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The EPA Draft Report of Groundwater Contamination Near Pavillion, Wyoming: Main Findings and Stakeholder Responses

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Summary

On December 8, 2011, the U.S. Environmental Protection Agency (EPA) issued a draft report on its investigation of groundwater contamination near the town of Pavillion, Wyoming. EPA had initiated the investigation under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) in response to citizen complaints in 2008 about domestic well water quality. On June 20, 2013, EPA announced that it would not finalize the report but would defer to the state of Wyoming to assume the lead in investigating drinking water quality in Pavillion. The EPA draft report indicated that certain constituents in groundwater are consistent with some of the constituents used in natural gas well operations, including the process of hydraulic fracturing. EPA claimed that its approach to the investigation best supports the explanation that different compounds associated with hydraulic fracturing have contaminated the aquifer used for domestic water supply in the Pavillion area. EPA also stated that its approach indicates that gas production activities have likely enhanced the migration of natural gas in the aquifer. EPA did not appear to conclude that there was a definitive link to a release from the production wells, nor to the constituents found in domestic wells in shallower parts of the aquifer.

Because the draft report linked groundwater contamination in Wyoming to activities related to hydraulic fracturing, it had raised concerns about hydraulic fracturing practices in general. Some stakeholders took issue with some of the findings in the draft report. They questioned the scientific validity of EPA's contention that "the explanation best fitting the data for the deep monitoring wells is that constituents associated with hydraulic fracturing have been released into the Wind River drinking water aquifer at depths above the current production zone." In contrast, some environmental organizations cited EPA's findings in calling for more stringent regulation of hydraulic fracturing. Stakeholder groups commissioned independent assessments of EPA's draft report and released their respective assessments in May 2012. An assessment commissioned by an industry organization disagreed with EPA's findings, whereas an assessment commissioned by four environmental organizations supported the agency's findings.

EPA's draft report also has received attention within Congress. On January 20, 2012, 11 members of the Senate Environment and Public Works Committee sent a letter to EPA Administrator Lisa Jackson asking that the EPA investigation be considered a "highly influential scientific assessment and that any related, generated report is subject to the most rigorous, independent, and thorough external peer review process." In the House, the Subcommittee on Energy and Environment of the Committee on Science, Space, and Technology held a hearing on February 1, 2012, to examine EPA's findings. Concerns about the status of EPA's report and the scientific validity of its findings have continued into the 113th Congress.

In response to concerns about the adequacy of the original data, EPA worked with the U.S. Geological Survey and the state of Wyoming to collect additional samples from two deep monitoring wells installed by EPA. On September 26, 2012, the USGS released two reports regarding their sampling program for the two wells. The USGS provided raw data from only one well because the second well did not yield enough water to collect representative samples. A news report cited an EPA spokesperson stating that the USGS sampling results were generally consistent with findings from the earlier EPA draft report. An industry spokesperson stated that there was nothing surprising in the USGS results, based on a preliminary examination of the data. Now that EPA has decided not to finalize its report, whatever additional actions may be taken at the Pavillion site would appear to depend on the outcome of the investigation of the state of Wyoming and what continuing role EPA may play in a supporting capacity.

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On December 8, 2011, the U.S. Environmental Protection Agency (EPA) issued a draft report on its investigation of groundwater contamination near the town of Pavillion, Wyoming.[1] This CRS report provides a synopsis of the statutory authority for EPA's investigation under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA),[2] a summary of the primary findings in the EPA Draft Report, and a brief discussion of issues raised subsequent to the release of the draft report by proponents and opponents of the use of hydraulic fracturing for natural gas development.

EPA had extended the public comment period on its Draft Report through September 30, 2013, but on June 20, 2013, EPA announced that it no longer plans to finalize the report.[3] EPA indicated that it would defer to the state of Wyoming to assume the lead role in investigating drinking water quality in the area, and that the continuing role of EPA would focus on providing technical support and input to the state. The scope of the investigation by the state would seek to address water quality concerns by evaluating the water quality of certain domestic water wells, the integrity of certain oil and gas wells, and the historic use of waste disposal pits in the Pavillion area. In its announcement, EPA noted that the state intends to conclude its investigation and release a final report by September 30, 2014.

Although the EPA Draft Report focused on one specific region where hydraulic fracturing was employed to enhance the production of natural gas, it has raised concerns about hydraulic fracturing practices in general, and whether EPA's findings at Pavillion are more broadly applicable to other regions of the country.

Federal Role at Pavillion

EPA Investigation Authority

The EPA Draft Report stated that the agency received complaints from domestic well owners in the vicinity of Pavillion in 2008 who observed objectionable taste and odor in their well water. In response to these citizen complaints, the EPA Region 8 Office initiated an investigation of possible contamination of the drinking water aquifer underlying the town, using the authorities of CERCLA delegated to EPA by Executive Order 12580.[4] Section 104(a) of the statute authorizes

[1] U.S. Environmental Protection Agency, Region 8 and Office of Research and Development, National Risk Management Research Laboratory, *(Draft) Investigation of Ground Water Contamination near Pavillion, Wyoming,* EPA 600/R-00/000, December 2011, http://www.epa.gov/region8/superfund/wy/pavillion/EPA_ReportOnPavillion_Dec-8-2011.pdf. Hereinafter referred to as the EPA Draft Report.

[2] 42 U.S.C. §9601 et seq. For a more in-depth discussion of the authorities of CERCLA than presented in this report, see CRS Report R41039, *Comprehensive Environmental Response, Compensation, and Liability Act: A Summary of Superfund Cleanup Authorities and Related Provisions of the Act*, by (name redacted).

[3] See EPA Region 8 press release, "Wyoming to Lead Further Investigation of Water Quality Concerns Outside of Pavillion with Support of EPA," June 20, 2013, http://yosemite.epa.gov/opa/admpress.nsf/20ed1dfa1751192c8525735900400c30/dc7dcdb471dcfe1785257b90007377bf!OpenDocument.

[4] Executive Order 12580, "Superfund Implementation," 52 *Federal Register* 2923, January 23, 1987. The response authorities of CERLCA are delegated to EPA at sites that are not owned or operated by the federal government, and to other federal departments and agencies at federal facilities (including federal public lands). In conjunction with the states, EPA oversees the performance of response actions at federal facilities that are on the National Priorities List (NPL). The states primarily are responsible for overseeing response actions at federal facilities not on the NPL.

EPA to respond to a release or substantial threat of a release of a hazardous substance, or a pollutant or contaminant that may present an imminent and substantial danger to the public health or welfare.[5] This authority is available in such situations if EPA deems that response actions would be necessary to protect public health or welfare, or the environment, subject to the availability of appropriations under the Superfund program to carry out such actions. The federal regulations of the National Oil and Hazardous Substances Pollution Contingency Plan (often referred to as the National Contingency Plan or NCP for short) establish the procedures under which EPA may evaluate a site to determine where federal response actions may be warranted under Section 104(a) of CERCLA.[6] State or local officials often are responsible for elevating sites to EPA for evaluation under CERCLA, in their capacity as first responders under the NCP.[7]

Section 105(d) also establishes a mechanism under which citizens may request that EPA perform a preliminary assessment to determine whether response actions may be warranted at a site, if EPA has not previously assessed the site.[8] This provision provides the authority for any person who is, or may be, affected by a release or threatened release of a hazardous substance, pollutant, or contaminant to petition EPA to assess the potential hazards to public health and the environment that may arise from such a release or threatened release. EPA is required either to complete a preliminary assessment of a site within 12 months of the submission of a citizen petition, or to provide an explanation of why an assessment may not be appropriate.

As specified in the NCP, a citizen petition under CERCLA should be addressed to the EPA Regional Administrator in the region in which the site is located and should identify the location of the release, how the petitioner is or may be affected by the release, and to the extent available, what types of substances were or may be released and the nature of the activities that have occurred where the release is located.[9] Petitions also should indicate whether state and local officials have been contacted about the release. EPA would use such information to determine whether a site assessment may be warranted at the federal level under CERCLA. The EPA Draft Report for the Pavillion site indicated that the EPA Region 8 Office determined an assessment of the groundwater underlying the site was appropriate based on the observations about domestic well water quality cited in the citizen complaints that the agency received in 2008.[10]

See the **Appendix** at the end of this report for further discussion of EPA's response authorities under CERCLA.

Related Federal Public Health Study

To help inform its investigation of the groundwater underlying the Pavillion site, EPA requested that the Agency for Toxic Substances and Disease Registry (ATSDR), an agency of the U.S. Department of Health and Human Services, examine the potential health hazards that may be

[5] 42 U.S.C. §9604(a).

[6] 40 C.F.R. §300.410 for Removal Site Evaluations and 40 C.F.R. §300.420 for Remedial Site Evaluations.

[7] 40 C.F.R. §300.180(f). In the event of a release, the NCP outlines the general expectation that state or local officials would be the first responders to take initial measures that may be warranted to protect public health and welfare.

[8] 42 U.S.C. §9605(d).

[9] 40 C.F.R. §300.420(b)(5). Under this regulation as delegated by Executive Order 12580, a citizen request for an assessment of a release or threatened release at a federal facility (including federal public lands) should be submitted to the federal department or agency that administers the facility, rather than EPA.

[10] EPA Draft Report, p. 1.

associated with contaminants found specifically in private residential well water, but not other portions of the aquifer. Section 104(i)(4) of CERCLA authorizes EPA (or state or local officials) to request that the ATSDR provide consultations on potential health issues that may be associated with the release of a hazardous substance at a specific site.[11] In response to EPA's request under this authority, the ATSDR issued a Health Consultation for Pavillion in August 2010.[12]

The ATSDR concluded that exposure to some of the contaminants found in the private residential well water were at levels that could lead to certain health effects, based on the potential for exposure relative to the health screening criteria that the ATSDR applied, and that some of the contaminants (such as methane) could present potential explosive hazards in residences under certain conditions. The ATSDR recommended that residents use alternate or treated water supplies, and recommended certain other measures to address potential explosive hazards, such as ventilating bathrooms while showering.[13]

It should be emphasized that the ATSDR's study focused specifically on potential hazards associated with the private residential well water, whereas the scope of EPA's site investigation was broader in terms of identifying and characterizing contaminants across the aquifer more widely and at greater depths. The ATSDR's finding of the presence of potential hazards was limited to the private residential well water itself, at shallower depths common to most domestic wells, and not the greater depths of natural gas production wells. The distinction between chemical constituents found at shallow depths in the aquifer and those found in deeper portions is discussed below.

Primary Findings of the EPA Draft Report

Background

The Pavillion gas field lies within the Wind River Basin, a deep sedimentary basin extending across a large area of central Wyoming and bounded on the north and southwest by upfolded and faulted mountain ranges. (See **Figure 1**.) The Wind River Formation, an accumulation of sandstone, conglomerate, shale, and mudstone, is the major source of drinking water for domestic and public-supply uses in the Wind River Basin.[14] The Wind River Formation varies in thickness, and extends from the ground surface to as deep as 3,400 feet in the Pavillion gas field area.[15]

[11] 42 U.S.C. §9604(i)(4).

