Comments regarding the air quality permit from the VDEQ State Air Pollution Control Board for an Atlantic Coast Pipeline Compressor Station

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Shale gas development has the potential to cause adverse health impacts.[1] But due to a set of exemptions this industry received from key federal public health laws[2], these health issues have only recently begun to come to light.[3]

Reports of ill health in impacted people became evident over recent years, despite the lack of involvement from federal and state public health and environmental departments. Lists were generated by activists (List of the Harmed)[4] and surveys compiled (Earthworks' Survey of Health Impacts)[5]. A Health Impact Assessment[6] started in Battlement Mesa Colorado showed that air pollution was a stressor and particularly significant. And there is still no mechanism in place to monitor or track the health and environmental impacts from gas drilling operations, including the economic costs.

In 2012 Congress commissioned a report[7] which found that accidents happen and violations occur in this industry frequently, and even the best regulations have not prevented environmental disasters.

Physicians, Scientists and Engineers for Healthy Energy published an analysis of the peer-reviewed literature in 2015. Their results, as of 2015, indicated that at least 685 papers have been published in peer-reviewed scientific journals that are relevant to assessing the impacts of unconventional natural gas development (UNGD). 84% of public health studies contain findings that indicate public health hazards, elevated risks, or adverse health outcomes; 69% of water quality studies contain findings that indicate potential, positive association, or actual incidence of water contamination; and 87% of air quality studies contain findings that indicate elevated air pollutant emissions and/or atmospheric concentrations.[8] [9] There are, as of today, 1565 peer-reviewed studies on fracking in the PSE for Healthy Energy ROGER database.[10]

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[1] Shonkoff et al. April 2014. Environmental Public Health Dimensions of Shale and Tight Gas Development. EnvHealthPerspectives. Access at: http://dx.doi.org/10.1289/ehp.1307866

[2] http://www.ewg.org/research/free-pass-oil-and-gas/oil-and-gas-industry-exemptions

[3] Rabinowitz et al. Sept 2014. Proximity to Natural Gas Wells and Reported Health Status: Results of a Household Survey in Washington County, Pennsylvania. EHP. Access at: http://dx.doi.org/10.1289/ehp.1307732

[4] http://pennsylvaniaallianceforcleanwaterandair.wordpress.com/the-list/

[5] Steinzor, N, et al., Investigating Links Between Shale Gas Impacts and Health through a Community Survey Project in Pennsylvania, New Solutions, Vol. 23(1) 55-83 (May 2013). Access at: http://www.earthworksaction.org/files/publications/SteinzorSubraSumiShaleGasHealthImpacts2013.pdf

[6] Witter R, et al, Battlement Mesa HIA 2011 http://www.garfield-county.com/environmental-health/battlement-mesa-health-impact-assessment-draft2.aspx

[7] http://democrats.naturalresources.house.gov/sites/democrats.naturalresources.house.gov/files/2012-02-08_RPT_DrillingDysfunction.pdf

[8] http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0154164

[9] https://www.psehealthyenergy.org/our-work/publications/archive/the-science-on-shale-gas-development/

[10] https://www.psehealthyenergy.org/our-work/shale-gas-research-library/

Concerned Health Professionals of New York just completed the fifth edition of a compendium on the risks and health impacts of fracking.[11] The Compendium of Scientific, Medical, and Media Findings Demonstrating Risks and Harms of Fracking (the Compendium) is a fully referenced compilation of the evidence outlining the risks and harms of fracking. It is a public, open-access document that is housed on the websites of Concerned Health Professionals of New York (www.concernedhealthny.org) and Physicians for Social Responsibility (www.psr.org). For this fifth edition of the Compendium, as before, we collected and compiled findings from three sources: articles from peer-reviewed medical or scientific journals; investigative reports by journalists; and reports from or commissioned by government agencies. Peer-reviewed articles were identified through databases such as PubMed and Web of Science, and from within the PSE Healthy Energy database. The studies and investigations referenced in the dated entries catalogued in Compilation of Studies & Findings are current through December 2017.

Two years ago NY State DOH Commissioner, Dr Zucker, advised Governor Cuomo not to approve high volume hydraulic fracturing in NY because of the potential health risks, and he based it on the science.[12] The State of Maryland permanently banned fracking after 2 years of study, based on the potential for adverse public health and environmental impacts.[13] The EPA HF study has been completed, having only studied water, and shows that water has, in fact, been contaminated.[14]

Most importantly, there are many people who have already been impacted in states where gas extraction using high volume hydraulic fracturing is permitted. We posit that a careful study of the scientific information is fundamental to making informed decisions. As we review the studies already completed, and speak with impacted people, we are increasingly aware that fracking and its infrastructure causes stressors on health that cannot be mitigated.

Compressor stations are known to emit carcinogens and other organ system irritants; this is documented in a study by Russo and Carpenter.[15] It has been recommended that a Health Impact Assessment be done prior to permitting compressor stations. The Shale Health Impact Assessment (HIA) Template is designed to give a structured way to bring together data on the community potentially impacted, the expected emissions from shale gas or oil development, and the potential health risks posed to residents in the immediate area. This tool can provide decision-makers with a comprehensive perspective on the siting, expanding, or maintaining of a shale gas or oil compressor station.[16]

Recent studies in the field in NY State demonstrate that negative health effects have impacted residents in those communities. Unfortunately, no HIA was done prior to permitting. The studies include Summary

[11] http://concernedhealthny.org/compendium/
[12] http://www.health.ny.gov/press/reports/docs/high_volume_hydraulic_fracturing.pdf
[13] http://thinkprogress.org/climate/2015/05/29/3664098/larry-hogan-maryland-fracking-ban/
[14] https://www.epa.gov/hfstudy
[15] Russo, PN, Carpenter, DO. Health Effects Associated with Stack Chemical Emissions from NYS Natural Gas Compressor Stations: 2008-2014. October 12, 2017. https://www.albany.edu/about/assets/Complete_report.pdf
[16] https://www.environmentalhealthproject.org/

of Minisink Compressor Station Monitoring Results and Summary on Compressor Stations and Health Impacts.[17]

For these reasons (and with more detail provided below) fracking and the associated infrastructure such as compressor stations must be carefully studied and all the risks quantitatively assessed prior to proceeding with any permits.

1) **There are concerns about the adequacy and quality of the air modeling study.**

Local topography and weather patterns are usually not taken into account in the AEROMOD program. It is recommended to use results with localized data input.

Records of peak emissions which are a primary source of concern for human health are not represented.

2) **Health risks from relevant air contaminants receive inadequate treatment.**

Averages, peaks and health events

A "tons per year" measurement associated with the assessment of risk to the public's health near a compressor station is an archaic method, and does not address exposure adequately. Also, the National Ambient Air Quality Standards (NAAQS) used as a benchmark for air quality were not created to assess the air quality and safety in a small geographic area with fluctuating emissions. NAAQS effectively address regional air quality concerns. But these standards do not adequately assess risk to human health for residents living in close proximity to polluting sources such as compressor station sites, where emissions can be highly variable.

Generally, it has been shown that:

- Current protocols used for assessing compliance with ambient air standards do not adequately determine the intensity, frequency or durations of the actual human exposures to the mixtures of toxic materials released regularly at UNGD sites, including compressor stations.

- The typically used periodic 24-hour average measures can underestimate actual exposures by an order of magnitude. There remains the risk of serious harm to human health, including lung disease.

- Reference standards are set in a form that inaccurately determines health risk because they do not fully consider the potential synergistic combinations of toxic air emissions. Thus estimates of yearly totals of contaminants released by a compressor station do not allow for an assessment of the physiological impact of those emissions on individuals. NAAQS reflects what, over a region, over time, is deemed safe population-wide. This is very different than what is safe within for instance 1200 feet of this compressor station. Averaging over a year can wash out important higher spikes in emissions (thus exposures) that may occur at various points throughout the

[17] https://www.environmentalhealthproject.org/researchers/resources

year. What is needed is continuous, minute by minute data on a suite of surrogate compounds being emitted.

Researchers have demonstrated the wisdom of looking at peak exposures as compared to averages over longer periods of time. Darrow et al (2011) write that sometimes peak exposures better capture relevant biological processes. This is the case for health effects that are triggered by short-term, high doses. They write, "Temporal metrics that reflect peak pollution levels (e.g., 1-hour maximum) may be the most biologically relevant if the health effect is triggered by a high, short-term dose rather than a steady dose throughout the day. Peak concentrations … are frequently associated with episodic, local emission events, resulting in spatially heterogeneous concentrations…."[18] Delfino et al (2002) posited that maxima of hourly data, not 24-hour averages, better captured the risks to asthmatic children, stating, "it is expected that biologic responses may intensify with high peak excursions that overwhelm lung defense mechanisms."[19] Additionally, they suggest that "[o]ne-hour peaks may be more influenced by local point sources near the monitoring station that are not representative of regional exposures…."[20]

A specific example:

An EPA ATSDR report on air emissions from the Brigich compressor station in PA (2016) calculated detailed non-cancer and cancer risk evaluations that included excess lifetime cancer risk calculations for a subset of the constituents of potential concern. ATSDR concluded that, in general, these more detailed non-cancer and cancer exposure evaluations did not support the likelihood of human health harm from these air pollutants, although ATSDR could not rule out that some sensitive subpopulations may experience health impacts from hydrogen sulfide, PM2.5 or carbonyls.[21]

Hydrogen sulfide was monitored continuously, documenting the variability of potential exposures, along with the average. Spikes of H2S were quite high. EHP has similar finding from measurements of PM2.5 near compressor stations.

ATSDR has established that there were levels of exposure around the compressor station that raise health concerns. In particular, acetaldehyde, benzene, formaldehyde, carbon tetrachloride, chloroform, 1,2-DCA and 1,1,2-trichloroethane, crotonaldehyde, and 1-methoxy-2-propanone exceeded their respective comparison values (CVs).

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[18] Darrow LA, Klein M, Sarnat JA, Mulholland, Strickland MJ, Sarnat SE, Russell A, Tolbert PE. The use of alternative pollutant metrics in time-series studies of ambient air pollution and respiratory emergency department visits. Journal of Exposure Science and Environmental Epidemiology. 2011;12 (1): 10-19.

[19] Wolf Eagle Environmental. Town of DISH, Texas Ambient Air Monitoring Analysis Final Report. September 15, 2009.

[20] Delfino R, Zeiger RS, Seltzer JM, Street DH, McLaren CE. Association of asthma symptoms with peak particulate air pollution and effect modification by anti-inflammatory medication use. Environmental Health Perspectives. 2002; 110(10):A607-A617.

[21] ATSDR Health Consultation Exposure Investigation Natural Gas Ambient Air Quality Monitoring Initiative, Brigich Compressor Station Chartiers Township, Washington County, Pennsylvania. Access at https://www.atsdr.cdc.gov/HAC/pha/Brigich_Compressor_Station/Brigich_Compressor_Station_EI_HC_01-29-2016_508.pdf

SWPA EHP has prepared technical reports in response to the ATSDR reports on the Brigich and Brooklyn compressor stations, and they are available on the SWPA EHP website.[22]

- At the proposed compressor station, like other industrial facilities, multiple exposures will be occurring simultaneously or in close time frames. The consultants have not calculated cancer risk on an individual chemical basis. It is known that there are combinations of chemicals that increase the cancer risk several fold. This occurs, for instance, when PM2.5 is present in the air with carcinogens. The PM2.5 can increase a dose several fold by bringing other compounds into the deep lung with the fine particulates. To the extent that chemicals have not just additive but synergistic effects, those effects should be accounted for.

