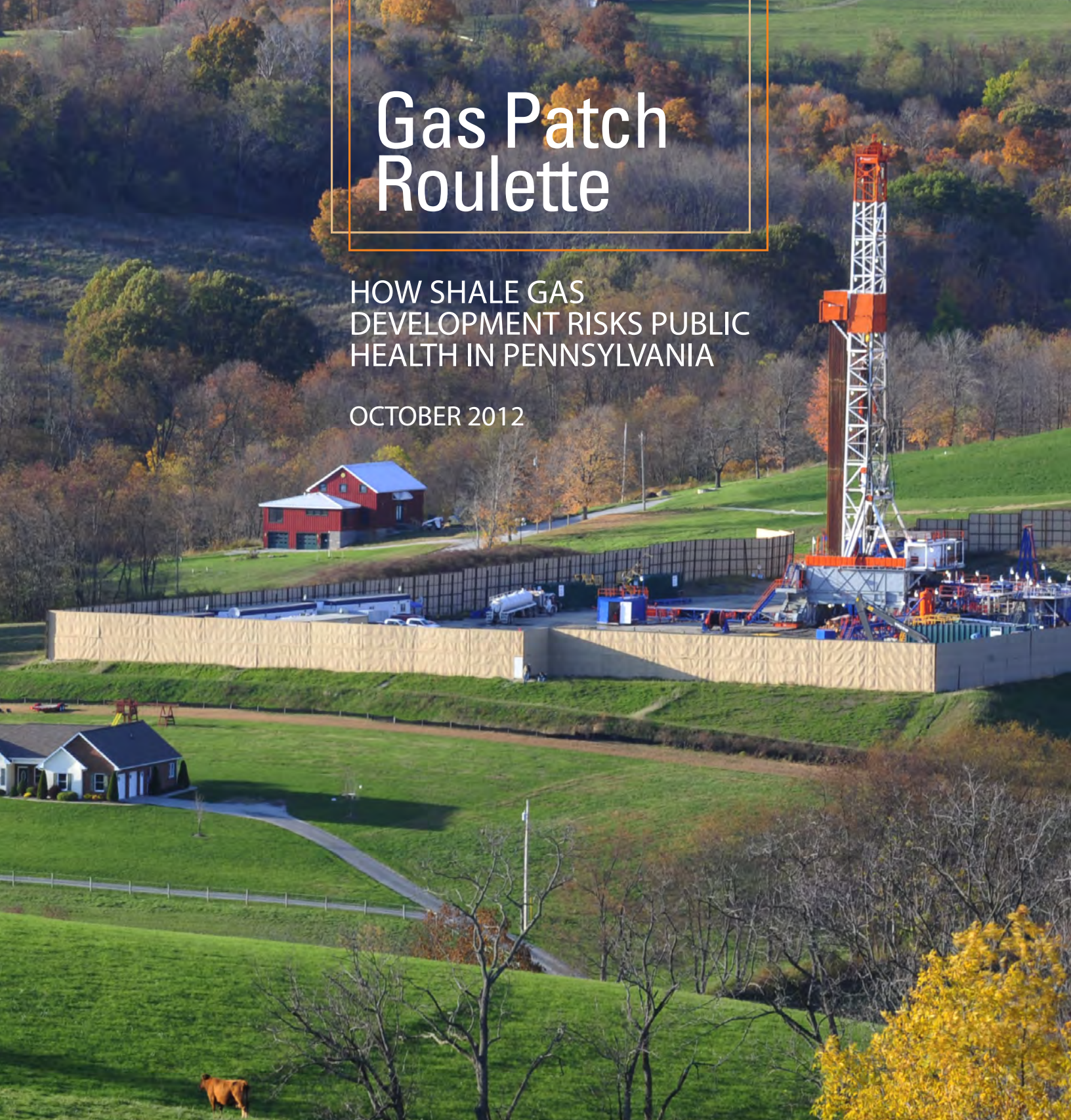


# Gas Patch Roulette


HOW SHALE GAS  
DEVELOPMENT RISKS PUBLIC  
HEALTH IN PENNSYLVANIA

OCTOBER 2012



EARTHWORKS™

OIL & GAS ACCOUNTABILITY PROJECT



## A WORD OF THANKS

A goal of this research project has been to give voice to the many people in Pennsylvania (and beyond) who directly bear the costs of the nation's dependence on fossil fuels.

This report reflects the tremendous concern, caring, and openness of the project participants. Thank you for giving your time, sharing what are often difficult and personal experiences, and trusting us to write about them.

We are also grateful to the many people from local communities and partner organizations who provided contacts and guidance. Special appreciation goes to the Southwest Pennsylvania Environmental Health Project, which provided advice early on in the research process and reviewed this report.

Finally, many thanks to the Colcom Foundation for its generous support of this project and commitment to protecting the environment and public health.

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For more information on this study go to: <http://health.earthworksaction.org>

Cover photo: Mark Schmerling; inset photos L-R: Frank Finan, Mark Schmerling  
Back cover photo: Nadia Steinzor; inset photos L-R: Roberto M. Esquivel/Herald-Standard, Nadia Steinzor

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# Table of Contents

<b>INTRODUCTION</b> .....	<b>5</b>
<b>1. BACKGROUND: THE MARCELLUS SHALE BOOM</b> .....	<b>7</b>
<b>2. THE STUDY</b> .....	<b>8</b>
2.1 OVERVIEW .....	8
2.2 METHODOLOGY.....	8
2.3 FINDINGS.....	10
PARTICIPANT OVERVIEW.....	10
HEALTH SYMPTOMS .....	11
ODOR EVENTS .....	20
2.4 ENVIRONMENTAL TESTING.....	21
AIR.....	21
WATER.....	25
SYMPTOM AND TESTING ASSOCIATIONS.....	28
2.5 CONCLUSIONS.....	31
<b>3. MISSING PIECES</b> .....	<b>32</b>
3.1 SCIENCE AND TESTING.....	32
3.2 POLICY AND REGULATION.....	34
<b>4. RECOMMENDATIONS</b> .....	<b>35</b>
<b>5. FINAL WORDS</b> .....	<b>37</b>
<b>6. REAL PEOPLE, REAL LIVES</b> .....	<b>39</b>



# Introduction

Where oil and gas development goes, health problems often follow.

For many people across the United States, this statement has rung painfully true for a long time. As the drilling boom picks up speed and reaches more places, it is now resonating in new communities. From a growing number of stories told by individuals nationwide<sup>1</sup> to conferences held by academics and public agencies,<sup>2</sup> the “dots” between health symptoms and gas facilities are very slowly but surely being connected.

The health survey and environmental testing project described in the following pages is part of this critical process. Between August 2011 and July 2012, Earthworks’ Oil & Gas Accountability Project (OGAP) investigated the extent, types, and possible causes of health symptoms experienced by people living in the gas patches of Pennsylvania.

Founded in 1988, Earthworks is dedicated to protecting communities and the environment from the impacts of irresponsible mineral and energy development while seeking sustainable solutions. We reform government policies, improve corporate practices, and work with landowners, organizations, agencies, and elected officials to adopt policies to protect public health and the environment and hold industry accountable for its practices.

The findings of this study stand in strong contrast to statements—often made by industry representatives and policymakers seeking to expand drilling—dismissing claims of health impacts as “personal anecdotes” and isolated incidents. Directly impacted people are frequently told that what they experience is a random occurrence and that some other source—traffic, lifestyle choices, family disease history, household products—is to blame.

We know that the gas and oil industry uses toxic substances that harm human health. For example, of about 300 compounds identified as being used in hydraulic fracturing to extract gas, 65 are listed as hazardous by the federal government.<sup>3</sup> In turn, this creates a real potential for negative health effects in any area where gas development occurs.<sup>4</sup> While general scientific links regarding the effects of such exposure have been established,<sup>5</sup> research on the direct relationship between health problems and gas and oil activities has been limited and inconsistent.<sup>6</sup>

Even as knowledge of impacts evolves slowly, gas and oil extraction and production continue to accelerate rapidly—allowing industry to put still-emerging technologies to use without first establishing their safety. State regulations remain too lax and outdated to prevent the impacts of modern-day energy development, and regulatory agencies are often unable to conduct the

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**Though knowledge of impacts evolves slowly, gas and oil extraction and production continue to accelerate rapidly—allowing industry to put still-emerging technologies to use without first establishing their safety.**

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Drilling directly behind the play yard.

Photo by: Nadia Steinzor

oversight and enforcement needed to protect air and water quality and, in turn, health and communities. Magnifying the consequences of this situation are special exemptions in provisions of the nation's bedrock environmental laws, which allow the industry to stifle key information and pursue risky practices.<sup>7</sup>

The overall result is that the burden of proof remains heaviest for impacted individuals and communities themselves. Companies can continue to avoid responsibility and downplay health-related concerns. Decisionmakers can continue to sidestep the need to recognize the damage and hold companies accountable.

Yet the realities, including those described in this report, can be documented—and when they are, they can no longer be denied. When many people in many places where gas development is occurring have similar health complaints, something is clearly wrong. OGAP believes that when health problems occur, action to solve and prevent them must follow.



# 1 Background: The Marcellus Shale Boom

The Marcellus Shale spans a distance of approximately 600 miles from central New York through much of Pennsylvania and into the eastern half of Ohio and western parts of West Virginia; small sections are also found in Maryland and Virginia.<sup>8</sup> The formation covers an area of about 54,000 square miles (slightly larger than Florida) and varies greatly in depth, from outcroppings above ground to some areas to 9,000 or more feet below the surface.<sup>9</sup>

For a long time, extracting and producing deep shale gas from formations across the United States was considered economically and technologically unfeasible. But recent advances in hydraulic fracturing methods and its combination with horizontal drilling have made it possible to drill much deeper and further than ever before and, bolstered by political pressure to expand domestic energy production, have spurred a boom in shale gas (and shale oil) production nationwide.

The Marcellus Shale, considered a “gas super giant,” has been at the center of this activity, particularly in Pennsylvania, an estimated 60 percent of which is underlain by the formation.<sup>10</sup> As of September 2012, nearly 5,900 unconventional oil and gas wells, primarily in the Marcellus Shale, had been drilled in the state and over 11,500 had been permitted; the pace of expansion has been stunning, with 75 percent of all unconventional wells having been drilled just since 2010.<sup>11</sup>

Gas and oil development is occurring in Pennsylvania and nearby states today more rapidly and with more extensive impacts than in the past. Current development uses a tremendous amount of water, chemicals, and land; requires heavy equipment; and produces large volumes of both wastewater and solid waste. The gas industry has plans for tens of thousands of additional wells across the Marcellus and Utica Shale regions and in other formations nationwide.

The complexity and intensity of this type of energy development opens up pathways of exposure that impact human health, including air and water pollution, traffic, noise, and soil contamination. Although no industrial process is harm-free, these problems can be particularly severe when operators act irresponsibly and are not required to take measures to prevent, minimize, or mitigate problems such as chemical and waste spills, emission releases, or equipment failure.



Rigs in the neighborhood.

Photo by: Mark Schmerling



Impoundment pits, which often contain contaminated waste, can leak and give off emissions.

Photo by: Robert Donnan

## 2 The Study

### 2.1. OVERVIEW

This research project had two central components, health surveys and air and water testing, and was undertaken in order to:

- Investigate the extent and types of health symptoms experienced by people living in the gas patches of Pennsylvania.
- Consider links between health symptoms and proximity to gas extraction and production facilities.
- Provide air and water quality testing to households in need of such information.
- Provide useful information to impacted residents, researchers, public officials, and partner organizations.
- Put forth common-sense recommendations for regulatory and policy changes to prevent negative health and environmental impacts.

This project represents a scaling-up (in terms of both the number of participants and geographic area covered) of community-based projects previously conducted by Earthworks' OGAP. We conducted health surveys with local residents and analyzed results in relation to contaminants identified through water quality investigations (Pavillion, Wyoming, 2010) and prior air quality monitoring (DISH, Texas, 2009).<sup>12</sup> In addition, in 2011 OGAP developed case studies of residents who reported health problems while living in close proximity to gas facilities in several counties in Texas.<sup>13</sup>



Separators split off heavy hydrocarbons from gas, and often vent methane and volatile organic compounds into the air.

Photo by: Nadia Steinzor

### 2.2. METHODOLOGY

The health survey instrument used in this project was designed by Wilma Subra, President of Subra Company, and air and water quality testing was managed by the non-profit organization ShaleTest based in Denton, Texas. Data from the surveys and associations with testing results were obtained by tabulating responses and calculating percentages of both symptom categories and individual symptoms.

The survey focused on a range of exposures, health symptoms, and disease history. Responses were gathered to identify patterns that occur across locations and improve understanding of the experiences of participants. All the symptoms included in the survey could potentially be caused by exposure to substances known to be associated with gas and oil facilities.

It should be noted that this project did not investigate additional factors that can influence health conditions or cause symptoms (e.g., through structured control groups in non-impacted areas and in-depth comparative health history research). Such work, while important and currently lacking, was beyond the scope of this particular project. In addition, we did not seek to link single facilities with particular health problems experienced by specific participants.



The survey was completed by 108 individuals living in 55 households in 14 counties. The largest number of surveys (85 percent) was collected in Bedford, Bradford, Butler, Fayette, and Washington Counties. Taken together, all the counties represent a geographical range across the state (i.e., northeast to southwest) and have had gas development long enough for reports of health impacts and declining air and water quality to surface.

Respondents answered questions on their own or provided them to a relative or friend. In some cases, members of the same household, including spouses and parents, completed surveys for participants, and a few participants chose to provide answers to OGAP staff in person or over the phone. Due to expressed concerns about confidentiality, participants were given the option of completing the surveys anonymously, which some chose to do.<sup>14</sup>

Survey distribution was initiated through existing contacts in the target counties. These individuals then chose to participate in the project themselves and/or recommended other possible participants, who in turn provided additional contacts. The survey was also distributed to individuals who expressed interest in participating directly to OGAP at public events.

Air and water are the primary pathways of exposure to chemicals and other harmful substances, which are inhaled, ingested, and absorbed through the skin. With this in mind, environmental testing was conducted on the properties of a subset of survey participants (70 people in total) in order to identify the presence of pollutants that might be linked to both gas development and health symptoms. Test locations were selected based on household interest, the severity of symptoms reported, and proximity to gas facilities and activities. Because the need for testing in such places far exceeded the resources available, we also considered whether households had already received other environmental testing and been provided with the results.

In total, 34 air tests and 9 water tests were conducted at 35 households in 9 counties. The air tests were conducted using Summa Canisters put out for 24-hours by trained members of ShaleTest. The samples were analyzed by three certified laboratories using U.S. Environmental Protection Agency-approved TO-14 and TO-15 methods, which test for a wide range of Volatile Organic Compounds (VOCs) such as benzene, toluene, ethylbenzene, and xylene (BTEX chemicals). The water tests used samples drawn directly from household sinks or water wells by technicians employed by licensed laboratories and covered the standard Tier 1, Tier 2, and Tier 3 (including VOCs/BTEX) and in one case, Gross Alpha/Beta, Radon, and Radium as well.



Condensate tanks pull off water from gas and can produce fumes and emissions.

Photo by: Nadia Steinzor



Placing an air canister at a test site for collecting emissions data.

Photo by: Nadia Steinzor

## 2.3. FINDINGS

### PARTICIPANT OVERVIEW

Among participants, 45 percent were male from 18 months to 79 years of age and 55 percent were female from 7 to 77 years of age. The closest a participant lived to gas facilities was 350 feet and the furthest away was 5 miles.

Participants had a wide range of occupational backgrounds, including animal breeding and training, beautician, child care, construction, domestic work, farming, management, mechanic, medical professional, office work, painter, retail, teaching, and welding. About 20 percent of participants reported occupational-related chemical exposure (for example, to cleaning products, fertilizers, pesticides, and solvents). At the time of survey completion, 80 percent of participants did not smoke and 20 percent did. While some of the non-smokers had smoked in the past, more than 60 percent never had.

