UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

Dominion Transmission, Inc.	**)**	**Docket Nos. CP14-497-000**

MOTION FOR LEAVE TO RESPOND AND RESPONSE OF DOMINION TRANSMISSION, INC. TO COMMENTS OF MADISON COUNTY, NEW YORK DEPARTMENT OF HEALTH

Pursuant to Rules 212 and 213 of the Rules of Practice and Procedure of the Federal Energy Regulatory Commission (the "Commission"), 1/ Dominion Transmission, Inc. ("DTI") hereby submits this motion for leave to respond and its Response to the "Comments of Madison County, New York Department of Health Concerning Docket No. CP14-497-000, Dominion Transmission, Inc." (the "Comments") filed in the above-captioned proceedings on October 15, 2014. The Comments filed by the Madison County, New York Department of Health ("MCDOH") concern the pipeline project proposed by DTI, known as its New Market Project, to provide incremental firm transportation service to two local distribution companies -- The Brooklyn Union Gas Company d/b/a National Grid (Brooklyn Union) and Niagara Mohawk Power Corporation d/b/a National Grid (Niagara Mohawk). For the reasons explained below, DTI respectfully submits this response to MCDOH's Comments.

1/ 18 C.F.R. §§ 385.212 and 213 (2014).

I. Motion for Leave to Answer, To The Extent Deemed Necessary

The Commission's regulations do not allow for answers to "protests" unless otherwise permitted by the decisional authority. 2/ MCDOH did not style its Comments as a protest. In the event that the Commission treats the Comments as a protest, however, DTI respectfully requests that the Commission waive this rule to the extent necessary to allow this answer. The Commission routinely permits answers to protests for good cause in order to assist the Commission in its decision-making and to provide a more complete record. 3/ DTI respectfully submits that this answer will do just that and, therefore, good cause exists for the Commission to accept this answer.

II. Background

On June 2, 2014, DTI filed an application pursuant to Section 7(c) of the Natural Gas Act ("NGA") and Part 157 of the Commission's Regulations for certificates of public convenience and necessity to construct, install, own, operate, and maintain certain compression facilities located in Chemung, Herkimer, Madison, Montgomery, Schenectady, and Tompkins Counties, New York (NY), which will be used to provide 110,000 dekatherms per day of incremental firm transportation service for Brooklyn Union and Niagara Mohawk (the "DTI Application").

On September 24, 2014, the Commission issued its Notice of Intent to prepare an Environmental Assessment ("EA") to discuss the environmental impacts of the New Market Project and announced the opening of its scoping process to help the Commission Staff determine what issues to evaluate in the EA (the "Scoping Notice"). On October 15, 2014, the MCDOH provided comments to FERC, in response to the Scoping Notice, regarding one of the

---

2/ 18 C.F.R. § 385.213(a)(2) (2014).

3/ *See, e.g*., *Dominion Transmission, Inc*., 124 FERC ¶ 61,146 (2008); *Dominion Cove Point LNG, LP*, 108 FERC ¶ 61,211 (2004); *Dominion Transmission, Inc*., 105 FERC ¶ 61,173 (2003); *Dominion Transmission, Inc.,* 100 FERC ¶ 61,108 (2002).

new proposed compressor stations for the Project, known as the Sheds compressor station, which would be located in Madison County.

The MCDOH Comments raise concerns regarding compressor station emissions (construction and operation) including fugitive emissions and blowdown; health risks from relevant air contaminants including average and peak exposures, particulate matter and noise; reported health effects specific to compressor stations including acute and chronic health impacts and radioactive elements; and concerns from its residents; with health and food safety being the top concerns. Based on its concerns, the MCDOH in its Comments presents recommendations and mitigation measures should the New Market Project (i.e. the Sheds compressor) Certificate be granted.

Due to the concerns raised in MCDOH's Comments, DTI contracted with ENVIRON International Corporation ("ENVIRON"), a nationally recognized environmental consultant to review MCDOH's Comments and provide an objective review of the findings and recommendations presented in the Comments. ENVIRON is a health and environmental consulting firm of over 1,000 professionals from a wide variety of disciplines including epidemiology, toxicology, risk assessment, engineering, environmental sciences, public health, industrial hygiene, environmental technologies, geosciences, and regulatory affairs. With its multi-disciplinary team and expertise, DTI believes that ENVIRON is uniquely positioned to comment on multi-disciplinary documents related to the possible relationships between exposures to environmental contaminants from industrial facilities and human health indicators. Further, ENVIRON possesses the necessary skills and backgrounds to conduct complex integrative research, and evaluate research studies in terms of the use of quality design and methods in generating accurate data and valid interpretations.

III. Response to MCDOH's Comments

DTI now files this response to submit ENVIRON'S "Report on Madison County Comments" dated March 9, 2015 (ENVIRON Report), which is attached as Attachment A hereto. DTI believes that the ENVIRON Report will assist the Commission in its decision-making and will provide for a more complete record. DTI is responding to the MCDOH Comments separately here; however, DTI plans to comment on the other scoping comments at a later date.

The ENVIRON Report provides a complete analysis of the MCDOH Comments, including noting the flaws and weaknesses of the findings and recommendations proposed by the MCDOH. Some of the key findings include:

- **Related to Compressor Station Emissions:**
  - Air emission and dispersion data are available for the proposed Sheds compressor station (as well as the Horseheads and Brookman Corners compressor stations) in the DTI Application and associated appendices. Additional information is publicly available for other similar DTI facilities. Further, substantial ambient air quality monitoring data are available for use to characterize ambient concentrations in the area. The typical constituents emitted from compressor stations are well known and have been adequately characterized.
  - Atmospheric dispersion modeling, utilizing local atmospheric conditions and baseline concentrations, has demonstrated that the U.S. Environmental Protection Agency's (EPA) health-based standards will not be exceeded during operation of the proposed Sheds compressor station.
  - Total emissions, including those from construction, operation, fugitive and blowdown activities, are below EPA and State of New York Major Source thresholds, which would only require a minor source permit.
  - Potential to emit calculations on an annual (instead of averages, peaks or catastrophic accident maximum concentrations) basis and the use of EPA's National Ambient Air Quality Standards (NAAQS) to establish health risks near the proposed Sheds compressor station have been demonstrated to be appropriate and defensible.

- **Related to Exposures:**
  - Although MCDOH refers repeatedly to potential synergistic toxicities from emissions resulting from the potential Sheds compressor station, no evidence suggests that such synergistic interactions would occur, and in fact synergistic interactions are not

expected. Similarly, the suggestion that there will be synergistic interactions between particulate matter (PM) and its components clearly does not understand the scientific literature regarding PM toxicity, which is based on epidemiological studies that already take into account the complete PM mixture.

- While MCDOH contends that conformance with NAAQS standards will not protect against short-term exposures or protect sensitive populations, conformance with NAAQS standards is appropriate to determine health risks. NAAQS are designed to be protective of human health (for acute and for chronic exposures) and the environment, including any sensitive populations living near the proposed Sheds compressor station.
- The intensity, frequency, and duration of exposure must be considered when evaluating potential health effects. While The MCDOH Comments recognize this concept, it is not applied consistently by MCDOH. For example, the Comments generally confuse "hazard identification" (what health effects might be associated with some concentration of exposure to a chemical) with "risk" (what health effects might be associated with a specific concentration of a specific chemical at residential locations near the proposed Sheds compressor station).
- The MCDOH Comments fail to take into account how emissions may reach people. In projecting exposures to the nearby population, it is essential to understand that people do not spend their time at the sources of these potential emissions. Instead, they spend some of their time in their homes, some at work and school, some time in their cars, and some time elsewhere.
- Exposure to equipment related to naturally occurring radioactive material (NORM) for pipeline workers or the public is already controlled and public exposure to radon in natural gas is insignificant.
- The proposed Sheds compressor station (which includes a Solar Taurus Model 70 turbine compressor unit to be located in an acoustically insulated compressor building) will be designed to meet the New York State Department of Environmental Conservation (NYSDEC) 6 A-weighted decibels (dBA) allowable incremental increase criterion (relative to existing conditions) as well as the FERC requirement of a maximum day-night sound level of 55 dBA at specified noise sensitive areas (NSA). The maximum sound level from the blowdown vent on the proposed Sheds compressor station (which will include a blow down silencer) will not exceed 60 dBA at 50 feet. For comparison, the nearest NSA in any direction is 1,300 feet from the proposed Sheds compressor station.

- **Related to Health Effects:**
  - The health studies evaluated in the MCDOH Comments included upstream gathering line compressor stations which deal with unprocessed natural gas. Gathering lines are not representative of interstate natural gas pipelines facilities. The gas from the interstate natural gas pipelines has been through various stages of processing and must be generally free of liquids, water vapor, and other impurities and has a higher level of methane than other (nonprocessed) compressed gas. Consequently, interstate or tariff quality natural gas will generally burn cleaner (and thus produce

lower emissions) than an equivalent station combusting natural gas from upstream gathering lines.
    - There is a lack of epidemiological data that specifically address health impacts from compressor stations. Further, the three cited studies are of poor methodological quality and should not be used to demonstrate causal associations between health effects and exposures attributable to compressor stations.

- **Related to Resident Concerns:**
    - Among the top concerns of residents are exposures through soil and food pathways. However, there is no data showing the potential for compressor emissions to impact offsite soils and crops.

- **Other General Findings:**
    - The MCDOH Comments refer to and rely on studies related to unconventional natural gas development (UNGD). The conclusions drawn from a study related to UNGD should not be applied to interstate pipeline compressor stations. To do otherwise, significantly inflates the potential environmental and health impacts associated with a compressor station.

The ENVIRON Report also reviews the feasibility and appropriateness of the recommendations made by MCDOH in its Comments. In summary, the ENVIRON Report suggests that the emissions from the proposed Sheds compressor station are not expected to exceed regulatory guidelines, which were developed to be protective of the public health and of the environment. Thus, conducting a baseline health assessment is of low priority, because no health effects are expected to follow from the construction or operation of the compressor station.

ENVIRON also concludes that a baseline air monitoring study is not justified or needed based on the information presented in the DTI Application in this proceeding for the Sheds compressor station because it is a single compressor station with a limited number of potential emission points that is classified as a minor source. The ENVIRON Report also notes that the noise abatement measures proposed by DTI as well as DTI's emergency plans, including its alert system, are adequate. Finally, the ENVIRON Report suggests that a regional health registry would likely collect health outcome information for a larger population than is likely to be

affected by a single gas compressor station such as Sheds. The regional registry would not allow for specific exposures to be tied to health outcomes, nor would it support epidemiological investigations that require comparison groups.

