Unconventional Resource Development and Hydraulic Fracturing

Information Session

Central Mountainview Action Group

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www.csur.com

CSUR Canadian Society for Unconventional Resources

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Mission

“To facilitate the factual and collaborative exchange of unconventional resources knowledge and challenges among government, regulators, industry and public stakeholders for the exploration and production of the resource in an environmentally sensitive and economical manner”

We encourage constructive dialogue among all parties, contributing to sound, fact-based and responsible decision making by industry, governments and regulators

The Oil and Gas Industry is Changing

- Unconventional resources are playing an increasing role in our energy mix
- In most cases, the development of unconventional resources requires some form of reservoir stimulation
- Horizontal wells now account for more than 70% of wells drilled
- Unconventional gas now accounts for more than 50% of United States natural gas supply and over 25% in Canada
- Advances in technology (horizontal drilling and multi-stage hydraulic fracturing) have enabled substantial growth in oil and natural gas supply in North America
- Abundance of natural gas supply has led to a significant reduction in natural gas prices
- Companies have shifted their emphasis towards “oilier” exploration opportunities as a result

Presentation Outline

Why Do We Need to Fracture Oil and Gas Wells?

Basic Hydraulic Fracturing Principles

Types of Hydraulic Fracturing Equipment

Hydraulic Fracturing Fluids and Proppants

Regulation and Groundwater Protection

Glossary of Terms

Reservoir	**The rock that contains potentially economic amounts of natural gas**
Porosity	**A measure of the amount of volume between grains in a rock**
Permeability	**A measure of the interconnectedness of pores, or the ease with which gas or liquid can move through a rock. The higher the permeability number, the greater the amount of fluid or gas that can flow through the rock over a fixed time period**
Hydraulic Fracturing	**Commonly referred to as fracing, this is the process where the reservoir rock is cracked using pressure and fluids to create a series of fractures in the rock through which the gas or liquids will flow to the wellbore**
Multi-Stage Fracturing	**The process of undertaking multiple fracture stimulations in a well whereby selected parts of the reservoir are isolated and fractured separately**
Microseismic	**The methods by which fracturing of the reservoir can be observed by geophysical techniques to determine where the fractures occurred within the reservoir**

What Are Unconventional Resources?

- Unconventional Resources refers to hydrocarbon resources that are found in difficult to produce reservoirs
- We subdivide unconventional resources into the specific rock type that hosts the oil or gas such as shale gas, tight gas sands, tight gas carbonates, natural gas from coal, tight oil and gas hydrates
- The amount of oil or gas that lies within these reservoirs is very large and can provide energy for Canadians for well into the next century based upon current production volumes
- In most cases, the oil or gas bearing reservoir rocks are of a lower quality and require enhanced technology types of completions to yield commercially successful wells
- Horizontal drilling and hydraulic fracturing are two of the technologies that are used by industry to access these oil and gas resources

What Are Unconventional Resources?

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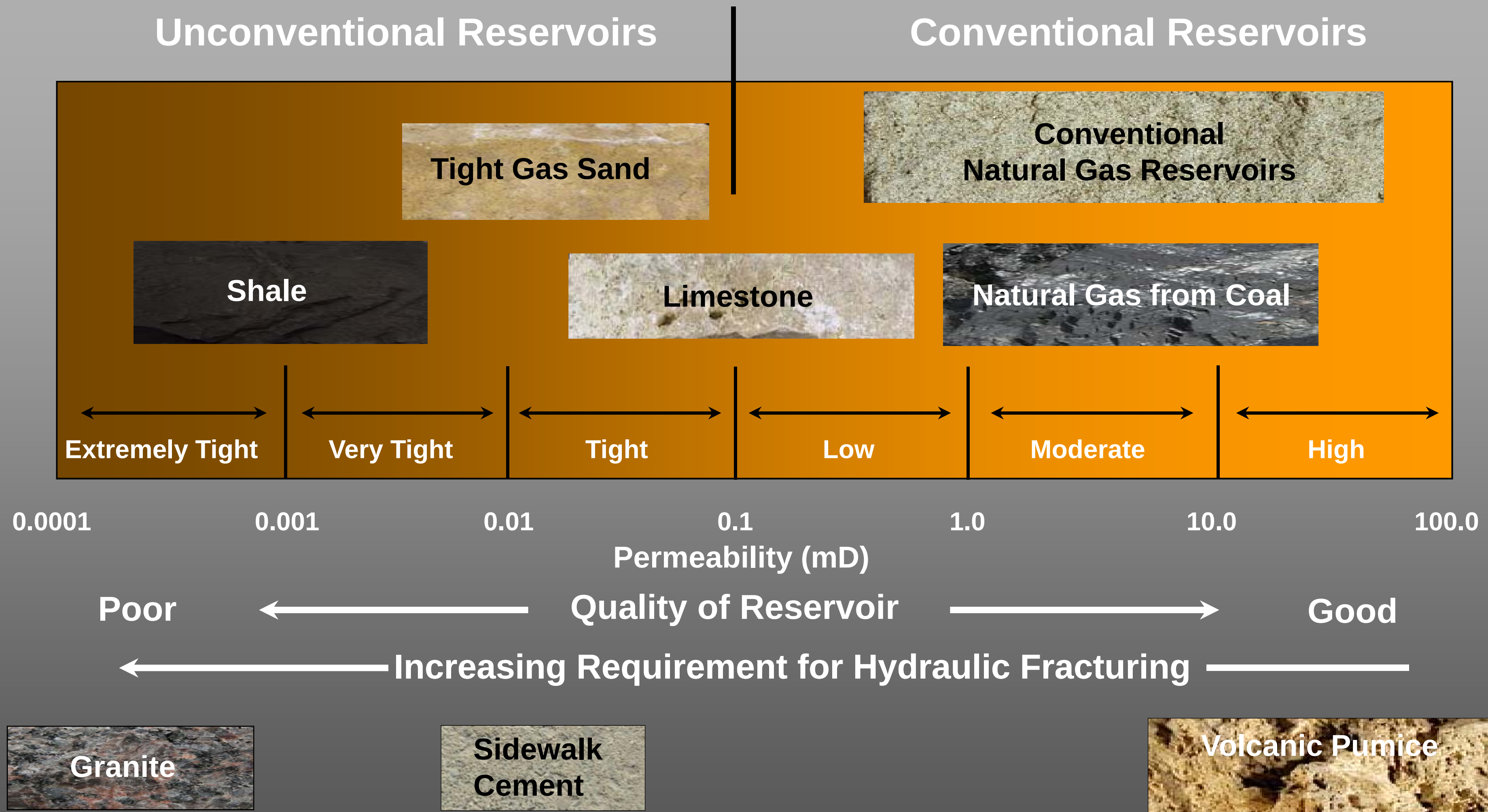
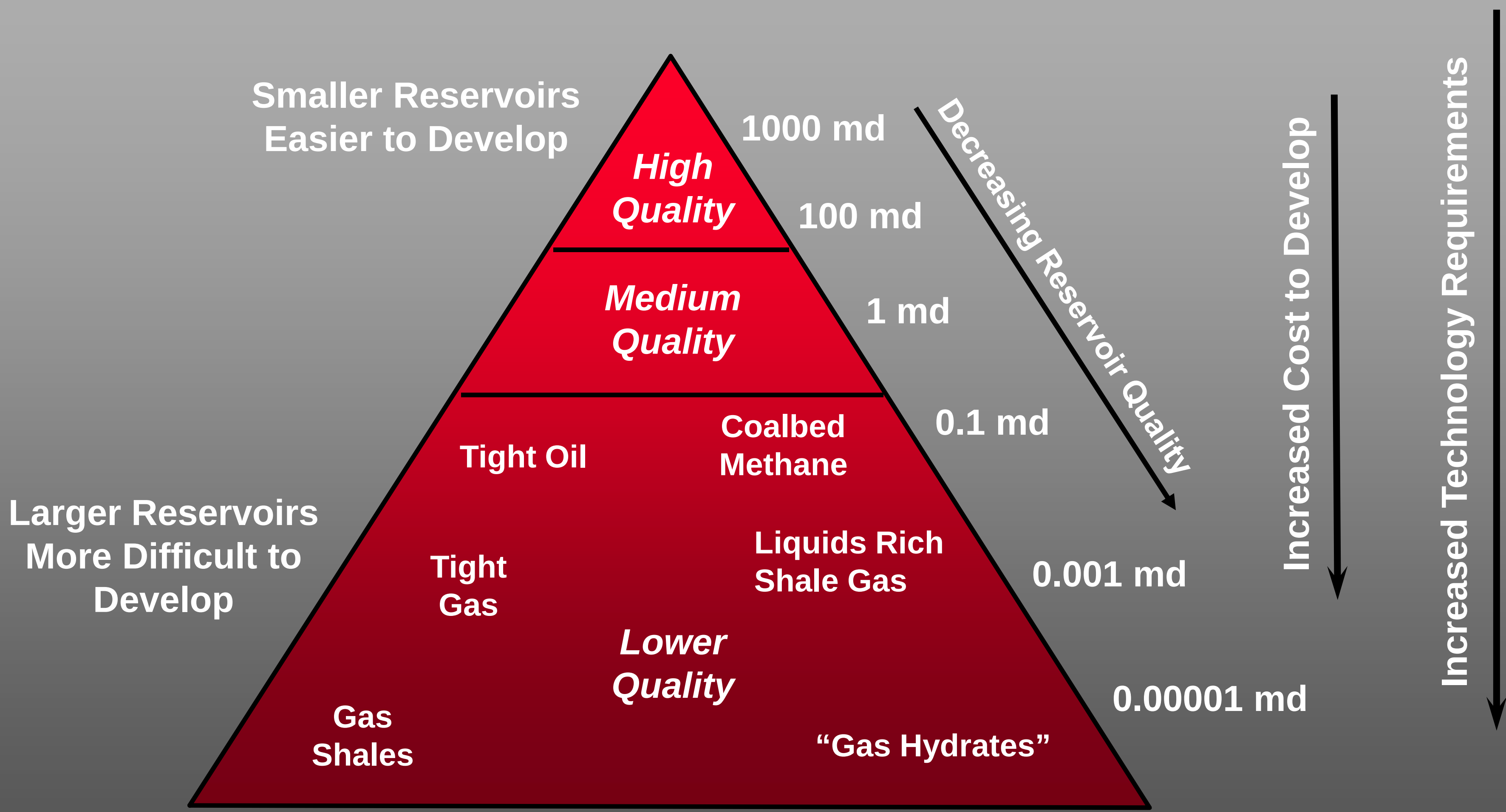