- Mixtures and sequential exposures

Mixtures of pollutants are a critically important topic in addressing the public health implications of UNGD broadly and compressor stations in this case. In fact, a very large number of chemicals are released together. Medical reference values are not able to take the complex nature of the shale environment, its multiple emissions and interactions into full consideration.[23] Chemicals that reach the body interfere with metabolism and the uptake and release of other chemicals. Some chemicals attack the same or similar target sites creating an additive effect. This is the case with chemicals of similar structure such as many in the class of VOCs. Some mixtures like PM and VOC act synergistically to increase the toxicity of the chemicals. Other chemicals released environmentally are rapidly absorbed and slowly excreted. These slowly excreted chemicals will interfere with subsequent actions of chemicals because the body has not yet cleared the effects from the earlier exposure.

The VOCs and HAPs shown in the tables will be emitting air mixtures with high levels of fine particulate matter. Inhaled particulate matter increases transport of the soluble VOCs into the deep lung by a factor of 10 or more. Combination of VOCs with particulates produces a primary synergistic action in air toxicity. Reference values are not determined with particulate matter in the mixtures. Therefore, the URF and the RFCs under represent the inhalation hazard in an atmosphere with high particulate matter.

Similarly, the cancer risk assessment is inadequate. Health Indexes are added when, in fact, there are synergistic effects with multiple chemicals. Thus the results remain inconclusive.

3) The treatment of Particulate Matter (PM) impacts in particular, but also of health impacts from compressors in general, is inadequate.

The air impacts permit application and modeling should address the full range of possible exposures to pipeline ready gas. That includes a human carcinogen, Particulate Matter (PM).

Particulate matter is known to impair lung function, aggravate asthma, cause high blood pressure and heart attack. PM can adhere with other compounds and then can carry these compounds, which may be

[22] http://www.environmentalhealthproject.org/resources/research-factsheets
[23] For additional information see, for instance, EPA's Integrated Risk Information System Database.

toxic, into the deep lung and this is a health concern near compressor stations where multiple toxins are emitted with PM.

Research by the SWPA-EHP in Minisink, New York, where one of the compressors studied is located, and where the gas is NOT raw field gas, but the same type of gas as traverses through Sullivan County, and presumably will also flow through the Atlantic Coast Pipeline, shows significant human health impacts including respiratory, neurological and dermatological impacts. (see "Summary of Minisink Compressor Station Monitoring Results" at http://www.environmentalhealthproject.org/researchers/resources.[24] In addition, and of significant concern, is the observation by 24-hour (continuous) SPECK PM monitoring by the researchers, that dangerous spikes of PM occur and that had no correlation at all with Ambient Air Quality monitors located in Newburgh, NY.

*A presentation can be found at the Town of Mamakating NY website. It is also be found as an addendum following these comments.

4) Radioactive waste

The International Atomic Energy Agency[25] and the International Commission of Radiation Protection have recommendations regarding radioactivity at oil and gas mining sites, and most countries which are members adhere to the recommendations. The US is a member but has instead exempted from federal oversight through RCRA (Resource Conservation and Recovery Act) the materials that come from down-hole which are, in many cases, radioactive. [26] Brown has reviewed the issue of radioactivity in fracking products.[27] It is important to note that some radioactive moieties selectively and preferentially travel with the gas product, namely radon. as radon decays within the pipeline, the solid daughter elements, polonium and lead, accumulate along the interior of the pipes. There is a concern that the gas transiting, and being compressed and regulated, will have radioactivity levels which will put at risk not only the workers at these stations and along the pipeline, but potentially also to the residents. Radon, a gas, has a short half-life (3.8 days) but its progeny are lead and polonium, and these are toxic and have relatively long half-lives of 22.6 years and 138 days respectively. This air permit modeling does not address the potential health risks of the radon decay progeny.

Radioactive waste products are typically removed from the pipelines after "pigging". How this toxic waste product is removed, handled, stored, transported and disposed of should be made clear to the public.

[24] http://www.environmentalhealthproject.org/resources/research-factsheets
[25] Recommendations from the International Atomic Energy Agency (IAEA) http://www-pub.iaea.org/MTCD/publications/PDF/TCS-40_web.pdf
[26] Federal exemption http://www.epa.gov/osw/nonhaz/industrial/special/oil/oil-gas.pdf
[27] Brown VJ. 2014. Radionuclides in fracking wastewater: managing a toxic blend. Environ Health Perspect 122:A50–A55; http://dx.doi.org/10.1289/ehp.122-A50

EPA region 3 reports that radium, measured as gross alpha and beta, in flowback water and produced waste in Pennsylvania wells, is significantly higher than in other shales.

The graphs found here, from a USGS report, illustrate the high radioactivity in Marcellus shale.[28]

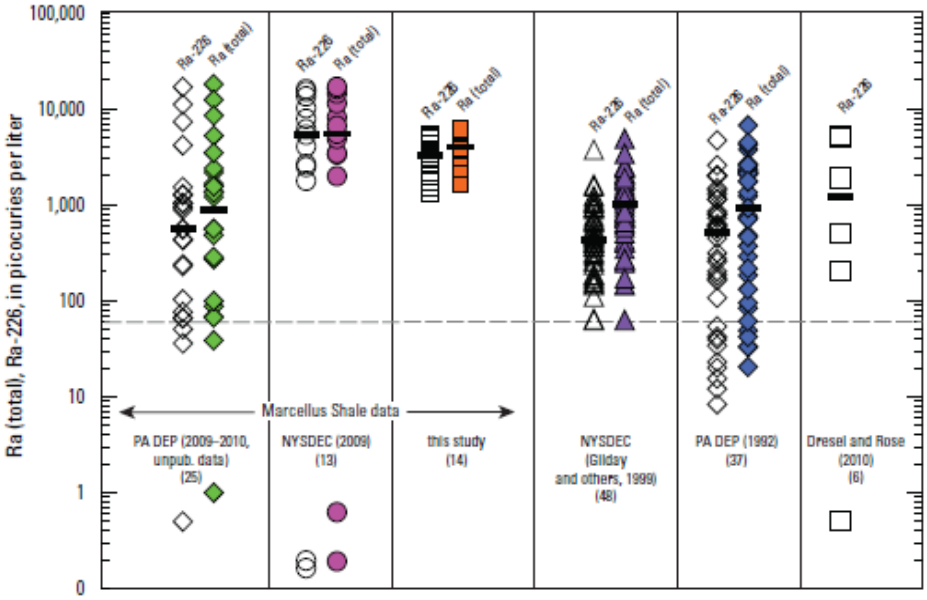


Figure 4. Measured activities for total radium (Ra-226 + Ra-228) and Ra-226 for each of the data sources used in the study. The three datasets for produced water from Marcellus Shale wells are shown on the left; the remaining three datasets are for non-Marcellus Shale wells. The number of points in each dataset is shown in parentheses, and the median values are plotted as heavy black lines. For reference, the dashed line shows the industrial effluent discharge limit (60 pCi/L) for Ra-226 (U.S. Nuclear Regulatory Commission, *http://www.nrc.gov/reading-rm/doc-collections/cfr/part020/appb/Radium-226.html*).

In the 2008 publication of the International Association of Oil & Gas Producers, the authors wrote: "During the production process, NORM flows with the oil, gas and water mixture and accumulates in scale, sludge and scrapings. It can also form a thin film on the interior surfaces of gas processing equipment and vessels. The level of NORM accumulation can vary substantially from one facility to another depending on geological formation, operational and other factors… NORM may accumulate, *e.g.* at wellheads in the form of scale; at Gas/Oil Separation Plants (GOSP) in the form of sludge; and at gas plants the form of thin films as the result of radon gas decay.

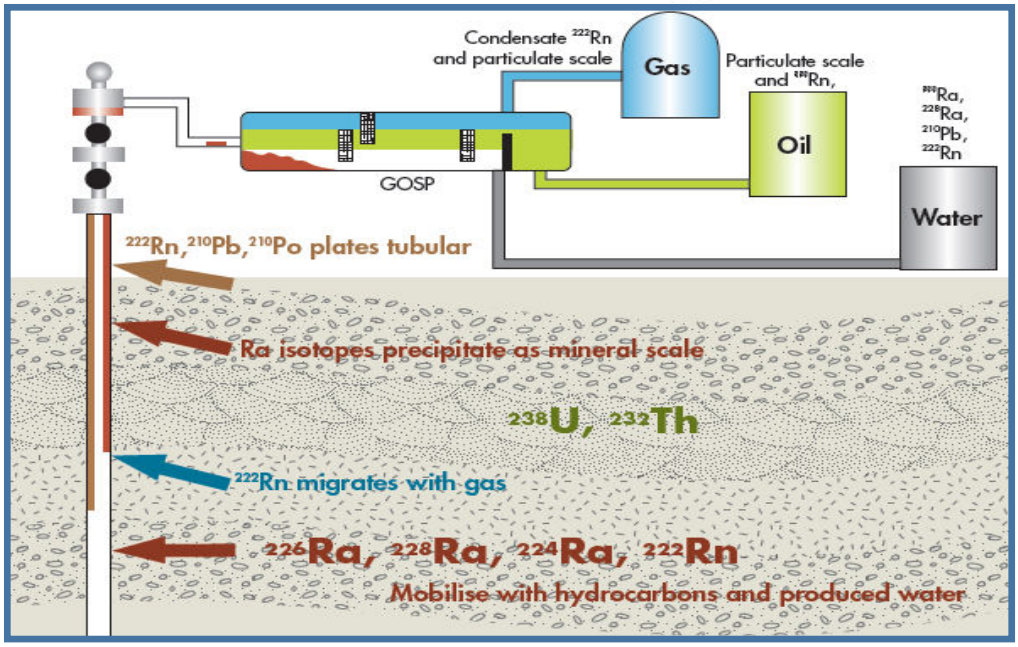
"…radionuclides such as Lead-210 and Polonium-210 can…be found in pipelines scrapings as well as sludge accumulating in tank bottoms, gas/oil separators, dehydration vessels, liquid natural gas (LNG) storage tanks and in waste pits as well as in crude oil pipeline scrapings."[29]

This graph from the same publication shows the origins of NORM, as well as where NORM can accumulate.

[28] http://pubs.usgs.gov/sir/2011/5135/pdf/sir2011-5135.pdf

[29] OGP, "Guidelines for the management of Naturally Occurring Radioactive Material (NORM) in the oil & gas industry" International Association of Oil & Gas Producers, Report No. 412, September 2008 http://www.ogp.org.uk/pubs/412.pdf

Figure 1.1 The origins of NORM, indicating where NORM may accumulate in the recovery process.