**Table 1: Survey location**

County surveyed	Number of surveys collected	Percent of surveys
Washington	24	22
Fayette	20	18
Bedford	20	18
Bradford	17	16
Butler	12	11
Jefferson	3	3
Sullivan	2	2
Greene	2	2
Warren	2	2
Elk	2	2
Clearfield	1	1
Erie	1	1
Susquehanna	1	1
Westmoreland	1	1
<b>TOTAL</b>	<b>108</b>	<b>100%</b>

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## A COMPARATIVE LOOK:

We established an informal comparison group of 5 individuals in 5 households in and around the city of Sayre in north-central Bradford County and in Waverly, New York, just over the state border from Sayre. This group generally lived further away from gas facilities than the main survey group, between 1.5 - 9 miles from gas wells and (in one case) 8 miles from a compressor station. None of the participants smoked and all reported being healthy. Taken together, these participants reported a total of 24 health symptoms, including some in the categories of skin, respiratory, digestive, muscles/joints, neurological, ear/nose/mouth, behavioral, and lymphatic. Only one or two participants reported each symptom or smelling odors of any kind—reflecting a lower level of impact than was generally documented among survey participants overall. While much smaller than the main survey group, the comparison group results indicate the possibility that fewer health symptoms exist at longer distances from facilities, an aspect indicated by the project findings overall that warrants further investigation and analysis.

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## HEALTH SYMPTOMS

Almost half of the survey participants answered the question of whether they had any health problems prior to shale gas development. About half of those responses indicated no health conditions before the development began and about half reported having had one or just a few, in particular allergies, asthma, arthritis, cancer, high blood pressure, and heart, kidney, pulmonary, and thyroid conditions.

In addition, 5 individuals volunteered (verbally or in writing) that their existing health symptoms became worse after shale gas development started and 15 that their symptoms lessened or disappeared when they were away from home. Members of four households also reported that they'd moved to new locations due to gas drilling and several others told OGAP staff that they would if their finances and jobs allowed it. Also of note is that participants in 22 households reported that pets and livestock began to have unexplained symptoms (such as seizures or losing hair) or suddenly fell ill and died after gas development began nearby.

The specific symptoms reported within each of the top reported categories varied.<sup>15</sup> (To see which specific symptoms were included in all the categories, see the full survey at <http://health.earthworksaction.org>.) However, the primary categories of health problems reported by participants were quite consistent across counties. For example, sinus/respiratory problems was the top complaint category for all participants, as well as in four of the five main counties and the other counties group; the second top complaint category, behavioral/mood/energy, was the first in one county, second in three and in the other counties group, and third and fourth in one each.

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**22 households reported that pets and livestock began to have symptoms (such as seizures or losing hair) or suddenly fell ill and died after gas development began nearby.**

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Industrial equipment containing combustible products, very close to home.

Photo by: Nadia Steinzor

**Table 2: Ranking of top 8 categories of symptoms, by county**

Symptom Category	All	Bedford	Bradford	Butler	Fayette	Washington	Others*
<b>Sinus/respiratory</b>	1	1	2	1	1	1	1
<b>Behavioral/mood/energy</b>	2	2	1	3	2	4	2
<b>Neurological</b>	3	5	5	8	7	3	3
<b>Muscles/joints</b>	4	3	3	4	8	5	6
<b>Ear/nose/mouth</b>	5	7	8	7	5	6	5
<b>Digestive/stomach</b>	6	4	7	5	4	8	7
<b>Skin reactions</b>	7	6	4	2	3	7	8
<b>Vision/eyes</b>	8	8	6	6	6	2	4

**Table 3: Most prevalent categories of symptoms**

Symptom category	Percent of individuals reporting conditions in category						
	All	Bedford	Bradford	Butler	Fayette	Washington	Others*
<b>Sinus/respiratory</b>	88	80	82	75	85	95	87
<b>Behavioral/mood/energy</b>	80	60	88	67	85	74	67
<b>Neurological</b>	74	45	71	50	70	79	60
<b>Muscles/joints</b>	70	55	82	67	70	74	47
<b>Digestive/stomach</b>	64	55	65	58	75	63	33
<b>Ear/nose/mouth</b>	66	40	59	50	75	68	47
<b>Skin reactions</b>	64	45	70	67	75	63	27
<b>Vision/eyes</b>	63	40	65	50	70	79	53

\* Includes Clearfield, Elk, Erie, Jefferson, Greene, Sullivan, Susquehanna, Warren, and Westmoreland Counties. The surveys from these counties (15) were analyzed together to create a group comparable in number to each of the counties where more surveys were collected.

The 25 most prevalent symptoms among all participants were increased fatigue (62%), nasal irritation (61%), throat irritation (60%), sinus problems (58%), eyes burning (53%), shortness of breath (52%), joint pain (52%), feeling weak and tired (52%), severe headaches (51%), sleep disturbance (51%), lumbar pain (49%), forgetfulness (48%), muscle aches and pains (44%), difficulty breathing (41%), sleep disorders (41%), frequent irritation (39%), weakness (39%), frequent nausea (39%), skin irritation (38%), skin rashes (37%); depression (37%), memory problems (36%), severe anxiety (35%), tension (35%), and dizziness (34%).

The survey asked questions designed to identify if there might be associations between symptoms and living near particular types of facilities (wells, waste impoundment pits, and compressor stations). However, because it turned out that most survey participants actually live in close proximity to more than one type of facility, it was difficult to determine connections with a specific type of facility. Instead, we examined whether the distance from any type of oil and gas facility had a bearing on the number of types of symptoms reported in the survey.

As seen in Table 4, many symptoms were commonly reported regardless of the distance from the facility (in particular sinus problems, nasal irritation, increased fatigue, feeling weak and tired, joint pain, and shortness of breath).

In general, as the distance from facilities decreases, the percentage of respondents reporting the symptoms increases. For example, when facilities were 1500-4000 feet away, 27 percent reported throat irritation; this increased to 63 percent at 501-1500 feet, and 74 percent at less than 500 feet. For severe headaches, 30 percent reported them at the longer distance, but about 60 percent at the middle and short distances.

However, when facilities were further away than 4001 feet, some percentages jumped back up. The data showed higher percentages of respondents experiencing certain symptoms at the longer than mid-range distances with regard to several other symptoms (e.g., throat irritation, sinus problems, nasal irritation, eye burning, and joint pain). It is possible that the chemicals that bring on these types of symptoms travel over much longer distances than would normally be expected, or that other factors were at play related to the landscape, weather conditions, participant reporting, and type of production.<sup>16</sup>

When the most prevalent symptoms are broken out by age and distance from facility, some differences are notable. In most age groups, symptoms are more prevalent in those living closer to facilities than those living further away. In sum, while the data presented in Figure 1 below do not prove that living closer to an oil and gas facility causes health problems, they do suggest a strong association.

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**In general, the closer to gas facilities respondents lived, the higher the rates of symptoms they reported.**

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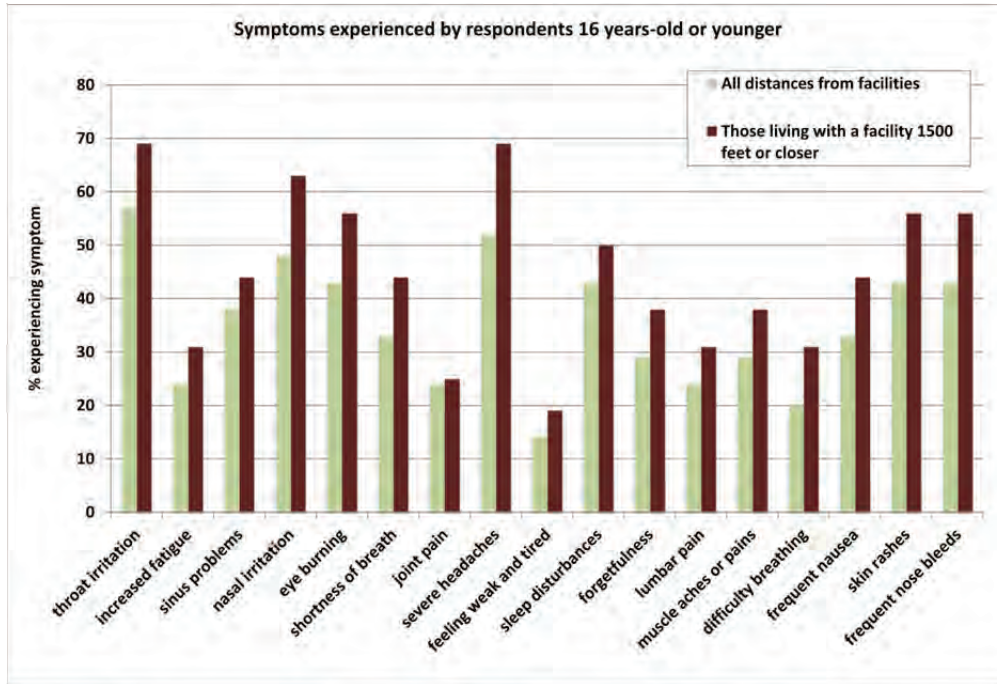
Drilling rig onsite.

Photo by: Frank Finan

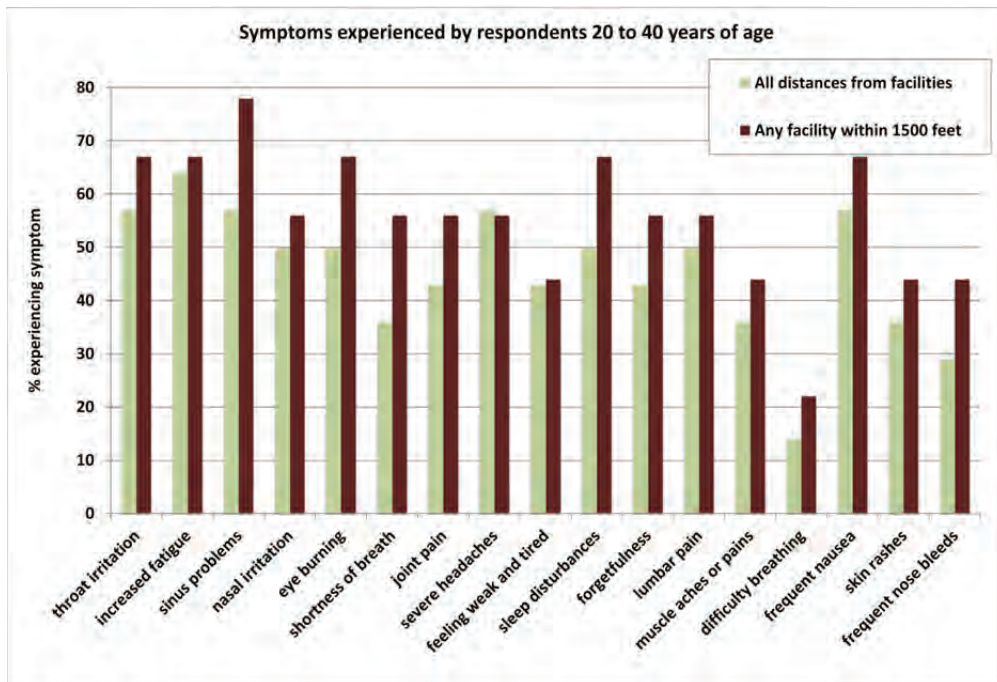
**Table 4. Differences in symptoms by distance from an oil/gas facility**

Distance	Number of surveys in this category	Age range	Number of smokers	Average number of symptoms per person	Number of symptoms experienced by 50% or more respondents	Top 15 symptoms (the / means the same percentage of respondents had the symptom – bringing the total to more than 15 symptoms in some cases)
Within 500 feet of any facility	27	1.5 to 76 (1 had no age data)	2	31	9	Throat irritation (74%), sinus problems (70%), nasal irritation/ eye burning/ joint pain/ severe headaches/ sleep disturbances (59%), skin rashes (56%), shortness of breath (52%), loss of sense of smell/ persistent cough/forgetfulness/ sleep disorders/ frequent nosebleeds/ swollen painful joints/ increased fatigue/ feeling weak and tired (44%)
501 - 1500 feet from a facility	40	3 to 79	12	30	11	Increased fatigue (68%), nasal irritation(65%), throat irritation (63%), eye burning/ severe headaches (60%), shortness of breath (55%), sleep disturbances/ sinus problems/ lumbar pain (53%), feeling weak and tired/ forgetfulness (50%), joint pain/ muscular pain/ memory problems/ weakness (48%)
1501 - 4000 feet from a facility	30	6 to 77 (1 had no age data)	9	27	1	Increased fatigue (57%), feeling weak and tired (47%), joint pain (43%), shortness of breath/ difficulty breathing (40%), sinus problems/ lumbar pain/ forgetfulness/ tension/ weakness of hands (37%), nasal irritation/ frequent nausea/ reduced muscles strength/ persistent skin problems (33%)
Greater than 4001 feet from a facility	11	34 to 76	2	29	8	Throat irritation/ nasal irritation/ feeling weak and tired (64%), sinus problems/ eye burning/ joint pain/ muscle aches or pains/ ringing in ears (55%), increased fatigue/ severe headaches/ shortness of breath/ sleep disturbances/ lumbar pain/ muscular pain/ weakness/ depression/ persistent hoarseness/ blurred vision (45%)

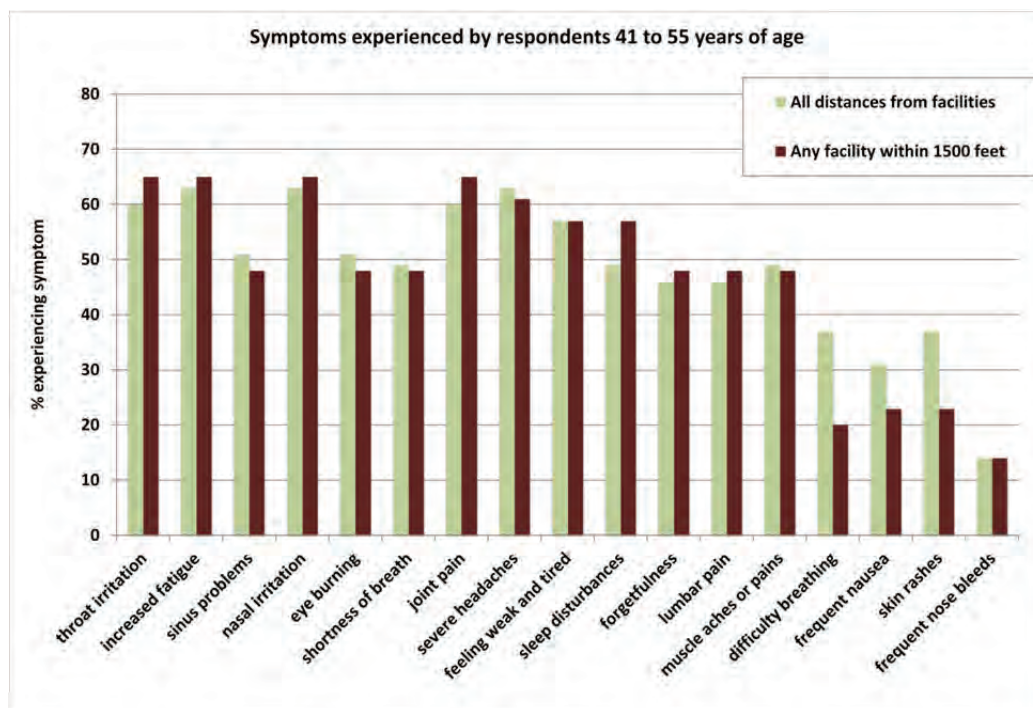
**Figure 1. Association of symptoms and distance from facilities, by age group**



