# HEALTH IMPACTS OF GAS INFRASTRUCTURE: COMPRESSOR STATIONS

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# Health Impacts of Gas Infrastructure

- potential impacts and health concerns, focus on compressors

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

View the build-out of infrastructure at www.fracktracker.org -- click on maps, and then NY

**An important impact of all this infrastructure is an exacerbation of climate change.**
**And climate change impacts human health, documented for example by Drs Sheffield and Landrigan, and others.**

**"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." CHPNY Compendium http://concernedhealthny.org/wp-content/uploads/2012/11/PSR-CHPNY-Compendium-3.0.pdf**

**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)**
**http://www.psehealthyenergy.org/data/PSE_ClimateImpactsSummary_ALLCitations_01Feb2013.pdf**

**Howarth tells us that methane contributes substantially to the greenhouse gas footprint on shorter time scales, dominating it on a 20-year time horizon.**
**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**

**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. Shindell et al, Improved attribution of climate forcing to emissions, Science.**

**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. http://www.nature.com/polopoly_fs/1.9982!/menu/main/topColumns/topLeftColumn/pdf/482139a.pdf**

**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. http://onlinelibrary.wiley.com/doi/10.1002/grl.50811/abstract**

**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… http://ipcc-wg2.gov/AR5/report/**

**"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" 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. Shindell et al, Improved attribution of climate forcing to emissions, Science.**
- **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." http://link.springer.com/article/10.1007%2Fs10584-011-0061-5**
- **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. http://www.nature.com/polopoly_fs/1.9982!/menu/main/topColumns/topLeftColumn/pdf/482139a.pdf**
- **2012 Howarth. While methane is only causing about 1/5 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. http://www.eeb.cornell.edu/howarth/publications/Howarth_et_al_2012_National_Climate_Assessment.pdf**
- **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. http://iopscience.iop.org/1748-9326/7/1/014019/pdf/1748-9326_7_1_014019.pdf**
- **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. http://onlinelibrary.wiley.com/doi/10.1002/grl.50811/abstract**
- **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… http://ipcc-wg2.gov/AR5/report/**

INFRASTRUCTURE
~ SILICA SAND / WATER WITHDRAWAL / STORAGE / WASTE DISPOSAL
~ PROCESSING AND FOSSIL FUEL PLANTS
~ **PIPELINE TRANSPORT** / OIL TRAINS / EXPORT TERMINALS

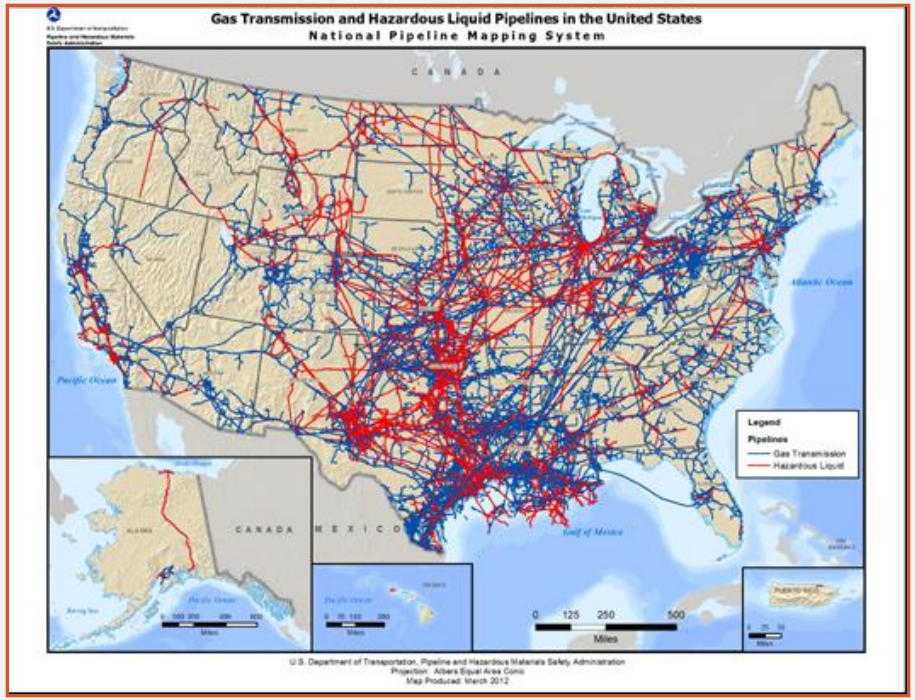
## SAFETY

**Accidents**
http://projects.propublica.org/pipelines/

**Spills**
http://earthjustice.org/features/campaigns/fracking-across-the-united-states

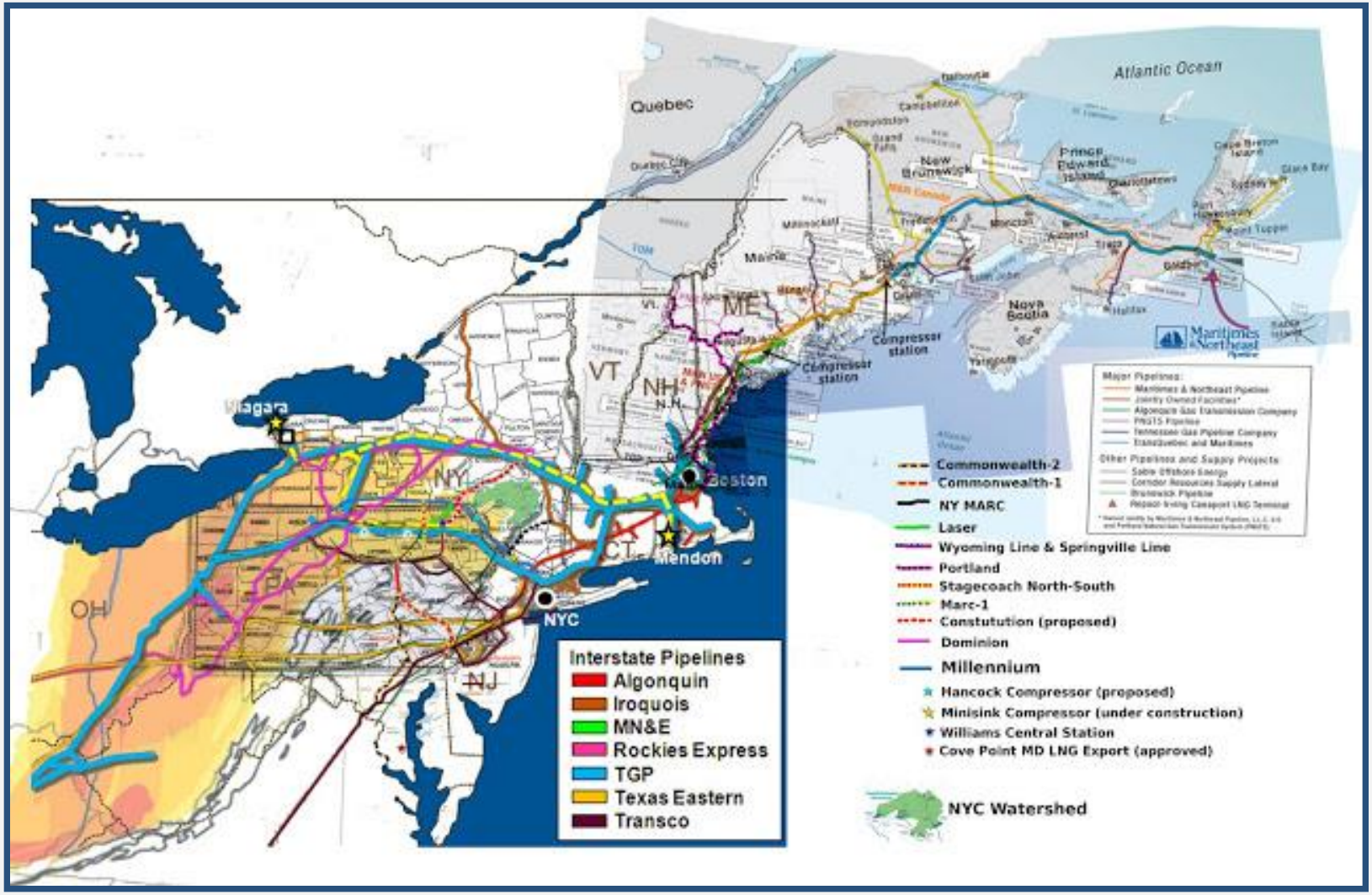
**Pipeline and Hazardous Materials Safety Administration**
http://primis.phmsa.dot.gov/comm/reports/safety/psi.html

