

To the Athens County Commissioners

Written Testimony of
Deborah R. Cowden, MD
Knox County Health Department Clinic Physician
Board Certified, Family Medicine
President, Greene County Medical Society

November 17, 2013

This is in reference to the K&H2 permit application.

Health Effects Associated with Class II Injection Wells (which receive fracking flowback and produced water)

Understanding fracking and its implications for human and environmental health requires time consuming effort. Comprehending the human health issues related specifically to class II injection wells and the fracking flowback and produced fluids they are designed to release into the subterranean environment is likewise complex. I applaud the Athens county commissioners for taking this opportunity to listen, learn, and record the data being presented to you today by citizens from multiple professions.

The extraction of deeply buried methane by processes used today requires the addition of chemicals that are known to have multiple negative health effects including inducing cancer. The toxic water injected under enormous pressure to fracture subterranean rock in natural gas extraction brings back up with it shards of the often radioactive rock it shattered, also laden with elements such as strontium and arsenic that are poisonous or toxic to human health. These compounds will be toxic whether located in water, spilled on the soil by sloppiness or vehicle accidents, or released to the air as a gas such as radon, hydrogen sulfide, or benzene.

Federal legislation in 1988 declared that the produced water from oil and gas exploration was “nontoxic” without divulging any studies on which this claim can be based. I will assume that others will describe to you in more detail the likely radioactivity of the fluids that will be injected into the land under your feet, as well as some of the other toxic compounds that are predicted be present in that fluid.

Many states will not allow the flowback and produced water from fracking to be disposed of within their borders. They have chosen not to expose their geologic formations, their water or their present and future citizens to the potential risks of storing that contaminated water within their borders.

Ohio's politicians of the last 10 years, however, have elected a different course. For example, monitoring for "leaking" or migrating chemicals in nearby freshwater wells and streams is possible, but Ohio's laws do not require monitoring by owners of injection wells or health authorities. Nor in Ohio do neighbors of properties with injection wells have easy recourse should their wells be contaminated.

Currently, most detection of injection well fluid migration is via homeowner wells that have become inadvertent monitoring wells by being contaminated. As an example, the Health Commissioner of Knox County has publicly stated that "**it is a matter of public record**" that **3 private water wells** all adjacent to an injection well in Knox County near Apple Valley Lake **have been found to have water that is unsafe to drink**. The local health department is unable to state publicly a plausible cause for this water contamination, but can unequivocally state that it was not caused by soil contamination as they tested for that.

Let me move from this topic to the important and related topic of the expected health effects of the chemicals thought to be in injection well fluids. While flowback water would contain higher amounts of the fracking chemicals, the produced water waste may contain higher amounts of radiation due to the fact that radium 226 is water soluble.

First, an overview of the health effects of ingesting radioactive water. Drinking water contaminated with radioactive compounds causes **kidney damage** since radioactive compounds are rapidly eliminated in the urine. Additionally it increases the rates of **bladder cancer** in males, **breast cancer** in females and **lung cancer** in both sexes. **Leukemia** increased when groundwater supplies showed an increased total radium concentration exceeding 185 mBq/L. Reproductive toxicity included increased rates of **cleft palate** when concentration of 226Ra was elevated as found in two different studies. A separate study showed adverse effects on **the brain**, and on **reproduction** including estrogenic effects. (Below are quotations from various articles supporting this paragraph as well as footnoted sources.)

Ingested radionuclides are absorbed into the blood ([International Commission on Radiological Protection 2007](#)) and accumulate in specific tissues that they may damage. Of absorbed uranium, 66% is rapidly eliminated via urine, while the rest is distributed and stored in the kidney (12–25%), bone (10–15%), and soft tissue ([Wrenn et al. 1985](#)). Radium deposits mostly in the bone ([Wrenn et al. 1985](#)). Ingested radon gas diffuses into the stomach wall, making the stomach wall the tissue most irradiated by ingested radon because of its short half-life (3.8 days) ([Hopke et al. 2000](#))."¹

Uranium induces chemical toxicity, especially nephrotoxicity, (**Kidney damage**) which is more harmful than radiotoxicity (radioactivity); whereas radium and radon are thought to

