

MICHIGAN

Unconventional Gas Development: Potential Health and Environmental Impacts

Larysa Dyrszka MD, April 10, 2014

Shale gas extraction and production using HVSWHFHL:

- Defining the scope of the process
- Determinants of health and the scope of potential impacts
- Environmental and community stressors include air pollution, water contamination, chemical mix, radioactivity, waste, truck traffic, noise and light pollution, changes in community character, worker health issues, climate change
- Public health concerns, Health Impact Assessment and the medical community's advocacy

2

Comprehensive sources of health information:

- PSE for Healthy Energy CONTINUING MEDICAL EDUCATION (CME) <http://www.psehealthyenergy.org/site/view/1052>
- PSE for Healthy Energy PSE STUDY CITATION DATABASE on Shale Gas & Tight Oil Development <http://www.psehealthyenergy.org/site/view/1180#sthash.CHpBvErJ.dpuf>
- Concerned Health Professionals of NY www.concernedhealthny.org
- University of Michigan Graham Sustainability Institute Integrated Assessment Plan <http://graham.umich.edu/knowledge/ia/hydraulic-fracturing>
- Southwest Pennsylvania Environmental Health Project www.environmentalhealthproject.org
- Pediatric Environmental Health Specialty Units <http://www.aepc.org/pehsu.htm>
- Chief Medical Officer of Health's Recommendations Concerning Shale Gas Development in New Brunswick (CANADA) September 2012 http://www2.gnb.ca/content/dam/gnb/Departments/h-s/pdf/en/HealthyEnvironments/Recommendations_ShaleGasDevelopment.pdf
- Ban Michigan Fracking www.banmichiganfracking.org

3

Some of the compendia of health impacts are listed here. Throughout the presentation there are many additional references on the slides (please see the pdf of slides).

❑ The new resource from Physicians, Scientists and Engineers for Healthy Energy is a searchable citation database of peer-reviewed studies on the subject of shale gas development. PSE's database is a valuable resource for the media, homeowners, legislators, government officials, academics and activists alike

<http://www.psehealthyenergy.org/site/view/1180#sthash.CHp8vErJ.dpuf>

❑ PSE for Healthy Energy CONTINUING MEDICAL EDUCATION (CME)

<http://www.psehealthyenergy.org/site/view/1052>

❑ Concerned Health Professionals of NY www.concernedhealthny.org

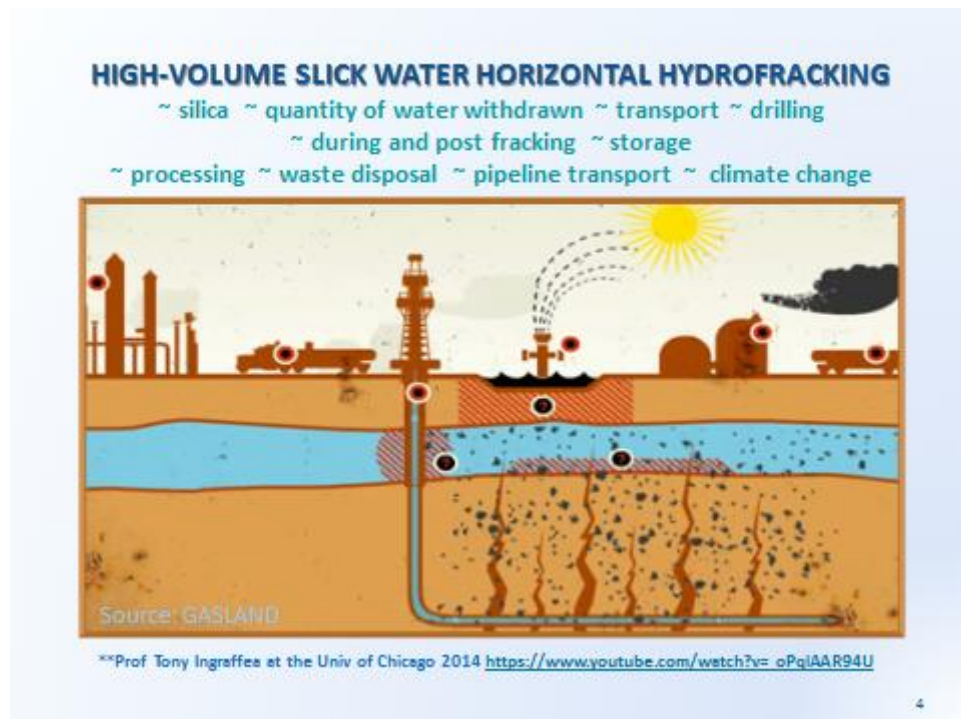
❑ University of Michigan Graham Sustainability Institute Integrated Assessment Plan

<http://graham.umich.edu/knowledge/ia/hydraulic-fracturing>

❑ Southwest Pennsylvania Environmental Health Project www.environmentalhealthproject.org

❑ Pediatric Environmental Health Specialty Units <http://www.aoec.org/pehsu.htm>

o Ban Michigan Fracking http://banmichiganfracking.org/?page_id=339



High volume, slick water, horizontal hydraulic fracturing is a new application of an old technology. That's why you hear that fracking has been done for 60 years—it has. That was the old type of fracking, not this new unconventional one which was only developed in the late 1990s. About ten times more water, silica and chemicals are used in the new unconventional well compared to the older conventional type.

The fracturing is done from a wellbore drilled into rock formations to increase the recovery of gas. The unconventional process uses 2-9 million gallons of water per frack, silica sand and chemicals blasted at high pressures. This enables the recovery of gas from low-porosity tight shale formations. However, in Michigan, one well used over 20 million gallons of water, and although it only contained 0.5% of hydrochloric acid, the total volume of acid used in the treatment was 116,377 gallons— the volume of nearly ten standard 12' x 24' swimming pools.

Fracking is just one part of the process of gas exploration and usually takes only a short time compared to the drilling and production phases.

In this presentation, I'll be speaking about the entire process of gas extraction and production, from beginning to the end, because environmental problems have been encountered, and adverse health impacts have been observed during all the steps.

For example,

- exposure during the mining of silica sand can cause lung diseases
- water withdrawal can cause the depletion of the water supply because exceptionally large amounts of water are used
- in transport there can be spills of chemicals and traffic accidents
- during drilling, aquifers can become contaminated with methane and chemicals due to casing failure
- there could be exposure to radionuclides, which are carcinogenic
- air pollution with ozone production from diesel transport vehicles, and then during drilling, venting, flaring and processing, and also at compressor stations occurs
- disposal of waste is a problem as there are few treatment facilities able to handle it
- noise and light pollution occur
- there are health issues from climate change
- and people can experience psychological stress during the entire process due to concerns about the potential loss of home value and loss of water, and health impacts.



DETERMINANTS OF HEALTH

Who might be impacted?

People...

- ~ in areas mining silica
- ~ where gas drilling and fracking occur
- ~ near pipelines, power plants and storage facilities
- ~ who receive their water from gas drilling areas
- ~ who are downwind of gas producing or processing areas
- ~ whose regions receive gas drilling waste
- ~ Marcellus shale gas consumers
- ~ who are workers in the gas industry
- ~ whose health is already compromised, or who are vulnerable, as well as animals, water, air and crops

8

The World Health Organization defines health as “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” (WHO 1948).¹

Overall health is influenced by a broad range of both individual and collective factors- and their interactions; these factors are referred to as “determinants of health”.²

http://www.nwci.ie/download/pdf/determinants_health_diagram.pdf and

http://www.euro.who.int/_data/assets/pdf_file/0010/74737/E89383.pdf and

http://www.swansea.gov.uk/hcswip/media/pdf/4/1/Determinants_of_Health_and_Wellbeing.pdf and

<http://www.healthknowledge.org.uk/public-health-textbook/disease-causation-diagnostic/2h-principles-health-promotion/responsibilities-health-physical-mental> and

http://www.local.gov.uk/health/-/journal_content/56/10180/3511260/ARTICLE and

<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2690205/> and

[http://www.thelancet.com/journals/lancet/article/PIIS0140-6736\(12\)60291-8/fulltext](http://www.thelancet.com/journals/lancet/article/PIIS0140-6736(12)60291-8/fulltext) “...Governments have a duty to provide healthy environments for all their citizens, especially for vulnerable and disadvantaged groups...”

¹ <http://www.who.int/about/definition/en/print.html>

² http://www.nwci.ie/download/pdf/determinants_health_diagram.pdf and http://www.euro.who.int/_data/assets/pdf_file/0010/74737/E89383.pdf and http://www.swansea.gov.uk/hcswip/media/pdf/4/1/Determinants_of_Health_and_Wellbeing.pdf and <http://www.healthknowledge.org.uk/public-health-textbook/disease-causation-diagnostic/2h-principles-health-promotion/responsibilities-health-physical-mental> and http://www.local.gov.uk/health/-/journal_content/56/10180/3511260/ARTICLE and <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2690205/> and [http://www.thelancet.com/journals/lancet/article/PIIS0140-6736\(12\)60291-8/fulltext](http://www.thelancet.com/journals/lancet/article/PIIS0140-6736(12)60291-8/fulltext)

The influence from each of these determinants varies, but in general the health of a population depends mainly on the combined influence of the social environment and the physical environment. (the yellow and purple in the diagram).

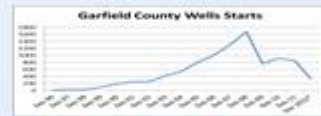
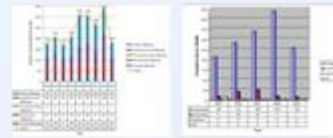
And that's what we're finding are most impacted by gas development.



This is a photo of the processing phase. West Virginia, SWPA and eastern Ohio, as well as Michigan have wet gas which requires separation of the gas from liquids, and requiring the processing plants. The infrastructure must be taken into the cumulative account of impacts.

Air emissions as seen with special infrared cameras are inserted on the bottom right. You cannot see them with the naked eye. However, wherever there is venting these emissions are present.

- traffic and road safety
- worker safety
- housing, community character, schools
- crime, sexually transmitted infections and substance abuse
- economic issues such as employment, value of home
- health infrastructure including availability, insurance, cost
- justice concerns such as vulnerable populations, equality
- cumulative effects of multiple stressors
- loss of viewshed, foodshed and watershed



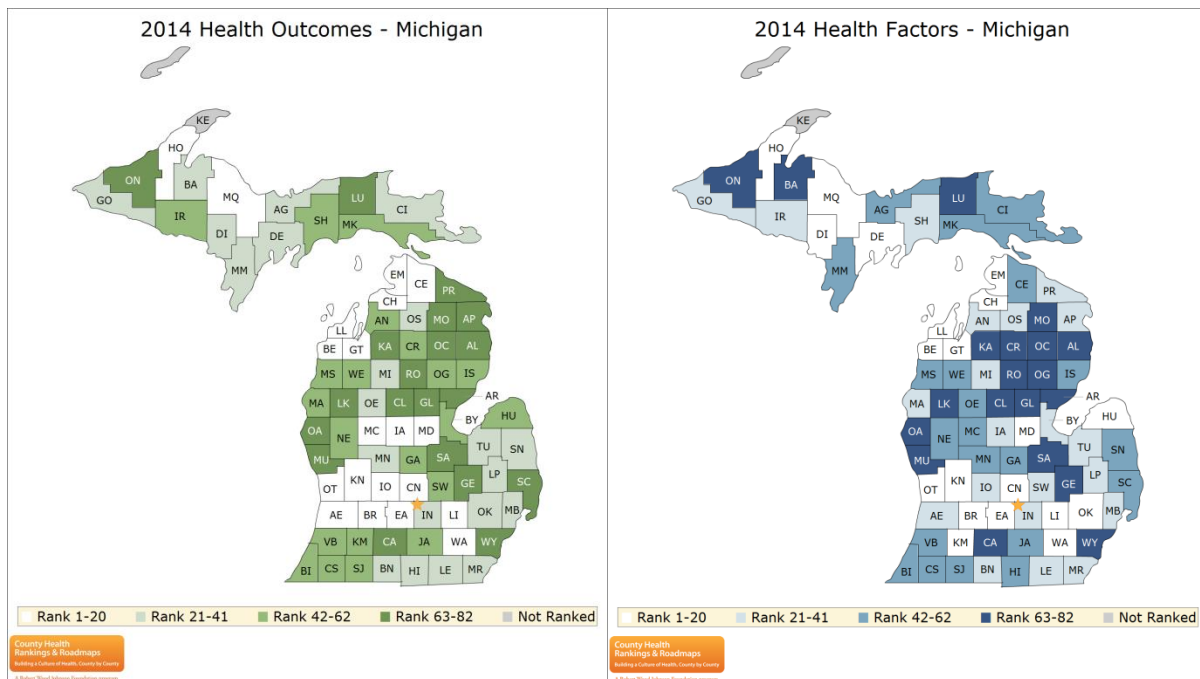
<http://www.nationalacademies.org/xoai/oai/group/@access/documents/webpage/085335.pdf>



<http://pubs.cas.psu.edu/freepubs/od's/ee0020.odf>

Environmental and social justice concerns include protection of children from environmental risks, and actions to address environmental justice in minority and low-income populations.

The eight counties in Michigan which are slated for drilling have among the worst health outcomes of 83 counties. These are the health rankings: Alcona 79, Alpena 74, Antrim 60, Crawford 58, Kalkaska 75, Montmorency 64, Oscoda 77, Otsego 37 <http://www.countyhealthrankings.org/app/michigan/2014/overview>³



People already under stress from an underlying illness, or poor socioeconomic status, or because they are simply very young or very old and therefore a vulnerable population, suffer environmental impacts less well than people who are not so stressed.

Yet, in the US, as probably in Michigan, gas drilling frequently occurs in areas which have underserved, rural populations and near vulnerable group activities such as schools.

On the bottom right is the surface disturbance from one well being drilled, 3-5 acres. Not only is there a loss of viewshed, but of foodshed and watershed.