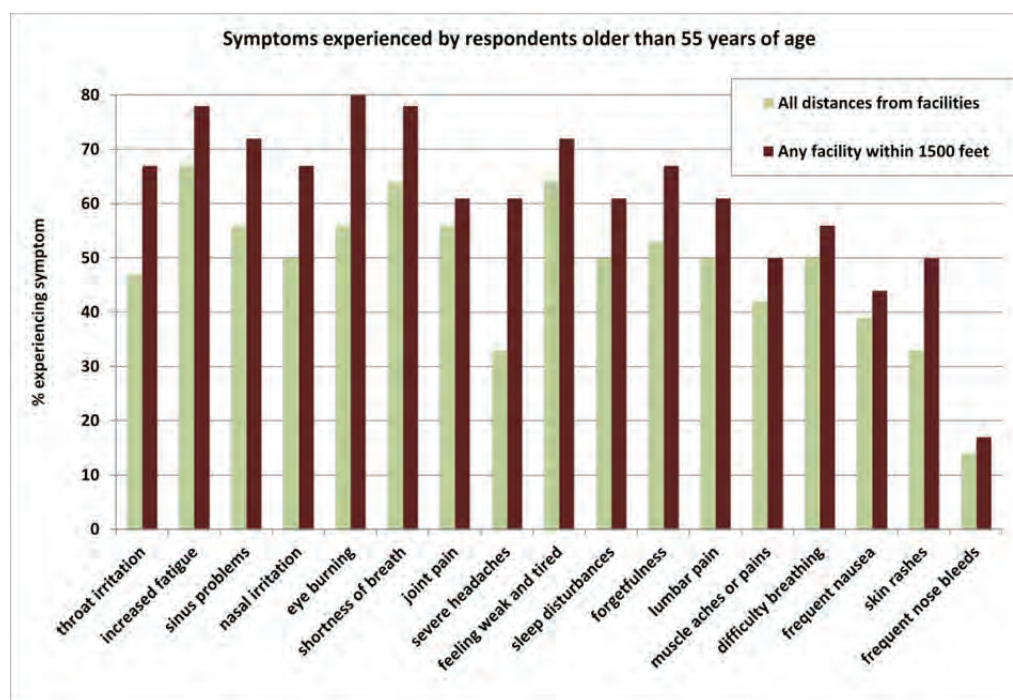
In the youngest age group (1.5-16 years old), the most common symptoms were related to sensitive mucous membranes (throat, eyes, nose) and skin. **Even these youngest respondents had conditions not typically associated with children (e.g., severe headaches, joint pain, lumbar pain, and forgetfulness).**<sup>17</sup> In the subset of this young age group living 1500 feet or closer to a facility, the percentage of respondents with symptoms increased. For example, the number of respondents experiencing throat irritation jumped from 57 to 69 percent, and severe headaches increased from 52 to 69 percent. **Of all age groups, this group had the highest occurrence of frequent nosebleeds within 1500 feet of facilities (56%).**<sup>18</sup>



In the next age group (20-40 years old), there was a high occurrence of symptoms related to the throat, eye, and nose; fatigue, nausea, and severe headaches were also common symptoms. For those living 1500 feet or closer to a facility, the percentage of respondents with symptoms increased for all symptoms except one (headaches). In some cases, the percentage reporting symptoms was considerably higher (e.g., for sinus problems, eye burning, shortness of breath, and sleep disturbances). **44 percent of 20 to 40-year-olds living within 1500 feet of facilities complained of frequent nosebleeds, compared to 29 percent of all participants of this age.**



Approximately 60 percent of participants in the third age group (41-55 years old) reported throat irritation, increased fatigue, nasal irritation, joint pain, and severe headaches. Although the occurrence of some symptoms (e.g., throat irritation, joint pain, and sleep disturbances) increased in the subset of this group living closer to facilities, the increases were not as dramatic as those experienced in other age groups. In some cases, the percentages actually went down in the subgroup of those living closer to facilities.



In the oldest age group (56-79 years old) the symptoms most frequently experienced were increased fatigue, shortness of breath, and feeling weak and tired. For some symptoms (e.g., throat irritation, sinus problems, nasal irritation, eye burning, shortness of breath, severe headaches and skin rashes) **there were large increases in the subset of this age group who lived closest to facilities.**





The survey also asked respondents to indicate whether or not they were smokers. Table 5 shows that while smokers had, on average, more symptoms than non-smokers, and more symptoms in common with each other, the most frequently reported symptoms were very similar to non-smokers (including forgetfulness, increased fatigue, lumbar pain, joint pain, eye burning, nasal irritation, sinus problems, sleep disturbances, severe headaches, throat irritation, shortness of breath, frequent nausea, muscle aches or pains, and weakness).

The fact that the non-smokers reported symptoms that are commonly considered to be side effects of smoking (e.g., persistent hoarseness, throat irritation, sinus problems, nasal irritation, shortness of breath, and sleep disturbances) suggests that there are likely factors other than smoking that contribute to these symptoms.

**Table 5. Comparison of symptoms in smoking and non-smoking subgroups of similar ages 19**

	Number in this category	Age range	Average number of symptoms per person	Number of symptoms experienced by 50% or more of respondents	Top 15 symptoms (in order of highest percentage reporting symptom)
Non-smokers	54	23 - 70	27	6	Forgetfulness (59%), lumbar pain/ joint pain (57%), increased fatigue (56%), eye burning/ nasal irritation (54%), sinus problems/ sleep disturbances (48%), severe headaches/ throat irritation (44%), shortness of breath (43%), frequent nausea/ muscular pain/ persistent hoarseness (41%), weakness (39%)
Smokers	27	24 - 70	38	13	Increased fatigue (70%), eye burning/ lumbar pain (59%), sinus problems/ nasal irritation/ joint pain/ forgetfulness/ severe headaches/ sleep disturbances (56%), shortness of breath/ throat irritation/ frequent nausea/ muscular pain (52%), feeling weak and tired/ weakness (48%)

Breaking down the data further, as shown in Table 6, **it appears that the symptoms most frequently reported by smokers and non-smokers were remarkably similar within each age group.** For example, in the age group 20-40, increased fatigue, sinus problems, throat irritation, frequent nausea, and sleep problems were among the top symptoms for smokers and non-smokers. In the 41-55-year-old group, increased fatigue, throat irritation, eye burning, severe headaches, and feeling weak and tired were among the top symptoms in both groups, and in the over-56 age group, eye burning, sinus problems, increased fatigue, joint pain, and forgetfulness were among the top symptoms of smokers and non-smokers.

Furthermore, the data from smokers did not greatly affect the results in the “all respondents” category. When compared to the non-smoking subgroup, the only notable difference was in the 41-55-year-old age group, where the average number of symptoms in the “all respondents” was 30, versus 22 in the non-smoking subgroup. The top symptoms, however, were very similar.



**Table 6. Symptoms by age group, and by smoking or non-smoking status**

Age category	Sub-category	Number in sub-category	Average number of symptoms per person	Number of symptoms in 50% or more respondents	Top 15 symptoms (in order of highest percentage reporting the symptom)
16 and under	All respondents (None were smokers)	21	19	2	Throat irritation (57%), severe headaches (52%), nasal irritation (48%), skin rashes/ abdominal pain/ eye burning/ frequent nose bleeds/ sleep disturbances (43%), sinus problems/ persistent cough (38%), shortness of breath/ frequent nausea (33%), skin irritation/ asthma/ difficulty breathing/ allergies/ diarrhea/ dry eyes/ muscle aches or pains/ forgetfulness/ behavioral changes/ frequent irritation (29%)
20 - 40	All respondents	14	29	12	Increased fatigue (64%), severe headaches/ sinus problems/ throat irritation/ frequent nausea (57%) abdominal pain/ nasal irritation/ eye burning/ muscular pain/ lumbar pain/ weakness/ sleep disturbances/ depression (50%), dry/cracked red skin/ feeling weak and tired/ sleep disorders/ allergies/ sores or ulcers in mouth/ forgetfulness/ joint pain/ severe anxiety (43%)
	Non-smokers	10	29	10	Increased fatigue/ severe headaches/ abdominal pain, (60%), sinus problems/ throat irritation/ frequent nausea/ nasal irritation/ dry, cracked red skin/ feeling weak and tired/ sleep disorders (50%), eye burning/ muscular pain/ lumbar pain/ sleep disturbances/ depression/ allergies/ sores or ulcers in mouth/ forgetfulness/ skin rashes/ shortness of breath/ diarrhea/ extreme drowsiness/ tension/ persistent skin problems/ loss of sense of smell/ lumps or swelling neck (40%)
	Smokers	4	28	28	Weakness (100%), increased fatigue (75%), sinus problems (75%), throat irritation (75%), frequent nausea (75%), eye burning (75%), muscular pain (75%), lumbar pain (75%), sleep disturbances (75%), depression (75%), joint pain (75%), severe anxiety (75%), frequent irritation (75%), severe headaches/ nasal irritation/ allergies/ sores or ulcers in mouth/ forgetfulness/ swollen painful joints/ muscle aches or pains/ loss of sex drive/ irregular or rapid heart beat/ persistent hoarseness/ reduced muscle strength/ difficulty concentrating/ severe pain in eyes/ compulsive behavior/ weight loss (50%)

41 - 55	All respondents	33	30	8	Severe headaches/ nasal irritation/ increased fatigue (63%), joint pain/ throat irritation (60%), feeling weak and tired (57%), sinus problems/ eye burning (60%), shortness of breath/ sleep disturbances/ depression, muscles aches or pains (49%), lumbar pain/forgetfulness (46%), memory problems (43%)
	Non-smokers	22	22	8	Joint pain (68%), nasal irritation (64%), throat irritation (59%), severe headaches/ increased fatigue/ feeling weak and tired (55%), sinus problems/ depression (50%), eye burning/ muscle aches or pains (45%), shortness of breath/ memory problems/ lumbar pain/ skin rashes (41%)
	Smokers	13	44	18	Severe headaches/increased fatigue (77%), sleep disturbances (69%), nasal irritation/ throat irritation / feeling weak and tired/ eye burning/ shortness of breath/ forgetfulness/ sleep disorders/ loss of sex drive (62%), sinus problems/ muscle aches or pains/ lumbar pain/ skin irritation/ muscular pain/ persistent hoarseness/ agitation (54%)
56 - 79	All respondents	36	32	11	Increased fatigue (67%), shortness of breath/ feeling weak and tired (64%), sinus problems/ eye burning, joint pain (56%), forgetfulness (53%), difficulty breathing/ nasal irritation/ lumbar pain/ sleep disturbances (50%), throat irritation (47%), weakness/ reduced muscle strength/ memory problems (44%)
	Non-smokers	28	32	9	Feeling weak and tired (68%), increased fatigue/ shortness of breath (64%), sinus problems/ eye burning/ sleep disturbances (54%), joint pain/ forgetfulness/ throat irritation (50%), difficulty breathing/ nasal irritation/ weakness/ memory problems/ sleep disorders/ frequent urination (46%)
	Smokers	8	35	18	Increased fatigue/ joint pain/ lumbar pain (75%), shortness of breath/ sinus problems/ eye burning, forgetfulness/ difficulty breathing/ nasal irritation/ tension/ frequent nausea (63%), feeling weak and tired/ reduced muscle strength/ arthritis/ muscular pain/ persistent skin problems/ diarrhea/ skin rashes (50%)

## ODOR EVENTS

Bad and unusual odors are an indication of the presence of a substance or chemical, and are a common complaint of people living near gas facilities. Among survey participants, 81 percent reported experiencing bad odors sometimes or constantly. The frequency ranged from 1 to 7 days per week and from several times per day to all day long; 18 percent said they could smell odors every day.

Participants were asked to describe the suspected source of the odors. Nearly all responses related odors to gas facilities and events, including drilling; gas wells; well pads; fracturing; compressor stations; condensate tanks; drinking contaminated water; flaring; waste pits; retention ponds; diesel engines; truck traffic; pipelines and pipeline stations; spills and leaks; subsurface events; seismic testing; and blue-colored particles in air (possibly a sign of catalytic compounds or particulate matter).

When asked in the survey whether health symptoms occurred in conjunction with odor events, participants reported the associations listed below. Most indicated that symptoms would last from a few hours to a few days and, in some cases, a few weeks.

- **Nausea:** ammonia, chlorine, gas, propane, ozone, rotten gas.
- **Dizziness:** chemical burning, chlorine, diesel, ozone, petrochemical smell, rotten/sour gas, sulfur.
- **Headache:** chemical smell, chlorine, diesel, gasoline, ozone, petrochemical smell, propane, rotten/sour gas, sweet smell.
- **Eye/vision problems:** chemical burning, chlorine, exhaust.
- **Respiratory problems:** ammonia, chemical burning, chlorine, diesel, perfume smell, rotten gas, sulfur.
- **Nose/throat problems:** chemical smell, chlorine, exhaust, gas, ozone, petrochemical smell, rotten gas, sulfur, sweet smell.
- **Nosebleeds:** kerosene, petrochemical smell, propane, sour gas.
- **Skin irritation:** chemical smell, chlorine, ozone, sulfur.
- **Decreased energy/alertness:** chemical gas, ozone, rotten/sour gas, sweet smell.
- **Metallic/bad taste in mouth:** chemical burning, chlorine, turpentine.

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**81%** reported experiencing bad odors sometimes or constantly. The frequency ranged from 1 to 7 days per week and from several times per day to all day long.

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Centralized compressor stations move large volumes of gas to and through pipelines. Emissions can include volatile organic compounds such as benzene and toluene, nitrogen oxides, and formaldehyde.

Photo by: Nadia Steinzor

## 2.4. ENVIRONMENTAL TESTING

### AIR

As seen in Table 7, the 34 Summa canister air tests, taken together, detected a total of 19 VOCs. In sum, there was considerable consistency in the chemicals present in many of the samples, although concentrations varied. This could in part be due to differences in the reporting limits and suite of chemicals analyzed by the three labs used in this project. It is possible, for example, that more VOCs were present in more locations, but Pace Analytical had much higher reporting limits than Columbia and Con-Test so the Pace results showed “non-detect” for many substances.<sup>20</sup>

**Table 7. VOCs in ambient air, sorted by highest percent detection; concentrations are in micrograms per cubic meter,  $\mu\text{g}/\text{m}^3$  (n = total number of canister samples that were analyzed for a particular chemical; NA = VOC not included in the analysis)**

Volatile Organic Compound (VOC)	n	Number of samples detecting VOC	Percent of n detecting VOC	Min.	Max.	Mean*	Chemical reporting limits for the three labs used		
							Columbia	Con-Test	Pace**
2-Butanone	17	16	94	0.95	2.9	1.52	0.85 - 1.3	NA	NA
Acetone	17	15	88	8.0	19	11.85	6.5 - 10	NA	NA
Chloromethane	34	27	79	1.0	1.66	1.21	0.59 - 0.90	0.1	1.39 - 1.53
1,1,2-Trichloro-1,2,2-trifluoroethane	34	26	76	0.54	0.73	0.64	0.22 - 0.34	0.38	5.13 - 5.67
Carbon tetrachloride	34	26	76	0.46	0.76	0.62	0.091 -	0.31	4.21 - 4.65
Trichlorofluoromethane	34	26	76	0.6	1.8	1.48	0.81 - 1.2	0.28	3.32 - 3.66
Toluene	34	22	65	0.68	7.9	1.83	0.53 - 0.82	0.19	2.52 - 2.79
Dichlorodifluoromethane	17	9	53	1.9	2.8	2.41	NA	0.25	3.32 - 3.66
n-Hexane	8	3	38	3.03	7.04	5.23	NA	NA	2.37 - 2.61
Benzene	34	11	32	0.31	1.5	0.85	0.46 - 0.67	0.16	2.14 - 2.36
Methylene Chloride	34	10	29	1.9	32.62	7.93	0.49 - 0.76	1.7	2.33 - 2.57
Total Hydrocarbons (gas) ***	8	2	25	49.8	146	97.9	NA	NA	46.9 - 52.2
Tetrachloroethylene	34	8	24	0.12	10.85	1.68	0.10 - 0.16	0.34	4.54 - 5.02
1,2,4-Trimethylbenzene	17	4	24	0.38	0.61	0.48	NA	0.25	3.30 - 3.64
Ethylbenzene	34	6	18	0.27	1.5	0.54	1.4 - 1.9	0.22	2.91 - 3.21
Trichloroethylene	34	6	18	0.17	5.37	2.71	0.08 - 0.12	0.27	3.60 - 3.98
Xylene (m&p)	34	5	15	0.92	5.2	1.98	2.5 - 3.8	0.43	2.82 - 3.12
Xylene (o)	34	5	15	0.39	1.9	0.76	1.2 - 1.9	0.22	2.91 - 3.21
1,2-Dichloroethane	34	1	3	0.64	0.64	0.64	0.59 - 0.90	0.2	2.71 - 2.99

\* Mean of samples detecting chemical.<sup>21</sup>

\*\* Pace reporting limits were in ppbv. We converted to  $\mu\text{g}/\text{m}^3$ .<sup>22</sup>

\*\*\* Total hydrocarbons reported as parts per billion volume (ppbv).