In January 2015, PA DEP released their TENORM report[30]. The DEP was quick to issue a press memo assuring that "There is Little Potential for Radiation Exposure from Oil and Gas Development".[31] Upon careful review of the report and the appendices, it was clear that there were elevated levels of radium and radon which needed to be mitigated; some areas should even be posted as radioactive areas, as per OSHA regulations.[32] The report has since undergone changes.

In the PA DEP report, wastewater treatment plants reported the following numbers for liquid waste Ra226:

Figure 4-1. CWT Influent and Effluent Liquid Ra-226 Minimum, Maximum, and Average

Wastewater Source	Filtered or Not	Min (pCi/L)	Max (pCi/L)	Ave (pCi/L)
Effluent	Filtered	18.0	14,900	2,100
Effluent	Unfiltered	42.0	15,500	1,840
Influent	Filtered	57.0	14,100	2,350
Influent	Unfiltered	17.5	13,400	1,870

It is clear that workers at wastewater treatment plants handling gas waste are being exposed to high radiation doses. "The maximum gamma radiation exposure rate measured was 502 μrem/hr on contact with the outside of a wastewater tank. Work in proximity of the tank could potentially result in an

[30] http://www.dep.pa.gov/Business/Energy/OilandGasPrograms/OilandGasMgmt/Oil-and-Gas-Related-Topics/Pages/Radiation-Protection.aspx
[31] http://files.dep.state.pa.us/OilGas/BOGM/BOGMPortalFiles/RadiationProtection/rls-DEP-TENORM-01xx15AW.pdf
[32] https://www.osha.gov/SLTC/radiationionizing/standards.html

exposure of 100 mrem in 200 hours of annual exposure or 10 percent of an employee's 2,000-hour occupational year."[33]

The method measuring Radium 226 and 228 and their progeny has recently received scrutiny, and a new set of methods has been developed by the EPA in collaboration with Nelson and Schultz at the University of Iowa[34]. The FPWHFO (flowback and produced water in hydraulic fracturing operations) matrix is considered to be a particularly challenging one due to its extremely high dissolved solids content and its complexity. This new method addresses that complexity.

In brief, the calculations done using the older EPA methods have likely significantly underestimated the radium content of flowback and produced water. Note that the methods used to detect radium in the USGS report[35] and in this recent PA DEP report on radioactivity[36] (using EPA methods 900 - 904[37]) may have underestimated the radium content because of the high salinity in the samples.

The gas which enters the pipeline carries gaseous radon with it; and as radon decays within the pipeline, the solid daughter elements, polonium and lead, accumulate along the interior of the pipes. There is concern that the gas transiting, and being compressed, will have radioactivity levels which will be a risk not only to the workers at these stations and along the pipeline, but potentially also to the residents.

Radon was measured at various locations around POTW plants "…at various indoor locations such as break rooms, labs, offices, etc., …The results ranged from 0.2 to 8.7 pCi/L."[38]

Radon has a short half-life (3.8 days) but its decay products, lead and polonium, have relatively long half-lives of 22.6 years and 138 days respectively. Lead causes neurologic and hematologic toxicity, and death; polonium causes cancer and death.[39] Radon and its radioactive decay products enter the body primarily through inhalation. Most of the radon is exhaled prior to radioactive decay but some of the solid radioactive polonium and lead remain in the lungs and may cause cancer. "Ninety-nine % of the health effects are caused by radon's daughter products; of most significance are the four short-lived ones, polonium-218 to polonium-214 inclusive, which are referred to as radon daughters, radon progeny, or radon decay products."[40]

Following is a description of the fate of radon in a processing plant; however, similar activities occur at a compressor station. Both compressors and processing plants dot Pennsylvania's landscape. "Radon enters the … piping where it decays into radioactive particulates that are deposited in the piping. During

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[33] http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-105822/PA-DEP-TENORM-Study_Report_Rev._0_01-15-2015.pdf pg 4-8

[34] http://www2.epa.gov/sites/production/files/2014-08/documents/epa-600-r-14-107_-_gross_alpha_-_gross_beta_508_km_08-08-2014.pdf

[35] http://pubs.usgs.gov/sir/2011/5135/pdf/sir2011-5135.pdf

[36] http://www.portal.state.pa.us/portal/server.pt/community/oil___gas_related_topics/20349/radiation_protection/986697

[37] http://files.dep.state.pa.us/OilGas/BOGM/BOGMPortalFiles/RadiationProtection/Sampling_and_Analysis_Plan-Part-II-Quality_Assurance_Project_Plan.pdf

[38] Ibid pg 4-3

[39] National Academy of Sciences 1988 report: Health Risks of Radon and Other Internally Deposited Alpha-Emitters: BEIR IV, page 5

[40] http://www.inive.org/medias/ECA/ECA_Report15.pdf pg 9

the working lifetime of a … plant, radon is constantly entering the system and adding to the level of radioactive progeny. Most radon progeny are short-lived, so when a … plant ceases operations, the short-lived progeny decay quickly. These short-lived radionuclides are the ones that produce the signature gamma ray spectrum that can be detected easily on the outside of the piping. As the short-lived radon progeny decays, it becomes more and more difficult to detect activity from the outside of pipes and tanks, even though there may be detectable radiation on the inside. As the short half-lived progeny decay away, the only radionuclides remaining are the relatively long-lived 210Pb (T1/2 21 y) and its progeny. 210Pb emits a gamma ray at 47 keV and has a transmission of only about 10to the minus7 to 10to the minus6 through a schedule-40 pipe. Unless the pipe had an access point, internal contamination might not be detectable from the outside."[41]

During production radon usually follows the gas stream. "Radon-222 produces, through natural decay, several radioactive nuclides (also known as radon progeny). Most radon progeny are short-lived, with the exception of Lead-210 and Polonium-210, which have relatively long half-lives…. Most of the radon decay products (90-99%) are attached to ambient aerosols, airborne particulates or surfaces. This can result in forming thin radioactive films on the inner surfaces of gas processing equipment such as scrubbers, compressors, reflux pumps, control valves and product lines."[42]

Activity concentration of ^{222}Rn, ^{210}Pb and ^{210}Po in natural gas (Reference 1)

Radionuclide	Reported Range (Bq/m³)
^{222}Rn	5 – 200,000
^{210}Pb	0.005 – 0.02
^{210}Po	0.002 – 0.08

Activity concentration of ^{210}Pb and ^{210}Po in NGL/hydrocarbon condensate (Reference 1)

Radionuclide	Reported Range (Bq/l)
^{222}Rn (NGL)	0.01 – 1,500
^{222}Rn (C3 -liq)	0.01 – 4,200
^{210}Pb	0.3 – 230
^{210}Po	0.3 – 100

[43]

In 2013, samples of natural gas were analyzed for Spectra and submitted to FERC (public record). The results are as follows:

[41] Krieger. 2005. http://radonattahoe.com/TENORM.pdf
[42] OGP. 2006. http://www.ogp.org.uk/pubs/412.pdf
[43] http://www.ogp.org.uk/pubs/412.pdf

Results of Samples for Spectra Energy

Date	Location	Analyzed[1]	Rn Conc (pCi/L)[2]	MDC (pCi/L)[3]
12/3/2013	Bechtelsville	12/4 - 12/5	29.9 ± 3.2	0.1
	Bechtelsville	12/11 - 12/12	29.4 ± 3.1	0.3
12/3/2013	Blank	12/4 - 12/5	0.16 ± 0.04	0.07
	Blank	12/11 - 12/12	0.19 ± 0.04	0.27
12/12/2013	Staten Island	12/13 - 12/14	20.6 ± 2.2	0.1
	Staten Island	12/23 - 12/24	20.5 ± 2.2	0.5
12/12/2013	Jersey City	12/13 - 12/14	20.7 ± 2.2	0.1
	Jersey City	12/23 - 12/24	20.4 ± 2.2	0.5
12/12/2013	Blank	12/27 - 12/28	-0.16 ± 0.04	6.69
	Blank	12/31 - 1/1/14	1.38 ± 0.15	12.86
12/16/2013	Ramapo	12/17 - 12/18	26.1 ± 2.8	0.1
	Ramapo	12/26 - 12/27	26.4 ± 2.8	0.4
12/16/2013	Mahwah	12/17 - 12/18	23.0 ± 2.5	0.1
	Mahwah	12/17 - 12/18	23.3 ± 2.5	0.4
12/16/2013	Blank	12/27 - 12/28	-0.23 ± 0.05	0.61
	Blank	12/31 - 1/1/14	0.14 ± 0.04	1.23
12/17/2013	Line 9	12/18 - 12/19	41.6 ± 4.4	0.1
	Line 9	12/30 - 12/31	41.8 ± 4.4	0.7
12/17/2013	Blank	12/18 - 12/19	0.22 ± 0.05	0.09
	Blank	12/30 - 12/31	0.60 ± 0.07	0.76

Radon concentrations between 20 and 41 pCi/L are elevated and could have significant human health impacts.

Table 3-18. Natural Gas Samples from Production Sites

Sample ID	County	Gas Source	Radon Conc. +/- 2 S.D. (pCi/L)	MDA (pCi/L)
WP 08 RG	Washington	Marcellus Shale	79.6 +/- 0.800	0.300
WP 09 RG	Washington	Marcellus Shale	78.8 +/- 4.20	0.300
WP 22 RG	Tioga	Marcellus Shale	42.8 +/- 0.200	0.100
WP 23 RG	Tioga	Marcellus Shale	39.6 +/- 0.800	0.200
WP 24 RG	Tioga	Marcellus Shale	73.8 +/- 0.400	0.200
WP 25 RG	Tioga	Marcellus Shale	44.4 +/- 2.60	0.200
WP 26 RG	Lycoming	Oriskany Sandstone	19.9 +/- 0.200	0.200
WP 27 RG	Tioga	Marcellus Shale	38.4 +/- 3.40	0.300
WP 28 RG	Tioga	Marcellus Shale	40.8 +/- 5.20	0.400
WP 16 RG	Washington	Marcellus Shale	50.0 +/- 5.20	0.300
WP 17 RG	Washington	Marcellus Shale	49.5 +/- 5.80	0.500
WP 19 RG	McKean	Upper Devonian Shale	18.3 +/- 4.40	0.400
WP 20 RG	McKean	Upper Devonian Shale	88.2 +/- 10.6	0.700
WP 21 RG	Forest	Upper Devonian Shale	92.2 +/- 6.40	0.400
WP 04 RG	Tioga	Marcellus Shale	49.6 +/- 29.6	1.20
WP 05 RG	McKean	Marcellus Shale	148 +/- 15.6	1.50
WP 12 RG	Lycoming	Marcellus Shale	37.6 +/- 33.4	2.20
WP 11 RG	Tioga	Utica	5.70 +/- 1.20	0.500
WP 29 RG	Sullivan	Marcellus Shale	23.4 +/- 4.00	0.240
WP 30 RG	Bradford	Marcellus Shale	25.5 +/- 2.70	0.200
WP 31 RG	Bradford	Marcellus Shale	3.00 +/- 1.20	0.300
WP 14 RG	Jefferson	Marcellus Shale	5.60 +/-0.100	0.140
		Average	**47.9**	
		Median =	**41.8**	
		Standard Deviation	**34.5**	