³ <http://www.countyhealthrankings.org/app/michigan/2014/overview>

- Fort Worth air quality study 2011 http://fortworthtexas.gov/uploadedFiles/Gas_Wells/AirQualityStudy_Final.pdf
- Witter R, et al, Battlement Mesa HIA 2011 <http://www.garfield-county.com/environmental-health/battlement-mesa-health-impact-assessment-draft2.aspx>
- NOAA ozone study 2011 <http://www.esnews.net/public/LandLetter/2011/04/21/1>
- McKenzie LM, et al, 2012, Human Health Risk Assessment of Air Emissions from Development of Unconventional Natural Gas Resources <http://www.ncbi.nlm.nih.gov/pubmed/22444058>
- Colborn T, et al, An Exploratory Study of Air Quality near Natural Gas Operations 2012 <http://www.endocrinedisruption.com/chemicals/air.php>
- Hill E, 2012 and 2013 Unconventional Natural Gas Development and Infant Health (in Pennsylvania and Colorado), <https://sites.google.com/site/elainehill/research>
- Currie et al, 2014, reported at American Economic Association conference, Bloomberg news report, Study Shows Fracking Is Bad for Babies, by Mark Whitehouse, January 4, 2014. Access at <http://www.bloomberg.com/news/2014-01-04/study-shows-fracking-is-bad-for-babies.html>
- Simpson I, et al, 2013 Air quality in the Industrial Heartland of Alberta, Canada and potential impacts on human health (increased male cancer) <http://concernedhealthys.org/wp-content/uploads/2013/07/Simpson2013-AB-in-press.pdf>
- Univ of Pittsburgh 2013 http://fortworthtexas.gov/uploadedFiles/Gas_Wells/AirQualityStudy_Final.pdf
- Recheel Rawlins, 2013, *Virginia Env Law Journal*, Volume 31, Planning For Fracking on the Barnett Shale: Urban Air Pollution, Improving Health Based Regulation, and the Role of Local Governments) http://www.velj.org/uploads/1/2/7/0/12706884/2_rawlins_-_barnett_shale.pdf
- McKenzie et al, 2014 Birth Outcomes and Maternal Residential Proximity to Natural Gas Development in Rural Colorado, *Env Health Perspectives* <http://ehp.niehs.nih.gov/2014/2014-0002>
- Helmig D, et al, 2014 Highly Elevated Atmospheric Levels of Volatile Organic Compounds in the Uintah Basin, Utah. *Environ. Sci. Technol.*, DOI: 10.1021/es405046r [10.1021/es405046r](https://doi.org/10.1021/es405046r)
- Brown et al, 2014 Understanding exposure from natural gas drilling puts current air standards to the test, *Reviews on Env Health*, doi: [10.1013/revah-2014-0002](https://doi.org/10.1013/revah-2014-0002)



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Total air pollution in an area of Texas which is heavily drilled, is more than double all the auto and truck exhaust. That area has seen a recent increase in the incidence of asthma to 25%, compared to half that in other Texas cities.⁴

One of the first papers that found air pollution from gas drilling was the greatest risk to human health was from Colorado, the Health Impact Assessment which reached its second draft and then was never implemented.⁵

In a follow-up to that study, MacKenzie found that residents living < ½ mile from wells were at greater risk for health effects, with benzene, a carcinogen, as the major contributor to the risk.⁶

The study by Dr Colborn last year found 44 air pollutants at a house located about 1 kilometer away from a well pad.⁷

The National Oceanographic and Atmospheric Administration, studied an area of Utah where high ozone levels were present during the winter, which isn't supposed to happen. These pollutants are emitted in large quantities by the region's oil and gas drillers, and the regulators concluded that they were the main contributors to the toxic

⁴ Fort Worth Natural Gas Air Quality Study Final Report 2011

http://fortworthtexas.gov/uploadedFiles/Gas_Wells/AirQualityStudy_Final.pdf

⁵ Witter R, et al., Battlement Mesa HIA 2011 <http://www.garfield-county.com/environmental-health/battlement-mesa-health-impact-assessment-draft2.aspx>

⁶ McKenzie LM, et al., Human Health Risk Assessment of Air Emissions from Development of Unconventional Natural Gas Resources 2012 <http://www.ncbi.nlm.nih.gov/pubmed/22444058>

⁷ Colborn T, et al., An Exploratory Study of Air Quality near Natural Gas Operations 2012 <http://endocrinedisruption.org/chemicals-in-natural-gas-operations/air-pollution>

emissions. Ozone can trigger asthma attacks and inflame conditions for people with bronchitis, emphysema and other respiratory ailments.⁸

Children are especially vulnerable because their lungs continue to grow and enlarge until about age 18. Plus they breathe faster and are closer to the ground. The result of chronic ozone exposure can be brittle lungs like those of an elderly adult.

Air pollution has also been shown to be associated with neurodevelopmental disorders, lower IQ in babies born to mothers with polycyclic aromatic hydrocarbon exposure during pregnancy, and learning disorders in exposed children. Much of this work has been done by Perera at Columbia Univ and Landrigan at Mt Sinai in NYC.

A study in 2010 compared residential proximity to a freeway with the incidence of autism, and found that for those living within 300 meters of the freeway during the third trimester, the odds ratio of being born with autism was more than twice as great as controls.⁹

Low birth weight infants and prematurity present a major and increasing problem. As pediatricians we know that these babies are susceptible to a host of problems including respiratory complications, visual problems and developmental disorders, such as cerebral palsy and autism. And there is evidence that gestational age is affected by environmental exposures.

Elaine Hill studied birth outcomes. She found that proximity to wells increases the prevalence of low birth weight and premature birth.¹⁰

Building on Hill's study, Currie looked at Pennsylvania birth records to assess the health of infants born within a 2.5-kilometer radius of gas drilling sites... "(t)hey found that proximity to fracking increased the likelihood of low birth weight by more than half, from about 5.6 percent to more than 9 percent. The chances of a low Apgar score, a summary measure of the health of newborn children, roughly doubled, to more than 5 percent."

Although the evidence is just emerging for an association between air pollution and low birth weight, birth defects and neurodevelopmental problems, there is clearly an overall trend of association. These findings 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. In addition to the public health problems, there is the cost to the government and the taxpayer. A child disabled because of preventable environmental exposure is not only a tragedy for the family, but a significant cost for the state.

The World Health Organization has classified diesel exhaust as a definite carcinogen, raising additional concerns for workers and other vulnerable groups exposed to diesel exhaust.¹¹

In the study from the Univ of California at Irvine¹², researchers working in the Alberta gas and oil fields found that, "... at the county level, the incidence of male hematopoietic cancers (leukemia and non-Hodgkin's lymphoma) was higher in communities closest to the Industrial Heartland compared to neighboring counties.

⁸ NOAA ozone study <http://www.eenews.net/public/Landletter/2011/04/21/1>

⁹ Volk, HE, et al. (2011) Residential Proximity to Freeways and Autism in the CHARGE study. *Environmental Health Perspectives* 119(6):873-7.

¹⁰ Hill E, 2012 and 2013 Unconventional Natural Gas Development and Infant Health (in Pennsylvania and Colorado), <https://sites.google.com/site/elainehill/research>

¹¹ IARC: Diesel Exhaust Carcinogenic 2012 http://www.iarc.fr/en/media-centre/pr/2012/pdfs/pr213_E.pdf

The report by the University of Pittsburgh School of Public Health documented significantly increased air pollutant levels associated with adverse health statistics in southwest Pennsylvania where shale gas extraction and other infrastructure are under accelerated development.¹³

Also at the end of 2013, in the Virginia Environmental Law Journal, Rachel Rawlins of the Univ of Texas wrote about air pollutants in the Barnett Shale, confirming the significant air pollution others have suspected, and documenting an increase of childhood asthma as well as childhood leukemias.¹⁴

A study published in 2014 by the Colorado School of Public Health¹⁵ linked congenital birth defects with gas drilling: they found an increase in congenital heart disease in babies whose mothers lived in the most exposed tertile and a higher prevalence of neural tube defects in the highest exposure tertile.

In the March 2014 Utah study, the authors conducted observations of VOCs from the Uintah Basin in Utah. Their measurements identified highly elevated levels of atmospheric alkane hydrocarbons, build-up of ozone, and aromatic compounds benzene and toluene, considered air toxics, were also elevated. There was a strong causal link between oil and gas emissions, accumulation of air toxics, and significant surface production in the atmospheric surface layer.¹⁶

Also just published is a review by David Brown and his colleagues at SWPA – EHP...they have seen more patients impacted by gas drilling operations than any other group. They note that human health risks near gas development sites are derived from average population risks without adequate attention to the processes of toxicity in the body. They report that current methods of collecting emissions data, as well as the analyses of these data, are not sufficient for accurately assessing risks to individuals or protecting the health of those near gas development sites.¹⁷

Recently I met several families from West Virginia and southwest Pennsylvania. One family with four children was living near gas wells and several compressor stations. Numerous air toxins were documented around their home. Over the course of the past year, the boys' behavior deteriorated and they developed movement disorders requiring treatment with anti-seizure medication. The adults in the family developed anxiety and depression, also requiring medication. A teenage daughter was found to have suffered a mild stroke. All of these neurological problems could be associated with air pollution. No State or federal public health agency investigated. A legal complaint was filed and because they had a good case, they have now entered into a non-disclosure agreement and can no longer speak about their case. And their information will never be part of any sort of state or national database because of the non-disclosure agreement.

¹² Simpson I et al, Air quality in the Industrial Heartland of Alberta, Canada and potential impacts on human health 2013 <http://concernedhealthny.org/wp-content/uploads/2013/07/Simpson2013-AE-in-press.pdf>

¹³ Univ of Pittsburgh 2013 http://fortworthtexas.gov/uploadedFiles/Gas_Wells/AirQualityStudy_final.pdf

¹⁴ Rachael Rawlins, 2013, Virginia Env Law Journal, Volume 31, Planning For Fracking on the Barnett Shale: Urban Air Pollution, Improving Health Based Regulation, and the Role of Local Governments) http://www.velj.org/uploads/1/2/7/0/12706894/2._rawlins_-_barnett_shale.pdf

¹⁵ McKenzie et al, <http://ehp.niehs.nih.gov/1306722/>

¹⁶ Helmig D, et al, 2014 Highly Elevated Atmospheric Levels of Volatile Organic Compounds in the Uintah Basin, Utah. Environ. Sci. Technol., DOI: 10.1021/es405046r [10.1021/es405046r](https://doi.org/10.1021/es405046r)

¹⁷ Brown D et al, 2014, <http://www.degruyter.com/view/j/reveh.ahead-of-print/reveh-2014-0002/reveh-2014-0002.xml>



Studies of the past quarter century indicate exposure to H₂S, even in tiny amounts, can cause permanent damage to the brain and central nervous system.

Dr. Marvin Legator of the University of Texas Medical Branch noted "studies have documented that H₂S causes persistent toxic effects after chronic low-level exposure."¹⁸ Also presenting research at the conference was Dr. Kaye Kilburn, Professor of Medicine at the University of Southern California, Environmental Sciences Laboratory. He concluded that "Hydrogen sulfide poisons the brain and the damage is irreversible."¹⁹ Dr. Kilburn's ongoing studies find that "Brief exposures to H₂S are neurotoxic, effects are persistent, and exposures to low doses appear cumulative."²⁰

Workers have died as a result of exposure to hydrogen sulfide gas, and one example is a young man from Rifle, Colorado. Before he died of liver and pancreatic cancer, he described the work he did cleaning out tanks. The company was guilty of violations and fined for exposing this worker to the toxic hydrogen sulfide. Another worker also exposed described severe headaches, eye problems, difficulty breathing and talking after exposure to this toxic gas.

Hydrogen sulfide was eliminated from the Clean Air Act (CAA) list of extremely hazardous substances by powerful last minute oil and gas lobbying.

¹⁸ Alexander, Jeff. The Sunday Muskegon Chronicle, Gas exploration may affect health, 12/7/97.

¹⁹ Editorial, The Muskegon Chronicle, Sour Gas Risks Should Merit a New Evaluation, 12/21/97

²⁰ Kilburn, Kaye, MD, The American Journal of the Medical Sciences, Case Report: Profound Neurobehavioral Deficits in an Oil Field Worker Overcome by Hydrogen Sulfide, 1993, (304). And Kilburn, Kaye H. MD, Southern Medical Journal, Vol. 90, Number 10, Exposure to Reduced Sulfur Gases Impairs Neurobehavioral Function, 1997, (1004-1005).

Therefore, H₂S is regulated by states, and each state regulates toxins such as hydrogen sulfide differently. In Michigan, there are to be warning signs placed at the site and there is supposed to be an audible warning with any release.

But residents near gas drilling sites receive little or no warning. In the top left picture, the yellow flag at the drill site announces that poisonous H₂S gas may be present.

On the bottom left is a sulfur removal plant. The process for removing hydrogen sulfide from sour gas is called 'sweetening' the gas.

The map on the bottom right shows where the "sour gas" occurs most often, and that includes Michigan.

The Ban Michigan Fracking site has links to some of the peer-reviewed work done on the H₂S issue—by people like Lana Skrtic, a white paper report by Dana Schindler, as well as Dr. Kaye Kilburn's work.

In his 2003 paper, Dr Kilburn observed that impairments associated with H₂S were similar in 19 workers (44% had been unconscious) and in 16 bystanders who had not been unconscious.

On Christmas eve, 2011, a rotten-egg odor could be smelled across northern Michigan, according to news reports. Hydrogen Sulfide gas was detected from a gas release near Grayling and in towns far north of that, as far as the Mackinac Bridge. A failed valve at a well in Beaver Creek Township, Crawford County, was cited as the cause of the leak. The well owner's spokesman said: "We apologize if anybody was alarmed. We don't believe there is any danger. (It was) just a bad smell." However, Dr. Kaye Kilburn, Professor of Medicine at the University of Southern California, disagreed, saying that: "Hydrogen sulfide poisons the brain and the damage is irreversible....H₂S is dangerous any time you can smell it."²¹

Additional H₂S references:

<http://erg.berkeley.edu/people/Lana%20Skrtic%20-%20Masters%20Paper%20H2S%20and%20Health.pdf> **Lana Skrtic**

<http://www.un-naturalgas.org/MichiganReport-HydrogenSulfideReleases.pdf> **Dana Schindler**

http://journals.lww.com/smajournalonline/Abstract/2003/07000/Effects_of_Hydrogen_Sulfide_on_Neurobehavioral.3.aspx **Kaye Kilburn**

<http://www.businessinsider.com/youve-never-seen-anything-like-the-williston-oil-boom-2012-3?op=1#ixzz2bj922pEn> and

<http://banmichiganfracking.org/?m=201112>

http://www.michigan.gov/deq/0,1607,7-135-3311_4111_4231-9162--,00.html#2. What are the effects?

²¹ <http://banmichiganfracking.org/?m=201112#sthash.8xKaDc3S.dpuf>

The 2013 paper from Duke reported on elevated levels of radioactivity, salts and metals found in river water and sediments at a site where treated water from oil and gas operations is discharged into a western Pennsylvania creek.²⁷

Michelle Bamberger and Robert Oswald researched several cases where chemicals associated with drilling were implicated in negative health outcomes.²⁸ They focused mostly on animals because animals are the sentinels of disease in humans due to the fact that their reproductive cycles and their lives are shorter. Their study illustrates several plausible links between gas drilling and negative health effects.

Two cases provided inadvertent control experiments since herds of cows were kept in different pastures. In brief, cows exposed to gas drilling chemicals had significantly more illness, deaths, stillbirths and congenital malformations.

Two other cases involved deaths and congenital malformations of companion animals (pets) and one of the implicated routes of exposure was waste spreading on roads, which the animals either drank or licked off their paws; in the other case, exposure was from an aerated impoundment of waste. In addition, their water had turned after drilling but they had continued to use it.

In one of the homes studied, a child became ill with fatigue, confusion, abdominal pain and back pain. After several animals in the household had died, the doctor became suspicious of toxins, and testing revealed arsenic in the child. The family then stopped drinking the water, and the child eventually recovered, having lost a year of school. In these cases, there were 25 wells within two miles of the homes, and there was also the aerated impoundment, and two compressor stations within a mile. While checking for other toxins in these two homes, random urine tests on family members revealed phenol, a metabolite of benzene; symptoms observed by families in both homes included extreme fatigue, headaches, nosebleeds, rashes, and sensory deficits (smell and hearing). Were it not for the deaths of the animals, the human health effects would not have been found.

The graphic on the right shows potential gas and fluid movement pathways and how connections can be made from formation layers to aquifers, underground structures and the surface.

Casing is an inch or so thick. It's man-made, sometimes flawed, and doesn't last forever. 6-9% of casings immediately fail, and there's a 60% failure in 30 years.^{29 30}


²⁷ Duke, 2013. <http://www.nicholas.duke.edu/news/radioactive-shale-gas-contaminants-found-at-wastewater-discharge-site>

²⁸ Bamberger and Oswald—2012 New Solutions
http://www.psehealthyenergy.org/Impacts_of_Gas_Drilling_on_Human_and_Animal_Health

²⁹ Anthony Ingraffea, 'Fluid Migration Mechanisms Due To Faulty Well Design And/Or Construction' 2012; Bruffatto et al., 'Oilfield Review', ConocoPhillips & Schlumberger, 2003.


