Horizontal Drilling and Hydraulic Fracturing Practices

Woolsey Companies

Woolsey Energy Corporation * Woolsey Operating Company, LLC
Woolsey Energy II, LLC * American Pipeline Company, L.L.C.
Bluestem Gas Marketing, L.L.C. * Red Hills Well Service, LLC
The Woolsey Companies, with headquarters in Wichita, Kansas, are privately held oil and gas exploration and production companies that have operated in the Mid-Continent area for 41 years.

**WOOLSEY COMPANIES AT A GLANCE**

Woolsey Energy Corporation (WEC) is the parent company that owns 100% of; Woolsey Operating Company, LLC, Woolsey Energy II, LLC, American Pipeline Company, L.L.C., Bluestem Gas Marketing, L.L.C. and Red Hills Well Service, LLC.

Woolsey Energy Corporation is an Exploration and Production Company that has a proven track record of consistently increasing reserves economically through the drill bit. Woolsey Operating Company, LLC (WOC) operates over 400 producing wells and manages the company’s interest in an additional 150 non-operated wells in Kansas, Oklahoma and Texas.

We are committed to meeting the highest standard of corporate citizenship by protecting the health and safety of our employees, vendors and land owners; safeguarding the environment and making a positive impact on the communities in which we do business. Our commitment balances good business with sound, socially responsible engagement.
THE ILLINOIS BASIN

Woolsey Energy Corporation through its leasing affiliate, Woolsey Energy II, LLC is actively building a significant lease position in the Illinois Basin. Woolsey Operating Company, LLC, the drilling and operating arm of Woolsey Energy Corporation, is planning on drilling and developing this acreage both vertically and horizontally using the latest technology to exploit, not only conventional reservoirs but also unconventional "Tight Rock" and "Source" type reservoirs.

Woolsey Energy Corporation believes these reservoir targets hold hundreds of millions of barrels of crude oil and trillions of cubic feet of natural gas. Developing these new reserves will bring the potential for tremendous growth of the petroleum industry to the region and with it high paying jobs, increased revenues for the States and Counties as well as the landowners.
HORIZONTAL DRILLING

Horizontal drilling is not new, with the first directionally drilled well in the U.S. completed in 1929. With the advent of computerized downhole telemetry and durable downhole motors in the 1980’s directional or horizontal drilling became widespread. Today, with thousands of horizontal wells being drilled all over the world, the technology is well established and being applied to new and old reservoirs alike.

The surface location of a horizontal well is slightly larger (3-4 acres) and commonly constructed from more durable and weather resistant materials such as gravel compared to a vertical well pad. However, since a horizontal well can take the place of 4 – 6 vertical wells, the overall impact to the surface is much reduced. Additionally, by drilling a deviated wellbore there is more flexibility in positioning the location. This allows the pad to be constructed at the edges of a lease away from the high value cultivated portion. The drilling working pits are steel and isolate the drilling fluids from the ground. The drilling fluids themselves are most commonly water based with a clay matrix. Drill cuttings are generally dehydrated and buried on location as they would be on a vertical well. The length of time to drill a horizontal well is dependent on
many factors but commonly takes between 25 – 30 days. Again, compared to multiple vertical wells, a single horizontal well uses less resources to drill.

Although the subsurface tools and equipment used for drilling a horizontal well are unique, the drilling rig and procedures are very similar to that of drilling a vertical hole. In fact, there is almost no difference in the construction and drilling of the well until kick off point “KOP” (the point at which deviation from vertical begins). From KOP to horizontal a broad curve is built using a downhole directional motor and telemetry. Generally, once the curve reaches 90°, or close to it, an intermediate string of casing is run and cemented to protect the wellbore. From there a smaller drill bit and downhole motor are used in conjunction with various measurement while drilling (MWD) tools to direct the drilling of the lateral portion of the hole. Depending on
geological variables of the target reservoir the lateral section can be anywhere from hundreds of feet long to thousands. A recent horizontal well in Russia was drilled nearly 35,000 feet laterally. Again, depending on reservoir characteristics, various completion techniques may be used. A liner can be set through the lateral and cemented to be selectively perforated and fracture stimulated in stages, a liner with isolation packers can be set in the lateral section where the intervals between the packers are selectively stage fraced.

At the surface, the production facilities for a horizontal well are only slightly different from that of a vertical well. Generally, there are more and larger vessels to handle the greater amounts of fluid and gas produced but the footprint is not that much greater than
the facilities that would be needed for the 4 – 6+ vertical wells replaced by one horizontal well. As the well is commonly produced by gas lift or electric submersible pump (ESP) there is no conventional pumping unit over the well so the surface intrusion is far less.

