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A Typical Groundwater Study for Proposed Hydraulic Fracturing

Background

Concerns have been raised about the possible impact to groundwater resources resulting from hydraulic fracturing (HF) or fracking. In general, the oil and gas industry has taken the position that the process of HF does not lead to groundwater contamination. Whereas, environmental and citizen groups have taken the position that impacts have already occurred and will continue to occur (e.g. the documentary "Gasland"). However, the data to support either position is limited. Thus, the position of the regulatory and scientific communities is that additional data and analysis is needed.

The Energy Bill of 2004 gave the oil and gas industry exemptions from certain environmental laws (e.g. Clean Water Act and Resource Conservation and Recovery Act [RCRA]). Therefore, at present (2013), there is no Federal requirement to evaluate groundwater conditions as part of a proposed HF program.

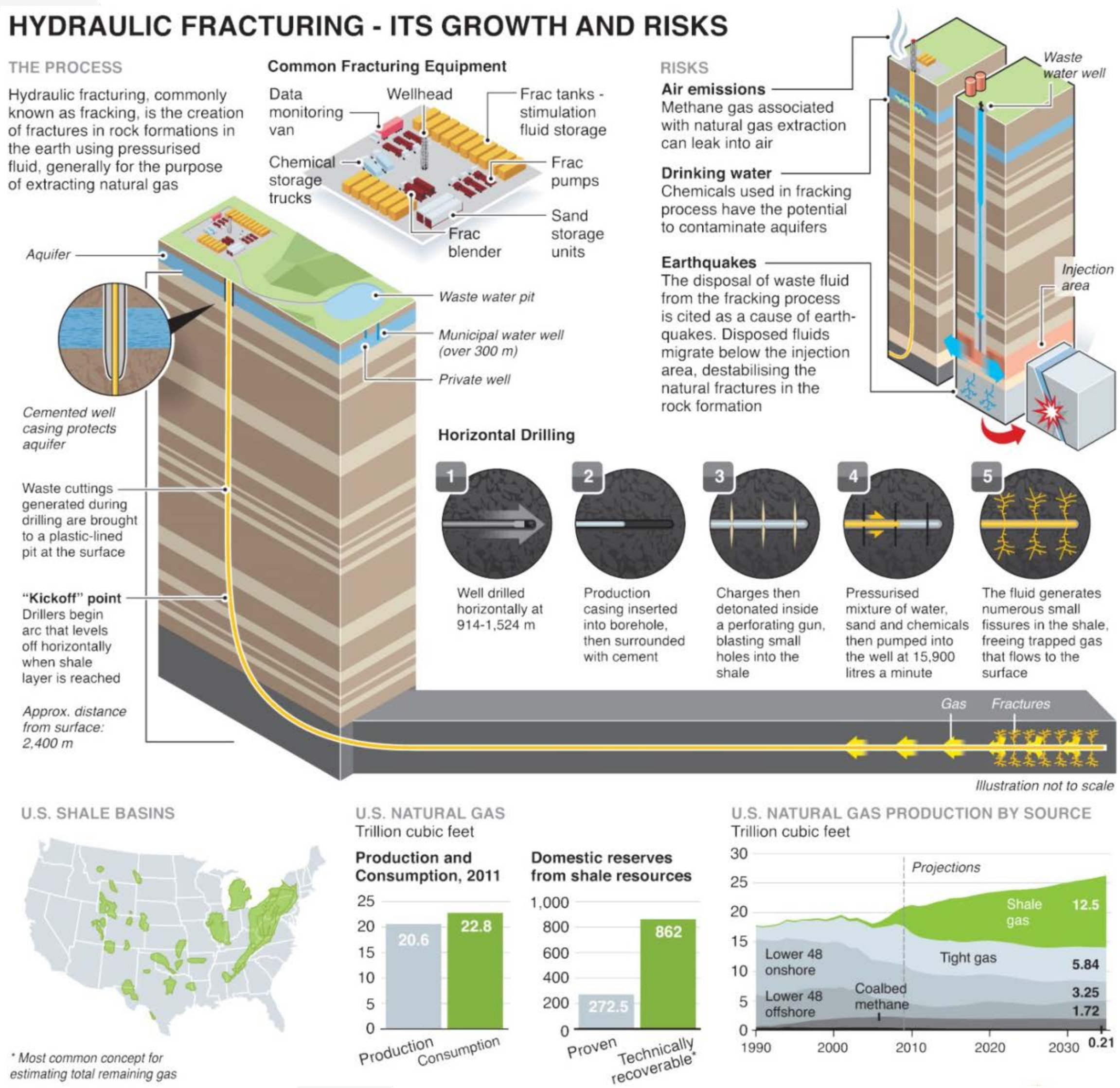
With respect to the link between HF and water quality impacts, industry (and some States) has taken the position that impacted parties should "prove that HF caused the observed impact". However, the cost of demonstrating that HF is the likely source of observed decontamination is high, as is the cost of long-term groundwater monitoring. These costs are far more than what an individual land-owner or famer can afford. Environmental and citizen groups, and some States, have advocated the "precautionary principal". That is, the HF proponent needs to demonstrate that the process will not cause harm before the HF program can proceed.

