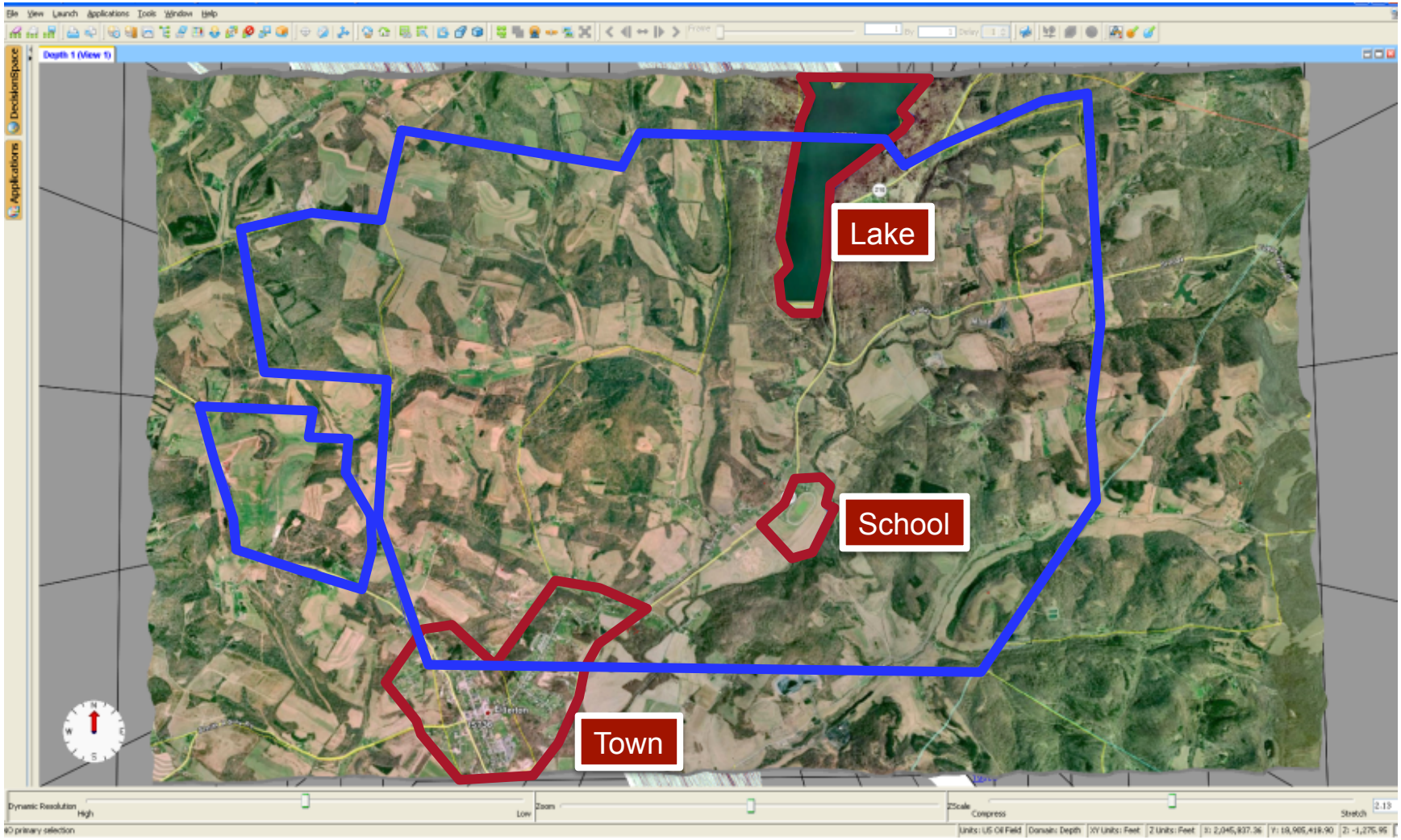
Surface Location



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