[12] U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry, *Health Consultation: Evaluation of Contaminants in Private Residential Well Water at Pavillion, Wyoming, Fremont County*, August 31, 2010, available on the agency's website: http://www.atsdr.cdc.gov/hac/PHA/Pavillion/Pavillion_HC_Well_Water_08312010.pdf.

[13] Subsequent to the ATSDR's findings, the governor of Wyoming directed the Wyoming Water Development Commission in September 2010 to study public water supply options for Pavillion. The commission completed its study in October 2011. The study focused on water supply options for the residents of Pavillion to ensure the safety of the supplies, but did not further investigate the groundwater contamination nor potential sources of contaminants across the aquifer. The study, *Pavillion Area Water Supply Level I Study: Final Report*, October 2011, is available on the Wyoming Water Development Commission's website: http://wwdc.state.wy.us/agency_publications/PavillionWaterSupplyLl_2011.pdf.

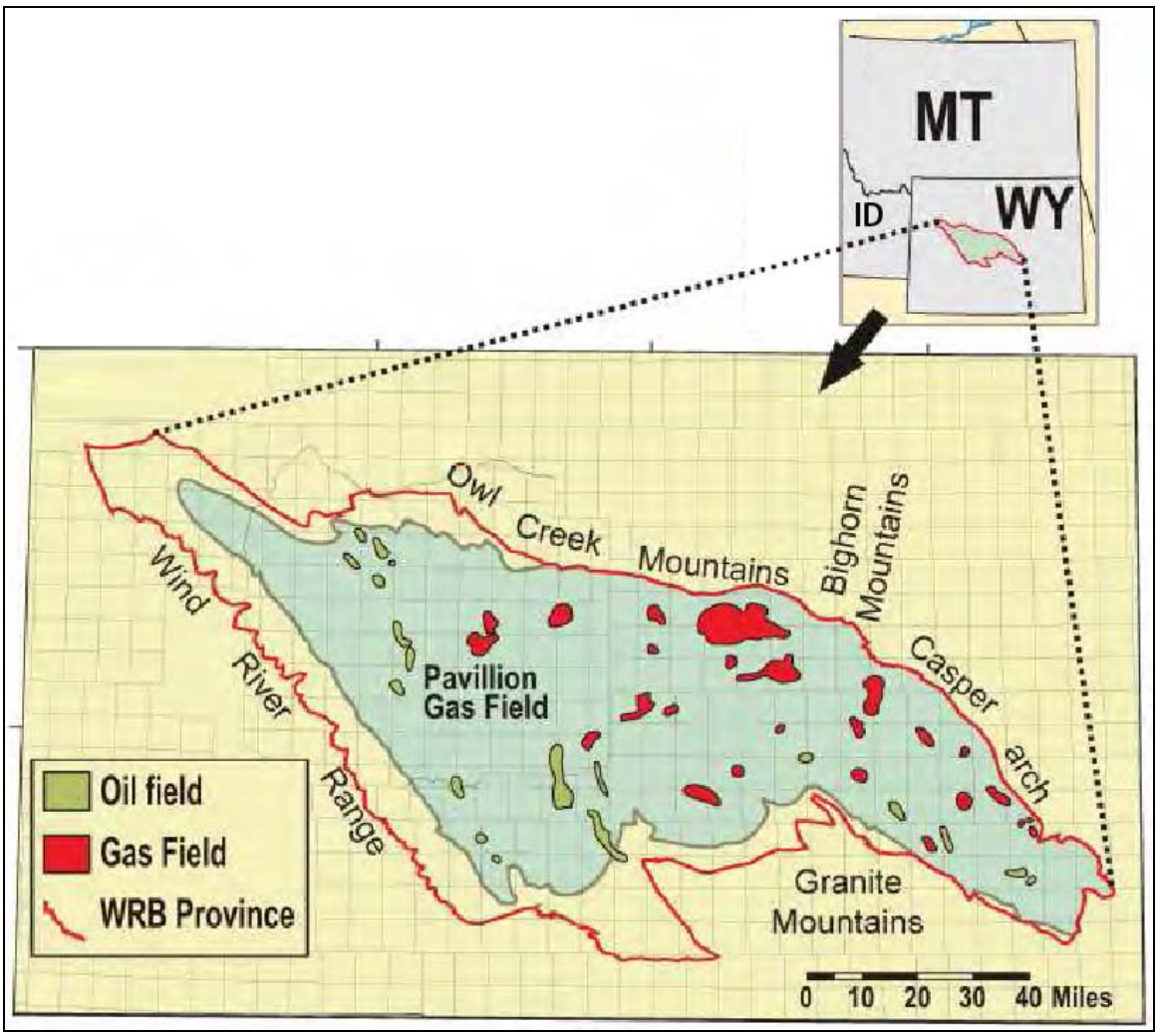
[14] Richard L. Daddow, *Water Resources of the Wind River Indian Reservation, Wyoming*, U.S. Geological Survey, Water Resources Investigations Report 95-4223, Cheyenne, WY, 1996, p. 21.

[15] EPA Draft Report, p. 2.

Natural gas is produced from wells drilled into the Wind River Formation, and from deeper wells drilled into the Fort Union Formation, which lies directly underneath the Wind River Formation. The most productive zone of natural gas extraction is from the bottom of the Wind River Formation, although hydraulic fracturing to enhance gas production has occurred at locations as shallow as 1,220 feet below ground surface, according to the EPA Draft Report.[16]

Figure 1. Location of the Wind River Basin, Wyoming

(showing the location of the Pavillion Gas Field)



Source: U.S. Environmental Protection Agency, Region 8 and Office of Research and Development, National Risk Management Research Laboratory, *(Draft) Investigation of Ground Water Contamination near Pavillion, Wyoming,* EPA 600/R-00/000, December 2011, http://www.epa.gov/region8/superfund/wy/pavillion/EPA_ReportOnPavillion_Dec-8-2011.pdf. Modified by CRS.

The EPA sampled residential wells, stock wells, shallow monitoring wells, and two municipal wells. The domestic wells range in depth from approximately 20 feet to nearly 800 feet, and the

[16] EPA Draft Report, p. 2.

two municipal wells are 505 and 515 feet deep.[17] The shallow monitoring wells were approximately 15 feet deep. According to the EPA Draft Report, the early phases of the investigation detected the presence of methane and diesel-range organic chemicals in some of the deeper domestic wells, which prompted EPA to install two deep monitoring wells in June 2010.[18] EPA stated that the purpose of installing two deep monitoring wells—one at 785 feet and the second at 980 feet—was to differentiate potentially deep sources from potentially shallow sources of contamination.[19] Shallow sources of contamination were thought to be related to leakage from surface pits used for storage and disposal of drilling wastes and produced and flowback water. Potential deeper sources were thought to be related to gas production, which would include drilling and hydraulic fracturing, as well as actual gas production.

Detecting and distinguishing between potentially shallow and potentially deep sources of groundwater contamination lies at the heart of the primary findings in the EPA Draft Report. Whether the report clearly links groundwater contamination to drilling or hydraulic fracturing activities at depth has been the source of relatively heated commentary by proponents and opponents of the use of hydraulic fracturing for natural gas development. The primary findings in the report and examples of reactions and commentary by stakeholders are discussed below.

Detecting Contamination in Groundwater

Contaminants in Shallow Groundwater—Surface Pits

According to the EPA Draft Report, the objective of the EPA investigation was to determine the presence of groundwater contamination above the Pavillion gas field, and to the extent possible identify the source of the contamination.[20] The investigation identified a suite of contaminants in samples from shallow monitoring wells—wells that monitor the upper portions of the Wind River aquifer. The contaminants identified in the shallow portions of the aquifer included benzene, xylenes, gasoline-range organics (GROs), and diesel-range organics (DROs).[21] According to the report, at least 33 surface pits were likely sources for the contaminants detected in shallow groundwater: "detection [of these contaminants] in ground water samples from shallow monitoring wells near pits indicates that pits are a source of shallow ground water contamination

[17] EPA Draft Report, Table A1, pp. A2-A4.

[18] Diesel-range organics (DROs) are a group of compounds similar to, and including, diesel fuel. DROs include, for example, phenols, phthalate esters, kerosene, and home heating oil.

[19] EPA Draft Report, p. 5. The depths of the monitoring wells refer to the bottom of the screened interval for a well. The screened interval is the portion of the well where the well casing is not solid steel, but consists of a stainless steel mesh that allows water from a productive layer in the aquifer to flow into the monitoring well. For example, the screened interval for the shallower monitoring well extends from 765 to 785 feet; and the screened interval for the deeper well extends from 960 to 980 feet.

[20] EPA Draft Report, p. 33.

[21] Petroleum fuels and oils are complex mixtures of many hydrocarbon compounds. Testing can be done for specific chemicals of concern, such as benzene, and for chemically similar compounds to help identify possible sources of contamination. Gasoline-range organics (GROs) comprise a group of hydrocarbon compounds structurally similar to, and including, gasoline. Diesel-range organics (DROs), as discussed above, are a group of compounds similar to, and including, diesel fuel. DROs contain longer carbon chains than GROs, and DROs include, for example, phenols, phthalate esters, kerosene, and home heating oil. For analytical purposes, test methods are available to identify and measure the concentration of different compounds within the GRO and DRO ranges.

in the area of investigation."[22] The pits were used for disposal of drilling cuttings, hydraulic fracturing flowback, and water produced from the formation.

The Draft Report further noted that EPA is a member of a stakeholder group working with the gas field operator—Encana Oil & Gas Inc., a subsidiary of the Canadian Encana Corporation—to "determine the areal and vertical extent of shallow ground water contamination caused by these pits."[23] EPA added that Encana is currently engaged in investigating and remediating several pit areas. Encana has contributed to the cost of furnishing alternate supplies of drinking water to some Pavillion citizens while its investigation continues as part of the stakeholder group.[24] Encana acquired the natural gas field and its infrastructure in 2004; however, drilling for natural gas began in the 1960s and the surface pits were excavated prior to 2004.[25]

The EPA Draft Report does not discuss the shallow groundwater contamination in much detail, and it does not indicate that the source of the contaminants in shallow groundwater is anything other than the surface pits. Reactions to the report and commentary by stakeholders also have not focused on the shallow groundwater issues, or on the surface pits as likely sources of contaminants. The focus of the EPA Draft Report and the issues raised by proponents of natural gas development and hydraulic fracturing concern the detection and source of contaminants in the deeper portions of the aquifer. Domestic water wells in the Pavillion area generally use groundwater from the shallower portions of the aquifer.

Contaminants in Deeper Groundwater—Natural Gas Operations and Hydraulic Fracturing?

