THERE IS NO EVIDENCE THAT THE HYDRAULIC FRACTURING PROCESS HAS EVER CAUSED CONTAMINATION OF DRINKING WATER AQUIFERS

During the May 23 forum on "Shale Development: Best Practices and Environmental Concerns" convened by the Senate Committee on Energy and Natural Resources, Chairman Wyden invited participants to address the question of whether hydraulic fracturing has caused contamination of drinking water aquifers. As discussed below, Halliburton Energy Services, Inc. ("HESI") maintains that, despite a number of allegations of "contamination" of drinking water sources, over the course of more than sixty years of use of the technique in over a million wells the hydraulic fracturing process has never been shown to have caused contamination of drinking water aquifers. Rather, alleged incidents of contamination have been determined to be unfounded or have been associated with causes other than hydraulic fracturing, such as issues relating to cementing of wells.

Numerous Authorities Have Confirmed That They Are Unaware of Instances of Drinking Water Contamination Due to Hydraulic Fracturing

EPA and state regulators have repeatedly affirmed that there are no confirmed instances anywhere in the U.S. of hydraulic fracturing causing contamination of drinking water aquifers. For example, in 1998 the Ground Water Protection Council ("GWPC") surveyed state agencies responsible for oil and gas development regarding the extent of hydraulic fracturing of coalbed methane ("CBM") wells in the states and whether there were documented cases of contamination of drinking water supplies attributable to hydraulic fracturing.[1]

The study found no evidence to support claims that public health is at risk as a result of hydraulic fracturing of CBM wells despite the fact that CBM production typically occurs at much shallower depths than production of oil and gas from shales or other tight sands.[2] The 25 states that responded to the survey reported the existence of over 10,000 CBM wells in those states, the majority of which had been hydraulically fractured.[3] Nevertheless, among all these states there was only one reported complaint of drinking water contamination due to hydraulic fracturing, and after careful investigation and analysis of water samples by the U.S. Environmental Protection Agency ("EPA") and Alabama regulators that complaint was not substantiated.[4] GWPC concluded that existing state authorities had been sufficient to protect drinking water aquifers from contamination due to hydraulic fracturing.[5]

The Interstate Oil and Gas Compact Commission ("IOGCC") likewise surveyed its members in 2002 and found that nearly one million wells had been hydraulically fractured

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[1] Ground Water Protection Council, *Survey Results on Inventory and Extent of Hydraulic Fracturing in Coalbed Methane Wells in the Producing States* (1998), available at http://cogcc.state.co.us/RuleMaking/PartyStatus/FinalPrehearingStmts/HESIExhibits.PDF.

[2] *Id*. at 10.

[3] *Id*.

[4] *Id*. at 9. The complaint in question involved the McMillian well in Alabama.

[5] *Id*. at 10.

over the course of several decades but again found no evidence of substantiated claims of contamination of drinking water supplies due to hydraulic fracturing.[6]

State regulators have continued to reach the same conclusion. For example, the New York State Department of Environmental Conservation ("NYSDEC") concluded in 2009 after extensive study that hydraulic fracturing of shales does not pose any risk to drinking water supplies associated with the fluids pumped into the target formation during the hydraulic fracturing process.[7] In reaching this conclusion, NYSDEC relied in part on the statements of regulatory officials from 15 states – including Colorado, New Mexico, Pennsylvania, Ohio, Texas and Wyoming – that hydraulic fracturing operations have not led to groundwater contamination.[8] The Alaska Oil and Gas Conservation Commission reaffirmed in 2011 that "[i]n over fifty years of oil and gas production, Alaska has yet to suffer a single documented instance of subsurface damage to an underground source of drinking water."[9] The Colorado Oil and Gas Conservation Commission ("COGCC") did likewise. As the Commission director stated in responding to questions from the Senate Committee on Environment and Public Works:

> we have found other instances where activities associated with oil and gas operations have impacted water supplies. These events have typically been tied to incidents such as a leaking storage pit, a poorly cemented oil and gas well, or leaking production equipment. These cases, however, have not been linked to the specific act of hydraulic fracturing hydrocarbon layers thousands of feet below the surface, and typically, thousands of feet below groundwater supplies.[10]

In 2012, regulators from a number of states – including Arkansas, Colorado, Louisiana, North Dakota, Ohio, Oklahoma, Pennsylvania and Texas – again confirmed to the U.S. Government Accountability Office that, based on state investigations, the hydraulic fracturing process had not been identified as a cause of groundwater contamination in their states.[11]

Similarly, regulators at the federal level have acknowledged the absence of evidence that the hydraulic fracturing process has caused contamination of drinking water aquifers. For example, EPA Administrator Lisa Jackson stated in May 24, 2011 testimony before

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[6] Interstate Oil and Gas Compact Commission, *States Experience with Hydraulic Fracturing: A Survey of the Interstate Oil and Gas Compact Commission*, 3 (2002), available at http://www.mde.state.md.us/programs/Land/mining/marcellus/Documents/Interstate_Oil_Gas_Compact_Commission_States_Experience_w_Hydraulic_Fracturing_2002.pdf.