IV. Conclusion

WHEREFORE, for all the foregoing reasons, DTI respectfully requests that the Commission (1) accept this response; and (2) consider the findings and analysis outlined in the ENVIRON Report for its analysis of the environmental and health impacts of the Project, including the Sheds compressor station.

Respectfully submitted,

/s/ Margaret H. Peters

Margaret H. Peters
DOMINION RESOURCES SERVICES, INC.
120 Tredegar Street, RS-2
Richmond, VA 23219
(804) 819-2411
margaret.h.peters@dom.com

Counsel for
DOMINION TRANSMISSION, INC.

Dated: March 10, 2015

CERTIFICATE OF SERVICE

I HEREBY CERTIFY that I have this day served the foregoing document upon each person designated on the official service list compiled by the Secretary in this proceeding.

Dated at Washington, D.C., this 10th day of March, 2015.

/s/ Margaret H. Peters

Margaret H. Peters
DOMINION RESOURCES SERVICES, INC.
120 Tredegar Street, RS-2
Richmond, VA 23219
(804) 819-2411
margaret.h.peters@dom.com

ATTACHMENT A



Report on Madison County Comments

Prepared for:
Dominion Transmission, Inc.
Glen Allen, Virginia

Prepared by:
ENVIRON International Corporation
San Francisco, California

Date:
March 9, 2015

Project Number:
03-36887A

ENVIRON

Executive Summary

On June 2, 2014, Dominion Transmission Inc. (DTI) filed an application with the Federal Energy Regulatory Commission (FERC) for the New Market Project. The New Market Project consists of two new compressor station facilities and changes to four existing gas transmission facilities in Chemung, Tompkins, Madison, Herkimer, Montgomery and Schenectady Counties, New York. In a letter dated October 15, 2014, the Madison County Department of Health (MCDOH) provided comments to FERC regarding one of the new proposed compressor stations, known as the Sheds compressor station, which would be located in Madison County.

The MCDOH comment letter individually assesses the following topics:

- Compressor station emissions (construction and operation) including fugitive emissions and blowdown
- Health risks from relevant air contaminants including average and peak exposures, particulate matter and noise
- Reported health effects specific to compressor stations including acute and chronic health impacts and radioactive elements
- Concerns from residents; with health and food safety being the top concerns
- Recommendations for framing and scoping the public health issues including the gathering of baseline health and environmental data
- Identification of data gaps and other challenges for implementing a health assessment
- Recommendations and mitigation measures should the permit be granted

Based on their review, MCDOH identifies the following as data gaps:

- Baseline health studies
- Chemical constituents, specifically for compressor station emissions
- Chemical toxicity and chemical mixtures
- Pipeline and metering station emissions
- Radioactive emissions from natural gas
- Air dispersion modeling
- Soil and farm products due to the increased placement of natural gas transmission infrastructure in rural farming communities

Key finding from ENVIRON's review of the MCDOH comments include:

- **Key Findings Related to Compressor Station Emissions:**
  - Air emission and dispersion data are available for the proposed Sheds compressor station (as well as the Horseheads and Brookman Corners compressor stations) in

the DTI Application and associated Appendices. Additional information is publically available for other similar DTI facilities.
- Substantial ambient air quality monitoring data are available for use to characterize ambient concentrations in the area.
- The typical constituents emitted from compressor stations are well known and have been adequately characterized.
- Atmospheric dispersion modeling, utilizing local atmospheric conditions and baseline concentrations, has demonstrated that the Environmental Protection Agency (EPA) health-based standards will not be exceeded during construction or operation of the proposed Sheds compressor station.
- The MCDOH comments also suggest, based on several references cited, that many other compounds such as methyl tertiary-butyl ether (MTBE), tetrachloroethylene (PCE), trichloroethylene (TCE), benzene, ethane, propane, methanol and naphthalene are emitted from compressor stations. However, many of these constituents are also found in typical combustion sources including internal combustion engines (e.g., automobiles) and cannot be assumed to be from compressor stations. In fact, neither MTBE (a gasoline additive) or PCE or TCE (dry cleaning chemicals) would be expected to be present in the combustion byproducts of interstate or tariff quality natural gas.
- Total emissions, including those from construction, operation, fugitive and blowdown activities, are below EPA and State of New York Major Source thresholds. Therefore, the proposed Sheds compressor station would require only a minor source permit.
- Potential to emit calculations on an annual (instead of averages, peaks or catastrophic accident maximum concentrations) basis and the use of EPA's National Ambient Air Quality Standards (NAAQS) to establish health risks near the proposed Sheds compressor station have been demonstrated to be appropriate and defensible.

- **Key Findings Related to Exposures:**
  - Regarding chemical toxicity and chemical mixtures there is not any evidence to suggest that synergistic interactions would occur from the estimated emissions resulting from operation of the proposed Sheds compressor station. Such interactions are rare, especially at environmentally relevant air concentrations, and the default assumptions of, at worst, summing potential health risks are conservative and appropriate as a first approximation of risks. The point about synergy is again raised regarding particulate matter (PM) and its components. However for any interactions that might occur with PM and its components would already be taken into account by epidemiological studies, as the studies are on the complete PM mixture.
  - Conformance with NAAQS is protective of human health (for acute and for chronic exposures) and the environment, including sensitive populations living near the proposed Sheds compressor station. Where appropriate, both shorter (1 hour or 24 hour) and longer (annual) forms of the NAAQS exist. Furthermore, comments that NAAQS are inappropriate to determine health risk for sensitive populations are not justified. NAAQS are designed to protect human health, with an adequate margin of

safety, including sensitive populations such as children, the elderly, and individuals suffering from respiratory diseases.

- It is important to consider the intensity, frequency, and duration of exposure when evaluating potential health effects. The MCDOH comments recognize this in some places (for example, where the comments state that annual averages – or even daily averages – may obscure transiently higher exposures), but then confuses the two concepts in other places. In addition, the MCDOH comments often confuses "hazard identification" (what health effects might be associated with some concentration of exposure to a chemical) with "risk" (what health effects might be associated with a specific concentration of a specific chemical at residential locations near the proposed Sheds compressor station).
- It is important to take into account how emissions may reach residents. In projecting exposures to the nearby population, it is essential to understand that people do not spend their time at the sources of these potential emissions. Instead, they spend some of their time in their homes, some at work and school, some time in their cars, and some time elsewhere.
- Based on review of the MCDOH comments and supporting literature, it is clear that exposure to equipment related to naturally occurring radioactive material (NORM) for pipeline workers or the public is already controlled and public exposure to radon in natural gas is insignificant.
- The proposed Sheds compressor station (which includes a Solar Taurus Model 70 turbine compressor unit to be located in an acoustically insulated compressor building) will be designed to meet the New York State Department of Environmental Conservation (NYSDEC) 6 A-weighted decibels (dBA) allowable incremental increase criterion (relative to existing conditions) as well as the FERC requirement of a maximum day-night sound level of 55 dBA at specified noise sensitive areas (NSA). The maximum sound level from the blowdown vent on the proposed Sheds compressor station (which will include a blowdown silencer) will not exceed 60 dBA at 50 feet. For comparison, the nearest NSA in any direction is 1,300 feet from the proposed Sheds compressor station.

- **Key Findings Related to Health Effects:**
  - The health studies evaluated in the MCDOH comments included upstream gathering line compressor stations which deal with unprocessed natural gas. These are not representative of interstate natural gas pipelines as related to the proposed Sheds compressor station. The gas from the interstate natural gas pipelines has been through various stages of processing and must be generally free of liquids, water vapor, and other impurities and has a higher level of methane than other (nonprocessed) compressed gas. Consequently interstate or tariff quality natural gas will generally burn cleaner (and thus produce lower emissions) than an equivalent station combusting natural gas from upstream gathering lines.
  - There is very little epidemiological data that specifically address health impacts from compressor stations. The available literature is of poor methodological quality and can be used only to generate hypotheses, not to demonstrate causal associations between health effects and exposures attributable to compressor stations. The three cited studies each relied on self-selected groups of individuals reporting on the

prevalence of each of a list symptoms. The symptoms included in the list are common and have many ubiquitous causes; they cannot be specifically tied to exposures potentially attributable to compressor station functions. None of the three studies included a valid comparison group or collected specific exposure information that could be linked to a compressor station. The use of self-selected study groups and symptom checklists, and the lack of appropriate comparison populations and lack of exposure data are substantial design flaws; these studies do not provide information that can be used to suggest causal associations between compressor station exposures and health outcomes.

- **Key Findings Resident Concerns:**
  - Among the top concerns of residents are exposure through soil and food pathways. There is no data showing the potential for compressor emissions to impact offsite soils and crops. In fact, the majority of chemicals constituents likely to be emitted from the proposed Sheds compressor station are semi-volatile or volatile and therefore are unlikely to deposit on soils and crops.

- **Other General Key Findings:**
  - The MCDOH comments refer to and rely on studies related to unconventional natural gas development (UNGD). This compressor station is not related to UNGD, such as those using hydraulic fracturing in shale or tight sand gas development. Lumping compressor stations into overall UNGD, obscures the focus of the proposed project which is one compressor station and inflates the potential environmental and health impacts associated with a compressor station.

If the “permit is granted”, the MCDOH is recommending the following studies and mitigation measures:

- Perform a baseline health study to establish the health of the surrounding community prior to construction of the compressor stations.

  ENVIRON Comments:
  - No emissions from the proposed Sheds compressor station are expected to exceed regulatory guidelines, which were developed to be protective of the public health and of the environment. Thus, conducting a baseline health assessment is of low priority, because no health effects are expected to follow from the construction or operation of the compressor station.

- Perform baseline air pollution monitoring studies.

  ENVIRON Comments:
  - MCDOH is recommending that a baseline air monitoring study be conducted to provide data distinguishing background concentrations and additional impacts from the proposed Sheds compressor station. This baseline air monitoring study is not justified or needed based on the information presented in the DTI Application. The data presented in the DTI Application demonstrates that the proposed Sheds compressor station would have a limited number of potential emission points and would be classified as a minor source.

- It is important to note that many sources besides the proposed Sheds compressor station can effect air concentrations in a community including other sources of chemical emissions (e.g., pesticide application, industrial facilities, gas stations, vehicles, gas stoves, fireplaces), lifestyle (e.g., occupational, driving, smoking), and airborne pollens. This could happen if the results of the study are questioned and emissions from other sources cannot be distinguished from compressor station emissions. This could lead to a false implication that the compressor station is the source of the emissions and for any concomitant health impacts associated with the emissions.

- Require best practices to ensure that effective emissions control measures are kept up to date specifically mentioning that upgrades to equipment should be required for continued operation of the compressor stations and special noise abatement measures should be implemented.