³⁰ http://www.psehealthyenergy.org/data/PSE_Cement_Failure_Causes_and_Rate_Analysis_Jan_2013_Ingraffea1.pdf

Example--BRADFORD COUNTY, PA



Pennsylvania regulators determined that gas development damaged the water supplies for at least 161 Pennsylvania homes, farms, churches and businesses between 2008 and the fall of 2012
<http://thetimes-tribune.com/news/sunday-times-review-of-dep-drilling-records-reveals-water-damage-murky-testing-methods-1.1491547>
 May 2013

...examples from other states reported in 2014 by Kevin Begos
<http://bigstory.ap.org/article/some-states-confirm-water-pollution-drilling>



Which areas have been hit hardest by fracking accidents?
<http://earthjustice.org/features/campaigns/fracking-across-the-united-states>

For Michigan, view Dr. Chris Grobell--April 2012 Environmental Risks of Michigan Oil and Gas Development
http://banmichiganfracking.org/?page_id=339#sthash.W5U9xiyn.dpuf

11

This is the infrastructure for the gas drilling activities in Bradford County Pennsylvania. Other than the roads and township boundaries, every mark on the map includes something that was not there before gas exploitation.

- today there are 1125 gas wells in Bradford County. And a lot of problems...

In an investigative report in May 2013, Pennsylvania State environmental regulators determined that oil and gas development damaged the water supplies for at least 161 Pennsylvania homes, farms, churches and businesses.³¹

An Associated Press investigation similarly [confirmed many cases of water contamination](#) in four states they examined, noting that this casts “doubt on [the] industry view that it rarely happens.”³²

If you click on the link in the Earthjustice box slide, you will see reports of contaminated drinking water, polluted air, unexplained animal deaths, industrial disasters and explosions.³³

A leak at a 1000-foot-deep gas well drilled in Michigan's northwestern Lower Peninsula using fracking caused a shutdown of operations in February of 2011 because of a leak. And I refer you to Dr Grobbel's presentation where he has listed several additional cases of failed gas wells.³⁴

³¹ <http://thetimes-tribune.com/news/sunday-times-review-of-dep-drilling-records-reveals-water-damage-murky-testing-methods-1.1491547>

³² <http://bigstory.ap.org/article/some-states-confirm-water-pollution-drilling>

³³ <http://earthjustice.org/features/campaigns/fracking-across-the-united-states>

³⁴ http://banmichiganfracking.org/?page_id=339#sthash.W5U9xiyn.dpuf

CHEMICAL MIX

~is considered proprietary

"includes known or suspected carcinogens, mutagens, endocrine disruptors, neurotoxins, hazardous air pollutants
 "many of the chemicals in these products have effects at low doses, and children and pregnant women should not be exposed to some at all.

- Dr Theo Colborn has described the chemicals associated with gas drilling operations; many are endocrine disruptors <http://www.endocrinedisruption.com/files/GasManuscriptPreprintforweb12-5-11.pdf>
- A University of Missouri School of Medicine study linked fracking with dangerous hormone-disrupting chemicals in the water near gas drilling sites, including the Colorado River <http://dx.doi.org/10.1210/en.2013-1697>
- In this recent study of a large cohort, an association was observed between density and proximity of natural gas wells within a 10-mile radius of maternal residence and prevalence of congenital heart defects and possibly neural tube defects. *Environmental Health Perspectives* <http://ehp.niehs.nih.gov/1306722/>

Some of the chemicals used in gas drilling and hydraulic fracturing that are toxic to human health:

- Benzene (known carcinogen)
- Ethylbenzene
- Toluene (causes miscarriages, placenta previa)
- Xylene
- Diesel (recently classified by WHO as a carcinogen)
- Naphthalene (neurotoxin; carcinogen)
- Polynuclear aromatic hydrocarbons (PAHs) (carcinogens)
- Formaldehyde (known carcinogen)
- 2-Butoxyethanol (2BE) (known carcinogen); active component of Corexit which was used as a dispersant in the Exxon Valdez and BP Gulf disasters <http://endocrinedisruption.org/assets/media/documents/cp02893Colborn20082022colbornmatanc2-8tocomments.pdf> and <http://www.ehponline.org/viewof.aspx?pid=115-c2.pdf>



12

The case for the picture on the right was described by Bamberger and Oswald in their paper -- the deaths of 17 cows within one hour from exposure to hydraulic fracturing fluid. What do we know about the chemicals which are so toxic that they can kill cattle?

Not much because the gas industry calls the formulations "proprietary".

In fact, a doctor cannot obtain the chemical blend in the case of an emergency, as happened in the case of a nurse in Colorado who treated a worker with a chemical spill on his clothing. He was OK, she almost died from multiple organ failure and during the time she was in the intensive care unit, her doctor could not obtain the name of the chemicals that spilled.

Dr Theo Colborn of Colorado has studied these chemicals. According to Dr Colborn, 47% of the products can affect the endocrine system. And these endocrine disruptors have an impact at minute doses.³⁵

The University of Missouri School of Medicine study also linked gas drilling with dangerous hormone-disrupting chemicals in the water near gas drilling sites in Colorado.³⁶

Here is a very short list of toxins—there are many more.

One of these, 2-Butoxyethanol (2BE) (a known carcinogen), is a solvent that, at very low doses (as low as 0.02 parts per million) affects the endocrine system and which causes also adrenal, kidney and liver tumors, blood

³⁵ <http://www.endocrinedisruption.com/files/GasManuscriptPreprintforweb12-5-11.pdf>

³⁶ <http://dx.doi.org/10.1210/en.2013-1697>

dyscrasias and other health problems.³⁷ It is used throughout the whole life cycle of the well. It's in the cuttings and in the waste. It is also the active ingredient in Corexit, the dispersant used in both the Exxon Valdez and BP disasters.

Benzene primarily affects the central nervous system (CNS) and the hematopoietic system, resulting in anemia and leukemia.

Toluene is a risk for pregnancy, and developmental delays and neurobehavioral difficulties are higher for the children of women who were exposed to high concentrations of organic solvents during pregnancy.

A study just done in Colorado links congenital birth defects with gas drilling.³⁸

Three years ago I spoke to a group of people on Paradise Road in Wyalusing PA which is in Bradford County. The residents in this area all had water buffalos on their lawns because their water had been contaminated by gas wells also on their property. The woman who hosted the meeting was pregnant, and the baby was born with a heart defect. At that point we did not know that there might be an association between birth problems and gas wells. It is not clear what caused this child's heart defect. In any case, no public health agency had spoken to these people. And there still is no monitoring or surveillance in place, neither in PA or any other state.

WASTE

- **hazardous with current disposal methods** <http://www.nrdc.org/energy/fracking-wastewater.aspx#update> and http://www.shalegas.energy.gov/resources/060211_earthworks_petroleumexemptions.pdf and <http://www.dcbureau.org/201308148881/natural-resources-news-service/new-york-imports-pennsylvania-radioactive-fracking-waste-despite-failed-water-tests.html#more-3331>
- **waste contains radioactive elements, brine and gases** <http://www.grassrootsinfo.org/pdf/radioactivewaste.pdf> and <http://www.grassrootsinfo.org/pdf/white-report.pdf>
- **exempt from federal oversight** <http://www.epa.gov/osw/nonhaz/industrial/special/oil/oil-gas.pdf>
- **In 2012, local Michigan activists reported months of road spraying with flowback** <http://banmichiganfracking.org/?p=1082> and <http://banmichiganfracking.org/?p=1423>
- **Radioactive Waste Dumped by Oil Companies Is Seeping out of the Ground in North Dakota**, <http://www.globalpossibilities.org/radioactive-waste-dumped-by-oil-companies-is-seeping-out-of-the-ground-in-north-dakota/>
- **Duke study, 2013** Impacts of Shale Gas Wastewater Disposal on Water Quality in Western Pennsylvania used isotope hydrology to connect shale gas waste, treatment sites and discharge into drinking water supplies; *Elevated levels of radioactivity, salts and metals have been found in river water and sediments at a site where treated water from oil and gas operations is discharged into a western Pennsylvania creek* Environmental Science & Technology. <http://www.nicholas.duke.edu/news/radioactive-shale-gas-contaminants-found-at-wastewater-discharge-site>
- **Julie Weatherington-Rice PhD, 2013 presentation** <http://youtu.be/0K2V3yrcd2I>
- **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>



13

³⁷ <http://endocrinedisruption.org/assets/media/documents/cP02591Colborn20021022coalbedmethane2-BEcomments.pdf> and <http://www.atsdr.cdc.gov/ToxProfiles/tp118-c2.pdf> and <http://www.ncbi.nlm.nih.gov/pubmed/9878593> and <http://pubchem.ncbi.nlm.nih.gov/summary/summary.cgi?cid=8133>

³⁸ <http://ehp.niehs.nih.gov/1306722/>

In the waste is extremely salty “brine”, at least 5-10X the salinity of the sea. The shale was a sea millions of years ago.

Also brought up are naturally occurring volatile organic hydrocarbons such as benzene, ethylene, toluene, and xylene, as well as radionuclides which cause cancer, reproductive problems and neurological issues.

Shales, more than any other kind of rock, trap heavy metals such as lead, arsenic, barium, strontium, and chromium. And when shale is fracked, these heavy metals are released and brought to the surface with the gas and produced fluids.

In the presentation by Dr. Julie Weatherington-Rice of Ohio, she speaks of radioactivity in fracking waste. She says that for proper assessment of Radium, a minimum waiting period of 21 days is required. That is not usually done.

Currently, the waste disposal is via--underground injection wells (which cause earthquakes and which Michigan allows), on soil farms, road spreading (as de-icers and dust control), and dispersed into streams and rivers via waste treatment plants.

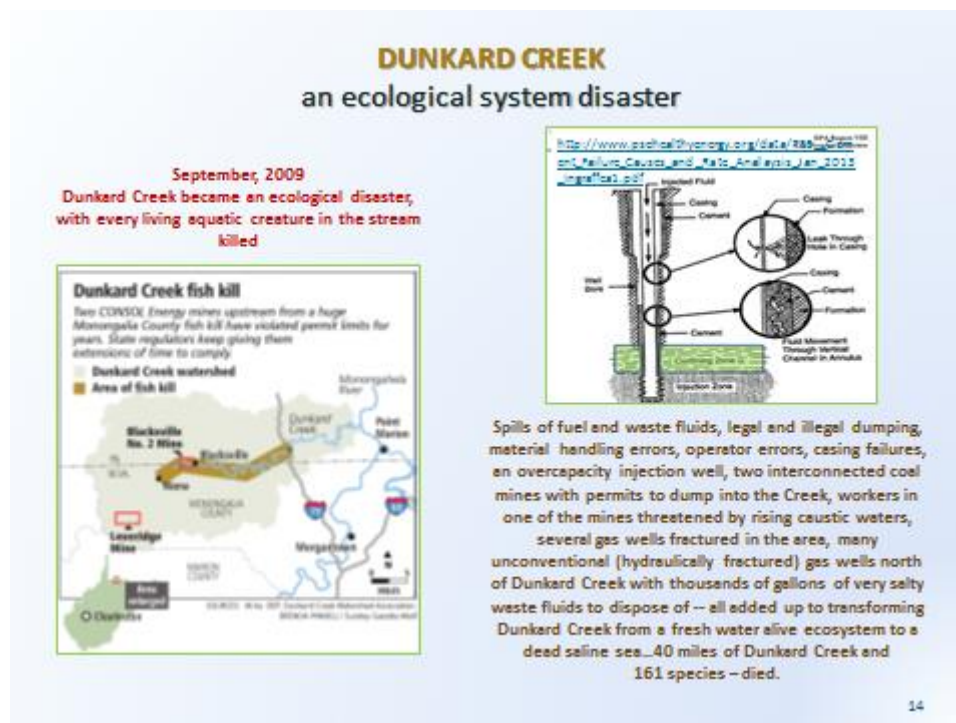
In the summer of 2012, Michigan activists unearthed some disturbing information -- Encana had sprayed a significant portion of its flowback water onto roads, more than 40,000 gallons for “dust control”. And it was done legally with a permit from the DEQ. One of the chemicals that the DEQ said is in the flowback water was an acid inhibitor and the safety data sheet stated it is “explosive, poisonous and fatal”. The incident was investigated by the activists of Ban Michigan Fracking. They also found radium at levels in the thousands; the acceptable radium concentration in water is 5pCi/L. This was called to the attention of DEQ, and there was no response.

(The report on radium 226 and 228 was from a sample taken at the wellhead of Excelsior 1-13, showing levels of 2394 and 2221 pCi/L respectively. Together that is 4615 pCi/L, almost a thousand times the EPA's maximum allowable level for drinking water of 5 pCi/L..)

- hazardous with current disposal methods <http://www.nrdc.org/energy/fracking-wastewater.asp#sec-update> and http://www.shalegas.energy.gov/resources/060211_earthworks_petroleumexemptions.pdf and <http://www.dcbureau.org/201308148881/natural-resources-news-service/new-york-imports-pennsylvanias-radioactive-fracking-waste-despite-falsified-water-tests.html#more-8881>
- waste contains radioactive elements, brine and gases <http://www.grassrootsinfo.org/pdf/radioactivewaste.pdf> and <http://www.grassrootsinfo.org/pdf/whitereport.pdf>
- exempt from federal oversight <http://www.epa.gov/osw/nonhaz/industrial/special/oil/oil-gas.pdf>
- In 2012, local Michigan activists reported months of road spraying with flowback <http://banmichiganfracking.org/?p=1082> and <http://banmichiganfracking.org/?p=1423>
- Radioactive Waste Dumped by Oil Companies Is Seeping out of the Ground in North Dakota, <http://www.globalpossibilities.org/radioactive-waste-dumped-by-oil-companies-is-seeping-out-of-the-ground-in-north-dakota/>
- Duke study, 2013 Impacts of Shale Gas Wastewater Disposal on Water Quality in Western Pennsylvania used isotope hydrology to connect shale gas waste, treatment sites and discharge into drinking water

supplies; Elevated levels of radioactivity, salts and metals have been found in river water and sediments at a site where treated water from oil and gas operations is discharged into a western Pennsylvania creek Environmental Science & Technology. <http://www.nicholas.duke.edu/news/radioactive-shale-gas-contaminants-found-at-wastewater-discharge-site>

- Julie Weatherington-Rice PhD, 2013 presentation <http://youtu.be/0K2V3yrcd2I>
- 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>



In September 2009 I was just beginning to learn about gas drilling. A headline that made an impression on me was the Dunkard Creek kill. Spills of fuel and waste fluids, legal and illegal dumping, material handling “errors”, “operator errors”, casing “errors”, an overcapacity injection well, two interconnected coal mines with permits to dump into the Creek, several gas wells fractured in the area, and thousands of gallons of very salty waste fluids to dispose of -- all added up to transforming Dunkard Creek from a fresh water alive ecosystem to a dead sea...40 miles of creek and 161 species, from mussels to minnows and muskies – died.

There is still debate about the exact cause.