Note: All results adjusted to account for the fact that Rn was counted in methane, but the scintillation cells were calibrated for Rn in air. Range of α particles is greater in methane than in air. All results divided by 1.054, according to Jenkins et. al., Health Physics, Vol. 106, No. 3, March 2014. 44

[44] http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-112658/Pennsylvania%20Department%20of%20Environmental%20Protection%20TENORM%20Study%20Report%20Rev%201.pdf

When it enters the environment, radon gas "… can move to air, groundwater, and surface water. Decay products of 222Rn, such as 218Po and 214Pb, are solids that can attach to particles in the air and be transported this way in the atmosphere. They can be deposited on land or water by settling or by rain. Radon will undergo radioactive decay in the environment."[45]

"...radon and subsequent decay product atoms are charged and tend to attach to aerosol particles. Radon progeny are similarly charged, readily aggregate, form clusters, and attach to dust particles in air. The main health problems arise when primarily those radon progeny that are attached to dust particles (termed the attached fraction) are inhaled, deposit in the airway (particularly the tracheobronchial tree), and irradiate nearby cells repetitively with alpha particles as each atom transforms through the decay chain..."[46]

Regarding workers at gas operations sites and radon exposure, ATSDR notes: " …exposure to high concentrations can occur in any location with geologic radon sources. A list of common occupations that have the potential for high radon and progeny exposure … include mine workers … employees of water treatment plants, and radioactively contaminated sites can include … oil refineries, power plants, and natural gas and oil piping facilities."[47]

The amount of radon released by natural gas operations is not insignificant: "Fishbein (1992) has reported that coal residue and natural gas emissions release 20,000 and 10,000 Ci of 222Rn each year, respectively…"[48]

Interestingly, "Regulations regarding the land disposal of radionuclides, as set forth in 10 CFR 61 (USNRC 2008), do not apply to radium, radon, or its daughters...regulation of radon is up to the individual states."[49]

The gathering of information about radon releases has been limited. "There is no information on releases of radon to the atmosphere from manufacturing and processing facilities because these releases are not required to be reported (EPA 1998)."[50] The air permit and modeling as proposed do not address radioactivity.

[45] http://www.atsdr.cdc.gov/ToxProfiles/tp145.pdf
[46] Ibid, pg 16
[47] http://www.atsdr.cdc.gov/ToxProfiles/tp145.pdf, pg 124
[48] http://www.atsdr.cdc.gov/ToxProfiles/tp145.pdf, pg 126
[49] http://www.atsdr.cdc.gov/ToxProfiles/tp145.pdf, pg 118
[50] Op cit, ATSDR, pg 124

As radon decays within the pipeline, the solid daughter elements, polonium and lead, accumulate inside the pipes. PCBs and other contaminants such as black powder,[51] and anaerobic microbials, do as well [52] [53]. PIGs (Pipeline Inspection or Intervention Gauge/Gizmo/Gadget [54]) inspect or clean out the pipe, and become repositories of these toxins. These PIGs, with pipe film, black powder, bacteria, scale and sludge, must be removed from the pipeline, stored and eventually disposed.[55] [56] [57] [58]

[51] Baldwin, Richard M. "Black powder problem will yield to understanding, planning." Pipeline and Gas Industry 82 (1999): 109-112. http://muellerenvironmental.com/Documents/100-056-Black%20Powder.pdf and Baldwin, Richard M. "Black powder control starts locally, works back to source." *Pipeline & Gas Industry* (1999): 81-87. http://www.muellerenvironmental.com/Documents/100-058%20Black%20Powder2.pdf

[52] Mueller, Fred, and Mark Null. "Impurities in the Gas Stream." Mueller Environmental Designs, Inc. Technical Document, 2005. http://www.muellerenvironmental.com/public/ProductDocuments.aspx

[53] Zhu, Xiang Y., John Lubeck, and John J. Kilbane. "Characterization of microbial communities in gas industry pipelines." Applied and environmental microbiology 69.9 (2003): 5354-5363. Access at http://aem.asm.org/content/69/9/5354.full.pdf

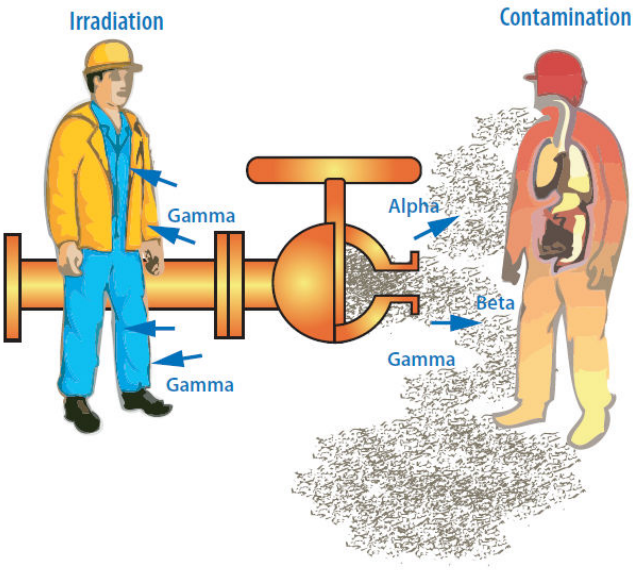
[54] http://en.wikipedia.org/wiki/Pigging)

[55] http://www.rigzone.com/training/insight.asp?insight_id=310&c_id=19

[56] http://www.pigtek.com/advanced_pipeline_cleaning.php

[57] Tsochatzidis, Nikolaos A., and Konstantinos E. Maroulis. "Methods help remove black powder from gas pipelines." Oil and Gas Journal 105.10 (2007): 52. http://www.desfa.gr/files/dimosieyseis/Tsochatzidis%26MaroulisOGJMar2007.pdf

[58] Lindner, Hubert. "A new cleaning approach for black powder removal." Pigging Products and Services Association, 2006. http://www.ppsa-online.com/papers/2006-Aberdeen-8-Lindner.Pdf



NORM materials may become an inhalation risk when the material is dislodged by mechanical forces, such as wire brushing, pipe rattling *etc.* [59]

At each step, precautions must be taken to avoid contaminating workers and residents.

"Natural gas plant scale typically consists of Rn decay progeny that accumulate on the interior surfaces of plant pipes and equipment ... As a result, the only radionuclides that remain and adhere to the interior surfaces of machinery/pipes are the Rn decay progeny Po-210 and Pb-210. These longer-lived decay progeny are not readily detected on the outside of pipes. However, Pb-210 and Po-210 emit α and β radioactive particles that may be a potential inhalation or ingestion hazard when pipes and machinery are opened for maintenance and/or cleaning. Access to the internal surfaces of pipes and equipment for surveys of surface α and β activity was not available. However, the facility propenizer equipment opened and sampled during filter change-out is representative of interior conditions… A Pb-210 activity result of 3,580 pCi/g was identified…. The results confirm the build-up of the longer-lived Rn decay progeny in equipment and pipes. The concentration of Pb-210 identified may present a potential inhalation or ingestion hazard during routine system maintenance."[60]

Reviewer 6 of the PA DEP report wrote "…that maintenance workers at midstream facilities can also be exposed to Pb-210 and Po-210 when working on internals of pipe and equipment. Progeny tend to plate out on surfaces where there is turbulence in the flow. That would include pumps, elbows, pig launchers/catchers, etc., in addition to the compressor stations themselves."[61]

He continues: "It is the opinion of this reviewer that the alpha and beta contamination potential (and hazard) on well sites and compressor stations, gas plants, et al., is underestimated because there was no access to equipment internals. Also, Po- 210 does not appear to be considered, and that is an internal

[59] http://www.ogp.org.uk/pubs/412.pdf
[60] http://www.dep.pa.gov/Business/Energy/OilandGasPrograms/OilandGasMgmt/Oil-and-Gas-Related-Topics/Pages/Radiation-Protection.aspx sec 6-3
[61] http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-112656/Appendix_L-Peer%20Review%20Comment%20and%20Resolution%20Document.pdf Appendix L page 39 of original document

hazard. Maintenance workers, on and off site (e.g., at repair shops) could be exposed to significant contamination based on years of experience in the industry."[62]

Conclusion

There is a growing but already significant body of scientific evidence showing harms to public health from gas development, including compressor stations. And yet, despite this evidence, the monetary costs associated with the health impacts--premature death, birth defects, prematurity of birth, cancer, autism, learning disabilities and other problems--have never been entered into an economic analysis of fracking.

Some have supported gas development for the purported economic boost. The contrary is true—the industry will not be a recession buster.[63] From the peer-reviewed literature provided, it is also clear that the economic papers boasting a boon have been industry-sponsored, and have not taken into account the economic loss from existing economies like tourism and agriculture. In addition, the costs of health impacts have never been considered, and those will be significant.

A Health Impact Assessment, as described earlier, should be done to study the potential risks to the nearby population, including all vulnerable groups.

Residents of Buckingham have compiled this reasonable list of public concerns as it regards the DEQ air permit:

- **Request to extend comment period an additional 30 days, or 60 days total;**
- **Address inadequate compliance and monitoring plans;**
- **Address the lack of access to technical documents;**
- **Technical aspects of air permit that have not have been considered, like 24 hr monitoring;**
- **Comprehensive impacts;**
- **Take into account the higher radioactivity of Marcellus shale;**
- **Consider vulnerable populations such as children, the elderly and infirmed; an HIA would do this.**

And the residents of Buckingham request:

[62] Ibid, pg L-42
[63] http://theconversation.com/the-false-promise-of-fracking-and-local-jobs-36459

· **A Quantitative Risk Assessment (QRA) and Comprehensive Health Impact Assessment (HIA) to address the complex and multifaceted concerns presented by residents of Buckingham;**

· **Institutionalization of EJ, public safety, and health review before permitting or construction of large-scale infrastructure in minority and low-income communities;**

· **Meaningful participation by impacted populations in permitting and monitoring;**

· **Reduction of state disparity in exposure by which black and brown communities disproportionately experience harm from toxic air, unsafe water, and public safety risks;**

· **Development of clean and renewable energy alternatives.**

At a minimum, the following should be done:

- **Cumulative environmental impact study with a comprehensive Health Impact Assessment, including pre- during and post-construction health monitoring;**
- **Baseline measurements of air emissions, methane, radon and water quality, and continuous monitoring if compressor is approved;**
- **Cumulative emissions to include condensate tank emissions and fugitive methane;**
- **Best technologies, and for compressors, electric power source;**
- **Hazardous Materials Management Plan including plan for disposal of waste from condensate tanks and pipelines, and a NORM Monitoring Plan;**
- **An extension of the comment period to 60 days to allow residents in an area underserved by internet to access materials and submit comments.**

Respectfully submitted,
Larysa Dyrszka, MD
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Co-founder Concerned Health Professionals of NY www.concernedhealthny.org
Exec board member Physicians for Social Responsibility PSR NY www.psr.org

ADDENDUM: additional information from a presentation (by Dr L Dyrszka) to several town boards in Sullivan County NY which requested additional information, then passed resolutions in opposition to the Millennium ESU.

