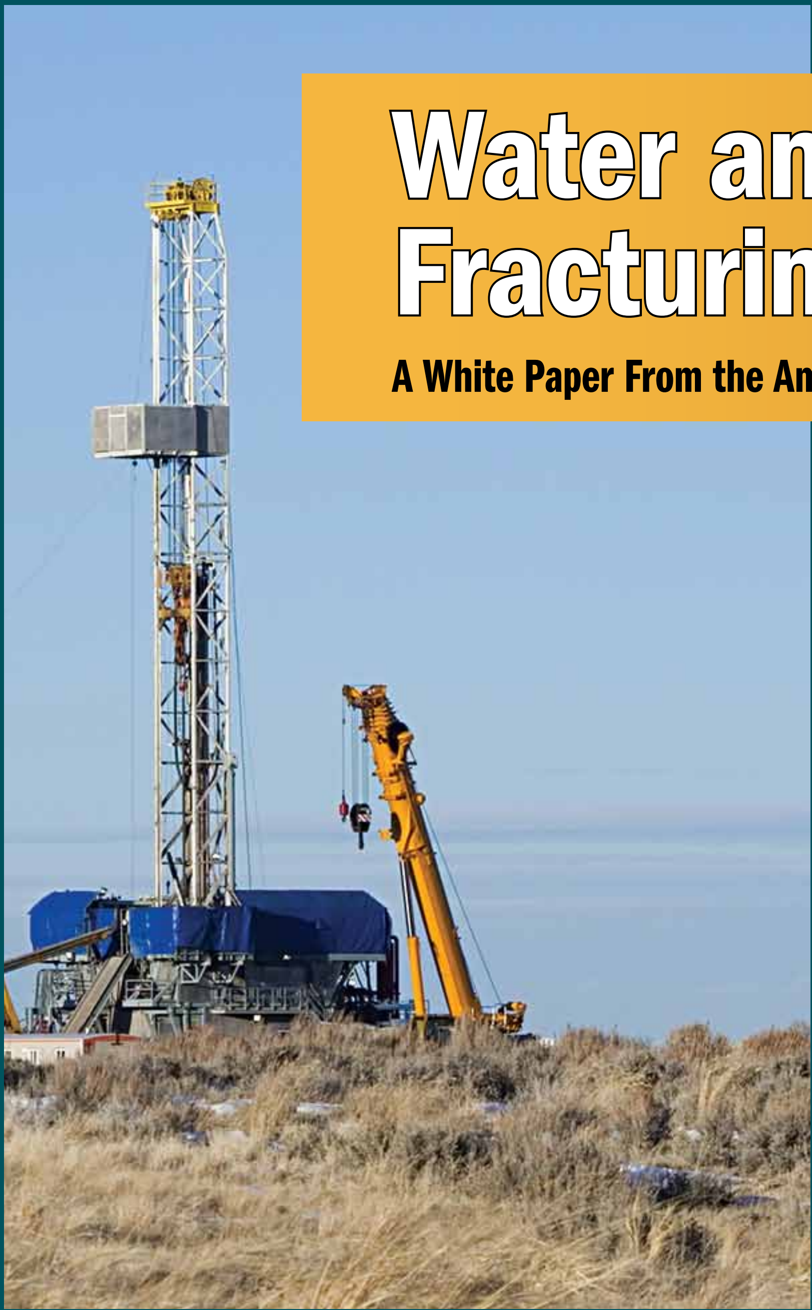
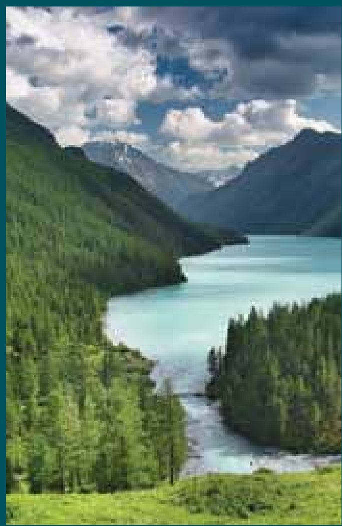
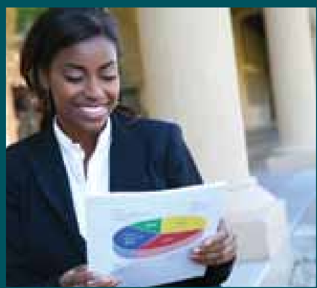
Water and Hydraulic Fracturing

A White Paper From the American Water Works Association







www.awwa.org/fracturing

American Water Works Association

The Authoritative Resource on Safe Water®

Source: Keith Srakocic, AP

Above, a natural gas well is being drilled. The different-diameter pipes are placed inside each other and cemented together inside the well to protect water resources, and are known as casing.

Fracking facts: Hydraulic fracturing and its impact on water resources

Introduction

In recent years, there has been substantial public scrutiny of the process of hydraulic fracturing, commonly known as "fracking." Citizens' groups, environmental advocates, municipal leaders, and others have expressed concern that the process and activities associated with fracking could result in the contamination of water resources. Media has elevated these concerns in many national and local stories, but the facts and risks surrounding hydraulic fracturing are not widely understood.

AWWA has produced this white paper in response to growing public awareness and concern about hydraulic fracturing and related activities. The paper provides water utilities with background, facts, and resources to help them understand and communicate fracking processes, risks, and regulations. Additionally, the paper considers both hydraulic fracturing itself and other components in the life cycle of oil and natural gas development that may present concerns to drinking water utilities. Although this document primarily discusses drinking water utility risks and concerns—and ways to mitigate them—it is important to remember that any policy decisions regarding energy development must take both risks and benefits into account. Although summarized briefly, the benefits of energy development—which can be substantial—are not discussed in detail in this paper.

What is hydraulic fracturing?

Hydraulic fracturing is a process used as a step in the development of many oil and natural gas wells. It involves the injection of a fracturing fluid (a mixture of mostly water and sand with some chemical additives) under pressure to create artificial fissures in subsurface oil and gas bearing-rocks. The fissures created by fracking allow oil and/or natural gas to flow more freely from the underground formation to a well.[1] In many areas of the country, it would not be feasible to recover oil and natural gas without hydraulic fracturing.[2]

The technology involved in fracturing has existed for decades.[3] However, recent improvement in the technology—along with horizontal drilling—now allows for energy development in vast areas in many states. This increased development includes some areas where little development previously existed or where it had declined over time.[4] These recent changes in hydraulic fracturing and drilling technologies have fueled a dramatic expansion in oil and natural gas production and have brought substantial visibility and controversy to the process in many parts of the country.