Hydraulic Fracture Stimulation (Fracing or Fracking)

As with most basins worldwide experiencing these types of new resource plays, the production will come from horizontal wells and hydraulic fracture stimulation (“fracing”). While artificial induced fracturing has been used since 1866 when the first nitroglycerin “torpedo” was patented, modern hydraulic fracturing was introduced in 1947. By 1988 over 1 million “frac jobs” had been completed in the U.S.. Over the decades, tens of thousands of wells in the Mid-Continent have been drilled through the United States largest and most important water aquifer, the Ogallala. During that period a great many of these wells were fracture stimulated and there has never been any reported contamination of the aquifer from these treatments despite large volume fracs and relatively shallow production zones. Over the last several years, during which time horizontal drilling and multi-staged hydraulic fracturing have moved into areas not familiar with this technology, there has been an outcry that fracing will contaminate the ground water. Much of the misconceptions about horizontal drilling and fracing were propagated by the political docudrama movie “Gasland”. Widely used by oil and gas opponents, the movie falsely misstates a number of issues and was thoroughly debunked by the State of Colorado Oil and Gas Conservation Division and others. Notably, the dramatic flaming water faucets were found to be contaminated with methanogenic gas seeps found naturally occurring on the landowner’s property and had nothing to do with the drilling of
natural gas wells. Likewise, no frac induced chemicals were ever found in the water wells.

The chief source for potential groundwater contamination is from the surface. The majority of modern hydraulic fracing used in horizontal wells today is done with primarily fresh water. More than 95% of the fluid injected is fresh water with no chemicals and is stored in steel tanks or lined pits. The minor amount of chemicals added are injected just ahead of the wellhead and are safely stored in isolated tanks. The hydraulic fracing procedure is a closed system with all pumped fluid injected directly into the producing reservoir.

To protect the ground water below the surface from the injected frac fluid and later, the produced oil, gas and water, the well is constructed of multiple strings of heavy steel casing cemented through the lowest aquifer to surface. The frac fluid is thus isolated to the production zone alone many thousands of feet below. Although the amount of fluid injected seems large, it is in fact only a tiny amount compared to the enormous volume of rock being treated. As such, there are no induced earthquakes as some have claimed nor does the frac communicate to the surface where it could affect the shallow aquifers.

The oil and gas industry is one of the most heavily regulated in the world and strives to maintain a strong record of environmental protection.
CEMENTING: A Seal for Safety

Oil and natural gas well construction relies on multiple layers of steel and cement barriers to isolate energy production from groundwater.

While steel casing serves as the primary shield to groundwater, specialized cement is used to create a pressure-tested seal between each layer of casing. Proper well cementing ensures safety.

CEMENTING

A In between each layer of steel casing is a space that must be filled to hold the casing in place and create a solid, sealed barrier between the well and groundwater.

B Specialized cement, developed in laboratories for the unique conditions found in oil and gas development, is used as the glue to seal layers of casing together.

C During well construction, cement is pumped down the interior of casing forcing the cement up from the bottom of the well so that it completely fills the space between the outside walls of the drilled hole and the casing inside of it.

TESTING

Drillers use multiple, high-tech tools, including measuring the travel times of sound waves, to verify that cement has created a solid bond with the casing. These tools are used to verify the strength of seals in the well before energy production begins.

Together, multiple layers of cemented steel casing provide a redundant barrier to isolate energy production from groundwater.

Sources:
"Well Construction and Groundwater Protection," FracFocus.
Appendix:

1. Horizontal Drilling Summary
   Article by Lynn Helms, North Dakota Department of Mineral Resources
   www.oilgas.nd.gov

2. Shale Energy and Hydraulic Fracturing
   Reprinted from the American Petroleum Institute
   www.API.org

3. Fracing Fluids, Chemical Constituents
   From the Department of Energy
   Office of Fossil Energy
   National Energy Technology Laboratory

   State of Colorado Oil and Gas Conservation Commission
   Department of Natural Resources

Other Available Resources:

Modern Shale Gas Development in the United States
US Department of Energy


Multi-Stage Hydraulic Fracturing
Technical Paper by Maurice Dusseault & John McLennan


History of Fracturing Oil and Gas Wells

http://aoghs.org/technology/shooters-well-fracking-history/

History of Oil & Gas Exploration in Illinois


Geology of the Illinois Basin Province
By David L. Macke

http://certmapper.cr.usgs.gov/data/noga95/prov64/text/prov64.pdf

Review of the factual errors in the Movie GasLand
energyindepth.org

http://www.energyindepth.org/debunking-gasland/
**Explanation**

Horizontal drilling is the process of drilling a well from the surface to a subsurface location just above the target oil or gas reservoir called the “kickoff point”, then deviating the well bore from the vertical plane around a curve to intersect the reservoir at the “entry point” with a near-horizontal inclination, and remaining within the reservoir until the desired bottom hole location is reached.