[7] New York State Department of Environmental Conservation, *Revised Draft Supplemental Generic Environmental Impact Statement on the Oil, Gas and Solution Mining Regulatory Program*, 6-47 (2011) ("Revised Draft SGEIS"), available at http://www.dec.ny.gov/energy/75370.html.

[8] Revised Draft SGEIS at 6-41.

[9] Alaska Oil and Gas Conservation Commission, *Hydraulic Fracturing in Alaska* (Apr. 6, 2011), available at http://doa.alaska.gov/ogc/reports-studies/HydraulicFracWhitePaper.pdf.

[10] David Neslin, Written Answers to Follow-up Questions from the Senate Committee on the Environment and Public Works (May 17, 2011), available at http://cogcc.state.co.us/Announcements/Hot_Topics/Hydraulic_Fracturing/EnviroPublicWorksQA.pdf.

[11] U.S. Government Accountability Office, *Information on Shale Resources, Development and Environmental and Public Health Risks* (Sept. 2012), at 49, available at http://www.gao.gov/assets/650/647791.pdf.

the House Committee on Oversight and Government Reform that she was "not aware of any water contamination associated with the recent drilling" in the Marcellus Shale.[12] BLM Director Bob Abbey likewise stated in 2011 that he had "never seen any evidence of impacts to groundwater from the use of fracing technology on wells that have been approved by" BLM.[13]

Several recent reports have further confirmed the lack of evidence of groundwater contamination due to hydraulic fracturing operations. For example, MIT performed a study in 2011 on the potential risks of hydraulic fracturing to groundwater aquifers and found that "no incidents of direct invasion of shallow water zones by fracture fluids during the fracturing process have been recorded."[14] Most recently, in January 2013 the U.S. Geological Survey ("USGS") released a study that examined groundwater samples representing approximately one-third of the Fayetteville Shale gas production area and found no regional effects on groundwater from activities related to gas production.[15]

In fact, a broad spectrum of experts agrees that the potential risks associated with shale gas development that warrant the most attention do *not* include risks related to hydraulic fracturing. Resources for the Future recently issued a report setting forth the results of a survey of 215 experts from state and federal regulatory agencies, academia, non-governmental organizations and industry regarding the "priority environmental risks related to shale gas development."[16] The experts were asked to identify priorities from among 264 potential "risk pathways" for both routine operations and accidents. The report states that "almost every priority routine pathway that garnered broad attention from experts has to do with risks present in most drilling operations or with the disposal of waste produced by fracturing, not with the actual hydraulic fracturing process itself."[17] The report further states that with respect to "pathways involved with the fracturing process and its effect on groundwater, only the flowback of reservoir fluids breaks any groups' top 20 most selected pathways."[18] As for accidents, the report indicates that all groups (regulators, academia, NGOs and industry) shared the same top

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[12] Pain at the Pump: Policies that Suppress Production of Oil and Gas, Hearing Before the H. Comm. on Oversight & Gov't Reform, Rep. No. 112-54, at 87 (May 24, 2011), available at http://oversight.house.gov/wpcontent/uploads/2012/04/5-24-11-Full-Committee-Hearing-Transcript.pdf.

[13] *Challenges Facing Domestic Oil and Gas Development: Review of Bureau of Land Management/U.S. Forest Service Ban on Horizontal Drilling on Federal Lands*: Hearing before the Subcomm. on Energy and Mineral Resources of the H. Comm. on Natural Resources and the Subcomm. on Conservation, Energy and Forestry of the H. Comm. on Agriculture, 112th Cong. (July 8, 2011).

[14] MIT Energy Initiative, *The Future of Natural Gas: An Interdisciplinary MIT Study*, Appx. 2E (2011), available at http://mitei.mit.edu/system/files/NaturalGas_Report.pdf.

[15] Kresse, T.M. et al., *Shallow groundwater quality and geochemistry in the Fayetteville Shale gas-production area, north-central Arkansas, 2011*, U.S. Geological Survey Scientific Investigations Report 2012-5273 (Jan. 2013) ("USGS Arkansas Study"), available at http://pubs.usgs.gov/sir/2012/5273/sir2012-5273.pdf. *See also* Warner, N.R., et al., *Geochemical and isotopic variations in shallow groundwater in areas of the Fayetteville shale development, north-central Arkansas*, Applied Geochemistry (2013), available at http://dx.doi.org/10/1016/j.apgeochem.2013.04.013.

[16] Resources for the Future, *Pathways to Dialogue: What the Experts Say about the Environmental Risks of Shale Gas Development* (Feb. 2013), at 1, available at http://www.rff.org/centers/energy_economics_and_policy/Pages/Shale-Gas-Expert-Survey.aspx.

[17] *Id*. at 26.

[18] *Id*.

two priorities, i.e., casing failure and cementing failure.[19] In short, those most knowledgeable about the actual risks posed by shale development – including those affiliated with NGOs – do not view the hydraulic fracturing process as a primary concern.