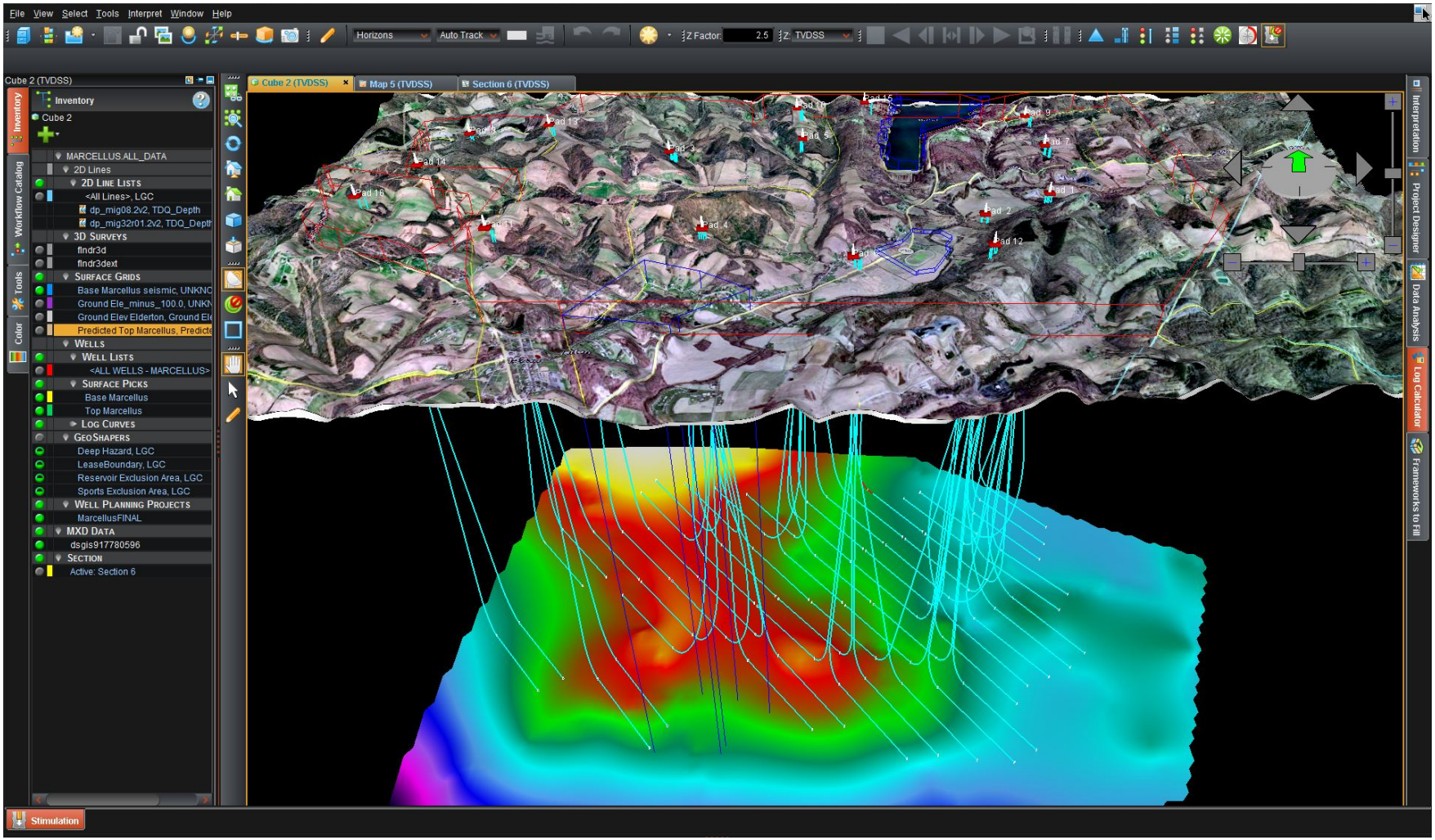
Technology Optimizing Field Development