**Purpose**

Most oil and gas reservoirs are much more extensive in their horizontal dimensions than in their vertical (thickness) dimension. By drilling a well which intersects such a reservoir parallel to its plane of more extensive dimension, horizontal drilling exposes significantly more reservoir rock to the well bore than would be the case with a conventional vertical well penetrating the reservoir perpendicular to its plane of more extensive dimension (fig. 1).

The achievement of desired technical objectives via horizontal drilling comes at a price. A horizontal well can cost up to 300 percent more to drill and complete for production than a vertical well directed to the same target horizon. Due to its higher cost, horizontal drilling is currently restricted to situations where vertical wells would not be as financially successful. In an oil reservoir which has good matrix permeability in all directions, no gas cap and no water drive, drilling of horizontal wells would likely be financial folly, since a vertical well program could achieve a similar recovery of oil at lower cost. But when low matrix permeability exists in the reservoir rock (especially in the horizontal plane), or when coning of gas or water can be expected to interfere with full recovery, horizontal drilling becomes a financially viable or even preferred option producing 2.5 to 7 times the rate and reserves of vertical wells. The higher producing rate translates financially to a higher rate of return on investment for the horizontal project than would be achieved by a vertical project.

**Methodology**

The initial vertical portion of a horizontal well, unless very short, is typically drilled using the same rotary drilling technique that is used to drill most vertical wells, wherein the entire drill string is rotated at the surface. The drill string consists of many joints of steel alloy drill pipe, drill collars, and the drill bit itself.

From the kickoff point to the entry point the curved section of a horizontal well is drilled using a hydraulic motor mounted directly above the bit and powered by the drilling fluid. The drill bit can be rotated by the hydraulic motor without rotating the drill pipe from the motor to the surface. Steering of the hole is accomplished through the employment of a slightly bent or “steerable” downhole motor (fig. 2). By orienting the bend in the motor and drilling forward without rotating the pipe, known as slide drilling, the hole can be steered around a curve from horizontal to vertical and/or to the left or right. The curved section typically has a radius of 300-500 feet. To return to drilling straight ahead, the pipe is rotated slowly while the downhole motor also continues to rotate the bit.
Downhole instrument packages that transmit various sensor readings to operators at the surface are included in the drill string near the bit. At a minimum, sensors provide the azimuth (direction versus north) and inclination (angle relative to vertical) of the drilling assembly. Modern downhole instrumentation allows the directional drilling crew to calculate the position (x, y, and z coordinates) of the drill bit at all times. Additional downhole sensors can be, and often are, included in the drill string.

These sensors may provide information on the downhole environment (for example, bottom hole temperature and pressure, weight on the bit, bit rotation speed, and rotational torque). They may also provide any of several measures of physical characteristics of the surrounding rock such as natural radioactivity and electrical resistance, similar to those obtained by conventional wire line well logging methods, but in this case obtained in real time while drilling ahead. The downhole instruments, whatever their composition, are referred to as a measurement-while-drilling (MWD) package. The information is transmitted to the surface via small fluctuations in the pressure of the drilling fluid inside the drill pipe.

Tests which indicated that commercial horizontal drilling success could be achieved were carried out between 1980 and 1983 by the French firm Elf Aquitaine in four horizontal wells drilled in southwestern France and offshore Italy. Early production well drilling using horizontal techniques was subsequently undertaken by British Petroleum in Alaska’s Prudhoe Bay Field, in a successful attempt to minimize unwanted water and gas production.

Taking a cue from these initial successes, the first generation of modern horizontal drilling expanded rapidly into naturally fractured formations such as Texas’ Austin Chalk and North Dakota’s upper Bakken shale.