Breaking out the air data by county, the highest number of VOCs were detected in samples from Washington County (15), Butler County (15), Bradford County (11), and Fayette County (9). Washington County also had the highest measured concentration of five and the second highest concentration of 11 VOCs.<sup>23</sup> Samples from Butler and Bradford Counties had the highest concentrations of five and three VOCs, respectively. Five chemicals were detected in all nine of the samples from Washington County and in the six samples from Butler County: 1,1,2-Trichloro-1,2,2-trifluoroethane; carbon tetrachloride; chloromethane; toluene; and trichlorofluoromethane. (Detailed data for all the counties where air testing occurred are available at <http://health.earthworksaction.org>.)

In 2010, the Pennsylvania Department of Environmental Protection (DEP) conducted air testing around natural gas wells and facilities in three regions across the state, in part using the same canister sampling methods as in this project.<sup>24</sup> When compared to the DEP's results, OGAP's results showed some similarities in both the chemicals detected and concentrations.

Figure 2 shows benzene, toluene, ethylbenzene, and m&p-xylenes (o-xylenes not included) broken down by county from our project, as well as samples taken by DEP at control sites (rural, forested areas with no nearby gas development), oil and gas sites (including some nearby residences), and an industrial site (the Marcus Hook monitoring site, which is close to two oil refineries in an industrialized area of the state<sup>25</sup>). Also shown in the chart are the number of detections and the number of samples in each category (e.g., benzene was detected in four of six air samples in Butler county).

As seen in these charts, BTEX chemicals measured in our project in Butler and Washington counties were consistently higher than concentrations found at DEP control sites (ethylbenzene and m&p-xylenes were not detected at any of the control sites). When compared to the sampling done by DEP around oil and gas facilities the concentrations in Butler and Washington counties were in the same range for benzene, but were considerably higher for toluene, ethylbenzene, and m&p-xylenes. It is also striking that some of the concentrations of ethylbenzene and xylene measured at homes in Butler and Washington counties were higher than any concentration detected by the DEP at the Marcus Hook industrial site. Again, while factors such as topography, type of gas, and emission control technologies can influence air results, it is highly possible that air quality at the sites where we tested—all in rural and residential areas—was worse overall because of the proximity of gas facilities.

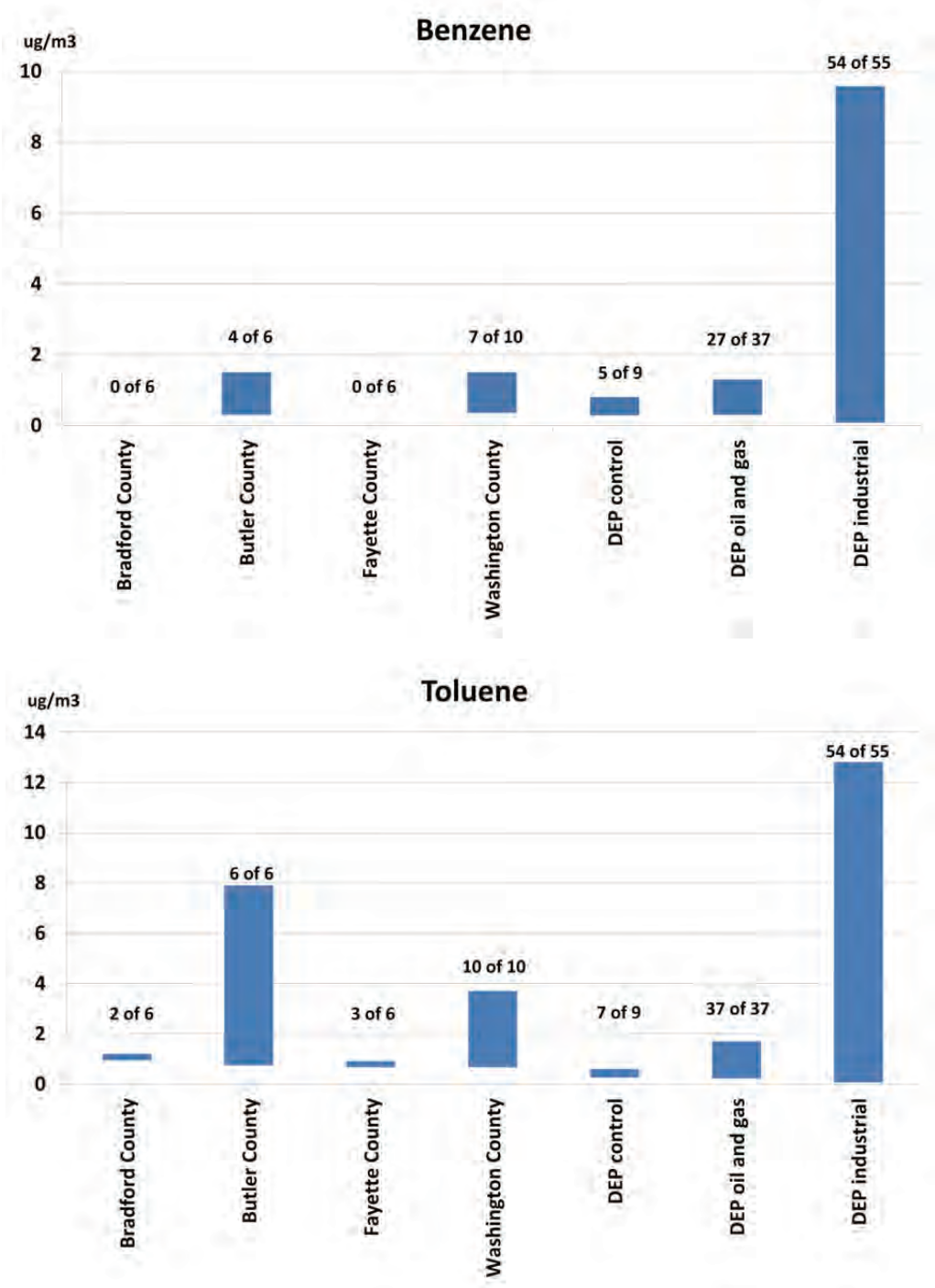
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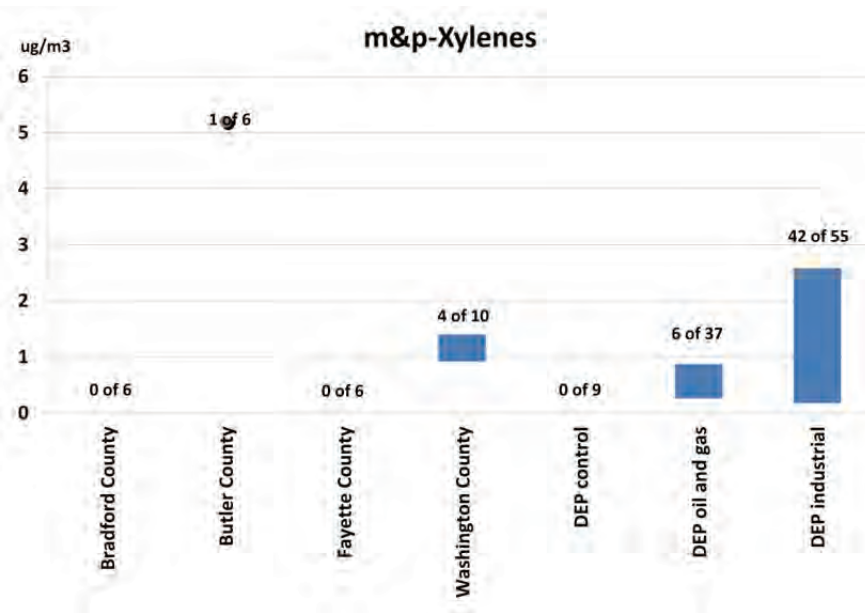
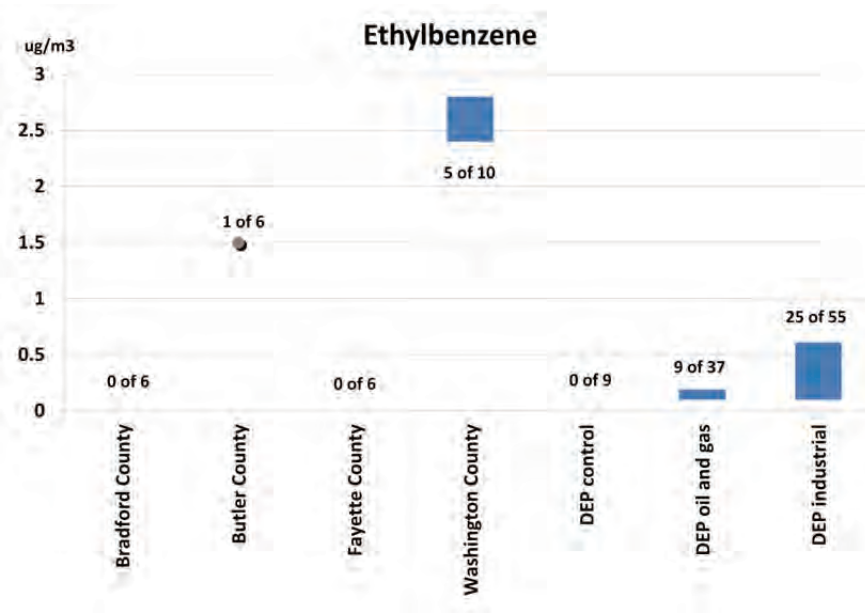
**Concentrations of ethylbenzene and xylene measured at homes in Butler and Washington Counties for this project were higher than in air tests done by the DEP at the Marcus Hook Industrial site.**

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According to the DEP, some of the VOCs found in our study are present in ambient air because they were once widely used and persist in the atmosphere.<sup>26</sup> The DEP indicates that acetone and the BTEX chemicals, however, may be attributed to gas development.<sup>27</sup> (In addition, the presence of VOCs clearly influences air quality overall.)

**Figure 2. The four charts that make up Figure 2 show comparisons of BTEX concentrations where they were detected in project samples (Bradford, Butler, Fayette, and Washington Counties only) and DEP samples (control, oil and gas facility, and an industrial site).**





To provide some perspective on benzene concentrations found in our results, we examined data on national benzene concentrations in the U.S. (based on annual average concentrations at 22 urban sampling locations). Between 1994 and 2009, benzene in ambient air declined.<sup>28</sup>

In 2009, 80 percent of the urban sites had average annual benzene concentrations between 0.4 and 1.5 micrograms per cubic meter ( $\mu\text{g}/\text{m}^3$ ), with the average and median concentrations for the 22 sites being less than 1  $\mu\text{g}/\text{m}^3$ . Five of our air canister tests had benzene above the national (urban) average, and two had concentrations equal to the maximum average annual concentration measured by EPA in U.S. urban areas in 2009 (i.e., 1.5  $\mu\text{g}/\text{m}^3$ ).<sup>29</sup>





As mentioned previously, the current project's sampling locations were in rural areas of Pennsylvania. While local traffic may have contributed some benzene, the most likely primary sources of benzene in these areas are oil and gas facilities; increased truck traffic associated with these sites could also be a contributing factor.

It is important to note that the concentrations found in our study were one-time samples, while the EPA concentrations represent an average of many samples taken over the course of a year. So there may have been some individual samples in urban areas that were higher than  $1.5 \mu\text{g}/\text{m}^3$ . It is also possible, however, that benzene concentrations at the sampling locations in our project could have exceeded  $1.5 \mu\text{g}/\text{m}^3$  if numerous samples were taken over the course of several months or a year.

Finally, the chemicals sampled in our project were limited to a selection of VOCs. The analytical methods used did not test for some chemicals known to be associated with oil and gas facilities such as formaldehyde, which is commonly emitted from compressor stations. According to the U.S. EPA, the major toxic effects caused by acute formaldehyde exposure via inhalation are eye, nose, and throat irritation and effects on the nasal cavity.<sup>30</sup> These were symptoms experienced by high percentages of survey respondents. In addition, hydrogen sulfide, a known toxic compound with many of the health effects documented in this project, is often associated with oil and gas development. Testing for such chemicals would have required different types of air sampling methods than applied here.

## WATER

The nine water samples taken for this project were sent to laboratories that analyzed for dozens of substances. Table 8 shows the 26 parameters that were detected in at least one sample (including water temperature and pH). Several of the chemicals found in samples are known to be associated with oil and gas drilling operations. For example, barium, bromide, calcium, chloride, iron, manganese, magnesium, potassium, sodium, sulfate, strontium, and Total Dissolved Solids (TDS) have been measured in effluent from a Pennsylvania wastewater plant that only treats oil and gas industry brine and hydraulic fracturing flowback.<sup>31</sup>



Operators flare gas that's uneconomical to process or to burn off certain compounds. Flaring emits a host of air pollutants determined by the chemical composition of the gas and the temperature of the flare.

Photo by: Frank Finan

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**Drinking water standards do not even exist for some contaminants, such as methane, bromide, sodium, strontium, or Total Suspended Solids (TSS).**

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**Table 8. Water quality results from nine private water wells in Bradford and Butler Counties, Pennsylvania**  
(Note: not all parameters were analyzed in every sample)

Parameter	Units	Number of samples	Number above detection limit	Min. <sup>a</sup>	Max.	Mean <sup>b</sup>	PA DEP MCL <sup>c</sup>	Number of samples above MCL
Barium	mg/L	9	9	0.029	0.5	0.25	2	0
Calcium	mg/L	9	9	33	66.2	43.7	None	
Magnesium	mg/L	9	9	4.5	16.8	9.1	None	
Sodium	mg/L	9	9	9.2	64.1	20.9	None	
Strontium	mg/L	9	9	0.126	1.7	0.5	None	
Hardness (Total as CaCO <sub>3</sub> )	mg/L	9	9	120	234	147	None	
pH	Std Units	9	9	6	7.9	6.5	6.5 - 8.5	2 below
Alkalinity (Total as CaCO <sub>3</sub> )	mg/L	9	9	38	285	130	None	
Total Dissolved Solids	mg/L	9	9	138	392	218	500	0
Sulfate	mg/L	9	9	6.7	231	33	250	0
Manganese	mg/L	9	7	<0.005	6.44	1.04	0.05	7
Chloride	mg/L	9	7	<5.0	84.3	24.1	250	0
Iron	mg/L	9	6	<0.04	153	19.5	0.3	5
Potassium	mg/L	6	6	1.14	1.57	1.1	None	
Specific Conductance	µmhos/cm	6	6	287	552	326	None	
Methane	µg/L	9	5	1.06	57.4	10	None	
Arsenic	mg/L	9	4	<0.001	0.0282	0.005	0.010	1
Lead	mg/L	9	4	<0.001	0.113	0.01	0.005*	3
Total Coliform	per 100 mL	9	4	Absent	Present		None	
Total Suspended Solids	mg/L	6	4	<5	448	118	None	
Temp, water	Deg. Celsius	3	3	25	29	28	None	
Turbidity	NTU	3	3	0.22	5.7	2.3	None	
Nitrate	mg/L	3	3	0.076	0.71	0.46	10	0
E. coli	per 100 mL	9	2	Absent	Present		None	
Sulfur	µg/L	1	1	<1,000	7,550	2,850	None	
Bromide	mg/L	1	1	0.26	0.26	0.26	None	

<sup>a</sup> **Minimum values:** If reports included non-detects of a particular chemical, the minimum value in the table was shown as being less than (<) the lowest laboratory detection limit.

<sup>b</sup> **Mean values:** Non-detected chemicals were assigned a concentration equal to half of the detection limit *only if* there were other samples that detected the chemical.

<sup>c</sup> **MCL:** Maximum Contaminant Levels published by the Pennsylvania Department of Environmental Protection Division of Drinking Water Management.