Note: Natural Gas from Coal reservoirs are classified as unconventional due to type of gas storage

modified from US DOE

What Are Unconventional Resources?

Hydrocarbon Resource Triangle



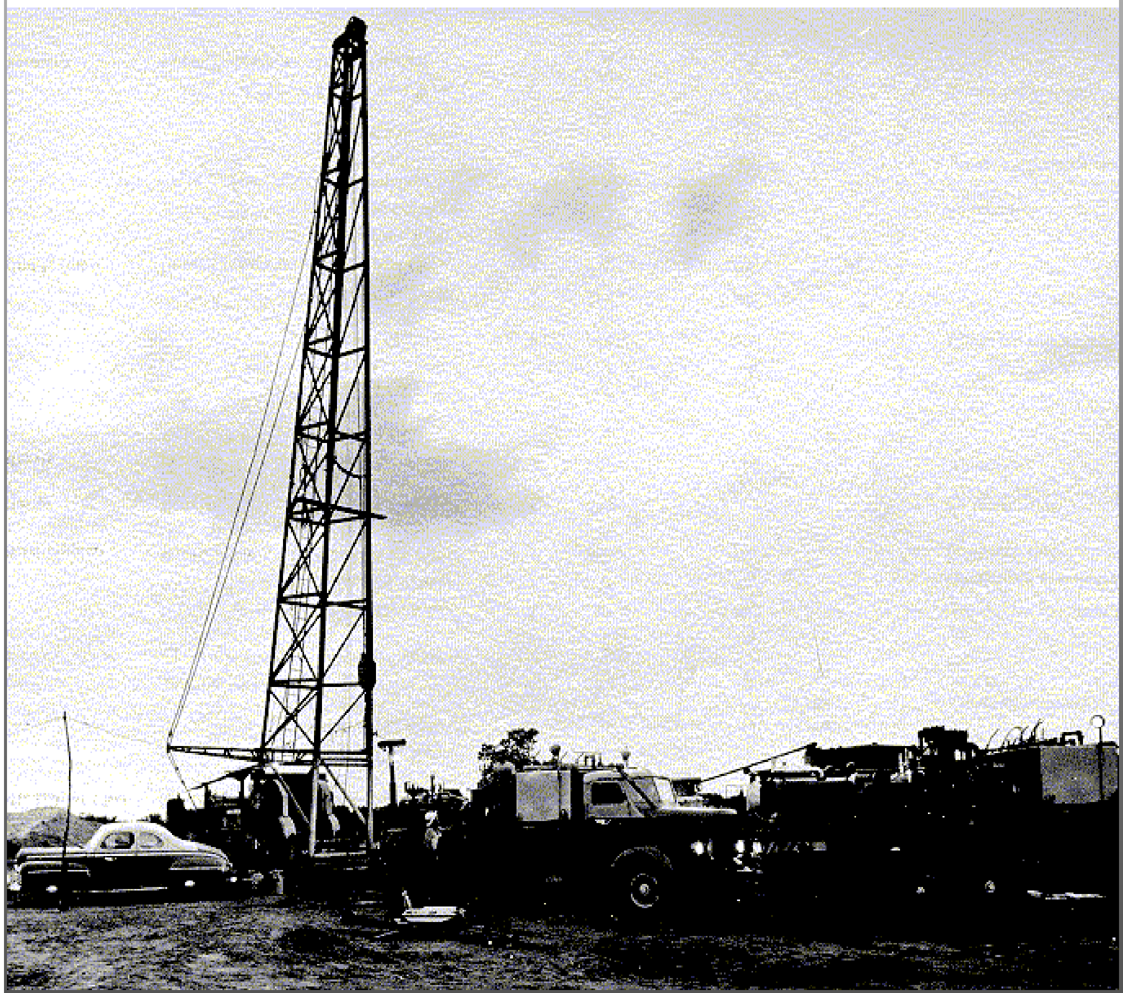
modified from Schmezl, 2009

What Are Unconventional Resources?

Conventional hydrocarbon plays have traditionally relied on the low hanging fruit for success

Unconventional resource plays have a large resource base but require more advanced technology to capture the reward

Hydraulic Fracturing has a long history and is not something new



Over the past 50 + years, industry has continued to improve the technologies of hydraulic fracturing including pumping and zonal isolation equipment, fracture fluids and additives, proppant types and properties and methods in monitoring and computer modelling and simulation

First Commercial Frac Job was at Velma, Oklahoma in March of 1949

Courtesy of Halliburton

Why Do We Need To Hydraulically Fracture?