1 Ground Water Protection Council (GWPC), ALL Consulting, National Energy Technology Laboratory, and the U.S. Department of Energy. April 2009. *Modern Shale Gas Development in the United States: A Primer.* DE-FG26-04NT15455 Available at http://www.netl.doe.gov/technologies/oil-gas/publications/epreports/shale_gas_primer_2009.pdf. Page ES-4.

2 Montgomery, C.T., and M.B. Smith. December 2010. *Hydraulic Fracturing History of an Enduring Technology. Journal of Petroleum Technology.* Available at http://www.spe.org/jpt/print/archives/2010/12/10Hydraulic.pdf. Pages 27-28.

3 Ibid. Page 27.

4 GWPC *et al*. 2009. Page ES-1.

The development of an oil or gas well begins with siting, which involves determining exactly where a well will go, based on factors such as availability of mineral rights and restrictions on where "well pads" (on which the drilling rig will sit) can be located. Once siting has been decided and a well pad constructed, drilling begins. With the drilling, there is an iterative installation of casing (installing steel piping to isolate the wellbore from water aquifers and other non-target zones) and cementing (securing the casing in place with cement). Once the well has reached the targeted geologic formation, it may be "fracked" (or another well stimulation technique may be used) to increase the flow of oil or gas from the oil- or gas-rich formation. The majority of a well's active life is in the production period, when oil and gas comes to the surface through the wellbore for processing and use. Wastewaters that require disposal or recycling are produced (described in more detail below) throughout the cycle. Once the well no longer produces enough oil or natural gas to be economically viable, it will be closed through a process called abandonment. Abandonment usually involves the use of cement designed to permanently isolate the production zone, drinking water aquifers, and the surface from one another.

Many concerns about hydraulic fracturing often incorrectly refer to other parts of the oil and gas development life cycle.

Many concerns about hydraulic fracturing often incorrectly refer to other parts of the oil and gas development life cycle, rather than to hydraulic fracturing *per se*. From a strictly engineering standpoint, it is not appropriate to attribute to fracking any issue that is actually associated with other phases in the life cycle of an oil or gas well. Because other activities are often mistakenly associated with fracking in the media and elsewhere, there can be significant confusion on the entire subject. This in turn often leads to difficulty in communicating information about risks, benefits, scientific research, regulatory systems, and policies. This paper discusses both hydraulic fracking and other stages of the oil and natural gas development cycle.

What are the risks of oil and natural gas development to drinking water?

Oil and gas development is an industrial activity, and like all industrial activities, it carries some degree of risk. AWWA believes these risks can be managed via prudent and reasonable protections implemented through a combination of state and federal regulations, best practices, and monitoring. A number of studies are currently under way to characterize and quantify risks associated with oil and gas activities, including fracking, well construction, the possibility of spills or accidents, and waste management issues. When completed, these studies will help fill knowledge gaps and inform future research. Given current knowledge, it is possible to qualitatively describe with a high degree of confidence the potential risks to drinking water supplies from oil and gas development activities, but it is not currently possible to quantify those risks with confidence.

Source: Ed Andrieski, AP

Crew members work on a drilling platform. The drilling of a well takes place prior to hydraulic fracturing.

Potential for groundwater contamination

The issue of spills and accidents is not limited to wells utilizing hydraulic fracturing, but rather applies to all oil and gas development as well as many other industrial activities.

A properly constructed and managed oil or natural gas well that complies with regulations and utilizes industry best practices is unlikely to directly cause groundwater contamination, although it cannot be said that such contamination is impossible. Although depths vary by the local geology, hydraulic fracturing generally takes place hundreds to thousands of feet below the deepest drinking water aquifer, and experts consider it unlikely that fissures stretching from the production zone into a drinking water aquifer could be accidentally created.[5] There are several technological, regulatory, and procedural safeguards commonly practiced throughout the oil and natural gas industry that are specifically designed to prevent such contamination. These safeguards include proper surface casing, deep-well casing, well construction techniques, and cementing processes. They serve to prevent the escape of fracturing fluids, waste materials, or oil and natural gas into drinking water aquifers. An escape of fluids and gases into drinking water aquifers is possible, although it would generally require the simultaneous failure of multiple safeguards. If leaks do occur as the result of defects in these practices, it is possible to seal them.[6] In some cases in which groundwater contamination has been linked to oil and gas development, the problem has been found to stem from a degradation of the well casing over time. Given technological advances, casing in modern wells is expected to be less likely to degrade. A study on this issue did not implicate the hydraulic fracturing process itself as a source of or contributor to contamination of drinking water aquifers, and the risks of this type of degradation can be reduced through monitoring and testing.[7] A type of methane contamination known as "stray gas" has been observed in drilling water wells in a few cases where casing and cementing problems of oil and natural gas wells, the water wells themselves, or both, has resulted in migration of gas from zones close to the drilling aquifer. These zones are much closer to the surface than the areas where the fracking takes place, and if stray gas issues arise they can result in safety problems and even explosion hazards if not detected and remedied.[8] Methane also exists naturally in some aquifers and is not automatically a sign of contamination.

Source: David Zalubowski, AP

A worker surveys operating at an active natural gas development site.

Improper closure or abandonment of a well could also provide a pathway through which contamination could occur if production zones, drinking water aquifers, and the surface are not properly isolated from one another. Fortunately, regulation and best practice make improper abandonment unlikely at modern wells,even though there may be many old wells that were improperly abandoned.[9]

Potential for surface water contamination

Oil and natural gas operations can cause surface water contamination through several potential pathways. Surface water is at risk from spills and accidents at and around well sites, from pipelines and storage facilities, through trucks delivering chemicals or removing wastes, and from improper or illegal disposal of wastes. These risks can be mitigated through prudent and simple measures such as the use of reputable disposal companies (reducing risks of improper or illegal disposal) and safety-conscious management. The issue of spills and accidents is not limited to wells utilizing hydraulic fracturing, but rather applies to all oil and gas development as well as many other industrial