  ENVIRON Comments:

  - DTI is planning on installing a state of the art natural gas combustion turbine fitted with SoLoNox controls and oxidation catalyts to further control emissions. The engines will be monitored 24 hour a day and subject to a maintenance schedule to ensure the engines are running properly to reduce air emissions and comply with all permit limits.
  - In terms of noise abatement measures, the proposed Sheds compressor station (which includes a Solar Taurus Model 70 turbine compressor unit to be located in an acoustically insulated compressor building) will be designed to meet the NYS DEC 6 A-weighted dBA allowable incremental increase criterion (relative to existing conditions) as well as the FERC requirement of a maximum day-night sound level (L_{dn}) of 55 dBA at specified NSAs. The maximum sound level from the blowdown vent on the proposed Sheds compressor station (which will included a blow down silencer) will not exceed 60 dBA at 50 feet. For comparison, the nearest NSA in any direction is 1,300 feet from the proposed Sheds compressor station.

- Establish an alert system for blowdowns or other large emissions and/or noise events.

  ENVIRON Comments:

  - DTI has a plan for alerting local law enforcement, 911, other local police/fire agencies as appropriate and nearby residents. This plan is discussed further in Section 9 of this response to comments.

- Put emergency plans in place for pipeline release events, metering station events and compressor station accidents.

  ENVIRON Comments:

  - In the DTI Application (RR11 – Reliability and Safety), Section 11.4 – Measure to Protect the Public, DTI discusses their safety program. This program includes establishing an emergency plan that provides written procedures to minimize the hazards from a gas pipeline emergency. This plan is further described in Section 9 of this response to comments.

- At residences within one mile of the compressor station, monitor air emissions and impacts to soil and crops.

ENVIRON Comments:

- The data presented in the DTI Application demonstrates that the proposed Sheds compressor station would have a limited number of potential emission points and would be classified as a minor source. Typically, construction of minor source facilities do not require pre- or post-construction air monitoring due to their size and limited impact to human health or the environment. Additionally, the concentration of formaldehyde and total hazardous air pollutants are calculated to be below 0.3 tons per year and monitoring for these constituents would not be cost effective relative to the value of the information to be gained. **Therefore offsite sampling is not warranted.**
- Regarding the air monitoring proposed by MCDOH, it is our understanding that MCDOH would like to conduct air monitoring before, during and after the construction of the proposed Sheds compressor station. The purpose of this monitoring would be to determine the identity of the constituents (and concentrations) that will be emitted, how long they are emitted and the time of day that peak emissions occur. They are also proposing to monitor at select residences one mile from the proposed Sheds compressor station. This information would be compared to sample data collected during the baseline air monitoring or potentially the modeling data. It is our understanding that MCDOH would sample for 30 seconds to 24-hours using Tedlar bags and summa canisters.
- It is unclear what MCDOH hopes to achieve with a limited set of short-term concentrations and what health benchmarks they would be compared to (there are no 30-second health benchmarks that ENVIRON is aware of). Similarly, 24-hour samples give you an indication of concentration on that day but does not capture changes in time over the long term. It should be noted that it is difficult to collect a sufficient number of air samples to characterize both temporal and spatial variability of air concentrations. It would be important that the goals of the study along with the comparison criteria be clearly defined before any sampling is conducted. In addition, it would be premature to monitor at all residences within one mile of the proposed Sheds compressor station or soil and crops before verifying that concentrations at the project boundary exceeded any levels of concern. In fact, one of their major goals is to “support the development and initiation of mitigation for health consequences if any are found”. ENVIRON believes that this information, while being collected to ostensibly protect the health of nearby residents, could lead to problematic outcomes. The most likely being the misinterpretation of the data and the linkage of marginal air quality values with existing and/or perhaps seasonal health effects of the residents.

- Institute a regional health registry so that long term health effects from natural gas infrastructure can be adequately assessed.

  ENVIRON Comments:

  - A regional health registry would collect health outcome information for a larger population than is likely to be affected by a single gas compressor station that is a minor source. It would not allow for specific exposures to be tied to health outcomes, nor would it support epidemiological investigations that require comparison groups. A health registry might allow for the detection of “signals” indicating potential health

issues that should be investigated among the population in the region, but hypotheses of similar quality might also be generated by other means, including analyses of administratively collected data such as those compiled in birth registries, cancer registries, and hospital discharge data files.

Contents

1 Compressor Station Emissions

Dominion Transmission Inc. (DTI) is seeking authorization from the Federal Energy Regulatory Commission (FERC) pursuant to Section 7(c) of the natural gas act to construct and operate the proposed New Market Project. The New Market Project consists of two new compressor stations and changes to four existing gas transmission facilities in multiple counties in New York State. The DTI Application (filed June 2, 2014) included the proposed Sheds compressor station (proposed Sheds compressor station) to be constructed and operated in Madison County, New York. The proposed Sheds compressor station is part of the New Market Project proposed by DTI.

In response to the DTI application (Docket No. CP14-497-000, 2014), the Madison County Department of Health (MCDOH) submitted comments to FERC on the application (MCDOH comments), dated October 15, 2014. According to the Executive Summary of the MCDOH comments, the MCDOH has expressed concerns that the impacts of the construction and operation of the proposed Sheds compressor station to public health has not been adequately addressed in the FERC application. MCDOH's concerns include:

- An Environmental Protection Agency (EPA) Inspector General report (USEPA 2013a) that documents a lack of emissions data from oil and gas facilities;
- Quantifying fugitive and blowdown emissions to include in the total compressor station-wide potential to emit, and;
- The appropriateness of using annual (instead of averages, peaks or catastrophic accident maximum concentrations) emissions data and the EPA National Ambient Air Quality Standards (NAAQS) to establish health risks near the proposed Sheds compressor station.

While the MCDOH comments present sources and data collected and assessed as to potential impact and concerns, the usefulness and inferences as to the potential impacts is limited by the choices of evidence presented in their response. Data appears to be cherry picked to support initial inferences of linkages to questions of concern and supporting data within the MCDOH comments is inappropriately or inaccurately reported and cited. Many of the assumptions and inferences presented in the comments are flawed, outdated, and erroneous. **The recommendations listed do not appear to mitigate concern but provide avenues of further concern and in some cases conflicting and inefficient additional research that will likely not provide the decision makers a guide to determining actual concerns with the proposed Sheds compressor station.**

For example, the MCDOH comments state that, in the EPA Inspector General report, (USEPA 2013a) "there is inadequate information available on direct measurement emissions from oil and gas production activities". If careful reading of that report is conducted, it can be determined that the lack of information regarding emissions from the facilities are from non-point sources and not from typical construction or operation activities. Most of the uncertainty in the report is focused on smaller, non-point sources.

According to the EPA Inspector General report, “the Air Emission Requirements (AERR) rule requires states to report emissions of criteria pollutants and ozone precursors (e.g., volatile organic compounds or VOCs) from a variety of sources to EPA’s National Emission Inventory (NEI). These sources include large stationary sources called point sources, small stationary sources called nonpoint sources, and mobile sources. States are not required to report air toxic emissions, although some do voluntarily. Emissions from point sources are reported on a facility-specific basis. Examples of point sources in the oil and gas sector are gas processing plants and compressor stations. Examples of nonpoint sources include smaller, upstream sources and processes, such as well production pads.”

The main data gaps identified by the EPA Inspector General report (USEPA 2013a) include:

- “EPA has not developed default emission estimates for oil and gas nonpoint sources.
- EPA has not ensured state submission of nonpoint source oil and gas data as required by AERR.
- Some states are not collecting emissions data from smaller (i.e., nonpoint) oil and gas production facilities due to a lack of permitting requirements.”

However, the proposed Sheds compressor station is a point source of pollution (as discussed above), and therefore not the focus of the EPA study (which focused on nonpoint sources).

Based on the review of the MCDOH comments, this section will fill in perceived data gaps identified by the MCDOH and provide additional information to support the application. One of the data gaps asserted in the MCDOH comments was the lack of combined emissions data for construction and normal operation of the proposed Sheds compressor station. Air emission and dispersion data are available for the proposed Sheds compressor station (as well as the Horseheads and Brookman Corners compressor stations) in the DTI Application and associated Appendices. Additional information is publically available for other similar DTI facilities.

Contrary to the MCDOH comments, substantial ambient air quality monitoring data are available for use to characterize ambient concentrations in the area (NYDEC 2013). Madison County is in a federally-designated Air Quality Control Region (AQCR) that involves the compliance with the implementation plan. On Table 9.1-2 of the DTI Application (2014), ambient air quality data representative of the project area are presented. Table 9.1-2 of the DTI Application also shows multiple monitoring stations operated by the State of New York and the monitored concentrations of various pollutants in the project area.

The MCDOH comments also suggest, based on several references (PDEP 2010, Steinzor et al 2013, TCEQ 2010, WEE 2009) that many other compounds such as methyl tertiary-butyl ether (MTBE), tetrachloroethylene (PCE), trichloroethylene (TCE), benzene, ethane, propane, methanol and naphthalene are emitted from compressor stations. However, many of these constituents are also found in typical combustion sources including internal combustion engines (e.g., automobiles) and cannot be assumed to be from compressor stations in the area. In fact, neither MTBE (a gasoline additive) nor PCE or TCE (dry cleaning chemicals) would be expected to be present in the combustion byproducts of natural gas from a compressor station.

Addtionally, planned operation of the compressor station will provide safeguards such as the use of solar turbines (SoLoNOx), oxidation catalysts and good engineering practices to reduce emissions during periods of blowdown or as the equipment ages.

In addition to DTI's best management practices, Federal and State regulations require that compressor stations obtain air permits. These permits require trailer emissions testing of the turbines on a regular basis. Depending on factors related to typical permit conditions, this testing could range from once a year to every 5 years. While conducting emissions testing, DTI is required to notify the respective Federal and/or State environmental agency in advance of the work being conducted. Additionally, DTI must make the operation open and available for state inspection (In New York, the NYSDEC) during the testing. DTI is required to be in compliance with state mandated emission limits outlined in the air permit.

DTI also conducts annual inspections and maintenance on the turbine to include performance evaluation, filter changes, and washing as necessary. The work that is done is required by the manufacturer to maintain peak turbine efficiency and the lowest emissions possible. In the following sections, the construction/operation, blowdown/events and fugitive emissions are discussed for the proposed Sheds compressor station.

