Ms Margaret Liveris, Committee Clerk, Standing Committee on Environment and Public Affairs, Legislative Council, Parliament House, GPO Box A11 Perth WA 6837, fax: 9222 7508 or email: lcepac@parliament.wa.gov.au

Please find herein my submission addressing the issues raised in your inquiry into hydraulic fracturing (fracking). The guideline for submission seems built on the premise that fracking will be a reality, which would be a negligent decision, considering all the evidence. Therefore, my submission is exploring all the evidence, written by experts in the field who have no 'conflict of interest' apart from presenting the truth. This is an important point, in realizing the true impacts, as industry supplied data will never be adequate or transparent as an obvious conflict of interest exists.

My findings illustrate how hydraulic fracturing negatively impacts current and future uses of land, and how the land is unrecoverable after the fracking process, because of the well case failings, which exposes the land/ air and ground water to the cocktail of harmful chemicals used and the radioactive particles brought to the surface. I will also talk about what the failure to regulate the industry in the use and disclosure of chemicals has meant for the effected communities so far, in other places of the world. My submission will address the use of unsustainable amounts of ground water, and how our present technology will not clean the ground water to a standard fit for any future safe use or recycling. Considering the fracking process destroys all natural habitat, and effects animals, livestock, and ofcourse humans- living even kilometres away, as well as poisoning ground water- potentially harming our aquifers, there can be no reclamation of land that has been hydraulically fractured. All of these points are addressed along with other relevant issues pertaining both directly and indirectly to your inquiry.

You will find many quotes from industry experts to support my submission. Please use the links below each quote to see articles in more detail, and to view references. In my effort to be as informative as possible, there is a lot of information contained herein, and ask for your indulgence in reading all material.

Well Case Failings

The most important issue regarding hydraulic fracturing is well case failings. The incidents of well case failure and its impact on land, and health are directly linked to each and every issue I will present apart from seismic activity. Cement will not last forever, and the seal, regardless of how many layers upon layers will be compromised, either straight away, or in years to come. The absolute certainty of well case failure whether now or in the future, underpins my main argument in the unsustainability of the fracking practice, and leads to all the other issues surrounding land use, land, air and water contamination, health and fugitive emissions.

These are some comments Dr Ingraffea made the New York State Dept of Enviromental Conservation in response to the future of shale gas development in New York. His letter is extensive and has been shorted for ease of read but can be viewed in its entirety through the link below. His points are especially relevant as our shale formation will require horizontal fracking to extract gas economically.

'The claim that Shale Seam Gas is safe confuses different integrity issues, and are based on absence of, or inapplicable, evidence, rather than a true analysis of the available scientific literature.

Groundwater impacts associated with well drilling and construction would include such phenomena as contamination of groundwater with drilling fluids during the drilling process, and migration of hydrocarbon gases and liquids due to faulty casing and/or faulty or absent cement during and after the construction process. These mechanisms can be exacerbated with repeated pressurization of the casing, with open-hole sections along the casing, and with high gas pressures entering such open-hole sections. Note that effectively open-hole situations can occur in "cemented" non-vertical wells, since it is well known that cement effectiveness is substantially reduced in such wells. All of these exacerbating factors lead to more rapid occurrence and upward growth of circumferential fractures, essentially disbonding, in the rock-cement and /or the cement-casing interface.

A schematic depiction of the phenomenon of gas, or additional fluid, migration upwards along a wellbore is presented in Figure 1 for the simplest case of bypass by disbonding of surface casing.

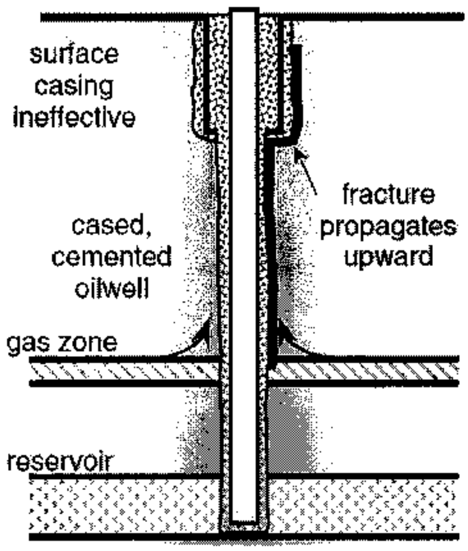
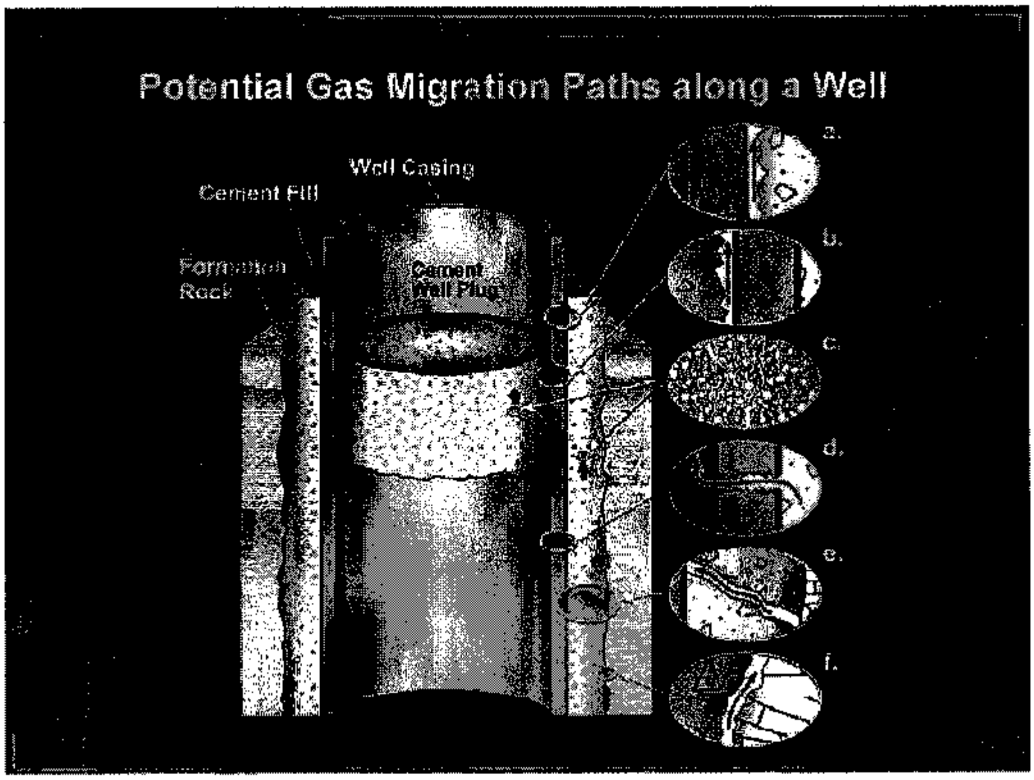


Figure 1. Simplified schematic showing phenomenon of upward gas migration along a casing string. From Dusseault *et al.*, 2000.

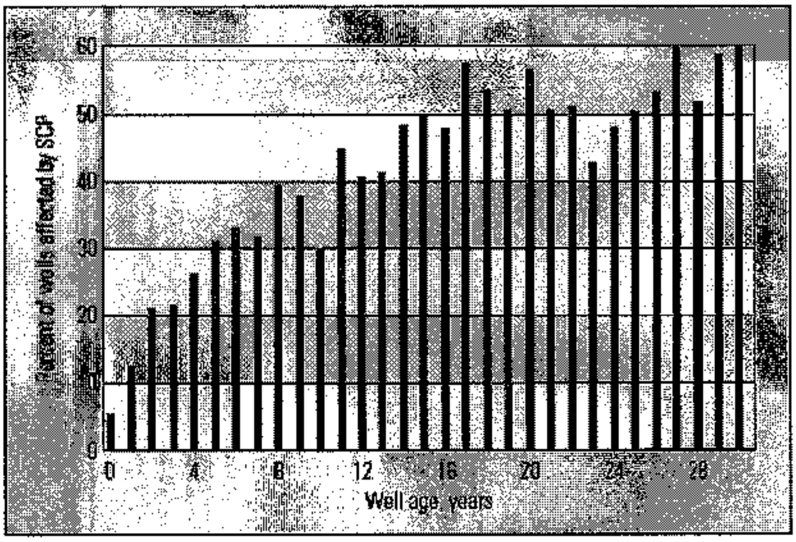
Figure 2 is a close-up schematic showing other possible fluid pathways. **Additional layers of casing and attendant cement interfaces, do not eliminate these phenomenon; they may, in fact, increase its likelihood.**



Source: Alberta Energy Utilities Board

Figure 2. Schematic of details of possible fluid migration paths.