The EPA Draft Report acknowledged that "[d]etection of contaminants in ground water from deep sources of contamination (production wells, hydraulic fracturing) was considerably more complex than detection of contaminants from pits necessitating a multiple lines of reasoning approach common to complex scientific investigations."[26] The Draft Report further explained that, "[w]hile each individual data set or observation represents an important line of reasoning, taken as a whole, consistent data sets and observations provide compelling evidence to support an explanation of data."[27] According to the report, this approach led to its primary finding, "that constituents associated with hydraulic fracturing have been released into the Wind River drinking water aquifer at depths above the current production zone."[28]

The first set of "lines of reasoning" described in the report refers primarily to chemical constituents detected in the two deep monitoring wells the EPA installed during June 2010.

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[22] EPA Draft Report, p. 33. Although now banned in many states, unlined pits and lagoons have long been used to dispose of wastewater associated with oil and gas production.

[23] EPA Draft Report, p. 33.

[24] Encana Oil & Gas, News Release, *Why Encana Refutes U.S. EPA Pavillion Groundwater Report*, December 12, 2011, http://www.encana.com/news-stories/news-releases/details.html?release=632327. The stakeholder group includes Encana, the Wyoming Department of Environmental Quality, the Wyoming Oil and Gas Conservation Commission, Wyoming Geological Survey, Wyoming State Engineer's Office, and the Department of the Interior's Bureau of Land Management.

[25] EPA Draft Report, p. 1.

[26] EPA Draft Report, p. 33.

[27] EPA Draft Report, p. 33.

[28] EPA Draft Report, p. 33.

Monitoring Well 1 (MW01) was screened (open to the aquifer) between 765 and 785 feet below ground surface; Monitoring Well 2 (MW02) was screened between 960 and 980 feet below ground surface. For comparison, the domestic wells sampled during the EPA investigation ranged between 20 and 800 feet deep, and the two municipal wells included in the study were 505 and 515 feet below the ground surface. However, EPA also notes in the report the absence of baseline groundwater monitoring data that could indicate groundwater conditions prior to gas production in the area.

The EPA Draft Report also provided a second set of "lines of reasoning" for supporting the agency's conclusion that "[a]lthough some natural migration of gas would be expected above a gas field such as Pavillion, data suggest that enhanced migration of gas has occurred to ground water at depths used for domestic water supply and to domestic wells."[29] These "lines of reasoning" refer to chemical data from other wells, to the length of casing and the presence or absence of cement in gas production wells, and to the nature and timing of citizens' complaints about taste and odor problems with their drinking water.

A brief description of the "lines of reasoning" that led EPA to its explanation for the contaminants in deeper groundwater follows.[30]

High pH Values

The EPA Draft Report cited "unusual and unexpected" pH values measured in both monitoring wells.[31] The pH values ranged from 11.2 to 12.0. (A pH of 12 is unusually high for most natural waters, and is approaching the caustic or strongly pH range.)[32] The Draft Report noted that pH values in domestic wells ranged between 6.9 and 10, indicating that groundwater measured in the deep monitoring wells was between 10 and 100 times more alkaline than the most alkaline domestic well sampled during the investigation.[33] In the report, EPA also cited geochemical modeling results indicating that the addition of a strong base, such as potassium hydroxide (KOH), to groundwater of the Pavillion aquifer at depths of 328 feet or more would increase pH values significantly. The EPA Draft Report noted that KOH was used in fracking operations in the Pavillion gas field as a cross-linker and in a solvent, and suggested that the addition of a strong base (such as KOH) was "the causative factor for elevated pH in the deep monitoring wells."[34]

[29] EPA Draft Report, p. 37.

[30] The last section of this report discusses several of the arguments raised to date against some of the individual lines of reasoning and against EPA's tentative overall conclusion that the presence of petroleum hydrocarbons and other chemical compounds in the ground water "is consistent with migration from areas of gas production" where hydraulic fracturing is taking place.

[31] EPA Draft Report, p. 20.

[32] A pH of less than 7.0 is considered acidic, while a pH of greater than 7.0 is considered basic (alkaline); a pH of 7.0 is defined as "neutral." pH is reported on a log scale, so that each pH unit represents a 10-fold change in concentration. For example, a pH of 10 is 10 times more alkaline than a pH of 9, and 100 times more alkaline than a pH of 8.

[33] These values for domestic wells were reported in the EPA Draft Report text on p. 33; however, Table A2a indicates that domestic wells contained pH values as high at 10.47 (sample PGDW32), and the lowest pH value for a deep monitoring well was 11.24 (MW01). Using the numbers reported in Table A2a, the pH of MW01 was 5.9 times as alkaline as sample PGDW32.

[34] EPA Draft Report, p. 20. A cross-linker is added to fracking fluids to increase the viscosity of the fluid in order to transport the proppant, commonly sand, more effectively into the induced fractures. (Proppants hold open the fractures and allow gas to flow to the well.)

Elevated Potassium and Chloride Concentrations

The EPA Draft Report stated that the inorganic chemistry of the groundwater measured from deep monitoring wells is distinctive from the groundwater in domestic wells sampled in the study and from the expected composition of groundwater in the Wind River Formation. In particular, the report cited elevated concentrations of potassium and of chloride. According to the report, potassium levels in the monitoring wells were between 8.2 and 18.3 times the mean value of levels observed in domestic wells. Chloride levels in MW02 were 18 times the mean value for chloride concentrations measured in domestic wells.[35] (Chloride values in MW01, however, were approximately 23 milligrams per liter, less than the mean value for domestic wells of 25.6 milligrams per liter.)[36] It is difficult to ascertain from the report whether the higher potassium and chloride levels represent a range of natural variability in the deeper portions of the aquifer, or whether they are related to drilling and hydraulic fracturing activities.

The report cited information from well completion reports and material safety data sheets (MSDSs) for each of the wells indicating the use of chemicals containing potassium and chloride in fracture fluids. Namely, the report noted the use of potassium chloride, potassium metaborate, potassium hydroxide, and ammonium chloride in foam jobs and as cross-linkers in fracture fluids.[37] However, the report did not include any information linking the use of these chemicals with site-specific hydraulic fracturing jobs, nor did it cite specific groundwater pathways from hydraulic fracturing to the monitoring wells. The report also considered alternate explanations for elevated potassium and chloride levels, such as contamination by drilling fluids and additives used in constructing the monitoring wells, contamination from well completion materials, and contamination from surface soils. But in its description of how the wells were constructed and how the materials were handled, EPA did not state that these alternative explanations were responsible for elevated potassium and chloride levels in the monitoring wells.

Detection of Synthetic Organic Compounds

During its investigation, EPA detected several synthetic organic compounds in water samples taken from MW01 and MW02. The synthetic organic compounds would not be expected to occur naturally in groundwater. These compounds included isopropanol, diethylene glycol, and triethylene glycol. The EPA Draft Report noted that these three compounds were used in hydraulic fracture fluids, as a foaming agent, and in solvents, according to well completion reports and MSDSs.[38] EPA reported that *tert*-butyl alcohol was also detected in MW02. *Tert*-butyl alcohol is a known breakdown product of methyl *tert*-butyl ether, or MTBE, a gasoline additive used to raise the oxygen content of the fuel. It is also a breakdown product of *tert*-butyl hydroperoxide, a gel breaker used in hydraulic fracturing fluids. *Tert*-butyl hydroperoxide was not listed on MSDSs or on well completion logs, according to the EPA Draft Report. However, the report added that *tert*-butyl alcohol is not expected to occur naturally in groundwater, and its source in Pavillion groundwater remains unresolved.

[35] EPA Draft Report, p. 34. As indicated earlier, EPA noted in the report the absence of baseline groundwater monitoring data that could indicate groundwater conditions prior to gas production in the area.

[36] EPA Draft Report, Table A2a.

[37] EPA Draft Report, p. 34.

[38] EPA Draft Report, Table 4.

Detection of Petroleum Hydrocarbons

The EPA Draft Report stated that a number of petroleum hydrocarbons were detected in groundwater in wells MW01 and MW02. These compounds included benzene, toluene, ethylbenzene, and xylene (BTEX), trimethylbenzenes, GROs, DROs, and napthalene. The report noted that compounds listed on MSDSs that were used in hydraulic fracturing solutions contained the petroleum hydrocarbon constituents listed above. For example, the report stated, MSDSs indicate that diesel fuel was used in a guar polymer slurry; an aromatic solvent that was typically a BTEX mixture was used as a breaker; and other compounds were used in different components comprising the suite of chemicals that make up a hydraulic fracture fluid.[39]

Breakdown Products of Organic Compounds

The EPA Draft Report stated that more organic chemicals were detected at higher concentrations in the deeper monitoring well (MW02), whereas breakdown products of those organic chemicals were detected at higher concentrations in the shallower well (MW01).[40] Examples of breakdown products found in these wells included acetate and benzoic acid, which can be formed from the breakdown of BTEX and glycols. The report cited the occurrence of flowing stock wells as evidence of an upward hydraulic gradient in the study area,[41] which the report suggested concurs with the presence of enriched breakdown products in shallower, downgradient monitoring well MW01. In other words, the report suggested that groundwater containing organic compounds such as BTEX and glycols would travel in an upward direction, and during the course of that travel those compounds would break down, or degrade, into acetate and benzoic acid.

Well Design and Integrity of Gas Production Wells[42]

The EPA Draft Report stated that the design and integrity of gas production wells were possibly "one causative factor in deep ground water contamination at this site."[43] The report noted several components of well design and integrity that could have been involved: (1) the surface casing of most production wells did not extend below the deepest domestic wells; (2) there was little vertical separation between the uppermost zones that were hydraulically fractured and the deepest

[39] EPA Draft Report, pp. 35-36.

[40] EPA Draft Report, p. 36.

[41] A flowing well is also known as an artesian well, in which the groundwater in the aquifer is at a sufficient pressure to flow naturally to the land surface without requiring pumping. In such cases, the direction of groundwater flow, or hydraulic gradient, is from the deeper parts of the aquifer towards the shallower parts of the aquifer.

[42] Oil and gas production on private and state lands is regulated by the states. The Wyoming Oil and Gas Conservation Commission has responsibility for administering the oil and gas rules and related permitting, inspection, and enforcement activities. The state revised its rules effective September 15, 2010. Revisions include requirements for directional drilling reporting and certification, and expanded requirements for well stimulation (such as hydraulic fracturing). The well stimulation rules address well integrity, casing setting depths, and casing design and cementing; protection of utilizable groundwater; disclosure of hydraulic fracturing fluid contents and concentrations; and management of recovered fluids. The rules now require surface casing to be run to a depth below known or estimated utilizable groundwater, and to specified depths below water wells. Operators are required to provide detailed information regarding the fracturing process, including the source of water and/or trade name fluids, type of proppants, and estimated pump pressures. After a treatment is complete, the operator must provide fracturing data and production results (Wyo. Rules and Regs. Oil Gen §§3-8, 22, 45, and elsewhere). Also, the state revised its rules governing water well construction in 2011.