Alleged Instances of Contamination Are Not the Result of Hydraulic Fracturing

These conclusions regarding the lack of evidence of contamination due to hydraulic fracturing are not based on blind faith. Specific allegations of contamination of drinking water wells by fracturing fluids have been investigated by federal and state officials and have not been substantiated. For example, EPA investigated a number of allegations of contamination as part of its 2004 study regarding hydraulic fracturing and CBM wells.[20] These allegations came from a number of areas around the country that were experiencing significant CBM development. EPA "did not find confirmed evidence that drinking water wells have been contaminated by hydraulic fracturing fluid injection into CBM wells."[21]

Some of the more recent incidents mentioned during the forum discussion have likewise been extensively investigated and determined not to be caused by hydraulic fracturing. This is certainly true of the allegations concerning Dimock, Pennsylvania. In January 2009, after an explosion was reported in an outside, below-grade water well pit at a home in Dimock Township, the Pennsylvania Department of Environmental Protection ("PADEP") began an investigation to determine if the incident was the result of drilling activities in nearby gas wells.[22] PADEP collected samples from wells that provide drinking water to homes located near the gas wells and the samples contained elevated levels of dissolved methane gas and/or the presence of combustible gas. PADEP concluded that the methane in the drinking water wells was *not* related to hydraulic fracturing.[23]

The well operator subsequently entered into a Consent Order and Agreement ("CO&A") with PADEP concerning the gas migration allegations and other alleged violations.[24] As part of the CO&A, the operator agreed to provide drinking water to nineteen Dimock homes; PADEP has since allowed the operator to end its water deliveries to the Dimock residents.[25] A December 2011 report prepared by URS Corporation based on sampling data from Dimock revealed no environmental condition that required cleanup or remediation.

On December 2, 2011, EPA sent an email to Dimock residents saying that after visits to the residents' homes on November 10, 2011 and preliminary review of well sampling

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[19] *Id*. at 36.
[20] U.S. Environmental Protection Agency, *Evaluation of Impacts to Underground Sources of Drinking Water by Hydraulic Fracturing of Coalbed Methane Reservoirs* (2004) ("EPA 2004 Study"), available at http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/wells_coalbedmethanestudy.cfm.
[21] *Id*. at ES-1.
[22] Commonwealth of Pennsylvania Department of Environmental Protection, Consent Order and Agreement, 2 (Nov. 4, 2009) (modified on Dec. 15, 2010).
[23] *Id*.
[24] *Id*.
[25] *Id*. at 13.

data, the data did not indicate that the well water presented an immediate health threat to users.[26] Nevertheless, on January 19, 2012, EPA announced plans to perform water sampling at Dimock-area homes based on private well data it received from Dimock residents for 18 drinking wells.[27] However, after reviewing its own sampling data gathered in early 2012, EPA announced on July 25, 2012 that it did not find levels of contaminants that would require additional action and stated that it has no plans to conduct further testing of drinking water wells in Dimock.[28] At no time during the course of these events was there a suggestion that fracturing fluids had made their way into the Dimock drinking water wells.

Several other instances of alleged contamination of drinking water sources previously cited by critics of hydraulic fracturing likewise relate to the presence of methane – not fracturing fluids – in drinking water.[29] For example, a 2011 report from Duke University researchers reported elevated concentrations of methane in drinking water wells in northeast Pennsylvania that the authors attributed to development of the Marcellus Shale.[30] However, the authors specifically noted that they found no evidence of hydraulic fracturing fluids in the drinking water wells. The report indicated that the most likely cause of the presence of methane in the drinking water wells was "leaky gas-well casings." Moreover, a subsequent study released in December 2011 assessed over 1,700 samples taken from water wells in Susquehanna County in northeast Pennsylvania prior to any shale gas development and found that methane was present in 78 percent of the water wells sampled.[31] The study also found that the source for methane was not the Marcellus Shale; rather the characteristics of the methane found in the well samples were consistent with methane found in the Catskill and Upper and Middle Devonian deposits overlying the Marcellus Shale.[32] Furthermore, the study found that the methane concentrations in the water well samples exhibited no relationship to existing natural gas production activities.[33]

Similarly, critics of hydraulic fracturing have cited a study of water quality in an area of the Piceance Basin in Garfield County, Colorado known as the Mamm Creek field which

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[26] Email from Trish Taylor, U.S. EPA, *Follow-up status re: Nov 10, 2011 visit with Dimock PA residents* (Dec. 2, 2011), available at http://eidmarcellus.org/wp-content/uploads/2011/12/EPA-message.pdf.

[27] Memorandum from Richard M. Fetzer, On-Scene Coordinator, Eastern Response Branch, U.S. EPA, to Dennis P. Carney, Associate Division Director, Hazardous Site Cleanup Division, U.S. EPA, regarding Action Memorandum - Request for Funding for a Removal Action at the Dimock Residential Groundwater Site, Intersection of PA Routes 29 & 2024 Dimock Township, Susquehanna County, Pennsylvania, (Jan. 19, 2012), available at http://www.fossil .energy.gov/programs/gasregulation/authorizations/Orders_Issued_2012/58._EPA_III.pdf.