Unconventional Reservoir Continuum

Conventional Reservoirs

→

Tight Reservoirs

→

"Hybrid" Reservoirs

→

Shale or Coalbed Methane Reservoirs

The shift from conventional to unconventional reservoirs reflects a change in grain size from higher permeability, coarser grained rocks towards very fine grained rocks with lower permeability

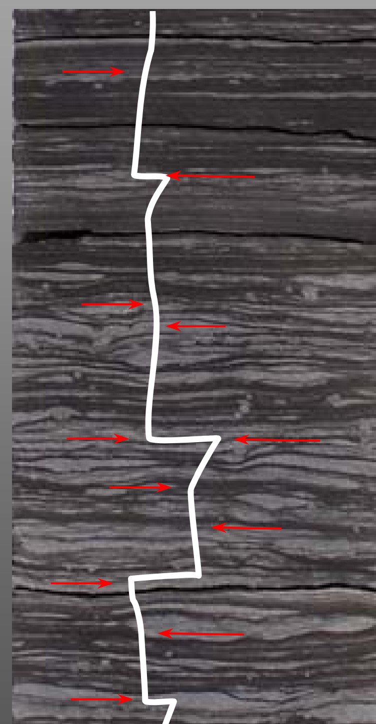
Hydraulic Fracturing is one method used to access and recover the hydrocarbons trapped in the lower quality reservoir rocks

Core photos courtesy of Canadian Discovery

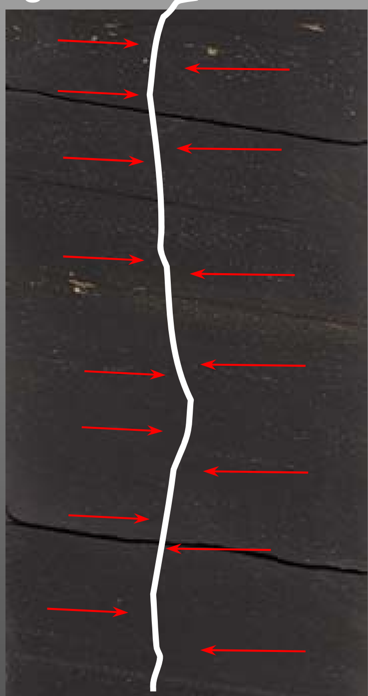
Why Do We Need To Hydraulically Fracture?

The purpose of a hydraulic fracture is to create a series of pathways that connect the wellbore to the natural fractures or permeable flow paths within the reservoir

Silt - Laminated Shale or Hybrid



Organic-rich Black Shale



Highly Fractured Shale

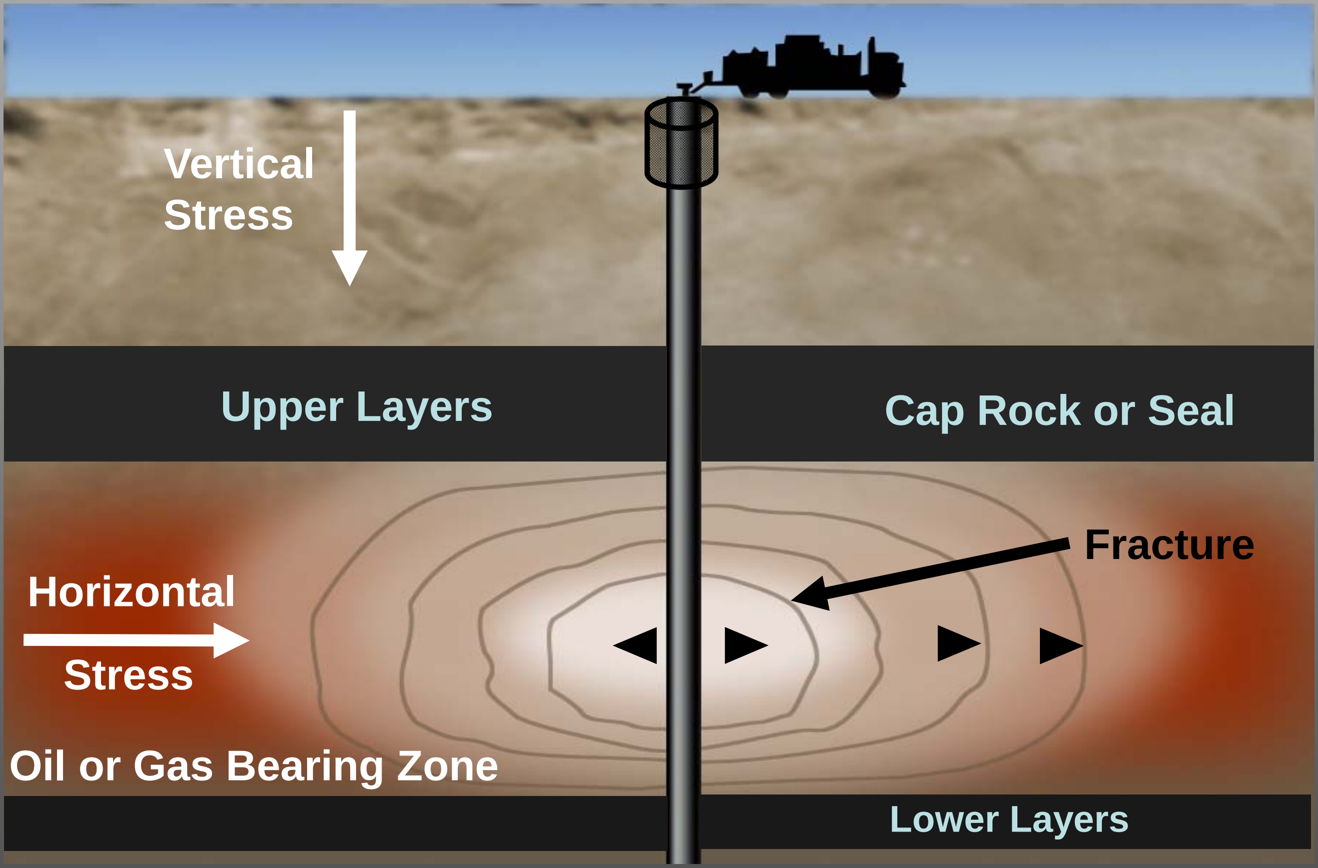
Migration of hydrocarbons to the induced fracture

Modified from Hall, 2008

Basic Hydraulic Fracturing Principles

The World is Made of Stress !!!

From a geological perspective there are a number of stresses (or pressures) that are present that affect the ability of rock in the subsurface to fracture



Principle of hydraulic fracturing is to create enough pressure on the rock in the subsurface to overcome the stresses that lie within the rock and create a fracture

Modified from Halliburton, 2010

Basic Hydraulic Fracturing Principles

- If Vertical Stress is < Horizontal Stress commonly fractures will tend to be horizontal and follow a bedding plane within the reservoir (possible in very shallow reservoirs)
- If Vertical Stress is > Horizontal Stress fractures (deeper reservoirs) will tend to be vertical and either intersect existing fractures in the reservoir or create new fractures
- Reservoir variability due to changes in lithology and rock strength can lead to complex fractures being created
- Changes in rock characteristics tend to terminate growth of fractures both upward and downward
- Object of the fracturing process is to create a fracture, induce growth of the fracture but confine it to the reservoir zone and allow proppant to be placed into the fracture to keep it propped open once the pressure has been released

Hydraulic Fracturing is Essentially a 4 Step Process

Step 1 Pressure the reservoir rock using a fluid to create a fracture

Step 2 Grow the fracture by continuing to pumping fluids into the fracture(s)

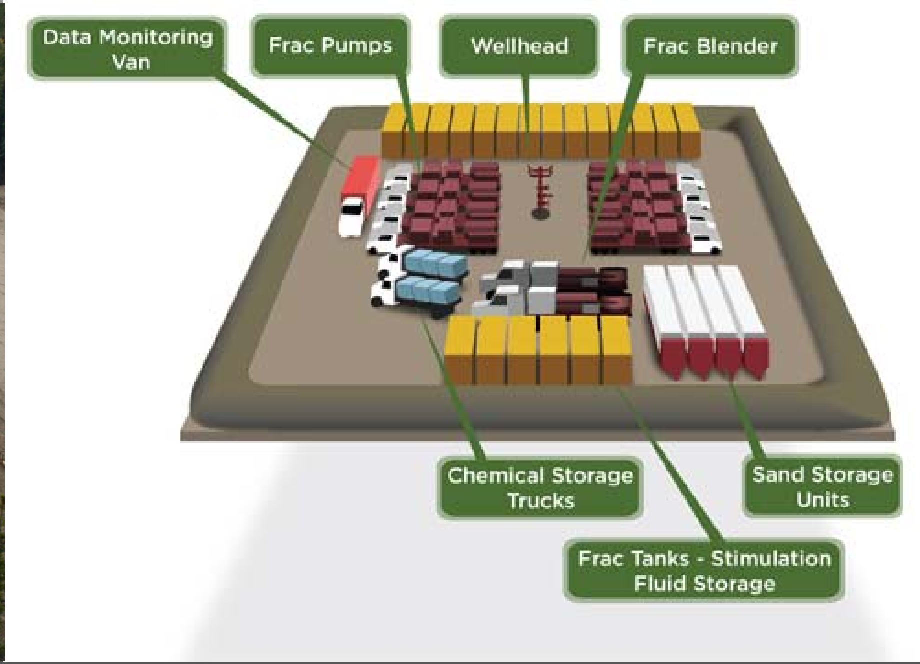
Step 3 Pump proppant materials into the fracture in the form of a slurry as part of the fracture fluid

