Public Health Dimensions of Horizontal Hydraulic Fracturing: Knowledge, Obstacles, Tactics, and Opportunities

A Report for the 11th Hour Project

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INTRODUCTION

The United States (US) sits on an estimated 482 trillion and 827 trillion cubic feet of natural gas with 141 trillion cubic feet stored in the Marcellus shale formation (which underlies parts of Pennsylvania, New York, West Virginia, Virginia, and Maryland) alone (EIA 2012). In the 1990s, powerful new drilling techniques allowed natural gas to be extracted from previously unexploited deep geological formations (shales, tight sands, and coal seams). Subsequently natural gas wells spread rapidly throughout the US, with especially high concentrations in Pennsylvania, Delaware, West Virginia, Wyoming, Colorado, and Texas. To date, Pennsylvania alone has issued nearly 9,000 natural gas drilling permits in the Marcellus Shale, with Bedford County, Pennsylvania alone host to more than 1,950 (Fractracker 2012).

The original natural gas extraction technique, developed in the 1940s (Haliburton 2012) (hereafter referred to as *traditional fracking*), consists the injection of fluids (usually a mixture of water, sand, and chemicals) under high pressure into oil and gas wells to more efficiently extract natural gas. However, the type of hydraulic fracturing employed more recently, was developed in the late 1990s and is called high-volume slick water horizontal hydraulic fracturing (hereafter referred to as *fracking*, *hydraulic fracturing*, or *horizontal hydraulic fracturing)*.

The primary differences between modern fracking and traditional fracking are that the modern form:

- Uses a **different mix of chemicals** including "friction reducers" (hence the term *slick*).
- **Drills deeper** (up to 3,000 feet vertically) into shale, and other formations,
- **Drills horizontally** into these formations (NY DEC 2009).
- Instead of using 20,000 to 80,000 gallons of water per fracking event, modern fracking uses between 2 and 7.8 million gallons of fluid (average **5 million gallons**) (NY DEC 1992; NY DEC 2009) – 70 to 300 times the amount of fluid used in traditional fracking.

Natural gas has been rapidly ushered into the US energy mix facilitated by the narrative that natural gas is a "bridge" or a "transition" fuel and will to help to navigate the US from a politically- and environmentally-dirty coal and fossil fuel-based economy to an economy that relies on cleaner renewable energy. However, this narrative has received substantial pushback from the environmental and public health arenas and by impacted communities as reports of air pollution, fouled drinking water wells, explosions, and industrial landscapes permeate and spread across rural America.

Significant knowledge gaps persist in the public health literature that hinder the work of non-governmental organizations (NGOs), community based organizations (CBOs), activists, academics, and integrated campaigns that aim to slow the growth and mitigate the risks of fracking. Therefore, the aim of this report is to explore the public health dimensions of hydraulic fracturing in the following areas:

1. The known public health risks posed by fracking.
2. The hurdles to identify public health threats associated with fracking.
3. The tactics that NGO, government, funders, etc. are using to identify these health threats.
4. Strategies to mitigate effects that have already been identified.
5. Recommendations for efforts that funders could support in these areas.

METHODS

Information and data included in this report was sourced from a combination of peer reviewed and grey literature, a survey, and a number of semi-structured and unstructured interviews with foundations, NGOs, CBOs, and other experts in the field.

Disclaimer: A common misconception is that public health concerns of fracking are rooted only in the process of hydraulic fracturing for natural gas in shale formations. Public health concerns of hydraulic fracturing are actually present throughout the entire supply chain of natural gas, as well as oil production. This report focuses on the extraction process of natural gas (especially shale gas and coal-bed methane) using modern horizontal hydraulic fracturing and predominantly excludes the issue of oil extraction. Additionally, although climate change has health consequences (Kovats and Haines 2005; McMichael, Woodruff et al. 2006; Bell, Goldberg et al. 2007; Patz, Campbell-Lendrum et al. 2008) most climate impacts associated with fracking are beyond the scope of this overview report.

CHAPTER 1: PUBLIC HEALTH THREATS POSED BY HORIZONTAL HYDRAULIC FRACTURING

Robust, quantitative data that describes the interactions between fracking activities and public health are relatively rare for a variety of reasons (see chapter 2). To be clear, a dearth of health data does not indicate a lack of legitimate health concerns. However, the lack of robust, causal data that links hydraulic fracturing to health has slowed the efforts of NGOs, activists, and others focused on regulatory reform and community health protection. In this chapter, I present a summary of what is known from the peer reviewed literature, white papers, and government reports.

To assess the public health dimensions of fracking, as well as other environmental health issues, the *Environmental Exposure Pathway* Framework, is often used to describe how pollutant sources are linked to their associated health effect via emissions, environmental concentrations of pollutants, pollutant exposure (through mouth, nose, ears, eyes, skin, etc.), and dose (i.e., micrograms of pollutant ingested per day) (Figure 1). In general, from what is known to date, the most notable health concerns associated with hydraulic fracturing are rooted in exposures to contaminated air and drinking water. For this reason, this chapter focuses predominantly on air and water contamination concerns.

Figure 1. Environmental Exposure Pathway

AIR QUALITY CONCERNS

Air pollutant emissions from hydraulic fracturing can be grouped into two main categories: 1) emissions from transportation and 2) emissions from natural gas drilling and processing.

Transportation

Each well requires between 2 to 7.8 million gallons of fracking fluid per fracking event. Since water – the primary constituent of fracking fluid – is not generally pumped directly to wells, water must be transported by diesel trucks, each of which has an approximate capacity of 3,000 gallons (EPA 2011). Because an average fracking event requires 5 million gallons of water (excluding the sand and the chemicals required), over 1,660 trucks (excluding trucks to carry chemicals and sand) are required for a single fracking event (EPA 2011). With each well expected to be fracked between one and ten times over its lifetime, and with thousands of such wells concentrated in high extraction regions, unprecedented levels of air pollution are being brought to these rural areas.

The pollutant of primary health concern emitted from the transportation component of hydraulic fracturing is fine diesel particulate matter (PM). A review by the California Air Resources Board (2008) indicates that there is a 10% (CI: 3% to 20%) increase in the number of premature deaths per 10 $\mu g/m^3$ increase in $PM_{2.5}$ exposure (CARB 2008). Additionally, nitrogen oxides (NOx) and volatile organic

compounds (VOCs) – other prevalent pollutants in diesel emissions – react in the presence of sunlight and high temperatures to produce tropospheric (ground-level) ozone, a strong respiratory irritant that is associated with increased respiratory morbidity and mortality (Jerrett, Burnett et al. 2009) (Table 2).

Table 2. Health Risks of Tropospheric Ozone and Particulate Matter Exposure

Ground-level Ozone	Health Effects	Particulate Matter
x	Coughing, irritation of the airways, discomfort in the chest or when breathing	
x	Premature aging of the lungs	
x	Faster or more shallow breathing	x
x	Aggravation of asthma, emphasema, and other respiratory diseases	x
x	Increased risk of respiratory infections	x
x	Premature death (primarily among older adults and those with existing heart and lung disease)	x

Adapted From: (Clean Air Trust 2012)

Differences in Air Pollution between Different Types of Fracking: Transportation-related air pollution varies between different types of fracking (i.e., between coal bed methane and shale) and depends primarily on the volume of water needed for each fracking event. While coal-bed methane extraction requires approximately 16 to 115 trucks to transport between 50,000 to 350,000 gallons, respectively, of water per well, shale gas extraction requires, as mentioned, an average of roughly 1,660 trucks to transport an average of 5 million gallons of water per well (EPA 2011) and is likely more damaging to air quality.

Natural Gas Extraction Process and Air Quality

The natural gas extraction process itself produces emissions of multiple health-hazardous air pollutants including benzene, toluene, ethylbenzene, and xylene (BTEX), formaldehyde, hydrogen sulfide, acrylonitrile, and methylene chloride.[1] This results in elevated air pollution concentrations that far exceed US EPA guidelines for both carcinogenic and non-carcinogenic health risks (Armendariz 2009; Colborn, Kwiatkouwski et al. 2011; Larson, Breech et al. 2012). Fracking also produces fugitive methane (CH_4), which, although not considered a health-damaging pollutant in its own right, atmospherically transforms to toxic ground-level ozone, as described above (Table 2).

Ozone precursor emissions from oil and gas extraction activities are predicted to be very high. For example, in the Dallas Fort-Worth Metropolitan Area (D-FW) in 2009 it is estimated that 165 tons of ozone precursor emissions (NOx and VOCs, and CH_4) were emitted per day while the entire mobile sector (cars, trucks, etc. – excluding air travel) of D-FW emitted only 121 tons per day (Armendariz 2009). In fact, it is estimated that during the summer of 2009, more than 300 tons of ozone precursor emissions were generated by fracking activities per day in D-FW, with over half of the fugitive emissions arising from the condensate and oil tanks used in the operations (Figure 2). In other words, oil and gas extraction was responsible for more tropospheric ozone levels than the entire fleet of cars, trucks, and other mobile sources combined (Armendariz 2009).