The United States Environmental Protection Agency (USEPA), United States Department of Energy (USDOE), industry and other parties are currently performing investigations at certain pilot sites to evaluate the potential impact to groundwater resources associated with HF. However, definitive results from these studies may not be available for several years. In addition, hydrogeologic conditions vary considerably across the country (and even across a single oil field); therefore, the applicability of results from studies conducted in Wyoming (for example) to conditions encountered in New York or California may be limited.

Despite the ongoing concerns, many States are proceeding with HF without any requirement for groundwater monitoring; whereas, in some areas, concerns over environmental issues have resulted in moratoriums on HF (e.g. in the drinking water catchment for New York City).

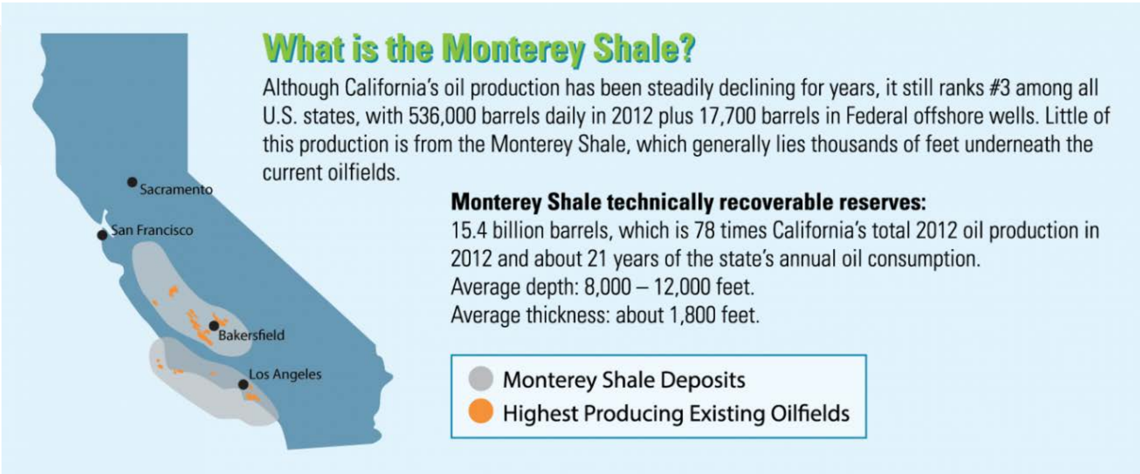
Additionally, in some States, pending legislation will require groundwater studies for proposed HF activities; however, the scope of these studies is not prescribed.

Figure 1: Hydraulic Fracturing: How It Works



Source: http://blog.thomsonreuters.com/index.php/hydraulic-fracturing-fracking-graphic-of-the-day/

Figure 2: Shale Oil in California



Source: http://thenextgeneration.org/blog/post/monterey-shale-series-climate-conundrum/

California SB 4 (Pavley Fracking Bill)

On September 20, 2013, California Senate Bill (SB) 4 (also known as the Pavley Fracking Bill) was signed into law by Governor Brown on September 20, 2013. Senator Pavley initially drafted SB 4 to "*Address the growing national concern about the impacts of hydraulic fracturing (otherwise known as "fracking") on communities and the environmen*t." Further, as presented by Senator Pavley, "*SB 4 directs the California Division of Oil Gas and Geothermal Resources (DOGGR) to enact comprehensive hydraulic fracturing regulations, in consultation with additional regulators, which include advanced public notice of planned fracking activities and fracking fluid chemical disclosure"* (http://sd27.senate.ca.gov/legislation/2013-legislation).

Thus, SB 4 (Pavley) provides a comprehensive statutory framework for HF in California, and will, amongst other things:

- Require an independent scientific study of well stimulation;
- Require full disclosure of the composition and disposition of hydraulic fracturing and well stimulation fluids to DOGGR;
- Require that well operators obtain a permit for well stimulation. The well stimulation permit application will include estimates of the amount of water and the composition of the stimulation fluids planned to be used, a disposal plan, and a **groundwater monitoring plan**;
- Provide for **regional groundwater monitoring** in the vicinity of oil and gas fields in areas where no existing regional groundwater monitoring plan is currently in place; and
- Require at least 30 days advance notice to the public, neighbors (including tenants) and the Regional Water Quality Control Board (RWQCB) of the intent to apply HF or stimulate a well. As part of this requirement, SB 4 will allow the neighbors in the vicinity of the HF application to have baseline and follow-up water quality testing performed on water wells and surface

water by applicant. In this paper, we present an approach and an outline of a potential scope for a groundwater study at an oil or gas well where HF is proposed.

