PSE Healthy Energy
SCIENCE SUMMARY
MAR 2014

Surface and groundwater contamination associated with modern natural gas development

Peer-Reviewed Literature, 2011-2013

Documentation of water contamination associated with modern natural gas development is a complex issue. The list of studies reported here should be seen as conservative and limited reporting of water contamination, as it only contains evidence from peer-reviewed scientific studies and does not include incidences that exist in inspection records.

Differences in local geologies and hydrologic characteristics, land-use histories, industry practices, and monitored water contaminants can complicate comparisons across studies. Baseline conditions for water quality are often unknown or may have been affected by other activities. **Nonetheless, empirical evidence of surface and groundwater contamination as a result of modern natural gas operations is documented.**

Pennsylvania (*Marcellus*). Several studies indicate degradation of ground and surface waters in dense drilling areas of Pennsylvania. Studies [1,2] found significantly **higher concentrations of thermogenic methane** in private water wells within 1 km of one or more natural gas wells (6 and 17 times on average, respectively; Fig 1).

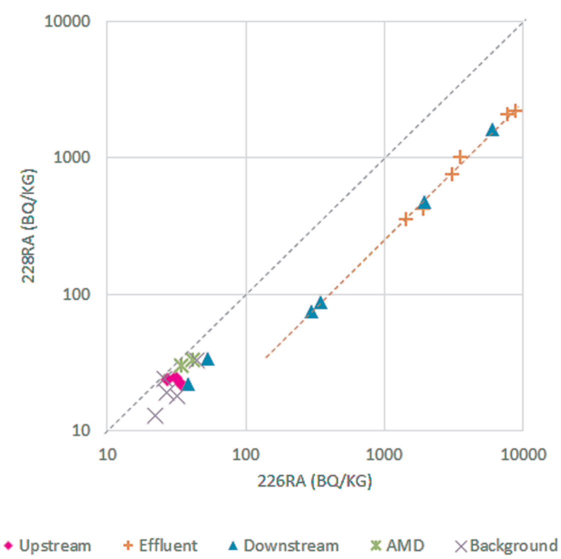

Figure 2. Activities of 228Ra/ 226Ra in river sediments collected upstream, adjacent, and downstream of a Marcellus shale wastewater discharge site. Despite waste treatment, downstream water quality still reflects the chemical signatures of fluids produced in natural gas extraction, as downstream ratios closely match those of Marcellus brines (orange dashed line; 0.25; Source: Warner et al. 2013).

An examination of water chemistry and isotopic signatures[3] of effluents from a brine treatment facility, stream sediments near the discharge site, and surface waters downstream and upstream of the discharge site showed **elevated levels of chloride and bromide** in downstream waters consistent (combined with isotopic data) with produced-waters from Marcellus shale wells. Radium-228/Radium-226 ratios in downstream waters and near source sediments also closely matched ratios measured in Marcellus wastewaters (Fig 2) **Radium-226 concentrations** in near-source sediments (544−8759 Bq/kg) were found to be approximately 200 times greater than upstream and background sediments and in excess of U.S. radioactive waste disposal threshold regulations.

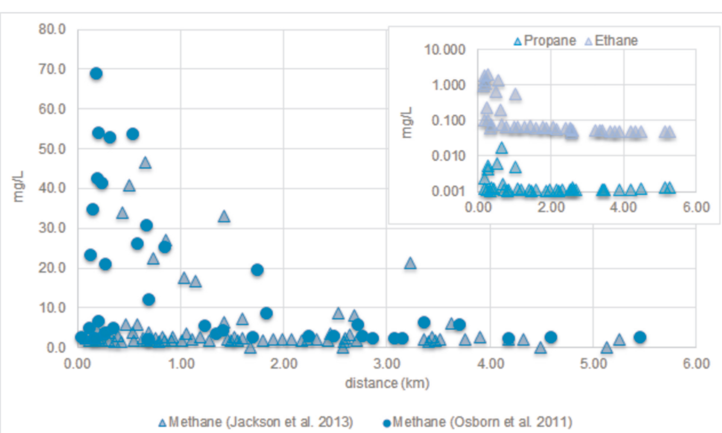

Figure 1. Hydrocarbon concentrations (mg/L) in groundwater by distance to unconventional gas wells. Private water wells within 1 km of an shale gas well show higher levels of natural gas constituents (methane, ethane, and propane). Isotopic analysis indicates that the hydrocarbons are thermogenic in nature (Source: Osborn et al. 2011; Jackson et al. 2013).

Texas (*Barnett*). A study of groundwater quality in the Barnett shale, TX[4] revealed significantly **higher levels of heavy metals** (strontium, selenium, arsenic) in private water wells located within 2 km of active gas wells relative to private wells located further from drilling activity (Fig 3). This study was unique in that it used historical data from the region to create a baseline measure of groundwater quality before the expansion of natural gas operations. Arsenic, strontium, and selenium concentrations were also found to be significantly higher in active drilling areas relative to this historical baseline. Shallower water wells near drilling activity showed the highest levels of contamination. These findings suggests that mechanical disturbance (i.e. subsurface vibrations) of water wells, surface spills and/or faulty well casings/cement as possible causes of contamination.