These phenomena are not rare in the oil and gas industry. Data on failure rates for cement jobs leading to sustained casing pressure and possible fluid migration into USDW can be found, for example, in Figure 3 who evaluated over 15,500 wells. The authors state: "...many of today's wells are at risk. Failure to isolate sources of hydrocarbon either early in the well-construction process or long after production begins has resulted in abnormally pressurized casing strings and leaks of gas into zones that would otherwise not be gas bearing".



^ Wells with SCP by age. Statistics from the United States Mineral Management Service (MMS) show the percentage of wells with SCP for wells in the outer continental shelf (OCS) area of the Gulf of Mexico, grouped by age of the wells. These data do not include wells in state waters or land locations.

Figure 3. Data on frequency of occurrence of sustained casing pressure (SCP). From Brufatto *et al.* (2003).

In their statistical analysis of information about nearly 315,000 oil and gas wells, Watson and Bachu (2009) state: "The majority of leakage occurrence is because of time-independent mechanical factors controlled during wellbore drilling, construction, or abandonment— mainly cementing. Several of these factors may be inferred from readily available information such as spud date relating to regulation, oil price and technology." Together, this extensive, industry-produced data show that the expected rate of failure of containment of migration by cement is on the order of 5% (1 well in 20) initially. **They also show that failure rate increases, as expected with age of a well.**

Figure 4. Data on frequency of occurrence of sustained casing vent flow (SCVF) and groundwater migration. From Watson et al. (2009). A statistical analysis of documented incidents of hydrocarbon migration into USDW in the Marcellus play in Pennsylvania, and develop its own prediction of immediate and long-term rate of cement failures for shale gas development in New York. For example, my review of the Pennsylvania DEP database on violations (http://www.dep.state.pa.us/dep/deputate/minres/oilgas/OGInspectionsViolations/OGInspviol.ht m) shows that, **during the first 8 months of 2011, 65 Marcellus wells were cited for faulty casing and cementing practices**. During this same period, about 1300 Marcellus wells were drilled, yielding a normalized citation rate of about 5%. Sixty-four such citations were issued in 2010, when a total of 1386 Marcellus wells were drilled, yielding a similar citation rate. Granted, citations for such violations are not proof of migration and contamination of USDW; however, they are an indication that, despite ultra-modern cementing technologies operating in a supposed exacting regulatory environment, cementing failures are still occurring at rates similar to those cited. **I do not think it is possible to perform a rational cost-benefit analysis of shale gas development in New York without a science-based, probabilistic**

estimate of the number of expected well contamination incidents due to faulty well construction and inevitable break-downs in cement.

Current practice in some shale gas developments involve 16 or more closely spaced (on the order of only 10 feet) verticals, and 8 or more sub-parallel laterals; pad spacing can be less that length of laterals. It is well-known that communication among laterals on the same pad, and also among laterals on adjacent pads can occur. This means that total injection time during which migration through a faulty casing or cement job must include all fracing stages not on a single well, but on all wells on a pad, and, with horizontal communication known to be possible, also on all wells within communication distance.

Additional Well Casing to Prevent Gas Migration: In most cases, an additional third, cemented well casing is required around each well to prevent the migration of gas. The three required casings are the surface casing, the new intermediate casing and the production casing. The depths of both surface and intermediate casings will be determined by site-specific conditions. **Neither additional well casing, nor any other technology or practice currently known, can "prevent" gas migration**. Even an initially perfect cement job in all annuli can, over time, fail in one of the manners previously described herein. Some technologies, like certain additives to the cement, can decrease the rate of occurrence and/or the intensity of leakage, but the word "prevent" implies "no possibility", and that is "impossible". '

Dr Ingraffea

http://www.psehealthyenergy.org/data/SGEIS_Scientific_Failings_Ingraffea_Jan_20121.pdf

'The two simplest explanations for the higher dissolved gas concentrations that we observed in drinking water are (i) faulty or inadequate steel casings, which are designed to keep the gas and any water inside the well from leaking into the environment, and (ii) imperfections in the cement sealing of the annulus or gaps between casings and rock that keep fluids from moving up the outside of the well. In 2010, the Pennsylvania Department of Environmental Protection (DEP) issued 90 violations for faulty casing and cementing on 64 Marcellus shale gas wells; 119 similar violations were issued in 2011. Distinguishing between the two mechanisms is important because of the different contamination to be expected through time.

Casing leaks can arise from poor thread connections, corrosion, thermal stress cracking, and other causes. If the protective casing breaks or leaks, then stray gases could be the first sign of contamination, with less mobile salts and metals from formation waters or chemicals from fracturing fluids potentially coming later.

In contrast, faulty cement can allow methane and other gases from intermediate layers to flow into, up, and out of the annulus into shallow drinking water layers. In such a scenario, the geochemical and isotopic compositions of stray gas contamination would not necessarily match the target shale gas, and no fracturing chemicals or deep formation waters would be expected, because a direct connection to the deepest layers does not exist; also, such waters are unlikely to migrate upward. Comprehensive analyses of well integrity have shown that sustained casing pressure from annular gas flow is common. A comprehensive analysis of ~15,500 oil and gas wells showed that 12% of all wells drilled in the outer continental shelf area of the Gulf of Mexico had sustained casing pressure within 1 y of drilling, and 50–60% of the wells had it from 15y onward. For our dataset, there is a weak trend to higher methane concentrations with increasing age of the gas wells (P =0.067 for [CH] vs. time since initial drilling). **This result could mean that the number of drinking water problems may grow with time or that drilling practices are improving with time; more research is needed before firm conclusions can be drawn**. In addition to well integrity associated with casings or cementing, two other potential mechanisms for contamination by hydraulic fracturing/horizontal drilling include enhancing deep-to- shallow hydraulic connections and intersecting abandoned oil and gas wells. Horizontal drilling and hydraulic fracturing can stimulate fractures or mineralized veins, increasing secondary hydraulic connectivity. The upward transport of gases is theoretically possible, including pressure-driven flow through open, dry fractures and pressure-driven buoyancy of gas bubbles in aquifers and water-filled fractures. Reduced pressures after the fracturing activities could also lead to methane exsolving rapidly from solution. If methane were to reach an open fracture pathway, however, the gas should redissolve into capillary-bound water and/ or formation water, especially at the lithostatic and hydrostatic pressures present at Marcellus depths.

Legacy or abandoned oil and gas wells (and even abandoned water wells) are another potential path for rapid fluid transport. In 2000, the Pennsylvania DEP estimated that it had records for only 141,000 of 325,000 oil and gas wells drilled historically in the state, leaving the status and location of ~184,000 abandoned wells unknown. However, historical drilling activity is minimal in our study area of north- eastern Pennsylvania, making this mechanism unlikely there.'

'This study examined natural gas composition of drinking water using concentration and isotope data for methane, ethane, pro- pane, and 4He. Based on the spatial distribution of the hydro- carbons, isotopic signatures for the gases , wetness of the gases, and observed differences in 4He:CH4 ratios, we propose that a subset of homeowners has drinking water contaminated by drilling operations, likely through poor well construction.