Possible Groundwater Contamination

The process of HF at an oil or gas well can lead to potential groundwater contamination in the following three ways:

1. The general oil field operations that result in spills and leaks (see Oil Field Contaminants at http://www.aquilogic.com/COCs.php).
2. The migration of HF fluids in the subsurface to overlying groundwater resources (e.g. diesel, diluent, proprietary mixtures).
3. The resultant migration of oil reservoir chemicals to overlying groundwater resources (e.g. methane and naturally occurring radioactive materials [NORMs]).

The following contaminants of concern (COCs) may be present in an oil field (see Oil Field Contaminants at http://www.aquilogic.com/COCs.php):

- Methane gas (CH_4), hydrogen sulfide (H_2S), and increased carbon dioxide (CO_2);
- Total petroleum hydrocarbons (TPH; aliphatic, aromatic, and poly-aromatic);
- Specific aromatic hydrocarbons, such as benzene, toluene, ethylbenzene, and total xylenes (BTEX);
- Poly-aromatic hydrocarbons (PAHs), such as naphthalene and benzo(a)pyrene;
- Oil field brines;
- Diluents used to thin highly viscous oil (e.g. kerosene);
- Trace metals;
- Barium-based drilling fluids;
- NORMs;
- Arsenic-based biocides;
- Oil-process chemicals (e.g. sulfolane); and,
- Small-batch chemicals used at an oil field (e.g. solvents).

Approach

Due to borehole drilling, well construction, and well completion methods, casing leaks and failures in the shallow geology (less than 1000 feet below ground surface [bgs]) at an oil well are rare. Therefore, it is less likely that the actual oil well used for HF will result in impact to water resources. It is more likely that impacts will be associated with the following:

- Preferential vertical geologic pathways exist (e.g. faults and major fracture zones) that facilitate the vertical movement of contaminants to overlying water resources; and,
- Other activities associated with HF, such as ponds used to temporarily store HF fluids.

Monitoring of groundwater in the immediate vicinity of the HF well and around associated ponds is often warranted. However, rather than restrict groundwater studies to the immediate vicinity of each oil well where HF is proposed, it is recommended that the studies focus on the entire oil fields, or larger portions of an oil field. Broadening the studies would increase study costs. However, these studies would encompass multiple oil wells where HF is planned; thus, reducing overall investigation costs per well.

Objectives

The objectives of the proposed groundwater studies should be as follows:

- Establish baseline conditions prior to HF;
- Characterize hydrogeology above planned hydraulic fracturing activities;
- Identify pathways for vertical migration of contaminants; and
- Install a long-term groundwater quality monitoring system.

Typical Work Scope

A possible work scope for a typical groundwater study is described below:

1. Develop a work plan, quality assurance plan (QAP), sampling and analysis plan (SAP), and health and safety plan (HASP).
2. Engage with stakeholders (e.g. DOGGR, RWQCB, and local agencies).
3. Review existing data, such as oilfield geophysics, oil well logs, water well logs, geologic reports, water supply reports, and geochemical data.
4. Develop a preliminary site conceptual groundwater model based on existing data.
5. Perform surface geophysics to map faults and other geologic features that extend into groundwater, if existing studies are insufficient.
6. Perform CH_4/CO_2 surveys, both for near-ground air and subsurface soil gas.
7. Perform baseline surface water sampling and ecological surveys, where appropriate.
8. Perform baseline groundwater sampling at existing water supply wells and monitoring wells.
9. Perform baseline on-site groundwater sampling at selected HF well locations and in area of preferential vertical pathways. This could include, but may not be limited to, the following:
    a. Direct push (e.g. cone penetrometer testing [CPT]) and discrete-depth (e.g. hydropunch) sampling for shallow unconsolidated deposits;
    b. Deeper borings (e.g. Sonic and mud-rotary drilling) and hydropunch sampling to the base of freshwater;

c. Borehole geophysics at all borings;
d. Collection and analysis of soil samples for basic soil geotechnical properties (e.g. porosity and permeability); and
e. Collection and analysis of initial groundwater samples for CH_4, CO_2, TPH, BTEX, and selected samples for stable carbon isotopes, tritium isotopes, and general minerals (cations, anions, general water quality parameters).

10. To allow for ongoing monitoring of groundwater, install monitoring wells in the vicinity of HF operations (shallowest groundwater), selected HF wells (to within drinking water aquifers), and in area of preferential pathways (to the basal depth of potable water).
11. Evaluate hydrogeologic conditions and potential contaminant fate and transport.
12. Where deemed necessary, develop groundwater flow and solute transport models to evaluate fate and transport of any detected COCs.
13. Prepare a groundwater study report.
14. Perform periodic (annual) sampling of monitoring wells with analysis for CH_4, CO_2, TPH, BTEX (and carbon isotopes for selected samples); and
15. Prepare annual groundwater quality reports.

Further Information

Further information about HF can be found at http://www.fractfinder.com/

Those interested can also subscribe to FractFinder eNews, a weekly newsletter summarizing news articles about HF and associated environmental/water quality impacts and regulatory issues, at http://www.fractfinder.com/subscribe.html

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