Step 4 Flowback to the well to recover the fracture fluids while keeping the proppant in place

There are variations of these stages or sub-stages depending on the nature of the fracture treatment including variations of pressure and flow rates to control the growth and height of the fracture

Hydraulic Fracturing Equipment

- To fracture the reservoir rock, a fracture fluid (or gas) is pumped using mechanical means under sufficient pressure into the reservoir
- To achieve sufficient downhole pressure commonly pumping units are placed in tandem to achieve sufficient pumping capacity to reach fracture pressures
- Volumes of fluid, proppant as well as fracturing pressures are monitored and controlled onsite



Courtesy of Trican

www.hydraulicfracturing.com

Hydraulic Fracturing Equipment

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The size of the hydraulic fracture (and the amount of equipment needed on site) will vary dependent on the reservoir depth and properties

www.jptonline.org/index

www.marietta.edu/~petr/images/field/images

Shale gas or tight gas reservoirs commonly require large fracture stimulations in a multi-stage setting in order to create complex fractures in the reservoir

Hydraulic Fracturing Fluids and Proppants

- Hydraulic fracturing fluids can consist of gases, or fluids that are capable of being pumped under pressure into the reservoir as well as capable of supporting proppant material

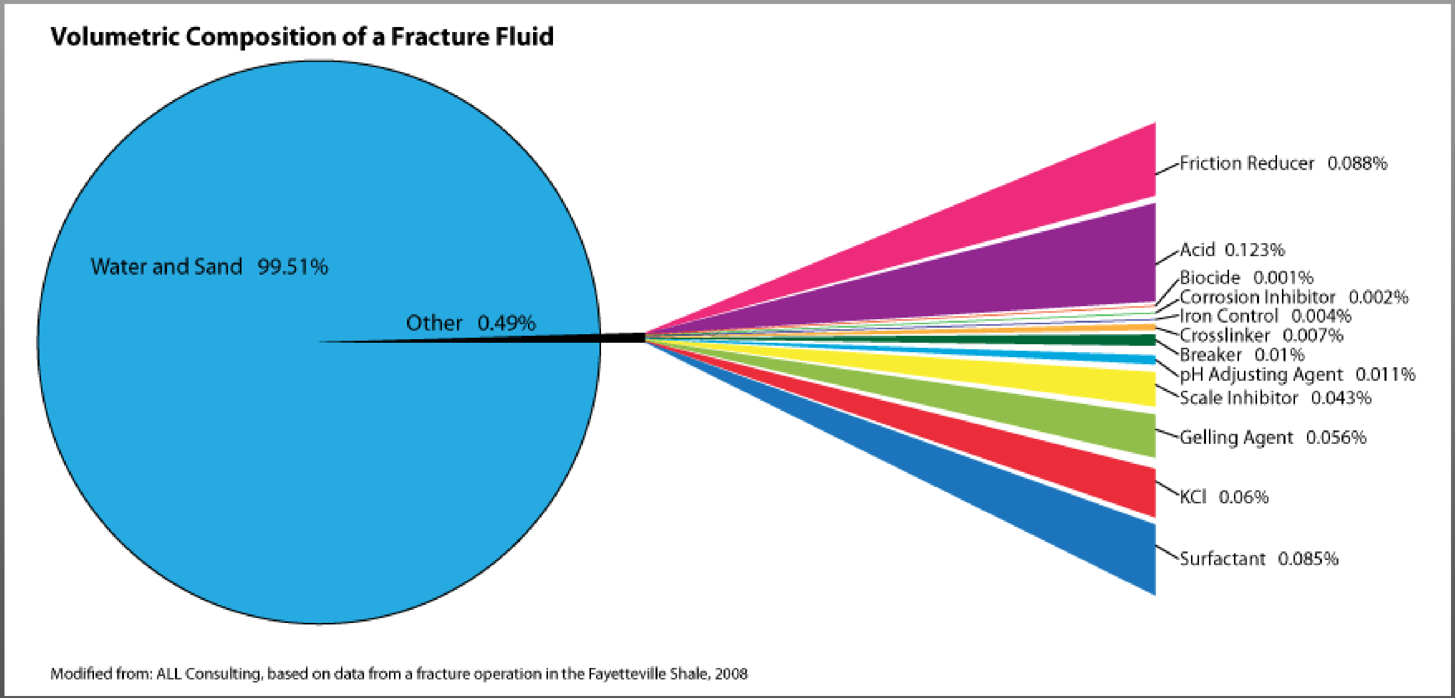
- The most common fluid used is water (or variations) although in some cases, nitrogen, propane, oil and CO_2 have been used. The choice of fluid is dependent on reservoir properties, cost and availability. Compatibility tests between fracture fluid and reservoir properties are commonly completed prior to fracture treatment

- Proppant materials commonly consist of sand or ceramics of specific size that can be carried within the fluid as well as withstand reservoir pressures once the fracture treatment is completed

- Where necessary small amounts of chemicals are added to the fracture fluid to minimize some of the reactions that may occur between the fracture fluid and the reservoir or hydrocarbons

Hydraulic Fracturing Fluids and Proppants

- "Slick Water" fracture fluid consists mostly of water and is the most common fluid used in shale gas completions
- The volume of fracture fluid used is dependent on the size of frac treatment as well as the number of fractures planned for the wellbore
- Tight oil reservoirs such as the Cardium Formation may require different types of fracture fluids and proppant to optimize wellbore production