POTENTIAL IMPACTS AND HEALTH CONCERNS, WITH A FOCUS ON COMPRESSORS

For an audio presentation on infrastructure, visit http://www.psr.org/resources/webinar-health-impacts-of-gas-infrastructure.html

An important impact of the gas infrastructure is an exacerbation of climate change which has been referred to in the journal "Lancet" as a medical emergency.[64]
(Dr. Dyrszka) has recently co-authored relevant publications, and those are referenced here.[65]

Importantly, climate change has national security implications.[66]

In September, scientists at the Climate Implementation Project prepared a report, The Human Face of Climate Change, perspectives and recommendations for the next US President. Burke et al. 2016. Health: The Human Face of Climate Change Perspective and Recommendations for the Next U.S. President. [67]

"A range of studies has shown high levels of methane leaks from gas drilling, fracking, storage, and transportation, undermining the notion that natural gas is a climate solution or a transition fuel. Major studies, some cited here, have concluded that early work by the U.S. Environmental Protection Agency (EPA) greatly underestimated the impacts of methane and natural gas drilling on the climate. Drilling, fracking, the transport and expanded use of natural gas threaten not only to exacerbate climate change but also to stifle investments in, and expansion of, renewable energy. Further, the widely touted claim that the U.S. fracking boom is helping to drive recent declines in carbon dioxide emissions in the United States has been upended by new research showing that almost all of the emission reductions between 2007 and 2009 were the result of economic recession rather than coal-to-gas fuel switching, as was previously presumed."[68]

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[64] **http://www.climateandhealthalliance.org/news/2015-lancet-commission-on-health-and-climate-change**
[65] **Webb et al. 2016. Potential hazards of air pollutant emissions from unconventional oil and natural gas operations on the respiratory health of children and infants. June 1, 2016. RevEnvironHealth. DOI: 10.1515/reveh-2014-0070. Access at: https://www.ncbi.nlm.nih.gov/pubmed/27171386**
Too Dirty, Too Dangerous. 2017. Physicians for Social Responsibility. Access at: http://www.psr.org/assets/pdfs/too-dirty-too-dangerous.pdf
Concerned Health Professionals of New York. 2016. Compendium of Scientific, Medical, and Media Findings Demonstrating Risks and Harms of Fracking. Access at: http://concernedhealthny.org/compendium/
[66] **https://www.eenews.net/assets/2016/09/21/document_pm_02.pdf**
[67] **Access at: https://woods.stanford.edu/sites/default/files/Burke-Walsh-Barry-Paper.pdf**
[68] **CHPNY Compendium**

Methane is the second largest contributor to human-caused climate change, after carbon dioxide. Natural gas systems are the single largest source of anthropogenic methane emissions in the U.S., representing almost 40% of total emissions (EPA 2011 data)[69]
Howarth tells us that methane contributes substantially to the greenhouse gas footprint on shorter time scales, dominating it on a 20-year time horizon. [70]
Since the first Howarth paper was published, other studies have shown the need to consider methane emissions at the shorter time scales. Both a report from the United Nations and a paper by Shindell show that controlling CO2 alone is not sufficient. The only way is to reduce methane emissions, beginning immediately.[71]
What evidence is there that the natural gas industry is the #1 source of methane emissions in the US? In an area near Denver Colorado, where gas drilling is the prominent industry, they are losing about 4% of their gas to the atmosphere — and that does not include additional losses in the pipeline and distribution system.[72]
And recently, a federal agency, the National Oceanic and Atmospheric Agency (NOAA), wrote that the rate of methane emissions from natural gas production was 6.2-11.7% of average hourly natural gas production. And this will offset the climate benefits of natural gas over other fossil fuels.[73]

This body of research tells us that methane emissions from unconventional gas development have been significantly underestimated by both the gas industry and the US EPA. Methane leaks have to be kept below 2 % for natural gas to be better than coal for slowing climate change.

The 2014 Intergovernmental Panel on Climate Change (IPCC) warns us that impacts of climate-related extremes include alteration of ecosystems, disruption of food production and water supply, damage to infrastructure and settlements, morbidity and mortality, and consequences for mental health and human well-being... People who are socially, economically, culturally, politically, institutionally, or otherwise marginalized are especially vulnerable to climate change… [74]

And climate change impacts human health, documented for example by Drs Sheffield and Landrigan, and others.
"The overall risks of climate change impacts can be reduced by limiting the rate and magnitude of climate change." These risks are all dependent on the emission scenarios, and all within our control.

- **2009 Sheffield and Landrigan. Global climate change costs significant healthcare dollars "Global Climate Change and Children' s Health: Threats and Strategies for Prevention" [75]**

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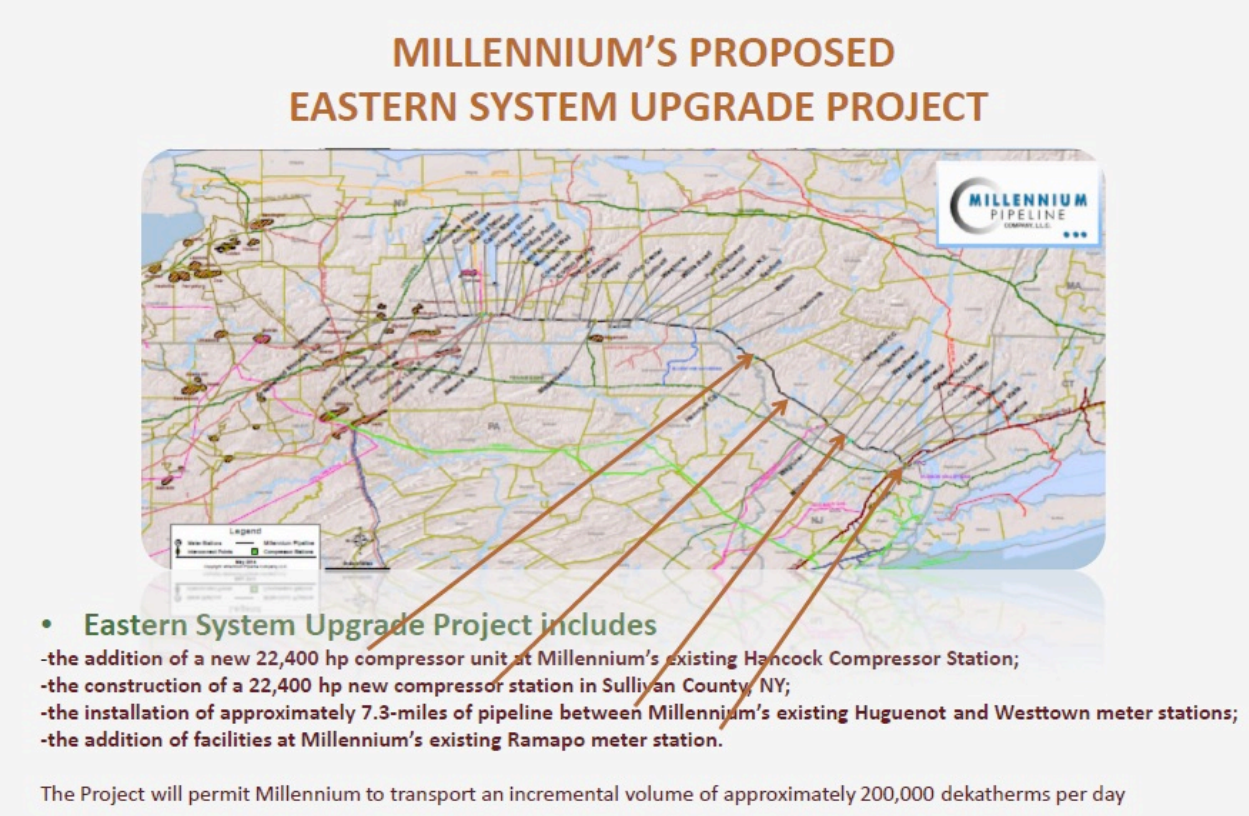
[69] http://www.psehealthyenergy.org/data/PSE_ClimateImpactsSummary_ALLCitations_01Feb2013.pdf
[70] http://link.springer.com/article/10.1007%2Fs10584-011-0061-5 and http://www.eeb.cornell.edu/howarth/publications/Howarth_et_al_2012_National_Climate_Assessment.pdf
[71] Shindell et al, Improved attribution of climate forcing to emissions, Science.
[72] http://www.nature.com/polopoly_fs/1.9982!/menu/main/topColumns/topLeftColumn/pdf/482139a.pdf
[73] http://onlinelibrary.wiley.com/doi/10.1002/grl.50811/abstract
[74] http://ipcc-wg2.gov/AR5/report/
[75] http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3059989/

- **2009 Shindell. Methane is a potent greenhouse gas, 33 times more efficient at trapping heat than carbon dioxide over 100 years, and about 100 times more potent than carbon dioxide over 20 years. [76]**
- **2011 Howarth, Santoro and Ingraffea. "The footprint for shale gas is greater than that for conventional gas or oil when viewed on any time horizon, but particularly so over 20 years.[77]**
- **2012 Tollefson. In an area known as the Denver-Julesburg Basin, where gas drilling is the prominent industry, they are losing about 4% of their gas to the atmosphere — not including additional losses in the pipeline and distribution system.[78]**
- **2012 Howarth. While methane is only causing about 1/5th of the century-scale warming due to US emissions, it is responsible for nearly half the warming impact of current US emissions over the next 20 years.[79]**
- **2012 Myhrvold, N. P. and K Caldeira. The carbon dioxide emitted from burning natural gas contributes significantly to greenhouse gas emissions driving global climate change.[80]**
- **2013 NOAA and CIRES. An emission rate corresponding to 6.2-11.7% of average hourly natural gas production in Uintah County was measured in the month of February.[81]**
- **2014 Intergovernmental Panel on Climate Change (IPCC). Impacts of climate-related extremes include alteration of ecosystems, disruption of food production and water supply, damage to infrastructure and settlements, morbidity and mortality, and consequences for mental health and human well-being... People who are socially, economically, culturally, politically, institutionally, or otherwise marginalized are especially vulnerable to climate change… [82]**

[76] **Shindell et al, Improved attribution of climate forcing to emissions, Science.**
[77] **http://link.springer.com/article/10.1007%2Fs10584-011-0061-5**
[78] http://www.nature.com/polopoly_fs/1.9982!/menu/main/topColumns/topLeftColumn/pdf/482139a.pdf
[79] http://www.eeb.cornell.edu/howarth/publications/Howarth_et_al_2012_National_Climate_Assessment.pdf
[80] **http://iopscience.iop.org/1748-9326/7/1/014019/pdf/1748-9326_7_1_014019.pdf**
[81] **http://onlinelibrary.wiley.com/doi/10.1002/grl.50811/abstract**
[82] **http://ipcc-wg2.gov/AR5/report/**



From permit applications we know that compressor stations emit:
-Nitrogen oxides (NOx) which are associated with respiratory disease. Ozone is formed when NOx and Volatile Organic Compounds (VOCs) react in the presence of heat and sunlight.
-Volatile organic compounds (VOCs) are neurotoxins and have significant cognitive and behavioral effects. They are known hepatotoxins, reproductive toxins and fetotoxins, and have been associated with teratogenesis and fetal wastage. All are dermatotoxins.
-Formaldehyde which is a carcinogen.
-Sulfur dioxide (SO_2) is associated with respiratory and neurological illness, and death.
-Particulate matter is of small size and carries toxic pollutants deep into the lungs, and is a carcinogen.