Future research and greater data disclosure could improve understanding of these issues in several ways. More research is needed across the Marcellus and other shale gas plays where the geological characteristics differ. For instance, a new study by Duke University and the US Geological Survey showed no evidence of drinking water contamination in a part of the Fayetteville Shale with a less fractured or tectonically deformed geology than the Marcellus and good confining layers above and below the drinking water layers. More extensive predrilling data would also be helpful. Additional isotopic tools and geochemical tracers are needed to determine the source and mechanisms of stray gas migration that we observed. For instance, a public database disclosing yearly gas compositions (molecular and isotopic δ13C and δ2H for methane and ethane) from each producing gas well would help identify and eliminate sources of stray gas. In cases where carbon and hydrogen isotopes may not distinguish deep

Marcellus-derived methane from shallower, younger Devonian methane, the geochemistry of 4He and other noble gases provides a promising approach. Another research need is a set of detailed case studies of water-quality measurements taken before, during, and after drilling and hydraulic fracturing. Such studies are underway, including partnerships of EPA- and Department of Energy-based scientists and industry in Pennsylvania, Texas, and North Dakota. In addition to predrilling data, disclosure of data from mud-log gases and wells to regulatory agencies and ideally, publicly would build knowledge and public confidence. Ultimately, we need to understand why, in some cases, shale gas extraction contaminates groundwater and how to keep it from happening elsewhere.'

Increased stray gas abundance in a subset of drinking water wells near Marcellus shale gas extraction

Robert B. Jacksona,b,1, Avner Vengosha, Thomas H. Darraha, Nathaniel R. Warnera, Adrian Downa,b, Robert J. Poredac, Stephen G. Osbornd, Kaiguang Zhaoa,b, and Jonathan D. Karra,b

http://www.pnas.org/content/early/2013/06/19/1221635110.full.pdf+html

Air and Soil Contamination

'Unconventional natural gas development causes air pollution from multiple sources. **Many particulates and chemicals are released into the atmosphere, including sulfuric oxide, nitrogen oxides, volatile organic compounds (VOCs), benzene, toluene, diesel fuel, hydrogen sulfide, and radon gas, all of which can have serious health implications.** Further, the venting or flaring of wells during drilling and production contributes to local air pollution.

The drilling sludge, which is brought to the surface during the drilling process, contains fracking fluid, drilling mud, and radioactive material from the subsurface land formation, hydrocarbons, metals, and volatile organic compounds. Sludge, often left to dry on the surface in waste pits, may be removed to waste disposal sites (but not always to hazardous waste sites) or may be tilled into the soil in "land farms." These practices raise the risk of contaminating soil, air, and surface water, as a result of the fine dust becoming airborne thus affecting local air quality and raising the risk of respiratory disease. Based on concerns about the exposure to dust containing silica sand, the US Occupational Safety and Health Administration, along with the National Institute of Occupations Safety and Health (NIOSH), released a joint hazard alert on fracking silica in June, 2013.

Unconventional natural gas development requires many diesel trucks for the transportation of the products used in drilling as well as the removal of flowback fluid. Diesel emissions contain nitrogen oxides and volatile organic compounds, which can react to sunlight to produce ozone, a strong respiratory irritant associated with increased respiratory morbidity and mortality.'

Modern Natural Gas Development and Harm to Health: The Need for Proactive Public Health Policies

Madelon L. Finkel,1 Jake Hays,2 and Adam Law3

http://www.hindawi.com/isrn/public.health/2013/408658/

Water Contamination and Usage

'**Fluid migration is not rare**. For example, industry researchers Watson and Bachu, in a Society of Petroleum Engineers paper in 2009, examined 352,000 Canadian wells and found sustained casing pressure and gas migration.
They found that **about 12 per cent of newer wells leaked, considerably more than older wells**. Yes, the industry's own researchers found that a substantial percentage of wells leak initially, an even higher percentage of wells leak eventually, and now more wells are leaking than in the past; the process is getting worse, not better.

Most recently, the U.S. Environmental Protection Agency found benzene, methane and chemicals in water-monitoring wells in Pavilion, Wyoming, and EPA chief Lisa Jackson admitted "It is possible that fracking in one bearing zone may have impacted nearby areas that may contain some groundwater."
Does The Gas Industry Need a New Messenger
Dr Ingraffea
http://www.cbc.ca/news/canada/new-brunswick/does-the-natural-gas-industry-need-a-new-messenger-1.1002634

'Whereas the conventional method of natural gas production utilizes about 20,000 to 80,000 gallons of fluid, **the unconventional method utilizes up to 5 million gallons of fluid per hydraulic fracturing event, which includes not only water and sand, but also numerous toxic chemicals**. The potential for contamination of aquifers by the residual fracking fluids that remain underground must be considered. The likelihood of spills throughout the entire lifecycle of development also must be taken into account. Blowouts (uncontrolled release of natural gas from a gas well after pressure control systems have failed) allow gas and/or highly contaminated produced waters to flow to the surface; hoses come undone, gaskets fail, pits or tanks that hold the fracking fluids leak raising the serious risk of ground and water contamination. **Even small quantities of the toxic fracking fluids can contaminate shallow aquifers with hydrocarbons, toxic chemicals, heavy metals, and radioactive materials**.

Further, improper wastewater disposal, specifically the handling of fracking fluids including flowback wastewater (a byproduct of the process), can lead to contamination of ground and water. The flowback can be taken to sewage plants, but **it is widely acknowledged that sewage plants are not equipped to handle the contaminants**. **There have been reports of untreated wastewater being dumped into rivers and streams and sprayed on rural roads and forests**.

The New York Times, in its analysis of more than 30,000 pages of federal, state, and company records relating to more than 200 gas wells, **found that radioactive wastewater from the process has been discharged into rivers that supply drinking water to millions of people in Pennsylvania and Maryland**. At least 12 sewage treatment plants in three states have discharged waste that was only partly treated into rivers, lakes, and streams. There have been well-publicized instances of water contamination in Pavillion, WY, and Dimock, PA , and **gas has seeped into underground drinking water supplies**

in five states (Colorado, Ohio, Pennsylvania, Texas, and West Virginia). Further, a study conducted in Northeastern Pennsylvania found that water wells near a fracking site were 17 times more likely to exhibit methane contamination than wells not near drilling sites.'
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The major route of exposure in the cases documented here is through water contamination. This is perhaps the most obvious problem (seen in all three case studies), but other routes of exposure are of serious concern. Soil contamination can be significant in situations such as that described in Case 3. Although the cases we have documented thus far include only a handful of exposures through affected air, the actual incidence of health effects may be underestimated due to a lack of air sampling. In Case 1, toxicological testing suggested high levels of ambient benzene due to a nearby impoundment pond, but air canister tests were not done at the time. **Neither drilling companies nor state environmental regulatory agencies routinely offer air canister tests as a part of testing protocols, and due to the expense, many property owners are reluctant to pursue them on their own.** Nevertheless, the effects of air pollution on cardiovascular and respiratory health have been well documented, and we believe that exposure to contaminated air may contribute significantly to the health problems of both people and animals living near gas drilling operations. In several cases where air monitoring was done, the results confirmed the presence of carcinogens commonly known to originate from gas industrial processes such as exploration, drilling, flaring, and compression. Thus, the Environmental Protection Agency (EPA) must include a study of air in its congressionally mandated hydraulic fracturing study if it is to be complete.
Impacts Of Gas Drilling On Human And Animal Health
Michelle Bamberger Robert E. Oswald
http://baywood.metapress.com/media/hfphxmtrwjv5c9j3kg0v/contributions/6/6/1/4/661442p346j5387t.pdf

Areas like Perth with limited water supplies put their drinking water at serious risk of wastage and contamination. Areas with flooding like the Kimberley put their whole area at risk from contamination as the waters collect together, merge and spread toxic chemicals.