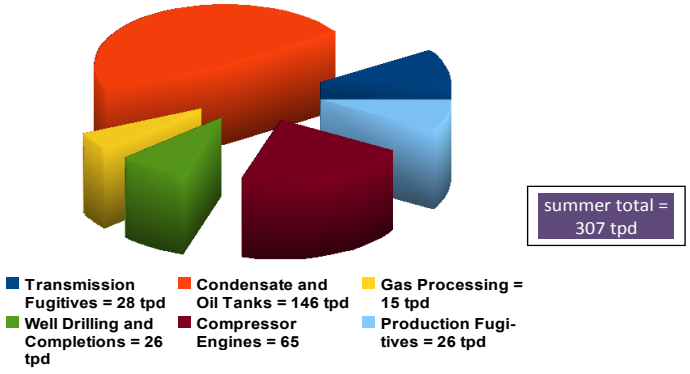

Figure 2. Summer Emissions of Ozone Precursors (NOx and VOCs) from Barnett Shale Fracking in 2009

[1] Please see Colborn et al (2011) and FracTracker for more in depth lists of these chemicals

Cited From: (Armendariz 2009)

Geographical and Geological Differences in Air Pollution: No studies have focused on whether the type of geological formation being fracked influences the amount or type of air pollution produced. However, under high temperatures, emissions of gases from condensate and oil tanks often increases because pressure increases as temperatures rise, forcing gases out of the tank and into the environment. Thus, natural gas extraction in locations and seasons with high temperatures can expect higher emissions of CH_4, NOx, VOCs, and other hazardous gaseous compounds compared with those locations where and seasons when temperatures are lower (Armendariz 2009).

WATER QUALITY CONCERNS

There are five main pathways of water contamination in the fracking process, each with its own associated levels of risk: 1) transportation spills of fracking fluid or produced water; 2) well casing leaks; 3) leaks through fractured rock; 4) drilling site discharge; and 5) wastewater disposal (Rozell and Reaven 2012). A recent study found that wastewater disposal is a particularly worrisome pathway, carrying a potential risk of water contamination several orders of magnitudes larger than the other pathways (Rozell and Reaven 2012).

Drilling Chemicals and Fracking fluids

In the first step of the fracking process, chemicals are added to drill "muds" to allowing drilling in the bore hole to proceed with reduced friction and to ensure the return of the drilling mud wastes to the surface (Colborn, Kwiatkouwski et al. 2011). The second step of the process involves water, sands, and toxic chemicals forced into the gas well at high pressure to break up the geologic zone to facilitate the release of the natural gas. Many chemicals used in these two processes are highly toxic (Colborn, Kwiatkouwski et al. 2011) and rarely disclosed to the public (see Chapter 2 for reasons for non-disclosure).

Flowback and Produced Water

Both 'flowback water' (hydrofracking fluid withdrawn from the well after the fracking process) and 'produced water' (water that returns to the surface along with the natural gas) contain the chemicals used in the fracking fluid as well as compounds found deep in the earth, such as salts, chlorides, heavy metals (cadmium, lead, arsenic, etc.), organic chemicals (i.e., BTEX), bromide, and naturally occurring radioactive materials (radon, etc.) – many of which are associated with health effects (Colborn, Kwiatkouwski et al. 2011). Even after the flowback and produced water is treated and released as effluent, many of the chemicals persist in high quantities because treatment facilities are unable to screen for and eliminate the complex soup of compounds.

For instance, a recent meta-analysis (Alley, Beebe et al. 2011) of chemical and physical characterizations of produced waters from unconventional fossil fuels (shale gas, coal-bed methane, and tight gas sands) found that most of the produced water generated from natural gas extraction from shale and tight gas sands contained so much chloride, that they were classified as saline (>30,000 mg/l) or hyper-saline (>40,000 mg/l). The treatment of these produced water involves substantial reverse osmosis, a practice that could generate a waste stream too large to justify the activity (Alley, Beebe et al. 2011). Only the coal-bed methane produced waters were considered fresh. Beyond the salinity concerns, the toxicity of the produced waters from shale gas, tight gas sands, and coal-bed methane exceeded toxicity thresholds in nearly all of the monitored chemicals (including heavy metals such as aluminum, barium, arsenic, cadmium, lead, strontium, and uranium) (Alley, Beebe et al. 2011). These results agree with other reports that fracking fluids, drilling fluids, and flowback and produced waters in drilling evaporation pits all contain levels of chemicals associated with health effects ranging from skin and eye irritation to neurological and nervous system damage, cancer, and endocrine disruption (Colborn, Kwiatkouwski et al. 2011). Moreover, between July 2009 - June 2010, 192.5 million gallons of produced water (PW) was reported in Pennsylvania alone with uncertainties as to what to do with all of it (DEP 2010).

In at least ten states where coal-bed methane is routinely extracted[2], the coal deposits are geographically located near or are connected to freshwater aquifers used for household and agricultural consumption (Sumi 2005). Thus, the use of hydraulic fracturing for coal-bed methane may pose a greater risk of groundwater contamination than in other types of formations, at least in terms of on-site risks.

Moreover, toxic flowback and produced waters are often contained in evaporation ponds, in some cases in very close proximity to residences. The ponds are lined to protect against leakage, although there have been a number of reported ruptures to these liners, that have lead to water and soil contamination and contributed to documented fish and livestock deaths (Bamberger and Oswald 2012).

Fugitive Methane in Water

In certain regions, methane can naturally occur in aquifers and there are conflicting scientific opinions about whether its presence is caused or exacerbated by fracking (Davies 2011; Saba and Orzechowski 2011; Schon 2011). However, very convincing findings shed light on the likelihood that fracking is associated with high methane levels in drinking wells: Communities in Pennsylvania with active shale gas fracking (one or more gas wells within 1 km) were found to have significantly higher concentrations of methane in their water wells than in non-extraction sites (no shale gas wells within 1 km) (Figure 4) (Osborn, Vengosh et al. 2011). What is more, the chemical signature of the methane found in the active area drinking water wells indicated that it came from a high-pressure, deep earth source. Alternatively, the methane from non-active sites had signatures of shallow earth origins. This suggests that the methane contamination was caused by the fracking activities nearby.

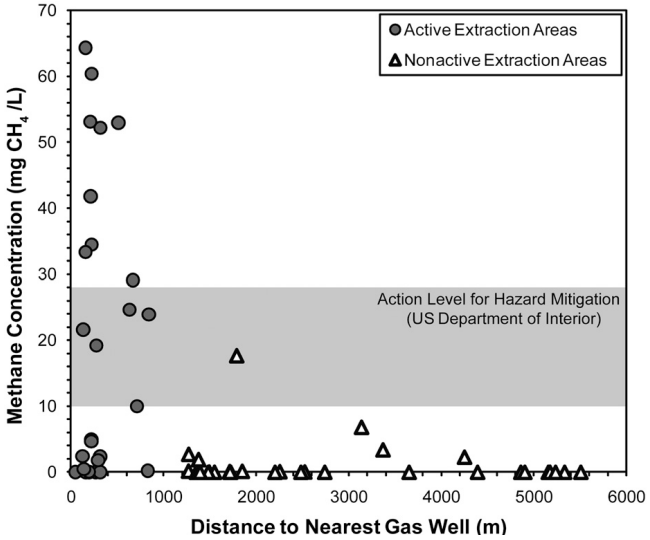

Figure 4. Methane Concentrations (mg of methane per liter of water) as a function of distance to the nearest gas well from active (closed circles) and non-active (open triangles) drilling areas

Cited From: (Osborn, Vengosh et al. 2011)

Explosions: Methane contamination of drinking wells and aquifers due to nearby fracking activities have caused dangerous explosions. For example, in 2007, methane seeped into a water well and an entire home exploded in Geauga County near Cleveland, Ohio. The Ohio Department of Natural Resources blamed a faulty concrete casing in a nearby fracking well (Ohio DNR 2008). In Dimock, a poverty stricken town in Pennsylvania, several drinking water wells exploded and nine others were found to contain so much natural gas that the home owners were instructed to open a window while taking baths to avoid asphyxiation. The EPA has charged Cabot Oil and Gas Corp. with that contamination, which was also likely caused by a leaking drill casing (Lustgarten 2009; Lustgarten 2012).