[43] EPA Draft Report, p. 37.

domestic wells; and (3) there was an absence of cement, or only sporadic bonding between the cement, well casing, and formation, in several production wells. Typically, cement fills the gap between the outside of the well casing and the formation to prevent any leakage of fluids along the outside of the wellbore into an aquifer. The EPA investigation relied on geophysical logs of the production wells to infer that in many instances cement was lacking along portions of the wellbore or that sporadic bonding existed just above the zones of hydraulic fracturing. The absence of cement or the sporadic bonding of some portions, inferred by EPA from the geophysical logs, implies that fluids could have leaked from the fractured intervals up along those zones to the aquifer above.

Excursion of Fracture Fluids from Sandstone Units and Along the Wellbore

A lithologic barrier, such as a thick layer of impermeable shale, would typically prevent or limit the amount of natural gas that would seek to migrate from the gas-filled sandstone lenses upward toward the surface.[44] The EPA Draft Report suggested that the absence of a lithologic barrier above the gas production zone, such as a laterally continuous shale layer, meant that gas might have migrated upward "in the event of excursion from fractures."[45] Similarly, if fluid leaked vertically from hydraulically induced fractures in thin sandstone lenses, it could also have migrated laterally to nearby wellbores, and then travelled vertically upward along the wellbore if cement was lacking or if the cement was only sporadically bonded to the well casing and formation, according to the report.

Enhanced Migration of Natural Gas?

In addition to the seven "lines of reasoning" summarized above, the EPA Draft Report also claimed that "data suggest that enhanced migration of gas has occurred to ground water at depths used for domestic water supply and to domestic wells."[46] The report noted that some natural migration of gas would be expected above the gas field at Pavillion. However, the report listed a second set of "lines of reasoning" to support the interpretation that hydraulic fracturing and gas development activities allowed gas and other constituents to migrate into the aquifer where they would not have if gas development had not taken place.

Isotopic Data

Analysis of carbon isotopes can often be used to identify the source of organic compounds. The EPA Draft Report pointed to analyses of carbon isotopes indicating that the methane found in monitoring wells is similar to the methane found in production wells. The isotopic data indicate that the methane gas is "thermogenic," derived from the thermal breakdown of organic matter under pressure in deeper source rocks. Thermogenic methane is distinguished from "biogenic" methane, which is produced by the breakdown of organic material by organisms called methanogens. Biogenic methane typically occurs close to the earth's surface (e.g., methane gas in landfills is biogenic) and is thus distinguished from methane associated with oil and gas

[44] Sandstone lenses refer to the intervals of sandstone that are discontinuous in the horizontal direction (i.e., are not continuous layers of sandstone). The lenses of sandstone are interbedded with other lithologies, such as shale, in both a vertical and horizontal direction.

[45] EPA Draft Report, p. 37.

[46] EPA Draft Report, p. 37.

operations. The EPA Draft Report suggested that the patterns indicated by carbon isotope data support the hypothesis that organic compounds in the study area migrated upward from depth.

Proximity of Methane in Domestic Wells to Production Wells

The EPA Draft Report stated that levels of dissolved methane in domestic wells generally increase in wells closest to gas production wells in the Pavillion study area.[47] The report said that methane was not detected in domestic water wells that had two or fewer production wells within approximately 2,000 feet (with the exception of two domestic wells where methane was detected).

Methane Concentrations Highest Near MW01

The EPA Draft Report observed that methane concentrations were highest in samples in an area encompassing MW01 and two domestic wells labeled PGDW30 and PGDW05 (shown in Figure 5 on p. 6 of the EPA Draft Report). The report noted that high levels of methane were found in well PGDW30 at a depth of 260 feet, much shallower than MW01 at 784 feet. The report also stated that a blowout occurred during gas drilling in 2005 at a depth of 520 feet in a well adjacent to well PGDW05. The report cited data from a mud-gas log conducted in 1980—prior to most of the gas production activities—in a well nearly 1,000 feet from where the blowout occurred that did not indicate the presence of natural gas. From that log, EPA inferred that natural gas was not present at depths shallower than 1,000 feet in the area where the blowout occurred prior to natural gas development.

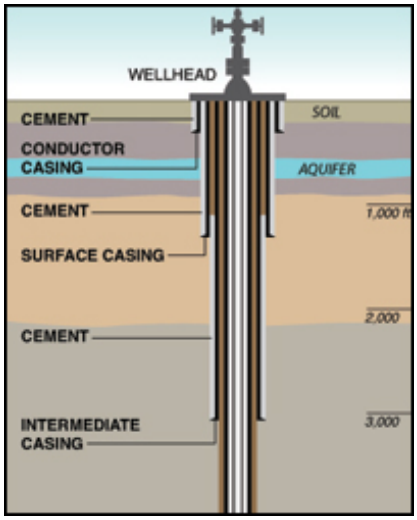
Shallow Surface Casing, Lack of Cement, Sporadic Bonding

The EPA Draft Report noted that surface casing of gas production wells does not extend deeper than the maximum depth of domestic wells in the Pavillion study area (with the exception of two production wells). In other words, portions of nearly all the production wells were uncased at the same depth in the aquifer where the deepest domestic wells obtained their water. EPA asserted that the shallow surface casing, combined with data suggesting lack of cement or sporadic cement bonding between production casing and the formation (discussed above), would facilitate upward migration of natural gas from deeper gas production zones toward shallower domestic wells.

Figure 2 is a diagram of a well showing a typical array of casing types extending from the ground surface downwards. It shows the casing extending through and beneath the aquifer. According to the EPA Draft Report, most gas wells in the Pavillion field were not constructed with casing extending completely through the deepest portion of the aquifer.

[47] EPA Draft Report, p. 38.

Figure 2. Well Construction Showing Casing Extending Through an Aquifer



Source: Adapted from the American Petroleum Institute, *Hydraulic Fracturing*, http://www.api.org/policy/exploration/hydraulicfracturing/upload/HYDRAULIC_FRACT_ILLUSTRATION_121609.pdf . Modified by CRS.

Notes: Not to scale. Shown for illustration purposes, not representative of wells in the Pavillion field.

Citizen Complaints

Last, the EPA Draft Report stated that citizen complaints about odor and taste problems with their well water that began concurrently with or after hydraulic fracturing were "internally consistent," but no baseline data for domestic wells are available for comparison. Baseline data would help determine past levels of gas flux to domestic wells. Nevertheless, the report stated that "[c]itizens complaints often serve as the first indication of subsurface contamination and cannot be dismissed without further evaluation, particularly in the absence of routine ground water monitoring prior to and during gas production."[48] Furthermore, Section 105(d) of CERCLA would have obligated EPA at least to perform a preliminary assessment of the site once potentially affected citizens submitted a petition, unless the agency had determined that such an assessment were inappropriate and had provided the citizens with an explanation for such a determination.

Summary of EPA's Reasoning

In summary, EPA claimed that its "lines of reasoning" approach best supports the explanation that inorganic and organic compounds associated with hydraulic fracturing have contaminated the aquifer at or below the depths used for domestic water supply in the Pavillion area. EPA also stated that its approach indicates that gas production activities have likely enhanced the migration of natural gas in the aquifer and the migration of gas to domestic wells in the area.

[48] EPA Draft Report, p. 39.

Stakeholder Responses to the EPA Draft Report

Because the EPA Draft Report linked groundwater contamination in Wyoming to activities related to hydraulic fracturing, it had raised concerns about hydraulic fracturing practices in general. Some stakeholders took issue with some of the findings in the draft report. Various organizations representing private business interests within the oil and gas industry questioned the scientific validity of EPA's contention that "the explanation best fitting the data for the deep monitoring wells is that constituents associated with hydraulic fracturing have been released into the Wind River drinking water aquifer at depths above the current production zone." In contrast, some environmental organizations cited EPA's findings in calling for more stringent regulation of hydraulic fracturing. Some stakeholders also commissioned independent assessments of EPA's Draft Report and released their respective assessments in May 2012. An assessment commissioned by an industry organization disagreed with EPA's findings, whereas an assessment commissioned by four environmental organizations supported the agency's findings. Stakeholder responses of various industry and environmental organizations are discussed further below.

Industry Organizations

Encana Oil & Gas, Inc.

On December 12, 2011, Encana Oil & Gas (USA), Inc., issued a press release in which the company disagreed with the preliminary conclusions of the EPA Draft Report.[49] (Encana Oil & Gas Inc. acquired the Pavillion gas field in 2004 and drilled 44 wells between 2004 and 2007.) In the press release, Encana asserted that EPA's data align with previous testing done by Encana and do not show any impacts to domestic wells from oil and gas development. Encana further asserted that EPA's findings that compounds used in hydraulic fracturing have contaminated Pavillion groundwater "are conjecture, not factual and only serve to trigger undue alarm."

Encana's press release raised several issues that the company felt cast doubt on the conclusions of the EPA Draft Report:

- The Pavillion area has a "unique geology and hydrology."
- Previous reports have indicated poor water quality in the Pavillion aquifer.
- EPA's two deep monitoring wells were drilled into a natural gas reservoir and detected components of natural gas, which is not unexpected, according to the company.
- The chemical results from the deep monitoring wells are "radically different than those in domestic water wells ... thereby showing no connection."
- Several of the manmade chemicals detected in the two deep monitoring wells were not detected in other wells sampled, but some were detected in quality control samples. In the press release, Encana states that this indicates problems with EPA's methodology in drilling and sampling.

[49] Encana Oil & Gas, Inc., press release, "Why Encana Refutes U.S. EPA Pavillion Groundwater Report," December 12, 2011, http://www.encana.com/news-stories/news-releases/details.html?release=632327.

- The press release stated that EPA's results from the investigation do not exceed state or federal drinking water quality standards for any constituent related to oil and gas development.

In its press release, Encana called on EPA and other government officials to subject their data to independent third-party review. In announcing the opportunity for public comment, EPA had stated its intention to convene an independent panel of scientific experts for external peer review in addition to the review of any comments that may be submitted by members of the public.[50]

Energy in Depth

Energy in Depth (EID) is an outreach campaign started by the Independent Petroleum Association of America in 2009 to promote the development of U.S. onshore energy resources.[51] In December 2011, EID released a set of questions about the EPA Draft Report, some of which echo concerns voiced by Encana Oil & Gas, such as why were chemical results from the deep monitoring wells different from those found in the domestic water wells.[52] The questions touched on whether chemicals used by EPA in drilling its monitoring wells may have affected the results of sampling the deep groundwater. The group also raised the issue that high levels of potassium and chloride have been found previously in the Pavillion area, and that high levels found in the monitoring wells may reflect background water quality and natural variations in groundwater flow or composition.

The Petroleum Association of Wyoming

On December 9, 2011, the Petroleum Association of Wyoming issued a press release also raising concerns with the EPA Draft Report.[53] The press release stated concerns similar to those raised by Encana Oil & Gas, Inc., and by EID about the deep monitoring wells being drilled into gas-bearing zones, the differences between compounds found in the deep monitoring wells and in domestic water wells, and quality assurance issues with EPA's drilling and testing.