Health Impact For Humans and Animals

'This type of unconventional natural gas development relies on clustered, multi-well pads and long, horizontal laterals. Wells are drilled vertically (often thousands of feet) and horizontally in multiple directions. The method entails injecting large volumes of fluid consisting of chemicals, water, and sand into the well to fracture the shale rock that releases the natural gas. The internal pressure of the rock formation also causes a portion of the injected fracking fluids to return to the surface (flowback fluids); these fluids are often stored in a tank or pit before being pumped into trucks for transport to a disposal site. Flowback has been shown to contain a variety of formation materials, including brines, heavy metals, radionuclides, and organics, which can make wastewater treatment difficult and expensive. Further, **other studies found that 20% to 85% of fracturing fluids may remain in the formation, which means the fluids could continue to be a source of groundwater contamination for years to come**. By 2009, there were more than 493,000 active natural gas wells across 31 states, almost double the number in 1990, of which approximately 90 percent have used hydraulic fracturing to extract gas.

Whereas shale gas has the potential to become a significant, economical energy source, **the potential for harm and the potential of giving a false sense of energy security are often dismissed by its proponents**. The process is potentially polluting and damaging not only to human and animal health but also to the environment, as a result of clearing of land for well pads, drilling the wells, extracting the gas, storing the byproducts of the extraction, transporting the gas by diesel trucks, and the final capping of the well. The potential for harm to children is especially worrisome.

The health impacts related to unconventional natural gas development may not be evident for years, as **medical conditions with long latency periods will present over time**. While the potential long-term, **cumulative effects will not be known for years**, we argue that it would be prudent to begin to track and monitor trends in the incidence and prevalence of diseases that already have been shown to be influenced by environmental agents. Meanwhile, the natural gas industry needs to address the risks to human and animal health and take steps to limit, preferably to eliminate, the exposure pathways. **We need far greater transparency and full chemical disclosure**. There needs to be an end to discharging effluent into rivers, streams, and groundwater. There needs to be much more attention paid to curtailing or preferably eliminating spills and leaks of radioactive wastewater. **There needs to be an end to the disposal of radioactive sludge from drilling sites in landfills**. There needs to be a safer way to develop this resource to limit the exposure to silica, which can cause silicosis, chronic obstructive pulmonary disease, and lung cancer. Banning the practice of burning off the initial flow of natural gas (flaring) needs to be mandated sooner than 2015, the date when EPA ruling goes into effect. And, perhaps most importantly, there needs to be a well-designed epidemiologic study conducted to empirically assess health status among those living proximate to active development compared to those living in areas where development is not occurring.'

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'Environmental concerns surrounding drilling for gas are intense due to expansion of shale gas drilling operations. Controversy surrounding the impact of drilling on air and water quality has pitted industry and lease holders against individuals and groups concerned with environmental protection and public health. **Because animals often are exposed continually to air, soil, and groundwater and have more frequent reproductive cycles, animals can be used as sentinels to monitor impacts to human health**. This study involved interviews with animal owners who live near gas drilling operations. The findings illustrate which aspects of the drilling process may lead to health problems and suggest modifications that would lessen but not eliminate impacts. Complete evidence regarding health impacts of gas drilling cannot be obtained due to incomplete testing and disclosure of chemicals, and nondisclosure agreements. Without rigorous scientific studies, the gas drilling boom sweeping the world will remain an uncontrolled health experiment on an enormous scale.

As shale gas drilling expands across the northeastern United States, exposure of animals and humans to environmental toxicants can result from negligence, illegal actions, catastrophic accidents (at drilling pads or compressor stations), or normal operations. Negligence and illegal actions are difficult to prevent and may have contributed to the health problems we documented. **Suspected illegal dumping of wastewater and the alleged compromise of the liner of a wastewater impoundment were most likely responsible for cattle deaths in two instances that we studied**. Cases of alleged wrongdoing illustrate **the vulnerability of agricultural operations** in the midst of large volumes of toxic waste. Dumping and other intentional violations are difficult to prevent or regulate given the large numbers of small companies involved in servicing drilling operations and **the lack of willingness and funding on the part of state environmental regulatory agencies to investigate and fine the gas industry**. The prevalence of small subcontractors increases the possibility that best practices will not be followed due to inadequate training and supervision.

Although accidents might be minimized with strict safety standards and careful inspection, regulatory agencies would require sufficient staff to monitor operations. This is obviously not the case in Pennsylvania, where 666 environmental health and safety violations have been reported in 2011 as of June. With a staff of 37 inspectors and 64,939 active wells (as of December, 2010), regulatory oversight is essentially impossible. The situation is even worse in New York State, where only 16 inspectors are currently on the staff of the Department of Environmental Conservation. Although the number of staff positions required to police this industry adequately would necessarily be very large, hiring of new inspectors is essential if environmental and health damages are to be minimized. New York, Pennsylvania, and Iowa are the only active drilling states that have no severance tax for drilling operations. A severance tax could fund additional inspectors and help insure compliance with existing regulations, although this will require the political will to levy a tax sufficient to fund the required number of inspectors. Given the high probability that accidents will happen, increasing setbacks between homes, barns, schools, ponds, and streams would provide some additional security. The current regulation in Pennsylvania is a setback of 200 feet from water supply springs and wells, 100 feet from surface water bodies, and 200 feet from wetlands. The revised draft supplemental generic environmental impact statement in New York indicates a 500-foot setback from private water wells. Increasing these setbacks 5- to 10-fold would decrease but not eliminate the impacts of accidents such as the April 20, 2011 spill in Bradford County, PA. Contamination of the air by compressor station blowouts and contamination of streams leave an imprint that cannot be easily mitigated by even the most stringent setbacks.

Normal practices can be modified to reduce but not eliminate exposure of humans and animals to toxicants associated with gas drilling. **One of the important problems associated with shale gas drilling is the huge volume of wastewater generated.** This wastewater, which includes flowback and produced water, contains at different times in the process the chemicals used in the hydraulic fracturing fluid as well as compounds and minerals extracted in the fluid flowing back with hydrocarbon gas. **The materials extracted from underground can be equally or more toxic than the hydraulic fracturing fluid, and include radioactive material (e.g., radium-226, radon-222, and uranium-238), arsenic, lead, strontium, barium, benzene, chromium and 4-nitroquinoline-1- oxide.** However, despite the actual toxicity of this material, according to the EPA, "drilling fluids, produced waters, and other wastes associated with the exploration, development, or production of . . . natural gas" are considered "solid wastes which are not hazardous wastes". This allows the substances to be spread on roads as deicing solutions and as solutions to minimize dust and sets up a potentially lethal threat, particularly to companion animals, wildlife, and children. Typically these solutions contain high salt concentrations and attract dogs and cats, as was illustrated in Case 1. This hazard can be easily mitigated by not allowing wastewater to be spread or sprayed on roads.

Before wastewater is removed from a drilling site, it is often stored in large impoundments (sometimes serving multiple well pads) where the volume is decreased by evaporation. This increases the concentration of some toxic substances in the impoundment (salts, heavy metals) and also introduces other toxicants into the atmosphere (e.g., volatile organics such as benzene and toluene). In addition, impoundments are associated with a number of deaths of both cattle and wildlife. These effects raise the question of whether wastewater should be stored in open impoundments. Whereas this may be economically advantageous to the drilling company, the environmental and agricultural impacts are too great to allow this practice to continue. In Pennsylvania, **some progress has been made in recycling increasing fractions of the wastewater. This decreases the total volume of wastewater but increases its toxicity due to the successive increase in the concentrations of total dissolved solids.** The alternative is to store wastewater in metal containers at the drilling site before it is removed for disposal.