1.1 Construction/Operation

The MCDOH comments question the content (identification) of compressor emissions based on typically reported constituents such as criteria pollutants, VOCs and hazardous air pollutants (HAPs) due the construction and operation of the proposed Sheds compressor station. The DTI Application (2014) provides an analysis of typically generated constituents from compressor stations such as criteria pollutants (PM, PM_{10}, $PM_{2.5}$, SO_2, NO_2, CO, ozone, lead), greenhouse gases (CO_2, CH_4, N_2O, and CO_2-equivalents [CO_2e]), VOCs, formaldehyde, and total HAPs. During construction-related activities, fugitive dust is generated from land clearing, grading, and vehicle traffic as presented in the DTI Application (2014). In addition, dust (including various forms of PM, such as PM_{10} and $PM_{2.5}$), greenhouse gases (GHGs) (CO_2, CH_4, N_2O, CO_2e) and other pollutants (CO, NO_x, SO_2, and VOCs) may be generated from many sources, including off-road construction equipment, commuting vehicles and on-road construction vehicles. The emissions generated from these activities are presented as totals for the New Market Project in the DTI Application Table 9.1-4 through Table 9.1-9, and presented by site in the Appendices of the DTI Application.

The MCDOH comments question the grouping of the emissions from all sites and requested that the emissions be presented for the proposed Sheds compressor station only. These data were presented in the Appendices of the DTI Application; however, for convenience they are provided in Table 1 of this response. Note that this table includes controlled fugitive dust emissions for construction activities (not uncontrolled fugitive dust emissions for construction activities). Also, note that these represent concentrations within the fence line of the proposed Sheds compressor station, and will be reduced with distance off-site.

Table 1 Construction and Operations Emissions DTI Sheds Compressor Station (from DTI Application)

Category	Pollutant	Controlled Construction Fugitive Dust Emissions (total)[1] (tpy)	Non-Road Equipment and Off Road Engines Construction[2] (tpy)	Construction Totals (tpy)	Operations Totals [3] (tpy)
Criteria Pollutants	NOx	0.00	8.46	8.46	24.40
	CO	0.00	5.57	5.57	6.60
	VOC	0.00	0.97	0.97	2.90
	SO_2	0.00	0.03	0.03	0.70
	PM_{10}	6.85	0.65	7.50	6.40
	$PM_{2.5}$	0.69	0.64	1.33	6.40
HAPs	Other HAPs	0.00	0.00	0.00	0.20
	Formaldehyde	0.00	0.00	0.00	0.10
GHG Pollutants	CO_2	0.00	2248.30	2248.30	0.00
	CH_4	0.00	0.11	0.11	0.00
	N_20	0.00	0.04	0.04	0.00
	CO_2e	0.00	2264.49	2264.49	54351.00

Notes:
1. DTI Application "Construction Fugutive Dust Emissions" Table in Appendix 9-A. Dust control efficiency = 50%.
2. DTI Application "Construction Fugutive Dust Emissions" Table in Appendix 9-A.
3. DTI Application, Table 9.1-13.

Emissions from activities during operation of the proposed Sheds compressor station have been calculated in the DTI Application and modeled to support the determination that a minor source permit is warranted (including compliance with the health-based NAAQS, VOCs, HAPs and formaldehyde). These data have been reproduced in Table 1, above. Please note that the DTI Application, in Table 9.1-13 (page 26 of the DTI Application) lists that (1) VOC emissions include 1.7 tons per year of fugitive emissions, 0.145% from methane; (2) total HAPs include 0.1 tons per year for fugitive emissions, 0.0093% from methane; and (3) CO_2e include 1,195 tons per year of CO_2e for fugitive methane emissions. The potential emissions from these activities are discussed in Section 1.3.

Potential air emissions can be calculated through direct measurement, the use of emission factors, and engineering calculations. Emission factors are representative values that relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. EPA and States use emission factors to produce emission estimates for specific sources or processes at a facility. Engineering calculations refer to the estimation of emissions using engineering parameters. The DTI Application (FERC 2014) utilized emission factors and engineering calculations (including modeling) to determine the proposed Sheds compressor station's Potential to Emit (PTE). These are the industry-standard and are used throughout the US to estimate the emissions from these types of facilities. Emission factors are generally long-term averages for sources in the applicable industry category. The MCDOH comments also allege that there was "an inadequate assessment of the local weather patterns on dispersal of air pollutants (air dispersion modeling)." Contrary to the MCDOH comments, the modeling in the

DTI Application did include an adequate assessment of the effects of local weather conditions on the dispersal, fate and transport of constituents emitted from the facility. The DTI Application also used an EPA-approved, sophisticated air model (AERMOD) that includes the effects of upper and lower atmospheric data, air-constituent interactions, and local terrain effects.

The MCDOH comments list examples of chemicals detected in ambient air at or near compressor stations. ENVIRON has reviewed the documents referenced in the MCDOH comments and was unable to determine the type of compressor stations that were included in references cited in the MCDOH comments. It is unclear from these references whether the compressor stations under investigation in the references were similar in use, number, mode of operation, fuel use, size and horsepower rating to the proposed Sheds compressor station. Differences in these conditions will have a direct impact on the potential composition and concentration of potential emissions.

The MCDOH comments note an important caveat: that there is no relevant background concentration data for the studies in the references cited in the MCDOH comments, and conclude that “it is not possible to say with certainty that the chemicals found are the result of the compressor station.” Although the MCDOH comments note that these stations are the only industrial activity in the areas, there may be other sources of pollutants. First, many of the detected chemicals have common sources, including emissions from burning coal and oil, gasoline vapors at gasoline service stations, motor vehicle exhaust, cigarette smoke, wood-burning fires, some adhesives, and other sources (USEPA 2009). However, some of the chemicals listed as in the MCDOH comments as being detected near compressor stations, for example Freon 113, MTBE, PCE and TCE, are not known to be associated with natural gas compressor stations.

The MCDOH comments reference a Pennsylvania Department of Environmental Protection (PA DEP) inventory (PA DEP 2010) and states that two compressor stations will emit various VOCs and HAPs. However, this claim could not be independently verified since it was referenced incorrectly and could not be identified.

The MCDOH comments also reference emissions from a compressor station in DISH, Texas (WEE 2009) that they claim exceed Texas Effects Screening Levels (ESLs) (TCEQ 2015). According to a follow-up report (Ethridge 2009), the Texas Council on Environmental Quality evaluated the Wolf Eagle report (WEE 2009) and stated that “The highest potential 1-hour maximum benzene concentration is below the health effects level observed in short-term animal and human studies; however, it is possible that adverse health effects could occur from exposure to this concentration. It was not possible to determine if residents were exposed to this concentration of benzene based on the information provided.” A subsequent study by the Texas Department of State Health Services (TDSHS) found “Biological test results from a Texas Department of State Health Services investigation in Dish, Texas, indicate that residents’ exposure to certain contaminants was not greater than that of the general U.S. population” (TDSHS 2010).

According to the MCDOH comments, another reference (Steinzor et al 2013) states that “In 2011 and 2013, Earthworks, a non-profit organization, collected air samples within 0.33 miles of

two compressor stations: Springhill compressor in Fayette County and the Cumberland/Henderson compressor station in Greene County, Pennsylvania." However, upon review of the Steinzor et al (2013) report, no statements about samples "within 0.33 miles of two compressor stations…." can be found. Further comments on this study can be found in Section 5 of this response to comments (Health Effects Associated with Compressor Stations).

1.2 Fugitives

Fugitive emissions are typically generated from equipment including valves, connectors, flanges, compressor seals, and related equipment. The MCDOH comments had a question regarding the fugitive dust emissions from construction activities. The DTI Application (2014) includes all the sites that comprise the New Market Project. The MCDOH comments request that the application show the emissions for the proposed Sheds compressor site (the only one in Madison County, NY) quantified. Table 1 (above) shows the total construction related fugitive dust emissions (PM from construction engines and earthmoving equipment as well as windborne dust) for the proposed Sheds compressor station as provided in the application.

The MCDOH comments discuss a report prepared by the Eastern Research Group and Sage Environmental Consulting (2011), and claim that it supports that the compressor station had "a total of 2,126 fugitive emission points" for eight compressor stations. However, the ERG & SEC (2011) report states that open tank thief hatches were the highest source of fugitive emissions for the stations. Quoting the ERG & SEC report "The largest source of fugitive emissions detected with the IR camera was leaking tank thief hatches. Emissions were detected at 252 tank thief hatches resulting in a combined TOC emission rate of 4,440 tons/yr. Some of these emissions were due to the operators simply leaving the hatches unsecured……" However, construction of the proposed Sheds compressor station will minimize fugitive emissions by a number of preventative measures, including (1) limiting the area of earth impacted during construction, (2) spraying surfaces to reduce windblown dust, and (3) covering trucks, reducing idling of vehicles and proper operation and maintenance. Therefore, the emissions estimated in the DTI Application are reasonable for construction.

The MCDOH comments cite the ERG & SEC (2011) paper as providing evidence that "It has been suggested that fugitive emissions will increase over time as machinery begins to wear." This is not mentioned in the cited reference.

During a discussion in the MCDOH comments concerning formaldehyde, the statement is made that "It is one of the emissions chemicals that the natural gas development industry is required to report, for instance to the PA DEP. According to these reports, compressor stations are the highest UNGD source for formaldehyde." (PA DEP 2012). However, this reference is actually a spreadsheet, published by PA DEP, which does not make this statement. It is therefore unclear how this conclusion was derived by the MCDOH authors.

Formaldehyde is mentioned again in MCDOH's comments that it would be emitted from compressor stations "from 0.00 TPY to 22.5 TPY". However, this reference is also a spreadsheet, and in fact supports the conclusion that many facilities produce less than 1 ton per year of formaldehyde (PADEP 2011). Note that the proposed Sheds compressor station is estimated to have much lower emissions at 0.1 tons per year.

1.3 Blowdowns and Events

DTI anticipates that the operation of the proposed Sheds compressor station may result in planned blowdowns as well as unplanned events generating fugitive emissions. The number and magnitude of unplanned events cannot be estimated due to their random, unpredictable nature.

The possibility of a catastrophic event for any compression station is low, but real (FERC 2013). According to this reference, the answer to the question ***"Q:** Are there special safety or fire issues associated with compressor stations?"* is ***"A:*** All interstate natural gas facilities, including compressor stations, are required to comply with the U.S. Department of Transportation's Minimum Safety Standards. Compressor stations are constructed with many safety systems, such as gas and fire detection systems and emergency shutdown equipment. These systems are designed to ensure that in the event of an accident, the compressor station would be safely shut down with minimal risk to the public."

In order to minimize the likelihood of an event, the proposed Sheds compressor station will maintain best management practices, develop an alert system for planned blowdowns and keep an emergency plan in place to ensure that first responders have the information they need to handle an explosion or fire at the facility.