## PIPELINES IN THE US

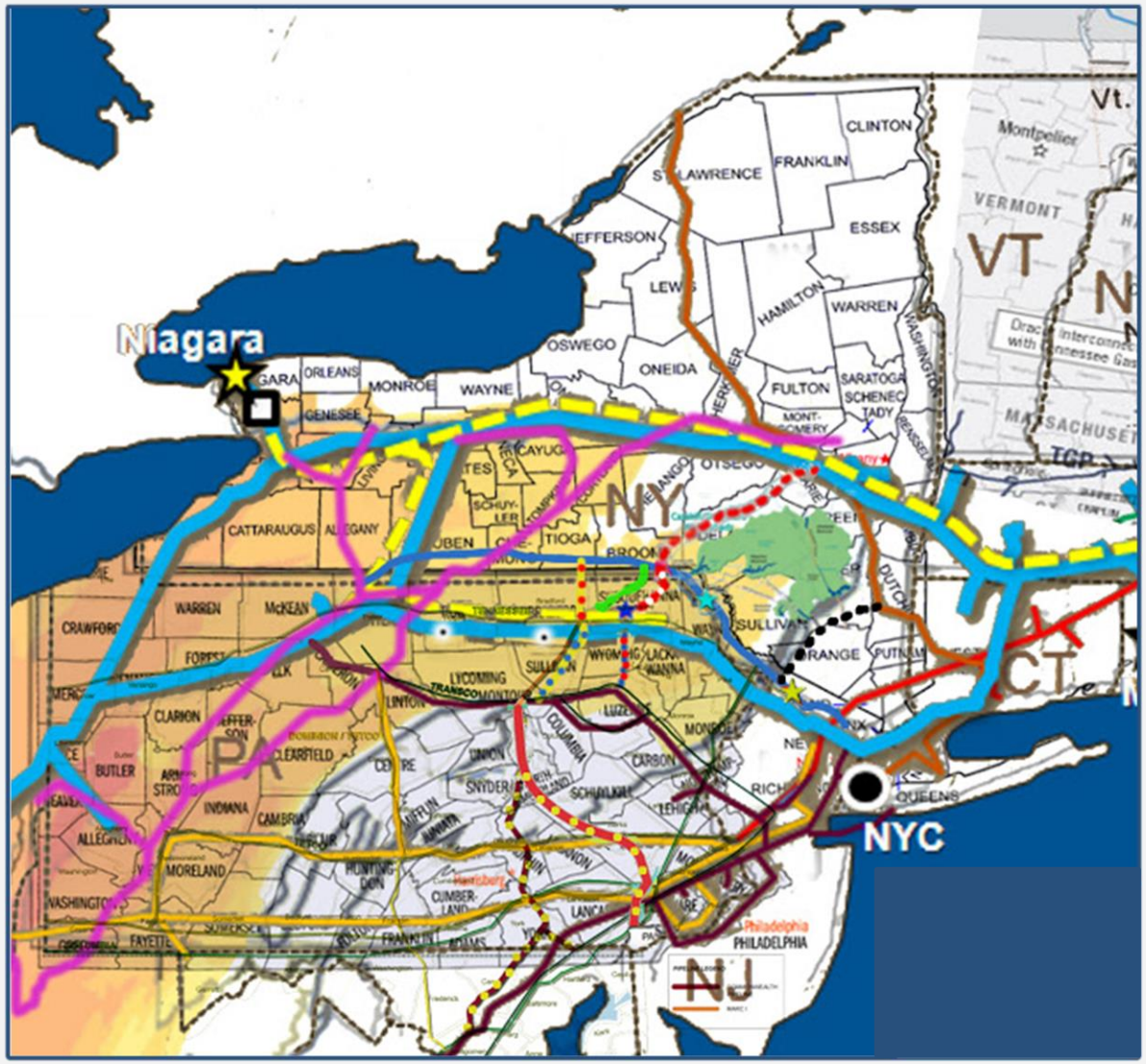



## HEALTH

http://www.iom.edu/~/media/Files/Activity%20Files/Environment/EnvironmentalHealthRT/2012-04-30/Robinson.pdf and
http://sape2016.files.wordpress.com/2013/10/air_quality_and_climate_impacts_of_shale_gas_operations.pdf and
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 and
http://www.cleanair.org/program/outdoor_air_pollution/shale_gas_infrastructure/milford_compressor_station_air_impacts_commun and
http://www.environmentalhealthproject.org/wp-content/uploads/2015/06/Summary-of-Minisink-Results.Public.pdf and
http://www.environmentalhealthproject.org/wp-content/uploads/2012/03/Compressor-station-emissions-and-health-impacts-02.24.2015.pdf and
https://www.madisoncounty.ny.gov/sites/default/files/publicinformation/madison_county_doh_comments_-_docket_no._cp14-497-000.pdf




http://williamahuston.blogspot.com/p/various-pipeline-maps.html




http://williamahuston.blogspot.com/p/various-pipeline-maps.html

# MILLENNIUM'S PROPOSED EASTERN SYSTEM UPGRADE PROJECT


- **Eastern System Upgrade Project includes**

**-the addition of a new 22,400 hp compressor unit at Millennium's existing Hancock Compressor Station;**
**-the construction of a 22,400 hp new compressor station in Sullivan County, NY;**
**-the installation of approximately 7.3-miles of pipeline between Millennium's existing Huguenot and Westtown meter stations;**
**-the addition of facilities at Millennium's existing Ramapo meter station.**