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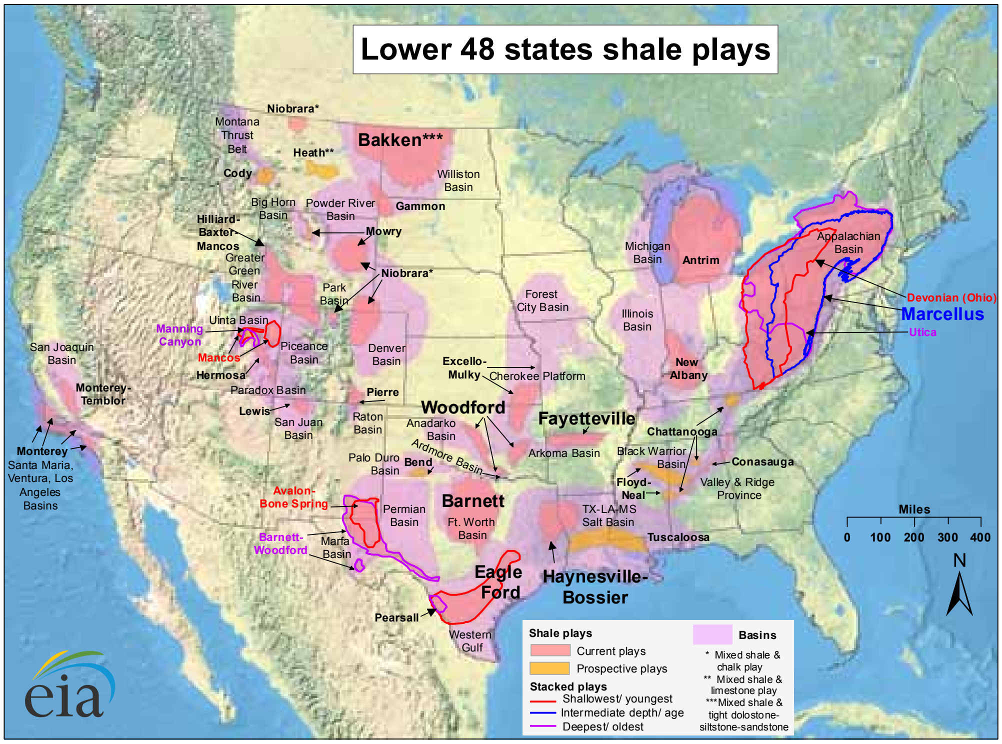
[5] GWPC *et al.* 2009. pages 56-61.

[6] Kell, S. August 2011. *State Oil and Gas Agency Groundwater Investigations and Their Role in Advancing Regulatory Reforms. A Two-State Review: Ohio and Texas*. Groundwater Protection Council. Available at http://fracfocus.org/sites/default/files/publications/state_oil__gas_agency_groundwater_investigations_optimized.pdf.

[7] Ibid.

[8] Veil, J. 2012. *A White Paper Summarizing the Stray Gas Incidence & Response Forum.* Ground Water Protection Council. Available at http://www.gwpc.org/sites/default/files/files/stray%20gas%20white%20paper-final.pdf.

[9] Kell. 2011.



Source: U.S. Energy Information Administration

Shale plays are areas most likely to have current or future oil and natural gas development utilizing hydraulic fracturing.

activities. Although most spills are small and are captured in containment facilities, some could have the potential to reach source waters. Accidents and spills are typically monitored by state agencies, and there are federal notification requirements for larger spills.

The use of horizontal drilling has reduced the number of well pads, and therefore the total surface land area affected, for a given amount of oil or gas produced. However, wells are being constructed in areas where there were few or no wells in the past. Although the effects related with stormwater runoff from well pads, service roads, pipelines, and other related infrastructure may be small for any given site, the total area of land involved could potentially give rise to changes in water quality because of runoff and soil erosion. These impacts are similar to other construction activities and can occur even in the complete absence of contamination directly related to the oil and gas activities.[10]

Water quantity/Water use issues

Drilling and fracturing of wells requires a substantial amount of water. The water required for hydraulic fracturing varies with the local geology, but typically totals from under a million to several million gallons for each fracturing "event." Some wells are reported to have required as much as 13 million gallons.[11] Generally, wells are fractured in several phases, each creating fissures along a different segment of the production zone. All the fracturing events at a given oil or gas well—the fracking phase of well development—generally require a few days to complete. At some later point in the production process, the developer may fracture the well again to further increase the level of oil or gas production.

In some areas, "frack water" is ultimately returned to the watershed, but in most cases it is not. Although this consumptive use may only represent a small percentage of water demand in water-rich areas of the country, in water-scarce areas and in times of drought, any added water use has the potential to divert needed supply away from water utilities. Intensity is another important consideration, as the need for water in the life cycle of a well tends to occur in short but intense bursts. These could temporarily put significant strain on water resources. The oil and gas industry is researching improved water recycling techniques as well as methods to use high-salinity water that public water systems wouldn't usually use. These techniques are likely to reduce risks to water

Generally, wells are fractured in several phases, each creating fissures along a different segment of the production zone.

[10] Banks, K.E., and D.J. Wachal. 17 December 2007. *Demonstrating the Impacts of Oil and Gas Exploration on Water Quality and How to Minimize These Impacts Through Targeted Monitoring Activities and Local Ordinances.* ID No. CP-83207101-1. Available at http://www.epa.gov/npdes/pubs/oilandgas_impactgrant.pdf.

[11] Cooley, H., and K. Donnelly. June 2012. *Hydraulic Fracturing and Water Resources: Separating the Frack from the Fiction.* The Pacific Institute. Available at http://www.pacinst.org/reports/fracking/full_report.pdf.

Oil and natural gas development is regulated through multiple state and federal environmental laws.

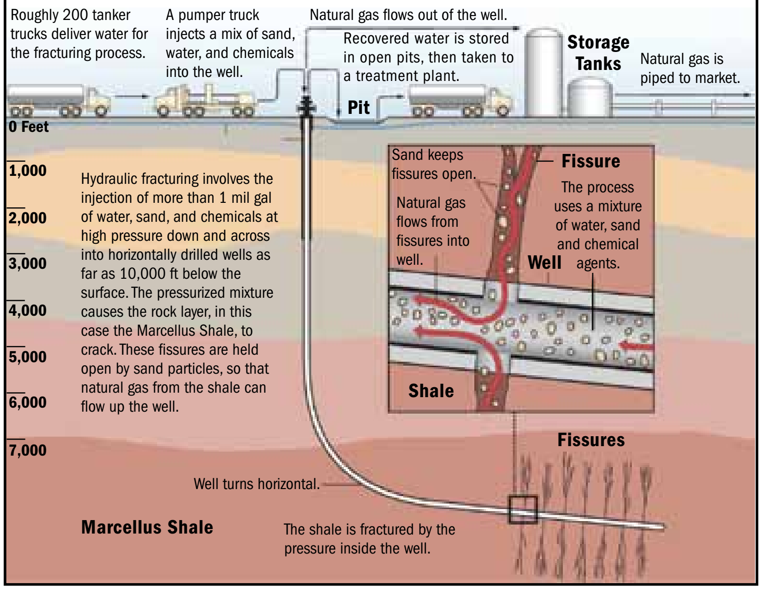
quantity if they prove feasible and are fully implemented.[12] Although comprehensive statistics are not currently available, some oil and gas development companies have indicated that they will reach nearly 100% water recycling within a few years. Recycling rates are likely to vary by company, local geology, and water availability. Drinking water utilities and water resource managers may wish to determine how much water is likely to be used for the development of oil and gas wells in their area, and what sources will be used. They may also want to establish baselines to compare pre- and post-drilling impacts across a watershed.