Two of the water samples, both from Butler County, were more acidic than the recommended pH for drinking water. Iron, manganese, arsenic, and lead were detected in water well samples from Bradford and Butler Counties at levels higher than the Maximum Contaminant Levels (MCLs) set by DEP's Division of Drinking Water Management.<sup>32</sup>

It is important to note that while laboratory tests may not show exceeded levels for some of the other substances, drinking water standards on which to base such determinations often do not exist, including for methane, bromide, sodium, strontium, or Total Suspended Solids (TSS).

More than half of the project water samples contained methane. Although some groundwater can contain low concentrations of methane under normal conditions, its presence could also indicate natural gas migration from improperly cased or damaged gas wells. In addition, a recent analysis of U.S. Geological Survey water monitoring data for an aquifer near Pavillion, Wyoming found that thermogenic gas (which likely comes from shale formations), as well as chemicals associated with hydraulic fracturing, are present—evidence that strongly suggests that these substances can seep into water supplies following fracturing.<sup>33</sup>

Concentrations of some metals such as manganese and iron may be elevated in Pennsylvania surface waters and soils either naturally or due to past industrial activities, and levels can vary regionally and seasonally.<sup>34</sup> In 2012, Pennsylvania State University (PSU) researchers found that some drinking water wells in the state contained elevated concentrations of certain contaminants prior to any drilling in the area.<sup>35</sup> For example, PSU researchers found that 27 percent of pre-drilling water samples had manganese above the DEP drinking water standard.<sup>36</sup> In this project, 7 out of the 9 water supplies sampled (78 percent) had manganese levels above the state MCL; this is a much higher percentage than the PSU study. If there was no impact from drilling, one would expect that fewer than three of our project samples would have had manganese above the MCL.

Even when metals in ground water are naturally occurring or pre-date gas development, drilling and hydraulic fracturing have the potential to mobilize substances in formations such as Marcellus Shale, which is enriched with barium, uranium, chromium, and zinc and other metals.<sup>37</sup> Also, drilling can cause physical and chemical changes to groundwater aquifers that may result in elevated metals and sediment concentrations in drinking water.<sup>38</sup> In the PSU study, there were three cases where wells within within 3,000 feet of the nearest Marcellus gas well experienced changes in manganese, iron and sediment after drilling occurred. For example, each water well had pre-drilling manganese concentrations near or below the drinking water standard (0.05 mg/L) that increased far above the standard following drilling.<sup>39</sup>



Drinking water wells have been contaminated with methane, chemicals, and other substances.

Photo by: Nadia Steinzor

## SYMPTOM AND TESTING ASSOCIATIONS

More research would be required to state “cause and effect” connections between the chemicals present in air and water in specific locations and symptoms reported by particular residents. Nonetheless, associations can be made, as many of the chemicals detected through testing are known to be linked to both oil and gas operations and with the health symptoms reported in the surveys.<sup>40</sup>

The air tests together detected 19 chemicals that may cause sinus, skin, ear/nose/mouth, and neurological symptoms, 17 chemicals that may affect vision/eyes, 16 that may induce behavioral effects, 11 that have been associated with liver damage, 9 with kidney damage, and 8 associated with digestive/stomach problems. In addition, the brain and nervous system may be affected by 5 chemicals that were detected, the cardiological system by 5, muscles by 2, and blood cells by 2.<sup>41</sup>

More specifically, benzene, toluene, ethylbenzene, xylene, chloromethane, trichloroethene, and acetone were detected at project sites where residents reported associated symptoms in health surveys, including in the categories of sinus/respiratory, skin, vision/eyes, ear/nose/mouth, and neurological. Some of these chemicals, as well as others (such as carbon tetrachloride and tetrachloroethylene), were found at sites where survey participants reported associated symptoms in the categories of digestion, kidney and liver damage, and muscles. (For a full list of health symptoms associated with the chemicals detected, see <http://health.earthworksaction.org>.)

As shown in Table 9, 68 percent of the respondents at households where chemicals were detected reported symptoms known to be associated with those chemicals. Fayette and Washington Counties had the highest rate of association, followed by Greene, Bedford, and Butler. **The total number of symptoms reported by individual participants ranged from 2-111, but more than half of participants reported having over 20 symptoms and nearly one-quarter reported over 50.** The highest number of number of symptoms in households where we conducted air testing were reported by a 26 year-old female in Fayette County (90 symptoms) and a 51 year-old female in Bradford County (94 symptoms).

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Many of the chemicals detected through testing are known to be linked to both oil and gas operations and with the health symptoms reported in the surveys.

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The many stages of gas development create multiple pathways for exposure to air and water pollution, such as emissions, spills, leaks from compressors, impoundments, and other facilities.

Photos by: Nadia Steinzor (top); Frank Finan (bottom)

**Table 9. Match between health symptoms reported by individuals at air testing sites and known effects of chemicals detected**

County	Number of individuals surveyed at homes where testing was conducted	Association between known effects of chemicals detected and symptoms reported	
		Average	Range
<b>Overall</b>	65	68%	33 - 100%
<b>Fayette</b>	17	73%	33 - 100%
<b>Washington</b>	15	73%	33 - 100%
<b>Bradford</b>	10	58%	16 - 100%
<b>Butler</b>	12	63%	56 - 68%
<b>Bedford</b>	6	69%	63-100%
<b>Elk</b>	2	64%	53 - 74%
<b>Clearfield</b>	1	None	None
<b>Greene</b>	1	70%	70%
<b>Susquehanna</b>	1	50%	50%

In addition, as shown in Table 10, the percent of individuals reporting particular types of symptoms that are associated with chemicals detected in the air testing was generally consistent across counties.

**Table 10. Percent of individuals at air testing sites reporting symptoms associated with chemicals detected at those sites, by symptom category**

Symptom Category	All	Bedford	Bradford	Butler	Fayette	Washington	Others *
<b>Sinus/respiratory</b>	83	100	88	100	81	73	80
<b>Vision/eyes</b>	73	--	100	63	69	67	60
<b>Digestive/stomach</b>	69	50	63	88	75	80	--
<b>Skin reactions</b>	63	50	63	88	69	53	40
<b>Neurological</b>	60	50	88	75	44	53	60
<b>Behavioral/mood/energy</b>	54	67	50	63	63	47	40
<b>Ear/nose/mouth</b>	33	50	--	38	44	33	20
<b>Muscle problems</b>	--	--	--	--	--	40	--

\* This includes air samples from Clearfield, Elk, Greene, and Susquehanna Counties

As mentioned above, iron, manganese, arsenic, and lead were detected in water samples at levels above Pennsylvania drinking water standards. These substances are known to be associated with

numerous symptoms reported by individuals living in the homes where those tests were conducted, including in the categories of sinus/respiratory, skin reactions, digestive/stomach, vision/eyes, ear/nose/mouth, neurological, muscle/joint, behavioral/mood/energy, and liver and kidney damage. In addition, survey participants in the homes where water test results showed the presence of methane reported health symptoms known to be associated with the gas, including in the categories of sinus/respiratory, digestive/stomach, neurological, and behavioral/mood/energy.

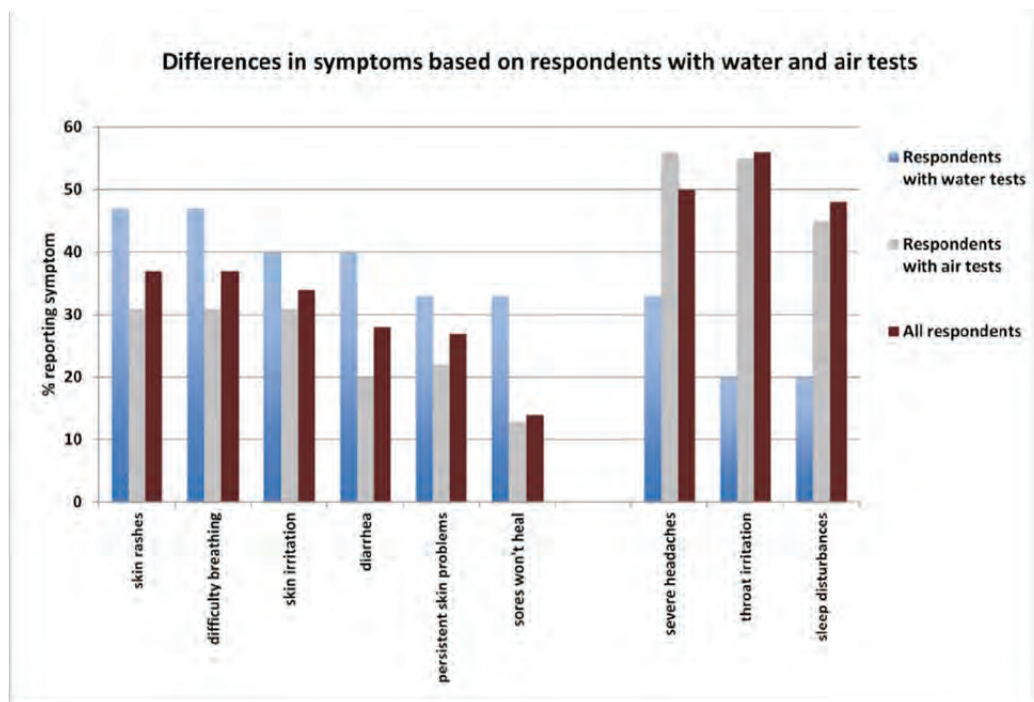
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**Where water test results showed the presence of methane, participants reported health symptoms known to be associated with the gas.**

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Even though many participants indicated they had concerns with both water and air, the different types of testing conducted at different households provides a way to explore whether there might be particular symptoms more commonly associated with one type of exposure. As indicated in Figure 4, there were notable differences in several of the top symptoms reported at households where water versus air was tested, and among survey participants as a whole. Participants with water tests had a higher occurrence of skin rashes, difficulty breathing, skin irritation, diarrhea, persistent skin problems and sores that wouldn't heal, as well as a lower occurrence of severe headaches, throat irritation, and sleep disturbances, than those with air tests and all respondents.

**Figure 4: Differences in symptoms based on respondents with water and air tests**



## 2.5. CONCLUSIONS

The data gathered through this project point to three central conclusions: (1) contaminants that are associated with oil and gas development are present in air and water in areas where residents are experiencing health symptoms consistent with such exposures; (2) there is a strong likelihood that residents who are experiencing a range of health problems would not be if widespread gas development were not occurring; and (3) by permitting widespread gas development without fully understanding its impacts to public health—and using that lack of knowledge to justify regulatory inaction—Pennsylvania and other states are risking the public’s health.

This project documented health symptoms and the presence of air contaminants at longer distances from gas facilities than in other locations where similar projects have been conducted.<sup>42</sup> This could be because the previous air testing was conducted in a limited geographical area very close to facilities, while the surveys and testing in Pennsylvania took place in areas where wells and facilities are more spread out. This could also help to explain why Pennsylvania residents who don’t have gas facilities located on their own properties often report health problems and indicates that air contaminants and odors can travel further than might have previously been assumed.

Because of the short-term nature of the air canister testing (24 hours) and the single water tests conducted at households, our results reflect conditions at particular “moments in time.” Factors such as the stage of drilling, weather conditions, wind speeds, topography, geology, and whether facilities are in operation or shut down may have an impact on the testing results. In addition, some chemicals may have been present in water or air below detection limits or prior to when the tests were conducted, meaning that other exposures may have also occurred that caused the reported symptoms. Given this, more continuous testing over longer periods of time and at additional locations would likely reveal different chemicals, chemical concentrations, and associations with health impacts.

A related consideration for future research is the wide variation of results, and therefore conclusions about the presence and levels of chemicals, that occur depending on the laboratory used. This project used three laboratories to supply canisters and analyze samples (a step taken to compare the capacity and protocols of labs and to have “back up” should one of the labs have proven inadequate). However, while all the labs tested for the same core suite of chemicals, testing for other chemicals and the reporting limits for detection varied. In addition, the labs did not all analyze the samples for the same VOCs. For example, only Columbia Analytical analyzed for Acetone and 2-Butanone, while only Pace Analytical analyzed for n-Hexane and Total Hydrocarbons as gas.

More research is warranted to establish connections between reported health problems and particular events related to gas operations, such as chemical spills, leaking waste pits, and flaring and venting. This could include, for example, examination of case files compiled by regulatory agencies, interviews with residents near the facilities where problems occurred, and daily odor and symptom logs kept by residents.

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**More continuous testing over longer periods of time and at additional locations would likely reveal different chemicals, chemical concentrations, and associations with health impacts.**

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Photo by: Frank Finan

## 3 Missing pieces

*Public health was not brought into discussions about shale gas extraction at earlier stages; in consequence, the health system finds itself lacking critical information about environmental and public health impacts of the technologies and unable to address concerns by regulators at the federal and state levels, communities, and workers...*

—Institute of Medicine at the National Academies of Science<sup>43</sup>

### 3.1. SCIENCE AND TESTING

Simply put, scientific investigation has not been able to keep pace with the rapid expansion of potential pathways of exposure and associated risks of gas development. Widespread interest by the health, medical, and environmental research community in examining the impacts of oil and gas development is relatively recent, perhaps coincident with the geographic expansion of activities and increased risk of impacts.

In addition, environmental testing and monitoring has long been primarily conducted for a limited number of air contaminants and in areas of high population density,<sup>44</sup> while testing at oil and gas facilities in states like Pennsylvania began only recently.<sup>45</sup> The result is a lack of data on which to base health-related research or for use by agencies charged with protecting health and air and water quality. Further, only a few states require any kind of baseline water testing before drilling begins, and this information is largely not accessible to the general public.<sup>46</sup> This makes it difficult for researchers, regulators, and communities to establish clear connections after gas operations begin.

People living in oil and gas development areas day in and day out—as well as workers at job sites where hazardous substances are continuously used—are subjected to chronic, long-term exposure to multiple toxic substances from a number of facilities. Yet this experience is often not reflected in the standards used to determine the impacts of chemicals and the relative safety or risk of exposure to them through both air and water.<sup>47</sup> In turn, this calls into question reference to these standards (including by the gas industry and regulators) as a basis on which to judge the “risk” and “safety” of operations or to claim that evidence of harm does not exist. As summarized by the Agency for Toxic Substances and Disease Registry, “...most toxicological testing is performed on single chemicals, but human exposure is rarely limited to single chemicals...A particular issue is whether a mixture of components, each of which is present at less than guidance concentrations, may be hazardous due to additivity, interactions, or both.”<sup>48</sup>

Similarly, risk assessments for many chemicals use a high dose

**People living in oil and gas development areas and workers are exposed to multiple toxic substances from a number of facilities. Yet this experience is often not reflected in the standards used to determine the safety or risk of exposure.**



Well equipment close to home.

Photo by: Nadia Steinzor



as the starting point for calculating levels at which negative effects can be observed—potentially minimizing the exposure risks of low doses of many chemicals.<sup>49</sup> A recent paper, for example, showed that endocrine disrupting chemicals can have different but still harmful effects at low doses than at high ones, concluding that fundamental changes in chemical testing and safety protocols are needed to protect human health.<sup>50</sup> In addition, many chemicals have not yet been studied with regard to their health impacts. For example, as stated in a study on air toxics by the University of California-Berkeley School of Public Health, “Of the 188 hazardous air pollutants (HAPs) listed in the Clean Air Act, only a handful have information on human health effects. Lack of consistent monitoring data... makes it difficult to assess the extent of low-level, chronic, ambient exposures to HAPs that could affect human health.”<sup>51</sup>

Finally, many areas of the country already have compromised air and water quality from various sources, such as traffic, agriculture, industry, and even previous mining and fossil fuel development. Today’s oil and gas operations add even more chemicals and pollutants to the environment. For individuals with underlying conditions (e.g., asthma, heart conditions, or cancer), this can potentially cause a “trigger effect” and result in both new and the worsening of old health problems.