The Project will permit Millennium to transport an incremental volume of approximately 200,000 dekatherms per day

- **FERC pre-filing number PF16-3** http://www.ferc.gov
  http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14420742

**What is the purpose of compressors?**

**Natural gas is physically moved through pipelines as a result of pressure, specifically pressure differentials. Compressors provide the force and are powered by electric motors or by natural gas or diesel fired engines that compress or squeeze incoming gas and push it out at a higher pressure. Compressor stations are facilities that house the compressors. They are built every 50 to 100 miles along the length of a transmission pipeline to boost the system pressure to keep the gas flowing.** http://primis.phmsa.dot.gov/comm/NGCompressor.htm

**The pressures in transmission pipelines typically range from 500 to 1000 pounds of pressure per square inch, or psi.**

**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 (SO2 ) 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.**

| | COMPRESSOR LOCATION | | | | |
|---|---|---|---|---|---|
| Pollutant | Sheds (tons/year) | Horseheads (tons/year) | Minisink (tons/year) | Brookman Corners (tons/year) | Town of Highland (tons/year) |
| Formaldehyde | 0.1 | 0.1 | | 2.2 | ? |
| VOC | 1.2 | 1.2 | 3.43 | 16.3 | ? |
| CO | 6.6 | 6.6 | 29.6 | 33.4 | ? |
| NOx | 24.4 | 24.4 | 28.8 | 66.3 | ? |
| PM10 | 6.4 | 6.4 | 11.04 | 13.1 | ? |
| PM2.5 | 6.4 | 6.4 | 11.04 | 13.1 | ? |
| SO2 | 0.7 | 0.7 | 7.20 | 1.1 | ? |
| GHG | 54,351 | 53,949 | 61,000 | 96,683 | ? |
| Total pollutants (tons/year) | 54,397 | 54,397 | 61,751 | 96,775 | ~125,000 |
| Horsepower (HP) | 11,000HP | 11,000HP | 12,200HP | 18,643HP | 22,400HP |

**On the previous slide is a comparison with several other NYS compressors…we do not yet have a NUMBER of the tons of pollutants to be emitted per year since that was not in in the pre-filing application. But based on the HP, and comparing to similar gas-powered compressors in NYS, this is the estimate of annual total pollutants for the Town of Highland compressor: ~ 125,000 tons of emissions per year.**

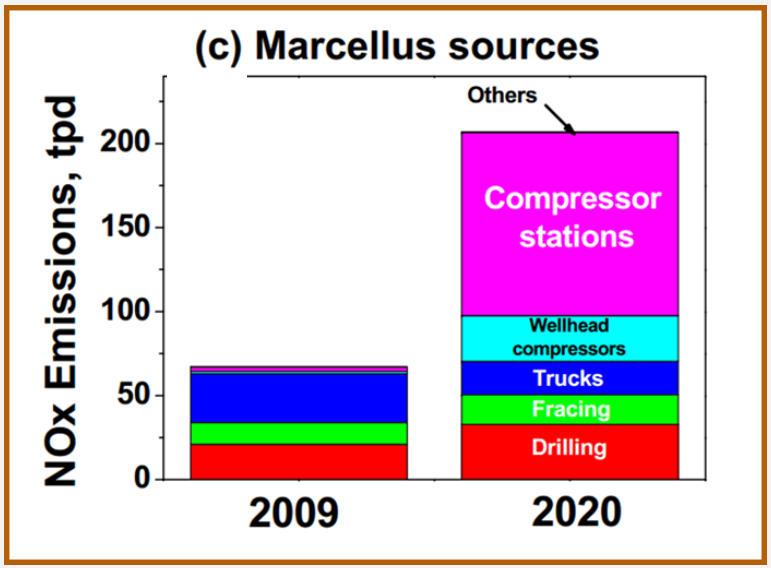
**A pediatrician, Dr Curtis Norgaard, writing in DotHouse Health, "A compressor station in New Hampshire? Analysis of health risks", estimated the following health outcomes for a similar compressor in New Hampshire:**
**Nitrogen dioxide: Increased respiratory hospitalizations (2%), heart failure (1.7%)**
**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%)**

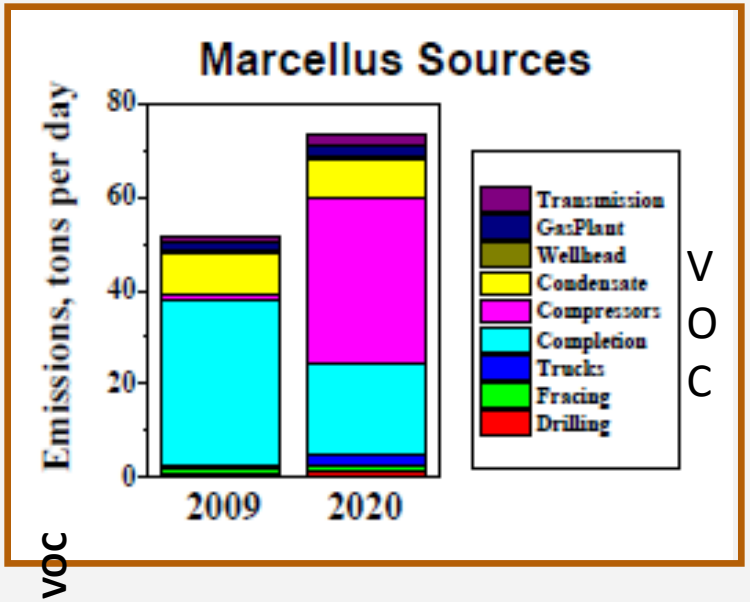
**In the EA for Minisink the standards for the air emissions used modelling rather than direct measurements. And based on the modeling, FERC wrote (https://www.ferc.gov/industries/gas/enviro/eis/2012/03-02-12-ea/section-b.pdf):**
**"… the Minisink Compressor Station would not be a major source of air 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, there is data from a pilot study in Minisink which suggests quite the opposite.**