ABBREVIATIONS:
FNL - Feet from north line
FSL - feet from south line
FEL - feet from east line
FWL - feet from west line
FTMD - feet measured depth
TD - total depth
BH - bottom hole
BHL - bottom hole location
TVD - total vertical depth
FJ - flush joint

History

The concept of non-straight line, relatively short-radius drilling, dates back at least to September 8, 1891, when the first U.S. patent for the use of flexible shafts to rotate drilling bits was issued to John Smalley Campbell (Patent Number 459,152). While the prime application described in the patent was dental, the patent also carefully covered use of his flexible shafts or cables ordinarily employed are not capable of being bent to and working at a curve of very short radius ...

The first recorded true horizontal oil well, drilled near Texon, Texas, was completed in 1929. Another was drilled in 1944 in the Franklin Heavy Oil Field, Venango County, Pennsylvania, at a depth of 500 feet. China tried horizontal drilling as early as 1957, and later the Soviet Union also tried the technique. Generally, however, little practical application occurred until the early 1980s, when the advent of improved downhole drilling motors and the invention of downhole telemetry equipment, made the technology commercially viable.
The second generation of horizontal drilling is a result of the attainable horizontal displacement, particularly for medium- and long-radius wells, growing significantly. As operators and the drilling and service contractors have devised, tested, and refined their procedures, and as improved equipment has been designed and implemented, routinely achievable horizontal displacements rapidly climbed from 400 to over 8,000 feet. Second generation applications of horizontal drilling technology have included the drilling of stratigraphic traps, heterogeneous reservoirs, coal beds (to produce their methane content), and older fields (to boost their recovery factors), and fluid injection wells to boost both production rates and recovery factors. North Dakota examples of second generation horizontal drilling applications are the Cedar Hills-Red River and Wiley-Madison enhanced oil recovery projects, Nesson Anticline and Bowman County re-development drilling projects, and the Billings Nose-Birdbear drilling.

The third and current generation of horizontal drilling is a result of attaining much longer, deeper and more accurate placement of multiple horizontal well bores to exploit fractured source rocks (where it is coupled with new hydraulic fracturing technology) and heat injection wells (Canadian oil sands steam assisted gravity drainage) intended to boost both production rates and recovery factors. The present middle Bakken play in North Dakota and eastern Montana is an example of third generation horizontal drilling applications (figs. 3 and 4).

**Ancillary Benefits**

First, operators are often able to develop a reservoir with a significantly smaller number of wells, since each horizontal well can drain a larger rock volume than a vertical well could. The aggregate surface “footprint” of an oil or gas operation can be reduced by use of horizontal wells.

Second, use of a horizontal well may reverse or significantly delay the onset of production problems that engender low production rates, low recovery efficiencies, and/or premature well abandonment. This can significantly enhance oil and gas recovery as well as return on investment and total return.

Third, having the well cased into the producing formation during drilling of the horizontal section allows the operators to use lower density drilling mud. They can even allow the well to produce during drilling operations, preventing much of the formation damage that normally occurs when mud density must be high enough to keep well bore pressure greater than formation pressures.

**Special Regulatory Considerations**

Permitting and spacing processes use setbacks from the spacing unit boundaries to protect correlative rights and prevent waste. Consideration must be given to the different drainage patterns of horizontal wells and the small tool errors inherent in horizontal drilling that can be magnified over very long distances.

Regulatory inspection and oversight must be increased significantly. This is accomplished through more frequent drilling rig visits and requiring certified well bore surveys.

The geometry of horizontal well bores greatly impacts collection and dissemination of data such as cores, bottomhole pressures, gas oil ratios, and well logs.

The significantly larger well spacing and greater distance between wells impact oil transportation and measurement as well as gas gathering and flaring.
Shale Energy: 10 Points Everyone Should Know

1 **Hydraulic fracturing will account for nearly 70 percent of natural gas development in the future.**

Hydraulic fracturing and horizontal drilling apply the latest technologies and make it commercially viable to recover shale gas and oil. Without it, we would lose 45 percent of domestic natural gas production and 17 percent of our oil production within 5 years.2