[28] U.S. EPA Press Release, *EPA Completes Drinking Water Sampling in Dimock, Pa.* (July 25, 2012), available at http://yosemite.epa.gov/opa/admpress.nsf/d0cf6618525a9efb85257359003fb69d/1a6e49d193e1007585257a46005b61ad!opendocument.

[29] The Secretary of Energy Advisory Board's Shale Gas Subcommittee noted that methane leakage from producing wells is a greater source of concern than the likelihood of properly injected fracturing fluids reaching drinking water where there is a large depth separation between drinking water sources and the producing zone, which the subcommittee noted regulators and geophysical experts agree is remote. *See infra* note 71.

[30] Osborn, Stephen G., et al., *Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing*, 108 Proceedings of the National Academy of Sciences 8172 (May 17, 2011).

[31] Molofsky, Lisa J., et al., *Evaluation of Methane Sources in Groundwater in Northeastern Pennsylvania*, 3 Groundwater 333 (May-June 2013).

[32] *Id*. at 345-46.

[33] *Id*. at 347.

concluded that oil and gas develop had impacted water quality in drinking water wells, primarily in the form of elevated methane and chloride levels.[34] Similar to the Marcellus study, the Mamm Creek field study concluded that the potential causes for the presence of elevated levels of methane were leaking casings in the production wells or the existence of intervals in the wellbores that were entirely uncased. The report includes no suggestion that fracturing fluids were detected in the drinking water wells or that hydraulic fracturing was a cause of the methane "contamination." Moreover, a review of this study that was undertaken for the COGCC concluded that the presence of elevated levels of methane and chlorides in the drinking water wells was not, in fact, related to oil and gas development.[35]

Indeed, the presence of methane in drinking water wells in most cases is entirely unrelated to any oil and gas development activity. The January 2013 USGS study regarding the Fayetteville Shale in Arkansas found that samples from a number of drinking water wells contained methane but that this methane was the result of natural processes with no effects from gas production activities.[36] Likewise, the methane in the water of the homeowner prominently featured in "Gasland" lighting his tap on fire was found by the COGCC to come from the coal seams through which the water well was drilled; that methane was completely unrelated to any oil and gas activity.[37]

Other forms of alleged contamination cited by critics of hydraulic fracturing also have proved to be unfounded or unrelated to the hydraulic fracturing process. For example, one of the forum participants cited a recent article from the Scranton Times-Tribune as demonstrating that "oil and gas development" in Pennsylvania had resulted in the contamination of drinking water supplies.[38] As the forum participant's statement suggests, the article demonstrates that these incidents are associated with oil and gas development generally, not with hydraulic fracturing.[39] In fact, the article itself notes that in no case did PADEP conclude after investigation that an alleged contamination incident was due to the hydraulic fracturing

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[34] Thyne, Geoffrey, *Review of Phase II Hydrogeologic Study* (Dec. 20, 2008), available at http://cogcc.state.co.us (Library; Materials Related to the July 8-9, 2009 Commission Hearing in Glenwood Springs).

[35] S.S. Papadopulos & Assoc., Inc., *Technical Memorandum: Evaluation of "Review of Phase II Hydrogeologic Study" (December 20, 2008) for the Mamm Creek Field Area, Garfield County, Colorado* (May 2010), available at www.oil.gas.state.co.us/Library/PiceanceBasin/GarfieldHydrogeological/100506_SSPA_EvaluationOfThyneMammCrkRept.pdf. Another incident sometimes cited by critics of hydraulic fracturing involved a buildup of methane that led to an explosion in the basement of a house in Bainbridge, Ohio (there were no injuries and the house did not suffer any severe damage). NRDC and the Sierra Club have previously acknowledged in comments to the BLM that the primary cause of this incident was an inadequate cement job, not hydraulic fracturing, as Ohio investigators themselves concluded. *See* Ohio Department of Natural Resources, *Report on the Investigation of the Natural Gas Invasion of Aquifers in Bainbridge Township of Geauga County, Ohio* (Sept. 1, 2008), available at http://www.state.dr.ohio.us/Portals/11/bainbridge/report.pdf.

[36] USGS Arkansas Study, *see supra* note 13.

[37] State of Colorado Oil & Gas Conservation Commission, *Gasland Information Sheet*, available at http://cogcc.state.co.us/library/GASLAND%20DOC.pdf ("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 . . .").

[38] Laura Legere, *Sunday Times review of DEP drilling records reveals water damage, murky testing methods*, Scranton Times-Tribune (May 19, 2013), available at http://thetimes-tribune.com/news/sunday-times-review-of-dep-drilling-records-reveals-water-damage-murky-testing-methods-1.1491547.