Independent Petroleum Association of America

The Independent Petroleum Association of America (IPAA) commissioned an independent assessment of the EPA Draft Report, and released this assessment on May 16, 2012. It generally disagreed with the scientific basis of the agency's findings that hydraulic fracturing fluids have contaminated the groundwater.[54] The IPAA-commissioned report agreed with the EPA Draft Report's conclusion that surface pits were the source of shallow groundwater contamination in

[50] Environmental Protection Agency, "Draft Research Report: Investigation of Ground Water Contamination Near Pavillion, Wyoming," 76 *Federal Register* 77829, December 14, 2011.

[51] See "What's EID?" at http://www.energyindepth.org/whats-eid/.

[52] Energy in Depth, "*Update VI* Six—Actually, Seven—Questions for EPA on Pavillion," http://www.energyindepth.org/six-questions-for-epa-on-pavillion/.

[53] The Petroleum Association of Wyoming, press release, Petroleum Association of Wyoming States Serious Concerns with EPA's Unsubstantiated and Reckless Claims, http://www.pawyo.org/PAW_News%20Release_12082011.pdf.

[54] S. S. Papadopulos & Associates, Inc., *Review of U.S. EPA's December 2011 Draft Report: "Investigation of Ground Water Contamination Near Pavillion, WY*," Prepared for The Independent Petroleum Association of America, April 26, 2012, https://images.magnetmail.net/images/clients/IPAA_comm/attach/PavillionReport2012.pdf.

the area of investigation, but disagreed that constituents associated with hydraulic fracturing were released into the Wind River drinking water supply (Conclusion 2 of the EPA Draft Report), and that hydraulic fracturing has led to enhanced migration of natural gas to groundwater used for domestic water supply (Conclusion 3 of the EPA Draft Report).

The IPAA-commissioned report indicated that EPA's findings, using "multiple lines of evidence," were unconvincing and that the available data supported explanations other than hydraulic fracturing. For example, the IPAA report suggested that problems with sampling the two EPA monitoring wells, such as contamination by cement grout used for constructing the wells, led to measurements of high pH and detection of anomalous chemistry. The IPAA report also indicated that many of the organic compounds in the EPA analyses could have come from natural petroleum sources in the Wind River Formation. The IPAA report observed that EPA had not characterized the hydrogeology of the study area, and thus could not make definitive conclusions regarding the migration pathway from the zones where hydraulic fracturing took place to the shallow groundwater regions used for drinking water. In sum, the IPAA report concluded that all of the "lines of evidence" cited by EPA could be adequately explained with alternative hypotheses.

Environmental Organizations

Natural Resources Defense Council

A commentator from the Natural Resources Defense Council (NRDC)[55] pointed to the EPA Draft Report's findings to underscore the NRDC position that

> wells that will be hydraulically fractured be located in a geologically suitable location such that a suitable confining zone is present, any potential contamination pathways—including improperly constructed or abandoned wells—must be identified and remediated, and properly constructed wells, baseline testing, and site characterization are crucial to preventing contamination of USDWs [underground sources of drinking water].[56]

Another NRDC commentator also cited the results of the report to support the claim that many factors are at play in hydraulic fracturing, any one of which "can go wrong."[57] The commentator stated that much stronger rules are needed and that is why NRDC supports federal regulation of fracking under the Safe Drinking Water Act.[58]

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[55] The Natural Resources Defense Council is a not-for-profit, tax-exempt environmental organization. See http://www.nrdc.org/about/.

[56] Natural Resources Defense Council, Briana Mordick's Blog, *Groundwater in Pavillion, WY Contaminated by Hydraulic Fracturing Through Multiple Subsurface Pathways*, December 9, 2011, http://switchboard.nrdc.org/blogs/bmordick/groundwater_in_pavillion_wy_co.html.

[57] Natural Resources Defense Council, Amy Mall's Blog, "New EPA Report Ties Hydraulic Fracturing to Groundwater Contamination," December 8, 2011, http://switchboard.nrdc.org/blogs/amall/new_epa_report_ties_hydraulic.html.

[58] The Safe Drinking Water Act (SDWA) establishes the national program for protecting "underground sources of drinking water" (USDWs) by limiting, through regulation, underground injection that could contaminate usable aquifers. SDWA §1421 directs the EPA Administrator to issue regulations for state programs, and mandates that the EPA rules "contain minimum requirements for programs to prevent underground injection that endangers drinking water sources." UIC provisions, as amended, are contained in SDWA Part C, §§1421-1426; 42 U.S.C. §§300h-300h-5. The Energy Policy Act (EPAct) of 2005 (P.L. 109-58, §322), amended the SDWA to exempt from the definition of underground injection the injection of fluids or propping agents (other than diesel fuel) for hydraulic fracturing (continued...)

The NRDC also has partnered with the Wyoming Outdoor Council, Sierra Club, and the Oil and Gas Accountability Project to commission their own independent assessment of EPA's Draft Report. The NRDC released the assessment on May 1, 2012, which stated that "the EPA's conclusion is sound" and "it is clear that hydraulic fracturing has caused pollution of the Wind River formation and aquifer."[59] The NRDC-commissioned report agreed with all of EPA's conclusions, and dismissed other explanations, such as those raised by the IPAA-commissioned report discussed above. For example, the NRDC report asserted that EPA appropriately accounted for the potential that poor construction of the EPA monitoring wells could have led to anomalously high pH values. The IPAA-commissioned report argued that poor well construction was the most likely reason for the high pH values.

The NRDC-commissioned report also recommended further work to improve the EPA analysis, such as continuing to collect data to better verify the sources of the contaminant plume, installing deeper monitoring wells, mapping the depth to water, estimating vertical gradients, correlating the gradients to contaminated areas and their sources, and others.

Environmental Defense Fund

A commentator from the Environmental Defense Fund (EDF) echoed remarks in the NRDC critique that the "draft report is Exhibit A on why stronger regulation and enforcement is necessary if the general public is EVER going to believe that shale gas development is a safe source of natural gas."[60]

Pro Publica

An article published by Pro Publica, an independent nonprofit news service, stated that findings from the EPA Draft Report "could be a turning point in the heated national debate about whether contamination from fracking is happening, and are likely to shape how the country regulates and develops natural gas resources in the Marcellus Shale and across Appalachian states." The article also stated that some of the findings in the report contradict what the drilling industry has argued about why fracking is safe. The article said that those industry arguments are "that hydrologic pressure would naturally force fluids down, not up; that deep geologic barriers provide a watertight barrier preventing the movement of chemicals towards the surface; and that the problems with the cement and steel barriers around gas wells aren't connected to fracking."[61]

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purposes (42 U.S.C. §300h(d)). For a discussion of hydraulic fracturing regulatory proposals and issues, see CRS Report R41760, *Hydraulic Fracturing and Safe Drinking Water Act Issues*, by (name redacted) and (name redacted).

[59] Tom Myers, *Technical Memorandum, Review of DRAFT: Investigation of Ground Water Contamination near Pavillion Wyoming*, April 30, 2012, http://docs.nrdc.org/energy/files/ene_12050101a.pdf.

[60] Environmental Defense Fund, Mark Brownstein, "EPA's Pavillion, WY Groundwater Contamination Study A Wake Up Call," December 8, 2011, http://blogs.edf.org/energyexchange/2011/12/08/epas-pavillion-wy-groundwater-contamination-study-a-wake-up-call/.

[61] Abrahm Lustgarten and Nicholas Kusnetz, "Feds Link Water Contamination to Fracking for the First Time," Pro Publica, December 8, 2011, http://www.propublica.org/article/feds-link-water-contamination-to-fracking-for-first-time.

Congressional Action

The issuance of EPA's Draft Report also received attention in the second session of the 112th Congress and in the first session of the 113th Congress. On January 20, 2012, 11 members of the Senate Environment and Public Works Committee sent a letter to EPA Administrator Lisa Jackson asking that the EPA investigation be considered a "highly influential scientific assessment and that any related, generated report is subject to the most rigorous, independent, and thorough external peer review process."[62]

Notwithstanding the Senators' request, EPA did not classify the Pavillion Draft Report as constituting "highly influential scientific information." However, the agency did classify the draft as "Influential Scientific Information" and explained as follows:[63]

> EPA classified the Pavillion draft report as "Influential Scientific Information" (ISI) rather than a Highly Influential Scientific Assessment (HISA) because the Pavillion investigation is a single study rather than the type of broad assessment involving an evaluation of a body of scientific or technical knowledge that comprises a HISA (as defined by OMB).[64] Such a classification, however, does not limit the rigor of the peer review. In recognition of the high profile of this investigation, the Agency is using the peer review procedures for the draft report that are equivalent to those required for a HISA, including higher standards for ensuring reviewer independence from the agency and making agency responses to the peer reviewers available to the public. In fact, EPA has gone one step beyond the HISA requirement of simply making the final peer review charge publicly available by soliciting public comments on the draft charge to the reviewers.

In the House, the Subcommittee on Energy and Environment of the Committee on Science, Space, and Technology held a hearing on February 1, 2012, to examine EPA's findings and stakeholder concerns.[65] The subcommittee received testimony from officials representing EPA

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[62] Letter from 11 members of the Senate Environment and Public Works Committee to EPA Administrator Lisa Jackson, January 20, 2012, http://epw.senate.gov/public/index.cfm?FuseAction=Files.View&FileStore_id=04ae8926-3ed7-427a-9ef9-488a4b9b58be.

[63] U.S. Environmental Protection Agency, Response to Questions for the Record, House Committee on Science, Space, and Technology, Subcommittee on Energy and Environment *Fractured Science—Examining EPA's Approach to Ground Water Research: The Pavillion Analysis*, 112th Cong., 2nd sess., February 1, 2012.

[64] Office of Management and Budget, *Issuance of OMB's "Final Information Quality Bulletin for Peer Review*," M-05-03, December 16, 2004, p. 1-2, http://www.whitehouse.gov/sites/default/files/omb/memoranda/fy2005/m05-03.pdf. This bulletin establishes government-wide guidance for peer review of government science documents. It states that "influential scientific information" (ISI) means "scientific information the agency reasonably can determine will have or does have a clear and substantial impact on important public policies or private sector decisions." Under the bulletin, OMB directs federal agencies to undertake a peer review of influential scientific information before they disseminate the information to the public. The bulletin notes that "different types of peer review are appropriate for different types of information," and leaves the selection of a peer review mechanism for ISI to the agency's discretion. Stricter minimum requirements are established for the peer review of highly influential scientific assessments (HISA), which are a subset of ISI. The bulletin states that "a scientific assessment is an evaluation of a body of scientific or technical knowledge which typically synthesizes multiple factual inputs, data, models, assumptions, and/or applies best professional judgment to bridge uncertainties in the available information. OMB leaves broad discretion to the agency formulating the peer review plan, but in general, an agency conducting a peer review of a HISA must ensure that the peer review process is transparent by making available to the public a written charge to the peer reviewers, the peer reviewers' report, and the agency's response to the peer reviewers' report. The bulletin states that "the use of a transparent process, coupled with the selection of objective and independent peer reviewers, should improve the quality of government science while promoting public confidence in the integrity of the government's scientific products."