Finally, **the disposal of wastewater presents significant environmental risks. Cases of alleged dumping of untreated wastewater in streams have been documented in the press (e.g.).** In the southwestern United States, wastewater is disposed of in injection wells; however, the prevalence of nonporous sand- stones and shales in Pennsylvania and New York State largely precludes the use of disposal wells. An earthquake of magnitude 3.2 was associated with injection into a hydraulically fractured vertical well on February 3, 2001 near Avoca, New York, suggesting that seismic considerations may further limit the development of injection wells in New York State. Similar seismic occurrences in other parts of the country, most recently in Ohio, may mean that New York and Pennsylvania will have fewer options for disposal of wastewater due to shale gas drilling. In May 2011, a voluntary moratorium was placed on the acceptance of hydraulic fracturing wastewater at sewage treatment plants in Pennsylvania. These plants are not equipped to handle either the radioactive and toxic compounds or the high salt content of this waste, and the increased use of recycling has magnified the problem. Discharge of water treatment plants into the Monongahela River led to the contamination of drinking water in Pittsburgh in 2010. Sewage treatment plants clearly are not a viable option for disposal of wastewater, and despite the industry's progress in recycling, suitable injection wells are unlikely to be located to support the scale of drilling planned in Pennsylvania and possibly New York State.

Animals, especially livestock, are sensitive to the contaminants released into the environment by drilling and by its cumulative impacts. Documentation of cases in six states strongly implicates exposure to gas drilling operations in serious health effects on humans, companion animals, livestock, horses, and wildlife. Although the lack of complete testing of water, air, soil and animal tissues hampers thorough analysis of the connection between gas drilling and health, policy changes could assist in the collection of more complete data sets and also partially mitigate the risk to humans and animals. Without complete studies, given the many apparent adverse impacts on human and animal health, a ban on shale gas drilling is essential for the protection of public health. In states that nevertheless allow this process, the use of commonsense measures to reduce the impact on human and animals must be required in addition to full disclosure and testing of air, water, soil, animals, and humans.'

Impacts Of Gas Drilling On Human And Animal Health
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http://baywood.metapress.com/media/hfphxmtrwjv5c9j3kg0v/contributions/6/6/1/4/661442p346j5387t.pdf

Food Safety

'A major problem is the lack of federal funding for food safety research. We documented cases where **food-producing animals exposed to chemical contaminants have not been tested before slaughter and where farms in areas testing positive for air and/or water contamination are still producing dairy, egg, and meat products for human consumption without testing of the animals or the products.** Some of these chemicals could appear in food products made from these animals. In Case 3, a quarantine was instituted after cattle were exposed to wastewater. However, basic knowledge, such as hold times for animals exposed to chemical contaminants as a result of gas operations, is lacking, and research in this area is desperately needed to maintain an adequate level of food safety in our country. Without this information, contaminants in the water, soil and air from gas drilling operations could taint meat products made from these animals, thus compromising the safety of the food supply.'

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http://baywood.metapress.com/media/hfphxmtrwjv5c9j3kg0v/contributions/6/6/1/4/661442p346j5387t.pdf

Fugitive Emissions

Unconventional gas/ methane is **not a cleaner fossil fuel**, and can threat to air-quality in shale gas extraction regions, as well as contribute to global warming at a higher rate to other fossil fuels.

'NASA climate scientist Drew Shindell's work, published in the prestigious journal, Science, shows that methane – **natural gas – is 105 times more powerful than carbon dioxide as a global warming contributor over a 20-year time horizon, and 33 times more powerful over a century. Unfortunately, unconventional gas drilling techniques actually leak more methane than conventional ones**. Leaks happen routinely during regular drilling, fracking and flowback operations, liquid unloading, processing, and along pipelines and at storage facilities. The rate of leakage is anywhere from 3.6 per cent to 7.9 per cent of the lifetime of production of a shale gas well, which means from **three to 200 per cent greater leakage rate** than from conventional gas wells. When it comes to global warming potential, production of gas from shale creates effects greater than that of coal or oil.' *Dr Anthony Ingraffia* (http://www.cbc.ca/news/canada/new-brunswick/does-the-natural-gas-industry-need-a-new-messenger-1.1002634)

'In January of 2013, for instance, the daily production of methane (CH4) in the United States rose to ~2 × 109 m3, up 30% from the beginning of 2005. Along with the benefits of rising shale gas extraction, public concerns about the environmental consequences of hydraulic fracturing and horizontal drilling are also growing. These concerns include changes in air quality, human health effects for workers and people living near well pads, induced seismicity, and controversy over the greenhouse gas balance. Perhaps the biggest health concern remains the potential for drinking water contamination from fracturing fluids, natural formation waters, and stray gases.

A first-order estimate of conventional air pollutant emissions, and the monetary value of the associated environmental and health damages, from the extraction of unconventional shale gas in Pennsylvania. Region-wide estimated damages ranged from $7.2 to $32 million dollars for 2011. The emissions from Pennsylvania shale gas extraction represented only a few per cent of total statewide emissions, and the resulting statewide damages were less than those estimated for each of the state's largest coal-based power plants. On the other hand, in counties where activities are concentrated, NOx emissions from all shale gas activities were 20–40 times higher than allowable for a single minor source, despite the fact that individual new gas industry facilities generally fall below the major source threshold for NOx. Most emissions are related to ongoing activities, i.e., gas production and compression, which can be expected to persist beyond initial development and which are largely unrelated to the unconventional nature of the resource. Regulatory agencies and the shale gas industry, in developing regulations and best practices, should consider air emissions from these long-term activities, especially if development occurs in more populated areas of the state where per-ton emissions damages are significantly higher. Such emissions can have direct physical impacts on health, infrastructure, agriculture and ecosystems. For example, short-term exposure to criteria pollutants such as sulfur dioxide (SO2) and nitrogen oxides (NOx) has been linked to adverse respiratory effects. Exposure to fine particulate matter (PM) and ozone (O3) may increase respiratory-related hospital admissions, emergency room visits, and premature death. The expanded use of natural gas could arguably reduce net emissions from the electricity sector if used in lieu of coal (US EPA 1999, NRC 2010). However, shale gas extraction activities such as diesel truck transport and natural gas processing at compressor stations could lead to increases in air pollution in regions where extraction occurs. Life cycle greenhouse gas (GHG) emissions from shale gas are often assessed to be greater than conventional natural gas.

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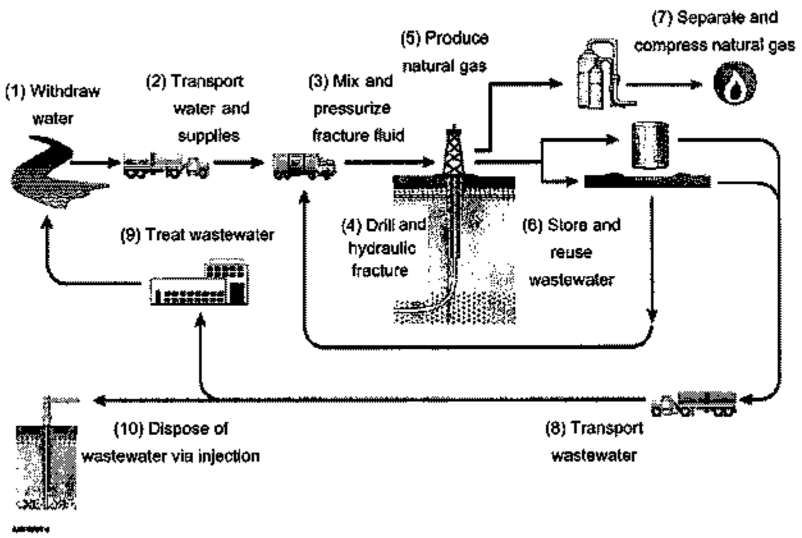

Figure 1. Major activities of shale gas extraction using horizontal drilling and hydraulic fracturing.