[39] *Id*.

process.[40] It is also worth noting that the article states that "the vast majority of complaints – 77 percent of 969 records" were determined by PADEP investigators to be "unfounded."[41]

A similar pattern was shown in a review of 43 alleged instances of contamination related to gas well drilling undertaken by MIT researchers (headed by current Secretary of Energy Moniz) in 2011. The research team found that the most common type of incident involved the presence of methane in groundwater, which was most frequently due to inadequate cementing of wellbores. The second most common type of incident involved surface spills arising from a variety of causes. The report stated that "[i]t is noteworthy that no incidents of direct invasion of shallow water zones by fracture fluids during the fracturing process have been recorded."[42]

Two other alleged incidents that have been previously cited by environmental groups as evidence that hydraulic fracturing has contaminated drinking water may be raised in response to Senator Wyder's invitation. One concerns Pavillion, Wyoming. Although EPA has released a draft report indicating that "constituents associated with hydraulic fracturing have contaminated groundwater at and below the depth used for domestic water supply" in Pavillion, the Agency has made no conclusive findings of such contamination.[43] This was confirmed by EPA Administrator Lisa Jackson, who stated six months after the draft report was released that "in no case have we made a definitive determination that the fracking process has caused chemicals to enter groundwater."[44]

Moreover, the Agency's investigation and preliminary conclusions have drawn heavy criticism from many quarters, including the State of Wyoming, the BLM and industry. The BLM submitted comments on EPA's draft investigation report that criticized the scope and implementation of the Agency's study and described EPA's conclusions as premature.[45] A review of EPA's draft report conducted by two consultants for HESI concluded that EPA's study design was flawed, the study implementation (*i.e*., field work and data quality evaluation) was very poor and raised serious questions about the validity of the data, and the analysis of the data was not based on sound science.[46] In April 2012, EPA and USGS conducted an additional round of sampling of the deep monitoring wells in the Pavillion study area based on a recognition that

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[40] *Id*.
[41] *Id*.
[42] *The Future of Natural Gas*, *supra* note 14.
[43] U.S. EPA, *Draft Investigation of Ground Water Contamination near Pavillion, Wyoming*, 39 (Dec. 2011), available at http://www.epa.gov/region8/superfund/wy/pavillion/EPA_ReportOnPavillion_Dec-8-2011.pdf. EPA stated in the Federal Register notice announcing the availability of the draft report for public comment that the draft "does not represent and should not be construed to represent any Agency policy or determination." 76 Fed. Reg. 77829 (Dec. 14, 2001).
[44] Lisa Jackson, Statement to Reporters (Apr. 30, 2012), available at http://www.youtube.com/watch?v=_tBUTHB_7Cs.
[45] Letter from Donald A. Simpson, State Director, Wyoming State Office, U.S. Department of Interior Bureau of Land Management to James B. Martin, Regional Administrator, U.S. Environmental Protection Agency, Region 8 (Mar. 1, 2012), available at http://www.regulations.gov/#!documentDetail;D=EPA-HQ-ORD-2011-0895-0243 ("two rounds of sampling at these two locations are not statistically valid to arrive at any reliable conclusion").
[46] *See e.g.*, Gradient Corp. and Environmental Resources Management, *Review of US EPA's 'Draft Investigation of Ground Water Contamination near Pavillion, Wyoming'* (June 25, 2012), available at http://www.regulations.gov/#!documentDetail;D=EPA-HQ-ORD-2011-0895-0241.

further sampling "is important to clarify questions about the initial monitoring results."[47] The results of this additional sampling activity confirmed the concerns of BLM and others regarding the development of the deep monitoring wells and the reliability of the data from those wells. EPA has extended the public comment period for the draft report to September 30, 2013.[48] EPA's draft report will undergo peer review before the report becomes final.[49]

Some have also cited a reference in a 1987 EPA report as evidence of groundwater contamination due to hydraulic fracturing. This report included a discussion about an alleged case of contamination caused by hydraulic fracturing in 1982 at a water well owned by a Mr. James Parsons in Jackson County, West Virginia.[50] The report indicated that Kaiser Gas Co. drilled a gas well on the Parsons' property in 1982 and fractured that well using a typical fracturing fluid or gel. The report also states that samples taken from the Parsons' nearby water well, after drilling and fracturing operations at the Kaiser Gas Co. well, contained dark and light gelatinous material along with white fibers. The Parsons' water well was determined to be contaminated and unfit for domestic use due to high levels of fluoride, sodium, iron, manganese and a strong hydrocarbon odor indicating the presence of gas.

However, the West Virginia laboratory commissioned to investigate the well did not conclude that hydraulic fracturing caused the contamination.[51] In fact, there are a number of possible alternative causes for the Parsons' well contamination, including the potential use of a gel product in drilling operations and migration of fracturing fluids not through the overlying rock formations but through nearby abandoned gas wells that had not been properly plugged and cased. A 1987 letter from the West Virginia Department of Energy offers another possible cause for the Parsons' well contamination. In the 1987 letter, the state's then deputy director of inspection and enforcement indicated that the shallow sandstone formation from which the Parsons well was drawing water was commonly fractured for its oil and natural gas resources and was not known in 1982 to contain potable water resources in some parts of Jackson County.[52] In other words, the gel contamination in the Parsons well may have been the result of fracturing treatments that targeted the shallower sandstone formation that at the time was thought only to be an oil and gas producing formation, but turned out to contain potable water.