Drilling and Completion Technologies

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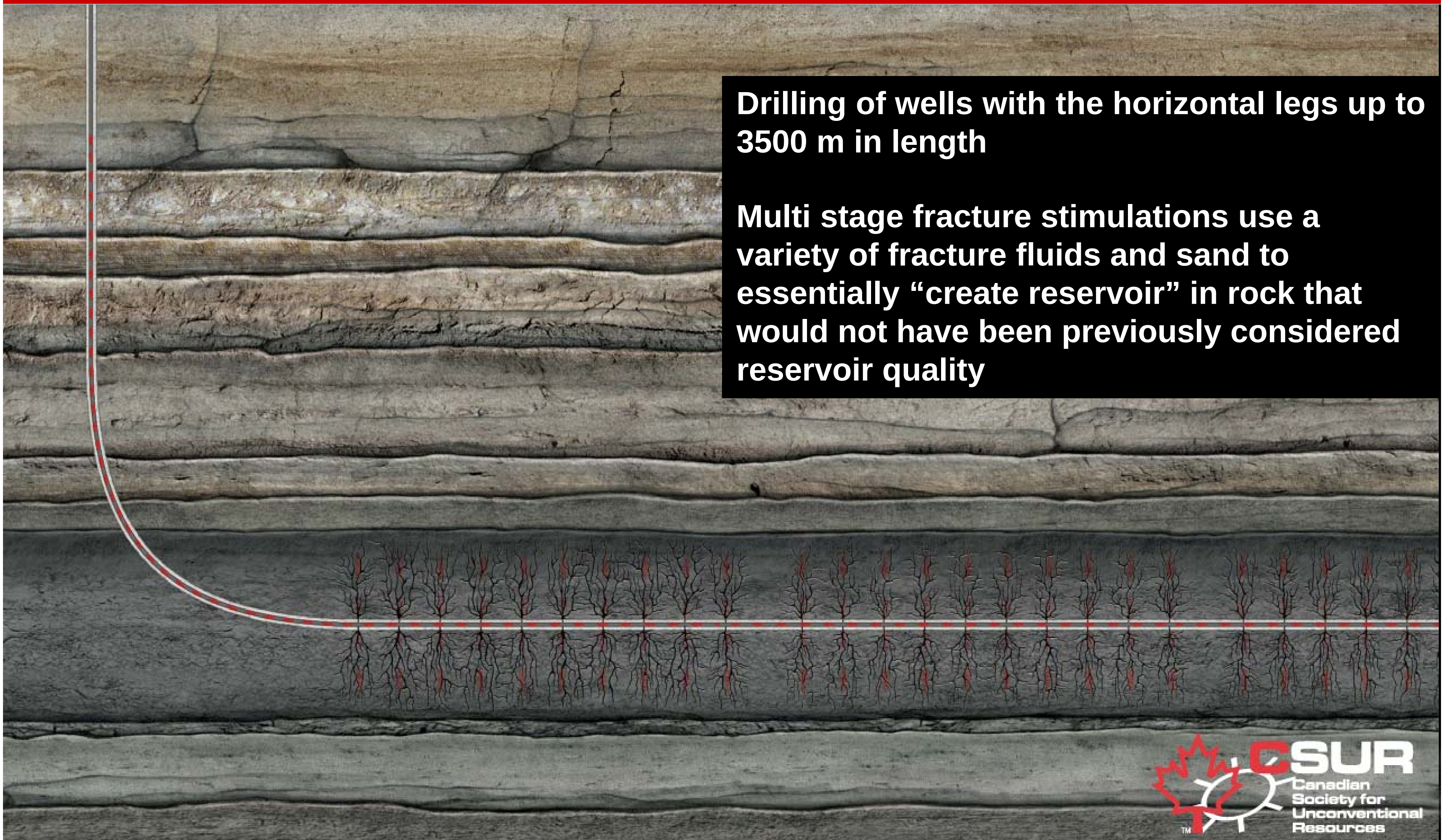
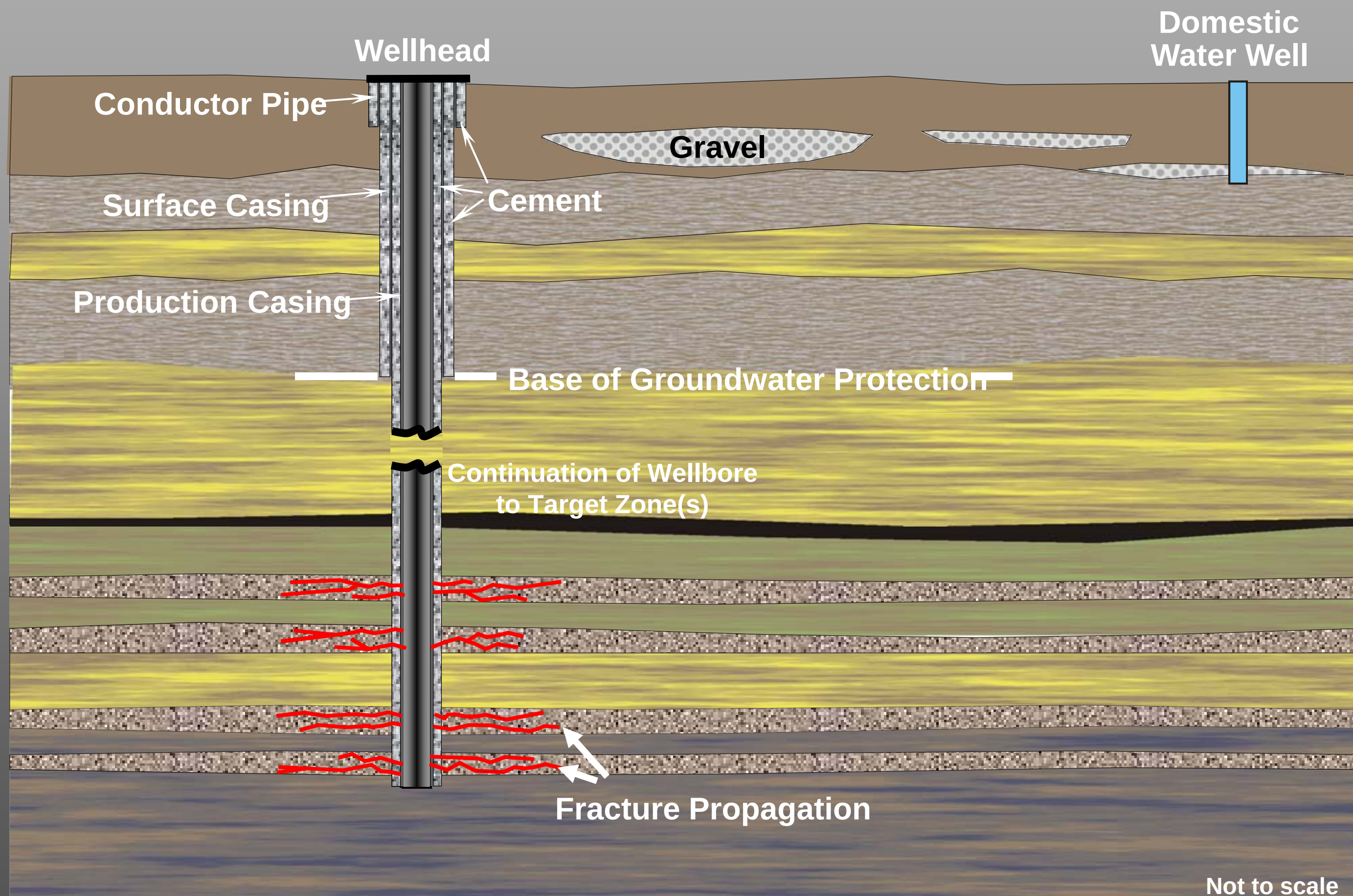


Drilling of wells with the horizontal legs up to 3500 m in length

Multi stage fracture stimulations use a variety of fracture fluids and sand to essentially "create reservoir" in rock that would not have been previously considered reservoir quality

Regulation and Groundwater Protection

With proper well construction, shallow groundwater aquifers are protected from fracture fluids or hydrocarbons in the wellbore using cement and steel casing



Optimization of Operations

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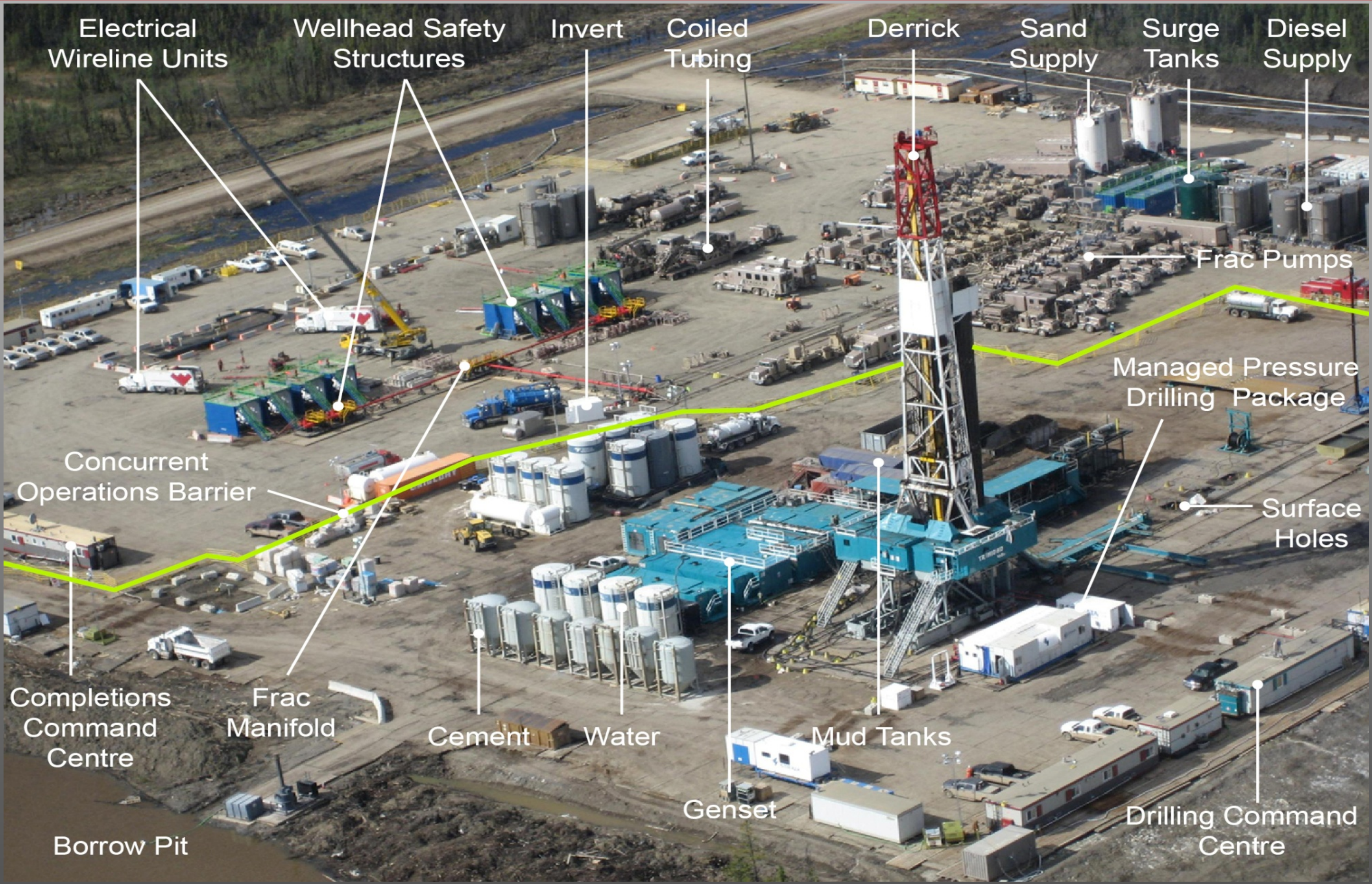