Following are the projected emissions from the ESU (from page 131 of the Millennium EA). Just the newly constructed compressors, not including the previously built Hancock compressor nor the metering/regulating stations, nor the Minisink compressor which really is part of this project, as well as the CPV power plant, will add over 200,000 tons per year of CO_2 equivalents.

Table B-17 Summary of Annual Operational Emissions (tpy)[a]								
Facility	NOx	SO_2	CO	PM_{10}	$PM_{2.5}$	VOC	CO_2e	Total HAPs
Huguenot Loop								
Fugitive emissions	N/A	N/A	N/A	N/A	N/A	4.6E-06	1.5	N/A
Huguenot Meter Station								
Fugitive emissions	N/A	N/A	N/A	N/A	N/A	1.9E-04	6.3	N/A
Westtown Meter Station								
Fugitive emissions	N/A	N/A	N/A	N/A	N/A	1.9E-04	6.3	N/A
Highland Compressor Station								
Proposed compressor	48.59	4.57	78.08	12.27	12.27	5.53	95,690	2.48
Proposed emergency generator	1.36	0.00	2.71	0.02	0.02	0.68	285	0.18
Proposed fuel gas heater	0.53	0.03	0.44	0.04	0.04	0.03	631	0.01
Fugitive and vented emissions	N/A	N/A	N/A	N/A	N/A	0.53	8,466.2	N/A
Subtotal	***50.48***	***4.60***	***81.23***	***12.33***	***12.33***	***6.77***	***105,086.2***	***2.67***
Hancock Compressor Station								
Existing PTE	35.21	8.26	49.56	12.49	12.49	4.43	69,718	0.74
Proposed compressor	47.92	4.51	77.28	12.10	12.10	5.45	94,373	2.45
Proposed emergency generator	1.36	0.00	2.71	0.02	0.02	0.68	285	0.18
Proposed fuel gas heater	0.53	0.03	0.44	0.04	0.04	0.03	631	0.01
Fugitive and vented emissions	N/A	N/A	N/A	N/A	N/A	0.54	8,652	N/A
Subtotal	***85.02***	***12.80***	***129.99***	***24.65***	***24.65***	***11.13***	***173,659***	***3.38***
Ramapo Meter Station [b]								
Existing PTE	12.89	0.08	19.65	1.00	1.00	3.93	15,788	1.35
Fugitive emissions	N/A	N/A	N/A	N/A	N/A	1.9E-04	6.3	N/A
Subtotal [b]	***12.89***	***.08***	***19.65***	***1.00***	***1.00***	***3.93***	***15,794.3***	***1.35***

PTE = potential to emit

[a] The numbers in this table have been rounded for presentation purposes. As a result, the totals may not reflect the sum of the addends.

[b] Operational emissions for the proposed fuel gas heater at the Ramapo Meter Station have not been quantified; however, the planned new heater is unlikely to require major source permitting.

It is important to note that these numbers are based on projected emissions from modeling. As we have seen previously, this modeling does not take into account large spikes in emissions. Spikes on the order of 400 mcg/m3 have been witnessed during the Minisink study, while the AQI for the day

read in the low teens. These are not accounted for in the emissions modeling. Therefore, the true cost in co2 equivalents, and hence in human health, is much underestimated.

In the EA for Minisink the standards for the air emissions used modelling rather than direct measurements. And based on the modeling, FERC wrote (https://www.ferc.gov/industries/gas/enviro/eis/2012/03-02-12- ea/section-b.pdf): "… the Minisink Compressor Station would not be a major source of air emissions under federal air quality permitting programs. In addition, the total potential emissions from the proposed station would comply with the EPA's NAAQS, in accordance with the CAA…"
In other words, they considered this safe. However, the data from a pilot study in Minisink suggests quite the opposite. (see Minisink study https://sape2016.files.wordpress.com/2014/01/summary-of-minisink-results-public-swpa-ehp.pdf)

A pediatrician, Dr Curtis Norgaard, writing in DotHouse Health, "A compressor station in New Hampshire: Analysis of health risks", estimated the following health outcomes for a similar compressor in New Hampshire:
Nitrogen dioxide: Increased respiratory hospitalizations (2%), heart failure (1.7%)
Carbon monoxide: Increased premature birth rates (4%), and put women at risk of having low birth weight babies (7%)
Sulfur dioxide: Low birth weight (3%), heart failure (2.4%)
Particulate matter: Increased fatality from heart and lung disease (5.3%), and new childhood asthma diagnoses (10-12%)

The components of natural gas and pipelines are:

- **Methane (CH4)**
- **Light and heavy alkanes**
- **BTEX - Benzene, toluene, ethylbenzene, and xylene**
- **Hydrogen and carbonyl sulfides**
- **Sulfur Dioxide (SO2)**
- **Formaldehyde**
- **Particulate matter (tiny soot-like particles)**
- **Carbon monoxide (CO)**
- **VOCs**
- **Radon, polonium and lead**
- **Polychlorinated Biphenyls (PCBs) [83]**

[83] http://sape2016.files.wordpress.com/2013/10/algonquin_incremental_market_project.pd
http://courses.washington.edu/envir300/papers/Steinzor_et_al_2013.pdf
http://sape2016.files.wordpress.com/2013/10/air_quality_and_climate_impacts_of_shale_gas_operations.pdf

The sources are:

- **Emissions and waste from transport vehicles, combustion at compressor stations, storage and condensate tanks, metering stations, processing plants, pipelines, compressor blowdowns, glycol dehydration units, amine units, separators.**
- **Flaring , venting and leaks[84]**

90% of individuals living within two miles of the compressors reported experiencing odor events from these facilities listed here. The exposure is cumulative and costly.[85] [86]

Following are some of the health impacts associated with infrastructure emissions:

NOx is associated with respiratory disease. Low levels cause eye, nose, throat & lung irritation; coughing, shortness of breath; tiredness, nausea. High levels of exposure can seriously damage tissues in the throat and upper respiratory tract and trigger the build- up of fluid in the lungs. Additionally, nitrogen oxides also contribute to acid rain and can react with other pollutants to form ozone and particulate matter.

Modelling* NOx health effects based on measurements*: (from Dr Curtis Nordgaard's presentation)
Health effects for 13.4 ug/m3 increase in NO2: *New diagnoses* of childhood asthma: Increase 7% *Clinic visits* for asthma (all ages): Increase 4.4% *ER visits* for asthma: Increase by 3.8%.
***Hospitalization* increased: Asthma (2.2%), COPD (6.7%), stroke (3.7%), heart failure (6.7%)**
***Death* from cardiovascular (1.1%) and respiratory (1.4%) diseases**

VOCs (Volatile organic compounds) are organic chemicals that have a high vapor pressure at ordinary room temperature; they are neurotoxins, hepatotoxins, reproductive toxins, fetotoxins, and dermatotoxins. Short-term exposure to VOCs can irritate the respiratory tract and eyes and cause dizziness and headaches. Long-term exposure is linked to cancer and a number of adverse neurological, reproductive, and developmental effects. VOCs can also impact health by combining with nitrogen oxides to form ozone.

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[84] **http://www.edf.org/sites/default/files/9235_Barnett_Shale_Report.pdf**
http://www.epa.gov/airquality/oilandgas/pdfs/20120417presentation.pdf
[85] **http://www.earthworksaction.org/files/publications/SUBRA_3_Shale_Gas_PlaysHealth_Impacts_sm.pdf**
http://www.post-gazette.com/news/state/2013/10/06/Marcellus-gas-facilities-near-to-one-another-or-even-linked-are-evaluated-individually-for-pollution/stories/201310060050

[86] **Litovitz, Curtright, 2013, "Estimation of regional air-quality damages from Marcellus Shale natural gas extraction in Pennsylvania". Access at http://iopscience.iop.org/1748-9326/8/1/014017/pdf/1748-9326_8_1_014017.pdf and also http://iopscience.iop.org/1748-9326/8/1/014017**

SO2 is associated with respiratory illness. At high exposure levels, sulfur dioxide can cause temporary breathing difficulty for people with asthma and long-term exposure to high levels can aggravate cardiovascular diseases. Sulfur dioxide also reacts with nitrogen oxides and other air pollutants to form particle pollution and acid rain, which damages forest and aquatic ecosystems.

Particulate matter also known as particle pollution is made up of a mixture of solid particles and liquid droplets suspended in the air. While some particles such as dust and soot are large enough to be seen with the naked eye, others are so tiny that they can only be viewed with the aid of a microscope. Produced primarily by the combustion of fossil fuels, particulate matter is one of the deadliest air pollutants. Each year, particle pollution causes an estimated 60,000 premature deaths. Fine particles are especially dangerous because they can bypass the body's natural defenses to lodge deep in the lungs where they can pass easily into the bloodstream.
It contributes disproportionately to human health risks, and includes brain lesions resulting in neurobehavioral abnormalities. With small increases in airborne particulate matter exposure, human risks increase for the following:

- **Cardiovascular disease-- heart attacks, strokes**
- **Respiratory disease-- asthma attacks, lung cancer**
- **Fetal and neonatal illness.**
- **Childhood illnesses: Pediatric allergies, ear/nose/throat and respiratory infections early in life, impaired lung development in children that affects lung function in adulthood, asthma, bronchiolitis, exacerbation of existing asthma and exacerbation of cystic fibrosis.**
- **in older people, it can lead to exacerbation of chronic obstructive pulmonary disease, congestive heart failure, heart conduction disorders, myocardial infarction and coronary artery disease, and diabetes in the elderly.**
- **Cancer**

Formaldehyde causes cancer.

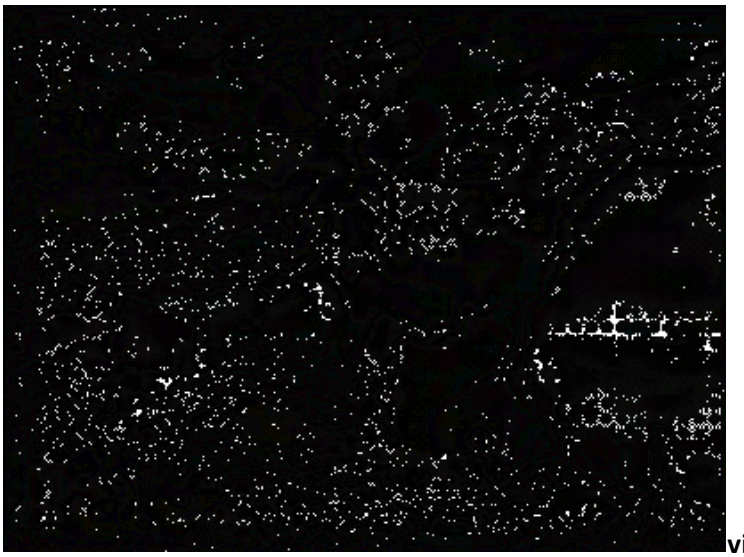
Tons of pollutants could seep into the soil and the regional watersheds.