HEALTH DATA ON FRACKING FLUID, DRILLING, AND PRODUCED CHEMICALS IN THE AIR AND WATER

In a recently published study, Colborn et al. (2012) identified 944 products used in the fracking process in the US, of which only 14% provided 95% to 100% of the ingredients, while 43% provided less than 1%

[2] Alabama, Arkansas, Colorado, Kansas, Montana, New Mexico, Virginia, Washington, West Virginia and Wyoming

of the ingredients. The researchers generated profiles of possible health effects from the chemicals identified in the natural gas process (Figure 3). Of these identified chemicals, over 90% were found to affect the skin, eyes, and sensory organs; approximately 50% could affect the brain/nervous system, immune and cardiovascular systems, and the kidneys; 37% could affect the endocrine system; and 25% could cause cancer and mutations.

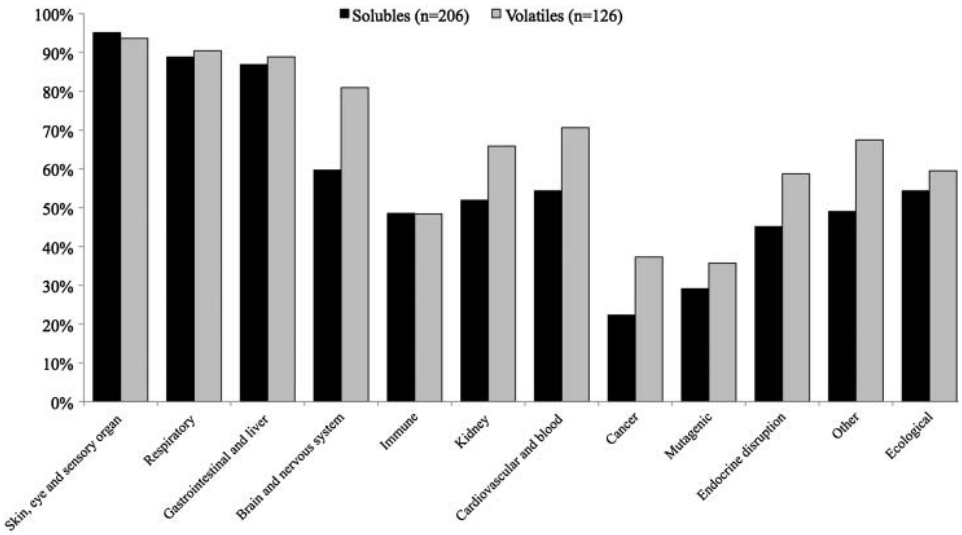

Figure 3. Profile of Possible Health Effects of Soluble (water-contaminating) and Volatile (air-contaminating) Chemicals with CAS numbers[3] Used in the Fracking Process
Cited From: (Colborn, Kwiatkouwski et al. 2011)

PSYCHOLOGICAL, SOCIAL, AND COMMUNITY EFFECTS

A significant body of literature shows that "boomtowns" – small towns that rapidly expand through natural resource extraction – can harbor disproportionate increases in health-relevant social and psychological problems including crime, poor mental health, community dissatisfaction, and education shortfalls. This boomtown model seems to align well with community shifts associated with hydraulic fracturing (Jacquet 2009). For example, although few data exist on the social effects of fracking, anecdotally, it has become associated with rapidly shifting demographics due to the influx of drilling workers, increased homelessness among community sub-populations previously housed (Dewitt 2012), and elevated rates of sexually transmitted infections (Covey 2011).

A NOTE ABOUT VULNERABILITY AND ENVIRONMENTAL HEALTH

Environmental health concerns are mostly found along two overlapping vulnerability continuums: 1) The likelihood of a population being exposed to an environmental hazard and 2) The sensitivity of a population to the environmental hazard if they are exposed (Fan, Alexeeff et al. 2010; Sadd, Pastor et al. 2011). For example, young children are more likely to be exposed to environmental pollutants because of their innate behaviors (i.e., putting things in their mouths, crawling on the floor, etc.) and are also more sensitive to the impacts of environmental pollutants when they are exposed (i.e., because their bodies are still developing; they eat more, drink more, and breathe more air in proportion to their body size then adults; their bodies are less able to breakdown and excrete pollutants; and their behavior can expose them more to chemicals and organisms) (Holguin, Flores et al. 2007; Perera 2008). For instance, benzene, a commonly emitted chemical in the fracking process, is toxic to all humans but contributes a disproportionate risk of leukemia to young children (Whitworth, Symanski et al. 2008), and a

[3] CAS Numbers: the Chemical Abstracts Service is the leading provider of health information of chemicals.

disproportionate risk of neural tube defects (Lupo, Symanski et al. 2010) and decreased fetal growth in offspring when pregnant mothers are exposed (Slama, Thiebaugeorges et al. 2009).

For example, of the 4,596 active wells in Pennsylvania, between January 1, 2008 and December 31, 2012 there were 2,392 violations that likely posed direct threats to human health and the environment (Madsen, Schneider et al. 2011). In terms of disproportionate risks to vulnerable populations, in Pennsylvania as of May of 2011, 320 daycare facilities, 67 schools, and 9 hospitals were found to exist within two miles of permitted wells (Staaf 2012).

Intrinsic versus Extrinsic Vulnerability

Although exposures to environmental contaminants alone are implicated in increased health impacts, physiological, social and economic factors are also fundamental to understanding the uneven distribution of adverse health outcomes across diverse populations (Shonkoff, Morello-Frosch et al. 2011). Thus, risk factors for fracking-associated health concerns can be categorized as *intrinsic* (i.e., age, disability, medical status) or *extrinsic* (e.g., housing in close proximity to natural gas extraction, lack of access to medical insurance and alternative drinking water sources, lack of ownership of mineral rights, and a lack of access to transportation to evacuate in necessary). Groups of low socioeconomic status are disparately affected by both of these risk categories (Shonkoff, Morello-Frosch et al. 2011). For example, approximately 42.9 million Americans rely on private water supplies typically sourced from shallow aquifers (Kenny, Barber et al. 2009). A wealthier household that can purchase bottled water if their aquifer becomes contaminated is at an advantage over a poor household who does not have this option.

CHAPTER 2: THE HURDLES TO IDENTIFYING PUBLIC HEALTH THREATS ASSOCIATED WITH FRACKING

The obstacles that prevent the identification of public health threats associated with natural gas extraction are numerous, pervasive, and tightly interwoven. The greatest obstacles that slow the identification of threats to public health, fall into five obstacle categories: regulatory obstacles, governmental obstacles, hurdles to data collection and analysis, and messaging control by the oil and gas industry.

REGULATORY OBSTACLES

Important environmental law exemptions at the federal level, and myriad regulatory and legislative bills at the state level, pose hurdles to identifying public health threats associated with fracking. I first address the national-level regulatory issues and state-level disclosure laws. Then, because a full investigation of all state and local bills and legislation is beyond the scope of this report, I focus on one bill recently passed in Pennsylvania that is particularly concerning in regards to the identification of public health impacts of fracking.

National Level Regulatory Issues: Due to stipulations in the Energy Policy Act of 2005, otherwise known as the "Halliburton Loophole", the fracking industry enjoys exemptions from seven major federal environmental laws that simultaneously protect public health: the Clean Water Act (CWA), the Clean Air Act (CAA), the Safe Drinking Water Act (SDWA), the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, otherwise known as the Superfund Act), the Resource Conservation and Recovery Act (RCRA), the Toxic Release Inventory under the Emergency Planning and Community Right-to-Know Act (EPCRA), and the National Environmental Policy Act (NEPA). Exemption from oversight under these laws creates a variety of direct and indirect public health implications and makes it difficult to improve knowledge of health risks associated with fracking and the burden of regulating the fracking industry has effectively been left to individual states. Although certain states have oil and gas commissions to oversee oil and gas extraction activities, the reality is that the primary focus of these agencies is to facilitate extraction of natural gas to increase public revenues; the focus is not on health and environmental protection (Colborn, Kwiatkouwski et al. 2011).

State and Local Regulatory Issues

The oil and gas industry has worked to ensure that weak, one-size-fits all laws supersede heterogeneous local ordinances that could be stricter. In other words, if the fracking industry only needs to adhere to simplified federal regulations, it is an easier landscape for them to operate in than if each state or county has its own regulations and laws.

Nonetheless, there are differences in laws for disclosure of the chemical content of fracking fluids between states[4]. For environmentalists and for the public health community, passing disclosure bills is an important step towards encouraging elected officials and oil and gas executives to recognize that some mandatory chemical disclosure (at minimum) is important. Yet each bill passed to date has fallen short of requiring companies to list all of the ingredients used in their fracking activities. As an example, the chemical disclosure law in Wyoming – the bill that currently acts as the model for fracking fluid disclosure in other states – continues to keep 146 chemicals obscured from the public eye through trade secret laws (Mark 2011).