The frequency and duration of blowdown was also the subject of a statement in the MCDOH comments, which (based on a TransCanada document) say: "As the natural gas rushes through the blowdown valve, a gas plume extends upward of 30 to 60 meters. The most forceful rush of air occurs at the very beginning, then the flow gradually slows down. The first 30 to 60 minutes of the blowdown are the most intense, but the entire blowdown may last up to three hours" (TransCanada 2005). However, this TransCanada document concerns pipeline blowdowns, not compressor station blowdowns which would likely be of lesser magnitude.

MCDOH comments also state: "One blowdown vents 15 MCf gas to atmosphere on average. Isolation valves leak about 1.4 Mcf/hr on average through open blowdown vents" (TransCanada 2005). The MCDOH comments cite this separately, but the reference contains a link to exactly the same reference (TransCanada 2005). However, the quotation in the MCDOH comments cannot be found in this reference (TransCanada). It is therefore unclear where this number came from.

Table 4 of the MCDOH comments uses the PA DEP measured concentrations (PA DEP 2010b) to show "variability in emissions at one compressor station near Hickory, Pennsylvania." First it should be noted that the PA DEP did not measure emissions, but concentrations at varying distances from the station. There is also a typographical error in MCDOH Table 4, the correct air concentration of ethylbenzene on the evening of May 20, 2010 is 2,788 micrograms per cubic meter ($\mu g/m^3$), substantially lower than the value listed in the table of 27,088 $\mu g/m^3$ (PA DEP 2010b).

The concentrations shown in Table 4 of the MCDOH comments are an example of cherry picking the data to justify desired conclusions. These data were collected by PA DEP using Open-Path Fourier Transform Infrared Spectroscopy (OP-FTIR) sampling techniques –

representing very short-term (2 minute) samples. The same areas were also monitoring by PA DEP using another sampling technique, involving summa canister passivated sampling (using stainless steel canisters, following the EPA Method TO-14) (usually collected for longer durations), and subsequent fixed-base laboratory analysis, to analyze the samples for these same VOCs. These samples (EPA Method TO-14) were analyzed in a fixed laboratory utilizing gas chromatograph/mass spectrometry analysis. The results from a mobile laboratory are not as reliable as those from a fixed-base laboratory. However, the more reliable canister sampling results did not confirm these initial findings of elevated VOC concentrations found in the OP-PTIR sampling. For example, although ethylbenzene, n-hexane, and n-butane were reported to be elevated using the OP-FTIR analysis, neither ethylbenzene nor n-hexane were found (n-butane was not analyzed) in any of the three summa canister samples from the Stewart compressor station, the subject of the reporting in Table 4 of the MCDOH comments. Although OP-FTIR provides *in situ*, real time monitoring of VOC concentrations in the ambient air, this technique is typically only used as a screening technique, to be confirmed with air samples using summa canisters.

DTI's operations focus on preventing excess gas emissions and keeping any emissions to a minimum. As much as possible, pressure is reduced in the system prior to completing any required maintenance thereby reducing any emission. Gas loss is calculated and must be accounted for. Gas loss is an expense to DTI, and therefore there is an incentive to keep gas loss to a minimum.

In addition, DTI incorporates controls in the compressor station to immediately shut off gas into and out of the station in case of emergency, isolating the station from the pipeline system, again reducing gas loss.

2 Chronic and Peak Exposures

The MCDOH comments correctly point out that the metric "tons per year" is only relevant for assessing long-term (annual average) exposures to pollutants of concern, and will not capture short-term peaks which might occur in the course of standard operations. Exposure can be roughly classified as chronic or acute. Chronic exposures occur either continuously over time or at some frequent, repeated pattern over a period of time. Acute exposures are generally transient (for example, lasting seconds, minutes, or hours), and then end. Acute exposures can repeat with time, but are generally separated by time. Usually, chronic exposures occur at lower concentrations and acute exposures occur at higher concentrations. Some pollutants are only associated with health impacts if exposure is high, even if only lasting for a short (acute) time. Other pollutants are only associated with health effects after long, prolonged exposures, and the concentrations associated with health effects following chronic exposures may be lower. The metric "tons per year" does not give one a sense of how long the exposures last, and thus is more applicable to chronic exposures.

For criteria pollutants, the regulatory NAAQS is examined separately for acute and chronic exposures. For example, particulate matter (PM) has both a standard that reflects 24-hour averaging times and annual averaging times, and nitrogen dioxide (NO_2) has standards with 1-hour, 8-hour, and annual averaging times (USEPA 2014b). The individual forms of the NAAQS are derived from scientific studies (epidemiology, controlled human clinical exposures, or experimental animal toxicity studies) taking the exposure durations and intensities into account. The MCDOH comments also state that use of NAAQS are inappropriate to determine health risk for sensitive populations. However, the mandate of the Clean Air Act is for EPA is to set standards designed to protect human health, with an adequate margin of safety, including sensitive populations such as children, the elderly, and individuals suffering from respiratory diseases. In addition to these primary standards, secondary standards are designed to protect public welfare from any known or anticipated adverse effects of a pollutant. **Conformance with NAAQS standards is therefore protective of human health (for acute and for chronic exposures) and the environment, including sensitive populations living near the proposed Sheds compressor station.**

For pollutants which are not covered by NAAQS, the EPA has developed reference values for chronic, but not acute exposures. These values, referred to as Reference Concentrations (RfC)[1] (USEPA 2014a) are meant to be protective of lifetime exposures that carry minimal appreciable risks. They are therefore not appropriate to apply to transient, acute exposures. For these pollutants, the higher concentrations associated with transient, short term exposures may be a more relevant metric to evaluate risk as compared to the RfC. However, these concentrations are often orders of magnitude higher than the RfC value, and comparisons need to be performed on a pollutant-by-pollutant basis.

It is therefore important to consider the intensity, frequency, and duration of exposure when evaluating potential health effects. The MCDOH comments recognize this in some places (for

[1] Reference concentration (RfC) is defined as: "An estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime…" (US EPA glossary)

example, where the comments state that annual averages – or even daily averages – may obscure transiently higher exposures), but then confuses the two concepts in other places. For example, in making the argument that acute exposures are the important metric to assess, the MCDOH comments cite a paper by Darrow et al (2011) to support the "wisdom of looking at peak exposures." However, the statement in Darrow et al (2011) about temporal metrics reflecting peak pollution levels (e.g., 1-hour maximum) being potentially the most biologically relevant, "if the health effect is triggered by a high, short-term dose rather than a steady dose throughout the day," was part of introductory material in the paper and the actual conclusions of the paper were that epidemiologic results were generally similar across different temporal metrics of the same pollutant and would have led to similar conclusions about the relationship between the pollutant and health effect evaluated (respiratory emergency room visits). In their discussion, the study authors support use of metrics based on the NAAQS (designed to capture peak concentrations) in future studies of ambient air pollution and respiratory health" (Darrow et al 2011).

Similar misleading statements about "episodic high exposures" resulting from emissions associated with natural gas compressor stations cite that "published air emission measurements shows the very real potential for harm from industry emissions" then cite a PowerPoint presentation about a study by a nurse practitioner who visits individuals that believe their health concerns are due to nearby gas drilling activities (SWPA-EHP 2013) and a white paper by the Texas Oil and Gas Association (Subra 2009), discussed in further detail within Section 5 of this response to comments.

In referencing Table 4 of the MCDOH comments, a statement is made that "… the EPA inhalation reference concentration (RfC) for ethylbenzene is 1 mg/m3 (equivalent to 1,000 ug/m3). Some of the reported emissions exceed this standard of health safety." The MCDOH comments incorrectly compare a short-term (2-minute value) ethylbenzene concentration to a chronic, long term toxicity regulatory value (according to EPA to be used for exposures greater than 7 years) (USEPA 1989). The correct comparison, as noted in the PA DEP report, is to compare these concentrations to the EPA acute exposure guideline, which for ethylbenzene has a value of 140,000 $\mu g/m^3$ (PA DEP 2010b). None of the ethylbenzene concentrations listed in Table 4 of the MCDOH comments exceeded this value. Indeed the MCDOH comments fail to mention the conclusion of the PA DEP report: "Results of the limited ambient air sampling initiative conducted in the southwest region did not identify concentrations of any compound that would likely trigger air-related health issues associated with Marcellus Shale drilling activities" (PA DEP 2010b).

2.1 VOCs

VOCs are a broad class of chemicals including benzene, methylene chloride, and formaldehyde. The MCDOH comments lump all these chemicals together and makes the statement "Short-term exposure can cause eye and respiratory tract irritation, headaches, dizziness, visual disorders, fatigue, loss of coordination, allergic skin reaction, nausea, and memory impairment. Long-term effects include loss of coordination and damage to the liver, kidney, and central nervous system." These blanket statements are impossible to understand without discussion of the specific VOCs and their corresponding concentrations associated with this laundry list of health concerns.

The MCODH comments make another blanket statement about the cancer potential of VOCs, citing a study by McKenzie et al (2012) which reported on the collection of 163 background air samples at locations >0.5 miles from unconventional gas well pads, comparing them to area samples collected within <0.5 miles of well pads during the well completion phase at a site in Garfield, Colorado. Results of the study showed that median concentrations of benzene were significantly higher within 0.5 miles from the well pad compared to >0.5 miles from well pads – 2.6 $\mu g/m^3$ (range of 0.9-69 $\mu g/m^3$) vs. 0.9 $\mu g/m^3$ (range 0.1-14 $\mu g/m^3$). The corresponding values for hexane were 7.7 $\mu g/m^3$ (range 1.7-255 $\mu g/m^3$) compared to 4.0 $\mu g/m^3$ (range 0.23-62 $\mu g/m^3$). It is important to note, however, that background benzene concentrations may exceed 120 $\mu g/m^3$ (37.5 ppb; median concentration) in U.S. cities (ATSDR 2007), and that hexane concentrations may exceed 85 $\mu g/m^3$ (24 ppb; average concentration) in urban settings (TOXNET 2015). Furthermore, benzene values such as this are not unusual near roadways in areas of Colorado without unconventional gas activities (USEPA 2005). These concentrations for benzene and hexane, essentially reflecting background concentrations, render the actual significance of the comparisons of concentrations >0.5 miles from well pads and within <0.5 miles of well pads for these chemicals meaningless. McKenzie and colleagues then assess the theoretical health consequences associated with these exposures by calculating cancer risk, as well as chronic and subchronic non-cancer hazard indices for residents living within a 0.5 mile radius of unconventional gas facilities and compared them with that of residents living greater than 0.5 mile away. Their analysis suggests that residents who lived closer to the wells were at greater risk of adverse health outcomes related to unconventional gas -related air emissions compared to those who lived more than 0.5 mile away. Specifically, the subchronic hazard quotient (HQ) of 5 observed for residents < 0.5 mile away from wells was considerably higher than the subchronic HQ of 0.2 observed for those living >0.5 mile away. However, McKenzie et al (2012) authors states that their study may have over-estimated non-cancer hazard indices and the cancer risks due to:

- Use of the 95% upper confidence limit (UCL) on the mean exposure concentrations;
- Maximum detected values for 1,3-butadiene, 2,2,4-trimethylpentane, and styrene because of a low number of detectable measurements;
- Default reasonable maximum exposure (RME) assumptions, such as an exposure time of 24 hour per day and exposure frequency of 350 days per year;
- Upper bound cancer risk and non-cancer toxicity values for some of the major risk drivers (e.g., benzene and xylene); and
- Use of (more conservative) chronic RfCs values instead of subchronic RfCs for 1,3-butadiene, n-propylbenzene, and propylene because subchronic RfCs were not available.

