From: Sandy Podulka
To: Ed Hanlon, US EPA
Date: 4/6/10
Subject: Comments on Scope of US EPA Hydraulic Fracturing Research Plan

I appreciate this opportunity to comment on the Scoping Materials for Initial Design of EPA Research Study on Potential Relationships Between Hydraulic Fracturing and Drinking Water Resources ("Scoping Materials").

I present the perspective of an individual who has a tremendous amount at stake with respect to gas drilling. As a landowner with 100 acres over the Marcellus shale of New York, I could make a great deal of money in a signing bonus (at roughly $5,000/acre) right now and potentially some royalties in the future. But, I have spent the last year, full-time, researching this issue and have come to the conclusion that shale gas drilling by hydraulic fracturing (HF) greatly endangers the health of people and our environment, as well as damaging communities economically and socially. In my county, approximately 6% of the adult population holds a gas lease, and thus could reap great financial benefits, yet 100% of the population will be affected by the environmental, health, and other costs. Because gas drilling is exempt from zoning laws in New York, communities cannot determine if and where drilling will occur. It was not easy to find solid scientific information on the impacts of shale gas drilling, so I welcome the EPA study and wish all the scientists involved much luck in tackling this very complicated but important issue.

Because many of my neighbors have signed gas leases, by New York law I am likely to be forced into a drilling unit and to have, against my will, toxic chemicals injected at high pressure underneath my home, my property, and the aquifer that supplies my drinking well.

I have lived in this area for 34 years and I love it. I love the rolling hills dotted with wild areas and farms, the clean air and water, and the community. I have developed a system of nature trails on my property, and my husband and I planned to live here for the rest of our lives. But, I value the health of my family, including my 11-year-old daughter, even more, and so if I feel a great threat from the looming gas drilling, we will have to move, reluctantly.

I am a biologist, not a geologist or engineer, so cannot comment heavily on technical aspects of this issue. But I have thought a great deal about the ethics of the issue, and how to frame questions whose answers will be useful to policy-makers and the public. I hope the EPA will consider these aspects of its study.

Defining the Scope of the EPA Study

The Relationship Between Hydraulic Fracturing and Drinking Water

Congress has urged the EPA to study "the *relationship* between hydraulic fracturing and drinking water." Although many in the gas industry have suggested, and more are certain to suggest, that the scope of this study be narrowly restricted to just the *effect* of hydraulic fracturing (HF) by itself on drinking water, that is not what Congress has indicated by asking that the *relationship* be investigated. Even if HF, by itself, does not cause drinking water contamination (and I would disagree with that assertion), it can still have a relationship with it, such that, for example, wherever HF occurs, drinking water becomes contaminated. "Why does that relationship exist?" is clearly a valid question within the scope of what Congress has asked.

As an example, consider downhill skiing. The ski industry, wishing to build a series of ski resorts in a remote area, could argue (loudly and repeatedly) that skiing has absolutely no effect on the environment or public health, because someone zooming down the hill on skis is not polluting air, land, or water or causing habitat destruction. Although technically that might be a true statement (ignoring the

potential damage to individual trees hit by skiers and a small amount of soil erosion from skiing over bare or slushy patches), it clearly does not address the impact of bringing skiing into that area. It ignores massive soil erosion from clearing slopes; air pollution from combustion engines of construction, slope manicuring, and snowmaking equipment; carbon dioxide generated in producing the electricity to run the lifts; and increased traffic in the remote area during both construction and operation of the facility. Any responsible and serious study of the impact of skiing would look at the building and operation of the ski resort, and not just the skier heading downhill.

So, too, must a realistic study of the impacts of HF look at the gas extraction process that *always, and without exception*, accompanies HF. In the Marcellus shale, this extraction process includes not only the actual HF (high-pressure underground injection per well per fracturing of an *average* of 5.6 million gallons[1] of fresh water mixed with 205,000 to 935,000 pounds[2] of chemicals--including benzene, formaldehyde, kerosene, naphthalene, and hydrochloric acid—many of which are highly toxic and some of which are known carcinogens[3, 4, 5]), but also clearing well pads of 3 to 5 acres upon which 6 to 8 or more wells are located and building access roads, pipelines, compressor stations, and chemical storage and processing facilities.