[65] U.S. Congress, House Committee on Science, Space, and Technology, Subcommittee on Energy and Environment, (continued...)

and the state of Wyoming, the Western Energy Alliance (an industry organization representing oil and natural gas exploration and production companies), and a public health scientist.[66]

Testifying for EPA, James Martin, Regional Administrator for EPA Region 8, noted that Pavillion Draft Report analysis "is limited to the particular geologic conditions in the Pavillion gas field and should not be assumed to apply to fracturing in other geologic settings." Mr. Tom Doll, testifying for the State Oil and Gas Supervisor at the Wyoming Oil and Gas Conservation Commission, questioned EPA's conclusions, stating that, "State of Wyoming experts do not support the EPA's data or analysis and recommend further testing before any conclusion of groundwater contamination by any source can be made." All of the witnesses agreed that more research is needed.

In the first session of the 113th Congress, some members of the Senate Committee on Environment and Public Works had expressed concern in January 2013 about the pending EPA Draft Report for the Pavillion site and the quality of the science upon which it was based.[67] EPA's June 20, 2013, decision not to finalize the Pavillion Draft Report, and to defer to the state of Wyoming to assume the lead role in investigating drinking water quality in the area, has received support from the entire Wyoming delegation.[68]

Discussion

On December 14, 2011, EPA officially issued notice of the public availability of its Draft Report and initially began a 45-day public comment period with a closing date of January 27, 2012.[69] Due to heightened interest, EPA subsequently extended the public comment period for an additional 45 days through March 12, 2012.[70] Shortly after this period expired, EPA announced on March 29, 2012, that the agency would continue to accept public comments through October 16, 2012.[71] EPA decided to continue accepting public comments for this longer period while the agency collected more data than first examined in the Draft Report. On March 8, 2012, EPA had announced its decision to collect additional samples from the deep monitoring wells in response

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Fractured Science—Examining EPA's Approach to Ground Water Research: The Pavillion Analysis, 112th Cong., 2nd sess., February 1, 2012.

[66] Opening statements and witness testimony for the hearing are available on the Subcommittee's website: http://science.house.gov/hearing/energy-and-environment-subcommittee-epa-hydraulic-fracturing-research.

[67] Letter from Senator Vitter, Ranking Member of the Senate Committee on Environment and Public Works, and Senator Inhofe, to EPA Administrator Lisa Jackson, January 17, 2013, http://www.epw.senate.gov/public/index.cfm?FuseAction=PressRoom.PressReleases&ContentRecord_id=4964ef96-c550-a429-40bc-488bc859d41a.

[68] See the following press release*, Delegation Supports EPA Decision to Turn Over Pavillion Testing to Wyoming*, June 20, 2013, http://www.enzi.senate.gov/public/index.cfm/news-releases?ContentRecord_id=dcb01487-8b37-4271-b6a3-656d10b78bde.

[69] U.S. Environmental Protection Agency, "Draft Research Report: Investigation of Ground Water Contamination near Pavillion, Wyoming," 76 *Federal Register* 77829-77830, December 14, 2011.

[70] U.S. Environmental Protection Agency, "Draft Research Report: Investigation of Ground Water Contamination near Pavillion, Wyoming," 77 *Federal Register* 3770-3771, January 25, 2012.

[71] U.S. Environmental Protection Agency, "Draft Research Report: Investigation of Ground Water Contamination near Pavillion, Wyoming," 77 *Federal Register* 19012-19013, March 29, 2012.

to concerns about the scientific validity of the agency's findings.[72] EPA stated that it would partner with the U.S. Geological Survey (USGS) and the state of Wyoming to perform the additional sampling and analysis, in collaboration with the tribes.

In conjunction with its decision to extend the public comment period, EPA delayed the convening of a panel of independent scientists to peer review the findings of its Draft Report until the additional sampling was completed and the data could be made available to the panel to incorporate into its review. On January 17, 2012, EPA had published a 30-day notice inviting public nominations of scientific experts to be considered as peer reviewers for the external review of the Draft Report.[73]

EPA subsequently extended the public comment period on its Draft Report to January 15, 2013,[74] and again to September 30, 2013.[75] On June 20, 2013, EPA announced that it no longer intends to finalize its Draft Report or to seek scientific peer review.[76] Instead, EPA has deferred to the state of Wyoming to assume the lead role in investigating drinking water quality in the vicinity of Pavillion, but noted that it would continue to provide technical support to the state. The Wyoming Department of Environmental Quality and the Wyoming Oil and Gas Conservation Commission are the two agencies that would lead the continuing investigation on behalf of the state. The scope of the investigation by the state would seek to address water quality concerns by evaluating the water quality of certain domestic water wells, the integrity of certain oil and gas wells, and the historic use of waste disposal pits in the Pavillion area. EPA reported in its June 20, 2013, announcement that the state's investigation would seek to clarify water quality concerns and assess the need for any further action to protect drinking water resources. EPA also noted that the state intends to conclude its investigation and release a final report by September 30, 2014. The following sections discuss various issues related to the EPA Draft Report, including subsequent sampling by the USGS, how EPA's findings may be used moving forward, and certain hydrogeological characteristics for consideration in interpreting and applying these findings.

Independent Sampling by the U.S. Geological Survey: Two Reports

On September 26, 2012, the U.S. Geological Survey released two reports on EPA monitoring wells MW01 and MW02 installed by the EPA during its initial investigation at Pavillion. One USGS report described the sampling and analysis plan developed for sampling the two wells.[77]

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[72] See EPA Region 8 press release, "Statement on Pavillion, Wyoming groundwater investigation, March 8, 2012," http://yosemite.epa.gov/opa/admpress.nsf/20ed1dfa1751192c8525735900400c30/17640d44f5be4cef852579bb006432de!OpenDocument.

[73] U.S. Environmental Protection Agency, "Request for Nominations for Peer Reviewers for the Draft Research Report Entitled, 'Investigation of Ground Water Contamination Near Pavillion, WY,'" 77 *Federal Register* 2292-2293, January 17, 2012.

[74] U.S. Environmental Protection Agency, "Draft Research Report: Investigation of Ground Water Contamination near Pavillion, Wyoming," 77 *Federal Register* 62234-62235, October 12, 2012.

[75] U.S. Environmental Protection Agency, "Draft Research Report: Investigation of Ground Water Contamination near Pavillion, Wyoming," 78 *Federal Register* 2396-2397, January 11, 2013.

[76] See EPA Region 8 press release, "Wyoming to Lead Further Investigation of Water Quality Concerns Outside of Pavillion with Support of EPA," June 20, 2013, http://yosemite.epa.gov/opa/admpress.nsf/20ed1dfa1751192c8525735900400c30/dc7dcdb471dcfe1785257b90007377bf!OpenDocument.

[77] Peter R. Wright and Peter B. McMahon, *Sampling and Analysis Plan for the Characterization of Groundwater Quality in Two Monitoring Wells near Pavillion, Wyoming*, U.S. Geological Survey, Open-File Report 2012-1197, (continued...)

The other USGS report provided data and other information from groundwater samples.[78] According to the sampling plan report, the purpose of the data collection effort was to provide an independent perspective of the quality of groundwater pumped from the two EPA monitoring wells. In its press release, the USGS noted that it collected the additional samples in cooperation with the Wyoming Department of Environmental Quality.[79]

The USGS made clear that it did not interpret the data from its sampling effort, and stated that the raw data results added to "the body of knowledge to support informed decisions."[80] The raw data include water quality properties, such as pH and temperature; inorganic constituents, such as sodium and chlorine; organic constituents, such as gasoline-range organics and diesel-range organics; dissolved gases, such as oxygen and radon; and other properties of the groundwater.

The USGS report contains raw data results only from EPA well MW01. The USGS was unable to collect samples from well MW02. The USGS noted in one report that the purge and sampling history for well MW02 indicated that the EPA had experienced much difficulty in collecting water level data from the well because pumping MW02 caused a rapid decline in water levels.[81] A rapid decline in water levels during pumping often indicates that the well has poor yield, and refills very slowly after pumping. In its report, the USGS stated that it is standard USGS practice to avoid sampling low-yield wells, if possible, because without an adequate purge of the standing borehole water the samples are at risk of containing artifacts that can compromise the representativeness of water in the actual formation.[82] The USGS attempted to redevelop well MW02 to increase its yield before sampling, but was unable to do so. Consequently, the USGS chose not to collect any samples from MW02.

In an initial news report, an EPA spokesperson stated that the USGS data are "generally consistent" with the earlier EPA draft report findings.[83] The news report also cited Rob Jackson of Duke University commenting that the results appear consistent with the earlier EPA study.[84] A spokesman from Encana stated that there was nothing surprising in the USGS results, based on a preliminary examination of the data.[85]

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September 26, 2012, http://pubs.usgs.gov/of/2012/1197/OF12-1197.pdf.

[78] Peter R. Wright et al., *Groundwater-Quality and Quality-Control Data for Two Monitoring Wells near Pavillion, Wyoming, April and May 2012*, U.S. Geological Survey, Data Series 718, September 26, 2012, http://pubs.usgs.gov/ds/718/DS718_508.pdf.

[79] USGS press release, "USGS Releases Reports on Groundwater-Quality Sampling Near Pavillion, Wyo.," September 26, 2012, http://www.usgs.gov/newsroom/article.asp?ID=3410#.UGRRa6PDtAe.

[80] Ibid.

[81] U.S. Geological Survey, Open-File Report 2012-1197, pp. 8-9.

[82] Ibid., p. 12.

[83] Alisha Johnson, U.S. EPA, quoted in Mark Drajem, "Diesel in Water Near Fracking Confirm EPA Tests Wyoming Disputes," *Bloomberg.com*, September 27, 2012, http://www.bloomberg.com/news/2012-09-26/diesel-compounds-found-in-water-near-wyoming-fracking-site-2-.html.

[84] Rob Jackson, Duke University, quoted in Drajem, "Diesel in Water Near Fracking Confirm EPA Tests Wyoming Disputes," 2012.

[85] Doug Hock, Encana, quoted in Drajem, "Diesel in Water Near Fracking Confirm EPA Tests Wyoming Disputes," 2012.

The USGS has chosen not to interpret the results from its sampling of MW01, and has no plans to do additional work at Pavillion.[86] In response to a question from CRS regarding whether the USGS would issue a future report interpreting the results from the study, a USGS spokesperson stated that USGS hydrologists concluded that interpretation would require a broad understanding of the hydrogeological setting and groundwater movement in the region, which is beyond the scope of this study.[87]

Moving Forward After the EPA Draft Report

The Draft Report indicates that EPA identified certain constituents above the production zone of the natural gas wells that are consistent with some of the constituents used in the well operations. EPA did not appear to conclude that there was a definitive link to a release from the production wells, nor to the constituents found in the domestic wells in the shallower portion of the aquifer. Absent such a link, EPA also did not conclude in its Draft Report that the constituents found in the aquifer were caused by a specific release that may pose a threat to human health or the environment at the Pavillion site.[88]

At this juncture, it does not appear that these findings would be revisited by EPA, now that the agency has decided not to finalize the report nor to subject it to independent scientific peer review. However, EPA did indicate in its June 20, 2013, announcement that the sampling data obtained during the agency's groundwater investigation at Pavillion would be considered by the state of Wyoming in its further investigation of drinking water quality in the area, and that EPA would offer input to the state in a supporting role. Although EPA acknowledged in its announcement that it "stands behind its work and data," the agency does not plan to rely upon the conclusions in its Draft Report. EPA noted the broader national research that it has been conducting under congressional direction on the potential relationship between hydraulic fracturing and drinking water quality in different areas of the United States.[89] EPA stated that it would "look to the results of that national program as the basis for its scientific conclusions and recommendations on hydraulic fracturing."