Similarly, the calculated cancer risks in the McKenzie et al (2012) paper are driven largely by benzene, which was measured at concentrations consistent with roadways. The same logic used in this analysis would find similar cancer risks in other Colorado urban locations, as reflected by calculations of the EPA National Air Toxics Assessment program (USEPA 2013b). Furthermore, emissions from the proposed Sheds compressor facility would be, if anything, less than the emissions from UNGD activities.

2.1.1 Benzene

The MCDOH comments spend considerable time cataloging the potential health effects of exposure to benzene. What is missing in this discussion is the connection of potential health outcomes that may occur if exposure is high enough, to a discussion of potential health effects that may occur at the anticipated concentrations from may result from the compressor station. For example, acute effects such as drowsiness, dizziness, and headaches are associated with brief exposures to benzene concentrations of 700–3,000 ppm, corresponding to air concentrations of 2,282 – 9,780 mg/m^3 (ATSDR 2007), concentrations which are orders of magnitude higher than occupational exposures let alone anticipated concentrations near a compressor station. Concerns about reproductive effects in women are based on studies where women were occupationally exposed to concentrations much higher than 1 ppm (3.26 mg/m^3) (ATSDR 2007). **This type of laundry list of hazard identification without connection to actual anticipated concentrations in the air near the proposed Sheds compressor station is not useful.**

Similarly, the MCDOH comments discuss cancer risks from exposure to benzene. While benzene is a known human carcinogen (IARC 2012), the studies finding such risks are in occupational settings where exposures would be much higher than those anticipated to be found near the proposed Sheds compressor station. Perhaps better comparisons might be to compare benzene concentrations anticipated at residences originating from the proposed Sheds compressor station to those found in urban environments and in vehicles due to benzene content of gasoline in vehicles (ranging from 1-22 µg/m^3), or benzene exposures from cigarette smoking (ranging from 5.9 to 75 µg per cigarette in mainstream smoke and from 345 to 653 µg per cigarette in side-stream smoke) (HEI 2007). Furthermore, it will be important to assess cancer risk based on lifetime exposures, not transient short-term exposures, as cancer risk calculations are based on assumptions of continuous exposures over a 70 year period. In this sense, the tons per year estimates of benzene emissions (as translated to actual exposure concentrations estimated at residences) are the appropriate metric to examine.

2.1.2 Aldehydes

Similar concerns exist about the statements in the MCDOH comments related to aldehydes (specifically, formaldehyde). The claims in the comments related to asthma-like symptoms, coughing, wheezing, shortness of breath, and asthma need to be put in context with the anticipated exposures to formaldehyde from the proposed Sheds compressor station. As discussed in Section 1 of this response to comments, formaldehyde emissions from compressor stations are expected to be rather low, with most estimates being no more than 1 ton per year (and the DTI Application estimates the proposed Sheds compressor station will generate 0.1 ton per year), and thus unlikely to impact the normal concentrations of formaldehyde in outdoor air. Indoor sources of formaldehyde, reported as resulting in indoor air concentrations ranging from 12-67 µg/m^3 (HEI 2007) are likely a much more significant source of exposure to formaldehyde than the proposed Sheds compressor station.

The statement in the MCDOH comments about formaldehyde formation near compressor stations being due “the chemical reaction between methane and sunlight” references a personal communication with Dr. David Carpenter (endnote 69 of the comments). This statement likely refers to the well-understood atmospheric reactions between ozone, NOx, and VOC, resulting in

formaldehyde (discussed in ATSDR 1999). Nevertheless, the MCDOH comments contain an inflammatory statement that "While it is well known that stationary compressor station engines emit formaldehyde, it is less well known that formaldehyde may also be formed at these sites through this chemical reaction." The comments continue by stating "While the research is ongoing, it suggests that health hazards associated with formaldehyde may be greater than previously thought." **The well understood atmospheric reactions between ozone, NOx and VOC do not require additional research to understand**.

2.2 PM

Much of the concern expressed in the MCDOH comments appear to be based on the literature related to ambient air pollution, and specifically particulate matter (PM). The relationship between exposure and the "physiological sequelae" of events at a receptor, resulting health effects being "produced immediately or in as little as one to two hours," the linkage of a single exposure being able to "cause injury or illness…." as in situation with "air contaminant induced asthma event," and other statements cite the extensive literature related to PM (Pope et al 2006, Brook et al 2010, Wellenius et al 2012). However, the majority of PM exposures are anticipated to occur during construction, a minor phase in the life of the proposed Sheds compressor station, and an event that would occur with the construction of any type of facility. By this logic, no construction projects should ever be allowed within Madison County. Additional emissions of PM may occur during operations and blowdown events.

It is not clear why MCDOH comments claim that PM effects are synergistic between the physical particles and the chemicals absorbed onto their surface, "enhancing or altering the effects of chemicals in sometimes known and unknown ways." Scientists' understanding of PM health effects comes from PM that include these chemicals, so these interactions (if they occur) would already be taken into account by the studies themselves.

The one study the MCDOH comments cite in support of the statement about synergy between PM and VOC, a paper by Amdur (1960), is actually a study involving guinea pigs exposed by inhalation to formaldehyde or formic acid alone, or in combination with sodium chloride aerosol. The formaldehyde in this study was used at a concentration at or above 1 ppm (1,250 $\mu g/m^3$), while only trace amounts of formaldehyde exposures (<0.1 $\mu g/m^3$) are anticipated from the compressor station, a difference of greater than 12,250-fold. The sodium chloride aerosol was comprised of sub-micron particles (geometric mean diameter of 0.04 µm) and is not representative of the PM that might be generated by the construction or operation of the proposed Sheds compressor station, or of the PM generally found in ambient air (which is largely in the range of 0.05-10 µm [HEI 2010]).

The MCDOH comments stress emissions from diesel trucks and equipment, particularly during the construction phase of the project. In addition to citing literature related to diesel exposures, the comments discuss the Mills et al (2007) study as providing evidence that "even dilute diesel emissions can induce risk." In this study, 20 men with prior myocardial infarction were exposed, in two separate sessions, to either filtered air or diesel exhaust at concentrations of 300 $\mu g/m^3$ for 1 hour during periods of rest and moderate exercise. They reported that the diesel exhaust exposures increased myocardial ischemia in these susceptible men, and increased endogenous fibrinolytic function. To put this in perspective, the EPA estimates background concentrations of

diesel PM from non-road sources in the US as 0.61 µg/m^3 (NATA) (USEPA 1996). The diesel PM concentrations in the environment potentially resulting from the proposed Sheds compressor station during the construction activities would be much lower than the diesel PM concentrations in the Mills et al (2007) study. Thus, although the diesel emissions used in the Mills study might be dilute as compared to the direct emissions generated directly at the source of an idling Volvo diesel engine (Mills et al 2007), they are much more concentrated than the concentrations that would be experienced by individuals near the proposed Sheds compressor station, even during the construction phase of the project.

2.3 Mixtures

The MCDOH comments repeatedly contend that exposure to multiple chemicals puts nearby residents at increased risk of both noncancer diseases and cancer, and implies that being exposed to multiple chemicals at the same time is a more risky situation than being exposed to each of the chemicals individually, or even more risky than simply adding the risks of being exposed to each chemical.

The MCDOH comments cite the Brown et al (2014) paper as providing evidence that "Reference standards are set in a form that inaccurately determines health risk because they do not fully consider the potential synergetic combinations of toxic air emissions." **However, synergetic effects are quite uncommon, especially at environmental exposure concentrations**.

When evoking the fear of synergistic effects, it is important to understand that we are exposed to mixtures of chemicals all the time with little risk. Environmentally relevant chemical mixtures are commonly nontoxic, and when toxicity exists, it is typically due to one or a few constituents of the mixture and not all of the components (Jonker et al. 1990, 1993, 1996).

Standard, scientifically accepted methods have been developed as to how to estimate risks from mixtures. In the simplest terms, risks from exposure to mixtures of chemicals can be viewed in one of three ways: (1) as being of similar risk to the sum of the risk of exposure to the individual components (additive), (2) as resulting in more risk than the sum of the risk of exposure to the individual components (synergistic, as implied in the MCDOH comments), or (3) as resulting in less risk than the sum of the risk of exposure to the individual components (antagonistic). These three possibilities are based on scientists' understanding of the biology of the response to exposure to the mixtures. Although the MCDOH comments suggest that the risk from exposures to various chemicals that might originate from the proposed Sheds compressor station somehow interact in a way that is synergistic, this is counter to the general scientific consensus (EFSA 2012, Meek et al 2011, WHO 2009, EPA 2000).

There are two common treatments of chemical mixtures for risk assessment (Meek et al 2011, Crofton et al 2005, Kortenkamp et al 2009). The first, dose addition, adds up the risks of the components for chemicals that act the same – on the same organs, or by the same mechanism. The second, response addition, treats the chemicals as if their toxicity does not interact but instead acts independently. In both of these cases, understanding the risk of exposure to multiple chemicals is fairly straightforward, and synergism need not be invoked. This does not mean that examples of synergy do not occur, but such examples are rare – heavy alcohol

consumption and infection with viral infection increasing the risks of liver cancer, for example, or cigarette smoking and exposure to high concentrations of asbestos increasing the risk of lung cancer. Furthermore, there is usually a recognized biological reason for the interaction, and when synergy does appear to occur as described in these examples, the exposures are generally high—as opposed to lower concentrations as found in the environment, even in the vicinity of an industrial facility.

Regulatory bodies recognize that people are exposed to chemicals as a complex mixture and have developed methods to take these joint exposures into account (EFSA 2012, EPA 2000, Meek et al 2011). Unless the risks from the mixture in question, like cigarette smoking (or a similar mixture) are known, these agencies take the approach of additivity.