**On the next slide is an analysis of the contribution of compressors to air pollution in Pennsylvania's gas fields. And … the volume of emissions from compressor stations is significant.**

**Emissions from compressor stations are significant; 60–75 % of the estimated damages (mostly health problems) from all natural gas activities result from compressor station activities.** From the 2013 RAND study of air-quality damages in Pennsylvania http://iopscience.iop.org/1748-9326/8/1/014017




**Graphs adapted from presentation of Dr Allen Robinson http://www.iom.edu/~/media/Files/Activity%20Files/Environment/EnvironmentalHealthRT/2012-04-30/Robinson.pdf and video http://www.iom.edu/Activities/Environment/EnvironmentalHealthRT/2012-APR-30/Day-1/Session-5/1-Robinson.aspx**

**see also Clean Air Council's Walker & Koplinka-Loehr presentation http://www.cleanair.org/program/outdoor_air_pollution/shale_gas_infrastructure/milford_compressor_station_air_impacts_commun**

**On the list on the next slide are the components of natural gas and pipelines:**

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**
- **Flaring , venting and leaks**

http://www.edf.org/sites/default/files/9235_Barnett_Shale_Report.pdf
http://www.epa.gov/airquality/oilandgas/pdfs/20120417presentation.pdf

**90% of individuals reported experiencing odor events from these facilities listed here.**

**The exposure is cumulative and costly.**

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
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

# POLLUTANTS

- Methane ($CH_4$)
- 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)




# SOURCES

- Emissions and waste from transport vehicles, combustion at compressor stations, storage and condensate tanks, metering stations, processing plants, pipelines
- Flaring , venting, blowdowns and leaks

## UNITS AT COMPRESSORS RELEASING EMISSIONS

Subra Earthworks

- Compressor Engines
- Compressor Blowdowns
- Condensate Tanks
- Storage Tanks
- Truck Loading Racks
- Glycol Dehydration Units
- Amine Units
- Separators
- Fugitive Emission Sources
- 90% of individuals reported experiencing odor events from these facilities

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% 3
*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.

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 previous 2 slides:**


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/

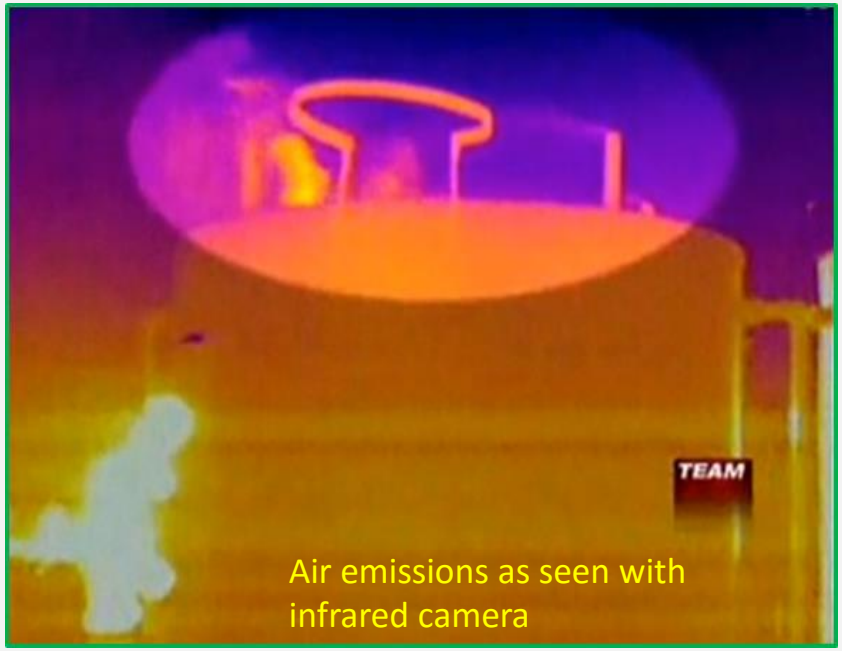
http://www.atsdr.cdc.gov/toxfaqs/TF.asp?id=396&tid=69

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

# COMMON COMPLAINTS NEAR COMPRESSORS



Air emissions as seen with infrared camera

**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

**Possible 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

**In these photos you are seeing thermal emissions with special infrared cameras, called FLIR. You cannot see them with the naked eye.**

http://www.flir.com/ogi/content/?id=66693 and http://www.flir.com/ogi/display/?id=55671

# Health Impacts reported by community members living near compressor stations and gas metering stations along gas transmission pipelines

http://www.earthworksaction.org/files/publications/SUBRA_3_Shale_Gas_PlaysHealth_Impacts_sm.pdf

***61% of health impacts associated with chemicals present in excess of short and long term health screening levels in the air**

- Nasal Irritation*
- Throat Irritation*
- Eyes Burning*
- Frequent Nausea*
- Allergies
- Sinus Problems*
- Bronchitis*
- Persistent Cough
- Chronic Eye Irritation*
- Shortness of Breath
- Increased Fatigue*
- Muscle Aches & Pains*
- Severe Headaches*
- Frequent Nose Bleeds
- Sleep Disturbances
- Joint Pain
- Difficulty in Concentrating
- Nervous System Impacts
- Irregular/Rapid Heart Beat*
- Strokes
- Dizziness*
- Forgetfulness/Amnesia
- Easy Bruising
- Weakness* & Tired*
- Ringing in Ears
- Sores & Ulcers in Mouth
- Urinary Infections
- Depression*
- Decreased Motor Skills*
- Falling, Staggering*
- Frequent Irritation*
- Brain disorders*
- Severe Anxiety*
- Excessive Sweating
- Abnormal EEG*
- Lump in Breast
- Spleen
- Pre-Cancerous Lesions*
- Abnormal Mammogram
- Thyroid Problems
- Endometriosis

**Most prevalent conditions in individuals living close to compressors**

**90% of individuals living and working within 2-3 miles of compressor stations report experiencing odor events and health impacts**

**Medical Conditions and % of Individuals Surveyed**

Respiratory Impacts 71%
Sinus Problems 58%
Throat Irritation 55%
Allergies 55%
Weakness and Fatigue 55%
Eye Irritation 52%
Nasal Irritation 48%
Joint Pain 45%
Muscle Aches & Pains 42%
Breathing Difficulties 42%
Vision Impairment 42%
Severe Headaches 39%
Sleep Disturbances 39%
Swollen & Painful Joints 39%