Development emissions damages range from about $2.5 to $5.5 million, but the majority of annual attributable emissions will continue for the life of the well and associated compressor facilities. This is true despite the relatively high level of development activity in 2011 and the relatively low number of actively producing shale gas wells, compared to what is expected in coming years. At the low end of our estimates, 66% of total damages in 2011 were attributable to long-term activities; at the high end, more than 80% of damages occur in the years after the well is developed. Nor are most emissions associated with well-site activities. More than half of emissions damages from this industry come from compressor stations, which may serve dozens of individual wells, including conventional ones. Our estimates indicate that regulatory agencies and the shale gas industry, in developing regulations and best practices, should account for air emissions from ongoing, long-term activities and not just emissions associated with development, such as drilling and hydraulic fracturing, where much attention has been focused to date. Even if development slows in the Marcellus region, as it did in 2012, the long-term nature of these emission sources will mean that any new development will add to this baseline of emissions burden as more producing wells and compressor stations come online.'

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Table 1. Air emissions damages, localization of effects, and relevant pollutants of concern.

Damage category	Damage location	Relevant emissions	Relevant stages	Inclusion in this analysis
Climate change	Local, regional, and global	GHGs: CO_2, CH_4, N_2O, O_3	• Stages 2, 8: transport • Stages 3, 4, 5: site activities • Stage 7: processing	No GHGs included in this study
Air quality	Local and regional	VOCs, NO_x, PM, SO_2, O_3, CO	• Stages 2, 8: transport • Stages 3, 4, 5: site activities • Stage 6: wastewater storage and reuse • Stage 7: processing	*Development activities*: (1) transport; (2) well drilling, hydraulic fracturing Ongoing activities: (3) production; (4) compressor stations *Pollutants*: direct: VOCs, NO_x, PM, SO_2; indirect: O_3 via VOCs and NO_x

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Table 2. Range of assumed well-site development emissions in this analysis.

Emissions activity	VOC	NO_x	$PM_{2.5}$	PM_{10}	SO_x
Total diesel and road dust development emissions (kg/well)	18–31	320–580	9.4–32[a]	9.8–32[a]	0.47–0.79
Total well-site development emissions (kg/well)	150–170	3800–4600	87–130	87–130[b]	3.8–110

[a] PM_{10} emissions were unavailable for heavy-duty trucks; in this case, it was assumed all diesel-related PM emissions were less than 2.5 μm. All road dust was also assumed less than 2.5 μm. Therefore aggregate PM_{10} counts differ from $PM_{2.5}$ only in light-duty vehicle emissions; at the high end of our range, this difference is not significant.
[b] Industry reporting often assumes all PM emissions are less than 2.5 μm and so PM_{10} counts are almost the same as $PM_{2.5}$.

Table 3. Range of assumed well-site production emissions used in this analysis.

Emissions activity	VOC	NO_x	$PM_{2.5}$	PM_{10}	SO_x
Total annual well-site production emissions per well (kg/well)	46–1200	520–660	9.9–50	9.9–50[a]	3.1–4.0

[a] Industry reporting often assumes all PM emissions are less than 2.5 μm and so PM_{10} counts are here the same as $PM_{2.5}$.

Estimation of regional air-quality damages from Marcellus Shale natural gas extraction in Pennsylvania

Aviva Litovitz1, Aimee Curtright2, Shmuel Abramzon1, Nicholas Burger3 and Constantine Samaras2

http://iopscience.iop.org/1748-9326/8/1/014017/pdf/1748-9326_8_1_014017.pdf

Chemicals in Slick Water

'Of great concern is the fact that the oil and gas companies are legally permitted to withhold information on the chemicals they use in their slick water, which hampers efforts to assess the potential for harm and the fact that they are exempt from many environmental law restrictions such as Clean Water Trigger Act.

Of the few studies that have looked at the chemical cocktails used in the process, **findings have identified chemicals that are known to cause cancers, mutations, and diseases of the nervous, immune, and endocrine systems, the kidney, gastrointestinal tract and liver, heart, and skin**. Colburn identified almost 1,000 chemical products and nearly 650 individual chemicals used in natural gas operations, many of which have the potential to cause adverse health effects as well as to potentially cause deleterious effects on the environment. Specifically, the researchers documented that the hydraulic fracturing process releases toxic and cancer-causing chemicals such as benzene, toluene, xylene (BTEX), and methylene chloride among other health-hazardous air pollutants. These health-hazardous pollutants are released from a number of sources including blowouts, flaring, condensate tanks, construction activity, engines, and venting. Methane, a powerful greenhouse gas, also is emitted throughout the oil and gas development process. Methane interacts with sunlight to produce tropospheric ozone, which is a strong respiratory irritant associated with increased respiratory morbidity and mortality.

Witter et al. were one of the first to present a detailed assessment of health trends in Garfield County, CO, that documented the negative impact of drilling on air, soil, water, and human health. Building on those findings, McKenzie et al. estimated health risks for exposures to air emissions from a natural gas development project also in Garfield County and found that residents living less than one-half mile away from wells were at greater risk for ill health effects than those living farther away. Although these studies focused on Garfield County, CO, the researchers maintain that the exposure pathways and related health risks would be similar wherever oil and gas development is occurring.'

Modern Natural Gas Development and Harm to Health: The Need for Proactive Public Health Policies

Madelon L. Finkel,1 Jake Hays,2 and Adam Law3

http://www.hindawi.com/isrn/public.health/2013/408658/

'**Communities living near hydrocarbon gas drilling operations have become de facto laboratories for the study of environmental toxicology**. The close proximity of these operations to small communities has created a variety of potential hazards to humans, companion animals, livestock and wildlife. These hazards have become amplified over the last 20 years, due in part to the large-scale development of shale gas drilling (horizontal drilling with high-volume hydraulic fracturing), encouraged by the support of increased drilling and exploration by U.S. government agencies. Yet this large-scale industrialization of populated areas is moving forward without benefit of carefully controlled studies of its impact on public health. As part of an effort to obtain public health data, we believe that particular attention must be paid to companion animals, livestock, and wildlife, as they may serve as sentinels for human exposures, with shorter lifetimes and more opportunity for data collection from necropsies.

All phases of hydrocarbon gas production involve complex mixtures of chemical substances. For example, in hydraulic fracturing fluids, chemical sub- stances other than water make up approximately 0.5 to 1 percent of the total volume; however, the very large volumes used require correspondingly large volumes of a variety of compounds. These substances range from the relatively benign to the highly toxic. Some of these are reported to the public and others are not, but the quantities and proportions used are largely considered trade secrets. **In addition to these added chemicals, naturally occurring toxicants such as heavy metals, volatile organics, and radioactive compounds are mobilized during gas extraction and return to the surface with the gas/chemical mix (waste- water); of the 5.5 million gallons of water, on average, used to hydraulically fracture a shale gas well one time, less than 30 percent to more than 70 percent may remain underground**. Hydraulic fracturing takes place over 2 to 5 days and may be repeated multiple times on the same well over the course of the potential 25- to 40-year lifetime of a well. Many of these chemicals are toxic and have known adverse health effects, which may be apparent only in the long term. A discussion of these compounds and their health effects is beyond the scope of this article; however, Colborn et al. have analyzed this topic in depth.

The large-scale use of chemicals with significant toxicity has given rise to a great deal of public concern, and an important aspect of the debate concerns the level of proof required to associate an environmental change with activities associated with gas drilling. Environmental groups typically invoke the pre-cautionary principle. That is, if an action is suspected of causing harm to the environment, then in the absence of a scientific consensus, the burden of proof falls on the individual or organization taking the action. The oil and gas industry has typically rejected this analysis and has approached the issue in a manner similar to the tobacco industry that for many years rejected the link between smoking and cancer. That is, if one cannot prove beyond a shadow of doubt that an environmental impact is due to drilling, then a link is rejected.