Induced seismicity

Researchers are investigating a possibility that oil and gas activities can cause earthquakes. This issue is known as induced seismicity. Many experts believe that—to the extent there is risk associated with induced seismicity—waste disposal wells are a more likely cause than hydraulic fracturing.[13] The National Academies of Science have determined, in fact, that induced seismicity from injection for waste disposal is likely to occur in some locations. However, the implications of this finding are not yet clear, as little actual impact has been identified from these events, which have generally been of very low magnitude. Research continues, including research into preventive measures that could decrease the incidence and severity of induced seismicity. See also Production and waste disposal, below.

Hydrofracking Details

Hydrofracking causes seismic-like activity, breaking up rock and opening many veins in the earth, thus releasing the gas.



Source: Al Granberg/ProPublica

The hydraulic fracturing process and some of the associated activities are depicted. The number of trucks and whether produced water is or is not stored in pits varies based on the company, geology, and state regulations.

Is hydraulic fracturing regulated?

Oil and natural gas development is regulated through multiple state and federal environmental laws. Given the complexity of the oil and gas processes involved, various facets fall under different regulatory structures.

Historically, and at present, well siting, drilling, casing, cementing, and most other facets of oil and gas production are regulated primarily under state law by a combination of regulatory requirements and permitting processes.[14] Certain regulatory frameworks are used in more than one state, and some of them are becoming more common across additional states. Programs such as the State Review of Oil & Natural Gas Environmental Regulations (STRONGER) review regulations across many states and make recommendations to enhance and update them as necessary.[15] Given the range of differences among states, this paper does not attempt to describe the oil and gas regulations of each state. Rather, it identifies trends and common practices. Utilities are encouraged to become familiar with the laws and

[12] GWPC *et al*. 2009. Page 70.

[13] National Research Council. 2012. *Induced Seismicity Potential in Energy Technologies. National Academies Press*. Available at http://www.nap.edu/catalog.php?record_id=13355 ISBN 0-309-25367-5.

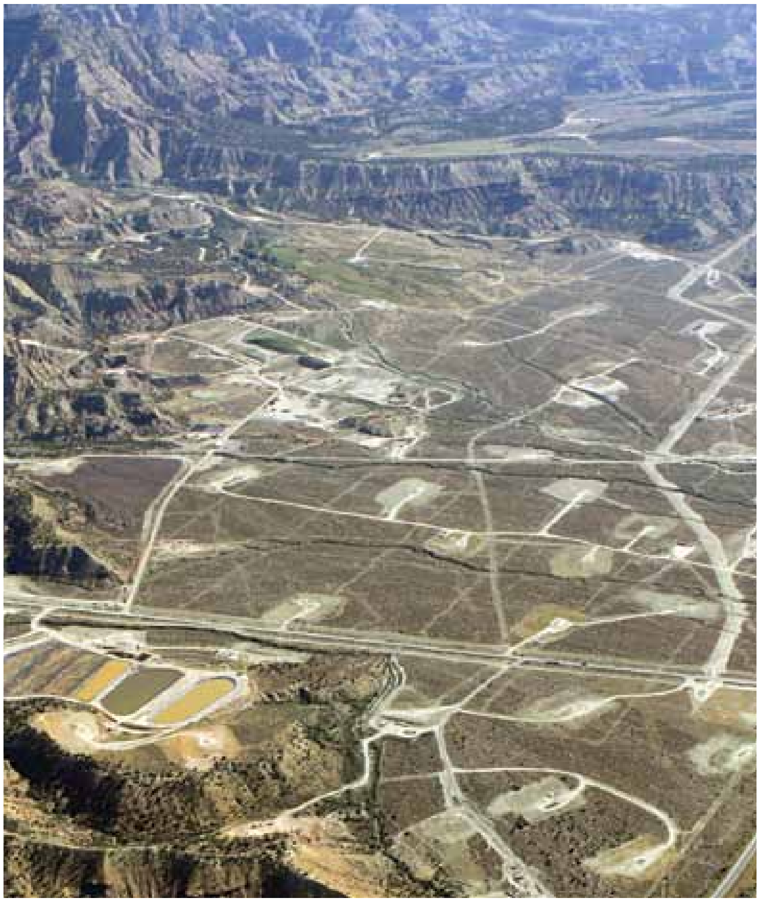
[14] GWPC *et al*. 2009.

[15] State Review of Oil & Natural Gas Environmental Regulations (STRONGER). 2012. *Our Mission*. Available at http://www.strongerinc.org/our-mission.

regulations of their states. Several reports are available that help with that task.[16, 17]

It is important that regulators have sufficient resources to properly and fully implement regulatory and enforcement programs. As with any industry, oil and gas developers come with ranges of regulatory compliance and safety records. Some exhibit excellent environmental and safety backgrounds and can boast innovative programs that go beyond requirements; some just do what is required; and some have less desirable records. A well-funded and managed regulatory and enforcement program can identify any companies that may be "behind the curve" in environmental protection and safety and take corrective steps to prevent future problems.

The primary exception to state-centered regulation involves drilling that takes place on or below federal lands, where the federal government generally serves as the regulator. In some areas, federal agencies have agreements with state regulators to manage regulations on federal lands. Federal laws and regulations also do apply to certain facets of the oil and gas production cycle. In addition to the laws discussed below, for example, certain federal workplace health and safety laws and regulations apply to oil and gas production activities. Those are outside the scope of this paper.



Source: Ed Andrieski, AP

Oil and natural gas activities are shown in Colorado. Construction and land use activity can result in increased stormwater runoff.

Finally, a few facets of oil and gas development are specifically exempted from federal requirements that otherwise might have applied. For example, although industry best practices can reduce runoff and sedimentation,[18] many oil and gas activities are exempt from the Clean Water Act's National Pollutant Discharge Elimination System (NPDES) stormwater permits for uncontaminated runoff. Such permits do apply to many other construction activities.[19] Some states regulate these activities more stringently than the federal government does.