2 **The economic impacts of developing shale gas resources are revolutionary.**

Development of shale resources supported 600,000 jobs in 2010.3 The number of direct and indirect jobs is constantly increasing. Affordable, domestic natural gas is essential to rejuvenating the chemical, manufacturing, and steel industries. The American Chemistry Council determined that a 25 percent increase in the supply of ethane (a liquid derived from shale gas) could add over 400,000 jobs across the economy, provide over $4.4 billion annually in federal, state, and local tax revenue, and spur $16.2 billion in capital investment by the chemical industry.4 They also note that the relatively low price of ethane would give U.S. manufacturers an essential advantage over many global competitors. Similarly, the National Association of Manufacturers estimated that high recovery of shale gas and lower natural gas prices will help U.S. manufacturers employ 1,000,000 workers by 2025 while lower feedstock and energy costs could help them reduce natural gas expenditures by as much as 11.6 billion by 2025.5 America’s Natural Gas Association (ANGA) estimates that lower gas prices will add an additional $926 of disposable household income annually between 2012 and 2015, and that the amount could increase to $2,000 by 2035.6
Robust state and federal regulations for hydraulic fracturing already exist. A comprehensive set of state, local, and federal laws address nearly every aspect of exploration and production. These include well design, water use, waste management and disposal, air emissions, surface impacts, health, safety, location, spacing, and operation. State regulation of oil and gas activities pre-dated federal regulation, and is particularly important because it allows laws to be tailored to local geology and hydrology. Organizations like the State Review of Oil and Natural Gas Environment Regulations (STRONGER) are available to help assess the overall framework of environmental regulations supporting oil and gas operations in any given state. States also exchange information on regulatory experiences and practices through periodic meetings of interstate organizations such as the Interstate Oil and Gas Compact Commission and the Groundwater Protection Council. To help protect environmental health and safety during oil and gas operations, companies must also comply with the following federal statutes and their supporting regulations: the Clean Water Act (CWA); the Safe Drinking Water Act (SDWA); the Clean Air Act (CAA); the Emergency Planning and Community Right to Know Act (EPRCA); and the Occupational Health and Safety Act (OSHA).

Industry has standards and practices for continuous improvement. API has a standards program accredited by the American National Standards Institute (ANSI) which also accredits programs at several of our national labs, and has a long history of developing highly technical standards, recommended practices, and guidance documents for oil and gas operations. Hundreds of API’s standards are referenced directly in state oil and gas regulations thousands of times. Three API guidance documents pertain specifically to hydraulic fracturing issues (HF1: Well Construction and Integrity, HF2: Water Management, HF3: Practices for Mitigating Surface Impacts Associated with Hydraulic Fracturing). An additional two documents, RP 51R: Environmental Protection for Onshore Oil and Gas Production Operations and Leases and Standard 65-2: Isolating Potential Flow Zones During Well Construction are also important for shale energy development. Although regional differences in state geology make a single set of regulations impractical, these documents provide a roadmap for responsible operations from the point of permitting to land reclamation after well closure, and Good Neighbor guidance on cooperating with landowners, host communities and other stakeholders.
5 Careful well construction keeps groundwater safe. Each well contains multiple layers of steel casing and cementing to effectively protect groundwater. Additionally, most modern wells are equipped with sensitive monitoring equipment and supervised by experienced, highly trained technicians.

6 The contents of fracturing fluids (which are mainly water) are disclosed. The typical fracturing fluid is approximately 90% water and 9.5% sand, with the remainder being additives that aid well production. The oil and natural gas industry has led the way in its support for public information about fracturing fluids, industry voluntarily discloses the contents of its fluids on the website FracFocus.org, which is run by the Groundwater Protection Council. FracFocus.org provides a public database that can be searched by well or well location so that concerned individuals can easily identify the constituents used to fracture specific wells. As of early 2012, nearly one hundred companies have already provided information about approximately ten thousand wells and that number increases every day.

7 Water is managed effectively and fluids are handled to prevent spills. Although hydraulic fracturing operations use considerable volumes of water, the oil and gas industry’s water use is small when compared to other industrial and recreational activities. Moreover, during permitting, operators typically must demonstrate that their water use and management plans will not adversely affect others in the region in times of flood or drought. Spill prevention, response, and clean up procedures are implemented before drilling activities begin and continually updated as operations progress. Numerous protective measures are in place at well sites including liners under well pads, rubber composite mats under rigs, storage tanks with secondary containment measures, and barriers to control and direct any potential runoff at the site. Appropriate on-site employees and contract personnel are trained in the safe and proper transportation, transfer, and containment of fluids and materials.

8 Wastes from production activities are managed responsibly. Operators manage waste conscientiously in accordance with applicable state and federal laws, as well as OSHA regulations. To the extent possible, fracturing fluid is recovered and recycled for re-use in future fracturing operations, or injected into Class II wells.
Hydraulic fracturing does not cause earthquakes. As seismologists and geologists across the country have already determined, the activity that occurs during the hydraulic fracturing process does not produce vibrations of noticeable size, and there is no evidence it causes earthquakes. As authorized under the Safe Drinking Water Act. Many state authorities require companies to submit waste management plans as part of the permitting process to ensure that waste management options are carefully weighed well in advance.