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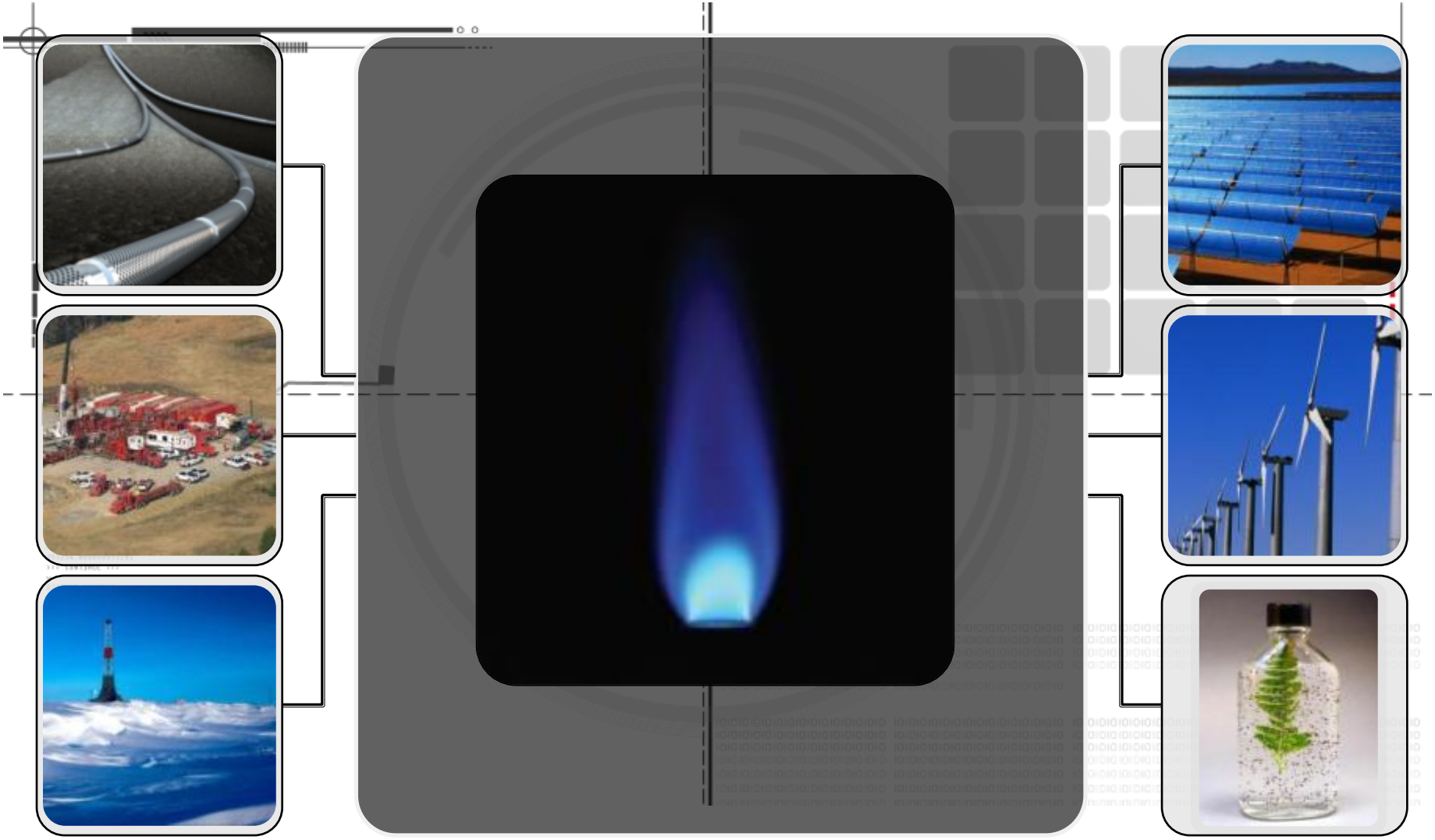
Your Energy Future Depends on Informed Decisions



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Sources of Information

STRONGER	In-depth peer review of the regulatory programs in OH, PA, OK, LA and CO www.strongerinc.org
API	Detailed guidance documents and recommended practices for industry www.API.org
IOGCC/GWPC	FracFocus website providing well by well hydraulic fracturing information to the public www.FracFocus.org
Energy In Depth	E.I.D. launches new grassroots initiatives in northeast PA, southern NY and eastern Ohio www.Energyindepth.org
Halliburton	HF microsite contains detailed fluid information and educational material www.Halliburton.com/HydraulicFracturing

Additional Information

Gradient Report – *National Human Health Risk Evaluation for Hydraulic Fracturing Fluid Additives*
http://www.energy.senate.gov/public/index.cfm/files/serve?File_id=53a41a78-c06c-4695-a7be-84225aa7230f

SPE 166142 – *Environmental Risk Arising From Well Construction Failure: Difference Between Barrier and Well Failure, and Estimates of Failure Frequency Across Common Well Types, Locations and Well Age*
http://www.spe.org/atce/2013/pages/schedule/tech_program/documents/spe166142-page1.pdf

Vicki Vaughan Article – *Water for fracking is dwarfed by other usage*
http://fuelfix.com/blog/2011/10/11/water-for-fracking-is-dwarfed-by-other-usage/

Chesapeake Energy Overview – *Water Use in Deep Shale Gas Exploration*
http://www.chk.com/media/educational-library/fact-sheets/corporate/water_use_fact_sheet.pdf

SPE 151597 Paper – *Measurements of Hydraulic-Fracture-Induced Seismicity in Gas Shales*
http://www.energy4me.org/hydraulicfracturing/wp-content/uploads/2013/08/SPE-151597-MS-P1.pdf

University of Texas Methane Study:
http://www.utexas.edu/news/2013/09/16/understanding-methane-emissions/

Kevin Fisher Article, Oil & Gas Reporter – *Data Confirm Safety Of Well Fracturing*
http://www.halliburton.com/public/pe/contents/Papers_and_Articles/web/A_through_P/AOGR%20Article-%20Data%20Prove%20Safety%20of%20Frac.pdf

Energy From Shale – Informational website:
http://www.energyfromshale.org/environment/ground-water-protection

Thank you