**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:**

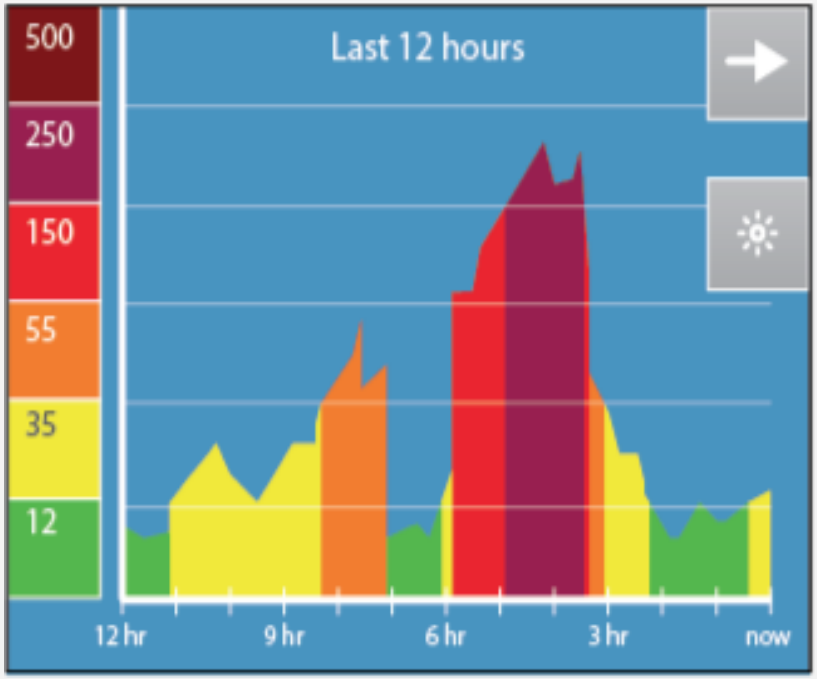

CEH, 2013, http://www.ceh.org/legacy/storage/documents/Fracking/fracking_final-low-1.pdf
World Health Organization http://www.who.int/ceh/capacity/Children_are_not_little_adults.pdf
Wilhelm at UCLA report on air pollution and premature births http://www.environment.ucla.edu/reportcard/article.asp?parentid=1700
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/

# Review of reported symptoms

**At SWPA-EHP, the clinicians were observing symptoms in people living near gas development, and those symptoms could be persistent, transient, or intermittent. These variations in symptom presentation are consistent with the changing and episodic nature of exposures.**
**The 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 (see next slide)**

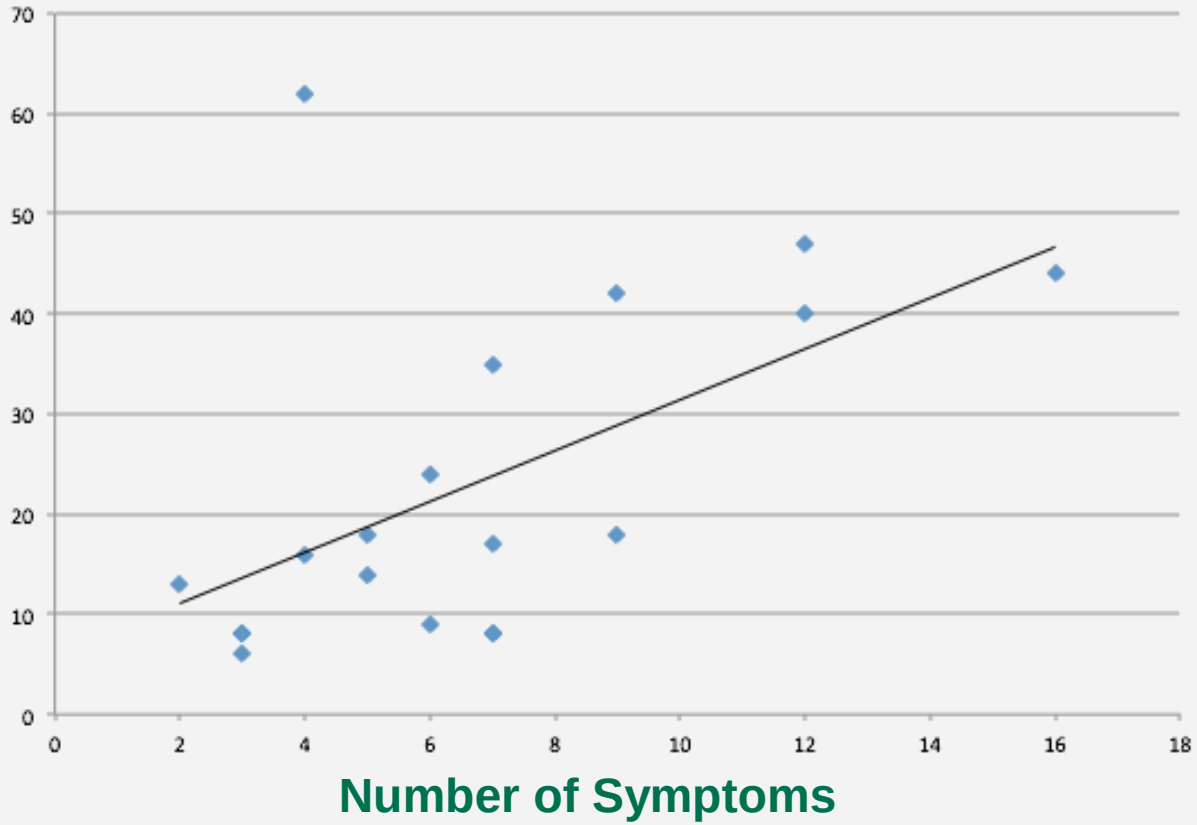
**Symptoms might be persistent, transient, or intermittent. These variations in symptom presentation are consistent with the changing and episodic nature of exposures.**






SOUTHWEST PENNSYLVANIA ENVIRONMENTAL HEALTH PROJECT

# PM 2.5 Peaks vs. Number of symptoms (N=17)



**SWPA-EHP reviewed 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.**

# Health findings and government air monitoring reports are in conflict

## Health Findings

Reports of acute onset sequale in humans:

- Respiratory
- Neurologic
- Dermal
- Vascular bleeding
- Abdominal pain
- Nausea, and vomiting

## Monitoring Reports

Assurances from air monitoring data that untoward exposures are not occurring.