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Air emissions from production activities are carefully monitored, managed and reported. Any emissions from oil and gas activity must remain within prescribed state and federal limits to ensure the health and safety of local communities. Natural gas is considered a clean burning fuel because of its comparatively low emissions of carbon dioxide, sulfur oxides, and nitrogen oxides. Industry has made considerable strides in reducing emissions through voluntary measures, and is working with the EPA to define New Source Performance Standards (NSPS) that will give rise to additional reductions by requiring measures like green completion techniques. Furthermore, the Mandatory Reporting Rule may help provide a more robust data set to use in evaluating the emissions from shale energy production.

Example of a completed well
Photo by Richard Ranger

1 National Petroleum Council, “Prudent Development: Realizing the Potential of North America’s Abundant Natural Gas and Oil Resources,” September 15, 2011.
7 STRONGER is a non-profit, multi-stakeholder organization which specializes in assessing the overall framework of environmental regulations supporting oil and gas operations. Their collaborative review teams encompass industry, regulators, and environmental/public interest stakeholders. Since its initiation, the state review process has completed reviews of 21 state programs responsible for the regulation of over 90% of the domestic onshore production of oil and natural gas. Stronger has completed specific hydraulic fracturing reviews in Colorado, Louisiana, Oklahoma, Pennsylvania, and Ohio. For more information, see http://www.strongergnc.org/.
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On average, 99.5% of fracturing fluids are comprised of freshwater and compounds are injected into deep shale gas formations and are typically confined by many thousands of feet or rock layers.

The documentary *Gasland* has attracted wide attention. Among other things, it alleges that the hydraulic fracturing of oil and gas wells has contaminated nearby water wells with methane in a number of states including Colorado. Because an informed public debate on hydraulic fracturing depends on accurate information, the Colorado Oil and Gas Conservation Commission (COGCC) would like to correct several errors in the film’s portrayal of the Colorado incidents.

**Background**

Methane is a natural hydrocarbon gas that is flammable and explosive in certain concentrations. It is produced either by bacteria or by geologic processes involving heat and pressure. Biogenic methane is created by the decomposition of organic material through fermentation, as is commonly seen in wetlands, or by the chemical reduction of carbon dioxide. It is found in some shallow, water-bearing geologic formations, into which water wells are sometimes completed. Thermogenic methane is created by the thermal decomposition of buried organic material. It is found in rocks buried deeper within the earth and is produced by drilling an oil and gas well and hydraulically fracturing the rocks that contain the gas. In Colorado, thermogenic methane is generally associated with oil and gas development, while biogenic methane is not.

The analytical methods used to differentiate between the two types of methane are well-known, scientifically accepted, and summarized in a well-known presentation by Dennis Coleman and papers by I.R. Kaplan and Dennis Coleman. These works, in turn, cite nearly 75 other references related to the topics of methane generation, “fingerprinting,” forensic investigations, and stable isotope geochemistry.

Based upon our review of hundreds of Colorado gas samples over many years, the COGCC is able to differentiate between biogenic and thermogenic methane using both stable isotope analysis of the methane and compositional analysis of the gas. In the Denver-Julesburg and Piceance Basins, the COGCC has consistently found that biogenic gas contains only methane and a very small amount of ethane, while thermogenic gas contains not just methane and ethane but also heavier hydrocarbons such as propane, butane, pentane, and hexanes.

As explained below, *Gasland* incorrectly attributes several cases of water well contamination in Colorado to oil and gas development when our investigations determined that the wells in question contained biogenic methane that is not attributable to such development.

**The Weld County Wells**

*Gasland* features three Weld County landowners, Mike Markham, Renee McClure, and Aimee Ellsworth, whose water wells were allegedly contaminated by oil and gas development. The COGCC investigated complaints from all three landowners in 2008 and 2009, and we issued written reports summarizing our findings on each. We concluded that Aimee Ellsworth’s well contained a mixture of biogenic and thermogenic methane that was in part attributable to oil and gas development, and Mrs. Ellsworth and an operator reached a settlement in that case.
However, using the same investigative techniques, we concluded that Mike Markham’s and Renee McClure’s wells contained biogenic gas that was not related to oil and gas activity. Unfortunately, *Gasland* does not mention our McClure finding and dismisses our Markham finding out of hand.

