Stanford Woods Institute for the Environment

Research Brief

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# Depth Matters: Fracking and Drinking Water Contamination

## Background

Hydraulic fracturing ("fracking") has made once inaccessible natural gas available to the market, lowering energy prices. One consequence in the United States has been the shift in electricity generation over the past decade, with the percentage of energy supplied by natural gas increasing from under 20 percent to nearly 40 percent during that time frame. Coal, which traditionally accounted for approximately half of U.S. electricity supply, has seen a decline to 40 percent or less. Another reason for the change in energy supply is the expectation of stricter greenhouse gas regulations. Natural gas has lower carbon dioxide emissions per unit of energy than coal has. However, the production of natural gas with hydraulic fracturing has generated a number of environmental concerns. One prevalent among these is the potential contamination of drinking water supplies by either methane leakage, the chemicals used in the fracking process, or waste water. Communities across the country and several states, notably New York, New Jersey and Vermont, have implemented fracking bans based in part on concerns of drinking water safety.

Photo Credit: Rob Jackson

The Environmental Protection Agency (EPA) recently completed a multi-year study of this very issue at the urging of the United States Congress. EPA's study concluded that while "*…there are above and below ground mechanisms by which hydraulic fracturing activities have the potential to impact drinking water resources.…We did not find evidence that these mechanisms have led to widespread, systemic impacts on drinking water resources in the United States.*"

### About the Researcher

Robert B. Jackson is Douglas Provostial Professor in the School of Earth, Energy, and Environmental Sciences and a Senior Fellow in the Woods Institute for the Environment and the Precourt Institute for Energy. He studies how people affect the earth, including research on the global carbon and water cycles, biosphere/atmosphere interactions, energy use, and climate change. Jackson is a Fellow in the American Geophysical Union and the Ecological Society of America and was honored at the White House with a Presidential Early Career Award in Science and Engineering. In recent years he directed the DOE National Institute for Climate Change Research for the southeastern U.S., co-chaired the U.S. Carbon Cycle Science Plan, and is currently chair of the Global Carbon Project (*www.globalcarbonproject.org*)

Many existing reports on this topic highlight the safety of hydraulic fracturing for drinking water if it occurs "many hundreds of meters to kilometers underground". But, because hydraulic fractures can spread up to 2,000 feet upwards, shallow wells (those found at hundreds of feet to a mile) may warrant special safeguards, including a mandatory registry of locations, full chemical disclosure, and, where horizontal drilling is used, pre-drilling water testing to a radius of 1,000 feet beyond the outermost horizontal point.

This brief is intended to provide new research findings that analyze the depths of hydraulic fracturing and water use across the United States, including the shallowest wells. It compares the prevalence of the practice across U.S. states, offers examples of best-practices from existing regulations on well depth, and provides policy-makers with data upon which to base decisions in the interest of public and environmental health and safety.

## Drilling Depths, Hydraulic Fracturing and Implications for Drinking Water

An adequate vertical separation between the depth of hydraulic fracturing and the overlying surface aquifers used for drinking water is critical to reducing the chances of water contamination from the fracking process. To date, limited research has been conducted to determine what constitutes an adequate vertical separation. A majority of hydraulically fractured wells in the United States are drilled more than a mile deep. However, a surprising number of hydraulic fracturing cases occur within a mile of the surface with little or no additional regulatory requirements, some of it less than 1,000 feet deep. Between 2010 and 2013, approximately 6900 wells were hydraulically fractured shallower than one mile, accounting for about 16 percent of total wells.

Drilling practices — from well depth to water usage — varies widely among the states with implications of shallow drilling being greater for some more than others. A few examples of note include:

- Twelve states have at least 50 wells drilled to depths shallower than one mile: Alabama, Arkansas, California, Colorado, Kansas, New Mexico, Oklahoma, Pennsylvania, Texas, Utah, Virginia, and Wyoming;
- The three states with the most frequent shallow hydraulic fracturing are Arkansas, Texas, and California;
- Texas had the most shallowly fractured wells at 2,872
- California (804) and Arkansas (1,224) had almost all of their hydraulically fractured wells within a mile of the surface, 88% and 85%, respectively. According to the FracFocus database, three additional states

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also had most of their fractured wells within a mile of the surface: Alabama (100%), Kansas (78%), and Virginia (77%)

- Five states with the highest reported water use per well between 2010 and 2013 were Arkansas (5,200,000 gallons), Louisiana (5,100,000 gallons), West Virginia (5,000,000 gallons), Pennsylvania (4,500,000 gallons), and Ohio (4,300,000 gallons).
- States with the lowest average water use per well for hydraulic fracturing included Alabama (38,000 gallons per well), Virginia (42,000 gallons), California (158,000 gallons), and Utah (382,000 gallons).