¹ Health Effects of Naturally Radioactive Water ingestion: the Need for Balanced Studies, Canu I, et al, [Environmental Health Perspective](#), 2011 Dec: 199 (12):1676-1680. Published online 2011 Aug 2; doi:10.1289/ehp.103224¹

induce solely radiotoxicity ([Wrenn et al. 1985](#)). ...[Bean et al. \(1982\)](#) examined the incidence of various cancer sites in 28 Iowa towns, based on two national cancer survey programs. They found **increased rates of bladder cancer in males, breast cancer in females, and lung cancer in both sexes** in association with increasing ^{226}Ra concentration in community water supplies. ... In contrast, [Lyman et al. \(1985\)](#) specifically focused on **leukemia incidence** in 27 Florida counties. They reported a strong association with the percentage of samples from groundwater supplies that showed total radium concentration exceeding 185 mBq/L in these counties. Potential reproductive toxicity of radium and radon was studied in Harris County, Texas. [Cech et al. \(2007\)](#) reported that rates of orofacial clefts (cleft palates) were significantly higher in administrative areas with ^{226}Ra concentrations exceeding 110 mBq/L than in areas with lower concentrations. Results were similar when the study was repeated in 1999–2002 using updated total radium measurements ([Cech et al. 2008](#)).²

The chemical toxicity of the metal (uranium) constitutes the primary environmental health hazard, with the radioactivity of uranium a secondary concern. The update of the toxicologic evidence on uranium adds to the established findings regarding nephrotoxicity, genotoxicity, and developmental defects. Additional novel toxicologic findings, including some at the molecular level, are now emerging that raise the biological plausibility of **adverse effects on the brain, on reproduction, including estrogenic effects, on gene expression**, and on uranium metabolism.³

Secondly, let us look at some of the volatile organic compounds that are found in flowback water. Benzene, Toluene and Xylene are three that are well known and all are noted in flowback water.

Benzene is a confirmed carcinogen causing blood cancers such as acute and chronic nonlymphocytic leukemia, acute myeloid leukemia, chronic lymphocytic leukemia, anemia, and other blood disorders. Benzene drops lymphocyte counts; this makes people more likely to develop lymphoma. Benzene negatively affects the immune system making people more susceptible to all causes of disease.⁴ Benzene is rapidly and extensively absorbed by inhalation and ingestion. In water the permissible maximum contaminant level is 5 ppb. In air 0.5 ppm is the limit for an 8 hour workday. 2.5 ppm is the inhaled 15 minute ceiling limit.

² Health Effects of Naturally Radioactive Water ingestion: the Need for Balanced Studies, Canu I., et al, *Environmental Health Perspective*, 2011 Dec: 199 (12):1676-1680. Published online 2011 Aug 2; doi:10.1289/ehp.103224² (www.ncbi.nlm.nih.gov > [NCBI](#) > [Literature](#) > [PubMed Central \(PMC\)](#))

³ Health Effects of uranium: New Research Findings, Brugge D., Bucher V., *Rev Environ Health*. 2011; 26(4):231-49.

⁴ McKenzie LM, et al, Human health risk assessment of air emissions from development of unconventional natural gas resources, *Sci Total Environ* (2012), doi: 10.1016/j.scitotenv.2012.02.018

Health effects of **xylene** exposure include difficulty in breathing (from chemical irritation), impaired lung function, and nervous system impairment. Maximum Contamination Level in public drinking water is set at 700 ppb.

Ingestion of **p-xylene** can result in a burning sensation, abdominal pain, dizziness, drowsiness, Headache and nausea. When swallowed it can cause chemical pneumonitis if breathed into the lungs.⁵

Toluene is classed as very toxic. It is teratogenic (causes birth defects) and embryo toxic. When ingested, symptoms include headache, nausea, dizziness, drowsiness and confusion. If swallowed, toluene can be drawn into the lungs causing severe lung damage and death.⁶ Its primary effect is central nervous system depression. In severe exposures it can lead to coma and death. It is also a respiratory irritant and exposure to it increases the chance of cardiac arrhythmias. NIOSH permits inhalation exposures of 100 ppm in an 8 hour day, with maximum 15 minute exposure of 150 ppm. Inhalation Levels of 500 ppm are considered immediately dangerous to life and health. The EPA safe standard for toluene level in water is 1 ppm.