Furthermore, *for every well drilled and fractured*, drilling muds (more chemicals) are used and 94 cu yards (assuming a well 3,000 feet deep) of drill cuttings (contaminated and radioactive to some degree) are produced[6] and must be disposed of. In NY, depending on their level of contamination, the cuttings may be buried on site or taken to a landfill: in both cases, this volume of hazardous waste may impact drinking water by moving down through the soil into groundwater or by being carried by runoff into reservoirs.

HF-Generated Air Pollution and Drinking Water

The large amounts of air pollution generated by HF activities (including the evaporation of used toxic hydraulic fracturing fluids from open flowback pits,[7] and the use of diesel and other engines during construction, drilling, and trucking, and at compressor stations and processing facilities) can certainly affect drinking water in at least two ways: (1) air pollutants can settle directly onto drinking water reservoirs, or onto land and streams, and be carried into reservoirs, and (2) rain can carry the pollutants to the ground, where they can soak into groundwater sources of drinking water (not all of the toxins can be biodegraded by soil bacteria).

The amount of air pollution generated per well is not insignificant (for example, each well drilled and hydraulically fractured requires about 1,700 to 1,900 tanker truck trips for bringing in workers, equipment, water, and chemicals, and removing wastes.[8]), but the amount of air pollution generated over a region experiencing HF could be staggering. Because of the large investment in equipment and infrastructure (pipelines, compressor stations, storage facilities for chemicals, and so on) required to economically extract gas by HF, gas companies prefer to develop shale gas intensively, with hundreds to thousands of wells in a local area. The recent prediction of there being a 50% chance of 17 trillion cubic feet of gas being produced over 5 years from the Marcellus Shale of NY[9] assumes a well pad every square mile with 8 wells per pad over 70% of the most productive part of the Marcellus shale. This scenario predicts 2,600 wells for my county, Tompkins, alone.[10] This adds 4.4 to 5 million tanker truck trips, as well as 7 billion gallons of toxic flowback fluid and 244,000 cu feet of drill cuttings requiring disposal over five years for just a single county.

Thus, to fully understand the impacts on drinking water, the EPA must also look at airborne pollutants created by HF.

Global Warming and Drinking Water

Some may argue that the effect of gas extraction by HF on global warming is not relevant to drinking water, but that is not true. Global warming, as most people know, via the thermal expansion of sea water and the melting of the ice caps, will cause a rise in sea level. As oceans rise, salt water will move inland, causing salinization of some fresh water resources, including aquifers and reservoirs for

drinking. Furthermore, a hotter global climate can presumably accelerate evaporation of drinking water reservoirs, and, depending on wind patterns, cause local changes in water availability. This is not my area of expertise, but I believe this relationship merits consideration and analysis.

Therefore, the degree to which natural gas extraction and use contributes to global warming should be part of the scope of this study. Through good PR by the gas industry, many people have been led to believe that natural gas is a cleaner source of energy than coal and oil. When considering only the burning, natural gas does release less carbon dioxide per BTU produced than coal or oil. But until fossil fuels appear magically before us ready to be burned, the effects of their extraction, processing, and disposal must also be taken into account when comparing their effects on global warming. Currently I am aware of no science-based, peer-reviewed research analyzing and comparing the life cycles of the different fossil fuels as to their contribution to global warming (and other environmental and health risks). The EPA study should include these life cycle analyses and comparisons.

A preliminary analysis by Robert Howarth[11] at Cornell University, however, estimates that when the effects of combustion, production, distribution, and leaked methane from hydraulically fractured natural gas are considered, per million joules of energy generated, natural gas contributes greenhouse gases that are approximately the equivalent of those emitted by coal, and significantly more than those from diesel or gasoline.