References for health effects:
http://www.atsdr.cdc.gov/toxfaqs/TF.asp?id=396&tid=69
http://www.psr.org/environment-and-health/climate-change/air-pollution/air-pollutants.html
Wendt JK, et al. (2014). Environ Res, v131, 50-8.
To T et al. (2015). BMJ Open, v5, e009075.
Strickland MJ et al. (2010). Am J Respir Crit Care Med, v182, 307-316. Mills IC et al. (2015). BMJ Open, v5, e006946. http://www.atsdr.cdc.gov/toxfaqs/TF.asp?id=396&tid=69
http://www.psr.org/environment-and-health/climate-change/air-pollution/air-pollutants.html
http://www.atsdr.cdc.gov/toxfaqs/TF.asp?id=396&tid=69
http://www.psr.org/environment-and-health/climate-change/air-pollution/air-pollutants.html
http://www.usatoday.com/story/news/nation/2014/06/09/air-pollution-autism-study/10226445/

http://www.atsdr.cdc.gov/toxfaqs/TF.asp?id=396&tid=69
http://www.psr.org/environment-and-health/climate-change/air-pollution/air-pollutants.html
http://ntp.niehs.nih.gov/ntp/roc/twelfth/profiles/formaldehyde.pdf
http://www.picarro.com/resources/literature_publications/hydrocarbon_emissions_characterization_in_the_colorado_front_ran_0

Compilation of complaints from residents living near compressors:
most common COMPLAINTS of residents living near compressors:

- **Skin rash or irritation**
- **Eye irritation**
- **Gastrointestinal problems such as pain, nausea, vomiting**
- **Respiratory problems such as difficulty breathing or cough**
- **Upper respiratory problems such as congestion, sore throat and nosebleeds**
- **Neurological problems such as headaches, movement disorders, dizziness**
- **Psychological problems such as anxiety, depression, stress, irritability**


visualization of emission using a FLIR camera

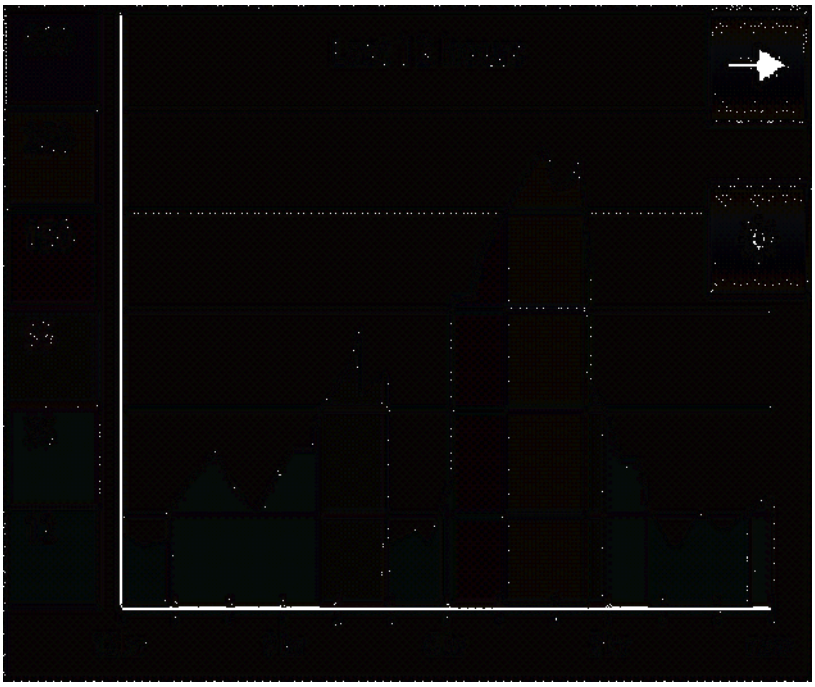
And long-term consequences:

- **Cardiovascular, such as heart attack and high blood pressure**
- **Respiratory, such as exacerbation of asthma, COPD**
- **Neurological such as stroke and cognitive deficits in children**
- **Birth defects**
- **Cancer**
- **Premature mortality**

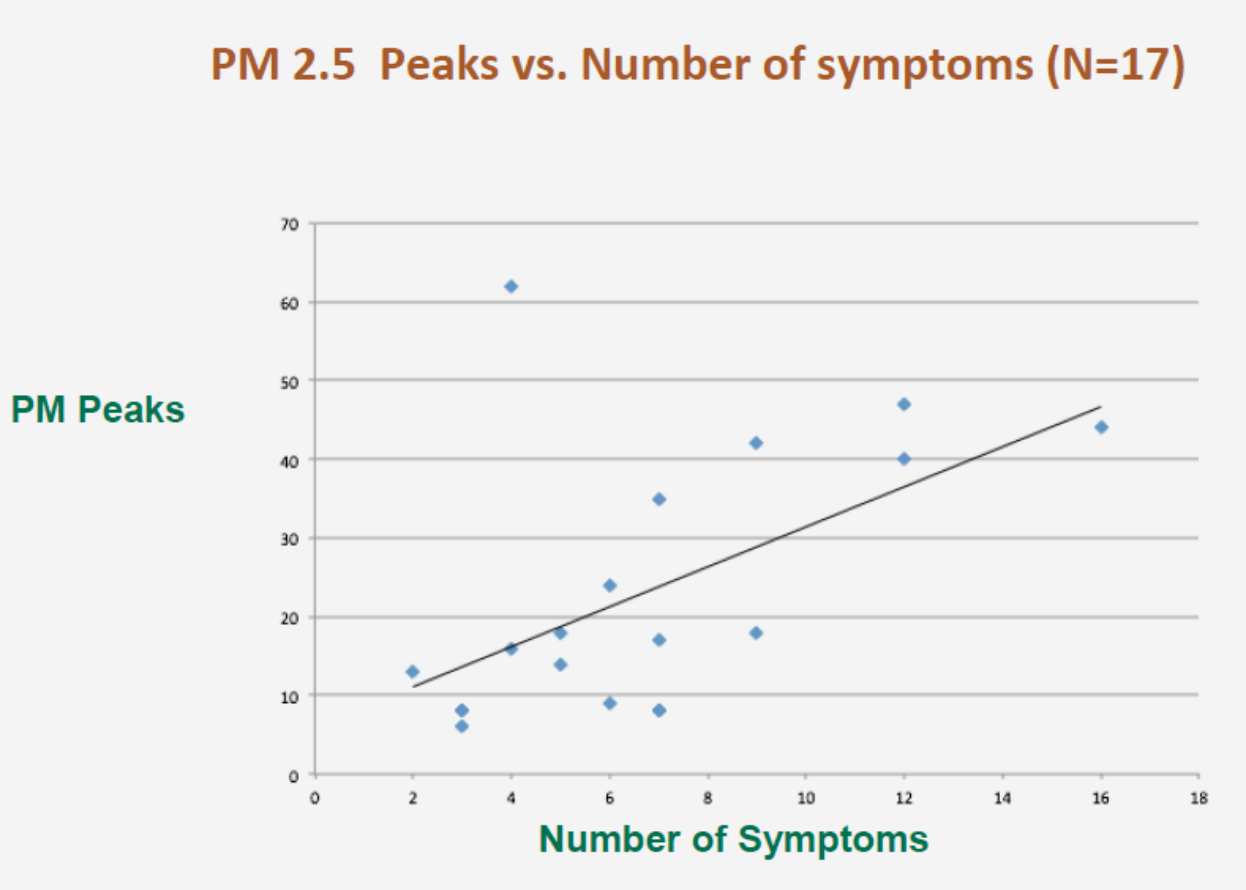
Children and pregnant women are particularly affected in adverse ways by environmental toxins. Children are especially vulnerable to air pollution because their lungs continue to grow and enlarge until about age 18. Plus, they breathe faster and are closer to the ground.
Air pollution has also been shown to be associated with birth problems, neurodevelopmental disorders, lower IQ in babies born to mothers with polycyclic aromatic hydrocarbon exposure during pregnancy and learning disorders in exposed children.
A recent Harvard Public Health study linked an autism spike to air pollution. Children whose mothers were exposed to high levels of fine particulate pollution in late pregnancy have up to twice the risk of developing autism as children of mothers breathing cleaner air. The greater the exposure to fine particulates, the greater the risk.
Overall, although the evidence is just emerging for an association between air pollution and low birth weight, birth defects and neurodevelopmental problems, there is clearly a trend of association with some pollutants at some points during pregnancy and early childhood. These findings clearly demonstrate the need for additional studies as the public health implications of increasing the numbers of premature and low birth weight babies, as well as children with autism and birth defects are enormous.

REFERENCES for health impacts in vulnerable populations:
CEH, 2013, http://www.ceh.org/legacy/storage/documents/Fracking/fracking_final-low-1.pdf World Health Organization http://www.who.int/ceh/capacity/Children_are_not_little_adults.pdf
Wilhelm at UCLA report on air pollution and premature births
http://www.environment.ucla.edu/reportcard/article.asp?parentid=1700 Perera, 2009
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2864932/
Perera et al, 2006. Effect of prenatal exposure to airborne polycyclic aromatic hydrocarbons on neurodevelopment in the first 3 years of life among inner-city children. Environ Health Perspect. Doi:114(8):1287–1292. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1551985/ Perera FP et al 2003 Effects of Transplacental Exposure to Environmental Pollutants on Birth Outcomes In a Multiethnic Population.
Environmental Health Perspectives 111:2 201-205
Weisskopf. December 2014. http://ehp.niehs.nih.gov/1408133/

The following graph is a screen shot of a SPECK Particulate Matter monitor 12-hour report. One would expect that symptom severity correlated with the height of the PM measurement.



And it did:



This alerted SWPA-EHP to review data previously collected.

Particulate Matter (PM) was used as a marker for all the emissions from the compressor. SPECK or DYLOS monitors measured Particulate Matter.
Symptoms were assessed and plotted against the PM peaks.
And they found a correlation between the number of symptoms and PM peaks. In other words, they found that the # of peaks related in a linear fashion to # of symptoms.
The higher the PM monitor readings, the more health symptoms were observed.
The SWPA-EHP Minisink pilot project on compressors (next slide) was a response to a community need and request for an accurate assessment of exposures and health impacts since what they were experiencing as far as health impacts was not in synch with what FERC, the EPA and State agencies were modeling, and then stating that there should be no health impacts. Please recall that the FERC uses models and predictions to arrive at their conclusion. Please note that the measurements that are done by the company or government agencies are on a sampling basis and not continuous.
The SWPA-EHP study included community participation, a health professional to do individual health assessments, continuous monitoring for Particulate Matter both indoor and outdoor, and episodic VOC sampling with summa canisters.
The predominant health impacts reported were:

- **Respiratory problems**
- **Neurological problems**
- **Dermatological problems**
- **Overall "quality of life" levels were below normal for half of the respondents when compared to a national standard (SF36).**

Individual health assessments were completed on eight families in Minisink. We filled out 35 health intakes, 12 of which were for children. This is the most complete set of intakes from one community yet collected by any group looking at infrastructure health effects.

