

Review of Well Operator Files for Hydraulically Fractured Oil and Gas Production Wells: Hydraulic Fracturing Operations

Background: As part of EPA's [Hydraulic Fracturing Drinking Water Study](#), the Agency conducted a survey of onshore oil and gas production wells hydraulically fractured in 2009 and 2010 by nine oil and gas service companies. Data from the survey were first used to describe the relationship between well design and construction and drinking water resources. The results were published in [Review of Well Operator Files for Hydraulically Fractured Oil and Gas Production Wells: Well Design and Construction](#), which was released in June 2015.

In a second report released in 2016, *Review of Well Operator Files for Hydraulically Fractured Oil and Gas Production Wells: Hydraulic Fracturing Operations*, EPA conducted additional analyses of the survey data to provide insights into the potential for hydraulic fracturing fluids, or subsurface fluids affected by hydraulic fracturing, to move to underground drinking water resources during hydraulic fracturing.

A statistically representative sample of 323 study wells was selected from a list of well identifiers corresponding to onshore oil and gas production wells that were reported to EPA by the nine service companies. These study wells are statistically representative of an estimated 23,200 wells hydraulically fractured by the nine service companies. The results are presented as estimates of occurrence with 95% confidence intervals.¹

Results: EPA found that 84 (67-94) percent of the wells had one hydraulic fracturing job, and 16 (6-33) percent of the wells had two or more hydraulic fracturing jobs. There were an estimated 28,500 (25,100-31,900) hydraulic fracturing jobs conducted at the wells represented in the study, because some wells were hydraulically fractured more than once.

Two factors that affect the potential for subsurface fluid movement during hydraulic fracturing were examined: (1) the mechanical integrity of the hydraulically fractured oil and gas production well² and (2) the potential intersection of newly-created fractures with protected ground water resources reported by well operators or nearby existing pathways. Situations that potentially allowed hydraulic fracturing fluids to move to protected ground water resources reported by well operators were identified in a small number of wells. These situations included:

Well integrity failures [0.5% (0.1-2%) of the hydraulic fracturing jobs]. In these cases, pipe (i.e., casing), cement, or packers³ failed during hydraulic fracturing and there were no additional casing or cement barriers between the point of failure and the operator-reported protected

¹ Confidence intervals reflect observed variability in estimated characteristics. The estimate provided is the center of the confidence interval and represents the best estimate of the true number of wells or hydraulic fracturing jobs in a category given this sample of hydraulically fractured oil and gas production wells.

² Mechanical integrity is the ability of the hydraulically fractured production well to transport fluids through the well to the targeted rock formation without leaking and to prevent fluid movement along the outside of the well

³ Packers are mechanical devices that surround casing (i.e., pipe). Once the casing is set in the drilled hole, packers swell to fill the space between the outside of the casing and the surrounding rock formation or the surrounding casing.

ground water. Information in the well files suggested that, in these cases, hydraulic fracturing fluid entered the annular space between the casing string used for hydraulic fracturing and the surrounding geology at depths corresponding to protected ground water resources reported by well operators. Based on the information contained in the well files, it was not possible to determine whether fluid moved from the into protected ground water resources in these cases.

Perforations used for hydraulic fracturing that were shallower than the base of the protected ground water resources reported by well operators [0.4% (0.1-3%) of the wells].⁴ When perforations used for hydraulic fracturing are shallower than the base of the operator-reported protected ground water resource, the potential for induced fractures to directly reach protected ground water resources is high, if the protected ground water resource is at that depth. Based on the information contained in the well files, it was not possible to determine whether hydraulic fracturing fluid entered protected ground water resources in these cases.

Information on the relative location of newly-created fractures to existing pathways was generally not found in the well files, although 1% (0.4-4%) of the wells reported a frac hit. Frac hits occurred when hydraulic fracturing at a well affected a nearby oil and gas production well. It was not possible to determine whether hydraulic fracturing fluids, or subsurface fluids affected by hydraulic fracturing, reached operator-reported protected ground water resources during the frac hits, because available information in the well files was insufficient to determine whether fluids flowed along the outside of the nearby oil and gas production well and into protected ground water resources.

Estimates of occurrence are presented at the national scale. Estimates may be different for different regions of the country, because of differences in local geologic characteristics, regulatory requirements, and company practices. The estimates may not apply to wells hydraulically fractured after 2010, because hydraulic fracturing practices and regulatory requirements change over time. Additionally, estimates are generated from data provided by oil and gas well operators. EPA did not attempt to independently and systematically verify the data. Consequently, the study results reflect the scope of the information request and are of the same quality as the supplied data and the analysis done by EPA.

These results, as well as other information on hydraulic fracturing characteristics and monitoring and testing activities before and during hydraulic fracturing, highlight important well design, construction, and operation practices that should be considered when assessing the potential impacts of hydraulic fracturing on drinking water resources.

For more information, please visit: www.epa.gov/hfstudy

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⁴ Originally reported in *Review of Well Operator Files for Hydraulically Fractured Oil and Gas Production Wells: Well Design and Construction* (EPA/601/R-14/002).