## State of Practice for Shallow Fracking

National, provincial, and state policies differ for practices associated with shallow hydraulic fracturing. Germany's current administration has proposed to allow hydraulic fracturing only if it occurs below 3,000 meters or approximately 10,000 feet. British Columbia takes a different approach, requiring a special permit if hydraulic fracturing is to occur above 600 meters depth.

For the United States, only Texas and Colorado appear to have special requirements and/or permits for shallow hydraulic fracturing. Texas prescribes a different casing and cementing process and additional pressure tests and cement evaluations for hydraulically fractured wells that meet certain specifications. Colorado has a policy targeting stimulation at depths of 2,000 feet or less rather than focusing on separation between usable groundwater and the gas formation. In contrast, all other states, including Arkansas, California, Pennsylvania, and Wyoming, do not impose standards tailored to wells with a minimum separation from ground water or wells that will be hydraulically fractured at shallow depths, instead regulating wells the same regardless of depth.

Many states have a general performance standard requiring oil and gas operations to protect ground water. Protected ground water is most often defined by suitability for use, which typically uses total dissolved solids, including salinity, as part of the standard. Some states require operators to include information about the known protected ground water in drilling applications or completion reports.

Alabama, California, and Colorado all require operators to conduct a groundwater assessment before hydraulic fracturing occurs, within a radius specified differently by state. Arkansas, California, and Wyoming require operators to report estimated fracture lengths in the completion report or the completion design report.

Disclosure rules for hydraulic fracturing chemicals also make no distinction between fracturing that occurs near the surface or deep underground. In general, most states now require disclosure of the names and CAS (Chemical Abstract Service) numbers of chemicals used in hydraulic fracturing, although typically with exemptions for trade secrets. A few states such as California also require disclosure of chemical concentrations.

## Recommendations for Policy-makers and Regulators

Given the extensive use of chemicals in shallow hydraulic fracturing and the fact that the practice carries a greater potential risk of contaminating drinking water than does deeper hydraulic fracturing, we recommend that policy-makers consider the following safeguards:

- Require operators to provide more information about fracture length, true vertical depth to the top of fractures, and distance between groundwater resources and potential fractures;
- Have states assess what additional safeguards are needed for hydraulic fracturing shallower than 3,000 ft based on the geologic and hydrologic data in specific oil and gas fields;
- Create a mandatory state or federal registry for all hydraulic fracturing occurring shallower than 3,000 ft. Such a registry would allow people to track the locations, depths, and volumes of chemicals used around them. Requiring full chemical disclosure — without trade secret exemptions — for all chemicals used in hydraulic fracturing above 3,000 feet would enhance transparency and public confidence but would undoubtedly be controversial;
- Require pre-drilling and post- stimulation water testing for all homeowners on private water wells within 2,500 horizontal feet of the oil or gas well or to a radius at least 1,000 feet beyond the greatest extent of horizontal drilling from the oil or gas well, whichever is greater, to provide additional assurance that shallow hydraulic fracturing is not impacting drinking water reservoirs.

## Conclusions

In summary, our analysis suggests that additional safeguards would be beneficial if shallow hydraulic fracturing continues in the future. Only Colorado and Texas provide additional oversight or data transparency regardless of how shallow the fracturing occurs, even when millions of gallons of water and chemicals are used. To protect people, the social license to operate for companies, and current and future sources of drinking water, the increased likelihood of contamination from the shallowest hydraulic fracturing should be acknowledged in the best practices and rules governing it.

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This brief is based on the paper "The Depths of Hydraulic Fracturing and Accompanying Water Use Across the United States" (Environmental Science & Technology, July 2015).

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