# Hydraulic fracturing near domestic groundwater wells

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**Hydraulic fracturing operations are generating considerable discussion about their potential to contaminate aquifers tapped by domestic groundwater wells. Groundwater wells located closer to hydraulically fractured wells are more likely to be exposed to contaminants derived from on-site spills and well-bore failures, should they occur. Nevertheless, the proximity of hydraulic fracturing operations to domestic groundwater wells is unknown. Here, we analyze the distance between domestic groundwater wells (public and self-supply) constructed between 2000 and 2014 and hydraulically fractured wells stimulated in 2014 in 14 states. We show that 37% of all recorded hydraulically fractured wells stimulated during 2014 exist within 2 km of at least one recently constructed (2000–2014) domestic groundwater well. Furthermore, we identify 11 counties where most (>50%) recorded domestic groundwater wells exist within 2 km of one or more hydraulically fractured wells stimulated during 2014. Our findings suggest that understanding how frequently hydraulic fracturing operations impact groundwater quality is of widespread importance to drinking water safety in many areas where hydraulic fracturing is common. We also identify 236 counties where most recorded domestic groundwater wells exist within 2 km of one or more recorded oil and gas wells producing during 2014. Our analysis identifies hotspots where both conventional and unconventional oil and gas wells frequently exist near recorded domestic groundwater wells that may be targeted for further water-quality monitoring.**

groundwater well | hydraulic fracturing | water quality | drinking water

United States (US) natural gas production derived from hydraulically fractured wells increased 10-fold between 2000 and 2015 (1). Hydraulic fracturing has enabled production of reserves that were otherwise uneconomic to extract with conventional oil and gas technologies. Although hydraulic fracturing technologies have been used to enhance hydrocarbon production for decades, concerns that hydraulic fracturing operations may contaminate groundwater have gained traction with the public in recent years (2, 3). As unconventional oil and gas reserves become more accessible economically (4), characterizing risk from hydraulic fracturing operations to groundwater will be critical for safeguarding groundwater quality and addressing public concerns (5).

To begin understanding, managing, and communicating (6) hydraulic fracturing risks to the public, it is important to understand both the (*i*) likelihood that mechanisms with the potential to contaminate groundwaters may occur, and (*ii*) potential population affected by a contamination event. Hydraulic fracturing is a stimulation process that pumps fluid through a well (henceforth referred to as a hydraulically fractured well) to fracture hydrocarbon-bearing rock to increase oil and gas production; the fluid is most often composed of water, sand, and chemical additives (https://fracfocus.org/chemical-use). There are a variety of mechanisms that have the potential to contaminate groundwater aquifers before, during, or after the hydraulic fracturing process (e.g., Table 1). Although the likelihood that each mechanism may occur is relatively small, the population using groundwater for domestic purposes that may be exposed to a potential contamination event associated with hydraulic fracturing operations has yet to be quantified, limiting our understanding of hydraulic fracturing risks (1).

According to the US Environmental Protection Agency (EPA), when hydraulically fractured wells are located near domestic water resources, "there is a greater potential for activities in the hydraulic fracturing water cycle to impact those resources" (1). Literature focused on individual case studies supports this sentiment: The proximity of groundwater wells to a contamination mechanism associated with hydraulic fracturing operations is important to identify potentially contaminated well waters (7–10). In 2016, the EPA evaluated the proximity of hydraulically fractured wells to public water supplies on a national scale (1). Citing a lack of aggregated groundwater well construction data, the EPA did not assess the proximity of hydraulically fractured wells to private, self-supply groundwater wells. Self-supply groundwater wells provide drinking water to 45 million US residents (1), and, unlike public water utilities, self-supply groundwater well owners are not required to monitor water quality regularly under the Safe Drinking Water Act (42 USC, §300f; ref. 11). Consequently, contamination in self-supply wells may be more likely to go unnoticed than contamination in public-supply wells. To understand contamination risks that hydraulic fracturing may pose to drinking-water wells, it is important to characterize the proximity of hydraulic fracturing operations to self- and public-supply groundwater wells.

The central objective of our study is to evaluate the horizontal proximity and vertical offset of recorded hydraulically fractured wells stimulated in 2014 and recorded domestic self- and public-supply groundwater wells constructed between 2000 and 2014. We recognize that (*i*) hydraulically fractured wells are but one type of well used to produce oil and gas, and (*ii*) some potential groundwater contamination mechanisms identified in

## Significance

**Millions of Americans rely on self-supply groundwater wells for drinking water, but the number of these wells that are located near hydraulic fracturing operations is unknown. Here, we show that approximately half of all hydraulically fractured wells stimulated in 2014 exist within 2–3 km of one or more domestic (public and self-supply) groundwater wells. Our finding that many hydraulically fractured and domestic groundwater wells are colocated emphasizes that determining how frequently hydraulic fracturing activities impact groundwater quality is important to maintaining high-quality water in many domestic wells.**

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