Other Effects Intrinsically Tied to HF

I strongly support the ideas in the Scoping Materials suggesting that the scope include impacts on public health and other aspects of the environment besides drinking water contamination. I also support the suggestions that the impacts of the entire HF lifecycle be researched: HF *never* occurs by itself, so narrowing the study to just the effect of HF would have no real-world meaning, and it would be ludicrous to base policy decisions on that alone.

There appears to be no other existing or proposed large-scale, science-based, non-industry-funded study of the impacts of gas extraction by HF on health and the environment by which federal and state policy may be guided. Thus, decision-makers are likely to rely heavily on the results of this EPA study. To focus narrowly on HF and drinking water and ignore the other impacts of gas extraction that are inseparable from the HF process puts policy-makers in the position of a blind man and an elephant.

The IPAA and Energy in Depth, whose members hope to profit greatly from gas extraction and desire as few regulations as possible, have argued that this study be framed around asking if existing "regulatory structures effectively manage the environmental risks of the fracturing process." I agree that this is an important topic to research. These industry groups, however, would have the EPA analyze state regulations for their theoretical effectiveness and rely on self-reporting by state agencies as to how successful they have been. There are several problems with this approach. (1) State agencies have a self-interest in underreporting problems, and often do not even gather data on many environmental and health effects of hydraulic fracturing operations. In New York alone, Toxics Targeting has reported many cases of drinking water and other environmental contamination due to oil and gas operations that were not reported by the state or that were not mentioned in summaries of regulation success by the state.[12, 13] (2) Many states are making a great deal of money by the leasing of state lands, and so have a conflict of interest with respect to gas drilling.

Furthermore, I would argue strongly that the best way to determine if state regulations are working is to examine the environment around gas drilling operations. This does not require guesswork or predicting the future, and does not rely on the reports of agencies with a vested interested in underreporting problems. The evidence should speak for itself. If the gas industry truly believes that its operations are benign and no risk to the environment or public health, they should welcome a science-based study to prove that they are correct. The harder an entity fights to prevent the gathering of science-based facts about its actions, the closer scrutiny its actions must require.

Framing the Research Questions

The Scoping Materials mention a need to "characterize and manage risks associated with HF activities," but I would prefer to frame this differently. I see two critical questions to be addressed in order to guide policy on gas extraction by HF:

(1) How much risk to health and environment is acceptable before we say "No" ?

(2) Can we learn enough about health and environmental effects—especially the effect on drinking water—to allow HF to proceed at this point? In other words, can we assess the risks thoroughly enough, and with enough confidence, to allow consideration of Question #1?

Question #1 is probably beyond the scope of the EPA study, although I would be happy to have the EPA address it. Question #2, however, must be considered the main purpose.

There are a multitude of excellent research questions on HF suggested by the Scoping Materials, but one key way to prioritize is to always keep in mind the above two questions, and which research questions will best allow solid answers to Question #2. I think it is likely that the answer to Question #2 in "no" at this point, without longer-term study, but that remains to be determined. All research should remain focused on this ultimate question. In this respect, it is even more important to keep track of what we do not know, than to compile exhaustive lists of every detail that we do know, especially with respect to mitigation of adverse affects. Mitigation of problems is extremely important, but could be done as smaller-scale research targeting specific problems, requiring smaller amounts of money, and therefore may not be the best use of the EPA's resources. Few researchers have the ability to address the larger picture—that is what we need the EPA to do. *We need the EPA to give us a clear understanding of the known risks being taken with gas extraction by HF and the magnitude of the known risks, and an honest appraisal of the unknown risks.*

If the US policy-makers are to keep the best interests of the citizens in mind—which is their duty--and not just profit-making by large (often multi-national) corporations, they must apply the precautionary principal. The policy-makers need the EPA's help to be able to do this. Because there is so much misinformation out there, so much money at stake, and such great potential for environmental and health devastation, this study must be done carefully and must be beyond reproach.

The Scoping Materials read as though a decision has already been made that gas extraction by HF is acceptable, and the EPA's job is to determine the details of mitigation and methodology that produce the least objectionable results. I would like to reframe the research to address the bigger question: do we know enough to be able to prove that gas extraction by HF is safe? This study needs to have a way for one possible valid outcome to be the answer "No." In any viable long-term scenario for the survival of humans on this planet, water is likely to become a more valuable resource than natural gas.