Source: Encana

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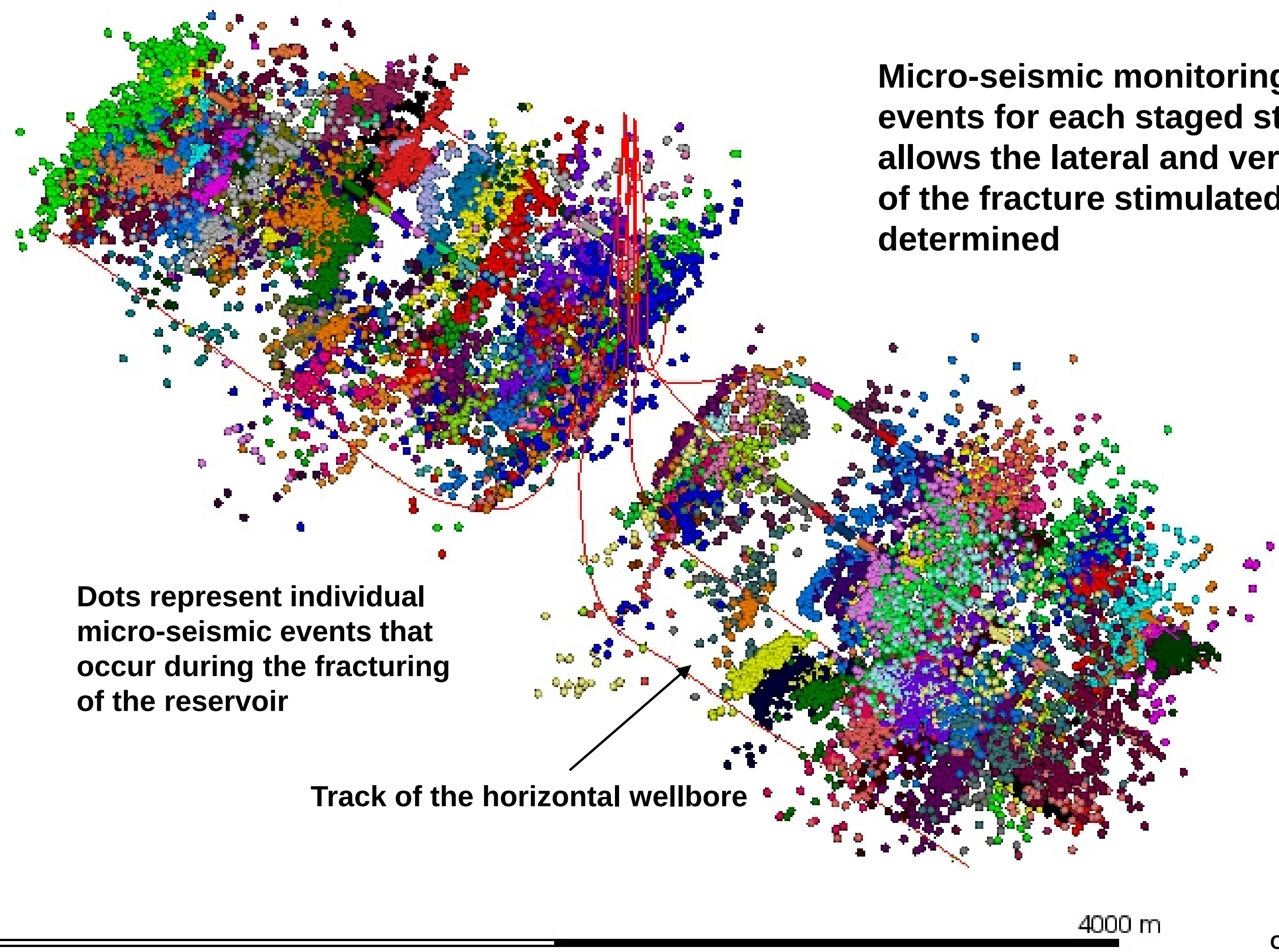
How Do We Measure Success?



Courtesy of Nexen, 2011

esg

What is different today in unconventional resource play development compared to what has been conventional oil and gas exploration ?

- Surface footprint has changed due to move towards horizontal wells
  - less wells but the surface footprint of a single multi-well pad will be larger and used for a much longer period of time creating other issues that regulatory agencies must address
  - vehicle traffic will not only be greater but also will be for an extended period of time (as much as 12 to 18 months or perhaps even being semi-permanent)
- Multi-stage fracture stimulations commonly are of a larger scale requiring more materials and equipment
  - water and fluid requirements for operations need to be balanced with regional availability
- Greater stakeholder concern about hydraulic fracturing and shale gas development

The Need for Factual Information

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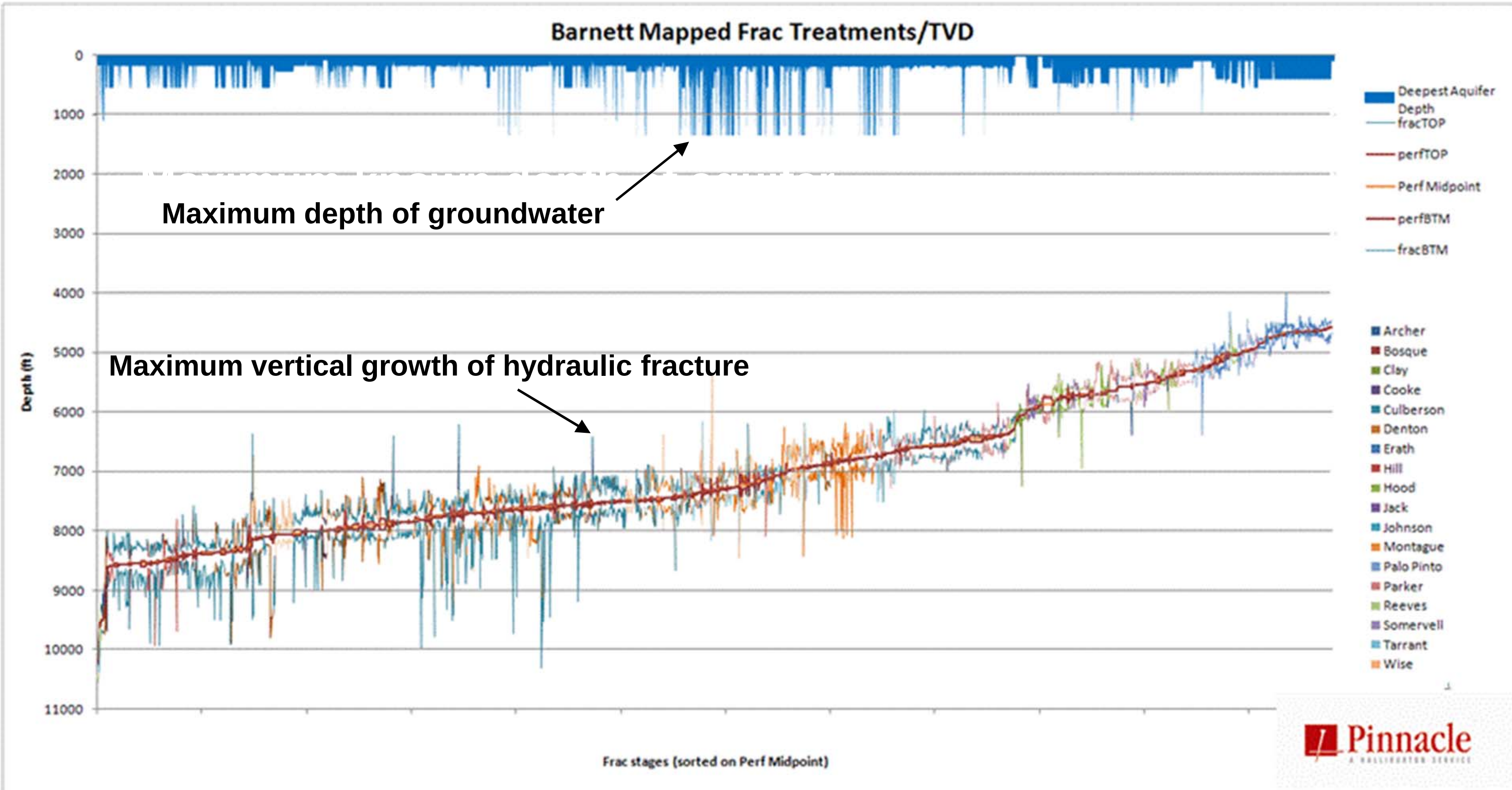
Public concerns about hydraulic fracturing has led to protests in many localities around the world