- Barnett Shale Texas (Bunch et al- 2013)
- Marcellus Shale Ambient Air sampling (Pennsylvania DEP 2010)
- City of Fort Worth Air Quality Study (ERG 2011)

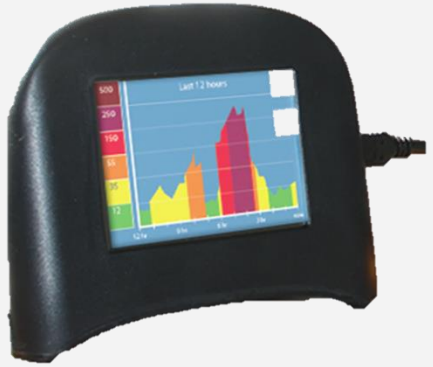
**The SWPA-EHP Minisink pilot project on compressors (next slide) was a response to a community need and request for an accurate assessment of exposures and health impacts since what they were experiencing as far as health impacts was not in synch with what FERC, the EPA and State agencies were modeling, 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 proposed to include 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.**

# Minisink: Pilot Project

## Summary of air monitoring and health assessment at 8 residences
## data compiled by Celia Lewis PhD

- Community coordinator
- Health assessments of 8 families
- $PM_{2.5}$ monitoring with Speck monitors
- VOC sampling with summa canisters



## in Minisink:

**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:**


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

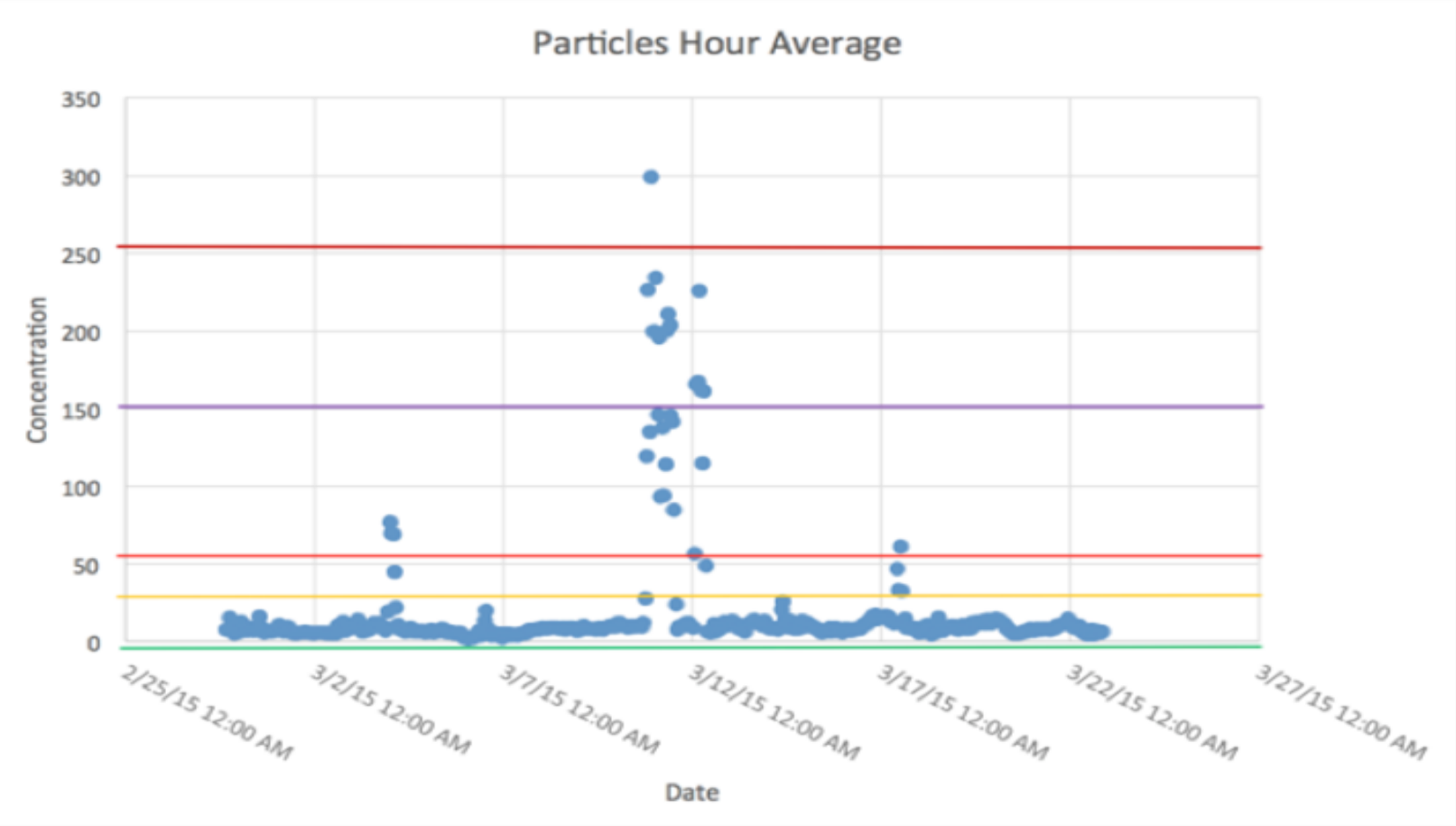
**EHP RESULTS SUMMARIES**
Physical, Mental and Environmental Impacts of Unconventional Oil and Gas Development
**Spring 2016**

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.




SOUTHWEST PENNSYLVANIA ENVIRONMENTAL HEALTH PROJECT

https://airnow.gov/index.cfm?action=aqibasics.aqi
https://airnow.gov/index.cfm?action=pubs.aqguidepart
https://www3.epa.gov/airquality/particlepollution/2012/decfsstandards.pdf

## EPISODIC HIGH LEVELS OF $PM_{2.5}$ OUTSIDE MULTIPLE HOMES OCCURRED WITHIN SIMILAR TIME FRAMES SEVEN TIMES OVER 59 DAYS. RESULTS ARE BASED ON HOURLY AVERAGES OF $UG/M^3$ 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 previous slide, the data is presented in graph form , showing 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.**

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

**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.**

**It will include:**

- **Madison County (Sheds compressor)**
- **Niagara**
- **Montgomery (Linden)**
- **Rensellaer**
- **Schoharie**
- **Minisink**
- **Sullivan County**

**The study goals are…**

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

# EHP STUDY of COMPRESSORS: Assessment Parameters

## Environmental

- Air Quality
  - PM
  - VOCs, Formaldehyde
  - Radon*
- Home Env. Assess.
- Water Quality*
  - Surface & Well*
    - *EPA Drinking Water Standards
- Noise*
- Traffic counts*

*Madison County only

## Health

- Residents
  - Health Questionnaires
  - Health Diary
  - Lung Function Test*
- Community Health* Assessment
  - Target health data (cancer, respiratory, cardio, birth)
  - School nurse reports
  - EMS/Police/ER logs
- DOH Complaint log*