(A) Characterization of the Hydraulic Fracturing Lifecycle

In discussing and researching HF and its impacts, it will be important to distinguish between traditional HF and the current techniques used to extract gas from shale, such as the Barnett and the Marcellus. Traditional HF, developed by Halliburton in the late 1940s, has been used for years. It is sometimes even used to stimulate flow from shallow water wells. The gas industry is fond of saying that HF is an old, tried, and tested technique, and nothing to worry about. Therefore, I think the EPA needs to be very clear to come up with a term that refers to the new type of HF.

The type of hydraulic fracturing that I assume that the EPA intends to study, used to extract shale gas, was developed in the late 1990s and goes by various names. It may be called "slickwater hydraulic fracturing" because it uses a different mix of chemicals than the older methods, "high-volume" hydraulic fracturing (HVHF) because it uses much more fluid, and "multi-stage" because a series of fracking events

are used along the pipeline. Although I refer to the newer type of hydraulic fracturing, I have used HF throughout these comments, to be consistent with the Scoping Materials.

(B) Potential Relationships to Drinking Water Resources

Please see my comments under "Defining the Scope of the EPA Study."

I would like to see a study designed to ask the question, "Can we prove that gas extraction activities that include HF do not harm drinking water?" It is very easy to not find evidence of harm, and to conclude that something is safe, but this is not good science. The EPA standard should be to design studies that, within a standard level of confidence, prove or disprove the hypothesis that gas extraction activities involving HF do not harm drinking water.

If it is found that there is some risk, then an effort should be made to quantify that risk, so that policy-makers and the public can make informed decisions about whether or not to allow gas extraction by HF. For example, the public needs to know, at the realistic level of development that accompanies HF, how many private and public water supplies are likely to be contaminated, and how many people will get cancer and other diseases through water. Other important questions are "What is the chance that water contamination will go undetected?" and "In what ways, if any, can contaminated water be cleaned up, and at what cost?"

I hope that several important missing data sets may be filled in by authority of the EPA. One is the secrecy surrounding which chemicals are put down particular wells during HF. If the EPA has access to that data, researchers should be able to do large-scale testing of drinking wells, aquifers, and reservoirs surrounding a number of gas wells for every chemical used, as well as methane. A second missing piece of data is the stories of people whose drinking wells have been contaminated and who have made deals with the gas industry that include gag orders not to talk about their negative experiences. EPA access to these people's stories could provide valuable information on the effects of gas extraction using HF on drinking water.

An important reference for the effect of gas drilling on drinking water is by Thyne.[14]

(C) Potential Health and Environmental Risks

As in (B), I think the study should stay focused on answering the question, "Can we prove that gas extraction activities that include HF do not pose any risk to public health or the environment?" and if not, should strive to quantify the risks. What is the risk that people will get cancer or other diseases due to air pollution generated by gas extraction using HF? The people taking the risks need to know what those risks are, before they can determine if they are acceptable. There is not much information in the scientific literature on the health effects of gas drilling, but two references by Witter may be useful[15, 16] as well as a recent study in the New England Journal of Medicine on the health effects of long-term exposure to low levels of ozone.[17]

The suggested strategy of setting both short-term and long-term goals is excellent. Over the short term, I hope the EPA will focus on gathering data from people and environments that have been exposed to the impacts of gas extraction by HF for a few years. I hope that studies will also be initiated to track the health of people, the quality of drinking water sources, and other environmental assets (such as air quality and soil quality (lack of compaction and erosion)), over the longer term.

In particular, there seems to be a lack of data on the amount of air pollution generated and its effects on health. The effect of noise from gas extraction (traffic, drilling, HF, and compressor stations) on people's health and quality of life has been virtually ignored in the scientific literature, and also should be examined.