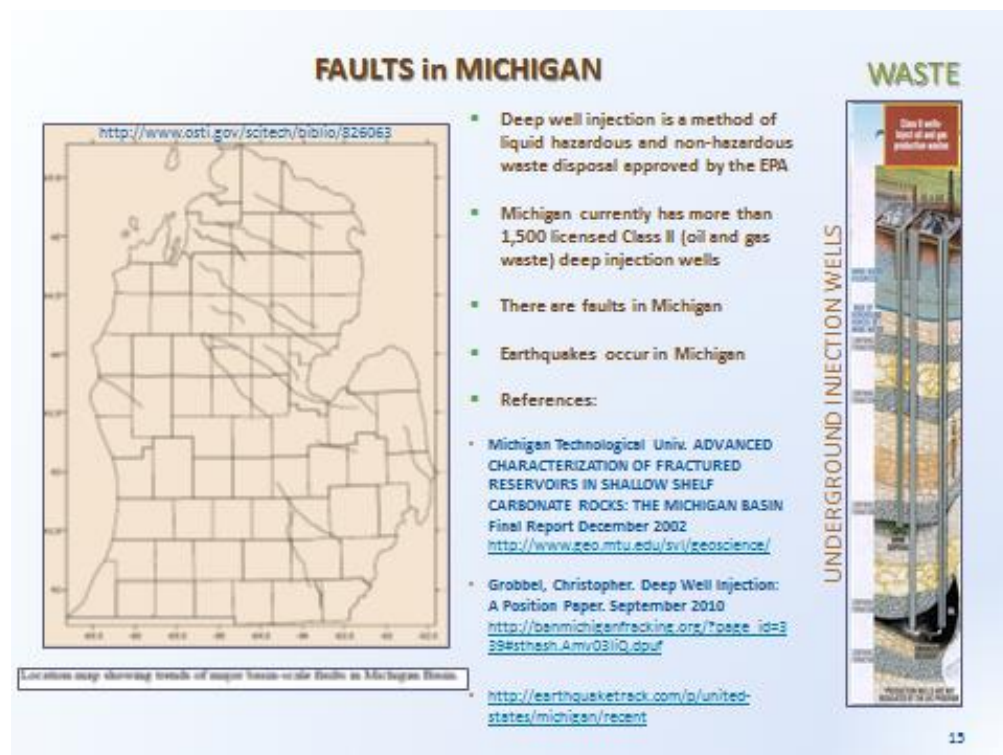
What scientists could say definitively about the fish kill is that there was a swift increase in "total dissolved solids," (TDS), creating the conditions for a bloom of toxic golden algae. TDS can be caused by both coal mine drainage and waste brine from Marcellus Shale gas drilling operations.

The graphic on the top right is of an injection well which you can see is very much like a gas well. Some injection wells actually are old gas wells which are no longer producing. After receiving a permit, the gas well can become an injection well. And just like failures with gas wells, because they are man-made materials—metal and cement—they can fail. In this graphic you can see the mechanism of failure.

6-7% of all well casings fail immediately.

A 2003 industry publication from Schlumberger, the world's No. 1 fracking company, and oil and gas giant ConocoPhillips, cited failure rates of 60 percent over a 30-year span.

Of note is that this ecosystem kill was due to lax regulations of waste and poor enforcement, and also of interest is that the injection well near the creek was at over capacity and likely contributed to the kill.



Although it has a relatively low seismic hazard risk, Michigan has experienced several earthquakes, the most recent would have been in June 2010. The quake started in Canada and was felt through the eastern region of Michigan. According to the USGS, the last earthquake originating within Michigan occurred in September 1994 and registered at a magnitude of 3.5. The western region of Michigan experienced a 4.8 back in 1947.

<http://earthquake.usgs.gov/earthquakes/states/michigan/hazards.php>


We know that the Michigan Basin is in fact extensively faulted and fractured, particularly in the central portion of the basin. This is in contrast to most of the previous references on the Michigan Basin, which tends to show few or minor faults. Most fault lines in Michigan run in a northwest to northeast pattern.³⁹

And we know that there is a relationship between the faults and a number of gas and oil reservoirs.

Chris Grobbel tell us that “Aside from well failure and injectate encountering an unplugged or improperly plugged deep well, the potential for upward migration along a naturally occurring fault is considered the most serious threat to losing waste confinement within a reservoir formation.”⁴⁰

EARTHQUAKES and UNDERGROUND INJECTION WELLS WASTE

- Disposal in underground injection wells can, and has caused earthquakes. Katie M. Karanen, Heather M. Savage, and Geoffrey A. Abers et al., “Potentially Induced Earthquakes in Oklahoma, USA: Links between Wastewater Injection and the 2011 Mw 5.7 Earthquake Sequence,” *Geology* vol. 41, no. 3 (March 26, 2013)
<http://geology.gsapubs.org/content/early/2013/03/26/G34045.1.abstract> and <http://www.columbia.edu/news-events/wastewater-injection-spurred-biggest-earthquake-yet-says-study> and <http://stateimpact.npr.org/texas/tag/earthquake/>
- “The petroleum industry needs clear requirements for operation, regulators must have a solid scientific basis for those requirements, and the public needs assurance that the regulations are sufficient and are being followed.” from *Injection-Induced Earthquakes* by William L. Ellsworth. *Science* 12 July 2013: 1225942 [DOI:10.1126/science.1225942]
<http://www.sciencemag.org/content/341/6142/1225942.abstract?sid=a09d332a-699d-452a-b828-a7b28e7466a6>
- “The fluids [in wastewater injection wells] are driving the faults to their tipping point...Areas with suspected anthropogenic earthquakes are more susceptible to earthquake-triggering from natural transient stresses generated by the seismic waves of large remote earthquakes.” from *Enhanced Remote Earthquake Triggering at Fluid-Injection Sites in the Midwestern United States*, by Nicholas J. van der Elst, Heather M. Savage, Katie M. Karanen, and Geoffrey A. Abers. *Science* 12 July 2013: 164-167. [DOI:10.1126/science.1238948]
<http://www.sciencemag.org/content/341/6142/164.abstract?sid=a09d332a-699d-452a-b828-a7b28e7466a6>



16

Seismic risk in Michigan is relatively small, and the eastern United States, in general, is difficult to evaluate because earthquakes are generally infrequent in comparison to plate-margin areas such as California. Also, active faults do not reach the surface in Michigan and therefore cannot be mapped without the aid of expensive subsurface techniques.

However, the recent drilling for oil and gas, as well as newer technology, plus recent research, have yielded new and more complete information. These are some facts :

- Deep well injection is a method of liquid waste disposal approved by the EPA
- Disposal in underground injection wells can, and has caused earthquakes.


³⁹ <http://www.osti.gov/scitech/biblio/826063>

⁴⁰ Grobbel <http://www.friendsofthejordan.org/advocacy/dwpp.pdf>


- Michigan currently has more than 1,500 licensed Class II (oil and gas waste) deep injection wells
- William L. Ellsworth wrote “The petroleum industry needs clear requirements for operation, regulators must have a solid scientific basis for those requirements, and the public needs assurance that the regulations are sufficient and are being followed.”
- And I’d like to mention the concept of dynamic triggering of earthquakes. Powerful earthquakes thousands of miles (km) away can trigger swarms of minor quakes near wastewater-injection wells. This is discussed in the Columbia paper from the summer of 2013,... Dr van der Elst wrote: “The fluids (in wastewater injection wells) are driving the faults to their tipping point...Areas with suspected anthropogenic earthquakes are more susceptible to earthquake-triggering from natural transient stresses generated by the seismic waves of large remote earthquakes.”

Health Impacts of earthquakes include possible trauma from collapse of structures, and injury or death from explosions from ruptured gas lines.



- **Disposal in underground injection wells can, and has caused earthquakes.** Katie M. Keranen, Heather M. Savage, and Geoffrey A. Abers et al., “Potentially Induced Earthquakes in Oklahoma, USA: Links between Wastewater Injection and the 2011 Mw 5.7 Earthquake Sequence,” *Geology*, vol. 41, no. 3 (March 26, 2013) <http://geology.gsapubs.org/content/early/2013/03/26/G34045.1.abstract> and <http://www.ldeo.columbia.edu/news-events/wastewater-injection-spurred-biggest-earthquake-yet-says-study> and <http://stateimpact.npr.org/texas/tag/earthquake/>
- **“The petroleum industry needs clear requirements for operation, regulators must have a solid scientific basis for those requirements, and the public needs assurance that the regulations are sufficient and are being followed.”** from *Injection-Induced Earthquakes* by William L. Ellsworth. *Science* 12 July 2013: 1225942 [DOI:10.1126/science.1225942] <http://www.sciencemag.org/content/341/6142/1225942.abstract?sid=a09d332a-699d-452a-b828-a7b28e7466a6>
- **“The fluids (in wastewater injection wells) are driving the faults to their tipping point...Areas with suspected anthropogenic earthquakes are more susceptible to earthquake-triggering from natural transient stresses generated by the seismic waves of large remote earthquakes.”** from *Enhanced Remote Earthquake Triggering at Fluid-Injection Sites in the Midwestern United States*, by Nicholas J. van der Elst, Heather M. Savage, Katie M. Keranen, and Geoffrey A. Abers. *Science* 12 July 2013: 164-167. [DOI:10.1126/science.1238948] <http://www.sciencemag.org/content/341/6142/164.abstract?sid=a09d332a-699d-452a-b828-a7b28e7466a6>



RADIOACTIVITY



- **recommendations from the International Atomic Energy Agency (IAEA)** http://www-pub.iaea.org/MTCD/publications/PDF/TC3-40_web.pdf
- **federal exemption** <http://www.epa.gov/osw/monhas/industrial/special/oil/gas.pdf>
- **Radon is a leading and preventable cause of lung cancer.** <http://www.youtube.com/watch?v=957VUu2D5w4&list=PL4wUwU1VfMds> and National Academy of Sciences, Health Effects of Exposure to Radon: BEIR VI, NATIONAL ACADEMY PRESS, Washington, D.C. 1999 <http://www.nap.edu/catalog/5499.html>
- **Radon and gas extraction.** Paschke, in Radiological Impact due to Oil and Gas Extraction, BUSINESS STRIVING : EXPLORATION & PRODUCTION 2003
- **Steinhäusler: workers and those living nearby are at risk from exposure to radioactive materials.** Steinhäusler, P, RADIOLOGICAL IMPACT ON MAN AND THE ENVIRONMENT FROM THE OIL AND GAS INDUSTRY: RISK ASSESSMENT FOR THE CRITICAL GROUP, Published in M.K. Zardindani, Mustafaev (eds.), Radiation Safety Problems in the Caspian Region, 120-134, © 2004 Kluwer Academic Publishers
- **Tait et al found an ~3 fold increase in maximum 222Rn concentration inside the gas field compared to outside of it.** Enrichment of Radon and Carbon Dioxide in the Open Atmosphere of an Australian Coal Seam Gas Field, Environ. Sci. Technol., Apr 2, 2013; 47(7): 1099-1104. doi: 10.1021/es304558g <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3632874/>
- **Nelson and Schultz describe the difficulty of measuring radioactivity in flowback water (FBW) from Marcellus shale drilling.** Nelson A, et al, Matrix Complications in the Determination of Radium Levels in Hydraulic Fracturing Flowback Water from Marcellus Shale, Environ. Sci. Technol. Lett., 2014, 1 (3), pp 204-208, DOI: 10.1021/es5000379 <http://pubs.acs.org/doi/abs/10.1021/es5000379>

<http://www.epa.gov/radon/states/michigan.html>

17

For decades we have known shale to be radioactive, particularly the Marcellus shale in my region.

The International Atomic Energy Agency 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 the RCRA (Resource Conservation and Recovery Act) the materials that come from down-hole which are, in many cases, radioactive.

The elements of concern during gas development are radium and its daughter product, radon, which further decays to polonium and lead. The radium is in a liquid state as it exits the wellhead, while the radon is in a gaseous state. As the liquids are separated from the gas, the radium will predominantly end up with the liquid waste, and the radon will flow with the gas into gathering lines and pipelines on the way to a point of consumption, such as a kitchen stove, space heater, water heater or gas-fed furnace in a residence. There are risks from the radioactive nature of the Marcellus shale in particular, which have not been adequately studied. (ATSDR lists stoves and furnaces as a source of radon.⁴¹)

In a 2014 paper by Andrew Nelson and Michael Schultz, the authors describe the difficulty of measuring radioactivity in flowback water (FBW) from Marcellus shale drilling.⁴² The typical and current method used is EPA 903.0, and it is useful for the detection of radium in drinking water, however, analysis of FBW by this method was questioned by these authors because of the remarkably high ionic strength and dissolved solid content observed, particularly in FBW from the Marcellus Shale region.

⁴¹ <http://www.atsdr.cdc.gov/csem/csem.asp?csem=8&po=5>

⁴² Nelson A et al, Matrix Complications in the Determination of Radium Levels in Hydraulic Fracturing Flowback Water from Marcellus Shale, *Environ. Sci. Technol. Lett.*, 2014, 1 (3), pp 204-208
DOI: 10.1021/es5000379. Access at <http://pubs.acs.org/doi/abs/10.1021/es5000379>

I'd like to focus on radon in particular. Radon is a leading and preventable cause of lung cancer.^{43 44} 21,000 lung cancer deaths per year in the US are attributed to radon exposure. Radon and its radioactive decay products (polonium mainly) enter the body 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 are the elements which cause cancer. Although zero is the only "safe" level for radon exposure, mitigation must be done for indoor levels of 4 picoCuries per liter in the US. The World Health Organization recommends mitigation at 2.7 picoCuries per liter (or about 100Bq/m³).

Paschoa, in ...2003, wrote that "...gaseous radon (222Rn) is concentrated in ethane and propane fractions due to the fact that the boiling point of radon lies between those of propane and ethane. Elevated Rn activity concentration values have been measured at several processing plant sites...It is well known that the radiological impact of the oil and gas-extracting and processing industry is not negligible." ... Steinhausler has written that workers and those living nearby are at risk from exposure to radioactive materials.⁴⁵

Areas overlying shale have high indoor radon, on average, already. Residents of many of these counties, with the richest gas deposits, have elevated radon concentration in their homes already--those areas shown as orange and dark red-- and will be at even greater risk from exposure to radioactivity.

I came across a recent article from Australia⁴⁶, where they measured radon (and CO2) to determine fugitive emissions from fracking for coal bed methane. Among other things, they found a significant relationship between the number of wells within 3 km of sampling sites and the maximum radon concentration over the 24 h period, and this led them to hypothesize that the high concentrations of ²²²Rn measured inside a CSG field during this study are derived not only from gas extraction infrastructure, but also from the depressurization (horizontal drilling, hydraulic fracturing, groundwater extraction) of the coal seams which may increase diffuse soil emissions.

The small map shows indoor radon—that is, at the surface-- concentrations in the US. The larger map, an EPA radon map for MICHIGAN, shows that Michigan is already at mitigation levels in several counties.

What are the potential health problems from radioactivity exposure, specifically to radon?

It is DNA damage.

The body's response is to try to repair the damage, and we have mechanisms in place to do that, but it may result in an altered sequence which can result in mutations which can lead to tumor initiation.

There are also possible teratogenic effects caused by radon exposure.

... If dissolved in a mother's blood stream, radon can pass through the placenta and into the developing child. If the developing child is only in the embryo phase, and a radon particle forms a progeny and deposits anywhere,

⁴³ National Academy of Sciences, Health Effects of Exposure to Radon: BEIR VI, NATIONAL ACADEMY PRESS, Washington, D.C. 1999 <http://www.nap.edu/catalog/5499.html>

⁴⁴ <http://www.epa.gov/radon/pubs/citguide.html>

⁴⁵ Steinhäusler, F, RADIOLOGICAL IMPACT ON MAN AND THE ENVIRONMENT FROM THE OIL AND GAS INDUSTRY: RISK ASSESSMENT FOR THE CRITICAL GROUP, Published in *M.K. Zaidi and I. Mustafaev (eds.), Radiation Safety Problems in the Caspian Region*, 129-134.

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⁴⁶ Tait et al, 2013. Enrichment of Radon and Carbon Dioxide in the Open Atmosphere of an Australian Coal Seam Gas Field, *Environ Sci Technol*. Apr 2, 2013; 47(7): 3099–3104.

doi: 10.1021/es304538g. Access at <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3621574/>

emitting alpha radiation, the formation of DNA lesions will most likely kill it....On the other hand, if the developing child is in the fetal stages, most of the bodily development has already occurred. In this case, a radon particle passing into the fetus would likely move to lipid portions of the unborn child, namely the brain and other organs. Since brain development is most crucial in this phase, ionizing radiation at this point might not kill the fetus but may cause severe inhibition in brain development leading to mental retardation after birth. Exposure of radon to a developed child after the first year of birth, when the brain is less lipid-like and the blood-brain-barrier is fully formed, follows the same pathways as for adults.