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[47] U.S. EPA Press Release, *Statement on Pavillion, Wyoming groundwater investigation* (Mar. 8, 2012), available at http://yosemite.epa.gov/opa/admpress.nsf/d0cf6618525a9efb85257359003fb69d/17640d44f5be4cef852579bb006432de!opendocument. USGS declined to sample one of the two deep monitoring wells that provided the data on which EPA based its preliminary conclusions because the flow of water in the well was so low. See U.S. Geological Survey Data Series 718, *Groundwater-Quality and Quality-Control Data for Two Monitoring Wells near Pavillion, Wyoming, April and May 2012*, available at http://pubs.usgs.gov/ds/718.

[48] 78 Fed. Reg. 2396 (Jan. 11, 2013).

[49] U.S. EPA Press Release, *EPA Releases Draft Findings of Pavillion, Wyoming Ground Water Investigation for Public Comment and Independent Scientific Review* (Dec. 8, 2011), available at http://yosemite.epa.gov/opa/admpress.nsf/20ed1dfa1751192c8525735900400c30/ef35bd26a80d6ce3852579600065c94e!OpenDocument.

[50] U.S. EPA, *Report to Congress: Management of Wastes From the Exploration, Development, and Production of Crude Oil, Natural Gas, and Geothermal Energy*, (Dec. 1987), available at http://www.epa.gov/osw/nonhaz/industrial/special/oil/.

[51] Environmental Working Group, *Cracks in the Façade* (Aug. 2010), at 13.

[52] Letter to Dave Flannery from Ted M. Streit, Deputy Director, Inspection and Enforcement, Division of Oil and Gas, West Virginia Department of Energy dated May 29, 1987, available at http://www.energyindepth.org/wp-content/uploads/2011/07/WV-17.pdf.

Numerous Studies Confirm that the Hydraulic Fracturing Process Poses Little or No Risk to Drinking Water Aquifers

The absence of evidence of drinking water aquifer contamination due to hydraulic fracturing is entirely to be expected. Drinking water aquifers are protected in the first instance by practices used in well construction, which is undertaken in accordance with government regulatory requirements as well as industry standards (such as those developed by the American Petroleum Institute ("API")) and other good engineering practices. Multiple layers of cement and steel casings provide zonal isolation – not only to protect the ground water but also to provide safe conduits for operations – including placing fracturing treatments in the desired formation. This is what minimizes any downhole risks associated with hydraulic fracturing. In fact, a consultant for the New York State Department of Environmental Conservation concluded that the probability of fracture fluids reaching an underground source of drinking water due to failures in the cementing or casing of a properly constructed well is estimated at less than 1 in 50 million wells.[53]

As discussed in Gradient's recent report, once the fracturing fluids are pumped into a tight formation such as a shale or tight sand being targeted for oil and gas production, it is simply not plausible that the fluids would migrate upwards from the target formation through several thousand feet of rock to contaminate drinking water aquifers.[54] There are a variety of factors that contribute to the implausibility of this scenario:

- Tight oil and gas formations are found in geologic settings that greatly restrict upward fluid movement due to the presence of multiple layers of low permeability rock and other factors such as the inherent tendency of the naturally-occurring salty formation water (brines) to sink and form a stable layer below rather than mingle with or rise above fresh water, as demonstrated by the fact that the oil and gas and the brines have been trapped in the target formation for millions of years.[55]

- The hydraulic fracturing process itself does not create conditions that would overcome these natural restrictions on fluid movement and allow fracturing fluids to migrate upwards thousands of feet to reach drinking water aquifers. First, the pressures associated with the hydraulic fracturing process are too short-term and localized to push fluids through thousands of feet of low permeability rock. A typical hydraulic fracturing stage lasts only 1-2 hours, and the pressures exerted extend only about 10 feet from the fractures that are created.[56] Moreover, any fluids introduced into a formation such as the Marcellus Shale will be soaked up

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[53] *See* ICF International, LLC, *Technical Assistance for the Draft Supplemental Generic EIS: Oil, Gas and Solution Mining Regulatory Program*, 21 (Aug. 7, 2009) ("ICF Study"), available at http://www.nyserda.ny.gov/Publications/Research-and-Development-Technical-Reports/Other-Technical-Reports/Natural-Gas-Environmental-Impact.aspx.

[54] Gradient Corp., *National Human Health Risk Evaluation for Hydraulic Fracturing Fluid Additives* (May 1, 2013). (*See* copy attached).

[55] *Id*. at ES-4. For example, the gas and brines in the Marcellus Shale have been trapped there for almost 400 million years.

[56] *Id*. at 35.

and trapped within the shale by natural capillary forces. At the same time, the removal of brine and gas from the well during long-term production reduces the pressure in the objective formation near the wellbore over a period of years, meaning that any fluid flow will be in that direction (*i.e.*, towards the wellbore or towards lower pressure in accordance with Darcy's Law). Therefore any remaining fluids would be drawn to the wellbore and would not be likely to migrate away.