Judging by a preliminary scan of public comments made by stakeholders, some of which are described above, proponents and opponents of hydraulic fracturing have disagreed over the EPA

[86] Email from David N. Mott, Director, Wyoming Water Science Center, U.S. Geological Survey, Cheyenne, Wyoming, September 27, 2012.

[87] Email from David N. Mott, Director, Wyoming Water Science Center, U.S. Geological Survey, Cheyenne, Wyoming, September 27, 2012.

[88] As such, EPA would not appear to be required under Section 105(d) of CERCLA at this juncture to evaluate the site to determine its eligibility for listing on the NPL under the Hazard Ranking System and whether cleanup may be warranted under the Superfund program.

[89] The broader national research conducted by EPA is directed in the conference report on the Department of the Interior, Environment, and Related Agencies Appropriations Act, 2010 (P.L. 111-88, H.Rept. 111-316). The "conferees urge[d] the Agency to carry out a study on the relationship between hydraulic fracturing and drinking water, using a credible approach that relies on the best available science, as well as independent sources of information. ..." As part of the study, EPA is conducting retrospective case studies at five sites to develop information about the potential impacts of hydraulic fracturing on drinking water resources under different circumstances. The case studies include (1) the Bakken Shale in Dunn County, ND; (2) the Barnett Shale in Wise County, TX; (3) the Marcellus Shale in Bradford County, PA; (4) the Marcellus Shale in Washington County, PA; and (5) coalbed methane in the Raton Basin, CO. EPA expects to issue the final report of research results in 2016. For more information, see: http://www2.epa.gov/hfstudy.

Draft Report's main conclusions linking hydraulic fracturing chemicals, and perhaps the hydraulic fracturing process specifically, with groundwater contamination in the Pavillion area. Some may attempt to generalize the EPA Draft Report's findings to regions where hydraulic fracturing is used to develop other natural gas resources, such as the Marcellus Shale in the Northeast, the Barnett Formation in Texas, and the Bakken Formation in North Dakota. However, the geology and hydrology of each region differs. The differences in geology and hydrology could make a significant difference in the likelihood of contaminating drinking water aquifers from hydraulic fracturing and from other natural gas development activities. The overall process of hydraulic fracturing and of exploration and production of natural gas, however, is broadly similar irrespective of region.

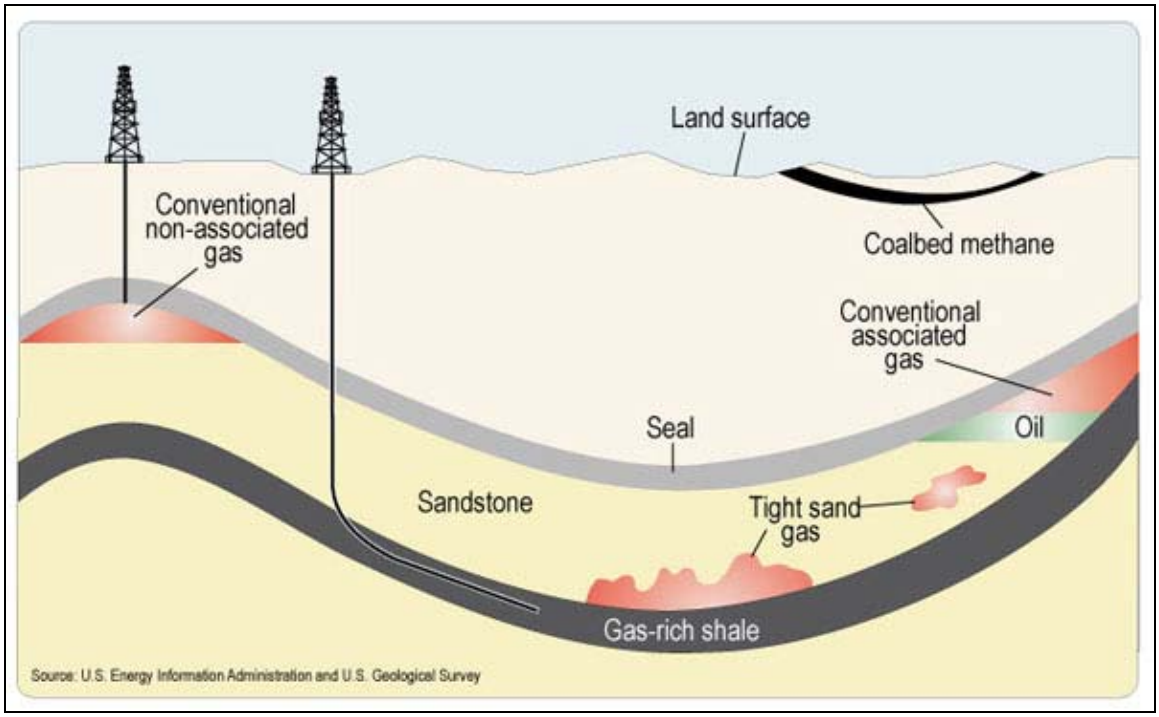
A few of the important similarities and differences between the Pavillion region and other gas-producing regions are described below, to offer some context for evaluating potential arguments for and against generalizing results from the EPA Draft Report more broadly.

Tight Sand Gas Versus Shale Gas

The Pavillion field is known as a tight sand gas field. Natural gas is extracted from sandstone lenses in the Wind River Formation and in the underlying Fort Union Formation. The sandstone lenses are interbedded with less permeable rocks, such as shales and mudstones. The natural gas did not originate in the sandstone lenses, but was likely formed in deeper and older rocks and then migrated into the sandstone lenses. The sandstone lenses, therefore, constitute the *reservoir* for natural gas, but not the *source*. The gas remains trapped in the sandstone reservoirs because the surrounding rocks are relatively impermeable to flow and keep the gas within the sandstone lenses.

Tight gas sandstones generally are defined as *unconventional* gas deposits because they generally have lower permeability than other types of sandstones in *conventional* deposits. Unconventional gas deposits require enhanced recovery techniques to produce the gas, such as hydraulic fracturing. *Conventional* gas deposits, by contrast, can produce gas to the surface via a well under the natural pressure and permeability of the reservoir (at least, until the natural pressure is depleted). **Figure 3** is a schematic showing conventional and unconventional types of natural gas deposits, including shale gas and tight sand gas.

Figure 3. Schematic Diagram Showing Conventional and Unconventional Natural Gas Deposits, Including Shale Gas and Tight Sand Gas



Source: U.S. Energy Information Agency, modified from U.S. Geological Survey Fact Sheet 0113-01, http://www.eia.gov/energyexplained/index.cfm?page=natural_gas_where.

Notes: In the Pavillion region, the tight sand gas deposits are exploited using vertical wells.

The crucial geologic difference between tight sand gas formations and shale gas formations is that shale gas formations are both the *source* rock and the *reservoir* rock. The natural gas is formed within the shale layers, but because shale is virtually impermeable to flow, the gas remains trapped and bound to the matrix of organic matter in the shale. Shale gas formations are also deemed *unconventional* gas deposits.

The distinction between tight sand gas and shale gas is important in the Pavillion area because in the upper 1,000 feet of the Wind River Formation, the sandstone lenses are also part of the aquifer used for water supply. The sandstone, in contrast to shale, has enough permeability to transmit groundwater to water wells in the region. In a sense, the sandstone lenses can act as a reservoir for both natural gas and for groundwater. Shale formations, such as the Marcellus Shale, are not permeable enough to transmit water and are generally not considered aquifers. In fact, thick layers of shale are considered to be barriers to groundwater flow

Hydraulic Fracturing in Deep Versus Shallow Reservoirs

The issue at Pavillion, where hydraulic fracturing and gas production are occurring only slightly deeper than the deepest water wells, would likely not be an issue for most shale gas plays. The uppermost region of hydraulic fracturing in the Pavillion field is within a few hundred feet of the deepest water wells. The close vertical proximity of natural gas development activities and the bottom of the drinking water aquifer means that injected fluids would not have to travel far to reach the aquifer, provided the fluids had a suitable pathway. Put another way, at Pavillion there is

less rock between the gas development activities and the aquifer. In contrast, deeper shale gas reservoirs, such as the Marcellus Shale in the northeast United States, are separated from overlying drinking water aquifers by thousands of feet of rock in areas under active development.

In addition, if the intervening interval contains layers of rock relatively impermeable to flow, such as other shale formations, then the chances of upward migration of injected fluids are reduced. In such cases, the only pathways for fluid migration from a deep shale gas reservoir would be along leaky old wells or poorly constructed production wells. Those types of wells would provide possible routes for fluids to migrate upward because the wells pierce the intervening rock layers and could connect the drinking water aquifer to the deeper, hydraulically fractured gas shale reservoir.

Vertical Wells Versus Horizontal Wells

Vertical wells were drilled in the Pavillion field to hydraulically fracture and produce natural gas. In tight sand reservoirs, such as the Pavillion field, often more wells are required to efficiently produce the gas from a given section of the reservoir than from conventional sand reservoirs.[90] In other words, one well in a tight gas reservoir will produce less gas over time than what would be expected from a well in a conventional sand reservoir. That means that the well spacing for tight gas sands could be much denser than for conventional sand gas fields. According to one source, well spacing in a conventional sand reservoir is generally 160 to 320 acres per well, but in a tight sand reservoir the well spacing can be as little as 10 acres per well.[91] The greater number of wells required to produce gas in tight sands also increases the number of potential vertical pathways from the fracture or production zone to the surface, or to a drinking water aquifer if some wells are improperly constructed or leak over time.

Well spacing for vertical wells in other unconventional gas reservoirs, such as the Marcellus Shale, would also be more dense as compared to conventional gas reservoirs. However, horizontal drilling is increasingly used to both hydraulically fracture and produce gas from shale gas reservoirs. According to one source, shale gas development could require only one horizontal well instead of four vertical wells to produce the same amount of gas.[92] Also, one drill pad is required for each vertical well drilled, while multiple horizontal wells could be drilled from the same drill pad. If four horizontal wells were drilled from a single drill pad, that would be the equivalent of drilling 16 vertical wells.[93] For shale gas fields where horizontal wells are chiefly used, the number of potential vertical pathways per land area that could transport leaked contaminants to overlying drinking water aquifers likely would be far fewer than for tight gas sand fields such as at Pavillion.[94]

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[90] Stephen A. Holditch, "Tight Gas Sands," *Journal of Petroleum Technology*, Distinguished Author Series, June 2006, http://www.spe.org/jpt/print/archives/2006/06/JPT2006_06_DA_series.pdf.