State Law Case Study: House Bill 1950 (Pennsylvania)

Minimized Local Control: Pennsylvania House Hill 1950 (HB 1950) simplifies the drill permitting landscape by removing communities' ability to pass public health-relevant decisions, such as setbacks (buffer zones), allowing natural gas companies to conduct their activities as close as 300 feet from houses, schools, hospitals, and sensitive ecological areas. This means that in the near future, people will likely live, work, and play only 300 feet away from gas well pads (that may function up to 24 hours per day, 7 days per week) fracking waste evaporation ponds, compressors, pipelines, and other industrial infrastructure.

Implications for Medical Care and Environmental Health Knowledge: Under HB 1950, when a patient seeks medical attention due to a chemical exposure, doctors must make a written request for information on the relevant chemicals used in fracking. After industry provides chemical information, the physician is then legally required to keep the disclosed chemicals confidential. Moreover, although the well operator is required to report the chemicals added to fracking fluids, drilling "muds", etc., they are under no obligation to disclose compounds that return to the surface in flowback and produced water (see chapter 1).

The effect of HB 1950 is that while physicians can treat those that come to hospitals, the medical community is essentially silenced under non-disclosure agreements and is thus unable to warn and protect communities that are at high risk of exposure. This law thus poses an unprecedented obstacle to the identification of public health threats and emerging health and exposure pathway information by putting a choke on the flow of information from hospitals and clinics where the majority of environmental health and chemical exposure concerns will be visible.

GOVERNMENTAL OBSTACLES

Federal, state, and local governments are integral to the protection of Americans from environmental and health hazards. The most important obstacle that inhibits the government from performing these duties effectively is, as mentioned above, the natural gas industry's exemption from the seven major federal environmental laws. However, there are other governmental obstacles that inhibit the identification of public health threats associated with hydraulic fracturing.

Political Obstacles

Lack of Environmental Health Expertise in National Advisory Committees: Although there is recognition of environmental public health concerns related to fracking, state and national advisory

[4] In lieu of a full analysis of the disclosure laws here, please see the thorough report prepared by the Wilderness Society The Wilderness Society (2011). Disclosure of Hydraulic Fracturing Fluids: Are States Doing a Good Enough Job? Washington, DC. Available at: http://www.shalegas.energy.gov/resources/tws_state_chemical_disclosure_requirements.pdf.

committees designed to respond to these concerns continue to lack recognizable environmental public health expertise (Goldstein, Kriesky et al. 2012). The lack of governmental personnel on hand to responsibly weigh in on health decision-making speaks to a larger and growing issue of the politicized nature of the health dimensions of fracking that inhibits investigation and action. For example, the Center for Disease Control (CDC), a governmental body responsible for national-level investigations of health concerns, has done little to investigate health dimensions of fracking beyond a few inconclusive case studies of groundwater contamination following an explosion of a well head (ATSDR 2011).

Electability Issues: Many government officials, including those responsible for health assessment regulation, are currently ineffective due to election concerns over alienating the oil and gas industry; especially when they serve in states whose economies rely heavily on oil and gas extraction. For example, New York State Governor, Andrew Cuomo is politically precluded from alienating the oil and gas industry if he has aspirations of one day running for president. Indeed, President Obama mentioned full support of domestic natural gas as an important element of the national energy portfolio in the 2012 State of the Union Address and in his more recent speeches on US energy Policy.

Lack of Capacity and Resources

Health- and environment-related government and regulatory departments are struggling to keep up with the current backlog of environmental health issues, aside from fracking, in a limited resource environment. These funding issues are exacerbated by the economic recession, related budget cuts, and layoffs. One reason why departments of health, environment, and human services have been relatively unresponsive to public health concerns around fracking is that they are severely understaffed for the magnitude of the monitoring, data analysis, and enforcement activities necessary to adequately understand the public health dimensions of the complex and quickly-evolving fracking industry. For example, in New York, a state slated to begin hydraulic fracturing in the near future, the Department of Environmental Conservation (DEC) lost 139 staff members last December and has cut nearly a quarter of its Environmental Agency staff since 1990. Moreover, Pennsylvania, the state with the highest number of fracking wells in the US, lags behind every other state in its number of public health workers, with only seven of its 67 counties having health departments (Phillips 2011). It is thus not surprising that the Department of Health in Pennsylvania had to respond to allegations that they had not compiled submitted health complaints associated with fracking activities into a centralized database to track and analyze (Phillips 2011).

HURDLES TO DATA COLLECTION AND ANALYSIS

Because the precautionary principle is not required to be obeyed in US policymaking, as it is in some other countries (i.e., the European Union) (Jasanoff 1990), state and federal policy changes require strong pre-existing bodies of science prior to making decisions that impact the private sector. Below are the key roadblocks that stand in the way of data collection and analysis activities.

Chemical Monitoring R&D and Technological Capacity: Government agencies, NGOs, CBOs, academics, and other parties are greatly hindered in their attempts to investigate the environmental health dimensions of fracking because the industry is exempt from the disclosure of the chemicals used and produced by the fracking process. Non-disclosure of these chemicals also holds implications for research and development (R&D) of assays and probes needed to monitor novel contaminants because it is difficult to measure something if you don't know what it is. Thus, the lack of monitoring capability and the dearth of R&D further inhibits data collection and analysis.

Funding: Academic institutions located in areas of the US that rely on oil and gas extraction to fuel their economies also tend to rely on the oil and gas industry for funding. As such, academics, universities, and their deans and chancellors are under substantial pressure to not investigate the practices of the oil and gas industry lest they arrive at findings that may cast the industry in a poor light. For example, at the University of Pittsburgh, an institution historically greatly financially supported by the oil and gas industry, Conrad (Dan) Volz was forced to resign as a professor in the School of Public Health because of

pressure from university administrators after publicizing his findings on water contamination downstream of fracking operations in Pennsylvania (Friedenberger 2011).

Obscured Data Sources in the Field: Impacted landowners often sign non-disclosure agreements with fracking companies in exchange for payments for their losses when they, their livestock, or their companion animals fall ill. For instance, sick or dead animals are often hauled away by industry employees who compensate landowners before autopsies are performed to investigate the cause of death (Bamberger and Oswald 2012).

Regulatory Exemptions and Monitoring Data: Beyond the lack of a regulatory apparatus to protect population health and the environment, a secondary effect of the seven federal environmental exemptions is that there is no mandate to collect monitoring data on source emissions, chemical environmental concentrations, or deleterious impacts that result from the hydrofracking process. In turn, no monitoring data is generated for analysis.

Lack of Epidemiological Studies: Although not all epidemiological study designs require long periods of time to complete (i.e., case control studies and acute clinical epidemiology), prospective cohort studies – the epidemiology community's holy grail for fracking at the moment – follow groups over 15-20 year periods to measure their exposures and health outcomes. Since hydraulic fracturing was not rolled out en masse until relatively recently, and the barriers to prospective cohort studies are great, these studies have not yet begun. Similarly, studies on the effect of chronic low-level exposures to chemicals used and produced by the fracking process – a notable concern (Bamberger and Oswald 2012) – would not produce results for many years.

Environmental Complexity and Causal Inference

Chemical inputs to the fracking process mixed with deep earth compounds produces a very complex soup of chemicals with individual, cumulative, and synergistic toxicities. Due to this complexity, and a dearth of exposure pathway information, it is difficult, from a toxicological perspective, to conclude that, for instance, geographic proximity to fracking operations *causes* headaches, bloody noses, fainting, memory issues, and other conditions. This is because the soup of chemicals involved is very difficult to understand (especially due to non-disclosure laws) and many health outcomes are relatively non-specific (i.e., headaches can be caused by dehydration, social stress, alcohol consumption, etc. as well). Indeed the tobacco industry argued successfully for years that smoking did not cause lung cancer and that other exposures such as asbestos were the culprit. Much like fracking fluid and produced water, cigarette smoke is composed of a complex mixture of chemicals that, to this day is still not fully understood. One thing is clear from the tobacco analogy however: engaging with industry on a chemical-by-chemical risk assessment basis is a long and arduous road due to the blunt epidemiologic and analytical tools available to scientists.

Lack of Training in Environmental and Occupational Medicine: Rural hospitals and clinics in drilling areas may not have the capacity or the training to diagnose and treat symptoms related to hydraulic fracturing (Saberi 2012). Without health professionals that are highly skilled in environmental and occupational medicine, clinics and hospitals will be unable to diagnose and treat patients and generate reliable exposure pathway information critical to sound clinical epidemiological assessment.