The Markham and McClure water wells are both located in the Denver-Julesburg Basin in Weld County. They and other water wells in this area draw water from the Laramie-Fox Hills Aquifer, which is composed of interbedded sandstones, shales, and coals. Indeed, the water well completion report for Mr. Markham’s well shows that it penetrated at least four different coal beds. The occurrence of methane in the coals of the Laramie Formation has been well documented in numerous publications by the Colorado Geological Survey, the United States Geological Survey, and the Rocky Mountain Association of Geologists dating back more than 30 years. For example, a [1976 publication by the Colorado Division of Water Resources](http://www.waterresources.state.co.us) states that the aquifer contains “troublesome amounts of . . . methane.” A [1983 publication by the United States Geological Survey](http://pubs.usgs.gov) similarly states that “[m]ethane-rich gas commonly occurs in ground water in the Denver Basin, southern Weld County, Colorado.” And a [2001 report by the Colorado Geological Survey](http://www.colorado.gov) discusses the methane potential of this formation and cites approximately 30 publications on this subject.

Laboratory analysis confirmed that the Markham and McClure wells contained biogenic methane typical of gas that is naturally found in the coals of the Laramie–Fox Hills Aquifer. This determination was based on a stable isotope analysis, which effectively “finger-printed” the gas as biogenic, as well as a gas composition analysis, which indicated that heavier hydrocarbons associated with thermogenic gas were absent. In addition, water samples from the wells were analyzed for benzene, toluene, ethylbenzene, and xylenes (BTEX), which are constituents of the hydrocarbons produced by oil and gas wells in the area. The absence of any BTEX compounds in these water samples provided additional evidence that oil and gas activity did not contaminate the Markham and McClure wells.

The COGCC has also reviewed the records for all oil and gas wells located within one-half mile of the Markham and McClure wells, which is more than double the typical hydraulic fracture length in Colorado. This review indicated that: all oil and gas wells near the Markham well were drilled and hydraulically fractured in 1991, except for two wells that were fractured in 2005 and 2006, respectively; and all oil and gas wells near the McClure well were drilled and hydraulically fractured in 2002, except for one well that was hydraulically fractured in 2005. The records do not reflect any pressure failures or other problems associated with these wells that would indicate a loss of fracture fluid or gas from the well bore into the surrounding geologic formations.

In support of its thesis that the Markham and McClure water wells were contaminated by oil and gas development, the *Gasland* website makes several arguments that merit a brief response. First, the website quotes Professor Anthony Ingraffea of Cornell University for the proposition that drilling and hydraulic fracturing could cause biogenic methane to migrate into aquifers under certain circumstances. However, Professor Ingraffea’s statement does not suggest that these circumstances apply to the Markham and McClure wells, nor does it address the extensive scientific literature establishing that biogenic methane is naturally present in the aquifer in question. Second, the website quotes Weston Wilson, an Environmental Protection Agency employee, speculating that oil and gas operators in Weld County are withdrawing large amounts of groundwater and that these withdrawals are releasing biogenic methane. However, oil and gas companies in Weld County obtain most of their water from municipalities, which obtain such water from surface water sources such as the Colorado-Big Thompson and Windy
Gap projects. Finally, the website asserts that the water in the Markham and McClure wells deteriorated after drilling and hydraulic fracturing occurred nearby. However, COGCC records indicate little or no temporal relationship between the Markham and McClure complaints and nearby drilling and hydraulic fracturing activities, which occurred several years earlier and in most cases many years earlier.

The West Divide Creek Seeps

Gasland also addresses complaints about oil and gas activity in the West Divide Creek area of the Piceance Basin in Garfield County, though it again confuses issues related to biogenic gas with those related to thermogenic gas. The film focuses on two seeps that are in close geographic proximity but derive from different origins. One of the seeps occurs in a wetland on property owned by Lisa Bracken, who appears in the film; it contains biogenic methane. The other seep, which the COGCC terms the West Divide Creek gas seep, is about 1,500 feet to the south on property owned by a neighbor; it contains thermogenic methane caused by EnCana’s failure to properly cement a natural gas well.

Gasland adopts the claim that the West Divide Creek gas seep was caused by hydraulic fracturing. After investigating the matter thoroughly in 2004, COGCC staff concluded the seep was caused by gas migrating up a gas well borehole that had not been properly cemented and in which the upper portion of the gas bearing Williams Fork Formation had not been isolated. On August 16, 2004, following a public hearing, the COGCC commissioners approved an enforcement order (Order 1V-276) that incorporated the staff’s causation conclusions and assessed a substantial fine against the operator.