For the past year, we have been documenting cases of animal and owner health problems with potential links to gas drilling. Many cases are currently in litigation. To protect individuals' privacy and due to ongoing legal action, the discussion will not include personal identifying information. We summarize the results of our investigation, and provide several case studies. Direct exposure to hydraulic fracturing fluid occurred in two cases: in one, a worker shut down a chemical blender during the fracturing process, allowing the release of fracturing fluids into an adjacent cow pasture, **killing 17 cows in one hour**; the other was a result of a defective valve on a fracturing fluid tank, which caused hundreds of barrels of hydraulic fracturing fluid to leak into a pasture **where goats were exposed and suffered from reproductive problems over the following two years**. Exposure to drilling chemicals occurred during a blowout when liquids ran into a pasture and pond where bred cows were grazing; **most of the cows later produced stillborn calves with or without congenital defects**. Exposure to wastewater occurred through leakage or improper fencing of impoundments, alleged compromise of a liner in an impoundment to drain fluid, direct application of the wastewater to roads, and dumping of the wastewater on creeks and land. The most common exposure by far was to affected water wells and/or springs; the next most common expo- sure was to affected ponds or creeks. Finally, exposures also were associated with compressor station malfunction, pipeline leaks, and well flaring. In addition to humans, the animals affected were: cows, horses, goats, llamas, chickens, dogs, cats, and koi. Other than photographing and recording the presence of dead and dying wildlife (deer,

songbirds, fish, salamanders, and frogs) in the vicinity of affected pastures, creeks and ponds, **the effect on wildlife has not been well documented**. Because production animals were exposed to the environment for longer periods and in greater numbers than companion animals, and because most of the farms we documented raised beef cattle, cows were represented to a greater extent than other animals. **Exposures through well water, ponds, springs, dumping of**
wastewater into creeks, and spills or leakage of wastewater from impoundments were believed by farmers to result in deaths over time periods typically ranging from one to three days, with cows going down and unable to rise despite symptomatic treatment. The most commonly reported symptoms were associated with reproduction. Cattle that have been exposed to wastewater (flowback and/or produced water) or affected well or pond water may have trouble breeding. When bred cows were likewise exposed, farmers reported an increased incidence of stillborn calves with or without congenital abnormalities (cleft palate, white or blue eyes). In each case, farmers reported that in previous years stillborn calves were rare (fewer than one per year). In most cases where diagnostics were pursued, no final diagnosis was made; in other cases, acute liver or kidney failure was most commonly found. Of the seven cattle farms studied in the most detail, 50 percent of the herd, on average, was affected by death and failure of survivors to breed. In one case, exposure to drilling wastewater led to a quarantine of beef cattle and significant uncompensated economic loss to the farmers.

The most dramatic case was the death of 17 cows within one hour after direct exposure to hydraulic fracturing fluid. The final necropsy report listed the most likely cause of death as respiratory failure with circulatory collapse. The hydraulic fracturing fluid contained, among other toxicants, petroleum hydrocarbons and quaternary ammonium compounds (tetramethylammonium and hexamethylenetetramine). Although petroleum hydrocarbons were reported to be found in the small intestine, lesions in the lung, trachea, liver and kidneys suggested exposure to other toxicants as well, and quaternary ammonium compounds have been described as producing similar lesions.

Two cases involving beef cattle farms inadvertently provided control and experimental groups. In one case, a creek into which wastewater was allegedly dumped was the source of water for 60 head, with the remaining 36 head in the herd kept in other pastures without access to the creek. **Of the 60 head that were exposed to the creek water, 21 died and 16 failed to produce calves the following spring. Of the 36 that were not exposed, no health problems were observed, and only one cow failed to breed**. At another farm, 140 head were exposed when the liner of a wastewater impoundment was allegedly slit, as reported by the farmer, and the fluid drained into the pasture and the pond used as a source of water for the cows. Of those 140 head exposed to the wastewater, approximately 70 died and there was a high incidence of stillborn and stunted calves. The remainder of the herd (60 head) was held in another pasture and did not have access to the wastewater; they showed no health or growth problems. These cases approach the design of a controlled experiment, and strongly implicate wastewater exposure in the death, failure to breed, and reduced growth rate of cattle.

Companion animals were defined as those animals that were kept as pets, and included horses, dogs, cats, llamas, goats, and koi. Companion animal exposures typically occurred when animals ingested affected water from a well, spring, creek or pond. Reproductive problems (irregular cycles, failure to breed, abortions, and stillbirths) and neurological problems (seizures, incoordination, ataxia) were the most commonly reported. Other commonly reported symptoms included those of gastrointestinal (vomiting, diarrhea) and dermatological (hair and feather loss, rashes) origin.

In the majority of cases, owners of animals were exposed upon using their well or spring water for drinking, cooking, showering and bathing. **Upper respiratory symptoms (including burning of the nose and throat) and burning of the eyes were the most commonly reported. Headaches and symptoms associated with the gastrointestinal (vomiting, diarrhea), dermatological (rashes), and vascular (nosebleeds) systems were commonly reported.**'

Impacts Of Gas Drilling On Human And Animal Health

MICHELLE BAMBERGER ROBERT E. OSWALD

http://baywood.metapress.com/media/hfphxmtrwjv5c9j3kg0v/contributions/6/6/1/4/661442p346j5387t.pdf

'The technology to recover natural gas depends on undisclosed types and amounts of toxic chemicals. **A list of 944 products containing 632 chemicals used during natural gas operations was compiled**. Literature searches were conducted to determine potential health effects of the 353 chemicals identified by Chemical Abstract Service (CAS) numbers. **More than 75% of the chemicals could affect the skin, eyes, and other sensory organs, and the respiratory and gastrointestinal systems. Approximately 40–50% could affect the brain/nervous system, immune and cardiovascular systems, and the kidneys; 37% could affect the endocrine system; and 25% could cause cancer and mutations**. These results indicate that many chemicals used during the fracturing and drilling stages of gas operations may have long-term health effects that are not immediately expressed. In addition, an example was provided of waste evaporation pit residuals that contained numerous chemicals on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and Emergency Planning and Community Right-to-Know Act (EPCRA) lists of hazardous substances. The discussion highlights the difficulty of developing effective water quality monitoring programs. To protect public health we recommend full disclosure of the contents of all products, extensive air and water monitoring, coordinated environmental/human health studies, and regulation of fracturing under the U.S. Safe Drinking Water Act.'

Natural Gas Operations from a Public Health Perspective

Theo Colborna, Carol Kwiatkowskia, Kim Schultza & Mary Bachrana

http://www.tandfonline.com/doi/full/10.1080/10807039.2011.605662#.UjWw1-AyG-I

Nondisclosure Agreements

Nondisclosure agreements makes the industry impossible to regulate and to be held accountable.

'**Nondisclosure agreements between injured parties and corporations make it difficult to document incidents of contamination**. Compensation in the form of cash, payment for all settlement expenses, an offer to buy the property and/or payment for medical expenses in exchange for a nondisclosure agreement **prevents information on contamination episodes and health effects from being documented and analyzed**. Nondisclosure agreements are common in all areas of business and are often essential to protect intellectual property. **However, when documentation of health problems associated with gas operations is shielded from public scrutiny by a nondisclosure agreement, this is clearly a misuse of this important business tool and should be prohibited.** Likewise the lack of prior testing of air and water, and of follow-up testing during drilling and after incidents of suspected contamination, impedes the analysis of health impacts. **Even when testing is done, the results are being withheld from interested parties either by government agencies (e.g., by incomplete responses to FOIA requests) or by the industry**. If the industry, government agencies, and the public truly want the facts, then appropriate testing must be done, and full disclosure of all data associated with both baseline and incidents of suspected contamination must be made. **Without full disclosure of all facts, scientific studies cannot properly be done.** Science should drive decisions on whether or not to use a practice such as shale gas drilling, and until scientific studies can proceed unimpeded, then an accurate assessment cannot be made.'

Impacts Of Gas Drilling On Human And Animal Health
Michelle Bamberger Robert E. Oswald
http://baywood.metapress.com/media/hfphxmtrwjv5c9j3kg0v/contributions/6/6/1/4/661442p346j5387t.pdf

Testing

'The most important requirement for an assessment of the impact of gas drilling on animal and human health is complete testing of air and water prior to drilling and at regular intervals after drilling has commenced. This includes chemicals used in the drilling muds, fracturing fluid and wastewater (the latter contains heavy metals and radioactive compounds normally found in a particular shale. Currently, the extent of testing (particularly for organic compounds) is frequently inadequate and limited by lack of information on what substances were used during the drilling process.