Moving on and summarizing, there are multiple other chemicals found in the flowback and produced water that is transported to Ohio to be placed in Class II injection wells. Regarding the vast array of chemicals that are used in fracking and that thus can come back in flowback fluid, Theo Colburn PhD (an expert in both the effects of environmental chemicals and in endocrine disruption) and her co-authors reported in 2012:

“The technology to recover natural gas depends on undisclosed types and amounts of toxic chemicals. A list of 544 products containing 637 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 kidney. **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 (fracking flowback water) that contained numerous chemicals on the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) and the Emergency Planning and Community Right-to-Know Act (EPCRA) lists of hazardous substances.”⁷

The paragraph above is technical but even to those not familiar with environmental pollution the presence of 637 chemicals is disturbing. Only 353 of those chemicals could be identified by chemical abstract service numbers (CAS) which serve as the exact

⁵ .wikipedia.org/wiki/P-Xylene. National Institute of Occupational Safety & Health. Retrieved 12 Feb 2013.

⁶ Canadian Centre for Occupational Health & Safety. www.ccohs.ca/oshanswers/chem_profiles/toluene.html accessed 9/16/13

⁷ Colburn T, Kwiatkowski C, Schultz K, et al. Natural gas operations from a public health perspective. Hum Ecol Risk Assessment: An International Journal, 17:5, 1039-1056.

identification by which chemicals can be looked up to ascertain what their properties are including a summary of their effects on people.

What of the other 284 chemicals? The researchers were apparently unable to identify those chemicals by CAS number. If you do not know exactly what a compound is, it makes it impossible to determine its health effects. If these researchers were unable to assess the other 284 chemicals, busy doctors are unlikely to have better success.

As a physician, one of my concerns is the fact that there are numerous chemicals to which flowback fluid exposes people simultaneously. The problem with simultaneous exposure to multiple chemicals is twofold.

First, our toxicity data was developed by exposing animals to only one chemical at a time. Recent research shows that when exposed to 3 or more chemicals simultaneously, animals become ill or toxic at much lower levels of the chemicals. They do not have to be exposed to the higher level that was considered "toxic" previously (from exposure to just one chemical) to become ill or to die. A much lower level of exposure from each of the chemicals will give toxicity if they are exposed to three chemicals at simultaneously.

Second, because I understand the part cytochromes play in helping humans clear toxic substances from their body, I believe that the exposure to multiple chemicals simultaneously in injection well fluids represents an increased public health risk.

We clear toxic substances (remove them from our body) largely through the cytochrome system of enzymes. While there are over 50 cytochrome systems in the body, only 4 of those cytochromes clear most of the medicines in use today. Unfortunately for us, it appears that the hydrocarbons produced in the fracking flowback that becomes injection well liquid are cleared by just 3 of these same 4 cytochromes. Thus, if we are exposed simultaneously to multiple chemicals from flowback whether by inhalation or ingestion it represents a significant danger.

Think of it this way: the cytochromes are like toll booths on an interstate. Think of the chemicals all in various trucks rolling down the wide interstate of our bloodstream. Unfortunately, when they come to tollbooths (the cytochromes), they all have to form into just 3 lines to get through the tollbooths. With this many chemicals, they get backed up even though our body is trying to get rid of them. When they back up, they give us chemical overload symptoms. The longer the exposure, the more damage is caused. Eventually repeated high dose exposures or even lower dose chronic exposures can give us disabling syndromes or cancer.

The concluding parts of the quote from Dr. Colborn et al. above mention that many of these chemicals "have long-term health effects that are not immediately expressed." The lag between exposure and the development of pervasive disease such as cancer, asthma, Parkinson's disease, or seizures (to name just a few) is one of the things that complicates establishing conclusively that any given industry or process has harmful

elements. It is partly because of this difficulty that in the past our nation has established laws regulating industries and other pollution sources, preferring to err on the side of caution in order to attempt to protect people from potential harms. The CERCLA law and the EPCRA laws were written to try to provide reasonable standards for corporations and other businesses that would allow them to continue to do business but that also attempted to protect innocent people who lived nearby or 'downstream'. The presence in injection fluids of so many chemicals found on the EPCRA and CERCLA inventories is a sobering reality.

Finally, let us look at the endocrine disruptors found in flowback and produced fluids.