Several studies have shown that children are more susceptible to radon exposure than adults. Children have different lung architecture and breathing patterns, resulting in a larger dose of radiation to the respiratory tract. Children also have longer latency periods in which to develop cancer. And, on average, children spend 70% more time in the house than adults.

For these reasons, radon exposure for vulnerable populations like children and pregnant women is especially risky.



Large quantities of silica sand are used during the hydraulic fracturing process.

In the course of mining and transport, silica dust is released into the air, causing a hazard to those employees involved in handling it.

Inhalation of silica sand causes silicosis which is an incurable but preventable lung disease. In addition to being an occupational lung carcinogen, inhaling silica dust causes chronic obstructive pulmonary disease (COPD), chronic renal disease and various autoimmune diseases. Individuals with silicosis are known to be at higher risk of tuberculosis. And these illnesses can impact the community in which the workers live.

- 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 is a carcinogen.
- Sulfur dioxide (SO₂) is associated with respiratory and neurological illness, and death.
- Particulate matter is of small size and large surface area, and carries toxic pollutants deep into the lungs.

Project Mariner West will bring the Marcellus shale to Michigan...as you can see in the insert on the right. It is a pipeline project for delivery of ethane from the liquid-rich Marcellus Shale processing and fractionation areas in Western Pennsylvania to the Sarnia, Ontario petrochemical market. They plan to use existing Sunoco Logistics pipelines, which will be modified for ethane service.

<http://www.sunocologistics.com/Customers/Business-Lines/Natural-Gas-Liquids-NGLs/NGL-Projects/208/>
<http://www.sunocologistics.com/Mariner-West/169/>

Additional references:

<http://www.iom.edu/~media/Files/Activity%20Files/Environment/EnvironmentalHealthRT/2012-04-30/Robinson.pdf> and

<http://www.iom.edu/Activities/Environment/EnvironmentalHealthRT/2012-APR-30/Day-1/Session-5/1-Robinson.aspx> and

http://sape2016.files.wordpress.com/2013/10/alconquin_incremental_market_project.pdf and

http://courses.washington.edu/envir300/papers/Steinzor_et_al_2013.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>



LNG import/export terminals

<http://ferc.gov/industries/gas/indus-act/lng/lng-proposed-potential.pdf> and
<http://concernedhealthny.org/wp-content/uploads/2013/10/Factsheet-Health-and-Security-Risks-of-LNG.pdf>



<http://simplylaw.com/LNG-TANKERS.htm>

In the past year there have been numerous applications made to the federal agency in charge (FERC) of permitting export terminals, largely due to the projections of increased gas volume, and also because gas can bring a lot more money from the international market.⁴⁷

The bottom picture is a representation of an LNG tanker (the orange structure is one big ship) pulling out of a harbor past 4 story townhomes.

LNG terminals are a security risk⁴⁸, their existence will increase unconventional gas development, and it will increase the price of domestic gas.

⁴⁷ <http://ferc.gov/industries/gas/indus-act/lng/lng-proposed-potential.pdf>

⁴⁸ <http://concernedhealthny.org/wp-content/uploads/2013/10/Factsheet-Health-and-Security-Risks-of-LNG.pdf>

Human-controlled sources of atmospheric methane from the United States for 2009, based on emission estimates from the U.S. Environmental Protection Agency in 2011; graph from Howarth (2012)

CLIMATE CHANGE

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.epa.gov/ghg/docs/ClimateImpactsSummary_Attributions_03Feb2013.pdf

Source	Approximate Emissions (in units of 10)
Natural gas systems	38
Landfills	22
Livestock	18
Fugitive emissions	12
Industrial processes	8
Other sources	2

- 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/PMC269999/>
- 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/s10654-011-0061-5>
- 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/policy_ft/1.22621/menu/main/topColumns/topLeftColumn/pdf/421129a.pdf
- 2012 Howarth. While methane is only causing about 1/3 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.esd.sacmill.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/1748-9226/7/1/014019/pdf/1748-9226_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/jen.20811/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://www.wri.gov/493/report/>

21

Climate change impacts human health, documented for example by Drs Sheffield and Landrigan, and others.

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

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.

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.

And just a few months ago, 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.

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/>



The United States is connected to a world that is unevenly vulnerable to climate change and thus will be affected by impacts in other parts of the world.

<http://waterwebster.org/documents/climate-impacts-report.pdf>

<http://news.nationalgeographic.com/news/energy/2013/01/130109-us-gas-wells-bakken-northern-view-of-gas-flaring/>



Satellite image sources: NASA & geology.com

22

These NASA satellite photos show the large areas of development in North Dakota's Bakken Field and the Eagle Ford in Texas. The white areas are either cities or flaring of gas—they look the same.

The rapid increase in shale oil and gas production means it is now often more economical to 'flare off' unwanted gas than to sell it. As a result, one field in North Dakota is now burning off enough gas to power all the homes in Chicago and Washington D.C. combined.

And the light being given off at the Bakken and Eagle Ford formations easily competes in intensity with that being emitted from cities.

The impacts of gas development are immense.



<http://www.crematist.com/article/30300304/News/503040003/Hydraulic-fracturing-in-michigan-what-does-it-mean-for-the-state>

- Frack sand mining
- Shale gas extraction
- Wastewater treatment
- Disposal wells

<http://www.fracktracker.org/2013/02/new-michigan-map-shows-off-new-frackmapper-functionality/>

Permitted gas operations in MICHIGAN



23

An excellent site to view the gas drilling operations, including the entire infrastructure such as disposal wells, is www.fracktracker.org -- click on maps, and then MICHIGAN.

In New York State, health issues have become the focal discussion point.

That came about as a result of a state law called the State Environmental Quality Review Act (SEQRA) which requires that an Environmental Impact Statement be done on any major land use decision. While the study is being done, there is a moratorium on the proposed land use, and is the reason that in NY we don't have high volume, slick water, hydraulic fracturing.

SEQRA requires an analysis of health impacts in addition to an environmental analysis on that major land use decision. When we New Yorkers analyzed the draft document, we found that there was almost nothing about health, and what was there was incomplete, outdated or plain wrong. So we submitted comments—over 250,000—and many comments were about the inadequacy of health protections.

We also began advocating for a comprehensive health impact assessment. That was an effort of all the environmental organizations, whether they were for a ban, moratorium or criminalization, or better regulations. It also included legislators and medical societies, as I will explain later.

In response, the Governor asked the Commissioner of Health to review the adequacy of the EIS with regard to health. Although this is not the transparent HIA that we asked for, the Commissioner is doing his own study, and meanwhile the moratorium is in place. We feel that with the studies coming rapidly now, there is no way a health commissioner who is a respected medical doctor would say that this practice, as currently done, is safe.

In Michigan, oil and gas are regulated under an antiquated 1939 law...and although all these processes are allowed, the production is still in an early stage.

Here are just a few Michigan regulations (from HYDRAULIC FRACTURING IN MICHIGAN INTEGRATED ASSESSMENT: POLICY/LAW TECHNICAL REPORT, SEPTEMBER 2013) :

Michigan has weak setback requirements—300 ft from a residence, a water well and river; these are less than the setbacks in Pennsylvania, and that state’s history of contamination was presented in an earlier slide.

There is no requirement for water withdrawal reporting or monitoring, in other words, if under 100,000 gpd are withdrawn, it is exempted by Michigan statute.

In Michigan, a health professional cannot obtain the name of the chemical used even in the case of an emergency.

In the past couple of years, several regulatory reform bills were introduced in the legislature...on water withdrawal, chemical disclosure, and landowner protection. But no hearings were held and they died.

It is unclear whether towns, cities and villages in Michigan can ban gas development altogether; apparently that has not been challenged in Michigan yet. In NY there are 75 bans, 102 moratoria, 87 movements for prohibitions (bans or moratoria), and that includes my town in Upstate NY which banned it. According to this list from Food and Water Watch *Mapping the Movement*, <http://foodandwaterwatch.org/water/fracking/fracking-action-center/map/>, there are 18 towns or counties in Michigan which have passed resolutions or laws restricting gas development or even supporting a ban on gas development.

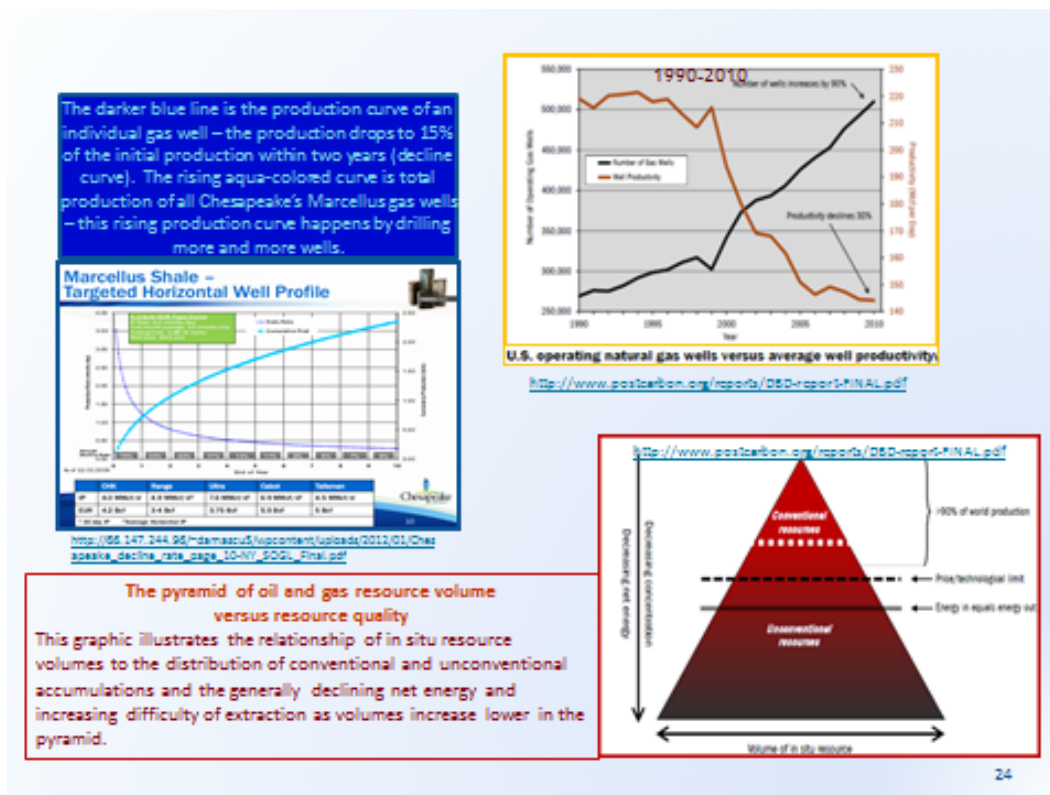
Cross Village Township passed a resolution urging their county and the state of Michigan to pass a ban http://documents.foodandwaterwatch.org/doc/Frack_Actions_CrossVillageTownshipMI.pdf. So did Dearborn. And Ingham County and Wayne County.

An interesting example is Cannon Township which attempted to ban the process but was informed by attorneys Mika Myers Beckett and Jones that they could not, and instead they suggested a 6 month moratorium, http://documents.foodandwaterwatch.org/doc/Frack_Actions_CannonTownshipMI.pdf. The only way to test a ban law is to pass such a law, and to see how the courts decide.



24

I recently travelled to WV to speak with impacted people and also to see some of the infrastructure. And that build-out is immense, as you can see from an aerial view of one such plant.



So all this gas will be extracted, the infrastructure built, with resulting environmental and health impacts ...and then how long will this gas last?

Not very long, as shown in these graphs.

The graph on the left is from CHESAPEAKE's 2010 STOCKHOLDERS REPORT filed with the federal government Securities and Exchange Commission (SEC).⁴⁹

The darker blue line in the graph is the production curve of an individual gas well.

The decline rate is 70% the first year. 85% of the gas is gone in two years and the well is unproductive in another year or so more. The rising lighter colored aqua curve is total production of all of Chesapeake's gas wells – this rising production curve happens by drilling more and more wells because the wells decline so fast.

On the top right is another reference for the production decline. It illustrates the law of diminishing returns. More and more wells must be drilled to maintain production as the average productivity per well is declining. Since 1990, the number of operating gas wells in the United States has increased by 90 percent while the average productivity per well has declined by 38 percent.⁵⁰

Another way of looking at oil and gas resources is illustrated by the resource pyramid, the figure on the bottom. The highest quality resources in the most concentrated accumulations which can be recovered at the lowest cost are at the top of the pyramid. These are supergiant and giant conventional oil and gas fields.

⁴⁹ http://66.147.244.96/~damascu5/wpcontent/uploads/2012/01/Chesapeake_decline_rate_page_10-NY_SOGL_Final.pdf

⁵⁰ <http://www.postcarbon.org/reports/DBD-report-FINAL.pdf>

Lower in the pyramid, resource volumes increase, resource quality decreases, hydrocarbons become more dispersed, and the energy required to extract them increases. The dashed line represents the transition from high quality, low cost, conventional resources to lower quality, higher cost, unconventional resources. The hydrocarbon resources at the base of the pyramid are very plentiful, but totally inaccessible.

The price/technology line reflects the fact that as prices go higher, the higher cost (but lower quality) resources become accessible through technological innovations, such as multi-stage hydraulic fracturing. The ultimate barrier is the second line, which is the point when the amount of energy in the resources that are recovered is less than or equal to the energy that must be invested to recover them.

All resources below this line represent an energy drain, not an energy source.⁵¹

<http://www.crainsdetroit.com/article/20130324/NEWS/303249962/hydraulic-fracturing-in-michigan-waiting-for-the-boom>
and <http://www.crainsdetroit.com/article/20130906/BLOG010/130909902>

Michigan, with low natural gas prices and slow at converting and retiring old, coal-fired electricity plants, is seeing both demand and incentives for extraction held down, and is therefore currently producing little gas.

It's not that the state of Michigan isn't trying.

In May 2010, the Michigan Department of Natural Resources set a record by auctioning off 118,000 acres of state land in 22 counties.

Over the past 10 years, the leasing of state-owned oil and gas rights has generated more than \$750 million in lease payments and royalties for the State.

52 permits for high-volume, horizontal hydraulic fracturing have been issued so far by the DEQ. Of those 52, five wells are actively producing; the rest are either capped, under development or exploratory wells.

Current gas prices are low at about \$3 per thousand cubic feet. It is estimated that natural gas prices would need to be around \$8 per thousand cubic feet before companies found it profitable.

The gas is also quite deep here—about 10,000 feet (down) as opposed to 5,000 feet in other areas of the country. **In other words, production costs are higher in Michigan than in other areas, partly because of the depth to which frackers must drill to access the gas.**

However, Michigan has wet gas which has been profitable in places like western Pennsylvania and West Virginia.

The Univ of Michigan economic report⁵², which explored how gas development affects state revenue, royalties, property value changes and employment, indicated that the ROI (return on investment) for Michigan might be less than ideal at this time.