Also exempted from federal regulation is the hydraulic fracturing step in oil or gas well development. Fracking was entirely unregulated under the Safe Drinking Water Act's Underground Injection Control Program (UIC) until litigation and debate in the 1990s and early 2000s questioned whether the UIC program should apply. In the 2005 Energy Policy Act, Congress answered that question by modifying the definition of "underground injection" to specifically exclude hydraulic fracturing and certain associated activities from UIC regulation, unless diesel fuels are used as a portion of the fracturing fluids.[20] In those situations, federal requirements relating to well casing, cementing, fracturing, and abandonment may be included under UIC permits administered through either USEPA regions or state primacy agencies.

The primary exception to state-centered regulation involves drilling that takes place on or below federal lands, where the federal government generally serves as the regulator.

[16] Resources for the Future. 2012. *A Review of Shale Gas Regulations by State.* Available at http://www.rff.org/centers/energy_economics_and_policy/Pages/Shale_Maps.aspx.

[17] US Energy Department (U.S. DOE) and the Ground Water Protection Council (GWPC). 2009. *State Oil and Natural Gas Regulations Designed to Protect Water Resources*. Available at http://www.gwpc.org/sites/default/files/state_oil_and_gas_regulations_designed_to_protect_water_resources_0.pdf.

[18] Independent Petroleum Association of America. Date Unknown. Guidance Document: Reasonable and Prudent Practices for Stabilization (RAPPS) of Oil and Gas Construction Sites. Available at http://fracfocus.org/sites/default/files/publications/rapps_guidance.pdf.

[19] USEPA. 9 March 2009. *Regulation of Oil and Gas Construction Activities*. Available at http://cfpub.epa.gov/npdes/stormwater/oilgas.cfm.

[20] SDWA § 1421(d) states that "the term 'underground injection' excludes ... the underground injection of fluids or propping agents (other than diesel fuels) pursuant to hydraulic fracturing operations related to oil, gas, or geothermal production activities."

Site selection

Practical and regulatory factors limit where well pads can be placed and where drilling can occur, although such limits vary substantially by state and location. In order to drill, the oil and gas developer must own, lease, or be granted permission to use the mineral rights under a parcel of land. Acceptable well locations are limited by state regulations, which may include factors such as minimum setback distances from water bodies, zoning requirements, and similar restrictions.[21]

Whether it is required or voluntary, sampling is essential for establishing water quality baselines and allowing for pre- and post-development comparisons.

Water quality monitoring

In some states, oil and gas developers are required to take pre-drilling samples of drinking water sources close to the drilling site, and in other states they will be presumed to be responsible for any contamination that does occur if they have not taken samples of drinking water sources prior to development. In still other cases, developers sample around most or all sites prior to drilling as a matter of company policy. Whether it is required or voluntary, sampling is essential for establishing water quality baselines and allowing for pre- and post-development comparisons.[22]

Depending on where development is taking place, some utilities may want to conduct additional testing to assure their supplies are not affected. Determining what to test for depends on local water quality concerns and the development activities involved, though monitoring typically includes key indicators, such as total dissolved solids (TDS), methane, and benzene, and may include other appropriate analytes. Thorough monitoring is one key to detecting water quality changes early, should they occur, and forms the basis for any investigation into potential contamination.

Drilling, casing, and cementing

Drilling, casing, and cementing occur on an iterative basis to reach the production zone without allowing substances such as fracturing fluid, oil, natural gas, and produced water to contaminate drinking water aquifers. Generally, state regulations require that a "surface casing" be installed inside the wellbore from the surface to a point below the deepest drinking water aquifer, plus layers of casing that extend deeper. The gap between the casing and the edge of the wellbore must be filled with cement.[23] The type, composition, thickness, and other properties of this casing and the cementing operation are typically specified in detail.[24] Proper casing and cementing are key steps in protecting drinking water aquifers from contamination. Best practices that cover many of these steps have been developed by the American Petroleum Institute (API) and others.[25]

Fracturing and chemical disclosure

Once an oil or gas well has been drilled into the production zone, hydraulic fracturing may occur. Many but not all oil and natural gas wells are fracked. A fracturing fluid mixture is injected into the well at high pressures to create fissures in the production zone rocks. Although the composition of the fluid varies by developer and local geology, it is generally about 98% sand and water, with 2% or less of chemical additives.[26] Although the percentage of chemicals is small, when millions of gallons of fracturing fluids are injected underground, the total volume of chemicals used at even a single well can be significant. The oil and gas industry reports that the addition of chemical additives to the fracturing fluid is necessary to inhibit the growth of microbes, control corrosion, reduce friction, and perform other functions.[27]

Increasingly, oil and gas developers are moving toward voluntary disclosure of the composition of fracturing fluids, and some states have implemented mandatory disclosure requirements.[28] Many of

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[21] Resources for the Future. 2012.

[22] U.S. DOE and GWPC. 2009.

[23] Ibid. Page 19.

[24] Ibid. Pages 16-21.

[25] American Petroleum Institute. October 2009. *Hydraulic Fracturing Operations—Well Construction and Integrity Guidelines.* API Guidance Document HF1. Available at http://www.api.org/~/media/Files/Policy/Exploration/API_HF1.ashx

[26] GWPC *et al*. 2009. Page ES-4.

[27] FracFocus Chemical Disclosure Registry. *What Chemicals Are Used*. http://fracfocus.org/chemical-use/what-chemicals-are-used.

[28] Resources for the Future. 2012.

these disclosure programs use an information repository known as FracFocus (www.FracFocus.org). It is a joint product of the Groundwater Protection Council and the Interstate Oil and Gas Compact Commission.[29] Since its introduction in 2011, tens of thousands of wells have been registered with FracFocus. Recognizing the controversy involved in the use of trade secrets, some states have included requirements that emergency responders and public health officials have access to confidential information, including the composition of fracking fluids, in the event of an emergency.[30]