MESSAGING CONTROL BY THE OIL AND GAS INDUSTRY

A recent study quantified the proportion of television news reporting on fracking to oil and gas industry fracking campaign ads and found that there was a ratio of approximately 1 hour's worth of news, over 9 different nights, to nearly 4.5 hours (of approximately 30 second ads) of oil and gas commercials on 367 different dates with some ads appearing on many different channels (Spencer 2012). This type of advertising and public relations campaign holds measurable implications for public opinion and issue interpretation; the National Cancer Institute demonstrated that the impact on the national public mind of marketing by the tobacco industry who poured resources into obscuring the connection between cigarettes and cancer was highly significant (NCI 2008).

CHAPTER 3: THE TACTICS ORGANIZATIONS USE TO IDENTIFY THE THREATS OF HYDRAULIC FRACTURING

Nearly as numerous as the obstacles to identify the public health threats of fracking are the tactics used by groups and organizations to overcome those obstacles. Here I provide an overview of the methods that NGOs, CBOs, academics, and other groups have used to fill the public health knowledge gaps of fracking.

SCIENTIFIC STUDIES AND INFORMATION SHARING

Peer Reviewed Scientific Studies: There are only a few peer-reviewed scientific papers written specifically on the public health dimensions of hydraulic fracturing and it is especially important to note the absence of studies that characterize exposures and health outcomes (Table 2).

Table 2. Human Health-Relevant Peer Reviewed Publications to Date on Hydraulic Fracking

Study	Human Environmental Epidemiology	Water Quality	Methane Contamination	Frack Fluid Contents	Animal Health	Risk Analysis	Policy	Environmental Health Governance
Bamberger & Oswald (2012)					X		X	
Colborn et al. (2011)				X			X	
EPA (2011)		X	X					
Finkel and Law (2011)		X	X	X			X	
Goldstein et al. (2012)								X
Osborn et al. (2011)			X					
Rozell & Reaven (2012)		X		X		X		

Sources: (Colborn, Kwiatkouwski et al. 2011; EPA 2011; Finkel and Law 2011; Osborn, Vengosh et al. 2011; Bamberger and Oswald 2012; Goldstein, Kriesky et al. 2012; Rozell and Reaven 2012)

To fill the epidemiological information gaps, universities are beginning to compete for funding, likely from the National Institutes of Health (NIH) to conduct a retrospective or prospective cohort study. A research team led by Brian Schwartz, MD, MS at Johns Hopkins School of Public Health submitted an NIH Research Project Grant Program (R01) grant application in October 2011 and will resubmit the grant in July of 2012. The team hopes to study the effect of fracking on human health in the Marcellus shale region with asthma as the primary health outcome, using electronic health record data over the past 10 years. The team will resubmit the grant for the July 5 NIH deadline (Schwartz 2012).

Health Impact Assessments (HIAs)

The Western Colorado Congress and Grand Valley Citizens Alliance campaigned for and won a county-sponsored HIA, a draft of which documented potential health effects of hydraulic fracturing in the retirement community of Battlement Mesa, Colorado (Witter, McKenzie et al. 2010). However, under pressure from the oil and gas industry, the county later voted not to finalize the HIA.

A Cautionary Note on HIA: The state of New York and a few major organizations are recommending stakeholder HIAs to assess the public health dimensions of fracking (Esch 2012). However, because HIAs largely function as processes that aim to influence policymaking, they can, when industry is involved, become mired in a polarized stakeholder process, sometimes rendering them counterproductive (Colson 2011). Of course many HIAs prove to be extremely productive, infusing policy decisions with clear and robust health information (HIP 2012). However, to date, the HIA in Battlement Mesa, Colorado is the only HIA attempted on fracking and the fact that the it was, under industry pressure, voted to not be finalized shows how the process can backfire (Colson 2011). Nonetheless, it is important to note that the Colorado HIA was a valuable process that generated rather stunning and robust results on the magnitude of human exposure and the scope of impact (Witter, McKenzie et al. 2010).

Citizen Environmental Monitoring and Health Surveys

In situations of data poverty and elevated community concerns – such as is currently the case for hydraulic fracturing – citizen environmental monitoring is a relatively rapid, efficient, and inexpensive method of generating data on environmental contamination aspects of an environmental health concerns. For instance, Global Community Monitor (GCM) – an NGO that trains and supports communities internationally in the use of environmental monitoring tools to understand and address industrial toxic pollution threats to their health (Larson, Breech et al. 2012) – helped to launch the only community-based environmental monitoring program to date in northwest New Mexico, southwest Colorado, and western Colorado to measure air pollution near natural gas facilities. GCM provided summa canisters (or "buckets") (Nevada DEP 2012) to enable community members to take air samples and found highly elevated concentrations of air pollutants.

To fill similar information gaps as community environmental monitoring projects, community health surveys provide opportunities for communities to highlight their health concerns to a greater scientific, political, and governance audience by providing self-reported health information. The Oil and Gas Accountability Project (OGAP) at EarthWorks, an environmental NGO focused on supporting communities impacted by hydrocarbon extraction around in the US, conducted community health surveys in DISH/Clark, Texas (Subra 2009) and Pavillion, Wyoming (Subra 2010). The community health survey in Pavillion, Wyoming acted as the basis for the EPA to launch its own investigation into potential impacts of hydraulic fracturing on drinking water resources (EPA 2011), the results of which are expected to be made public in mid- to late-2012.

White Papers and Reports

White papers and reports, otherwise known as "grey literature" are another important avenue used to generate and disseminate public health information on fracking. For instance, as discussed in Chapter 1, Armendariz (2009) studied health damaging air emissions from natural gas extraction in the Barnett Shale Area in Texas (Armendariz 2009). Witter et al. (2008) wrote one of the earliest white papers summarizing the potential exposure-related human health effects of oil and gas development(Witter, Stinson et al. 2008). Others have written reports on policy and research recommendations to fill information gaps around water contamination (Jackson, Rainey Pearson et al. 2011). Bishop (2011) wrote a chemical and biological risk assessment on fracking in New York State, which concluded that the extraction of methane from unconventional reservoirs with hydraulic fracturing in New York State is very likely to degrade the quality of air, surface water and ground-water, and to harm human health and aquatic and forest ecosystems (Bishop 2011). Lastly, the Pacific Institute is working to release a white paper, funded by the 11th Hour Project, focused on the policy and technical issues related to fracking with a special emphasis on the water quality concerns, relevant to public health and the environment.

Information Sharing and Conferences

To date there have been three main public health and fracking conferences in the United States: the Center for Healthy Environments and Communities (CHEC) at the University of Pittsburg has held two annual conferences and the Physicians, Scientists and Engineers for Healthy Energy (PSE) have held one. Additionally, the Institute of Medicine (IOM) will hold a roundtable workshop entitled, "The Health Impact Assessment of New Energy Sources: Shale Gas Extraction" from April 30 to May 1, 2012 in Washington, DC.

Specifically among funders, the Fracking Working Group, organized by the Health and Environmental Funders Network (HEFN), brings together funders interested in fracking and acts as a forum to share ideas and strategies.

CHEMICAL DISCLOSURE WEBSITES

There are two ways that fracking chemicals are disclosed to the public: 1) Mandatory disclosure through legislation and command-and-control regulation (as discussed, this is predominantly at the state-level);

and 2) "voluntary" disclosure, which allows the industry and individual drill operators to decide whether to disclose the chemical compounds used in their fracking activities or not.

FracFocus: Increasingly, voluntary disclosure occurs on FracFocus, a fracking disclosure registry run jointly by the Ground Water Protection Council and the Interstate Oil and Gas Compact Commission. FracFocus acts as a portal for fracking companies to post information about the contents of their fracking fluid, water usage, and the management of waste materials, on geographic and well-by-well bases (FracFocus 2012). Additionally, the disclosure laws in Texas and Colorado mandate companies to disclose their fracking chemicals on FracFocus in order to maximize the public availability of the information (EarthWorks 2012). It should be noted that the ingredient lists posted by industry on FracFocus are by no means exhaustive and many classes of compounds continue to be marked as trade-secret information. Some make the argument that FracFocus is a distraction from the important moral, environmental, and public health imperatives of mandatory disclosure through federal regulatory reform.

REGULATORY REFORM

Many NGOs, CBOs, researchers, and others are pushing hard to both strengthen chemical disclosure laws at the state-level as well as to reverse the federal exemptions at the federal-level. Please see Appendix 1 for a good list of organizations working on regulatory reform.

MEDIA

Film: For many, the documentary, *Gasland* by Joshua Fox was their first entrée to the public health dimensions of hydraulic fracturing. In the documentary, Joshua Fox interviews members of communities hosting fracking operations and focuses on the health and environmental issue that arise from the activity. The film provides startling images of faucets and rivers being lit on fire, glasses being filled from the kitchen sink faucet with highly turbid water, and stories of the decline of health and quality of life for families and communities throughout fracking regions in the United States. There are also additional efforts underway to film the issue. For example, "Gas Rush Stories" is a series of documentaries about natural gas extraction in Pennsylvania that is supported by the Heinz Endowments (Jansa 2012).