- Second, the fractures created during hydraulic fracturing operations are of limited height. This is confirmed by data from over 12,000 hydraulic fracturing operations in shale plays and other formations across the country, which show that the "tallest" fracture was about 2000 feet in height with typical fracture heights being far less (the median fracture height was less than 250 feet), and in all cases there were at least 1,500 feet (and usually more than 3,000 feet) of intact bedrock above the fractures. These data are consistent with the limits on fracture height growth suggested by basic geophysical principles, which indicate that fracture heights are limited by fracture fluid volume and that the amount of fluid used in a hydraulic fracturing operation is simply insufficient to propagate a fracture from the typical depth of a shale formation upward to a depth that is anywhere close to drinking water aquifers.[57] Additional factors limiting fracture height growth include (i) the existence of stress contrasts between sedimentary layers, which tend to limit the growth of fractures into adjacent layers,[58] (ii) the creation of fracture networks and the leakoff of fracture fluids that results in the energy created by the fluid pressure being spread across multiple fractures rather than being concentrated in driving a single fracture to its maximum possible height, and (iii) the tendency of fractures to become horizontal rather than vertical at shallower depths (above about 2,000 feet below ground surface).[59]

- Finally, the same microseismic data show that – despite speculation to the contrary – the presence of natural faults in the bedrock does not significantly contribute to the upward movement of fluids.[60]

Gradient found that even if the fracturing fluids could migrate upward through hundreds or thousands of feet of bedrock, the fluids would be so highly diluted that the concentrations of the chemical constituents would be well below levels that would begin to give

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[57] Fisher & Warpinski, *see supra* note 51.

[58] For example, in a study of the hydraulic fracturing of horizontal wells in the Inglewood Oil Field in California, 939 microseismic "events" were observed during microseismic monitoring during the hydraulic fracturing operations, of which only five occurred outside the shale formation being targeted. *See* Halliburton, *Inglewood Oil Field Hydraulic Fracturing Report* (July 13, 2012) at 115, available at http://www.inglewoodoilfield.com/fracturing-study.

[59] *Id*. at 35-38. *See also* Fisher & Warpinski, *Hydraulic Fracture Height Growth: Real Data*, Society of Petroleum Engineers SPE 145949 (Feb. 2012) ("Fisher & Warpinski"), available at http://www.spe.org/atce/2011/pages/schedule/tech_program/documents/spe145949%201.pdf. For example, the shallowest hydraulic fracturing job in the database used by Gradient, which occurred at about 1,600 feet below ground surface, had essentially no height growth.

[60] *Id*. at 39-40.

rise to any human health concerns.[61] Accordingly, the report concludes that the fluids pumped into a target formation as part of the hydraulic fracturing process do not present a risk to human health.[62]

A number of other studies have likewise concluded that the possibility that the chemicals used in the hydraulic fracturing process could contaminate drinking water aquifers is very small. For example, in its 2004 study concerning the potential impacts of hydraulic fracturing of CBM wells on drinking water supplies, EPA concluded that hydraulic fracturing of CBM wells posed little or no threat to underground sources of drinking water.[63] EPA stated that the removal of a portion of the fluids from the subsurface during the flowback process, combined with the mitigating effects of other several factors, minimizes the possibility that chemicals included in the fracturing fluids would adversely affect drinking water aquifers.[64] These other mitigating factors include the dilution and dispersion of particular chemical constituents in formation water, as well as adsorption of some constituents onto the formation being fractured and biodegradation of various constituents.[65] EPA also found that stress contrasts between adjacent geologic formations often result in a barrier to fracture propagation and fluid movement, which would provide further protection for aquifers containing drinking water sources.[66]

Other reports reaching similar conclusions include the following:

- An analysis undertaken by the consulting firm ICF International for NYSDEC in 2009 concerning the proposed development of the Marcellus Shale concluded that "hydraulic fracturing does not present a reasonably foreseeable risk of significant adverse impacts to potential freshwater aquifers."[67]

- The Energy and Climate Change Committee appointed by the British House of Commons concluded in May 2011 that "hydraulic fracturing itself does not pose a direct risk to water aquifers, provided that the well-casing is intact before this commences."[68]

- The Royal Society concluded in a June 2012 report that a variety of factors constrain fracture height growth and that while it might be theoretically possible to create pressures that would allow a fracture to grow vertically to shallow depths, the "volume of fluid injected is simply insufficient by orders of magnitude to create these pressures" and that "such an enormous pressure could not be

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[61] *Id*. at 42.
[62] *Id*. at ES-5.
[63] 2004 EPA Study at ES-16, *see supra* note 15.
[64] *Id*. at ES-17.
[65] *Id*.
[66] *Id*.
[67] ICF Study at 34, *see supra* n.51.
[68] United Kingdom Parliament, House of Commons, Energy and Climate Change Committee, *Fifth Report: Shale Gas* (May 10, 2011), available at http://www.publications.parliament.uk/pa/cm201012/cmselect/cmenergy/795/79502.htm.