In investigating the West Divide gas seep, the COGCC determined that it contains thermogenic methane. The gas composition and stable isotope signature of the gas closely matched that of the gas being produced from the Williams Fork Formation. The gas from both the West Divide Creek seep and the Williams Fork Formation is composed primarily of methane, but it also contains ethane, propane, butane, pentane, and hexanes. In addition, BTEX compounds were detected in ground and surface water in the vicinity of the West Divide Creek seep, which indicates that the gas is related to oil and gas activities and not of biogenic origin.

In contrast, the laboratory results for the gas samples collected from the seep on Ms. Bracken’s property have demonstrated that the gas is biogenic. The COGCC has collected nine gas samples on six different occasions during 2004, 2007, 2009, and 2010. With respect to each sample, the gas composition was found to be 100 percent methane, no heavier hydrocarbon compound was detected, and the stable isotope ratio indicated that the gas is biogenic. The COGCC has also collected six water samples on four different occasions during 2004, 2007, and 2009 and ten soil samples on multiple occasions during 2008 and 2009 from Ms. Bracken’s property. BTEX compounds and/or other hydrocarbons associated with oil and gas operations were not detected in any of these samples. Based on these results, the COGCC has concluded that the gas seep on Ms. Bracken’s property resulted from the fermentation of organic matter by methanogenic bacteria. This is not uncommon in wetland areas, such as those that exist along West Divide Creek.

Other Information

Oil and gas development is an industrial activity, and property owners sometimes complain that it has contaminated their water well. The COGCC investigates all such complaints and reports the results individually to the complainant and collectively to the Colorado Water Quality Control
Division. In some cases, the COGCC has found that the well contains thermogenic methane linked to oil and gas development. In most cases, however, the COGCC has found that contamination is not present or that the methane comes from biogenic sources and is not attributable to oil and gas production. The following excerpt from a report summarizing the COGCC’s investigation following the contamination of the Ellsworth water well is illustrative:

In response to concerns regarding the presence of methane gas in water wells completed in the Laramie/Fox Hills Aquifer, COGCC, Noble Energy, and Anadarko/Kerr McGee sampled a total of 28 water wells between March 25, 2009 and April 7, 2009 across an approximately 170 square mile area. Sample results show that these wells contained either no methane gas or biogenic (biological generated) methane gas. None of these wells, other than the Ellsworth water well, contained thermogenic methane gas. The sample results along with letters discussing the results were sent by COGCC staff to the 28 well owners [who had requested testing].

Nevertheless, it remains important to establish prudent regulations to ensure that other resources, such as groundwater, are protected. Producing oil and gas formations in much of Colorado, including the Denver-Julesburg and Piceance Basins, lie at depths of up to 8,000 feet below the ground surface, while the aquifers that sustain domestic water wells are generally less than 1,000 feet below the ground surface. COGCC regulations establish casing and cementing standards to ensure that gas being produced from 8,000 feet down does not leak into the shallower aquifers. These regulations require wells to be cased with steel pipe and the casing to be surrounded by cement to create a hydraulic seal within the annular space between the wall of the well bore and the steel pipe. In addition, a number of recent amendments to the COGCC regulations address concerns raised about hydraulic fracturing:

- Rule 205 requires operators to inventory chemicals, including fracturing fluids, and to provide this information upon request to the COGCC and certain health care professionals;
- Rule 317 requires cement bond logs to confirm that aquifers are protected;
- Rule 317B imposes mandatory setbacks and enhanced environmental precautions on oil and gas development occurring near public drinking water sources;
- Rule 341 requires well pressures to be monitored during hydraulic fracturing;
- Rule 608 mandates additional pressure testing and water well sampling for coalbed methane wells; and
- Rules 903, 904, and 906 impose enhanced requirements for pit permitting, lining, monitoring, and secondary containment to ensure that pit fluids, including hydraulic fracturing flowback, do not leak.

Finally, it should be understood that the COGCC Director, Dave Neslin, offered to speak with Gasland's producer, Josh Fox, on camera during the filming of the movie. Because the issues are technical and complex and arouse concerns in many people, Director Neslin asked that he be allowed to review any material from the interview that would be included in the final film. Unfortunately, Mr. Fox declined. Such a discussion might have prevented the inaccuracies noted above.