Investigative Journalism: ProPublica, which describes their organization as an independent, non-profit newsroom that produces investigative journalism in the public interest, has been on the front lines of Journalistic coverage of health concerns of hydraulic fracturing. Abrahm Lustgarten (ProPublica 2012) in particular has pushed the health dimensions of fracking into the public consciousness, making the term "fracking" a household word through his thorough and prolific investigative journalism. There are other notable contributions made by the New York Times and the Earth Island Journal (EIJ).

Data Compiling Websites: FracTracker compiles and analyzes data on natural gas development trends, including water contamination, environmental violations, and the distribution of wells across the US.

GOVERNMENT

New York, New Jersey, Maryland, and North Carolina all have bans on fracking until further study and scientific review is undertaken (Schmidt 2011; Sci Amer Editors 2011). A key piece of the scientific review process in New York is the drafting of the *Supplemental Generic Environmental Impact Statement* (SGEIS), which, until published, will freeze the approval of fracking permits in the state of New York (NY DEC 2011).

CLINICAL/MEDICAL ANGLE

Shale Gas Environmental Health Clinic: As explained above, many groups traditionally involved in environmental health investigation and scientific knowledge production (i.e., hospitals, clinics, academics, etc.) are not championing investigations of the health dimensions of hydraulic fracturing. The hurdles to data collection, data analysis, and results reporting holds grave implications for the production of rigorous scientific assessments on fracking and detracts from the work of NGOs and activists.

The scarcity of objective, reliable data on the health effects of gas extraction activities leaves many open questions concerning the origins and scope of health problems amongst residents (SWPA-EHP 2012). In

response to this, the *Southwest Pennsylvania Environmental Health Project,* funded by the Heinz Endowments, the Pittsburgh Foundation, and the Claneil Foundation (Hopey 2012) opened in McMurray, Pennsylvania in mid-February of 2012. The aim of the SWPA-EHP is to both assist and support residents in Washington County who believe their health has been, or could be, harmed by fracking activities (SWPA-EHP 2012) as well as to simultaneously collect information about chemicals and exposure pathways that may provide important information for environmental and clinical epidemiological studies.

CHAPTER 4: STRATEGIES TO MITIGATE HEALTH THREATS THAT HAVE ALREADY BEEN IDENTIFIED

Despite controversy surrounding fracking and its association with health outcomes, strategies to mitigate health threats have begun to be implemented. I report these strategies in terms of industry technology and best practices and exposure mitigation.

INDUSTRY TECHNOLOGY AND BEST PRACTICES

Industry technological retrofits and implementation of best practices could decrease the risk of water and air pollution and the subsequent human exposures that are associated with health effects. The following are a few important exposure mitigation strategies that the fracking industry could pursue: Casing improvements; on-site wastewater treatment; improved fugitive methane capture technologies; mandatory well integrity tests; required baseline air, water and environmental quality data collection before drilling and ongoing monitoring thereafter; establish reclamation fees, based on production to fund cleanup of orphaned wells; and green chemical/non-toxic fracking fluid development (Please see Appendix 2 for a more complete list of technological retrofits and industry best practices).

"DOWNSTREAM" EXPOSURE MITIGATION

Once environmental media including air and drinking water supplies are contaminated there are specific actions to have been taken to reduce exposures and risks of health impacts.

Bottled Water: In situations of drinking water contamination, some impacted residents purchase bottled water – a short-term solution, but integral to the protection of the health of households with unsafe drinking water. Additionally, the US EPA provided bottled water to households with contaminated who wells (Lustgarten 2012) and Cabot Oil and Gas Corp was mandated by the Pennsylvania Department of Environmental Protection to provide water to residents whose drinking water was contaminated with methane (Rubinkam 2011). Nonetheless, the provision of drinking water from oil and gas companies and regulators creates a complicated dynamic in that households must rely on these entities for safe water, which may be pulled away as soon as a lawsuit is settled or a regulation is overturned (Rubinkam 2011).

Air Pollution Indoor Day Suggestions: Regions in the United States that are regularly out of air quality attainment, such as Los Angeles, California have "smog warning days" in which it is recommended that people, especially vulnerable populations (the very young, the aged, and those that are immunocompromised) stay indoors. This could be extended to communities that are in the same airshed as fracking activities on days when the air quality becomes especially poor due to ozone, particulate matter, or other air pollutants.

Warning Systems: Disaster warning systems including community alarms or door-to-door campaigns can warn communities when leaks, explosions, or widespread contaminations occur.

CHAPTER 5: RECOMMENDATIONS FOR EFFORTS THAT FUNDERS COULD SUPPORT IN THESE AREAS[5]

SUGGESTED GUIDING PRINCIPLES FOR FUNDERS

To simultaneously identify and act to attenuate the public health impacts of hydraulic fracturing requires a well-coordinated effort with deeply integrated strategies and messaging across sectors, demographics, and scales. For instance, an NGO working in isolation to reverse exemptions at the federal level will likely be less impactful than a well-coordinated grassroots effort that simultaneously interpenetrates regulatory, geographic, sectoral, community, and strategic scales. Likewise, the effect of "one-off" projects, such as a single scientific study out of a university destined for an academic journal, will fade more quickly than a study informed and engaged with by impacted communities (Robinson 2012), popularized in the media, and translated into reports and other materials for popular consumption.

Fracking holds deleterious implications for coalitions that span sectors including labor, environment, agriculture, renewable energy, environmental justice, and public works. The wider and deeper the interconnection of a coalition, the fewer options industry has at its disposal to remain unaccountable. The funding recommendations below[6] would therefore be best implemented with organizations, networks, and coalitions that have a drive to work together in multiple areas and across multiple sectors with common goals. Highly advantageous investments would connect the communities that fight dirty energy (i.e., coal) to those working to eliminate toxics from the environment. Indeed fighting coal in isolation is part of the reason that we currently have a natural gas problem.

FUNDING SUGGESTIONS

1. **Build a Fracking Funders Network:** Given the large need and the small number of funders in this arena it is important to coordinate. Funding coordination increases efficiency, minimizes the duplication of efforts, increases networking possibilities, builds multi-sectoral power, and grows connectivity across the funding environment (which looks good for the cause). The funders that currently work on fracking issues relevant to public health are: the Heinz Endowments, the Park Foundation, the 11th Hour Project, the Claneil Foundation, and the Pittsburgh Foundation. Others such as the William Penn and the Colcom Foundations have expressed interest in making grants in this space. As discussed in Chapter 3, a fracking network has begun to emerge at HEFN, but could be strengthened by co-funding projects and other collaborations.
2. **Prepare a Strategic Collaboration Map:** In order to facilitate and understand the scattered landscape of fracking reform, it would be helpful to fund a project to organize the lead actors, NGOs, policies, laws, market forces, CBOs, and scientific knowledge into a strategy landscape map. This would provide a birds-eye view of the interlinkages, points of weakness for industry, information gaps, and coalition-building potential to focus on getting off the ground. Someone familiar with the fracking landscape as well as with the strategic collaboration mapping process should be funded to conduct this project.
3. **Pilot Projects[7]:** Pilot projects carry a low financial risk and a high impact potential because of the ability to scale them up quickly if they work or to try something different if they fail. For instance,

[5] Because the hydraulic fracturing and health arena is nascent, relatively uncoordinated, yet rich in NGOs and interest, it might be helpful to invite unsolicited grant proposals in the form of a 5-10 sentence coversheet. This would ensure that tactics and geographies are adequately covered and that the strongest coalitions and actors are identified. After this initial coversheet-screening process is undertaken, funders can initiate contact and solicit more information or full proposals.

[6] Please Note: For the purposes of space in this report, I do not make suggestions about groups and projects that the 11th Hour Project is investing in. Many of these groups are doing impressive work across scales and should continue to be funded.