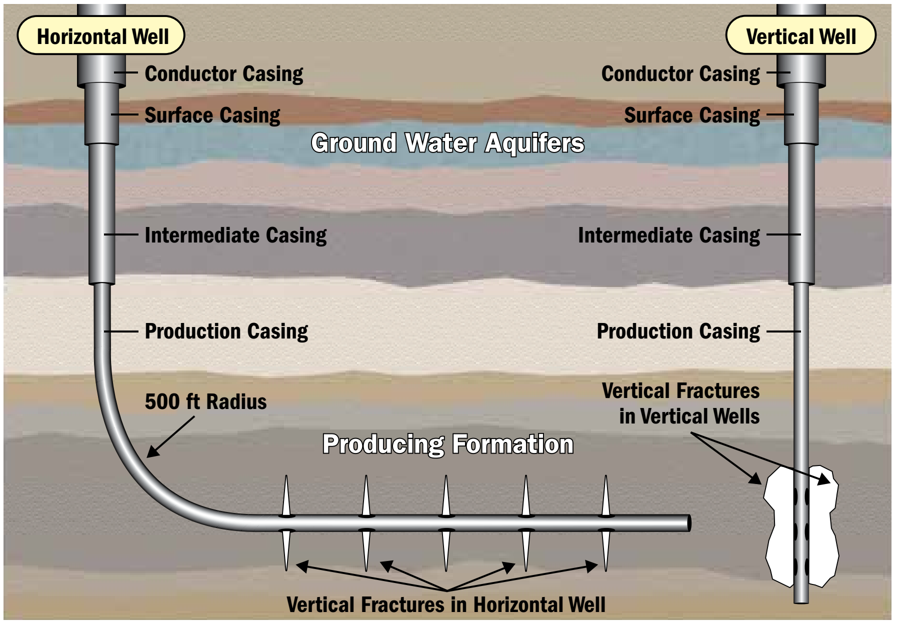
Production and waste disposal

Production represents the portion of the oil and gas well life cycle during which oil and gas flow from underground formations to the surface for recovery. This stage usually continues for years, compared with a few weeks or months for building the well (including drilling, casing, and cementing) and a few days for fracking. State regulations and industry best practices are designed to allow for the capture of as much of the oil or gas resource as possible while minimizing the risk of spills, accidents, or blowouts (where the oil and/or natural gas escapes to the surface in an uncontrolled fashion). Oil and gas activities do generate waste, and waste disposal takes place throughout a well's life cycle. A portion of the water used for fracturing may flow back to the surface, and is called "flowback." Water that originates in the production zone and comes to the surface along with oil and gas is called "formation water." Together, these waters are called "produced water." The chemical characteristics of produced water vary widely based on geologic conditions and other factors, but such water is often high in total dissolved solids (TDS) and may contain other undesirable constituents.

Water that originates in the production zone and comes to the surface along with oil and gas is called "formation water."

The disposal of oil and gas wastewaters may be regulated through federal standards. NPDES effluent standards under the Clean Water Act do apply when such wastewater is discharged to a surface water body.[31] There is a zero discharge standard for direct discharge of oil and gas wastewater under the Clean Water Act, meaning that it may not be discharged to surface water without first being treated. Generally this treatment is performed at an industrial treatment facility. Sometimes—although increasingly rarely—wastewaters are directed to a publicly owned treatment work (POTW). Improper or insufficient treatment of these wastewaters can lead to increased levels of compounds of concern in surface water, which can in turn harm downstream drinking water supplies. For example, bromide from produced waters can increase precursors to brominated disinfection by-products in treated drinking water.[32, 33] USEPA has indicated it plans to develop a pretreatment effluent limitation guideline (ELG) for produced water from shale gas development.

Example of a Horizontal and Vertical Well



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[29] FracFocus Chemical Disclosure Registry. Available at http://www.fracfocus.org.

[30] FracFocus Chemical Disclosure Registry. Date Unknown. *Chemicals & Public Disclosure.* Available at http://fracfocus.org/chemical-use/chemicals-public-disclosure.

[31] National Environmental Technology Laboratory. *Produced Water Management Information System—Federal Regulations: U.S. Environmental Protection Agency.* Available at http://www.netl.doe.gov/technologies/pwmis/regs/federal/epa/index.html.

[32] Volz, C.D., K. Ferrar, D. Michanowicz, C. Christen, S. Kearney, M. Kelso, and S. Malone. 25 March 2011. *Contaminant Characterization of Effluent from Pennsylvania Brine Treatment Inc., Josephine Facility Being Released into Blacklick Creek, Indiana County, Pennsylvania. Implications for Disposal of Oil and Gas Flowback Fluids from Brine Treatment Plants*. Center for Healthy Environments and Communities (CHEC), University of Pittsburgh. Page 53. Available at http://archive.org/stream/ContaminantCharacterizationOfEffluentFromPennsylvaniaBrineTreatment/Josephine_V2_CHEC_2011#page/n0/mode/2up.

[33] States, S., J. Kuchta, G. Cyprych, J. Monnell, M. Stoner, L. Casson, and F. Wydra. 2012. *Marcellus Shale Drilling Effects on Brominated THMs in Drinking Water.* Manuscript submitted for publication.

Source: Les Stone, C-RMBNews-R

Thousands of miles of pipeline for transporting gas are being laid throughout areas with natural gas development. Increased development has required the installation of new infrastructure.

A substantial majority of oil and gas wastewaters are disposed of through underground injection via a waste disposal well. A waste disposal well is different from an oil or gas well in that it involves the purposeful, permanent disposal of wastes through one-way injection into deep rock formations. In contrast to waste disposal, hydraulic fracturing involves injection of limited quantities of fluid underground to facilitate later removal of oil and gas from the target formation. The United States hosts approximately 150,000 disposal wells that accept wastes from the oil and natural gas industry, and the underground injection of oil and gas wastewaters has been standard practice in parts of the country for decades. This practice, which is also used by several other industries under different well classes, is regulated under Class II of the UIC program.[34] Regulation of Class II wells includes casing requirements, pressure monitoring, integrity testing, financial responsibility requirements, and a thorough permitting process. Many states administer both the NPDES and the UIC programs through state primacy. Where a state does not exercise primacy, the programs are administered by the USEPA region. Although thoroughly regulated, like all industrial processes, Class II wells are not immune from many of the risks described thoughout this paper.

Abandonment

State laws describe the processes that must be followed when a well will no longer be used for oil and natural gas production and is to be closed, a step the oil and gas industry calls abandonment. Abandonment involves plugging the well with a solid barrier; generally cement is used at various depths to prevent the exchange of materials into and out of aquifers and to and from the surface.[35] When production is suspended but expected to resume at a later date, some states allow wells to be "temporarily abandoned." Different plugging and monitoring requirements apply to such temporary status.

Federal lands

When wells are located on or drilled below federally owned or managed land, additional requirements may apply from the federal agency responsible for managing that land. The agencies involved are generally the Department of the Interior's Bureau of Land Management or the Department of Agriculture's U.S. Forest Service.[36] Requirements are laid out in lease agreements and in agency regulations and vary based on the agency and location of the federal lands. Many of these regulations and requirements parallel those common at the state level and in industry best practices. In some states, the federal agency utilizes agreements with state regulators under which the state manages the permitting process. Utilities wishing to know more about their states' oil and natural gas regulatory programs should contact their respective oil and gas commission or the equivalent regulatory agency. For federal land, they can contact the federal agency managing the land. Resources comparing and contrasting regulations across states are beyond the scope of this white paper but are readily available.[37, 38]

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34 U.S. Environmental Protection Agency. 2001. *Technical Program Overview: Underground Injection Control Regulations.* Available at http://www.epa.gov/safewater/uic/pdfs/uic_techovrview.pdf.