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## EMERGING KNOWLEDGE

Recent research has begun to establish links between oil and gas operations and health, including:

- A 2011 review of over 600 known chemicals used in natural gas operations concluded that many could have long-term health impacts, including on skin, eyes, and kidneys and respiratory, gastrointestinal, brain/nervous, immune, endocrine, and cardiovascular systems, as well as causing cancer and mutations.<sup>52</sup>
- A 2012 study in Colorado based on air sampling data showed that due to the toxicity of air emissions near natural gas sites, residents living closer to the sites had a greater risk of health-related impacts than those living further away.<sup>53</sup>
- A 2012 paper documented cases in which animals (both livestock and pets) exposed to natural gas operations and related toxic substances suffered negative health impacts and even death.<sup>54</sup>

## 3.2. POLICY AND REGULATION

Public health has not been a priority for policymakers making decisions about gas development. In just the last year, Maryland, Pennsylvania, and the U.S. Secretary of Energy established commissions to study the impacts of shale gas development, but none of the more than 50 members on these official bodies had health expertise.<sup>55</sup> In addition, New York's multi-year review of Marcellus Shale drilling has to date failed to analyze health impacts.<sup>56</sup>

Regulators do not require companies to provide information on potential health impacts in energy proposals and permit applications. Some associated concerns (such as traffic and noise) are often included in federal Environmental Assessments and Environmental Impact Statements, or when laws in 17 states spur similar analyses.<sup>57</sup> But only a few Health Impact Assessments (HIAs) have been conducted in the United States specifically on oil and gas development.<sup>58</sup>

Special exemptions for the oil and gas industry in sections of seven federal environmental laws compound the neglect of public health impacts in decisionmaking. Most notable is the ability of operators to keep secret the chemicals and chemical concentrations used in hydraulic fracturing (Safe Drinking Water Act); to measure air emissions based on single facilities, even if several make up a single operation (Clean Air Act); and to avoid classification (and thereby stringent transport and disposal requirements) of produced solid waste and wastewater as hazardous (Resource Conservation and Recovery Act).<sup>59</sup> These loopholes are replicated on the state level, where regulations developed for limited conventional drilling—in particular with regard to setbacks and waste disposal—are inadequate to address the complexity and intensity of shale gas development.

In addition, a crisis is underway in oil and gas industry monitoring and enforcement, likely adding to the pathways of pollution that are left undocumented and unaddressed. In a comprehensive analysis of programs in six states (Colorado, New Mexico, New York, Ohio, Pennsylvania, and Texas), Earthworks' OGAP found that regulatory agencies have been unable to keep up with oversight of existing wells, let alone the boom in shale gas development.<sup>60</sup> In Pennsylvania specifically, OGAP found that 86 percent of active wells were not inspected in 2011; violations by many operators are getting worse with time; the rate of enforcement has been declining; and penalties are too weak and inconsistent to have a deterrent effect.<sup>61</sup>

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**Special exemptions for the oil and gas industry in sections of seven federal environmental laws compound the neglect of public health impacts in decisionmaking.**

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Photo by: Frank Finan

## 4 Recommendations

The shale gas boom reflects a glaring mismatch in timing: knowledge about health and environmental impacts—and changes in policies and regulations to address them—are evolving slowly, while development is rapid and widespread.

**Because of this, our primary recommendation is that Pennsylvania (and other states) should put public health first and refuse to permit new gas development until they can assure affected communities that they (a) fully understand the associated public health risks and (b) have taken all necessary steps to prevent those health risks.**

To this end, the following measures can help prevent the further degradation of public health and air and water quality.

**GIVE PUBLIC HEALTH A CENTRAL ROLE IN GAS DEVELOPMENT DECISIONS.** States should conduct HIAs to analyze both problems that could arise over time and existing health and environmental risks that could be exacerbated by industrial activities.<sup>62</sup> Because HIAs help identify measures related to toxic exposure, air and water pollution, emergency response, and other aspects, their conclusions can (if adopted) help prevent problems from occurring in the first place.<sup>63</sup>

**INVOLVE STATE AND COUNTY DEPARTMENTS OF HEALTH.** These agencies should have the resources necessary to track reports of health problems near gas facilities and to respond to citizen complaints (e.g., through a database and online and telephone systems). Health departments could also train health and medical professionals on exposure pathways and symptoms related to gas operations, so that residents can receive informed advice and appropriate testing and care referrals.<sup>64</sup> The DEP and the Pennsylvania Department of Health (DOH) should establish an agreement to document and respond to spills of chemicals and waste, the underground migration of fracturing fluids, leaks, and other problems that could give rise to health problems. Financial assistance should be available for low-income residents whose health may be affected by gas operations to receive blood and urine tests for chemical exposure.

**PLAN AND PACE PERMITS.** Regulatory agencies like the DEP should have a long-term, comprehensive plan for the scope and pace of permits issued for wells and other facilities, rather than simply reviewing and approving them on a one-by-one basis. As part of this process, vital information on air and water quality concerns and pollution sources should be considered and, in turn, be factored into decisions on where wells and facilities can be built—particularly in relation to places where health would be most at risk, such as homes, schools, hospitals, and agricultural areas.

**STRENGTHEN REGULATIONS.** Among the most critical measures for Pennsylvania (as well as other states) to consider are significant increases in setback distances from facilities; requirements for operators to install and use advanced technologies to reduce emissions, odors, and noise; the replacement of open impoundment pits with closed-loop systems to store waste and drilling fluids; and required “green completions” to eliminate flaring and venting of methane gas and other pollutants.

**CLOSE THE ENFORCEMENT GAP.** Inadequate oversight of gas operations means that risks and damage to air and water quality are frequently not documented and measures not taken to ensure accountability, deter offenders, and prevent problems from occurring. Key steps include binding,



effective inspection protocols, inspection schedules, and wells-to-inspector ratios; significantly higher fines and penalties for violations; and more timely, thorough responses to citizen reports of problems.

**REVERSE SPECIAL EXEMPTIONS IN KEY PROVISIONS OF U.S. ENVIRONMENTAL LAWS.** These loopholes allow oil and gas operators to avoid rules that every other industry must follow and make it difficult to fully identify and calculate impacts to air and water quality and health. In turn, this skews information on the relative costs and benefits of gas development and slows action to prevent impacts. Closing them would increase the availability and transparency of information on contaminants and exposures and make it possible to resolve remaining questions about health impacts.

**CONDUCT BASELINE WATER TESTING AND CONTINUOUS AIR MONITORING.** Baselines should be done for both private wells and public drinking water supplies prior to drilling and (for air) at or near facilities during all phases of operations. Tests should cover a full suite of chemicals and results should be available to the public.<sup>65</sup> Air quality testing should be conducted at a range of facilities (e.g., well heads, compressor stations, and impoundment pits) that cause emissions and at distances both close to and further away from homes, schools, and other locations. The DEP or the DOH could jointly oversee the testing using independent laboratories.

**DEVELOP NEW TESTING MEASUREMENTS.** Federal agencies (in particular the Centers for Disease Control and Prevention, the Environmental Protection Agency, and the Occupational Safety and Health Administration) should develop guidelines for interpreting air and water tests that take into account simultaneous exposure to multiple chemicals. Drinking water and air standards should be developed for those chemicals for which none currently exist. Public agencies should advocate for giving low-level, chronic exposure greater prominence in policy decisions. The public health research community can help improve understanding of current types of exposure and advance data and protocols that better reflect conditions in gas development areas.

**PROHIBIT NON-DISCLOSURE AGREEMENTS (NDAS).** Often used in legal settlements involving business activities and intellectual property protection, NDAs have in recent years become widespread in oil and gas damages cases as part of negotiations over such aspects as monetary compensation and medical expenses.<sup>66</sup> As a result, documentation, testimony, and information critical to understanding and preventing health and environmental impacts are often not available. A possible solution would be public policies that preclude NDAs from covering factual statements and data in court filings and during discovery, or to require parties to present reasons why facts related to health and safety should be concealed before an NDA can be entered into.

## 5 Final words

*While we realize that human activities may involve hazards, people must proceed more carefully than has been the case in recent history. Corporations, government entities, organizations, communities, scientists and other individuals must adopt a precautionary approach to all human endeavors...When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically.*

–Wingspread Consensus Statement on the Precautionary Principle <sup>67</sup>

Across the oil and gas patches of the United States, people experiencing health problems voice the simple wish to be believed. Numerous participants in this project—and others in similar situations nationwide—report that their health has declined since gas development began nearby. Despite frequent statements by policymakers and regulators about the “potential” of “future” impacts, problems are happening right now, in Pennsylvania and across the gas patches of the United States. For many people, the situation has grown dire and urgent.

Social, economic, and political pressures often mean that industrial activities are allowed to happen long before their impact on health and safety is fully understood. Without a doubt, more research on the environmental and health dimensions of shale gas development is needed and can play a central role in ongoing decisions about complex and controversial energy issues. Yet an equally valid concern is the need for response even in the face of unanswered questions. To date, reports of health impacts and the situations of individuals—despite continually growing more widespread and serious—have not been defined as evidence or taken seriously enough to spur action and change.

For many proponents of unfettered gas development, the absence of incontrovertible evidence of direct links between gas facilities and specific health impacts amounts to proof that no harm exists. But for the individuals whose lives, families, and homes are at risk—as well as many others who believe health and the environment always deserve protection—what we don’t yet know only strengthens the need for caution.

The precautionary principle is warranted when it comes to both current and future gas and oil development. In particular, this means shifting the burden of proof of whether harm is being caused to those proposing the action—the gas industry and promoters of gas development at all levels of policymaking—rather than it continuing to be borne by those directly, and negatively, affected.

**Policymakers and regulators often speak of the “potential” of “future” impacts—but problems are happening right now in Pennsylvania, and across gas patches of the United States. For many people, the situation has grown dire and urgent.**



Photo by: Frank Finan

Earthworks' OGAP believes that corporations should be allowed to extract and process gas and other mineral fuels *only* if they can do so without harming human health or contaminating the air, water, and soil—with an eye to impacts at the local, regional, and global levels. This means:

1. **No Water Pollution:** protect public health, the environment, and the climate from toxic, hazardous, and carcinogenic chemicals used in the extraction of fossil fuel energy resources.
2. **Low Emissions:** protect public health, the environment, and the global climate from pollutants emitted during drilling and ongoing production of energy resources.
3. **No-Go Zones:** protect sacred areas, fragile ecosystems, neighborhoods, drinking watersheds, and densely populated areas targeted for energy development.
4. **Landowner and Community Consent:** continue to develop and then implement laws and policies making surface and mineral estates co-equal and ensuring that landowners have the right to negotiate and say “no” to energy development, and that communities wishing to restrict or prohibit development have the ability to do so.
5. **Prioritize Renewable Energy:** a comprehensive energy policy should work towards a long-term phase-out of fossil fuels in favor of energy efficiency and renewable sources like solar and wind.

These goals are achievable if decisionmakers are willing to slow the rush to drill, and if industry stops denying the serious problems left in its wake and instead invests the resources and time needed to fix and prevent them. The findings of this health survey and environmental testing project—coupled with similar patterns reported elsewhere and an emerging body of scientific and community-based research—provide a sufficient basis for strong action without further delay. Only then will the residents of Pennsylvania, and every other gas and oil producing state, be reassured that their health is not an acceptable casualty of fossil fuel use, but instead a basic and vital need deserving of protection.



## 6 Real people, real lives

This section profiles some of the people who participated in this study. There are many similar stories being told in Pennsylvania and other states that have been widely reported elsewhere. Some participants in this project requested anonymity and said they fear reprisals or legal problems if they speak out.

### ANGEL AND WAYNE SMITH, BEDFORD COUNTY

If proof is ever needed that gas development comes in many forms, it can be found on the Smith farm. Old gas wells drilled decades ago into the Oriskany Sandstone are now being used to store more recently produced gas. But the results of this process haven't stayed underground, and a well and compressor station were recently built nearby.

By 2007, Angel and Wayne knew something was changing, and very wrong. First their well water turned brown. Then water started bubbling up through their barn floor and an oily sheen and foam appeared on their pond. A strong propane odor laced the air. Headaches, nosebleeds, fatigue, sinus problems, throat and eye irritation, and shortness of breath soon set in. In the space of several months, a horse and three cows died and twelve calves were either miscarried or stillborn—a loss of animals unprecedented in the Smiths' many years of farming. Angel and Wayne's own health problems multiplied and trips to doctors are now routine.

"I'm often told to stop fighting what's happening because we get some royalties from the gas storage, but it hasn't been about the money in a really long time," says Angel. "It's about operators doing the right thing for people who have been harmed. We just want our lives, our land, and our health back."



Angel and Wayne Smith at their farmhouse.

Photo by: Nadia Steinzor

**"It's about operators doing the right thing for people who have been harmed. We just want our lives, our land, and our health back."**

## JANET AND FRED MCINTYRE, BUTLER COUNTY

For several months, the McIntyres hadn't been happy about the heavy traffic, intense odors, and the waste pits and rigs dotting surrounding farmland. But the turning point came when the entire family became sick after a meal that included glasses of tap water. Then the water in the kitchen and bathroom turned soapy and foamy and a dog suddenly died.

For Janet and Fred and many of their neighbors with similar problems, the quest for answers and help has been long, hard, and frustrating—and is far from over. Thanks to a weekly water drive supported by organizations, local residents, and churches, the McIntyres and their neighbors have bottled water to drink, but still have to bathe and do laundry in water that could be contaminated. While some ailments have abated, Janet, Fred, and their young daughter continue to have rashes, breathing problems, fatigue, eye and throat irritation, and headaches. Some previous health conditions have also grown worse.

"I had good water before, but now everyone around here has an issue with their well or health. Something's clearly not right," says Janet. "Can I put my finger on it and prove the precise cause beyond a doubt? No, but the only thing that's changed around here is gas drilling."



Janet helps coordinate the ongoing water drive for families in her community whose drinking water went bad after drilling began.

Photo by: Jason Bell

**"Now everyone around here has an issue with their well or health."**



## JENNY AND TOM LISAK, JEFFERSON COUNTY

On a warm summer day nearly 30 years ago, Jenny and Tom claimed their slice of heaven, purchasing a historic farmhouse surrounded by fields. Over the years, their hard work and determination paid off and Ladybug Farm, a certified organic produce farm, was born. So were three children, who grew up loving nature.

A few years ago, the Lisaks came face-to-face with an unexpected and unwelcome change to their environment, as Marcellus Shale operations got underway. First there was constant truck traffic, then wells were drilled not far from their house and crops. The Lisaks began to wake up to the strong smell of diesel and would experience frequent headaches, fatigue, sore throats, and eye and nose irritation whenever they were near gas facilities in the area. When a permit was issued for an impoundment pit and gas well on the property adjacent to their farm, stress, irritation, anxiety, and sleeping problems also set in.

“When living in the country, your time is marked by nature and each season comes with its own smells, sounds, and colors. But those colors have faded and our well-being, livelihood, and dreams are now threatened,” says Jenny. “I strongly object to being forced to breathe toxic fumes and other unhealthy conditions, and to my family facing the possibility of one day becoming refugees from our own home.”



Lisak family on their farm.

Photo by: Jason Bell

**“We are facing the possibility of one day becoming refugees from our own home.”**

## PAM JUDY, GREENE COUNTY

When Pam Judy and her husband built their dream house in 2006, they truly came home—settling on property that once belonged to her great grandparents and remained part of the family farm. Country life was going great until an unwelcome neighbor moved in just 800 feet away: a large gas compressor station.

At first, the resulting noise, odors, and emissions took away peace and quiet—and then also the entire family's health. Both parents and children became extremely tired and began to have severe headaches, runny noses, sore throats, and muscle aches. Pam has also experienced dizziness and vomiting. Everyone noticed that they felt better when they were away from home, and started avoiding being outside in their yard or on their porch.

Air testing (including by the Pennsylvania Department of Environmental Protection) in the Judy's yard and around the compressor station revealed the presence of a cocktail of chemicals, including known carcinogens like benzene, toluene, and xylene, and several others linked to symptoms the family was experiencing.

"It's bad enough feeling sick so much of the time, but we also have to worry about the serious health problems, like cancer, that prolonged exposure to emissions could cause," says Pam. "State and federal officials must take the complaints of residents seriously and demand that industry change its practices. By the time the dangers become completely clear, it will be too late for many people."