Several environmental justice issues are important to note. (1) Pollution of air and water will not affect everyone equally. Large landowners who make a lot of money from leasing may be able to leave the area and not have to face health problems or degradation of the local environment and community. Thus, people who rent or own little land may be affected disproportionately. (2) Currently, people who own a lot of land (or in some areas, mineral rights but not land) are allowed to determine whether or not

gas development occurs, by their choice of leasing. As discussed in (1), these are not the people likely to be most impacted. Shouldn't the people taking the risk be able to determine what is acceptable? The EPA could look at patterns of people leaving after leasing land, and who is most likely to suffer ill effects, and attempt to advise policy-makers of ways to right the potential environmental injustices.

Approach for Compiling Background Data and Information

The Scoping Materials state that one problem is the limited number of peer-reviewed, science-based research studies on the effects of gas extraction by HF. Again, one goal of the EPA must be to decide if enough is known for us to continue allowing HF. If not, a perfectly valid conclusion, applying the precautionary principal, is that we should wait until enough is known to make an educated and responsible decision.

The Scoping Materials bring up another key point: "Lack of validated and consistent data on chemicals and their concentrations may make it difficult to assess impacts from existing sites." If there is not enough data after 10+ years of gas extraction by HF to assess its impacts, then the EPA must fall back on one or more of the following: (1) we must apply the precautionary principal and not allow HF to continue until enough data can be gathered to determine its safety, even if this takes longer than the time-frame currently set for this study, (2) if data is not sufficient to determine the exact causes of problems at specific well sites, then a broader set of data must be considered to analyze the general patterns of health problems and environmental contamination as they relate to gas extraction activities, (3) major changes must take place in the secrecy surrounding chemicals used, the lack of diligence in testing water and air, and the recording of spills, accidents, and contamination incidents before using HF can even be considered in the future.

Initial Approach for Stakeholder Involvement

Congress has requested a "credible approach," relying on "the best available science, as well as independent sources of information." To be credible, the EPA study must not rely on data or reports from entities with a large financial interest in gas drilling. This includes the gas industry and groups, such as the Ground Water Protection Council, that are closely associated with the industry or whose major clients are the gas industry. Likewise, many state governments make a great deal of money by leasing to the gas industry, and many state agencies are composed of people from the gas industry.

In terms of stakeholders, this is an issue with two fairly clear opposing sides: pro and anti-drilling. On the pro side are gas industry investors, large gas corporations and large landowners who wish to lease, and some small landowners and others who hope to benefit from increased industrial activity. Opposing them are people who are concerned about health, environmental, and social issues, some large environmental groups (although these are divided), and many "average" people with little power or influence. In order to "design a stakeholder process that provides for balanced input in developing a sound scientific approach for the overall research strategy" the EPA will need to be sure people on both sides of this issue have equal access to the SAB panel and EPA officials. In general, this is not the case in Washington, D.C. as money translates to access, and money is enormously skewed toward the pro-drilling side of this debate. If input is to be truly balanced, the EPA will have to work very hard to overcome this inherent bias.

As one example, the Scoping Materials were up for 11 days before the comments were due. This greatly favors organizations with a lot of money and personnel over people who are reading and commenting on this material after work and on a non-professional basis. Giving more time and more broad notice might have helped to overcome this bias. I use this example mostly to illustrate a principle,

and not to complain, because I am happy to see the study moving along at a rapid rate! Once stakeholders are identified, it would be extremely helpful to communicate via mail or email, and not simply by posting notices in the Federal Register. The gas industry has many staff paid to monitor such news, but the average person does not, so this would further contribute to the existing bias. Because stakeholders are spread throughout the country, it also would be extremely helpful to use the EPA's regional offices for outreach. Every meeting held in Washington, D.C., where large corporations, investors, and other people with more than the average amount of money and power have greater access, contributes more to the existing bias.

Congress has also asked that the EPA "consult with appropriate State ..... regulatory agencies," and I would like to suggest caution with this approach. I have already listed many of my concerns with state agencies in paragraph three under "Other Effects Intrinsically Tied to HF." In addition to that I would suggest that the EPA be careful, if using data from states, to ask not just what data on problems that they have found, but how they collected the data and what, specifically, they did and did not look for, what the reporting requirements are, and whether or not they relied on self-reporting by industry.