sustained."[69] The report also found that "[u]pward flow of fluids from the zone of shale gas extraction to overlying aquifers via fractures in the intervening strata is highly unlikely" and that, in general, it is "very difficult to conceive" how such upward fluid flow might occur given the hydrogeological conditions found in the relevant areas of the U.K.[70]

- As noted above, the Shale Gas Production Subcommittee of the Secretary of Energy Advisory Board found in August 2011 that "[r]egulators and geophysical experts agree that the likelihood of properly injected fracturing fluid reaching drinking water through fractures is remote where there is a large depth separation between drinking water sources and the producing zone."[71]

- In a May 2012 report, the Council for the Taranaki Region in New Zealand examined potential impacts associated with hydraulic fracturing operations undertaken at depths of 2,400 to 4,000 meters below ground surface.[72] The Council found that there was no evidence of environmental problems related to the hydraulic fracturing operations that had been undertaken in the region over a period of almost 20 years and that there is little risk to freshwater aquifers from properly conducted hydraulic fracturing operations.[73]

- The New Zealand Parliamentary Commissioner for the Environment issued a report in November 2012 that reached similar conclusions.[74] The report stated that "there is no evidence that fracking has caused groundwater contamination in New Zealand" and that "[m]igration of contaminants into aquifers through the cracks created during the fracking process is only a remote possibility."[75]

- The South African Department of Mineral Resources issued a report in July 2012 on its investigation of proposed hydraulic fracturing in the Karoo Basin, where the formations being targeted for oil and gas production are found at depths of 1,500 to 4,000 meters below ground surface.[76] The Department found that "potable aquifers are expected to be far removed from shale gas target formations and safe

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[69] The Royal Society, Royal Academy of Engineering, *Shale gas extraction in the UK: a review of hydraulic fracturing*, 33 (June 2012), available at http://www.raeng.org.uk/mwginternal/de5fs23hu73ds/progress?id=DENzawDAqT.

[70] *Id*. at 37.

[71] Secretary of Energy Advisory Board, *Shale Gas Production Subcommittee Ninety-Day Report*, 19 (Aug. 11, 2011), available at http://www.shalegas.energy.gov/resources/081111_90_day_report.pdf.

[72] Government of New Zealand Taranaki Regional Council, *Hydrogeologic Risk Assessment of Hydraulic Fracturing for Gas Recovery in the Taranaki Region* (May 2012), available at http://www.trc.govt.nz/assets/Publications/guidelines-procedures-and-publications/hydraulic-fracturing/hf-may2012-graph-p19.pdf.

[73] *Id*. at 3-4.

[74] Government of New Zealand, Parliamentary Commissioner for the Environment, *Evaluating the environmental impacts of fracking in New Zealand: An interim report* (Nov. 2012), available at http://www.pce.parliament.nz/mwg-internal/de5fs23hu73ds/progress?id=JVtqqn+Uh+.

[75] *Id*. at 43.

[76] Republic of South Africa, Department of Mineral Resources, *Investigation of Hydraulic Fracturing in the Karoo Basin of South Africa* (July 2012), available at http://www.info.gov.za/view/DownloadFileAction?id=174015.

from contamination from injected fracking fluids, as the latter are immobile under normal conditions with no 'drive' once the fracturing operation has been completed."[77]

Recent field results are entirely consistent with the conclusions of these reports. For example, an October 2012 report regarding hydraulic fracturing operations in the Inglewood Oil Field in the Baldwin Hills area of Los Angeles County showed that, based on actual groundwater monitoring results, the groundwater quality in the area was not affected by hydraulic fracturing activities.[78] Moreover, microseismic monitoring showed that most of the fractures were contained within the target formation, and that the few fractures that were outside the target formation did not contain any proppant and therefore would have closed back up once the hydraulic fracturing operation was completed.[79] In addition, the January 2013 study from the USGS on the Fayetteville Shale in Arkansas which analyzed 127 groundwater samples for the potential effects of gas production activities concluded that the groundwater chemistry found in the samples was a result of natural processes and that there were no apparent effects on shallow groundwater quality from shale gas production.[80]

Conclusion

All evidence points to the fact that the hydraulic fracturing process and the introduction of fracturing fluids into subsurface formations as part of that process have not contaminated and will not contaminate drinking water aquifers. There is no confirmed evidence that this has ever occurred and numerous scientific studies have concluded that it will not occur. Where contamination has occurred, it has been due to well integrity issues or to spills or other releases of chemicals at the surface. Federal and state regulations are in place to address these issues.

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[77] *Id*. at 6.
[78] Inglewood Study, *see supra* note 47.
[79] Cardno Entrix, *Hydraulic Fracturing Study: PXP Inglewood Oil Field* (Oct. 2012) ("Inglewood Study"), available at http://www.inglewoodoilfield.com/mwg-internal/de5fs23hu73ds/progress?id=XnQQZo9P6v.
[80] USGS Arkansas Study, *see supra* note 13.