[91] Industry Technology Facilitator (ITF), *Understanding Hydraulic Fracturing and Tight Gas Sands*, July 4, 2011, http://www.oil-itf.com/index/news-app/story.104/title.understanding-hydraulic-fracturing-and-tight-gas-sands.

[92] J. Daniel Arthur, Brian Bohm, and Mark Layne, "Hydraulic Fracturing Considerations for Natural Gas Wells of the Marcellus Shale," presented at the Ground Water Protection Council 2008 Annual Forum, Cincinnati, OH, September 21-24, 2008, p. 8, http://www.dec.ny.gov/docs/materials_minerals_pdf/GWPCMarcellus.pdf.

[93] Arthur et al., 2008, p.8.

[94] Arthur et al., 2008, Table 1, shows a range of well spacings for different shale gas fields. The table indicates that well spacing varies from as few as 40 acres per well in the Marcellus and Haynesville formations to as many as 640 acres per well in the Woodford Formation.

The Hydraulic Fracturing Process

Although there would likely be some differences in the exact composition of hydraulic fracturing fluids used and the volumes of fluid injected, the overall hydraulic fracturing process used at the Pavillion field was probably generally similar to hydraulic fracture processes for other unconventional gas fields. Horizontal wells used for hydraulically fracturing shale gas fields, such as the Marcellus Shale, probably require a greater overall volume of fluid per well than is required for vertical wells drilled into tight gas sands, such as Pavillion. The requirement for greater volumes of water in shale gas fields would present different challenges regarding water supply and water disposal than for tight gas sand fields, such as Pavillion. In addition to greater volumes injected into the subsurface, greater volumes of fracture fluid would need to be stored at the surface during a hydraulic fracturing operation, which could also increase the likelihood of surface spills. Surface spills could infiltrate into shallow drinking water aquifers and pose a threat to nearby water wells.

Next Steps at Pavillion

In sum, the EPA Draft Report has raised many issues, questions, and concerns among potentially affected stakeholders, including the oil and natural gas industry, environmental organizations, and individual citizens. EPA's actions since the release of its Draft Report in December 2011 have entailed collecting additional samples from the deep monitoring wells to broaden the data for its analysis, and extending the public comment period and delaying the convening of the independent scientific peer review panel until the additional sampling and analysis are complete. Now that EPA has decided not to finalize its report, nor to subject it to independent scientific peer review, whatever additional actions may be taken at the Pavillion site would appear to depend on the outcome of the investigation of the state of Wyoming and what role EPA may play in a supporting capacity. (The following **Appendix** to this report reviews EPA's response authorities under CERCLA at the federal level.) Regardless of these outcomes, the potential applicability of either the findings of EPA or the state of Wyoming at the Pavillion site to other sites where hydraulic fracturing operations are conducted would depend heavily upon the extent to which the geology and hydrogeology are similar, as well as other site-specific factors.

Appendix. EPA Response Authority under CERCLA

The Pavillion site groundwater investigation outlined in the EPA Draft Report constitutes an early stage of the standard site-specific evaluation process under CERCLA. This process first focuses on characterizing a site to identify potential contamination and potential sources of contaminants to discern whether a release of hazardous substances may have occurred that may warrant further action under CERCLA. If EPA were to determine that cleanup of contamination is warranted to protect human health and the environment, certain exclusions, limitations, or exemptions could constrain the actions that EPA could pursue under CERCLA. In the case of a site like Pavillion, these constraints may include the exclusion of releases of natural gas from the reach of the statute,[95] the general limitation on the use of the authorities of the statute to respond to releases of hazardous substances that may be naturally occurring,[96] and the exemption from liability under the statute for response costs or damages resulting from federally permitted releases of hazardous substances (including permits issued by states with delegated federal authorities, and certain permits issued by states under their own authorities that govern underground injection involved in oil or natural gas production).[97]

Although the initial site-specific evaluation process under CERCLA may be funded and performed under EPA's Superfund program, it does not constitute the placement of a site on the National Priorities List (NPL). Rather, such an evaluation is the initial—and in most cases the only—stage of the site-specific process under CERCLA.[98] Most potentially contaminated sites initially brought to EPA's attention are deferred to the states for further action. EPA's investigation of the Pavillion site formally constituted the Preliminary Assessment/Site Inspection step of the site-specific evaluation process under CERCLA. EPA broadened the Site Inspection phase at the Pavillion site to an "Expanded Site Inspection" to collect additional samples and more fully characterize the contaminants that may be present in the groundwater and the potential sources.[99]

The primary purpose of this step of the process is to identify whether a release of hazardous substances may warrant emergency response actions to address immediate risks,[100] and whether the site may warrant listing on the NPL to take more extensive response actions.[101] Relatively few potentially contaminated sites reported to EPA result in an NPL designation. Approximately 50,000 potentially contaminated sites have been reported to EPA over time since the enactment of

[95] 42 U.S.C. §9601(14) and 42 U.S.C. §9601(33). For the purposes of CERCLA, natural gas is excluded from the statutory definition of a hazardous substance, and pollutant or contaminant, respectively.

[96] 42 U.S.C. §9604(a). EPA generally is prohibited from responding to a release of a hazardous substance that is naturally occurring, unless EPA determines that the release constitutes a public health or environmental emergency, and that no other person with the authority and capability to respond to the emergency will do so in a timely manner.

[97] 42 U.S.C. §9607(j) and 42 U.S.C. §9601(10). Entities conducting site operations performed under certain applicable federal permits (including permits issued by states with delegated federal authorities), or permits issued under state authorities specifically for underground injection involved in oil or natural gas production, are excluded from liability under CERCLA for response costs or damages resulting from a release allowed within the confines of such permits, unless the release were to violate permit requirements and therefore not be a permitted release in that sense.

[98] Information on the stages of the site-specific process under CERCLA is available on EPA's Superfund program website: http://www.epa.gov/superfund/cleanup/index.htm.

[99] According to EPA's Superfund Site Information Database, the most recent response action taken for the "Pavillion Area Ground Water Study" site was an Expanded Site Inspection, which was used as the basis for the December 2011 EPA Draft Report. See: http://cumulis.epa.gov/supercpad/cursites/cactinfo.cfm?id=0802735.

[100] 40 C.F.R. 300.410.

[101] 40 C.F.R. 300.420.

CERCLA in 1980. Of this total site universe, more than 21,000 sites have been the subject of Site Inspections similar to that conducted at Pavillion, of which 1,685 have been listed on the NPL to date, including sites that have since been deleted once the cleanup objectives were met.[102]

Whether EPA may pursue further action at a site under investigation depends on the findings. In its Draft Report for the Pavillion site, EPA did not reach a conclusion definitively linking contaminants found in the groundwater to a specific release that may present a risk to human health or the environment. Accordingly, the agency did not determine that cleanup actions were warranted, nor did the agency identify any potentially responsible parties as being liable for any response actions under Section 107 of CERCLA.[103] At any site, a source of contamination first would have to be confirmed and the potential risks further examined, before any determinations could be made as to whether cleanup may be warranted and whether any potentially responsible parties are identified who may be liable for the cleanup.

If EPA were to find that a release or threatened release of a hazardous substance may present a threat to human health or the environment, EPA would evaluate the potential hazards according to the criteria established under Section 105(a)(8)(A) of CERCLA to determine whether the site may be eligible for listing on the NPL.[104] These criteria and how to apply them are outlined in federal regulation under the Hazard Ranking System (HRS).[105] This system is based on a scale of 1 to 100 to rank the degree or severity of the potential hazards. Sites scoring 28.5 and higher generally are eligible for listing on the NPL. Whether EPA may list an eligible site on the NPL to elevate its priority for cleanup at the federal level would depend on numerous other criteria, including the criteria under Section 105(h) of CERCLA for deferring a site to the state in which the site is located instead of listing it on the NPL, if the state requests such deferment.[106]

If a site is not listed on the NPL but still is not deferred to the state, EPA may take certain actions at the federal level to address potential health and environmental risks, including the performance of emergency "removal" actions if warranted. Under CERCLA, removal actions generally are measures intended to address more immediate risks of exposure,[107] whereas "remedial" actions generally are measures intended to provide a more permanent solution to address long-term risks.[108] Although a site must be listed on the NPL to be eligible for Superfund appropriations to perform remedial actions,[109] removal actions are eligible for such federal funds regardless of a site's listing status. The initial stage of evaluating a site also may be funded with Superfund appropriations prior to any listing decision, to determine whether further response actions may be

[102] Site numbers are based on search results generated from EPA's Superfund Site Information Database on July 5, 2013, available at http://cumulis.epa.gov/supercpad/cursites/srchsites.cfm. The total site universe of approximately 50,000 sites includes archived sites at which no further federal action is planned. The total of 1,685 sites listed on the NPL includes 365 sites that EPA later deleted with state concurrence once the cleanup objectives were met.

[103] 42 U.S.C. §9607. Categories of potentially responsible parties who are financially liable for the costs of response actions taken under CERCLA include past and current owners and operators of facilities, generators of waste sent to facilities for disposal, and transporters of waste who selected the facility for disposal. Liability under CERCLA also extends to natural resource damages and the costs of federal public health studies.

[104] 42 U.S.C. §9605(a)(8)(A).

[105] 40 C.F.R. Part 300, Appendix A. Additional information on the Hazard Ranking System is available on EPA's Superfund program website: http://www.epa.gov/superfund/programs/npl_hrs/hrsint.htm.

[106] 42 U.S.C. §9605(h).

[107] 42 U.S.C. §9601(23).

[108] 42 U.S.C. §9601(24).

[109] 40 C.F.R. §300.425(b).

warranted. The use of Superfund appropriations at the Pavillion site was limited to the performance of the Preliminary Assessment/Site Inspection of potential groundwater contamination, upon which the EPA Draft Report was based.

EPA also may pursue mechanisms to enforce cleanup liability under CERCLA if the source of contamination is confirmed, the release that caused the contamination falls under the authorities of the statute, and the potentially responsible parties who can be held liable under the statute can be identified and are financially viable. These mechanisms include cleanup orders under Section 106[110] and cleanup agreements under Section 122,[111] neither of which hinges upon whether a site is listed on the NPL. However, Section 128(b) of the statute generally limits EPA's enforcement authority under CERCLA to issue a cleanup order under Section 106, if a state is already pursuing the cleanup of a site under its own authorities.[112]

EPA did not use any of these enforcement authorities of CERCLA at the Pavillion site. Rather, the EPA Draft Report identified constituents in certain portions of the aquifer that the agency characterized as being consistent with, or similar to, some substances used in the natural gas production operations. EPA did not definitively identify the source of the constituents, any potentially responsible parties, or any potential risks that may warrant cleanup.

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[110] 42 U.S.C. §9606.

[111] 42 U.S.C. §9622.

[112] 42 U.S.C. §9628(b).