The residents were given and instructed on SPECK PM monitors to document indoor and outdoor PM. The readings showed significant recurrent spikes in the amount of particulate matter in the air inside and out. The spikes tended to occur at night when stable atmospheric conditions hold particulate matter low to the ground. And based on the residents' health diaries and individual health assessments, we concluded that it is likely that the spikes in airborne particulate matter are causing acute health impacts in community members.
In reviewing the health data. we found an association between respiratory and neurological affects – specifically headaches – which appeared to be occurring together in this group. Dermatological symptoms (rashes that come and go, and that may be allergic reactions) also appeared in nearly 1/3 of the intakes, along with concerns about health and related stress. These health findings are consistent with information from other research reported in peer-reviewed literature and by other environmental health organizations.
To summarize the health findings, the predominant health impacts reported were:

- **Respiratory problems (22, includes 6 experiencing nosebleeds)**
- **Neurological problems, (12, all of whom report headaches)**
- **Dermatological problems (10)**
- **On the SF36, a standardized self-assessment--overall mental health and wellbeing levels were below normal for half of the respondents.**

Based on the monitoring results and health intakes, EHP concluded that families living near the Minisink Compressor station are exposed to elevated levels of PM2.5, when compared to the regional AQI.
And further, the episodic nature of health symptoms reported by residents is likely associated with the episodic high emissions that come from the compressor station. This conclusion is supported by the periodically high levels of PM2.5 recorded by the Speck monitors, and the onset of symptoms after the compressor came online, plus no other logical explanation.

REFERENCES for Minisink study:

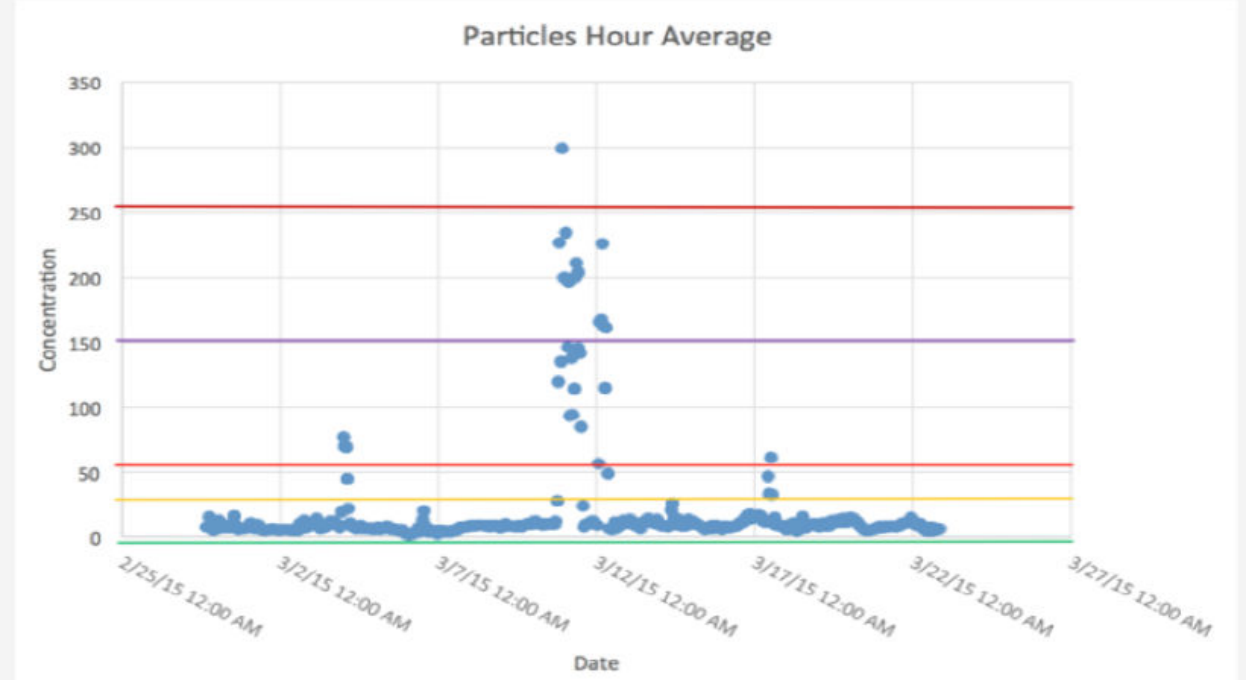
Human Exposure to Unconventional Natural Gas Development: A Public Health Demonstration of Periodic High Exposure to Chemical Mixtures in Ambient Air (Full Appendices)
Understanding exposure from natural gas drilling puts current air standards to the test

EHP RESULTS SUMMARIES

Physical, Mental and Environmental Impacts of Unconventional Oil and Gas Development Spring 2016
Summary of Minisink Compressor Station Monitoring Results
Summary on Compressor Stations and Health Impacts February 24, 2015

EXAMPLE OF SPECK RESULTS (UG/M3)

The speck monitor documented exceptionally high spikes that would not have been captured if averaged over a 24-hr period. The horizontal colored lines correlate with EPA aqi (air quality index) levels and the blue dots show the hourly spikes. The yellow line is the level at which sensitive individuals may be affected.



EPISODIC HIGH LEVELS OF PM2.5 OUTSIDE MULTIPLE HOMES OCCURRED WITHIN SIMILAR TIME FRAMES SEVEN TIMES OVER 59 DAYS. RESULTS ARE BASED ON HOURLY AVERAGES OF UG/M3 VALUES.

Date of Peak event	# of monitors showing a peak out of # in use	Recorded peak levels	Daily AQI average
10/30	3/4	31, 90, 426	5.0
11/5	2/5	33, 57	5.5
11/7	3/5	36.5, 114, 133	5.3
11/12	4/5	53.7, 131, 269, 325	9.0
12/3	3/5	40, 235, 399	5.0
12/6	2/5	76, 160	10.8
12/17	3/5	99, 162, 229	9.9

In the chart above, the data presented shows the episodic high levels of PM, and documented outside multiple homes.

It is clear that the recorded peaks were NOT captured by the AQI daily average (last column on the right). Nor would they be – since it is a 24-hour average for the region.
During the monitoring period, the SPECK monitors recorded at least three times the regional average of 6.3 micrograms per cubic meter (ug/M3), and regularly beyond the Environmental Protection Agency limit of 12. Multiple episodes of peaks into the hundreds were also recorded by Speck monitors.
A study published in June by Harvard epidemiologist Joel Schwartz and his colleagues identified the dangers of PM 2.5 even above 6. Each increase of one microgram per cubic meter increases the mortality rate by 1 percent for people over 65, they found.[87]

SWPA EHP is currently in the process of gathering information on several compressors in NY, in partnership with the Institute for Health and the Environment at Albany and the Madison County Health Dept.
That includes the Town of Highland and the Hancock compressor stations where the baselines have already been done.
The study goals are…

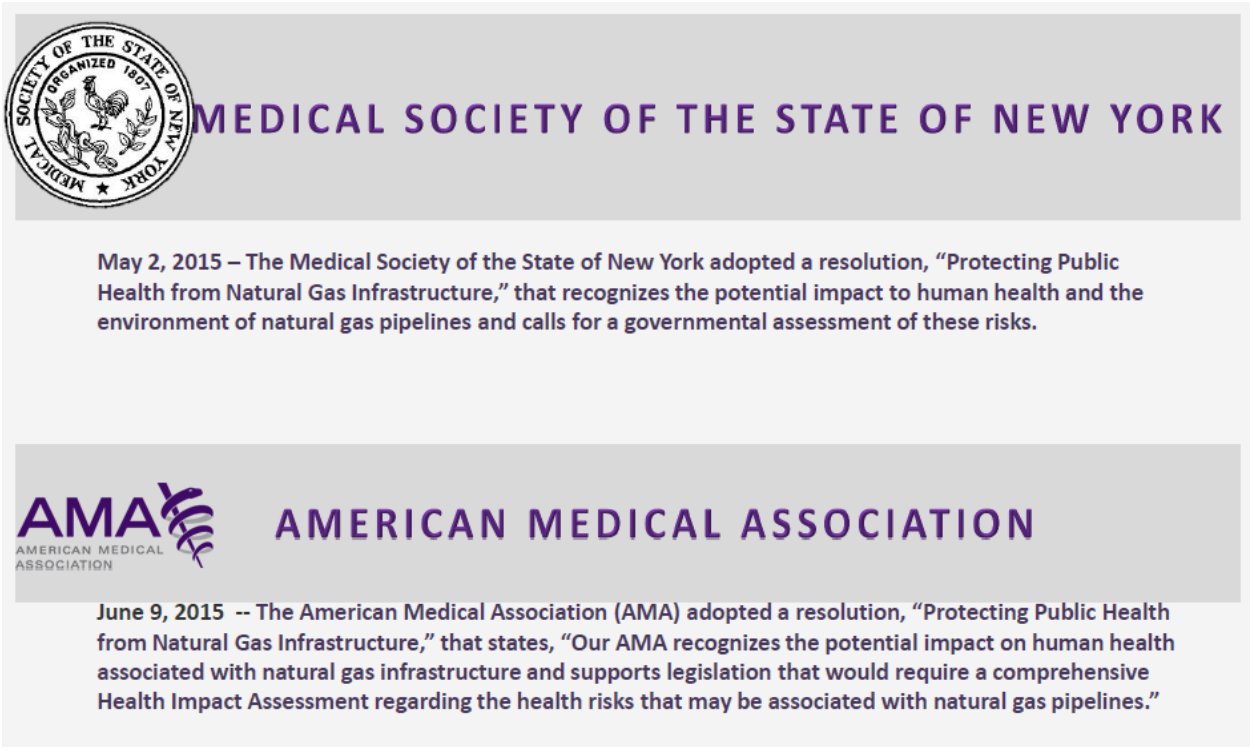
- **To assess residents' health status before, during and after construction**
- **Monitor the environmental factors**
- **And analyze the results**

There is a process which brings public health to the table and which can inform land use decisions and should be used prior to the development of regulations and before permitting. It is particularly important in the case of gas exploration and production.

"HIA IS A SYSTEMATIC PROCESS THAT USES AN ARRAY OF DATA SOURCES AND ANALYTIC METHODS AND CONSIDERS INPUT FROM STAKEHOLDERS TO DETERMINE THE POTENTIAL EFFECTS OF A PROPOSED POLICY, PLAN, PROGRAM, OR PROJECT ON THE HEALTH OF A POPULATION AND THE DISTRIBUTION OF THOSE EFFECTS WITHIN THE POPULATION. HIA PROVIDES RECOMMENDATIONS ON MONITORING AND MANAGING THOSE EFFECTS."
"IMPROVING HEALTH IN THE UNITED STATES: THE ROLE OF HEALTH IMPACT ASSESSMENT" [88]

87 http://www.templenh.org/sites/templenh/files/file/file/minisink_ny_compressor_health_study_fall_2015.pdf

88 HTTP://WWW.NAP.EDU/CATALOG.PHP?RECORD_ID=13229



This is needed, at a minimum:

- **Cumulative environmental impact study with a comprehensive health assessment, including pre- during and post-construction health monitoring**

- **Baseline measurements of air emissions, methane, radon and water quality, and continuous monitoring if compressor is approved**

- **Cumulative emissions to include condensate tank emissions and fugitive methane**

- **Best technologies, and for compressors, electric power source**

- **Hazardous Materials Management Plan including plan for disposal of waste from condensate tanks and pipelines, and a NORM Monitoring Plan**

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