Kentucky (*Appalachian*). A release of hydraulic fracturing fluids to a Knox County stream resulted in fish stress and mortality. Water chemistry analysis[5] of the impacted stream revealed **elevated conductivity, lowered pH and alkalinity, and toxic levels of metals**. Sampling of fish exposed to the contaminated water exhibited a high incidence of gill lesions consistent with impacts observed in fish exposed to low pH, dissolved heavy metals, or both. Among the species affected was the federally protected Blackside Dace.

Colorado (*Denver-Julesburg and Piceance*). An analysis of reported surface spills (Colorado Oil and Gas Conservation Commission, COGCC) within Weld County (Denver-Julesburg) and groundwater monitoring data associated with each spill[6] revealed BTEX (benzene, toulene, ethylbenzene, xylene) contamination of groundwaters. During a one-year period the authors noted 77 reported surface spills impacting groundwater; 62 of these records included BTEX analytical sampling during remediation. A large percent of samples show **BTEX concentrations in excess of federal standards** (Fig 4). Another study of surface and groundwater samples from drilling-dense areas in the Piceance basin[7] showed **higher estrogenic, anti-estrogenic, or anti-androgenic activities** near oil and gas activity relative to reference sites with little or no natural gas development.

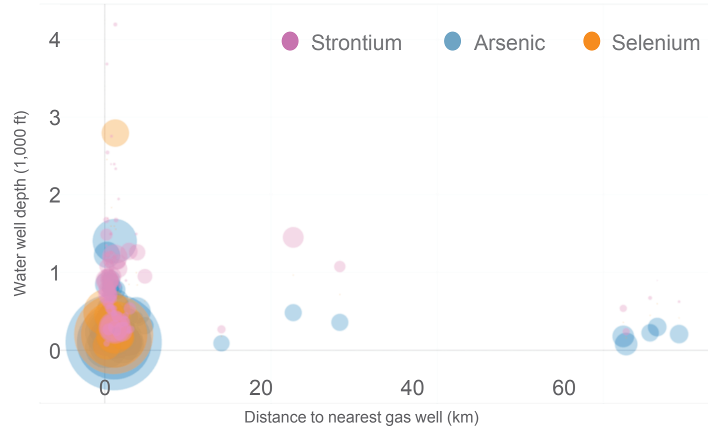

Figure 3. Arsenic (μg/L), strontium (mg/L) and selenium (μg/L) concentrations in groundwater versus distance to nearest active natural gas well and depth of water well. Circle size reflects levels of concentrations with larger circles denoting higher levels of contaminants. Risk of contamination to private water wells appears to increase with proximity to unconventional natural gas wells. Shallower water wells are particularly at risk, suggesting surface spills, mechanical disturbance of water wells, and/or faulty well casings as possible routes to contamination. (Source: Fontenot et al. 2013)

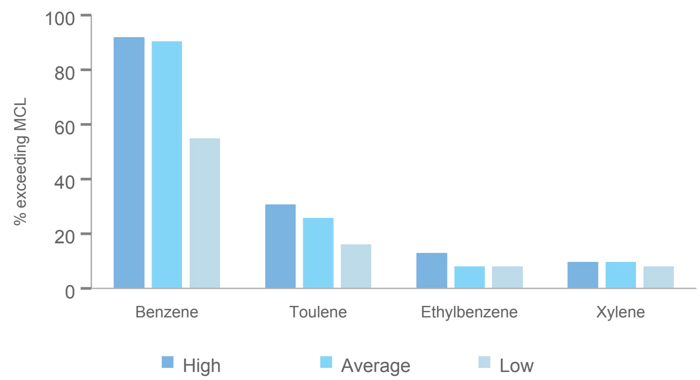

Figure 4. Percent of groundwater samples exceeding federal maximum contaminant levels (MCL) for BTEX species. Samples were taken at different stages of remediation following reported surface spills related to natural gas development. While many of the spills were effectively mitigated, >50% of samples still exceeded benzene MCLs after remediation; 16% of samples exceeded toulene MCLs post-remediation, and 8% of samples exceeded MCLs for both ethylbenzene and xylene. (Source: Gross et al. 2013)

References

1. Osborn, SG et al. (2011). Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing. *PNAS*. 108(20), 8172-8176.

2. Jackson, RB et al. (2013). Increased stray gas abundance in a subset of drinking water wells near Marcellus shale gas extraction. *PNAS*. 110 (28), 11250-11255.

3. Warner, NR et al. (2013). Impacts of shale gas wastewater disposal on water quality in western Pennsylvania. *Environ. Sci. Technol*. 47(20), 11849-11857.

4. Fontenot, BE et al. (2013). An evaluation of water quality in private drinking water wells near natural gas extraction sites in the Barnett Shale Formation. *Environ. Sci. Technol*. 47(17), 10032-10040.

5. Papoulias and Velasco. (2013). Histopathological analysis of fish from Acorn Fork Creek, Kentucky, exposed to hydraulic fracturing fluid releases. *Southeastern Naturalist*. 12(4), 92–111.

6. Gross, SA et al. (2013). Analysis of BTEX groundwater concentrations from surface spills associated with hydraulic fracturing operations. *J Air Waste Manag Assoc*. 63(4), 424–432.

7. Kassotis, CD et al. (2013). Estrogen and androgen receptor activities of hydraulic fracturing chemicals and surface and ground water in a drilling-dense region. *Endocrinology*. 155(3).