Most of the concerns are predicated on misinformation eg. "Gasland"

There have been no reported cases where hydraulic fracturing has resulted in shallow groundwater contamination

Facts About Fracing - Observations



http://nwis.waterdata.usgs.gov/nwis/inventory

Facts About Fracing - Observations

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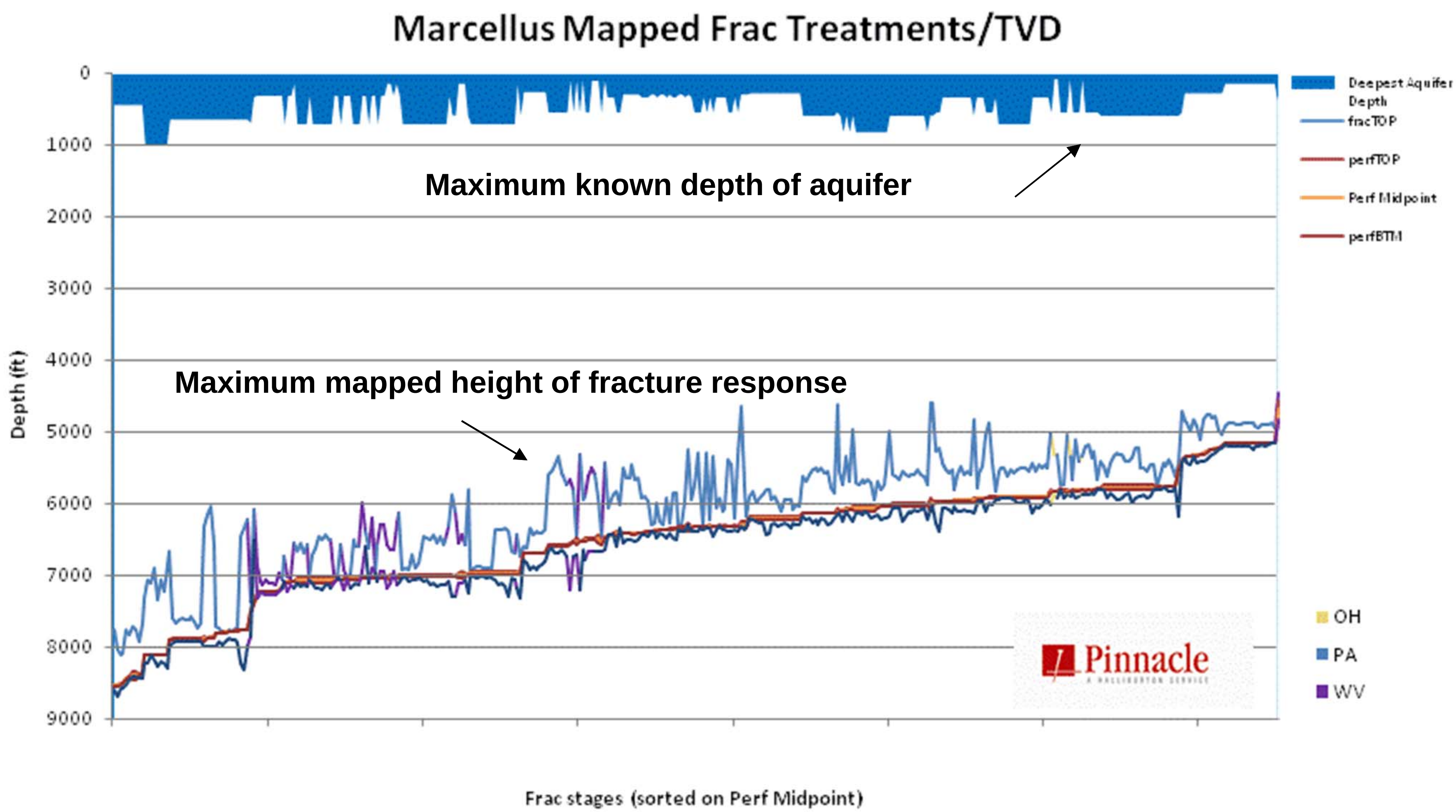

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GWPC Ohio and Texas Review – August, 2011

- Texas (1993-2008) – 187,788 wells drilled (including 16,000 horizontal with multistage fracs); 140,818 plugged (all vintages)
  - 211 groundwater contamination incidents including 57 legacy wells
  - 33% waste management and disposal, 25% tanks and flow lines, zero related to hydraulic fracturing
  - Zero incidents related to drilling, well construction, hydraulic fracturing, or production at any of the horizontal wells
- Ohio (1983-2007) – similar experience, 61,000 wells drilled or plugged
  - 185 groundwater contamination incidents; 53% during the first 5 years, > 25% legacy wells, pit construction 40%
  - Zero attributable to well construction, hydraulic fracturing, or production

Austin Energy Institute (University of Texas)

- Report issued early 2012
- Review of groundwater contamination reports in Barnett, Haynesville, Marcellus shale basins
- Team included geology, engineering, environment, law, public affairs and communications departments
- Preliminary conclusions
  - Incidents attributable to poor casing and cement or above ground spills/leaks
  - Lack of baseline groundwater data is the norm
  - Regulations stale dated in some jurisdictions
  - Media coverage overwhelmingly negative, little mention of actual science

New York State

- Supplemental Generic Environmental Impact Statement addressing hydraulic fracturing in particular was issued September, 2011 after more than 2 years work.
- Extremely comprehensive, includes the analysis and findings of an independent technical assessment of subsurface mobility of fracturing fluids:
  - Fracturing pressures which could drive fluid from the shale toward aquifers are applied for periods of time much too short to enable migration (hours vs years)
  - Any flow of frac fluid toward an aquifer through open fractures would be reversed during flowback and as pressures decline during production
  - The authors note that uncemented wellbores would enable higher fluid velocity, reducing the migration time; however, the hydraulic fracturing contractor would notice an anomaly (inability to achieve or sustain fracture pressure). The same reversal of fluid flow would occur during flowback.
- The State has indicated it will begin issuing permits for shale gas drilling in 2012