# Monitoring Events/Timeline

**Residents within 1 mile of station participate in baseline monitoring and follow-up assessments for a period of 2 years.**

**4 main monitoring events**

- **Baseline – Pre-Construction - MOST IMPORTANT**
- **Construction***
- **Post Construction**
  - **1 year**
  - **2 years**

***Madison County only**

# Basic Community monitoring and health assessment model

## PRE- and POST-CONSTRUCTION Monitoring

- 4 residences within about ½ mile for placement of continuous air monitors - one inside, one outside
- VOC and formaldehyde sampling at closest residences (1 or more 12-hour sample under appropriate weather conditions)

## PRE- and POST-CONSTRUCTION Health assessments

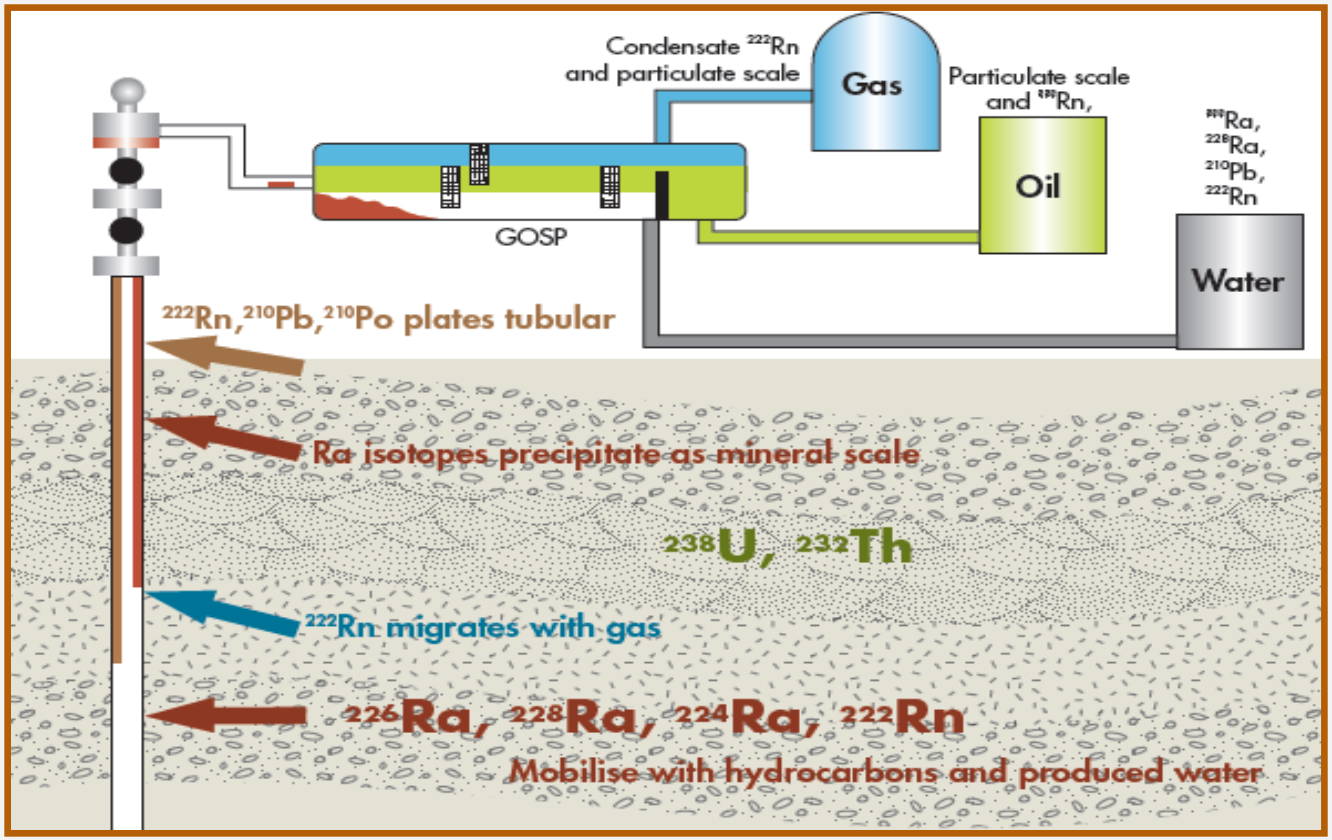
- Individual health assessment, SF36 and home environment assessment surveys on as many residents as possible within 1 mile
- Medically trained personnel review health assessments with residents

# RADIOACTIVITY

- **Recommendations from the International Atomic Energy Agency (IAEA)** http://www-pub.iaea.org/MTCD/publications/PDF/TCS-40_web.pdf

- **Federal exemption** http://www.epa.gov/osw/nonhaz/industrial/special/oil/oil-gas.pdf

- **Radionuclides such as Lead-210 and Polonium-210 can be found in pipeline scrapings as well as sludge accumulating in tank bottoms, gas/oil separators, dehydration vessels, liquid natural gas (LNG) storage tanks, at pigging stations and in waste pits.** International Association of Oil & Gas Producers, *Guidelines for the management of Naturally Occurring Radioactive Material (NORM) in the oil & gas industry, September 2008* *http://www.ogp.org.uk/pubs/412.pdf*

**For decades we have known shale to be radioactive, particularly the Marcellus shale** http://www.scientificamerican.com/article/marcellus-shale-natural-gas-drilling-radioactive-wastewater/ **and** http://pubs.usgs.gov/sir/2011/5135/pdf/sir2011-5135.pdf

**In the expanded model, such as Madison County's, there will also be a look at radioactivity.**

The International Atomic Energy Agency and the International Commission of Radiation Protection have recommendations regarding radioactivity at oil and gas mining sites. http://www-pub.iaea.org/MTCD/publications/PDF/TCS-40_web.pdf
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. So measurements are not routinely taken to determine the radioactivity of gas at extraction, processing or transport.
http://www.epa.gov/osw/nonhaz/industrial/special/oil/oil-gas.pdf

**The gas which flows through 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. Lead causes neurologic and hematologic toxicity, and death; polonium causes cancer and death. There is a 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. The PADEP TENORM report, in the appendices, gives actual readings at various gas sites, and the numbers are elevated.**

**This is confirmed in a description from the 2008 publication of the International Association of Oil & Gas Producers:**
"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. To determine whether or not a facility has NORM contamination, NORM survey, sampling and analysis needs to be conducted. NORM may accumulate, *eg* 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…".