⁵¹ <http://www.postcarbon.org/reports/DBD-report-FINAL.pdf>

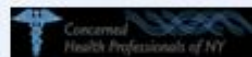
⁵² <http://graham.umich.edu/form/hydraulic-fracturing-technical-reports-and-integrated-assessment-comments>

Science and health professionals in the US working on shale gas impacts



Continuing Medical Education Series on Shale Gas Development

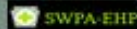
www.PSEhealthyenergy.org




Dr Sandra Steingraber has been an outspoken advocate for health rights, and co-founded www.concernedhealthny.org

Summary Report, Human Health Risks and Exposure Pathways of Proposed Horizontal Hydrofracking in New York State
<http://www.grassrootsinfo.org/summaryreport.pdf>



The Southwest Pennsylvania Environmental Health Project <http://www.environmentalhealthproject.org> has published a *Medical Toolkit* for medical professionals: 

Drs Michelle Bamberger and Robert Oswald are the guest editors of an online journal *New Solutions: A Journal of Environmental and Occupational Health Policy*
<http://www.environmentalhealthproject.org/new-solutions>

Wilma Subra and Nadia Steinzor of Earthworks Oil and Gas Accountability Project conducted and published a survey of common health complaints Gas Patch Roulette: Full Report 

Drs Adgate, Witter and Wornham were the lead authors on the first Health Impact Assessments on gas drilling <http://www.getfield-county.com/environmental-health/baltimore-mesa-health-impact-assessment-final-12-2010.pdf> and <http://www.getfield-county.com/environmental-health/baltimore-mesa-health-impact-assessment-final-12-2010.pdf> and <http://www.getfield-county.com/environmental-health/baltimore-mesa-health-impact-assessment-final-12-2010.pdf>

TEDX
The Endocrine Disruption Exchange

Dr Theo Colborn has been documenting health impact of chemicals and air toxics in Colorado

23

So who is looking whether there are health impacts?

We have medical colleagues who are working in the gas fields making observations about the health impacts and they are documenting them. Others are working on education or advocacy.

A series of online educational modules has been developed by Physicians, Scientists and Engineers for Healthy Energy (PSE) to educate medical professionals, and for which you can receive CME credits.⁵³

The Southwest Pennsylvania Environmental Health Project (SWPA-EHP) has published a [Medical Toolkit](#) for medical professionals focused on patient concerns and symptoms. And they see patients in their clinic.

Grassroots Env Education offer a summary report on health risks.⁵⁴

Drs Michelle Bamberger and Robert Oswald guest edited an online journal called New Solutions with an entire volume dedicated to health impacts and gas drilling.⁵⁵

⁵³ www.PSEhealthyenergy.org

⁵⁴ <http://www.grassrootsinfo.org/summaryreport.pdf>

Earthworks Oil and Gas Accountability Project published a survey of symptoms of impacted people.⁵⁶

Drs Adgate, Witter and Wernham were the lead authors on the first Health Impact Assessments on gas drilling, and they continue to publish work.

Dr Sandra Steingraber has been an outspoken advocate for health rights, and she and I co-founded Concerned Health Professionals of New York.⁵⁷

And Dr Theo Colborn has been documenting health impacts of chemicals and air toxins in Colorado since this industry took hold there.⁵⁸

There are more trailblazers...this was just to name a few. (please see pdf of powerpoint for additional clickable references)

What are medical professionals observing in areas of gas drilling and infrastructure development?

From Dr David Brown's presentation at the National Academy of Sciences workshop—
Review of SWPA-EHP experience
http://sites.nationalacademies.org/xpedito/groups/dbasse/site/documents/webpage/dbasse_083486.pdf

<p>Potential Airborne Hazards from Natural Gas Extraction</p> <ul style="list-style-type: none">• Benium• Arsenic• VOCs• PAHs• STEK• Methylene chloride• Glycols• Fine particulate matter• Carbon monoxide• Silica dust• Radium• Acetaldehyde/formaldehyde <p>Potential Waterborne Hazards from Natural Gas Extraction</p> <ul style="list-style-type: none">• All the chemicals listed above, plus• Bacteria• Microbial contamination• Components of drilling solvents• Lithium	<p>The necessary criteria for designating a symptom as attributable to gas extraction activities included:</p> <ul style="list-style-type: none">• Temporal relationship• Plausible exposure• Absence of a more likely explanation <p>Health Symptoms Temporally Associated with Gas Drilling Activities</p> <p>Most common symptoms experienced by individuals and families evaluated by SWPA-EHP:</p> <p>Symptom/% of individuals</p> <ul style="list-style-type: none">• Skin rash or irritation/48%• Nausea or vomiting/45%• Abdominal pain/38%• Breathing difficulties or cough/41%• Nosebleeds/21% <p>Other common complaints from SWPA-EHP clients population include:</p> <ul style="list-style-type: none">• Anxiety/Stress• Nervous system problems including headaches and dizziness• Eye irritation• Throat irritation
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27

This slide summarizes some of Southwest Pennsylvania Environmental Health Project's experiences.⁵⁹

They set out to identify the pathways for contamination and the likely chemicals to which individuals are exposed. A review of the literature of air exposures led their toxicologist to produce a list of compounds that have potent physiological impacts and are found in high concentrations in various phases of the extraction process.

⁵⁵ http://www.psehealthyenergy.org/Impacts_of_Gas_Drilling_on_Human_and_Animal_Health

⁵⁶ <http://www.earthworksaction.org/files/publications/Health-Report-Full-FINAL-sm.pdf>

⁵⁷ www.concernedhealthny.org

⁵⁸ <http://endocrinedisruption.org/>

⁵⁹ http://sites.nationalacademies.org/xpedito/groups/dbasse/site/documents/webpage/dbasse_083486.pdf

These are the classes of pollutants that are most likely to impact human health through the air pathway:

VOC-volatile organic compounds

PAH-polycyclic-aromatic hydrocarbons

BTEX-Benzene, Ethylbenzene, Toluene and Xylene

In the short term, these chemicals can cause some of the symptoms listed on the slide. Many of these are known carcinogens or have other long-term health impacts.

The results from the Southwest Pennsylvania Environmental Health Project study implicate air contamination as the likely cause of three-quarters of the associated illnesses. In some cases, high levels of fracking-related air pollutants were found in the air inside of people's homes.

Dr Brown describes the necessary criteria for designating a symptom as attributable to gas extraction activities, and that includes:

- Temporal relationship – Development of symptom (or exacerbation of pre-existing symptom) after onset of gas extraction activities
- Plausible exposure – Identifiable exposure source in proximity to the individual experiencing symptoms
- Absence of a more likely explanation – Symptoms were not attributed to gas extraction activities if an individual had an underlying medical condition that was as (or more) likely to have caused the symptom.

And further observations by medical professionals...

Public Health Risks of Shale Gas Development by John L. Adgate, Bernard D. Goldstein, and Lisa M. McKenzie
<https://doi.org/10.1093/ehp/116.10.1000>

"... the major stressors for both the working and community populations fall into eight major categories: air emissions, ground and surface water contamination, truck traffic, noise and light pollution, accidents and malfunctions, strain on health care systems, psycho-social stress associated with community change, and loss of property values."

"Health Effects...are associated with both short and long-term health risks in both worker and community populations. In worker populations the most serious risks are job-related mortality from worksite or traffic accidents."

Despite the demonstrated contact with chemical and nonchemical stressors and broad public concern, no comprehensive population based studies of the public health impacts of unconventional natural gas operations have been published."

"... there is both substantial public concern and substantial uncertainties that need to be addressed before we can reasonably quantify the likelihood of occurrence or magnitude of adverse health effects in workers and communities where development will likely occur"

28



These observations were reported in a recent National Academy of Sciences workshop.⁶⁰

They identified the major stressors, listed on the slide, and...

...concluded that “Health Effects...are associated with both short and long-term health risks in both worker and community populations...”

There is no public health agency in the United States that is routinely seeking and compiling information about people who have been adversely impacted by shale gas development...not on the local, or county, or state, or federal level.

Instead...

<http://news.nationalgeographic.com/news/2010/10/101022-energy-marcellus-shale-gas-environment/>

In some states doctors are gagged

<http://www.pennsylvaniaallianceforcleanwaterandair.wordpress.com/the-list/>
<http://www.frackracker.org/2013/03/pacwas-list-of-the-harmed-now-mapped-by-frackracker/>

Jenny Lisak's List of the Harmed has over 1500 names

<http://pennsylvaniaallianceforcleanwaterandair.wordpress.com/the-list/>
<http://www.frackracker.org/2013/03/pacwas-list-of-the-harmed-now-mapped-by-frackracker/>

non-disclosure agreements are common, and prevent important information-sharing

<http://onlinelibrary.wiley.com/doi/10.1002/hast.278/pdf>

29

NIEHS has funded several health and scientific studies, including the Environmental Consortium study led by Univ of Pennsylvania. But there is no public health agency in the United States systematically compiling information about people who have been adversely impacted by shale gas development.

So grassroots groups are attempting to fill that void.

Organizers, like Jenny Lisak, have now compiled over 1500 reports of people who have suffered health impacts.⁶¹

Non-disclosure agreements are common, and prevent important information-sharing, such as this case (of the Hollowich family^{62 63 64}) in Pennsylvania. I know of numerous cases where significant health information cannot be publicly shared since the families signed a non-disclosure agreement. So if a family has a legitimate complaint of health or environmental problems, they may receive a settlement from the gas company, like money or water

⁶⁰ http://sites.nationalacademies.org/xpedito/groups/dbassesite/documents/webpage/dbasse_083235.pdf

⁶¹ <http://pennsylvaniaallianceforcleanwaterandair.wordpress.com/the-list/> and

<http://www.frackracker.org/2013/03/pacwas-list-of-the-harmed-now-mapped-by-frackracker>

⁶² <http://news.nationalgeographic.com/news/2010/10/101022-energy-marcellus-shale-gas-environment/>

⁶³ <http://climate-connections.org/2013/08/02/range-resources-attorney-seeks-gag-order-on-7-and-10-year-old-in-pittsburgh-area-shale-gas-case/>

⁶⁴ <http://onlinelibrary.wiley.com/doi/10.1002/hast.278/pdf>

delivery or a new filtration system, but in return, the family has to sign this document which prevents them from discussing the terms and reasons for the settlement.

Another obstacle that has recently emerged in certain states is the sharing of medical information that doctors receive from industry in order to treat their patients⁶⁵. In Pennsylvania and Colorado, doctors are required to sign a non-disclosure agreement in exchange for life-saving information. A similar law was proposed in Michigan, **HOUSE BILL No. 5565** on April 24, 2012, by Reps. Brown, Bledsoe, Lipton, Bauer, Tlaib and Byrum, and it was a doctor's gag order⁶⁶; it didn't pass thankfully.

HOUSE BILL No. 5565

April 24, 2012, Introduced by Reps. Brown, Bledsoe, Lipton, Bauer, Tlaib and Byrum and referred to the Committee on Energy and Technology.

A bill to amend 1994 PA 451, entitled "Natural resources and environmental protection act," (MCL 324.101 to 324.90106) by adding sections 61506d, 61531, 61532, 61533, 61534, 61535, 61536, and 61537.

.....this part refers to doctors ...

SEC. 61536. (1) NOTWITHSTANDING SECTION 61534, A PERSON SHALL
12 SUPPLY THE FOLLOWING INFORMATION TO A HEALTH CARE PROFESSIONAL:
13 (A) INFORMATION REGARDING ADDITIVES OR CHEMICAL INGREDIENTS
14 REQUIRED BY THE HEALTH CARE PROFESSIONAL WHO NEEDS THE INFORMATION
15 FOR DIAGNOSTIC PURPOSES. THIS INFORMATION SHALL BE PROVIDED
16 DIRECTLY TO THE HEALTH CARE PROFESSIONAL AS FOLLOWS:
17 (i) IMMEDIATELY UPON REQUEST, IN A CASE IDENTIFIED BY THE
18 HEALTH CARE PROFESSIONAL AS A MEDICAL EMERGENCY. THE HEALTH CARE
19 PROFESSIONAL'S INITIAL REQUEST FOR INFORMATION NEED NOT SATISFY THE
20 REQUIREMENTS OF A STATEMENT OF NEED AS DESCRIBED IN SUBSECTION (2).
21 AS SOON AFTER THE EMERGENCY AS CIRCUMSTANCES PERMIT, THE HEALTH
22 CARE PROFESSIONAL SHALL THEN PROVIDE TO THE PERSON DISCLOSING THE
23 INFORMATION A WRITTEN STATEMENT OF THE NEED FOR THE INFORMATION.
24 (ii) UPON RECEIPT OF A WRITTEN STATEMENT OF NEED FROM THE
25 HEALTH CARE PROFESSIONAL, IN CASES THAT ARE NOT MEDICAL
26 EMERGENCIES.
27 (B) ANY OTHER INFORMATION, THE DISCLOSURE OF WHICH IS REQUIRED
1 BY A STATE OR FEDERAL LAW.
2 (2) THE STATEMENT OF NEED REFERRED TO IN SUBSECTION (1)(A)(i)
3 OR (ii) SHALL STATE ALL OF THE FOLLOWING:
4 (A) THE HEALTH CARE PROFESSIONAL HAS A REASONABLE BASIS TO
5 BELIEVE THE INFORMATION IS NEEDED FOR DIAGNOSIS OR TREATMENT OF AN
6 INDIVIDUAL.
7 (B) THE INDIVIDUAL BEING DIAGNOSED OR TREATED MAY HAVE BEEN
8 EXPOSED TO THE CHEMICAL INGREDIENT.
9 (C) KNOWLEDGE OF THE SPECIFIC CHEMICAL INGREDIENT IDENTITY IS
10 LIKELY TO ASSIST IN DIAGNOSIS OR TREATMENT.
11 (3) THE PERSON DISCLOSING INFORMATION PURSUANT TO SUBSECTION
12 (1)(A) SHALL PROVIDE THE HEALTH CARE PROFESSIONAL A STATEMENT OF
13 THE PROFESSIONAL'S CONFIDENTIALITY OBLIGATIONS PURSUANT TO SECTION
14 61537. THIS NOTIFICATION SHALL ACCOMPANY THE DISCLOSURE IN
15 NONEMERGENCY SITUATIONS OR BE MADE AS SOON AS CIRCUMSTANCES PERMIT
16 IN EMERGENCIES.
17 SEC. 61537. A HEALTH PROFESSIONAL TO WHOM INFORMATION IS
18 DISCLOSED UNDER SECTION 61536 SHALL HOLD THE INFORMATION

⁶⁵ <http://www.motherjones.com/environment/2012/03/fracking-doctors-gag-pennsylvania>

⁶⁶ <http://www.legislature.mi.gov/documents/2011-2012/billintroduced/House/pdf/2012-HIB-5565.pdf>

19 CONFIDENTIAL, EXCEPT THAT THE HEALTH PROFESSIONAL MAY, FOR
 20 DIAGNOSTIC OR TREATMENT PURPOSES, DISCLOSE INFORMATION PROVIDED
 21 UNDER THAT SECTION TO ANOTHER HEALTH PROFESSIONAL OR ACCREDITED
 22 LABORATORY. A HEALTH PROFESSIONAL OR ACCREDITED LABORATORY TO WHICH
 23 INFORMATION IS DISCLOSED BY ANOTHER HEALTH PROFESSIONAL UNDER THIS
 24 SECTION SHALL HOLD THE INFORMATION CONFIDENTIAL AND THE DISCLOSING
 25 HEALTH PROFESSIONAL SHALL INCLUDE WITH THE DISCLOSURE, OR IN A
 26 MEDICAL EMERGENCY, AS SOON AS CIRCUMSTANCES PERMIT, A STATEMENT OF
 27 THE RECIPIENT'S CONFIDENTIALITY OBLIGATION PURSUANT TO THIS
 14 SECTION.

DCS ATSDR NGE&P survey

- Damascus Citizens for Sustainability Natural Gas Exploration and Production survey of environmental and health impacts is a tool through which the Agency for Toxic Substances and Disease Registry will receive information about impacts, as well as a petition for a Public Health Assessment, from households in a survey impact area.
- The survey can be found at <http://www.damascuscitizensatsdr.org/>
- DCS will advocate on behalf of the survey-takers
- ATSDR's mission and possible outcomes

30

Damascus Citizens for Sustainability is a grassroots group in the Upper Delaware River Basin—GASLAND was dedicated to them. These were our observations:

Throughout the country we had heard countless cases of human illness and environmental contamination which can plausibly be explained by exposure to pollutants and other impacts of nearby gas activities.