35 Kell. 2011.

36 U.S. Department of the Interior Bureau of Land Management. 9 August 2012. *Oil and Gas.* Available at http://www.blm.gov/wo/st/en/prog/energy/oil_and_gas.html.

37 Resources for the Future. 2012.

38 U.S. DOE and GWPC. 2009.

What can water utilities do?

Water utilities may wish to closely examine oil and gas activities in their service areas and either monitor or take action as appropriate. Steps to manage risks associated with hydraulic fracturing and oil and natural gas development include:

- Conducting monitoring before and after hydraulic fracturing and other oil and natural gas development activities.
- Preparing spill and/or accident response plans.
- Developing strong relationships with regulators and policy makers.

In areas that have nearby oil and natural gas development, utilities can reach out to their state's oil and natural gas regulator and local oil and natural gas developers to discuss current source water protection requirements and to recommend any additional steps that should be taken. Some states have permitting processes that involve stakeholders, such as potentially affected water utilities, and utilities can engage in those processes. Many oil and natural gas developers and regulators appear to be responsive to requests for information and receptive to advice brought to them by water professionals. Utilities can also conduct baseline monitoring of groundwaters and surface waters for contaminants of potential concern before the introduction of oil and natural gas operations in their area, and then monitor afterward for changes. It may be possible to collaborate with the oil and gas developers and regulators on monitoring plans and funding.

Utilities can think in advance about the possible negative environmental impacts from oil and natural gas development, including the risks from accidents and spills, and develop response plans should these impacts occur. For example, utilities could determine if there is a notification system in place to inform them of spills and accidents that could affect the quality of their source waters and train staff on relevant protocols and mitigation options. USEPA's Spill Prevention, Control and Countermeasure (SPCC) Rule requires that most operations producing or storing oil or oil products create a response plan with a list of federal, state, and local authorities to be informed in case of a spill (40 CFR § 112.7). Utilities may check with these authorities to better understand communications channels in the case of a spill to determine if any additional procedures are necessary, and to prepare accordingly. As another example, utilities could study if and how produced waters are being disposed of in their area and make recommendations for safeguards to reduce any risks to drinking water supplies. Finally, drinking water utilities could benefit from maintaining strong relationships with regulators and state and local policy makers. Should a utility have concerns that aren't sufficiently addressed through recommendations here, it can detail its concerns in a clear, factual manner and present them along with specific recommendations to regulators and policy makers.

Several parts of the country do not have commercially viable oil and natural gas resources and will not likely see oil and natural gas development activities. However, utilities in those areas may wish to be aware of technological trends or economic changes that could allow for oil and natural gas development in the future, and be prepared to answer customer questions.

Many oil and natural gas developers and regulators appear to be responsive to requests for information and receptive to advice brought to them by water professionals.

What can water utilities tell their customers?

Water utilities with oil and natural gas operations in their service areas can provide clear and factual information to their customers, either proactively or upon request. Utilities that could be affected by nearby oil and natural gas development—either because their resources could be affected or because customers see local media stories on the issue—can benefit by keeping customers updated on utility interactions with oil and gas developers and regulators. Customers may be interested to know that their utility is proactive on this matter, and communication builds trust between customers and their water provider. Utilities can also remind their customers that their drinking water is monitored frequently for compliance with strict federal standards, and that water quality information can be obtained both from the utility's annual consumer confidence report and upon request.

Where can water utilities get more information?

Numerous organizations can provide more information about hydraulic fracturing and oil and gas development activities.

- AWWA maintains a resource page on hydraulic fracturing and related issues.[39] AWWA will update this page with scientific and policy sources relevant to drinking water utilities as those become available.
- USEPA maintains a list of resources and describes past and present research and regulatory efforts.[40]
- The latest scientific information regarding hydraulic fracturing and related issues can be obtained from USEPA's hydraulic fracturing website, the U.S. Geological Survey (USGS),[41] the U.S. Department of Energy,[42] the National Academy of Sciences,[43] universities, and scientific publications.
- Information about individual wells, including chemical disclosure, can be found for many (though not all) wells on the FracFocus Chemical Disclosure Registry at www.FracFocus.org. This is especially useful for wells drilled after mid-2011. Additional information may be available from the state oil and natural gas regulator, or the oil and natural gas developer itself.
- State oil and natural gas regulatory agencies, as well as trade associations and nonprofit organizations, have information about current and planned industry practices, historical and current trends of development, and other industry-specific information. These organizations include the Groundwater Protection Council (GWPC), the American Petroleum Institute (API), and the Independent Petroleum Association of America (IPAA).

[39] American Water Works Association. 2012. *Hydraulic Fracturing*. Available at http://www.awwa.org/fracturing

[40] U.S. Environmental Protection Agency. 2012. *Natural Gas Extraction—Hydraulic Fracturing*. Available at http://www.epa.gov/hydraulicfracture/.

[41] e.g., United States Geologic Survey. August 2012. *Summary of Studies Related to Hydraulic Fracturing Conducted by USGS Water Science Centers*. Available at http://water.usgs.gov/coop/products/energy/shale.cwp.summary.pdf.

[42] e.g., U.S. Department of Energy. 2011. *Hydraulic Fracturing Technology.* Available at http://www.fossil.energy.gov/programs/oilgas/shalegas/hydraulicfracturing.html

[43] e.g., National Research Council. 2012.

Conclusion

It is important to acknowledge that oil and gas production, like any industrial activity, carries some risk. Although the risks associated with these activities are difficult to quantify, evidence points toward the known risks being manageable through prudent regulations and industry best practices. It is also important to remember that oil and gas development also offers tangible and significant benefits to society, and its risks should be balanced against those benefits. First, the expansion of oil and natural gas development has created substantial economic opportunities and employment in many areas. Second, natural gas is a cleaner burning fuel that produces much lower emissions of a multitude of pollutants than its alternatives, and natural gas carries a smaller "carbon footprint" than other common fossil fuels. Finally, the increased production of oil and natural gas both domestically and globally has led to lower energy prices and greater certainty over access to future energy supplies. In turn, that is associated with cost savings and other economic benefits to both water utilities and their customers. Both benefits and risks should be closely examined when considering oil and gas development issues.