[7] Phil Johnson at the Heinz Endowments has expressed interest in co-funder involvement in pilot projects.

the Heinz Endowments has funded a series of projects that provide local groups with technical expertise to conduct coordinated citizen science and surveillance of industrial operations and related impacts in different parts of the Marcellus shale region. This project is now in the process of being replicated in other counties, is providing citizens with surveillance tools and protocols, and is generating sound environmental data. Similarly, many of the funding recommendations in this report could be started as pilot projects. Some other specific projects to pilot include:

- EarthWorks is exploring collaboration with the remote sensing company, SkyTruth to create a dynamic and interactive Google map that shows locations of new and existing wells and locations where hydraulic fracturing permits have been issued in relation to schools, hospitals, daycare centers, etc.
- Fund **Global Community Monitor** (see below) to team with a CBO(s) to build capacity and conduct citizen monitoring in new communities impacted by fracking that have not been monitored before.
- Fund a researcher to conduct baseline environmental monitoring in New York or California before fracking is rolled out full throttle.
- Provide funds for the **Marcellus Citizen Stewardship Project** (http://www.mtwatershed.com/marcellus.html), an initiative in conjunction with Three Rivers Waterkeeper, Group Against Smog and Pollution (GASP) Pittsburgh, Clean Water Action, PennEnvironment and the Fayette County Conservation District. The Marcellus Citizen Stewardship Project aims to "provide citizens with tools and knowledge to responsibly monitor Marcellus shale development" (Mountain Watershed Association 2012). Through trainings and reports, citizens are taught to collect data (free of equipment) and to upload their findings to the FracTracker web portal and data tool.

4. **Provide Environmentally Oriented NGOs Resources for a Public Health Hire:** Environmental law firms, big national environmental organizations, and other groups focused on fracking could benefit from in-house public health expertise in the form of, for example, a recent MPH graduate. This could help to strengthen the organization's work due to the increasing loads of analyses and clients with public health concerns about fracking. This would cost the equivalent of a salary and benefits. Here are some examples of organizations:
   - **Earth Justice** has done some impressive work in the Marcellus region, yet does not have public health professionals on staff.
   - **The Western Organization of Resource Councils (WORC)** has conducted a wide array of actions around fracking in the western US.
   - **The Environmental Law Clinic at the University of Pittsburgh** conducts pro-bono legal work on fracking and an increasing proportion of their client base is requesting their legal services for health-oriented litigation.
   - Big National Environmental Organizations such as the **Sierra Club**, **the Environmental Working Group (EWG)**, **the Natural Resources Defense Council (NRDC)**, etc. could also benefit from public health expertise added to their staff.
   - **Physicians, Scientists, and Engineers for Healthy Energy (PSE)** are interested in scaling up their efforts and are currently reaching out to funders for support.
5. **Science and Research:** As discussed, academic studies can be long and arduous undertakings that fail to meet the immediate needs of impacted communities that are exposed to risks and become ill while waiting for the results. At the same time, the development of a scientifically rigorous body of evidence of environmental health threats is crucial to the engagement in litigious battles, to drive regulation, and to hold the oil and gas industry accountable for their actions. Indeed, an enormous body of studies was an integral component in the struggle to bring the tobacco industry under regulation and it will likely take many authoritative studies do the same to the fracking industry. There are types of research to fund that would produce more immediate results, act as integral components of coalition-building, and also may be more appropriate for foundation resources than

15-year prospective cohort studies which perhaps could be left to NIH, NSF, and other traditional funding sources. I comment on each of these alternative types of research-oriented projects below:

Literature Reviews: Comprehensive literature reviews (even just one) that combine environmental health information known specifically about fracking with environmental health knowledge known about analogous environmental health threats (i.e., air and water contamination, rapid demographic shifts, poverty and chemical exposure, etc.) would be a major contribution to the field. A document like this that systematically lays out a framework to organize thinking about human health dimensions of fracking does not yet exist, and remains an impediment to both research and action. This approach would be relatively cost-effective compared to funding a study that requires primary data collection. This type of literature review is especially helpful to preliminarily fill information gaps in cases that meet the following criteria: 1) high levels of community concern; 2) moderate to high levels of scientific information on similar issues; and 3) low levels of scientific information on the particular subject at hand.[8] The case of hydraulic fracturing meets these criteria and would be a good candidate. Ideally this review would be published in a peer-reviewed journal and re-formatted into reports and other materials to reach diverse populations for messaging purposes. An environmental health researcher who understands the fracking process and who has experience publishing in academic journals should be funded to conduct this task.

Southwest Pennsylvania Environmental Health Project (SWPA-EHP): As discussed in Chapter 3 of this report, the aim of the SWPA-EHP is to assist and support residents in Washington County, Pennsylvania who believe their health has been, or could be, harmed by fracking activities (SWPA-EHP 2012) as well as to simultaneously collect information about chemicals and exposure pathways that may provide important information for environmental and clinical epidemiological studies. If the *SWPA-EHP* – funded by the Heinz Endowments, the Pittsburgh Foundation, and the Claneil Foundation (Hopey 2012) – proves to be impactful, options to scale this project to more locations may be put on the table, especially if it is co-funded. Heinz is also developing additional grantmaking to assess the extent of animal health and human health concerns as well as water and air quality indicators in areas affected by natural gas extraction. To speak about funding collaborations on these projects, please contact Philip Johnson at the Heinz Endowments.

***Citizen Environmental and Bio-Monitoring*:** The Coming Clean Collaborative, organized by the Environmental Health Fund, run by Judy Robinson is a non-governmental strategy and campaigning collaborative of 200 organizations and 300 individuals – including state, federal and international policy organizers, market campaigners, doctors, nurses, scientists, health advocacy organizations, sustainable business leaders and investor experts, environmental justice and community grassroots organizers and exposure monitoring experts – that all work in a coordinated communications approach to integrate strategies to reform the energy and chemicals industry. Coming Clean is currently working to fund an integrated knowledge-action project with the following three components:

- Citizen air monitoring (with GCM)
- Development of novel assays to monitor newly emerging contaminants that existing monitoring equipment is not designed for (with Theo Colborn and TEDX)[9]
- Conduct biomonitoring and body burden studies (with Commonweal)[10]

[8] Similar work has been done on environmental health and equity implications of climate change mitigation strategies in California, USA under similar data and political environments. Please contact Seth B. Shonkoff, MPH at UC Berkeley for details on how the process worked and the importance of publishing separately for multiple communities.

[9] This could be a very interesting collaboration and if inexpensive diagnostics could be developed, they could be used for further community water testing.

Citizen Monitoring of Drinking Water: Similar to the importance of citizens gathering data about their air quality, efforts could be undertaken to monitor community ground and surface water quality. Some NGOs that may be able to undertake this work are the Mountain Watershed Association and the Alliance of Aquatic Resource Monitoring. For other NGOs that have engaged in environmental monitoring please refer to Appendix 1.

Health Impact Assessments (HIAs): HIAs offer a framework to use the highest quality available data to generate rapid recommendations for decision makers. In terms of natural gas extraction, a primary goal of the HIA could be to enable decision makers to view all available evidence on potential health impacts during the process of issuing drilling permits in order to set conditions to reduce risks for public health. It is important to note that HIAs are fairly ineffective unless there are policy decisions that are open to input from an HIA. Thus, coordinated efforts of HIA researchers, NGOs, and activists should be integrated to first open regulatory change possibilities and then to subsequently infuse the process with an HIA with the best available data. As mentioned in Chapter 3, Professor Roxana Witter at the Colorado School of Public Health, University of Colorado has conducted an HIA in Battlement Mesa, Colorado. *Please see the cautionary note for using HIA in Chapter 3.*

6. **Aggregation of New York State Comments:** more than 60,000 comments were submitted to the State of New York to weigh in on lifting the current moratorium on fracking. Hiring a team to compile, analyze, and publicize the comments would be a contribution to messaging, research, and strategy development (Panek 2012).
7. **Investigative Journalism:** In addition to the fracking journalism powerhouses (ProPublica and the New York Times), the scaling efforts of other outlets would be useful for messaging and public understanding of the issue. Indeed the majority of Americans get their information on fracking from journalism. Here is one recommendation that could be a good fit:
   - The Earth Island Journal (EIJ) receives 60,000 web hits per month and conducts sound journalism at the interface of environment and society, including fracking issues. They have aspirations to scale up their fracking portfolio.
8. **Continue to Fund Regulatory Reform Work:** As demonstrated by the findings in this report, the common denominator of many public health identification issues with the fracking process is poor regulatory infrastructure. A particularly interesting recommendation is to fund a campaign for "frack-free school zones" in key states (EarthWorks 2012) because of its powerful narrative and sound-bite alignments with the tobacco-oriented "smoke free zone" and the anti-narcotic slogan, "drug free school zone". If this campaign leads to regulatory reform on setbacks from schools, it could also be major protection for the public health of a sensitive population.

For a longer list of organizations that work on fracking regulatory reform please see Appendix 1.