We also knew that the federal public health agency, ATSDR, was not monitoring these people nor collecting health data.

Our group developed a survey to fill that gap.⁶⁷

The Damascus Citizens for Sustainability Natural Gas Exploration and Production survey of environmental and health impacts is a tool through which the Agency for Toxic Substances and Disease Registry will receive information about impacts, as well as a petition for a Public Health Assessment, from households in a survey impact area.

DCS will advocate on behalf of the survey-takers while assuring confidentiality.

We knew: a) that ATSDR was not aware of cases of contamination or of health impacts, unless they were specifically asked to consult; b) that an agency, organization or individual can request a health consultation via the petition process (42 Code of Federal Regulations, Part 90, published in 55 Federal Register 5136, February 13, 1990) <http://www.atsdr.cdc.gov/HAC/PHAManual/toc.html>; c) that the public was not aware of this mechanism; d) that the survey provides a systematic reporting to a federal public health agency, ATSDR, using a mechanism accepted by that agency--the petition process).

FEDERAL EXEMPTIONS

The oil and gas industry was granted exemptions from key provisions in the major federal statutes intended to protect human health and the environment.

These statutes include:

- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
- Resource Conservation and Recovery Act
- Safe Drinking Water Act
- Clean Water Act
- Clean Air Act
- National Environmental Policy Act
- Toxic Release Inventory under the Emergency Planning and Community Right-to-Know Act
- Superfund Act

<http://www.earthworksaction.org/pubs/PetroleumExemptions1c.pdf>
http://www.citizenscampaign.org/PDFs/cce_hvhf_wp_final.pdf

31

In 2004 an EPA Study was misrepresented to Congress, and the result was that the 2005 Energy Policy Act. The oil and gas industry was granted exemptions from provisions in the major federal environmental statutes intended to protect human health and the environment.⁶⁸ These statutes are listed on the slide.

As a result of the exemptions, these are some of the things that we don't know, but should, to safeguard health:

- all the chemicals used, their quantity – concentrations & combinations

⁶⁷ <http://www.damascuscitizensatsdr.org/>

⁶⁸ <http://www.earthworksaction.org/pubs/PetroleumExemptions1c.pdf> and http://www.citizenscampaign.org/PDFs/cce_hvhf_wp_final.pdf

- how much water is used, what fluids are recovered & its destination
- what is in the drill spoils, evaporation and condensate pits & where does it go
- monitoring of drinking water quality and quantity, and immediate reporting of groundwater contamination
- monitoring of the amount and contents of the toxic air emissions produced by the drilling, along pipelines, at compressors and processing stations
- the Normally Occurring Radioactive Materials
- H₂S - Hydrogen Sulfide
- baseline levels of water, air and soil to gauge changes in quality

Highlights of Oil and Gas Industry Exemptions from Federal Statutes—

Safe Drinking Water Act (SDWA)

Hydraulic fracturing operations are completely exempted from regulation under SDWA and Underground Injection Control of fracking fluid was defined to exempt it from EPA regulation of Underground Injection Control.

Clean Water Act (CWA)

Expanded the definition of oil and gas operations and activities to include the construction of the drill site, waste management pits, access roads, in-field treatment plants and transportation infrastructure.

Eliminated “sediment” as a pollutant in managing stormwater run-off from drill pad site and all oil and gas field construction activities and operations.

National Environmental Policy Act (NEPA)

Weakened environmental review process by presuming that some oil and gas related activities should be analyzed and processed by the Interior and Agricultural Departments under categorical exclusions, which does not provide for a public comment period.

Comprehensive Environmental Response, Compensation and Liability Act (a.k.a. Superfund)

The list of covered hazardous substances section 101(14) excludes crude oil and petroleum.

Resource Conservation and Recovery Act (RCRA)

The Solid Waste Disposal Act of 1980 exempts oil field waste from Subchapter III of RCRA until the EPA could prove the wastes were a danger to human health and the environment. In 1988 EPA made a regulatory determination that oil field waste should be exempted because of adequate state and federal regulations. This includes produced waters, drilling fluids, and associated wastes.

Clean Air Act (CAA)

The CAA states that the oil and gas industry will not be aggregated together to determine if they are subject to Maximum Achievable Control Technology for each source. The exemption also extends to pipeline compressors and pump stations in some instances.

Toxic Release Inventory under the Emergency Planning and Community Right-to-Know Act (EPCRA)

The oil and gas industry is exempted from reporting under section 313 of EPCRA, even though it generally meets the requirements established for reporting.

Have federal and state agencies considered health impacts adequately?

- Most of the literature on health impacts has been published in the last 1-2 years, and usually not in the mainstream general practice medical literature, and the results have not been considered in the regulatory process
- Federal exemptions limit information at the national level
- Doctors are not adequately trained to recognize, nor do they have time to investigate, environmental exposures
- Public health professionals have not been at the table and the funding is inadequate
- Vulnerable populations, especially children, have not been addressed
- Community and environmental impacts from the public health perspective need attention
- Worker safety needs attention (workers are parents and members of the community)
- Non-disclosure agreements prevent access to health information
- Many impacted people are afraid to come forward, or their complaints discounted by authorities

32

HAVE HEALTH IMPACTS OF SHALE GAS DEVELOPMENT BEEN ADDRESSED? In a word—no.

Most of the peer-reviewed literature on health impacts has been published only in the last 1-2 years.

The Federal exemptions limit the information that the government can collect.

Doctors who are in general practice likely have little-to-no training in environmental or occupational medicine or in research, plus they have little time to investigate possible exposures.

Medical groups have just begun to express concerns, and recently (*The American Lung Association, the Medical Society of the State of New York, the American Academy of Pediatrics District II NYS, the NYS Chapter of the American Academy of Family Physicians, the NYS Nurses Association*) have requested attention to human health impacts. They are also asking for a process called a Health Impact Assessment in New York.

Accidents happen and violations occur, so even the best regulations would not prevent some disasters. And at this point, the regulations are poor.

Vulnerable populations and workers have not been addressed adequately and therefore are not protected. As an example, although the Occupational Safety and Health Administration has just issued silica guidelines for workers, the residents living nearby have no such protections.

Communities need to be educated, and community impacts need attention. This is actually where some of the best measureable impacts have already been documented; clinics are seeing an increase in sexually transmitted infections; police are documenting increases in crime; rent increases displace current residents.

Non-disclosure agreements hamper access to important information. I personally know several families who, upon receiving a settlement from a gas company, which could be money or a water system, stopped talking about their water or air contamination and health problems.

Many impacted people, many of whom live in remote rural areas are afraid to come forward because of real intimidation or perceived threats. They are likely uninformed that what they are experiencing may be due to the impacts of gas development activities. They may have mentioned it to their pediatrician or general doctor who also has no idea about potential health impacts, citing that he has not read of any health impacts in the medical literature. It is a difficult situation...In public health, you don't want to raise undue alarm. However, we medical professionals who have been investigating this issue, feel that it has gone to other extreme... that information which should be available to the public, to honest politicians, to residents and to other health professionals, is being hidden. Recall the obstacles that the tobacco industry imposed...

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

33

Where gas drilling has not yet begun, or there is a possibility of a moratorium, and there is political will to be advised by the results, there is a process that could bring public health to the table. However, it should be done prior to the development of regulations and certainly before issuing permits. It is particularly important in the case of gas exploration and production because health impacts must be taken into account before deciding whether to go forward with the largest land use decision of our time.

The practice of Health Impact Assessment (HIA) elevates the role of health in decision-making.

It can help create healthier communities by addressing the root causes of many health problems ...and have demonstrated success in a variety of issue areas, ranging from land use and transportation to housing policies, labor standards, natural resource extraction, education and economic policies.

Characteristics of an HIA

- it's prospective, preventive and proactive
- do it before a policy or regulation is implemented
- It focuses on the health consequences of policies
- It identifies vulnerable groups and includes all stakeholders
- An HIA uses data sources that already exist and predicts the impact by considering direct and indirect health risks and solutions
- It is a decision support tool and not intended to simply evaluate a decision after it is made
- It offers recommendations for further study, and recommendations to improve health, and the lead advocates for those recommendations
- It has the potential to save healthcare costs in the long run

HIA references:

- http://www.hiaconnect.edu.au/files/HIA_International_Best_Practice_Principles.pdf
- <http://www.iaia.org/>
- Quigley, R., L. den Broeder, P. Furu, A. Bond, B. Cave and R. Bos 2006 Health Impact Assessment International Best Practice Principles. Special Publication Series No. 5. Fargo, USA: International Association for Impact Assessment.
- http://www.euro.who.int/_data/assets/pdf_file/0003/98283/E90794.pdf
- http://www.healthimpactproject.org/resources#presentations_webinars
- <http://www.cdc.gov/healthyplaces/hia.htm>
- [Health Impact Assessment: Integrating Health into the NEPA Process, January 2011](#) Author: Aaron Wernham, M.D., M.S. Presented to: Transportation Resources Board, January 2011
- <http://www.apha.org/NR/rdonlyres/171AF5CD-070B-4F7C-A0CD-0CA3A3FB93DC/0/HIABenefitHlth.pdf> Health in All Policies, from the APHA
- <http://www.ph.ucla.edu/hs/health-impact/>
- <http://www.who.int/hia/en/>
- <http://www.naccho.org/topics/environmental/landuseplanning/HIAresources.cfm>
- http://www.apho.org.uk/default.aspx?QN=P_HIA
- http://www.dh.gov.uk/en/Publicationsandstatistics/Legislation/Healthassessment/DH_4093617
- http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/documents/digitalasset/dh_120110.pdf
- Institute of Medicine Conference, The Health Impact Assessment of New Energy Sources: Shale Gas Extraction <http://www.iom.edu/Activities/Environment/EnvironmentalHealthRT/2012-APR-30.aspx> Please also see the accompanying videos
- Legal Review Concerning the Use of Health Impact Assessments in Non-Health Sectors http://www.healthimpactproject.org/resources/body/Legal_Review_of_HIA_report.pdf
- National Research Council of the National Academies of Science, Improving Health in the United States: The Role of Health Impact Assessment, National Academies Press, November 2011 http://www.nap.edu/chapterlist.php?record_id=13229&type=pdf_chapter&free=1

- NAS brief review of HIA <http://dels.nas.edu/resources/static-assets/materials-based-on-reports/reports-in-brief/Health-Impact-Assessment-Report-Brief-Final.pdf>
- http://www.blm.gov/ak/st/en/prog/planning/npra_general/ne_npra/northeast_npr-a_final.html EIS/HIA
- Wernham, A. Inupiat Health and Proposed Alaskan Oil Development: Results of the First Integrated HIA/EIS for Proposed Oil Development on Alaskas North Slope. EcoHealth 4:500-513 (2007).

These New York State medical organizations support a moratorium so that scientific studies could be done prior to the decision on gas drilling

▪ American Academy of Pediatrics, District II, New York State	▪ THE MEDICAL SOCIETIES of the NY Counties of ONEIDA, HERKIMER, BROOME, MADISON, OTSEGO, OSWEGO, CAYUGA, CHENANGO, ONONDAGA, TOMPKINS
▪ Mt. Sinai Children's Environmental Health Center	▪ Medical Society of the State of New York
▪ NYS Conference of Environmental Health Directors	▪ Physicians for Social Responsibility
▪ Bassett Healthcare Network Board of Trustees and the Medical Staff	▪ Concerned Health Professionals of NY

34

Among the scientific studies requested is a transparent and comprehensive Health Impact Assessment.



Medical Society of the State of New York

- RESOLVED, that the Medical Society of the State of New York reaffirm its Policy on high-volume hydraulic fracturing that states:
"The Medical Society of the State of New York supports a moratorium on natural gas extraction using high volume hydraulic fracturing in New York State until valid information is available to evaluate the process for its potential effects on human health and the environment" (Council Action, December 9, 2010); and be it further
- RESOLVED, that the Medical Society of the State of New York supports the planning and implementation of a Health Impact Assessment to be conducted by a New York State school of Public Health; and be it further
- RESOLVED, that the Medical Society of the State of New York advocates for the establishment of an industry-funded, independently-arbitrated state trust fund for people that may be harmed as a result of hydraulic fracturing; and be it further
- RESOLVED, that the Medical Society of the State of New York oppose any non-disclosure provisions related to the practice of hydraulic fracturing that interferes with any aspect of the patient-doctor relationship and/or the ready collection of epidemiological data for future health impact studies.

The Medical Society of the State of New York called for a Moratorium in 2010.

And in April 2013, the MSSNY delivered the resolution reiterating their support for the moratorium and a Health Impact Assessment.



In 2010 the American Academy of Pediatrics, District II, NYS, representing more than 6,000 pediatricians and millions of children across the state, wrote a memo to the NYS Legislature strongly supporting a bill for a moratorium on gas drilling.

"AAP, District II, NYS membership is concerned about the potential negative impacts on water, air, soil contamination, increased traffic and possible spills of contaminated materials in areas where many children and families live. Allowing time for the EPA study will allow our state leaders to move forward on this issue fully informed about whether hydraulic fracturing is a good public policy for our state."

The American Academy of Pediatrics, District II, NYS, representing more than 6,000 pediatricians and millions of children across the state, strongly supported a moratorium bill.

Two years later they also supported the HIA bill.



What should enter into the decision

ENVIRONMENT—

Could regulations work?

We know many of the risks, but we don't know all the risks. Regulations are only useful if all the risks are known. There is currently sufficient evidence to invoke the Precautionary Principle.⁶⁹

The federal exemptions would need to be reversed, and state laws would need to be rigorous. There would need to be political will that is not influenced by industry. That is not the case.

ECONOMICS—There will be benefits for a few large landowners, like the State, from 1) the signing bonus, and 2) royalties for a time. If the well is profitable, the companies may benefit, however, the cost of drilling a gas well, especially an unconventional well, is high. Therefore, if there is not a large enough field to exploit, companies may not be as interested. And the opinion of experts is that much of the gas in Michigan is too deep or otherwise not economically recoverable.

GEOPOLITICS—this applies mainly to the decision on the national level. In the case of states, one should consider the terms separately... geography + politics. Michigan gas seems not to be economic to develop at this moment.

⁶⁹ <http://www.sehn.org/precaution.html>

But politically there seems to be motivation to develop the gas fields for the revenue from leases. However, the costs of environmental and health impacts have not been factored into the costs...

Opinion polls are another barometer that the Governor's office likely watches.

The trend in NY over the past year is a slow but steady increase in the %age that opposes gas drilling, mostly due to an increased awareness.

And so it is in Michigan. The [Pew Research Center did a survey](#) in March and September of 2013 and found that more Midwesterners now oppose fracking (48%) than favor it (47%) and that rose sixteen points from only 32% opposing it six months ago. Nationwide, more Americans now oppose fracking (49%) than favor it (44%). A year ago, the Ford School surveyed Michiganders and reported 52% of respondents favored establishing a "moratorium" on all fracking, horizontal and vertical.

(From Michigan HF report—Public Perception) A 2012 poll cited in the U of M HF report on Public Perceptions indicted the

Belief that state should impose a moratorium until there is a fuller understanding of possible risks					Somewhat to Strongly agree (%)	Somewhat to Strongly disagree (%)	Not sure (%)
MI	Early stage production	Oct. 2012	UofM& Muhlenberg College ₁	415	52	41	7

HEALTH -- If we knew all the chemicals used and the composition of all the waste, and if the federal public health agencies were tracking all cases of illness near gas drilling and infrastructure, and if the environmental agencies could track all cases of contamination, I believe that we would find that, at this point in time, the technology is not advanced enough to prevent significant harm to human health. Available studies and preliminary reports from ongoing studies are indicating that this is the case.