This paper demonstrates that fracking is just one limited aspect of overall oil and gas development activities. At this time, AWWA is aware of no proven cases of groundwater contamination directly attributable to hydraulic fracturing. However, shale gas development has brought new or increased concerns about the potential for adverse effects in many areas. These concerns include the risk of accidents and spills, improper construction, improper waste disposal, and improper well abandonment. Ultimately many concerns are about the safety of drinking water and water resources.

With respect to the first set of concerns, there are safeguards in place to encourage responsible oil and natural gas develpment. Oil and gas development is a regulated activity that involves legal controls and well-established industry best practices. In addition, drinking water utilities monitor their source water supplies to ensure they are of the highest possible quality even before those waters are treated for human consumption. That being said, even the best regulatory structure cannot prevent all possible accidents in energy development; therefore careful planning and preparation is essential.

With respect to concerns over the safety of our drinking water, it is important to remind the public that drinking water delivered to customers is subject to comprehensive regulation to ensure its safety. Drinking water is treated and tested frequently to ensure it meets strict federal and state standards, and any violations that do occur must be corrected immediately. Customers must also be informed—immediately in the case of acute threats to health—if any violations of drinking water quality standards have occurred.

Although some policy decisions will be made on the state or national level, ultimately, many critical decisions regarding the protection of particular watersheds and aquifers will be made locally, by regulators, oil and gas developers, and water utilities. In making these decisions, the protection of drinking water must be a paramount concern. Consequently, individual water utilities would be served well by evaluating risks and advocating for appropriate source water protection measures based upon their analyses. An informed water utility can be a key voice in ensuring that energy production and safe water coexist peacefully in the years ahead.

AWWA position on oil and natural gas development, including hydraulic fracturing

- The protection of drinking water sources, supplies, and infrastructure must be a paramount consideration for all industrial activities, including oil and gas development using hydraulic fracturing.
- Regulation at the federal, state, and local levels should be designed and enforced to minimize all risks of oil and gas development to drinking water sources, supplies, and infrastructure. Regulators should use their authorities under federal and state law to reduce these risks to the greatest extent possible.
- Appropriate government agencies must be provided with sufficient resources to adequately implement permitting, regulatory, enforcement, and outreach programs. To the extent that these programs are funded by industry, they should be managed to ensure they are sustainable programs without conflicts of interest.
- Oil and gas wells must be appropriately designed, sited, constructed, operated, and closed using sound engineering techniques, following all applicable regulations and industry best practices.
- Oil and gas developers must have financially sound strategies in place to manage hazards, including the means to assume financial responsibility for cleaning up water supplies should contamination occur, even if such contamination occurs after the facility has been closed.
- Monitoring of pre-drilling water quality should establish baseline conditions, and periodic monitoring should assess any changes in water quality that might occur during oil or gas development, so as to detect problems and allow for corrective action as soon as possible.
- For the protection of public health, drinking water utilities must be informed immediately when spills, accidents, or any other issue has the potential to impact the quality or availability of source waters. Water utilities should be provided with complete information on chemicals accidentally released, regardless of trade secret status. Such information is necessary to determine treatment options and inform the public should drinking water ever be placed at risk.
- Having a secure energy future does not mean choosing between development and clean water. America can and should have both, provided that energy development is undertaken consistent with these policy principles.

Glossary

Abandonment— The phase of an oil or natural gas well in which production has ended and the well is permanently closed. Abandonment usually involves the creation of cement barriers (plugs) to isolate the production zone, each drinking water aquifer, and the surface.

Casing— The steel pipe used to separate the fluids and gas going up and down a well from drinking water aquifers and geologic areas other than the production zone. Typically, there are several layers of casing at and above the deepest drinking water aquifer

Cementing— The process of securing the casing in place to the surrounding rock using cement, and securing inner layers of casing to outer layers.

Flowback water— Fracturing fluids that return to the surface through the wellbore after hydraulic fracturing is complete. Along with formation water, the mixture returning to the surface is known as produced water.

Formation water— The water naturally present in the production zone that comes to the surface through the wellbore. Along with flowback water, the mixture returning to the surface is known as produced water.

Frack water— The water that is used to create the fracturing fluid. The source could be drinking water, surface water, groundwater, or recycled produced water.

Fracturing fluid— A combination of water, sand, and chemical additives that is injected down the wellbore and into the production zone during hydraulic fracturing to create artificial fissures (fractures), which allow oil and natural gas to flow into the wellbore more easily.

Horizontal drilling— A technique that allows for drilling horizontally below the surface, to extend the wellbore into a larger area of the production zone. This also allows for multiple wells to be drilled from each well pad.

Hydraulic fracturing— A well stimulation technique that involves the injection of hydraulic fracturing fluid under pressure through the wellbore to create artificial fissures (fractures) that allow oil and natural gas to travel into the wellbore more efficiently.

NPDES— The National Pollutant Discharge Elimination System, part of the Clean Water Act regulating discharges of pollutants into surface water bodies, and administered either by USEPA or state primacy agencies.

Produced water— The combination of flowback and formation water that returns to the surface along with the oil and natural gas. Produced water can be disposed of through underground injection, industrial treatment prior to being returned to a surface water body, or through recycling and reuse on another fracturing operation.

Production— The stage of an oil or natural gas well when oil and/or natural gas is brought to the surface and captured.

Production zone— The geologic formation from which oil and natural gas is extracted. Although depths vary, this zone is generally several hundred to several thousand feet below the surface, and well below drinking water aquifers.

Proppant— A component of a hydraulic fracturing fluid mixture designed to hold open fractures after the fracturing process has been completed. Proppants are typically made of sand.

UIC— The Underground Injection Control program, part of the Safe Drinking Water Act, which regulates, among other types of injection wells, Class II Oil and Gas waste disposal wells.

Wellbore— The hole drilled into the ground for the purposes of oil and gas exploration. The interior of the wellbore is generally isolated from the surrounding environment through casing and cementing processes. The interior of the wellbore (inside of the casing) is where fracturing fluids are injected during fracturing and through which oil, natural gas, and produced water flow up during production.

Well pad— The physical location upon which a drill rig is located and from which the drill hole originates.

Well stimulation— Processes designed to increase the flow of oil and natural gas coming up the wellbore. Hydraulic fracturing is one example of a well stimulation technique.

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www.awwa.org/fracturing

Water and Hydraulic Fracturing

A White Paper From the American Water Works Association

AWWA is the authoritative resource for knowledge, information, and advocacy to improve the quality and supply of water in North America and beyond. AWWA is the largest organization of water professionals in the world. AWWA advances public health, safety and welfare by uniting the efforts of the full spectrum of the entire water community. Through our collective strength we become better stewards of water for the greatest good of the people and the environment.

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