Where synergy does occur, it appears to occur at high exposure concentrations and are not viewed as informative in predicting whether synergy will be seen at lower, environmental concentrations where additivity appears to prevail (EPA 2000, Crofton et al 2005, Kortenkamp et al 2009).

This theme of synergism appears elsewhere in the MCDOH comments, including the discussion of PM as discussed above. **However, these claims are general, and not supported by the scientific literature (either cited or uncited).**

3 Exposure

In evaluating potential risks to the nearby population that might result from the proposed Sheds compressor station, it is important to take into account how emissions may reach people. The MCDOH comments point out that in addition to emissions produced during normal operations of the compressor, there may also be fugitive releases, blowdowns, and events. These release possibilities are all discussed in Section 1 of this response to comments.

In projecting exposures to the nearby population, it is important to understand that people do not spend their time at the sources of these potential emissions. Instead, they spend some of their time in their homes, some at work and school, some time in their cars, and some time elsewhere.

To be conservative, it is often assumed that people will spend all their time at their homes, with the indoor concentrations of pollutants similar to the outdoor concentrations at that location. Importantly, the concentrations at these locations will be less than that at the point where emissions occur. Air movement can dilute and remove pollutants, and some pollutants are removed by absorption and deposition by snow, rain, and to surfaces. This dilution may be variable, according to the wind velocity and the air stability. Nevertheless, the concentration of pollutants 0.5 miles, or 1 mile from the proposed Sheds compressor station is expected to be less than that at the station itself. Furthermore, not all air outside a home finds its way indoors. Finally, although realistically people spend a large amount of their time in their homes, they also spend time in other locations (work, school, stores, cars) – locations that are even further from the proposed compressor.

One exposure pathway discussed in the MCDOH comments is by way of uptake of crops. This may be due to deposition onto the soil and subsequent uptake by plants, or due to direct deposition on plants. This exposure pathway is discussed further in Section 7 (Resident Concerns) of this response to comments.

4 Radioactive Elements

The MCDOH comments introduce two separate but related issues: 1) Naturally occurring radioactive material (NORM) from the natural gas extraction and production process, which can accumulate on equipment as scale, sludge, and scrapings; and 2) Radon gas contained in pipeline natural gas. The MCDOH comments suggest there are radioactivity risks to workers at stations along the pipeline as well as to residents using the natural gas. **Based on review of the MCDOH comments and supporting literature, it is clear that exposure to equipment NORM for pipeline workers or the public is already controlled, and public exposure to radon in natural gas is insignificant.**

The primary reference cited in the MCDOH comments on these issues is the International Oil & Gas Producers (IAOGP) Report No. 412, dated September 2008, titled "Guidelines for the management of Naturally Occurring Radioactive Material (NORM) in the oil & gas industry" (IAOGP 2008). The IAOGP document acknowledges that naturally occurring radionuclides are present at varying concentrations in the Earth's crust and can be concentrated by processes associated with the recovery of oil and gas. Sludge, drilling mud, and pipe scales are examples of materials that can contain elevated levels of NORM, and these radioactive materials can be moved from site to site as equipment and materials are reused. In addition, the IAOGP document notes that Radon (as R-222) is present in varying degrees in oil and gas formations and when produced will usually follow the gas stream. Radon gas decays rapidly along the transmission route but can produce daughter elements (Lead-210 and Polonium-210) which would typically be present in particles and adhere to surfaces and therefore be present as pipe scale downstream of the production site.

The MCDOH comments later cite a recent report from the Concerned Health Professionals of New York, titled Compendium of Scientific, Medical, And Media Findings Demonstrating Risks And Harms Of Fracking (Unconventional Gas And Oil Extraction) (CHPNY 2014). The Compendium report on Page 5 states "Unsafe levels of radon and its decay products in natural gas produced from the Marcellus Shale, known to have particularly high radon content, may also contaminate pipelines and compressor stations, as well as pose risks to end-users when allowed to travel into homes." **However, this conclusion is also not supported by the literature and underlying scientific data.**

ENVIRON's critique of the MCDOH comments and its conclusions related to the NORM and Radon issues are further discussed in the following paragraphs:

<u>Exposure to NORM from equipment or piping</u>

Although it is known that NORM may accumulate on gas exploration and production equipment, exposure to these potential hazards are already managed by the industry. For example, the IAOGP 2008 document includes recommendations for NORM disposal, control of NORM contaminated equipment and worker protection. These recommendations also protect the public from exposure to NORM and address Radon daughter products which may be present as scales inside the pipe, because the pipe scales would only present a potential hazard (to workers) when opened for maintenance or cleaning. Also, while NORM can vary between

geologic formations, a recent study procured by the Pennsylvania Department of Environmental Protection (PermaFix 2015) provides NORM measurements on equipment in the Marcellus Shale which are lower than those summarized in IAOGP 2008. For example in IAOGP Page 10, Table 1.10, external radiation levels of up to 300 microsieverts/hour (30,000 microrems/hour) are reported in crude oil downhole tubing, whereas PermaFix 2015 provides exposure rates from contact measurements of equipment (at a natural gas processing plant) are only as high as 900 microrems/hour (see Section 6.4, Page 6-2). The PermaFix report concluded; “There is little or limited potential for radiation exposure to workers and the public from the development, completion, production, transmission, processing, storage, and end use of natural gas.” Furthermore, unlike the natural gas processing facility discussed above, which involves production activities, the proposed Sheds compression station only involves relay of interstate transmission-quality natural gas. Thus, potential NORM exposures are expected to be lower than the cited study, and this comparison is therefore inappropriate.

Exposure to Radon from natural gas venting or use

It has been known for some time that naturally occurring Radon (as R-222) may be present in natural gas. The USEPA (1973) reported an average R-222 level of 37 pCi/L in natural gas at production wells. The more recent Permafix (2015) report recorded values at natural gas compressor stations in the Marcellus Shale between 28.8 and 58.1 pCi/L (Table 6-5). It should also be noted that with the very short half-life of R-222 (3.8 days), radon in natural gas at the consumer location would be reduced to 50% of its original value in just 4 days transportation time. Assuming consumers are exposed to this radon from direct-fired natural gas appliances in the home (i.e. in a stove burner), both of these reports concluded that radon exposure from natural gas use was insignificant.

With respect to air emissions of radon outside the home, the MCDOH comments state “the extent to which radioactive materials are emitted during venting, blowdowns or other events is not well known.” On the contrary, emissions of natural gas from compressor stations is both known and documented, but unfortunately radon is not one of the typical parameters measured. However, based on the short half-life discussed above and the dispersion in outdoor air it is unlikely that radon concentrations would exceed the average indoor radon concentration in New York State of 6.2 pCi/L.

5 Health Effects Associated with Compressor Stations

ENVIRON confirmed that the MCDOH comments identified the only epidemiological studies that were aimed at identifying health effects experienced by residents in the vicinity of natural gas compressor stations. The comments cite one published, peer-reviewed publication (Steinzor 2013) and two reports prepared by Earthworks, an advocacy organization (Steinzor 2012, Subra 2009). Each presents symptoms voluntarily reported by a self-selected sample of residents whose homes are at different distances from various gas extraction and production facilities, including but not limited to compressor stations. Different types of facilities produce different types and concentrations of emissions. Upstream gathering line compressor stations generally deal with unprocessed natural gas, for example, and are likely to encompass a larger suite of pollutants than may be found at compressor stations. Importantly, the proposed Sheds compressor station involves the transmission of interstate quality natural gas, and not the product resulting from gas extraction and production activities discussed in these studies. Exposures would therefore be expected to be much lower, and thus direct comparisons are inappropriate.

Steinzor et al.

Steinzor et al. used a self-reported health survey and environmental testing project carried out between August 2011 and July 2012 to identify health symptoms among those residing in gas development areas in Pennsylvania (Steinzor 2013). Although the occurrence of health symptoms was not tied to specific measured exposures, the authors asserted possible associations between reported symptoms and proximity to gas extraction and production facilities, which included compressor and pipeline stations, gas-producing wells, and impoundment or waste pits. The type of facility was not differentiated in the reported analyses.

The survey included 108 self-selected and peer-recruited volunteers, and employed inconsistent data collection methods including responses from both individuals and proxies, whose data were collected in-person, via telephone and via mailed surveys (Steinzor 2013). Both of these factors increase the likelihood of bias. The reliance on volunteers and those recruited by volunteers suggests selection bias, meaning that participants may be more likely than the general population of the area to have or to report health symptoms; this would increase the apparent association between prevalence of symptoms and residence near a facility. The use of different data collection methods may have resulted in information bias, if the quality and/or completeness of the data obtained differed by data collection method.

The symptoms included in the checklist were common, non-specific and multi-causal. According to the authors, the most common symptoms reported were: sinus/respiratory; behavioral/mood/energy; neurological; muscles/joints; digestive/stomach; ear/nose/mouth; skin reactions; vision/eyes. The authors reported prevalence of each, overall and by county (Steinzor 2013). However, participants resided in 15 different counties with between 1 and 24 respondents per county; nine of 15 counties included between one and three respondents, again indicating that selection bias may have influenced the results. Also, with only one to three respondents residing in more than half of the counties represented, there are inadequate data

(i.e., not enough respondents in each county) to determine whether or not there are differences in symptom prevalence by county.

Steinzor et al. asserted that having detected statistically significant differences in symptom prevalence according to residential distance from the facilities demonstrates the validity of their methods (Steinzor 2013). **This is a fallacy.** Statistically significant differences can easily occur due to biased study design, uncontrolled confounding, and chance, and may in fact be more likely to occur for one or more of these reasons than for any others, including the presence of a true, causal association. The authors' conclusion that these data suggest "a strong association" between occurrence of symptoms and residential distance to gas facilities is neither supported nor unsupported by the data. In fact, all of the results reported by the authors can be explained by selection bias and other characteristics of the design of the survey and its implementation.

Air and water samples were collected from 35 homes, accounting for a subset of 70 participants. Note that some participants resided in the same household, resulting in their data being weighted more heavily than the others'. The authors identified measurable levels of several substances in the air samples they retrieved and analyzed. They asserted that the specific chemicals they measured have been associated in the literature with the symptoms reported by the survey respondents (Steinzor 2013). They did not, however, discuss the exposure concentrations that have been linked to health effects (i.e., how high were the exposures when the health effects were seen?), nor did they compare those exposure concentrations to the concentrations measured in the homes. Moreover, the chemicals measured in the home air samples have many common sources, including motor vehicle emissions; their detection in the homes may, or may not, be due to the gas extraction activities in the region.