As an example of misleading information from states, consider the data on chemicals used in hydraulic fracturing provided by the New York Department of Environmental Conservation in its draft Supplemental Generic Environmental Impact Statement (dSGEIS) on shale gas drilling in the state. The dSGEIS states that many health effects of the chemicals to be used in HF in the state are not known (pp. 5-61 and 5-64). Furthermore, there are 45 products to be used for which DEC has incomplete ingredients (dSGEIS, Table 5.4) and 40 compounds whose ingredients are unknown because they are mixtures (dSGEIS p. 5-34). Nevertheless, the DEC concludes that there are no "potential exposure situations associated with horizontal drilling and high-volume hydraulic fracturing that are qualitatively different from those addressed in [a 1992 document called the GEIS]." The GEIS does not address health effects of hydraulic fracturing chemicals.

Conclusions

I realize that many of my suggestions involve ethical issues, something many scientists shun. But, I ask the scientists involved to seriously consider the ethics of this issue as they decide the scope and tenor of the study and carry out the research, because they will have the most thorough knowledge of the subject and thus will be in the best position to make judgments. I wish things were different, but I see little evidence that politicians pay much attention to science or ethics. Someone must do this, and I fear that if researchers do not attempt to interpret their findings and place them in an ethical context, no one else will. A consideration of the most effective and widely respected scientists of our day, will, I think, bring to light the fact that they are the people who communicate well with the public and who are not afraid to tackle ethical issues.

This EPA study is extremely important, but no matter how severe the health and environmental effects unearthed, I expect they will still be weighed by politicians against the perceived economic and energy supply benefits. This other half of the equation lacks as much solid scientific research as the health and environmental effects, and thus this research must be accompanied by a sister study that truly and carefully analyzes the net economic effect and the effect on energy supply and our future ability to kick the fossil fuel habit. My reading has lead me to the conclusion that shale gas drilling with HF brings net economic costs to the average person (see Headwaters study[18]), does not contribute to energy security (see p. 10 in Krueger[19]), and will merely delay our vital and inevitable switch to fossil fuels. In the future, water will surely be a much more valuable resource than natural gas.

References

[1] Water Use in Marcellus Deep Shale Gas Exploration: Fact Sheet, March 2010. Chesapeake Energy Corporation. http://www.chk.com/Media/MarcellusMediaKits/Marcellus_Water_Use_Fact_Sheet.pdf

[2] The typical percentage of chemicals in hydraulic fracturing solutions for the Fayetteville Shale is reported as 0.44% by weight (SGEIS, Section 5.4.3, p. 5–44). 0.44% by weight of 5.6 million gallons is 205,000 lbs. (water weighs 8.34 lb./gallon). The SGEIS also states that chemical additives typically comprise 2% or less of the fracturing fluid (Section 5.4, p. 5–33). 2% by weight of 5.6 million gallons is 905,000 lbs.

[3] The Endocrine Exchange (TEDX) has done much ground-breaking work in identifying chemicals in fracking fluid. An Excel spreadsheet with data on the chemicals they have identified and their health effects is at http://www.endocrinedisruption.com/chemicals.fracturing.php

[4] Berkowitz, M. November 2009. "Toxic Chemicals on Tap: How Natural Gas Drilling Threatens Drinking Water." Environment America Research and Policy Center Publication. http://www.environmentamerica.org/uploads/4f/e0/4fe0dcbda2ad62ab03a8440346c90cd8/AME-toxics-report-final-lo-res.pdf

[5] For a partial list of chemicals approved for use in NYS, see: New York State Department of Environmental Conservation. September 2009. "Draft Supplemental Generic Environmental Impact Statement On The Oil, Gas and Solution Mining Regulatory Program" (dSGEIS), Section 5.4.3, pp. 5–44 through 5–51. http://www.dec.ny.gov/energy/58440.html