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APPENDIX 1:

LIST OF NGOs, CBOs, GOVERNMENT, AND OTHER GROUPS FOCUSED ON FRACKING REGULATORY REFORM[11]

NGOs

- **Global Community Monitor**
- **The Endocrine Disruption Exchange (TEDX)** (Theo Colburn)
- **Coming Clean**
- **Commonweal Biomonitoring Resource Center**
- **Powder River Resource Basin Council**
- **Earthworks and the Oil and Gas Accountability Project (OGAP):** Works closely with affected communities and their affiliated local organizations in Colorado, New Mexico, Texas, and the entire Marcellus region; OGAP conducted health impact surveys and air and water testing projects in Texas and Wyoming, and has a project underway in Pennsylvania (a report will be released in Summer 2012); submitted comments on New York's draft hydraulic fracturing guidelines and regulations, with a focus on public health impacts.
- **Mountain Watershed Association**
- **Clean Air Council**
- **Clean Air Task Force**
- **Physicians, Scientists and Engineers for Healthy Energy (PSE)**
- **Catskill Mountainkeeper**
- **Citizens Campaign Fund for the Environment**
- **Environment America**
- **American Lung Association** (NY chapter)
- **As You Sow** (www.asyousow.org)
- **Environmental Defense Fund**
- **Sierra Club**
- **Natural Resources Defense Council**
- **Center for Health, Environment and Justice** (Lois Gibbs' org)
- **Food and Water Watch**
- **Earthjustice** and **Natural Resources Defense Council** provide legal and policy analysis on both federal and state concerns and litigate on gas development projects with negative environmental and health impacts.
- **Environmental Defense Fund**
- **PennEnvironment's Research and Policy Center** has issued reports on social and health impacts and associated regulatory and policy measures.
- **Environmental Working Group** has prepared research reports that have documented the use of diesel in fracking and has looked at potential cases of contamination resulting from fracking.

Community Groups

- **Chesapeake Climate Action Network**
- **Citizen Shale**
- **Sierra Club Maryland chapter**
- **Environment Maryland**

[11] This list was generated through a survey sent to researchers, NGOs, CBOs, foundations, and others working on fracking issues. It was also augmented with information from a literature review and interviews.

- **Clean Water Action**
- **Maryland League of Conservation Voters**
- **Savage River Watershed Association**
- **Youghiogheny River Watershed Association**
- **Friends of Deep Creek Lake**
- **Stop Arkansas Fracking (Greenbrier)**
- **Greers Ferry Lake Natural Gas Watch**
- **Wetzel County Action Group and WhiteDay Creek Watershed (Morgantown)**
- **GASP (PA)**
- **Peters Township Marcellus Shale Awareness (PA)**
- **Coalition to Protect New York**
- **Sustainable Otsego**
- **Shaleshock**
- **Students Against Fracking**
- **Catskill Mountainkeeper**
- **Citizen Action of New York**
- **NY Residents Against Drilling**
- **MD Citizen Shale**
- **Clean Water Action**
- **Food and Water Watch**
- **Sierra Club**
- **Delaware Riverkeeper Network**
- **State affiliates of Environment America**
- **Argyle Bartonville Communities Alliance** (ABCAlliance) (Texas) – conducted baseline environmental monitoring and tracks follow up testing; Logs and tracks health impacts for community members; provides chemical detects and health information on website after releases; updates community on drilling activity in neighborhood, documents impacts with photos and videos.
- **Denton Area Residents for Responsible Urban Drilling** (Texas) – conducted baseline and follow up testing and tracked health impacts; informed neighborhood with photos and videos
- **Fish Creek Monitor** (Arlington, VA) – new group starting to track health complaints and monitor industry activities. Fort Worth League of Neighborhoods – contracted with UTA professor for disbursement modeling relating to drilling activity in close proximity to public schools.
- **Clean Water Action and Group** Against Smog and Pollution (Pennsylvania) are conducting air monitoring in drilled areas to determine health-related exposures.
- **Powder River Basin Resource Council** (Wyoming) has worked with communities and members in Wyoming to push for chemical disclosure rules and to address contamination due to drilling and fracking.
- **Western Colorado Congress and Grand Valley Citizens Alliance** campaigned for and won a county-sponsored Health Impact Assessment, a draft of which documented potential health effects of natural gas drilling in the retirement community of Battlement Mesa. Under pressure from the oil and gas industry, the county later voted not to finalize the HIA.
- **Western Organization of Resource Councils (WORC):** The WORC Idaho Organizing Project campaigned for a newly-passed ordinance in Washington County, ID and the Western Colorado Congress won an ordinance limiting drilling in the watershed for the city of Grand Junction, CO. WORC's Idaho Organizing Project worked hard to win provisions requiring notification of landowners before well stimulation in Idaho's new oil and gas rules. Landowners in Idaho now have the option of requesting a baseline water test, conducted at the oil and gas operator's expense; Inspections and enforcement WORC and its member groups have researched, reported on and campaigned for appropriate inspection and enforcement resources, training, equipment and codes of

conduct for oil and gas inspectors at the federal and state levels, winning increases in the federal Bureau of Land Management's (BLM) inspection and enforcement budget. (Unfortunately, while these increases helped keep pace with increased drilling, they have not been sufficient to yield enough resources to ensure that all priority inspections have been conducted.) We have also organized and trained citizen inspectors and pioneered good inspection practices such as checklists for inspectors; WORC and its member groups, particularly Dakota Resource Council and the Powder River Basin Resource Council, have campaigned for stronger bonding requirements at the state and federal levels to help ensure that oil and gas sites are reclaimed. ND and WY now require higher bonds across the board and increased bonds for idle wells, which are at highest risk of being orphaned with out being reclaimed; WORC and its member groups, particularly Dakota Resource Council and Powder River Basin Resource Council have worked to win protections for split estate landowners who do not own the minerals beneath their surface. Advances include surface owner notification before leasing by the BLM, more fair surface damage payments in WY annual surface damage payments in ND.

- **The Northern Plains Resource Council** fought for and won numeric water quality standards for discharges to surface water in Montana, establishing specific, enforceable standards designed to protect agricultural users and aquatic habitat.
- **The Powder River Basin Resource Council** has pushed for restrictions on venting and flaring of natural gas, and the WY Office of State Lands is now finalizing a new policy to charge royalties for vented and flared natural gas.

Government

- **Tompkins County Council of Governments** and other counties that established gas drilling task forces to both educate members and prepare for/respond to drilling impacts
- **New York Department of Environmental Conservation**
- **Arkansas Department of Environmental Quality**
- **Some programs within EPA** have begun looking at ways to insert federal regulatory authority over aspects of fracking

Combinations of Groups and Coalitions

- **Coming Clean** is a non-public strategy and campaigning collaborative of 200 organizations and 300 individuals -- including state, federal and international policy organizers, market campaigners, doctors, nurses and scientists, health advocacy organizations, sustainable business leaders and investor experts, environmental justice and community grassroots organizers, exposure monitoring experts – that work to integrate strategies to reform the energy and chemicals industry.
- **Josh Fox (*Gasland*) and his staff** are working to form a united coalition of groups in New York
- **FrackAction**
- **National Grassroots Coalition**
- **Choose Clean Water coalition**
- **Susquehanna River Basin Commission coalition**
- **Federal Drilling Policy Coalition**
- **Texas Statewide Coalition**

APPENDIX 2:

INDUSTRIAL TECHNOLOGIES AND INDUSTRY BEST PRACTICES[12]

- On-site wastewater treatment
- Improved fugitive methane capture
- Improved Casing
- Information sharing across the industry
- Strong local government authority to ban and/or regulate oil and gas production sites and infrastructure
- Mandatory well integrity tests and tightened well integrity standards.
- Controls on freshwater use for fracking
- Setbacks from residences, schools, drinking and agricultural water supplies
- Require baseline air, water, land quality and public health testing, as well as ongoing monitoring, and make data publicly available
- Require site specific individual bonds to be set at the cost of reclamation, regularly reviewed
- Establish reclamation fee, based on production, to ensure clean up of orphaned wells
- Strengthen protections for surface owners, including fair compensation for damages and right to minimize impacts
- All regulatory agencies should have: 1) an inspection plan – required to budget for all needed inspections, and have authority to assess an inspection fee to cover all costs; 2) Clear mission statements that include protection of the environment and public health, as well as conflict of interest/ethics policies; 3) Effective inspection and enforcement training programs, equipment and authority
- Bans on venting and flaring and/or charge royalties for venting and flaring
- Limits on ratio produced water to produced oil/gas (marginal wells with highest environmental impacts must be shut down)
- Classification of gas wastes (solid and liquid) as hazardous, whenever applicable, to ensure proper transport, handling, and disposal
- Prohibition of brine spreading on roads and land and of drill cutting disposal in landfills
- Requirements for wastewater disposal only in properly equipped treatment plants
- "Green" or "non-toxic" fracking fluid development
- Tracers to identify the operator responsible, the toxics used and pathways of contamination
- Air emission control devices and technologies (including adoption of EPA Natural Gas Star Program recommendations)
- Prohibitions on open waste impoundments

[12] This list was generated through a survey sent to researchers, NGOs, CBOs, foundations, and others working on fracking issues. It was also augmented with information from a literature review and interviews.