There are measures which can be taken to reduce harm, such as drilling only in unpopulated areas. However, even then one still have to deal with the problems of climate change and impacts on waterways and animal life. Green completions might help, but they are not being widely used as yet because they cost the industry more money to implement.

I believe that there are problems with shale gas extraction which cannot be eliminated with current technology because it does not exist yet, or because they are too expensive to mitigate, or because federal and state laws are lax. This includes:

--ABANDONED WELLS

--ACCIDENTS

--AIR POLLUTION

--CHEMICAL TOXICITY

--CLIMATE CHANGE

--COMMUNITY IMPACTS

--FLARING

--DIESEL EXHAUST

--RADIOACTIVITY

--STRESS

--VULNERABLE POPULATIONS AND SOCIAL JUSTICE

--WATER CONTAMINATION

--WASTE

--WORKER HEALTH

What is Michigan doing?

- Currently permits silica sand mining, water withdrawal, gas drilling, waste disposal, underground injection
- **Michigan Integrated Assessment**
Several Univ of Michigan units and their partners are examining the multiple aspects of unconventional gas extraction, with an emphasis on impacts and issues related to the State of Michigan. Using an engaged problem-solving approach called integrated assessment, the project will first compile technical reports on key topics then focus on an analysis of policy options for Michigan.
- **Initiative Petition** "...proposes to amend the Natural Resources and Environmental Protection Act, 1994 PA 451, to prohibit the use of horizontal hydraulic fracturing in this state."



THE SOLUTIONS PROJECT: MICHIGAN
<http://thesolutionsproject.org/infographic/#mi>

"If not us, then who? If not now, then when?"
John Lewis

37

Permitting and leasing of state lands is ongoing.

Water withdrawal and silica sand mining are permitted, as well as waste disposal in landfills and as dust control, and underground injection.

Two years ago the Univ of Michigan initiated, with the support of the Governor, an integrated assessment of hydraulic fracturing. <http://graham.umich.edu/knowledge/ia/hydraulic-fracturing>

Integrated assessment is a rapidly growing field, and the Intergovernmental Panel on Climate Change uses this definition:

"Assessment is integrated when it draws on a broader set of knowledge domains than are represented in the research product of a single discipline. Assessment is distinguished from disciplinary research by its purpose: To inform policy and decision making, rather than to advance knowledge for its intrinsic value." (source: *Integrated Assessment 2*: 57–72, 2001.

Kluwer Academic Publishers. Printed in the Netherlands.

The relevance of participatory approaches in integrated environmental assessment)

In addition to various Univ of Michigan units preparing the reports on Human health • Social/public perception

Environment/ecology • Policy/law • Economics • Geology/hydrodynamics • Technology, representatives from the [Office of Governor Rick Snyder](#), the [Department of Environmental Quality](#), the [Michigan Oil and Gas Association](#), the [Michigan Department of Natural Resources](#), the [Michigan Environmental Council](#), and the [Tip of the Mitt Watershed Council](#) formed an [advisory committee](#) to provide input to the project.

- Mark Barteau, Director, U-M Energy Institute
- Valerie Brader, Senior Strategy Officer, Office of Strategic Policy, State of Michigan
- John Callewaert, Int. Assessment Program Director, U-M Graham Sustainability Institute
- James Clift, Policy Director, Michigan Environmental Council
- John De Vries, Attorney, Mika Meyers Beckett & Jones; Michigan Oil and Gas Association
- Hal Fitch, Director of Oil, Gas, and Minerals, Michigan Department of Environmental Quality
- Gregory Fogle, Owner, Old Mission Energy; Michigan Oil and Gas Association
- James Goodheart, Senior Policy Advisor, Michigan Department of Environmental Quality
- Andy Hoffman, Director, U-M Erb Institute for Global Sustainable Enterprise
- Drew Horning, Deputy Director, U-M Graham Sustainability Institute
- Andrew Maynard, Director, U-M Risk Science Center
- Tammy Newcomb, Senior Water Policy Advisor, Michigan Department of Natural Resources
- Don Scavia, Director, U-M Graham Sustainability Institute
- Tracy Swinburn, Managing Director, U-M Risk Science Center
- Grenetta Thomassey, Program Director, Tip of the Mitt Watershed Council
- John Wilson, Consultant, U-M Energy Institute

Work started in the fall of 2012, and the [seven technical reports](#) were made public in September 2013.

The Integrated Assessment Plan currently underway at the University of Michigan had the potential to be an excellent process at conception, and there seemed to be political will to be informed by it. In addition, the lead is a group with experience in Integrated Assessment. However, the reports are written by people with little or no on the ground experience with gas development. It may be helpful to add experts to the advisory committee, eg, for the Economics section, consider Deborah Rogers or Jannette Barth; for Geology—Tony Ingraffea; for Social/Public Perceptions—Simona Perry; Ecology/Environment—Sandra Steingraber; for Health—David Brown...and there are others, but these come to mind immediately as having years of experience in their fields as well as on the gas issue.

And further, there is a perception that the advisory committee, as it is currently composed, may be influencing the results in a particular, and unbalanced way.

In addition, the authors will not be making recommendations on their findings. It remains to be seen whether public involvement will be robust. The technical reports will be available in June for public comment, and then final project report is expected in mid-2014.

From our experience in NY, we found that it's important for all stakeholders-- ie, community leaders, advocates, public health professionals and activists, and most importantly the vulnerable populations—to make their voices heard.

An assessment such as this should be participatory so as to be maximally effective. The leads should seek input from diverse stakeholders, integrate that input, then interpret their findings, and make recommendations.

I would encourage everyone to read the technical reports and to submit comments.

Before coming to Michigan, I read several of the technical reports, but will limit my few comments here to the Health report.

Comments on the Univ of Michigan Public Health Technical Report

- The **literature review needs updating**; the most current reference was accessed more than one year ago, and as is clear from the presentation, a lot of literature has been published in the past year. Professor **Niladri Basu** is the author.
- The advisory team does not have a health professional, and neither is the Dept of Health represented. (<http://www.ncbi.nlm.nih.gov/pubmed/22233770> Goldstein et al, “Missing from the Table”).
- Need to monetize short and long-term costs of health impacts, as author also says: “...all energy development schemes have inherent risk and thus a health economist should be enlisted to help enumerate risks-benefits of hydraulic fracturing in Michigan versus alternate energy sources, both in terms of health outcomes but also economic value.”
- “Substantial gaps in data availability, not only in Michigan but elsewhere, prevent a full assessment of public health risks associated with hydraulic fracturing. Public policy should be grounded in strong, objective peer-reviewed science rather than anecdotes and beliefs. Speculative conclusions and opinions about possible hazards based solely upon anecdotes and oversimplified chronologies are not a sufficient foundation to advance state regulatory reforms or policies.” While he is correct to a degree, it is also vital to get out into the community and examine these patients, take their histories, do surveys in communities, institute monitoring and surveillance—none of this is being done...and so to make policy in the absence of data, but with warning signs present, and with peer-reviewed data now available is folly, and needs to be approached another way, possibly with a Health Impact Assessment.
- Regarding Michigan, he writes: “The greatest challenge in assessing the potential public health risks of hydraulic fracturing in Michigan is the lack of State-specific data.” The information from similar areas can be extrapolated to Michigan—HIAs are done prior to the policy decision, therefore, it should be possible to arrive at policy decisions based on data from other states, and in the meantime, start surveillance and monitoring of the residents of Michigan.
- And he further states-- “The lack of exposure assessment information for any hydraulic fracturing site limits the ability to perform meaningful risk assessments.” This is largely due to the **federal exemptions** and lack of access to sites for sampling purposes, as well as a lack of any monitoring or surveillance program.

So one begins to see a trend here that is also noted by the author of the report—that there are gaps in information. However, much of that gap could be bridged through the process of a transparent, independent and comprehensive Health Impact Assessment.

An HIA would add value to the policy decision on gas drilling because it would include:

- current health literature and it would provide for the inclusion of future research
- the medical profession
- a mechanism for broad stakeholder input, and also inclusion of vulnerable populations
- possible exposure pathways, even if remote

- risk assessment for specific chemicals
- a plan for monitoring and evaluation
- recommendations which would improve health outcomes; these might include one of the following actions: mitigation measures; or, if the policy or project is deemed too risky at this point in time, then the recommendation might be not to move forward with approval at this time.
- only after one gains a clear understanding of why people become ill near gas drilling operations can a decision be made whether to permit this activity.

And there are inaccuracies or incomplete information, such as...

- **Employment** from oil and gas development is over-estimated in the report which provided the number of 600,000 new jobs; the Bureau of Labor Statistics, which is the true expert, predicts less than one-fourth that number by 2018. At the same time, many jobs will be lost as agriculture and tourism are negatively impacted by high-impact industrial development <http://www.bls.gov/opub/mlr/2012/01/art4full.pdf> (see p 78)
- Further about the jobs... the on-the-job **fatality rate** in the O&G sector is 7-8X that of the average US worker <http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5716a3.htm>; Yet despite a high fatality rate, recorded injuries and days lost from work are the lowest, probably due to under-reporting. http://www.bls.gov/news.release/archives/osh_10212010.pdf (see table 1) <http://www.cdc.gov/niosh/docket/archive/docket213.html> "The data examined were limited to occupational fatalities, mainly because these are the most reliable data available for this industry. Significant gaps exist in the availability of non-fatal occupational injuries and illnesses data for the oil and gas extraction industry."
- P15 regarding **air pollution**, the author writes that "The cumulative impacts of these are not clear." This paucity of data is due to the federal exemptions and also the method of measurement...see the Brown paper and the papers I listed on my air pollution slide, most of which this author did not include, and they are peer-reviewed.
- P18 on **water**, the author write: "When compared to other users of water, such as agriculture, the amount used in hydraulic fracturing is much less." Once the water is contaminated with radionuclides and some of the chemicals, it is removed from the hydrological cycle as useful water; that is not the case with agriculture.
- There was very little mention of the risks from **radionuclide exposure** in this report.
- P7 the author cites a 2008 study as lacking any reference on **noise**—here is a 2011 WHO study Burden of disease from environmental noise http://www.who.int/quantifying_ehimpacts/publications/e94888/en/
- p11 the author compares several **chemical** studies, including the Waxman Congressional report and Theo Colborn's work, and also compares FracFocus...it should have been noted that although industry likes to refer to this site as a chemical reporting group, it is, in fact, voluntary; so, for example, on the FracFocus list there was no 2-BE which is one of the most commonly used chemicals in the industry; and in the table onp12, the author did not designate neurological impacts with **hydrogen sulfide**—this was probably a typo since he does discuss neurological problems in the text.
- P17-18 on **GHG emissions**, please refer to my slide on climate change for updated references not included in the UofM health report
- P21 on **earthquakes**, states: "To date, there is a lack of supportive data identifying hydraulic fracturing as a direct cause of earthquakes." That is not true—HF has been linked to earthquakes, and definitely

injection wells cause earthquakes—see my slide on earthquakes and this short overview http://www.usgs.gov/blogs/features/usgs_top_story/man-made-earthquakes/

A number of sections in the report were fairly well done, although very short; and thoughtful...

- Such as the sections on habitat, food and animals, and the boom and bust cycle.... And he emphasizes the need for baseline measurements which I agree are very important.
- The author makes this point: “It is ... important to conduct focused studies on individuals that reside amongst hydraulic fracturing development sites.” He cites the Bamberger and Oswald study...there have been other several surveys of impacted people...there is also the long-term Guthrie Health Systems study just begun...but there is no federal public health agency doing surveillance and monitoring.
- Regarding **Env justice... and vulnerable populations**--the author makes the point that “the mean household income is lower in each of the 8 counties identified earlier than the State-average, and the percent of individuals below poverty is slightly higher than the Michigan average for most Counties.” One can also look at county health rankings to see if these counties already have poor health outcomes, since people who are poor or in poor health suffer environmental stress less well than those who are not. And they do have poor health rankings: Alcona 79, Alpena 74, Antrim 60, Crawford 58, Kalkaska 75, Montmorency 64, Oscoda 77, Otsego 37
<http://www.countyhealthrankings.org/app/michigan/2014/overview>
- The author is correct that there exist limited, if any, exposure assessments, and epidemiological causation has not been established. Again, the reasons should be noted, which include federal exemptions and non-disclosure agreements.
- This was an important and insightful comment by this author, which invokes the **Precautionary Principle**: “There exist a myriad of hazards in the hydraulic fracturing industry, and not surprisingly many have advocated for the **precautionary principle**. Historically, action against harmful environmental and public health hazards has only occurred after the scientific community has proven its danger. In our report we were unable to find very many documented public health issues related to hydraulic fracturing (low-volume or high-volume) in Michigan, either because they have not been reported upon or they have not occurred. Nonetheless, before high-volume, horizontal drilling intensifies in Michigan, an opportunity should be seized to initiate basic yet important public health studies. The lack of these in other regions is leading to much criticism and debate, which Michigan has the chance to avoid.”

I would urge the Univ of Michigan IA team to continue to update the scientific information, to include on the advisory team experts who have worked in the field and published their research, to improve stakeholder engagement, to seek out the vulnerable populations and potentially impacted communities, and to emulate a Health Impact Assessment in the health study which would then become a part of the Integrated Assessment.

The IA team should make recommendations to protect public health, and if they independently come to the decision, as the NY medical community has for NY, that a moratorium should be put in place while the studies are ongoing, I would urge them to advocate for that.

And further, should they come to the independent conclusion that gas development in Michigan is too risky to proceed with at this time, as many health practitioners nationwide have already done, and as I have, that the practice of gas development as currently done is too risky, then they should advocate for a ban.

Comments from March 2013 can be found here <http://graham.umich.edu/media/files/March-5-Online-Comments-Summary.pdf>

The next project phase focuses on producing the Integrated Assessment.

The IA plan <http://graham.umich.edu/media/files/hydraulic-fracturing-ia-plan.pdf>

"If not us, then who? If not now, then when? Will there be a better day for it tomorrow or next year? Will it be less dangerous then? ..."

This was spoken in 1961 by Freedom Rider John Lewis, the son of an Alabama sharecropper, who led marchers to the Edmund Pettus Bridge, and eventually won civil rights for all people. <http://johnlewis.house.gov/john-lewis/biography>

Michiganders have a constitutional right to be involved in the legislative process by petition for initiative and referendum. http://www.michigan.gov/sos/0,4670,7-127-1633_41221---,00.html

A group has been working on this...The Committee to Ban Fracking in Michigan (letsbanfracking.org) In this last round they collected over 70,000 signatures, short of the required number...however, there are plans to resurrect the effort next year.

A concern that the petition organizers had was that embedded in Michigan's laws is language that compels the state, through the Department of Environmental Quality, to "foster the industry" and "maximize production" of oil and gas. The ballot proposal eliminates this language catering to the special interests of oil and gas companies and in its place, adds new language that would make the State consider protection of human health and water in its oil and gas decisions.

<http://letsbanfracking.org/index.php/2012-10-08-21-03-05> or <http://banmichiganfracking.org/?p=1601>

the COMMITTEE TO BAN FRACKING IN MICHIGAN: Initiative petition

Purpose: Petition proposes to amend the Natural Resources and Environmental Protection Act, 1994 PA 451, to prohibit the use of horizontal hydraulic fracturing in this state.

http://www.michigan.gov/documents/sos/Bal_Prop_Status_2013_410795_7.pdf

Very importantly, the conversation about a ban logically leads to the question of what to use for energy if not fossil fuels.

A study on renewables, for Michigan, spelling out how to switch to 100% renewable energy, would give the residents of Michigan, their children and future generations a chance for a livable planet.

A way to do that can be found in THE SOLUTIONS PROJECT: MICHIGAN

<http://thesolutionsproject.org/infographic/#mi>