[6] New York State Department of Environmental Conservation. September 2009. "Draft Supplemental Generic Environmental Impact Statement On The Oil, Gas and Solution Mining Regulatory Program" (dSGEIS), p. 5-29. A vertical well drilled 7,000' deep generates 125 cubic yards of cuttings, but the average Marcellus shale well in NY will be shallower (dSGEIS p. 4-19, map). A typical well 3,000' deep would generate 54 cu. yds. of drill cuttings (scaled down from 7,000' and 125 cu. yds.). A 3,000' horizontal extension adds 40 cu. yds. of cuttings (dSGEIS p. 5-30). Thus total cuttings are 94 cu. yds.

[7] The NYS dSGEIS, p. 7-88, indicates the extent to which evaporation from flowback impoundments can contribute to air pollution: "It is also determined that these larger off-site impoundments [of flowback] have the potential to qualify as a major source of Hazardous Air Pollutants (HAPs) due to certain chemicals."

[8] HF one well one time requires about 1,540 tanker truckloads of water and waste, assuming 5.6 million gallons of water are used, truck capacity is 5,460 gallons, and half of the fracking fluid comes back out (estimates vary widely from 15% to 70%). This estimate of tanker truck size is based on road sizes and conditions in the Southern Tier of NY. Trucks could be somewhat larger or smaller, affecting the numbers of trips. 220 to 364 more trips are needed to bring in equipment, materials, and employees. [Moss, K. "Potential Development of the Natural Gas Resources in the Marcellus Shale." National Park Service Geologic Resources Division. http://blogs.cce.cornell.edu/gasleasing/files/2008/12/grd-m-shale_12-11-2008_view.pdf]. So, assume 1,760 to 1,904 trips to build, drill, and HF one well.

[9] Engelder, T. 2009. Marcellus 2008: Report Card on the Breakout Year for Gas Production in the Appalachian Basin. *Fort Worth Basin Oil & Gas Magazine*, August 2009.

[10] The total land area of Tompkins County is 305,250 acres. 70% of this is 213,675 acres. Assuming a well pad with 8 wells every square mile (640 acres) results in 2,600 wells.

[11] Jon Hurdle, April 1, 2010, "Fracking Not a Cleaner Alternative: Cornell Prof," in *Planet Ark*. http://planetark.org/wen/57405

[12] Toxics Targeting Letter to DEC Commissioner Grannis, April 2, 2010: http://www.toxicstargeting.com/MarcellusShale/documents/dec-letter

[13] Toxics Targeting Letter to NY Governor Paterson, November 9. 2009. http://www.toxicstargeting.com/MarcellusShale/coalition_letter

[14] Thyne, G. December 20, 2008. "Review of Phase II Hydrogeologic Study." (Report prepared for Garfield County, Colorado.) http://s3.amazonaws.com/propublica/assets/methane/thyne_review.pdf

[15] Witter, Roxana, et al. Sept. 15, 2008. "Potential Exposure-Related Human Health Effects of Oil and Gas Development: A White Paper." http://www.catskillcitizens.org/Gas_Drilling_health_2.pdf

[16] Witter, Roxana, et al. August 1, 2008. "Potential Exposure-Related Human Health Effects of Oil and Gas Development: A Literature Review (2003-2008)." http://www.ccag.org.au/images/stories/pdfs/literature%20review%20witter%20et%20al%202008.pdf

[17] http://content.nejm.org/cgi/content/full/360/11/1085 New England Journal of Medicine 3/2/09 Report on Mortality Effects of long-term Ozone exposure

[18] Headwaters Economics. 2009. "Fossil Fuel Extraction as a County Economic Development Strategy: Are Energy-focusing Counties Benefiting?" http://www.headwaterseconomics.org/energy/HeadwatersEconomics_EnergyFocusing.pdf

[19] Krueger, Alan B. October 15, 2009. Remarks at *American Tax Policy Institute Conference*, Washington, DC. http://www.ustreas.gov/offices/economic-policy/AK-ATPI-1015.pdf

Thank you for considering these comments,

Sandy Podulka