First the definition of an endocrine disruptor:

From National Institute of Health: **Endocrine disruptors** are chemicals that may interfere with the body's endocrine system and produce adverse developmental, reproductive, neurological, and immune effects in both humans and wildlife. A wide range of substances, both natural and man-made, are thought to cause endocrine disruption. Research shows that endocrine disruptors may pose the greatest risk during prenatal and early postnatal development when organ and neural systems are forming. <http://www.niehs.nih.gov/health/topics/agents/endocrine/>, accessed 11/17/13.

From Wikipedia: **Endocrine disruptors** are chemicals that at certain doses can interfere with the endocrine (or hormone system) in mammals. These disruptions can cause cancerous tumors, birth defects, and other developmental disorders. Any system in the body controlled by hormones can be derailed by endocrine disruptors.

Specifically, endocrine disruptors may be associated with the development of learning disabilities, severe attention deficit disorder, cognitive and brain development problems; deformations of the body (including limbs); breast cancer, prostate cancer, thyroid and other cancers; sexual development problems such as feminizing of males or masculine effects on females, etc. The critical period of development for most organisms is between the transition from a fertilized egg, into a fully formed infant. As the cells begin to grow and differentiate, there are critical balances of hormones and protein changes that must occur. Therefore, a dose of disrupting chemicals may do substantial damage to a developing fetus (baby). The same dose may not significantly affect adult mothers http://en.wikipedia.org/wiki/Endocrine_Disruptors, accessed 11/17/13.

It has been noted and published in multiple sources (Including TEDX, The Endocrine Disruption Exchange) that fracking flowback fluids contain endocrine disruptors.

Suffice it to say that endocrine disruptors can change development in utero, in children, and teens. Infants and children in particular are still undergoing rapid neurological development. Teens are particularly vulnerable to any chemical exposure during or immediately after the onset of puberty. Endocrine disruptors can also have significant negative effects on adult endocrine systems such as the male hormone system, the

female hormone system, bone metabolism, the thyroid hormone system, or glucose metabolism.

Chemicals in injection fluids that serve as endocrine disruptors can alter or disrupt any one of the exquisite endocrine systems of our bodies at any age, and many of the changes so initiated are not reversible. Worse, the damage or changes may not become obvious at the time the exposure happens, but may only become evident 2-20 or more years later.

Madeline Finkel, PhD, a public health official and Adam Law, M.D., an endocrinologist wrote in 2011:

“Hydrofracking fluid and flowback fluids contain candidate **endocrine disruptors**, but because of the lack of disclosure by the drilling companies of the individual chemicals with their unique Chemical Abstracts Service registry numbers used in fracking fluids, it is difficult to truly assess their potential adverse effects, and so the cumulative exposure impact is not known.”^[8]

In conclusion, no informed community should be happy at the prospect of having a class II injection well in its midst. Why would people want to have so many toxic chemicals placed into their underground environment? Exposure to the chemicals in the flowback water and produced water from the fracking process has many negative health consequences as I have outlined. An intelligent, knowledgeable community would not voluntarily risk their health, their children's health and that of future generations by permitting this fluid to be stored in their midst.

Thank you for considering this testimony from an experienced family physician who is genuinely concerned about the health of those living in my home state. I would urge that precautions be taken to prevent exposing any in your community to long term storage of this toxic water in the form of injection wells. Prevention is 100% effective in protecting the public from these dangerous substances. Repair after something goes wrong is much less certain.

⁸The Rush to Drill for Natural Gas: a Public Health Cautionary Tale, Finkel M. & Law A., American Journal of Public Health, 2011 May; 101(5):784-5. doi: 10.2105/AJPH.2010.300089. Epub 2011 Mar 18

— — — — —
Other references for the concerned:

Diamanti-Kandarakis E, Bourguignon JP, Giudice LC, et al. Endocrine disrupting chemicals: an Endocrine Society scientific statement. *Endocr Rev.* 2009;30(4):293–342.

Witter R, Stinson K, Sackett H, et al. Potential exposure-related human health effects of oil and gas development: a literature review. Available at: http://docs.nrdc.org/health/files/hea_08091702c.pdf

Goldstein BD. The precautionary principle also applies to public health actions. *Am J Public Health.* 2001;91 (9): 1358–1361