Pam at the compressor station near her home.

Photo by: Mark Schmerling

**"By the time the dangers become completely clear, it will be too late for many people."**

## PAT KLOTZ, BRADFORD COUNTY

Fresh air and the outdoors have always been important to Pat Klotz, who for many years had a large garden and kept horses. Even after moving, she's stayed active caring for rescued dogs, renovating her home, and working as a home health aide. Which is why it felt so strange to get bad headaches and feel exhausted much of the time.

Then Pat started keeping track of what happened when—and concluded that her health began to decline soon after a gas well went in upslope behind her house. Every once in awhile, the air would smell like sulfur, and soon after she'd start having trouble breathing, get dizzy, or feel intense burning in her eyes and throat. Sometimes she'd get a strange metallic taste in her mouth or sudden leg cramps.

Relatives who live near gas facilities several miles away told Pat they were having the same symptoms, including sudden dental problems. Both households had dogs that would suddenly become lethargic and have seizures. When they all stopped drinking the tap water—which began to sometimes run fizzy and turn black in 2010—both people and animals felt better.

"Living in the country is supposed to be good for you, but our sense of peace and tranquility ended when drilling started," says Pat. "The doctors don't know what to do, even though more and more people have the same symptoms. Elected officials don't take our complaints seriously. So we're still here waiting for help."

**"Doctors don't know what to do and elected officials don't take our complaints seriously."**

## JANET AND CHRIS LAUFF, WASHINGTON COUNTY

To Janet and Chris Lauff, the property was perfect, with a rolling meadow ringed by forest and a stream. They bought it, built a house, and raised their young children. But nearly 15 years later, they're thinking about moving—that is, if anyone will buy the place (which isn't leased) with two well pads and a wastewater impoundment next door.

**"I just want to get my family out of here to a better place."**

This shift has been rather sudden, with quality of life affected in just the last few years, and conditions deteriorating rapidly in the last several months. The Lauffs date the start of their problems to when an access road to the well pads and the impoundment went in upslope behind their house. Now the impoundment is used 24/7 and truck traffic has become constant.

These events have brought bad odors, nose and throat irritation, and headaches. One of the Lauff's sons has asthma, raising concerns of how exposure to chemicals is affecting his health. At times, the odors have been so severe that the family has left home, and in 2010, the water from their well stopped running entirely. They've also found dead raccoons, fox, and deer near their stream. Both Janet and Chris—who holds degrees in biology and chemistry and has worked in the chemical and gas industry for 30 years—know such events can signal deeper health and environmental problems.

"It's impossible to know how much we're affected day-to-day and what that means for the future," says Janet. "Gas development changes your whole life. Your privacy is gone. Your peace of mind and sense of security are gone. I've been pretty calm until now, but after dealing with the odors, noise, dust, water, and air issues for almost three years, I just want to get my family out of here to a better place."



## LINDA AND DAVID HEADLEY, FAYETTE COUNTY

In rural Fayette County, big changes usually come slowly. After nearly 30 years in the area, Linda and David Headley were accustomed to a quiet, serene way of life, and the farm they bought seven years ago was the perfect place to settle with their two sons.

But just weeks after moving in, the Headleys were hit hard by the reality of not owning the oil and gas rights on their property. First it was the truck traffic and heavy equipment; then came the gas wells, separator tanks, and impoundment pit; and more recently a pipeline cutting across hayfields. Along with all this have been fuel spills, noise, bad odors, and a spring that started bubbling and can be lit on fire.

It wasn't only the Headley's property that was transformed—their health also changed. Linda has constant sore throats and coughing spells. Grant and Adam have bouts of intense stomach pain and nosebleeds. Everyone gets headaches and red, itchy skin after spending time outdoors. Even the Headley's horses have been affected, with brittle hooves and sore feet. And as Linda and David began talking to neighbors about the changes sweeping the community, it became clear that such symptoms were widespread.

"Our once peaceful existence has forever changed. We aren't getting answers about why our land is being damaged and so many people are sick," says Linda. "The industry is a loose cannon and regulators seem to be helpless in the face of all the development. If we could put a man on the moon decades ago, we can surely find a better, safer, healthier way to fuel our future."



Linda and David watch pipeline construction across their hayfields.

Photo by: Roberto M. Esquivel / Herald-Standard

**"If we could put a man on the moon decades ago, we can surely find a better, safer, healthier way to fuel our future."**

## CAROL FRENCH, BRADFORD COUNTY

As lifelong farmers, Carol French and her significant other Claude Arnold know what it's like to be tired at the end of a hard day's work. So they didn't think twice about how fatigued they were and how their bones ached. But then they began to wonder if it might be connected to the rashes, shortness of breath, and headaches they also were experiencing..

Fortunately, Carol knew what questions to ask and where to look for answers. A co-founder of Pennsylvania Landowner Group for Awareness and Solutions, she was spending every free moment learning about the impacts of gas development and sharing that knowledge with others. She also kept track of problems that arose with leases—including her own—and on properties where drilling was taking place.

Yet nothing could prepare Carol and Claude for when their own water went bad in 2011. Carol started tracking the timing of when it would run white, settle with a mossy substance on top of sand, or become like gelatin, and when nearby drilling activities and the family's health symptoms occurred. Her daughter Lynsey—who has an autoimmune disease that the family doctor said could make her more susceptible to chemical exposure—was hospitalized with a high fever, severe weight loss, and intense abdominal pain, and was found to have an enlarged liver and spleen and fluid retention. Once she recovered, she moved away and hasn't been sick since. In the meantime, several dairy cows have developed rashes and sores, and Carol and Claude continue to have skin and respiratory problems.

"Gas proponents dismiss and deny stories like ours, and some even say that developing the resource is so important that it's worth 'necessary sacrifice,'" says Carol. "But what gives them the right to decide whose health, family, property, and livelihood should be sacrificed?"



Carol French

Photo by: Nadia Steinzor

**"What gives gas proponents the right to decide whose health, family, property, and livelihood should be sacrificed?"**

## CAROL JEAN MOTEN AND DEBBIE PEEPLES, WASHINGTON COUNTY

The neighborhood where sisters Carol Jean Moten and Debbie Peeples have lived nearly their whole lives is tight-knit, with modest houses along a few streets where everyone knows and helps each other. Residents also long appreciated the quiet and fresh air that comes from living next to a county park—that is, until much of the park was leased for gas drilling and several well pads went in where trees once stood.

Soon after gas development began, the water in Carol, Debbie, and their mother Edna’s homes turned odd colors. A neighbor found sand coming through pipes into the sink. Periodically, often at night, the air would get hazy and gas and chemical smells would blow downhill from the park.

For Carol and Debbie, these episodes meant the onset of symptoms like headaches, shortness of breath, burning eyes and throat, dizziness, and disorientation. Carol, an artist, started having difficulty painting. Over time, both sisters developed skin lesions and often felt weak and tired. And they began to wonder if illnesses among cats and dogs in the neighborhood could be related.

“My family drank the water for a long time and now we’re breathing bad air. But the exposure is low-dose and doesn’t fit the criteria to gauge harm,” says Carol Jean. “Even a toxicology doctor told me that the only thing I can do is leave my home and move away. When it comes to hydrofracturing, there is no justice.”



Carol Jean Moten (right) with her mother Edna.

Photo by: Martha Rial

**“Even a toxicology doctor told me that the only thing I can do is leave my home and move away.”**

## 7 Endotes

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<sup>3</sup> A. Lustgarten, “Drill for natural gas, pollute water.” *Scientific American*, November 17, 2008.

<sup>4</sup> R. Witter et al., *Potential Exposure-Related Human Health Effects of Oil and Gas Development: A White Paper*, Colorado School of Public Health, University of Colorado, and Colorado State University Department of Psychology, 2008.

<sup>5</sup> Colborn, T., Kwiatkowski, C., Schultz, K., and Bachran, M. “Natural gas operations from a public health perspective.” 2011. *Human & Ecological Risk Assessment* 17(5):1039-1056.

<sup>6</sup> Witter, R., Stinson K., Sackett H., et al. *Potential Exposure-Related Human Health Effects of Oil and Gas Development: A Literature Review (2003-2008)*. Colorado School of Public Health, 2008.

<sup>7</sup> “Loopholes for Polluters: The oil and gas industry’s exemptions to major environmental laws.” Earthworks, 2011. [http://www.earthworksaction.org/library/detail/loopholes\\_for\\_polluters](http://www.earthworksaction.org/library/detail/loopholes_for_polluters)

<sup>8</sup> Durham, L.S. March, 2008. “Appalachian Basin’s Marcellus—the new target.” *Explorer*. American Association of Petroleum Geologists.

<sup>9</sup> “Marcellus Shale—Appalachian Basin Natural Gas Play.” *Geology.com*: <http://geology.com/articles/marcellus-shale.shtml> (accessed June 19, 2012).

<sup>10</sup> “Learn about the Marcellus Shale.” Pennsylvania Independent Oil and Gas Association. <http://www.pioga.org/marcellus-shale/> (accessed June 19, 2012).

<sup>11</sup> Based on data from “Oil and Gas Reports.” Pennsylvania Department of Environmental Protection. [www.portal.state.pa.us/portal/server.pt/community/oil\\_and\\_gas\\_reports/20297#InteractiveReports](http://www.portal.state.pa.us/portal/server.pt/community/oil_and_gas_reports/20297#InteractiveReports) (accessed September 10, 2012).

<sup>12</sup> “Community Health Survey of Current and Former Residents of DISH, Texas.” Earthworks OGAP, 2009. <http://earthworksaction.org/publications.cfm?pubID=438>; and “Community Health Survey Results of Pavillion, Wyoming.” Earthworks OGAP, 2010. [http://earthworksaction.org/PR\\_PavillionHealthSurvey.cfm](http://earthworksaction.org/PR_PavillionHealthSurvey.cfm)

<sup>13</sup> *Natural Gas Flowback: How the Texas gas boom affects community health and safety*. Earthworks’ OGAP, 2011. [http://www.earthworksaction.org/library/detail/natural\\_gas\\_flowback](http://www.earthworksaction.org/library/detail/natural_gas_flowback)

<sup>14</sup> All survey participants were assured by OGAP that their identifying information (e.g., name and address) would be kept confidential and not used for any other purposes than this project, including to follow up with additional questions, respond to requests for assistance, or to provide additional resources.

<sup>15</sup> Specific symptoms within each of the main categories included: SINUS/RESPIRATORY (loss of sense of smell, shortness of breath, hoarseness, asthma, sinus problems, abnormal lung function, difficulty breathing, persistent cough, wheezing, allergies, nasal irritation, throat irritation, coughing up blood/sputum). BEHAVIOR/MOOD/ENERGY (increased fatigue, feeling weak & tired, extreme drowsiness, sleep disorders, sleep disturbances, depression, loss of sexual drive, fainting, judgment problems, behavioral changes, suicidal thoughts, personality changes, severe anxiety, tension, compulsive behavior, agitation, difficulty with activities, appetite disturbances, frequent irritation). NEUROLOGICAL (memory loss, amnesia, forgetfulness, spelling difficulties, decreased motor problems, difficulty drawing, staggering/stumbling, falling nerve damage, tremors, seizures, weakness of hands, trembling of hands, tingling of hands, disorientation, hallucination, dizziness, balance difficulty, slurring of speech, difficulty concentrating). MUSCLES/JOINTS (swollen or painful joints, arthritis, muscular pain, muscle aches, lumbar pain, weakness, reduced strength). EAR/NOSE/MOUTH (deafness, hearing loss, ringing in ears, difficulty hearing, frequent nosebleeds, noises in ears, loss of sense of taste, discoloration of teeth, metallic taste on cough, gingivitis, redness/swelling/dyscoloration of gums, severe salivation, mouth sores or ulcers). DIGESTIVE/STOMACH (abdominal pain, rectal bleeding, change in bowel habits, black stool, red blood in stool, diarrhea, persistent indigestion, frequent nausea, vomiting, vomiting blood, loss of appetite, weight loss. SKIN (persistent problems; rashes, irritation, hives, boils, changes in color, sores, discolored areas, dry/cracked/red areas, pinpoint dots, burns, contact dermatitis, eczema, peeling hands and arms, thickening, yellowing). VISION/EYES (eyes burning, burns on eyes, conjunctivitis, blurred vision, dry eyes, blindness in either eye, severe eye pain, chronic eye irritation, vision difficulty, vision decrease, frequent tearing of eyes, swelling of eyes, uncontrolled eye movement, loss of ability to see colors, trembling of eyelids, yellowing of eyes).

<sup>16</sup> A possible explanation is that, given the topography and forest cover in many parts of rural Pennsylvania, distances to facilities (which were largely reported by survey participants and, where possible using publicly available data, verified by the project coordinator) were not exact because they were not visually apparent. In addition, natural features, wind speed, and other factors can also determine how far chemicals can travel at any given point in time. It is also possible that those living farther away from facilities may have certain symptoms because they are more directly downwind and therefore have more consistent, longer-term exposure to airborne contaminants than those living even closer to facilities. Or, facilities closer to some of the survey respondents may have had better



pollution control technologies or were processing different qualities of gas (e.g., wet gas contains higher concentrations of liquid hydrocarbons than dry gas) and therefore were emitting fewer of the chemicals that could cause these symptoms.

<sup>17</sup> Not only the respiratory tract, but other organs as well are affected by air pollution. Thus volatile hydrocarbons and carbon monoxide are transported to the brain and heart via the blood. Symptoms such as headaches, giddiness, nausea and pounding of the heart are the first indications of excessive exposure. In addition, according to the Swiss National Air Pollution Monitoring network, headaches can be an early indicator of excessive exposure to air pollutants such as volatile organic compounds.

<http://www.bafu.admin.ch/publikationen/publikation/00652/index.html?lang=en&download=NHZlpZiq7t,Inp6l0NTU042l2Z6ln1ad1lZn4Z2qZpnO2YUq2Z6gpJCGdn99fGym162dpYbUzd.Gpd6emK2Oz9aGodetmqaN19Xl2ldvoaCVZ,s-.pdf>

<sup>18</sup> For example, frequent nosebleeds are more common among children because their mucous membranes are less developed. If there are toxic chemicals in the air, nosebleeds in children may be an early-warning sign of an excessive exposure. This symptom has been experienced by other children in oil and gas producing areas and reported in previous reports by Earthworks OGAP.

<sup>19</sup> Table includes all smokers. There were 27 smokers between the ages of 24 and 70. The table compares the results from the smoking sub-group to the sub-group of non-smokers who were between similar ages (23-70 years old). Not included in this calculation were 22 non-smokers who were either younger or older.

<sup>20</sup> Eight of the samples (23.5%) were analyzed by Pace Analytical Services, nine (26.5%) by Con-Test Analytical Laboratory, and seventeen (50%) by Columbia Laboratories.

<sup>21</sup> Some studies calculate the average/mean by including all samples, and for non-detects a value equal to 1/2 of the minimum reporting limit (MRL)/detection limit is used. (For example, see: Pennsylvania DEP. Southern Delaware County Report.

<http://www.dep.state.pa.us/dep/deputate/airwaste/aq/toxics/projects/sdel/sdelrpt3.pdf> We did not do that because the one laboratory, Pace Analytical, had MRLs that were often much higher than the values actually detected by the other two laboratories. So the means would have been skewed (i.e., most likely higher than actual ambient concentrations).

<sup>22</sup> Pace Analytical reporting limits were reported in parts per billion volume (ppbv). We converted ppbv to micrograms per cubic meters ( $\mu\text{g}/\text{m}^3$ ). To convert values we used equations from "Air Unit Conversion Table" (Torrent Labs)

<http://www.torrentlab.com/torrent/Home/ResourceCenter.html> and EnviroGroup  
<http://www.envirogroup.com/IA%20Unit%20Conversion%20Table.xls>.

<sup>23</sup> Even though we found more VOCs and higher concentrations of the chemicals in Washington County than other counties, this does not necessarily mean that Washington County has worse air quality than other counties in this study. More research would be needed to confirm that, especially given that more samples were taken in Washington than in other counties in our study, thus increasing the chances for detection of VOCs. It is also possible that in some places, sampling did not occur when facilities were emitting high concentrations of chemicals or precisely when the wind was blowing contaminants toward canisters.