Facts About Fracing
Industry and Regulators Respond

- Steven Chu, Secretary of Energy in the Obama administration, was instructed to identify measures to reduce the environmental impact of shale gas production
  - Initial Subcommittee report concludes risk of contamination due to hydraulic fracturing is remote
  - Urges adoption of best practices in many areas
- GHG concerns raised by Cornell University report
  - Research released by MIT, US DOE National Energy Technology Laboratory, and Carnegie Mellon University during 2011 reach different conclusions
  - Carnegie Mellon researchers conclude Shale gas emissions are comparable to conventional gas
  - January 2012 – separate group of Cornell researchers rebut original Cornell report

- Pennsylvania
  - Numerous incidents attributed to inadequate well construction (methane migration) and water and frac fluid management practices (spills and leaks)
  - Thorough regulatory review undertaken and beginning in 2011 numerous regulation changes are being implemented, with a particular focus on well construction, cement, and casing standards
  - Regulatory staff levels dramatically increased

How About in Canada

- Alberta, British Columbia and Saskatchewan have a long history of oil and gas exploration and development including hydraulic fracturing
- The provinces have well established regulations to guide how a wellbore is drilled and completed, what testing is done, and what data is reported. In Alberta there are also specific regulations addressing shallow hydraulic fracturing
- Industry must comply with these regulations and if complications do arise that may compromise the integrity of the wellbore before or after the fracture stimulation, regulations are in place to ensure that corrective measures are completed
- Proper wellbore construction is critical to protection of groundwater
  - Surface casing is set and cemented in place to below base of groundwater protection
  - Intermediate casing is used to isolate hydrocarbon zones between the reservoir and surface casing
  - Wells are tested to validate cement integrity

Regulation and Groundwater Protection

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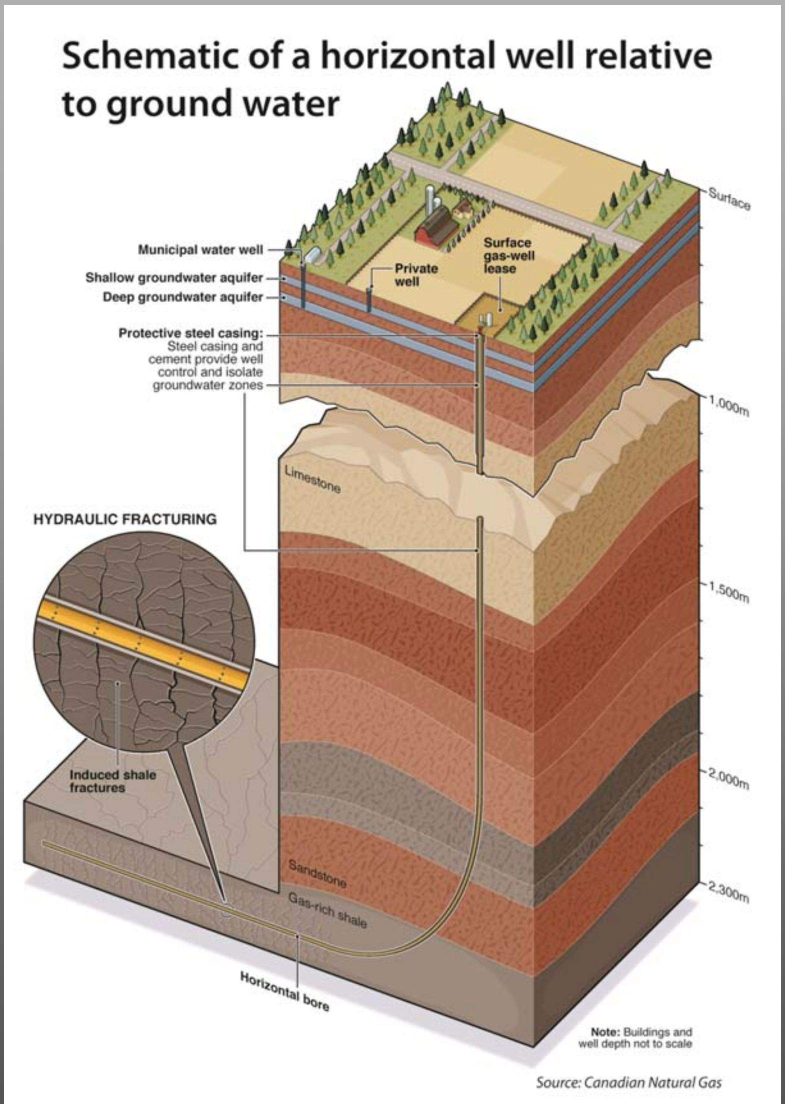
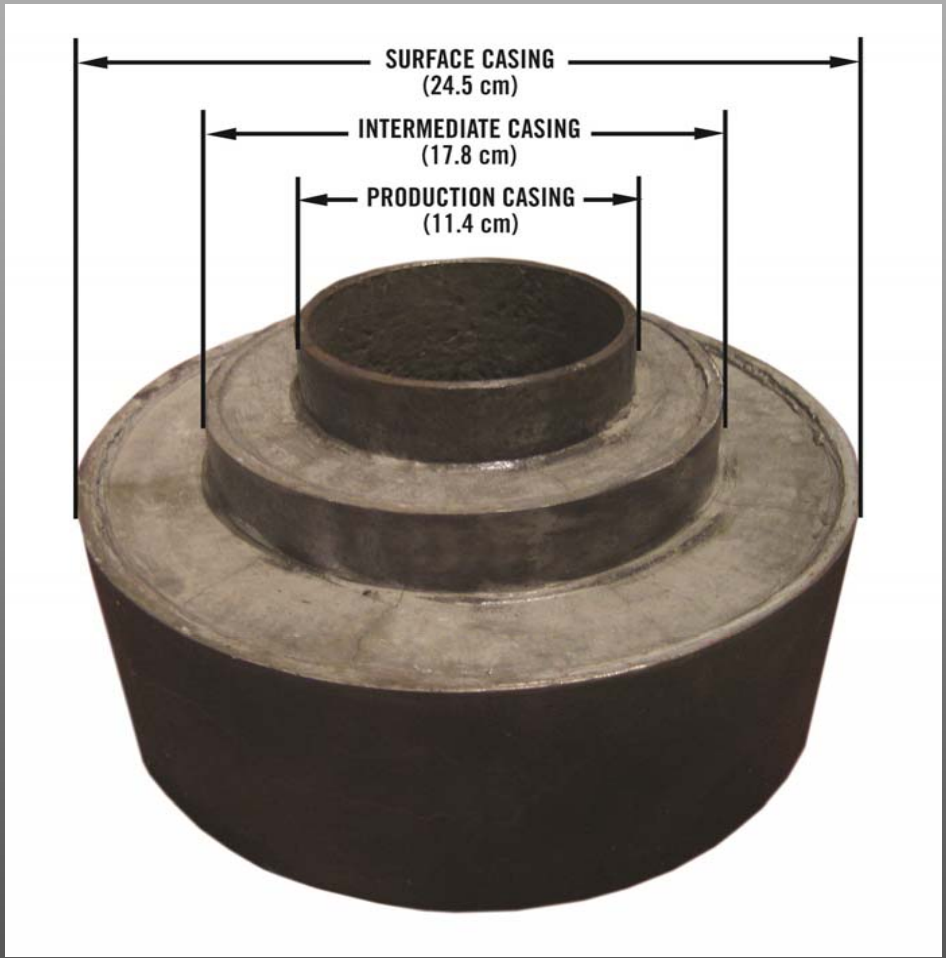


Proper well construction and groundwater protection is critical for oil and gas development



Key Messages

- The oil and gas industry has a long history of hydraulic fracturing of wellbores. Hydraulic fracturing is “not” a new process
- Types of hydraulic fracturing including fluids, proppants, size and number in a wellbore continue to change as new technologies are developed to improve access to the reservoir rock in the subsurface
- Multi-stage fracturing coupled with horizontal drilling has been very successful in unlocking the resource potential of many “tight” reservoirs, both oil and gas
- There have been no documented cases where hydraulic fracturing has led to contamination shallow groundwater horizons
- Proper well construction is critical for groundwater protection and hydrocarbon isolation

Unconventional Resource Development and Hydraulic Fracturing

Thank You for your Attention !

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