In a number of the cases that we have studied, **drinking water is clearly unsuitable for human and animal consumption, based not only on the smell**

and turbidity, but also on pathological reactions to drinking the water. Nevertheless, because of inadequate testing, the water is deemed fit for consumption and use, and neither bottled water nor the large plastic containers known as "water buffaloes" are typically provided for the affected individuals—and even less commonly for animals living on those farms.

In Case 1, water was reluctantly provided for the humans (after considerable effort) but not to the animals living on the farm. Even when identified, the health effects of chemicals associated with the drilling process are unknown in many cases. No Maximum Contaminant Levels (MCLs) have been set by the EPA for many of the compounds used, and those that have been set are based on older data that does not take into consideration effects at significantly lower concentrations (e.g., endocrine disruption). Furthermore, the disclosure of all chemicals involved in the drilling and hydraulic fracturing processes is not required if a component can be justified as a "trade secret." In order to be complete, air, soil and all sources of potable water used for humans and animals in the vicinity of a well site (at least within 3,000 feet for soil and water tests, and five miles for air monitoring, based on dispersion modeling of emissions from compressor stations) must be tested for all components that are involved in drilling and are likely to be found in wastewater, before any work on the site commences. Sampling must then be repeated at intervals following the commencement of drilling as well as upon suspicion of adverse effects.

The following practices must be part of a testing protocol:

1. The sampling must be done by a disinterested third party with a clear chain of custody between sampling and testing. A certified independent laboratory must do the testing, and the results must be available to all interested parties.
2. All chemicals (IUPAC names and CAS numbers, with concentrations) and concentrations of each chemical used in the hydraulic fracturing fluid at any concentration for each well must be disclosed to the property owners within a five-mile radius, testing laboratories, local governments, and state agencies. Material Safety Data Sheets (MSDSs) for each chemical and chemical mixture must accompany this disclosure. Following this procedure will allow prior testing to be targeted to specific chemicals to be used in the drilling process for a specific well, as well as providing valuable information to first responders and hospital personnel in the case of an accident.
3. Upon suspicion of adverse health effects, testing must include air, soil, wastewater, all sources of drinking water, and blood, urine and tissue samples from affected animals and humans. If methane is present in drinking water, isotopic analysis to determine the origin (thermogenic vs. biogenic) must be done.
4. As illustrated by several cases we documented, air canister tests are essential. This must be done as a baseline before drilling begins and during and after well flaring. It must also be done after a wastewater impoundment and a compressor station have been established.
5. Any fracturing fluid chemicals and chemicals released from the shale that are known or possible human carcinogens, are regulated under the Safe Drinking Water Act, or are listed as hazardous air pollutants under the Clean Air Act must have MCLs, which are set by the EPA. Many of the chemicals to which both people and animals are exposed as a result of high-volume hydraulic fracturing

are not listed as primary contaminants, and thus have no enforceable MCL. More than half of the chemicals listed as toxic chemicals in a recently released U.S. House of Representatives report have no MCL.
6. All testing expenses must be a part of the cost of doing business for gas drilling companies.
Testing before and during drilling operations is an important part of documenting health effects. If health effects are related to a chemical pre-existing in a pond or well, this would prevent a false association between drilling and water contamination. Alternatively, if a change in chemical composition is correlated to health changes, then a strong justification for compensation is provided. In numerous cases that we documented, compensation was not provided because adequate prior testing had not been done. By doing complete testing, at the proper times, a clear scientific justification can be made for providing or denying compensation. Beyond that, a better understanding of what practices lead to water contamination can be obtained. This will be a benefit to people living in the midst of shale gas drilling and will, in fact, benefit the industry by providing consistent and useful data to guide operations. The current practice of undertesting and denying any link between drilling and water, air, or soil contamination is beneficial to neither the public nor the industry.'
Impacts Of Gas Drilling On Human And Animal Health
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http://baywood.metapress.com/media/hfphxmtrwjv5c9j3kg0v/contributions/6/6/1/4/661442p346j5387t.pdf

Seismisc Activity

'Human-induced earthquakes have become an important topic of political and scientific discussion, owing to the concern that these events may be responsible for widespread damage and an overall increase in seismicity. It has long been known that impoundment of reservoirs, surface and underground mining, withdrawal of fluids and gas from the subsurface, **and injection of fluids into underground formations are capable of inducing earthquakes**. In particular, earthquakes caused by injection have become a focal point, as new drilling and well-completion technologies enable the extraction of oil and gas from previously unproductive formations.

Earthquakes with magnitude (M) ≥ 3 in the U.S. midcontinent, 1967–2012. After decades of a steady earthquake rate (average of 21 events/year), activity increased starting in 2001 and peaked at 188 earthquakes in 2011. Human-induced earthquakes are suspected to be partially responsible for the increase.

Microearthquakes (that is, those with magnitudes below 2) are routinely produced as part of the hydraulic fracturing (or "fracking") process used to stimulate the production of oil, but the process as currently practiced appears to pose a low risk of inducing destructive earthquakes. More than 100,000 wells have been subjected to fracking in recent years, and the largest induced earthquake was magnitude 3.6, which is too small to pose a serious risk. **Yet,**

wastewater disposal by injection into deep wells poses a higher risk, because this practice can induce larger earthquakes. For example, several of the largest earthquakes in the U.S. midcontinent in 2011 and 2012 may have been triggered by nearby disposal wells. The largest of these was a magnitude 5.6 event in central Oklahoma that destroyed 14 homes and injured two people. The mechanism responsible for inducing these events appears to be the well-understood process of weakening a preexisting fault by elevating the fluid pressure. However, only a small fraction of the more than 30,000 wastewater disposal wells appears to be problematic—typically those that dispose of very large volumes of water and/or communicate pressure perturbations directly into basement faults.

Injection-induced earthquakes, such as those that struck in 2011, clearly contribute to the seismic hazard. Quantifying their contribution presents difficult challenges that will require new research into the physics of induced earthquakes and the potential for inducing large-magnitude events. The petroleum industry needs clear requirements for operation, regulators must have a solid scientific basis for those requirements, and the public needs assurance that the regulations are sufficient and are being followed. The current regulatory frameworks for wastewater disposal wells were designed to protect potable water sources from contamination and do not address seismic safety. One consequence is that both the quantity and timeliness of information on injection volumes and pressures reported to regulatory agencies are far from ideal for managing earthquake risk from injection activities. In addition, seismic monitoring capabilities in many of the areas in which wastewater injection activities have increased are not capable of detecting small earthquake activity that may presage larger seismic events.

Injection-Induced Earthquakes

William L. Ellsworth
http://www.sciencemag.org/content/341/6142/1225942.short

Conclusion

In conclusion, the information presented leaves little doubt to the massive environmental impacts that are occurring in areas of the world where hydraulic fracturing is taking place. To consider allowing this industry to take hold of our precious land, air and water without stringent independent (no conflict of interest whatsoever) testing/ and regulation is folly. The risk is too high, considering the land use now and in the future is negatively impacted, the ground water compromised, and air quality affected and our health, and that of those in our care- children and animals put at stake. With our present technology, the waste water cannot be cleaned enough to allow for use other than more fracking fluid, and therefore has zero recycling potential. The lack of transparency in the industry points to hidden facts and failings, rather than trade secrets for the protection of intellectual property. **The industry has not perfected this practice to allow for both people and profit to be mutually balanced and is therefore acting negligently.** If our government allows this to happen, having been provided with such scientific data from experts quoted herein, it is gross negligence. Our government is here to govern and protect the people and land and as such need to balance economy and the environment sustainable with PROPER scientific research.

Sincerely in truth,

19 September 2013

Brenda McAuliffe Poznik