**The lower graph from this publication shows how NORM can accumulate.**

**National Academy of Sciences 1988 report: Health Risks of Radon and Other Internally Deposited Alpha-Emitters: BEIR IV, page 5**
**http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-105822/PA-DEP-TENORM-Study_Report_Rev._0_01-15-2015.pdf and**
**https://www.fractracker.org/2015/06/radioactivity/**
**http://www.ogp.org.uk/pubs/412.pdf**

# PIGS

**Pipeline Inspection or Intervention Gauge/Gizmo/Gadget**
**and**

# WASTE


Photo: Harvey Barrison

http://www.post-gazette.com/business/businessnews/2010/03/14/Neighbors-take-a-stand-on-noise-odor-of-gas-drilling/stories/201003140263

**PIGs (Pipeline Inspection or Intervention Gauge/Gizmo/Gadget ) inspect or clean out the pipe, and become repositories of these toxins, including the solid daughter products of radon decay - polonium and lead. These PIGs are another source of exposure to radioactivity, with accumulated waste of pipe film, black powder, bacteria, scale and sludge, are used in every pipeline, and the waste must be disposed of.**


http://en.wikipedia.org/wiki/Pigging)

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

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

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

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

http://www.pigtek.com/advanced_pipeline_cleaning.php

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

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

http://www.cleanharbors.com/assets/downloads/videos/video-popup-pipeline-coating.html


**The residents in this photo live 50 ft from the compressor station which collects waste in the condensate tanks pictured behind them. The condensate tanks emit air pollutants as they vent.**

http://www.post-gazette.com/business/businessnews/2010/03/14/Neighbors-take-a-stand-on-noise-odor-of-gas-drilling/stories/201003140263#ixzz3A8qom85n

# COMMUNITY IMPACTS

- air and water impacts
- community tension
- traffic and road safety
- abandonment by officials
- worker safety
- housing,  community character, schools
- economic issues such as value of homes
- cumulative effects of multiple stressors
- noise
- loss of viewshed, foodshed and watershed
- SOLASTALGIA


http://bigstory.ap.org/article/ny-town-911-workers-wages-gas-pipeline-fight

**We know that there will be air impacts and impacts on water and agricultural land.**

**Homes near the compressor station will likely be de-valued. Tension within the community will rise.**

**A cornerstone of this industrialization is all the truck traffic .**
**There will be noise which can cause Vibro-Acoustic Disease. Noise pollution raises the risk of heart attack and high blood pressure and cognitive deficits in children, and it can interfere with the ability to learn in children, as reported by the World Health Organization.**

**The gains will only materialize for the seller of the property.**

**Besides the feeling of helplessness and hopelessness, there is the feeling of abandonment from officials who have helped very little in protecting their constituents' health.**

**This can lead to stress and depression when the fabric of the community unravels, and people's health suffers in a county which is 61st of 62 NYS counties for health outcomes, and the value of their homes decreases.**

**SOLASTALGIA… Threats to mental health and wellbeing can come from changes to the non-urban environment. As opposed to acute stressors such as war, terrorism and natural disasters where post-traumatic stress disorder is a well-documented response and is treated by mental health professionals, many chronic stressors such as changes caused by industrialization of rural areas are generally not seen as often.**

**People living in their homes can experience place-based distress if they experience a profound environmental change. The people are still 'at home', but experience a 'homesickness' for what was. What these people lack is solace or comfort derived from their relationship to 'home'. The word 'solace' relates to both psychological and physical contexts. One meaning refers to the comfort one is given in difficult times (consolation), while another refers to that which gives comfort or strength to a person. A person or a landscape might give solace, strength or support to other people. Special environments might provide solace in ways that other places cannot. "Therefore, solastalgia refers to the pain or distress caused by the loss of, or inability to derive, solace connected to the negatively perceived state of one's home environment. Solastalgia exists when there is the lived experience of the physical desolation of home."**

http://www.citidep.pt/papers/articles/alvesper.htm and
http://www.fastcompany.com/1744151/air-pollution-causes-europeans-to-lose-16-million-years-of-healthy-living-annually-study
http://www.euro.who.int/__data/assets/pdf_file/0008/136466/e94888.pdf
Glenn Albrecht, Gina-Maree Sartore, Linda Connor, Nick Higginbotham, Sonia Freeman, Brian Kelly, Helen Stain, Anne Tonna and Georgia Pollard. 2007. Solastalgia: the distress caused by environmental change. Australian Psychiatry, Vol 15 Supplement. doi: 10.1080/10398560701701288 # 2007 The Royal Australian and New Zealand College of Psychiatrists

**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.**

## HEALTH IMPACT ASSESSMENT

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

# MEDICAL SOCIETY OF THE STATE OF NEW YORK

**May 2, 2015 – The Medical Society of the State of New York adopted a resolution, "Protecting Public Health from Natural Gas Infrastructure," that recognizes the potential impact to human health and the environment of natural gas pipelines and calls for a governmental assessment of these risks.**

# AMERICAN MEDICAL ASSOCIATION

**June 9, 2015 -- The American Medical Association (AMA) adopted a resolution, "Protecting Public Health from Natural Gas Infrastructure," that states, "Our AMA recognizes the potential impact on human health associated with natural gas infrastructure and supports legislation that would require a comprehensive Health Impact Assessment regarding the health risks that may be associated with natural gas pipelines."**

# Conclusions

- People are exposed to toxics through air, water and soil.
- The exposures are periodic and intense for several hours.
- Regulatory air and water screening will not detect the hazard.
- Most likely acute physical symptoms include headache, wheezing, ear/nose/throat problems (including nosebleeds), skin rash and fatigue.
- Biomonitoring methods need to be developed.
- Interventions and support at the patient level help coping.
- Individuals must monitor their health and exposure status.
- Sense of community trust and social capital is destroyed.
- Federal, State and Local public health and environmental agencies are not able to effectively respond. **The Public Health Process has become rule bound, restricted to standard environmental tests of air and water and research health protocols.**
- **Regulatory agencies do not have the flexibility to monitor health and environment appropriately.**

SOUTHWEST PENNSYLVANIA ENVIRONMENTAL HEALTH PROJECT

# AT A MINIMUM:

- Hearings (DEC and FERC)
- 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

# COMPREHENSIVE SOURCES OF HEALTH INFORMATION





- **PSE for Healthy Energy PSE STUDY CITATION DATABASE on Shale Gas & Tight Oil Development** http://www.psehealthyenergy.org/site/view/1180#sthash.CHp8vErJ.dpuf

- **Concerned Health Professionals of NY Compendium** www.concernedhealthny.org

- **Southwest Pennsylvania Environmental Health Project** www.environmentalhealthproject.org
  **724.260.5504** info@environmentalhealthproject.org

- **Physicians for Social Responsibility** www.psr.org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