<sup>24</sup> Ibid.

<sup>25</sup> According to DEP, the Marcus Hook ambient air sampling site was chosen because it is "close to several industrial facilities and near roads with high traffic volumes." PA DEP. 2003. *Southern Delaware County Air Monitoring Project. Third Interim Report.* p. 4.

[www.dep.state.pa.us/dep/deputate/airwaste/aq/toxics/projects/sdel/sdelrpt3.pdf](http://www.dep.state.pa.us/dep/deputate/airwaste/aq/toxics/projects/sdel/sdelrpt3.pdf) Data are for the 2010 monitoring year and were downloaded from DEP's website: [www.dep.state.pa.us/dep/deputate/airwaste/aq/toxics/sites/sdc.htm](http://www.dep.state.pa.us/dep/deputate/airwaste/aq/toxics/sites/sdc.htm) (both accessed September 20, 2012).

<sup>26</sup> For example, 1,1,2-trichloro-1,2,2-trifluoroethane, dichlorodifluoromethane, trichlorofluoromethane and chloromethane were once used as refrigerants and propellants but have been phased out due to destruction of the ozone layer. Carbon tetrachloride was used to produce these refrigerants but its production declined as use of the other chemicals was banned.

<sup>27</sup> See Pennsylvania Department of Environmental Protection, Northeastern Pennsylvania Marcellus Shale Short-Term Ambient Air Sampling Report; Northcentral Pennsylvania Marcellus Shale Short-Term Ambient Air Sampling Report, 2011; and Southwestern Pennsylvania Marcellus Shale Short-Term Ambient Air Sampling Report, 2010.

<sup>28</sup> U.S. Environmental Protection Agency. Ambient Air Concentrations of Benzene. In the "Metadata" section EPA explains that this does not necessarily represent a national trend because the data come from just 22 urban sites.

<http://cfpub.epa.gov/eroe/index.cfm?fuseaction=detail.viewind&lv=list.listbyalpha&r=231333&subtop=341> (accessed September 20, 2012).

<sup>29</sup> The five highest concentrations from our study were found in Butler: 1.5, 1.0  $\mu\text{g}/\text{m}^3$ ; and Washington: 1.5, 1.4, 1.2  $\mu\text{g}/\text{m}^3$ .

<sup>30</sup> U.S. Environmental Protection Agency. "Technology Transfer Network Air Toxics Site: Formaldehyde."

<http://www.epa.gov/ttn/atw/hlthef/formalde.html> (accessed September 20, 2012).

<sup>31</sup> C.D. Volz et al., Contaminant Characterization of Effluent from Pennsylvania Brine Treatment Inc., Josephine Facility Being Released into Blacklick Creek, Indiana County, Pennsylvania. Department of Environmental and Occupational Health, University of Pittsburgh, 2011.

<sup>32</sup> Pennsylvania Department of Environmental Protection, Division of Drinking Water Management, "Maximum Contaminant Levels," [www.portal.state.pa.us/portal/server.pt?open=18&objID=437830&mode=2](http://www.portal.state.pa.us/portal/server.pt?open=18&objID=437830&mode=2) (accessed July 20, 2012).

<sup>33</sup> Tom Myers, PhD. "Assessment of Groundwater Sampling Results Completed by the USGS." (Technical memo prepared for Earthworks, Natural Resources Defense Council, and Sierra Club. September, 2012.





<sup>34</sup>For example, according to the National Science Foundation, “Pennsylvania’s air, water and soils retain the signature of the steel industry and of coal-burning over the last century in their low-level manganese contamination.” National Science Foundation. Sidney Draggan, PhD (Topic Editor), “Can Marcellus Shale Development and Healthy Waterways Co-exist?” Last revised August 8, 2012 (accessed October 2, 2012). [http://www.eoearth.org/article/Marcellus\\_Shale\\_Gas\\_Development\\_and\\_Healthy\\_Waterways?topic=49463](http://www.eoearth.org/article/Marcellus_Shale_Gas_Development_and_Healthy_Waterways?topic=49463)

<sup>35</sup>Boyer, E., Swistock, B., Clark, J., Madden, M. and Rizzo, D. (Pennsylvania State University). 2011. *The Impact of Marcellus Gas Drilling on Rural Drinking Water Supplies*. The Center for Rural Pennsylvania. [http://www.rural.palegislature.us/documents/reports/Marcellus\\_and\\_drinking\\_water\\_2012.pdf](http://www.rural.palegislature.us/documents/reports/Marcellus_and_drinking_water_2012.pdf)

<sup>36</sup> *ibid.* p. 12.

<sup>37</sup> Banks, T. Jan. 2011. “Fluid Rock Interactions Associated with Hydraulic Fracturing and Natural Gas Development.” *Global Water Program Magazine*. (Johns Hopkins University) [http://globalwater.jhu.edu/magazine/article/fluid\\_rock\\_interactions\\_associated\\_with\\_hydraulic\\_fracturing\\_and\\_natural\\_gas/](http://globalwater.jhu.edu/magazine/article/fluid_rock_interactions_associated_with_hydraulic_fracturing_and_natural_gas/)

<sup>38</sup> ProChemTech International, Inc. “Marcellus Gas Well Hydrofracture Wastewater Disposal by Recycle Treatment Process.” [www.prochemtech.com/Literature/TAB/PDF\\_TAB\\_Marcellus\\_Hydrofracture\\_Disposal\\_by\\_Recycle\\_1009.pdf](http://www.prochemtech.com/Literature/TAB/PDF_TAB_Marcellus_Hydrofracture_Disposal_by_Recycle_1009.pdf) (accessed September 20, 2012).

<sup>39</sup> Boyer, E., Swistock, B., Clark, J., Madden, M. and Rizzo, D. (Pennsylvania State University). 2011. *The Impact of Marcellus Gas Drilling on Rural Drinking Water Supplies*. The Center for Rural Pennsylvania. [http://www.rural.palegislature.us/documents/reports/Marcellus\\_and\\_drinking\\_water\\_2012.pdf](http://www.rural.palegislature.us/documents/reports/Marcellus_and_drinking_water_2012.pdf)

<sup>40</sup>R. Witter et al., *Potential Exposure-Related Human Health Effects of Oil and Gas Development: A Literature Review (2003-2008)*. Colorado School of Public Health, 2008; and T. Colborn et al., “Natural gas operations from a public health perspective,” *Human & Ecological Risk Assessment* 17(5) (2011): 1039-1056.

<sup>41</sup> Agency for Toxic Substances and Disease Registry (ATSDR), “Toxicological Profiles,” <http://www.atsdr.cdc.gov/toxprofiles/index.asp> (accessed July 30, 2012); and New Jersey Department of Health, “Right to Know Hazardous Substance Fact Sheets,” <http://web.doh.state.nj.us/rtkhsfs/indexfs.aspx> (accessed July 30, 2012).

<sup>42</sup> “Community Health Survey of Current and Former Residents of DISH, Texas.” Earthworks OGAP, 2009. <http://earthworksaction.org/publications.cfm?pubID=438>; and Lisa Sumi, Earthworks’ Oil & Gas Accountability Project, “Air Sampling Conducted in Monroe, Conecuh, and Escambia Counties, Alabama,” 2007.

<sup>43</sup> “The Health Impact Assessment of New Energy Sources: Shale Gas Extraction.” Announcement and summary of meeting at the Institute of Medicine, April 30-May 1, 2012. See [www.iom.edu/Activities/Environment/EnvironmentalHealthRT/2012-APR-30.aspx](http://www.iom.edu/Activities/Environment/EnvironmentalHealthRT/2012-APR-30.aspx), (accessed June 27, 2012).

<sup>44</sup> U.S. Environmental Protection Agency. “Ambient Air Monitoring Program.” <http://www.epa.gov/airquality/qa/monprog.html> (accessed September 20, 2012).

<sup>45</sup> Clean Air Council. “PA DEP launches long-term air sampling.” [http://cleanair.org/program/outdoor\\_air\\_pollution/marcellus\\_shale/pa\\_dep\\_launches\\_long\\_term\\_air\\_sampling](http://cleanair.org/program/outdoor_air_pollution/marcellus_shale/pa_dep_launches_long_term_air_sampling) (accessed September 20, 2012).

<sup>46</sup> Pennsylvania law is unique in establishing a “zone of presumption,” by which operators of unconventional (i.e., shale) wells are responsible for pollution of a water supply if it is up to 2,500 feet away and the pollution occurred within 12 months of completion, drilling, stimulation, or alteration of the well. Operators are required to share this baseline information with homeowners. However, they can rebut the presumption under certain conditions. See “Act 13 Frequently Asked Questions,” Pennsylvania Department of Environmental Protection: [www.portal.state.pa.us/portal/server.pt/community/act\\_13/20789/act\\_13\\_faq/1127392](http://www.portal.state.pa.us/portal/server.pt/community/act_13/20789/act_13_faq/1127392), (accessed July 3, 2012). Colorado requires baseline surface water sampling in particular sensitive areas, downgradient of wells before and three months after drilling, operations, and completion; nearby landowners are provided with the test results: “COGA Baseline Groundwater Quality Sampling Program,” [www.coga.org/index.php/BaselineWaterSampling/FAQ](http://www.coga.org/index.php/BaselineWaterSampling/FAQ) (accessed August 15, 2012). Ohio requires permit applicants to conduct water sampling prior to drilling, at distances from wells of 300 feet in urban areas and 1,500 feet anywhere if horizontal drilling occurs. See summary of Senate Bill 315 by Ohio Department of Natural Resources: [www.ohiodnr.com/tabid/23947/Default.aspx](http://www.ohiodnr.com/tabid/23947/Default.aspx) (accessed July 6, 2012).

<sup>47</sup> See, for example, NIOSH Pocket Guide to Chemical Exposures (including recommended exposure limits), Centers for Disease Control and Prevention. [www.cdc.gov/niosh/npg/](http://www.cdc.gov/niosh/npg/); “National Primary Drinking Water Regulations” (including maximum contaminant levels), U.S. Environmental Protection Agency. <http://water.epa.gov/drink/contaminants/index.cfm>; “Permissible Exposure Limits,” U.S. Occupational Safety and Health Administration. [www.osha.gov/SLTC/pel/](http://www.osha.gov/SLTC/pel/) (all accessed July 20, 2012).

<sup>48</sup> Assessment of Joint Toxic Action of Chemical Mixtures. Guidance Manual. Agency for Toxic Substances and Disease Registry. 2004. Available at [www.atsdr.cdc.gov/interactionprofiles/ipqa.html](http://www.atsdr.cdc.gov/interactionprofiles/ipqa.html) (accessed July 20, 2012).

<sup>49</sup> Birnbaum, L.S. “Environmental Chemicals: Evaluating Low-Dose Effects.” *Environmental Health Perspectives*, 120(4):A143-144, 2012.

<sup>50</sup> Vandenberg, L.N., Colborn, T., Hayes, T.B., et al. “Hormones and Endocrine-Disrupting Chemicals: Low-Dose Effects and Nonmonotonic Dose Responses.” *Endocrine Reviews* 33: 0000–0000, 2012.

<sup>51</sup> Morello-Frosch, R.A., Woodruff, T.J., Axelrad, D.A., and Caldwell, J.C. “Air toxics and health risks in California: the public health implications of outdoor concentrations.” *Risk Analysis*, 20(2):273-91, 2000.



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- <sup>53</sup> McKenzie, LM., Witter, R.Z., Newman L.S., Adgate J.L.. "Human Health Risk Assessment of Air Emissions from Development of Unconventional Natural Gas Resources." *Science of the Total Environment*. 2012 May 1;424:79-87.
- <sup>54</sup> Bamberger, M. and Oswald, Robert E. "Impacts of Gas Drilling on Human and Animal Health." *New Solutions: A Journal of Environmental and Occupational Health Policy*. Vol 22(1)51-77, 2012.
- <sup>55</sup> Goldstein, B., Kriesky, J., Pavliakova, B. "Missing from the Table: Role of the Environmental Public Health Community in Governmental Advisory Commissions Related to Marcellus Shale Drilling." *Environmental Health Perspectives*. Vol 120(4)483-486, 2012.
- <sup>56</sup> Comments on New York's draft Supplemental Generic Environmental Impact Statement. Earthworks' OGAP. December 2011. [www.earthworksaction.org/library/detail/earthworks\\_new\\_york\\_sgeis\\_comments](http://www.earthworksaction.org/library/detail/earthworks_new_york_sgeis_comments)
- <sup>57</sup> "States with NEPA-like Environmental Planning Requirements." Council on Environmental Quality, National Environmental Policy Act website. [http://ceq.hss.doe.gov/state\\_information/states.html](http://ceq.hss.doe.gov/state_information/states.html) (accessed June 27, 2012).
- <sup>58</sup> The most notable examples are the North Slope of Alaska and Garfield County, Colorado. Health Impact Project, "HIA in the United States," [www.healthimpactproject.org/hia/us](http://www.healthimpactproject.org/hia/us), (accessed June 27, 2012).
- <sup>59</sup> Earthworks. "Loopholes for Polluters: The oil and gas industry's exemptions to major environmental laws." 2011. While some states have begun to adopt and strengthen disclosure laws, and industry has a website for limited, voluntary disclosure (see [www.FracFocus.org](http://www.FracFocus.org)), operators are still largely able to keep secret the types, mixtures, and concentrations of chemicals used and to claim proprietary "trade secret" privileges. See "Disclosure of toxic oil and gas chemicals," [www.earthworksaction.org/issues/detail/disclosure\\_of\\_oil\\_and\\_gas\\_hazardous\\_chemicals](http://www.earthworksaction.org/issues/detail/disclosure_of_oil_and_gas_hazardous_chemicals). On air emissions, see "The BREATHE Act," [www.earthworksaction.org/issues/detail/the\\_breathe\\_act](http://www.earthworksaction.org/issues/detail/the_breathe_act) (accessed July 3, 2012).
- <sup>60</sup> Earthworks' Oil & Gas Accountability Project. Breaking All the Rules: the crisis in oil and gas regulatory enforcement. 2012.
- <sup>61</sup> Earthworks' Oil & Gas Accountability Project. Enforcement Report: Pennsylvania Department of Environmental Protection. 2012.
- <sup>62</sup> A. Wernham, "Health Impact Assessment for Shale Gas Extraction," [www.healthimpactproject.org/resources/health-impact-assessment-for-shale-gas-extraction](http://www.healthimpactproject.org/resources/health-impact-assessment-for-shale-gas-extraction) (accessed July 10, 2012).
- <sup>63</sup> Garfield County, Colorado, "Battlement Mesa Health Impact Assessment," [www.garfield-county.com/environmental-health/battlement-mesa-health-impact-assessment-ehms.aspx](http://www.garfield-county.com/environmental-health/battlement-mesa-health-impact-assessment-ehms.aspx) (accessed July 10, 2012).
- <sup>64</sup> The Southwest Pennsylvania Environmental Health Project has prepared useful materials and presentations in this regard. See "Health concerns in the era of gas drilling—a basic toolkit for health care providers." [www.environmentalhealthproject.org/resources/medical-resources](http://www.environmentalhealthproject.org/resources/medical-resources) (accessed September 15, 2012).
- <sup>65</sup> Replacement water supplies should also be provided when changes in the quality and safety of drinking water occur following nearby gas operations—as required by Pennsylvania law but rarely enforced. See Pennsylvania Code, Oil and Gas Wells, Chapter 78, Section 51, "Protection of Water Supplies." <http://www.pacode.com/secure/data/025/chapter78/chap78toc.html> (accessed July 20, 2012).
- <sup>66</sup> Earthjustice, "Fracking Damage Cases and Industry Secrecy," <http://earthjustice.org/features/campaigns/fracking-damage-cases-and-industry-secrecy> (accessed July 10, 2012).
- <sup>67</sup> Science and Environmental Health Network, "Wingspread Consensus Statement on the Precautionary Principle," 1998, [www.sehn.org/wing.html](http://www.sehn.org/wing.html) (accessed July 18, 2012).



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