In similar fashion, the authors noted that levels of several metals in the well water of the subset of homes that provided samples exceeded drinking water standards set by PA DEP, and that the specific metals identified have been tied to health effects (Steinzor 2013). As with the substances measured in the air samples, Steinzor et al. did not report the levels of the metals or the routes of exposure that were associated with health effects in the literature, nor did they compare the levels detected in the well water to the levels associated with health effects according to the literature. The individuals residing in the homes providing water samples were not asked about their water use habits, such as use of well vs. bottled drinking water, so their exposure levels are unknown. The sources of the metals were not investigated; these may have been present in the ground water before the gas extraction and processing activities began in the region.

The authors concluded, "While the survey and testing results, and their related findings, do not constitute definitive proof of cause and effect, we believe they do indicate the strong likelihood that the health of people living in proximity to gas facilities is being affected by exposure to pollutants from those facilities" (Steinzor 2013). This reasoning is fallacious. The mere presence of measurable levels of a substance does not indicate that the substance is present at hazardous levels, nor have any steps been taken to identify the sources of the materials measured. The presence of a substance at hazardous levels does not mean that individual exposure levels occur at hazardous levels, as noted with respect to drinking water, above. The

symptoms reported by the self-selected group of survey respondents are not specific, and the survey methods used were substantially subject to bias that could easily explain the patterns noted by the authors.

Steinzor et al. stated, appropriately: “This project did not involve certain research elements, such as structured control groups in non-impacted areas and in-depth comparative health history research that aim to show a direct cause-and-effect relationship or to rule out additional exposures and risks” (Steinzor 2013).

Earthworks Reports

The second report cited in the MCDOH comments was completed by an advocacy organization, Earthworks, in 2012 (Steinzor 2012). It contained the following 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. 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.

Of these three conclusions, only the first one (“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”) is correct. However, the causal inference implicit in it and in the second conclusion (“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”) that the health symptoms reported by the residents are due to the measured contaminants is not sound. The cross-sectional nature of the data collection effort, the fact that it was conducted within a self-selected group of individuals rather than according to scientific principles that would result in a representative sample of participants, and the lack of a comparison group, means the data are insufficient for causal inference and that alternative explanations for any associations noted cannot be ruled out. Although the data collection instrument included subjective questions regarding changes in symptoms for time periods before and after the shale gas extraction activities were initiated, such data are subject to biases that render the results unreliable when placed in the context of the other design limitations listed above (i.e., cross-sectional design; self-selection of participants; and no comparison group). In addition to these general concerns

stemming from the design of the symptom survey, inspection of the results reported by Earthworks indicates internal inconsistencies that are difficult to explain except as the result of random variation and the invalid study design.

The third conclusion put forth in the Earthworks 2012 report ("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") (Steinzor 2012) is a mis-representation of the "precautionary principle". The precautionary principle is meant to provide an approach to risk management. It stipulates that a plausible risk of a definable harm must be scientifically demonstrated. While the precautionary principle is appropriately triggered by uncertainty, the existence of the suspected risk must still be supported by data and not easily refuted. The precautionary principle is not meant to be used as justification for banning or ceasing operations, but rather to trigger the implementation of steps to mitigate the potential harm (UNESCO 2005).

The MCDOH comments also rely on an earlier, 2009 report by Earthworks (referred to as the DISH/Clark report in this discussion) that also describes a survey of self-reported health symptoms (Subra 2009). The health survey queried 31 individuals from 14 households in October/November 2009 on their individual self-perceived health status (sick, health, both healthy and sick), frequency of illness, access to doctors and health care providers, occupational exposures, smoking history, "odor event" experiences, and medical conditions. An ambient air survey took place in seven locations from August 17-18, 2009, and the consequent analysis was seemingly limited to whether specific chemicals were detected in the samples.

While the DISH/Clark report provides information about "odor event" experiences in relation to gas compressor stations, "odor events" are not defined in the report (Subra 2009). For instance, the report does not clarify whether an "odor event" is a one-time occurrence, or a continuous event over a certain period of time. Further, while odor events may serve as a source of annoyance to communities, it is unclear whether the "odor events" in question are correlated with human health impacts. The presence or absence of odors is not always related to toxicity and/or human health impacts, and the impact of odors varies according to the chemical or chemical mixtures in question.

In addition to the uncertainties in "odor event" results presented for compressor stations, this report's overall study design yields results that are problematic and difficult to contextualize. Similar to the 2012 Earthworks report (Steinzor 2012) and to the Steinzor (2013) publication, this report relied on data from a self-selected population for its investigation (Subra 2009). As discussed previously, utilizing a self-selected population increases the likelihood of biases related to the participants who choose to provide information, and consequently affects the study's results. The DISH/Clark report, like the other two studies, does not clarify the number of survey respondents that were originally sought, the survey respondents who did not choose to participate in the survey, if there were any meaningful differences between participants who chose to respond and not respond, nor the contents of the administrated survey. Additionally, this report does not utilize a control population; it is unclear how the information reported by the self-selected DISH/Clark residents differs, if at all, from residents in other communities without natural gas activities.

Similar to the Steinzor (2013) report, the DISH/Clark report does not evaluate how exposure concentrations may or may not be correlated with health impacts.(Subra 2009) Rather, the DISH/Clark report surveys self-selected community members, presents the survey's results (including numerous reported "medical conditions"), conducts limited air sampling, and notes how regulatory exceedances of chemicals detected in the air samples can cause health effects similar to those reported by the DISH/Clark survey respondents. The presentation of this information is misleading for two reasons. First, the extent to which the DISH/Clark ambient air survey identified chemicals exceeding regulatory parameters is unclear; the report only states that chemicals were "detected." Second, the "overlapping" medical conditions (i.e., the overlap between DISH/Clark residents' "medical conditions" and the health effects listed as associated with regulatory threshold exceedances) are non-specific and multi-causal in nature. Specifically, the most prevalent DISH/Clark symptoms reported, such as "sinus problems," "throat irritation," and "allergies" may be attributable to a number of causes, and are not solely correlated with gas compressor activities or regulatory threshold exceedances.

In order for an epidemiological study to be considered valid and reliable, the study's design, methods, and interpretation of results must adhere to established standards of good epidemiological practice. This DISH/Clark report, although providing information about odors potentially associated with compressor stations, is based on anecdotal evidence and its results should be considered exploratory, pending additional investigation (Subra 2009). Though the authors do not make explicit conclusions regarding the health status of DISH/Clark residents, the results of this study are insufficient for making a causal determination between residents near gas compressor stations and potentially related health effects, namely due to unclear survey definitions, the self-selected study population, lack of a control population, and unclear relationships between the survey results, air sampling results, and natural gas exploration activities in this area.

Summary

The MCDOH comments open Section IV with the statement "[there are] few studies specifically address health impacts from compressor stations." The available literature is of poor methodological quality and can only generate testable hypotheses. No emissions from the proposed Sheds compressor station are expected to exceed regulatory guidelines, which were developed to be protective of the public health and of the environment. Thus, conducting a health assessment is of low priority, because no health effects are expected to follow from the construction or operation of the compressor station.

6 Noise

In their brief Noise section, the MCDOH comments express concern about the physical and psychological effects of excessive noise. In the studies cited in the comments (which are summaries of numerous noise studies), "excessive noise" is not consistently defined but is typically cited as values in the 60+ decibel (dBA) range. Generally, statistically-significant increased impacts to physical and psychological health were not identified in relation to long-term exposure below 55 dBA. According to the US Department of Health, National Institute on Deafness and other Communication Disorders (NIDCD), the average decibel rate for a normal conversation is 60 dBA.[2]

Resource Report 9 of the DTI Application presents the results of the measured existing ambient sound levels and calculated predicted total sound levels for the proposed Sheds compressor station operation. Calculations were provided for the property boundaries as well as at the 12 noise-sensitive areas (NSAs) (residences, schools, churches, etc.) nearest to the proposed compressor station. The proposed station (which includes a Solar Taurus Model 70 turbine compressor unit to be located in an acoustically insulated compressor building) will be designed to meet the New York State Department of Environmental Conservation (NYSDEC) 6 A-weighted dBA allowable incremental increase criterion (relative to existing conditions) as well as the FERC requirement of a maximum day-night sound level (L_{dn}) of 55 dBA at specified NSAs. As presented in Table 9.2-13 of Resouce Report 9, the maximum predicted total L_{dn} at any of the 12 nearest NSAs is 51.5 dBA (due entirely to existing ambient noise). The maximum increase at any NSA is 0.7 dBA, well below the 6 dBA incremental increase criterion identified. As specified in RR09, the maximum sound level from the blowdown vent on the proposed Sheds compressor station (which will included a blow down silencer) will not exceed 60 dBA at 50 feet. For comparison, the nearest NSA in any direction is 1,300 feet from the proposed Sheds compressor station.

As a separate issue, the MCDOH comments express concern about health effects due to vibration exposures, also known as vibroacoustic disease (VAD) resulting from exposure to low frequency (LF) noise (0-500 hertz). According to Alves-Pereira and Branco (1999), "…[VAD] is a noise-induced, whole-body pathology, of a systemic nature, caused by excessive and unmonitored exposure to LF noise." VAD is typically diagnosed in workers exposed to LF noise over the long-term, although non-occupational exposures in non-"noisy" environments have also been diagnosed (Alves-Pereira and Branco 1999). The study identifies occupational 8-hour 90 dB exposures in the 20-500 hertz range as causing irreversible organ system damage but does not provide any further guidance for acceptable levels of exposure. As presented in Resource Report 9 of the DTI Application, the measured LF sound pressure levels (31.5-500 hertz) at the NSAs nearest to the proposed Sheds compressor station range from 28-56 decibels (dB), well below the 90 dB exposures cited.

[2] http://www.nidcd.nih.gov/health/hearing/pages/noise.aspx

7 Resident Concerns

The MCDOH comments state that the key concern cited by residents was food safety. Specifically, comments addressed concerns regarding risks to crops, farms, gardens, and consumers from potential chemical exposure from air emissions through soil and food pathways and soil contamination from spills, leaks, and underground contamination.

The MCDOH comments report that the pathway for contamination through air is well documented citing Nadal et al (2003), Orechio (2010), and Kirk et al (2014). Nadal et al (2003), however, reported that the petrochemical complex was "not a relevant metal pollution source." Orechio (2010) describes the atmospheric deposition from one of the largest manufacturing gas plants in Sicily. Manufacturing gas plants create gas by the pyrolysis of coal, coke, and oil, and are have been known to contaminate nearby surface water, groundwater, and soils. The atmospheric deposition from the sites described in Kirk et al (2014) are related to large scale bitumen upgrading facilities and blowing dusts, not natural gas compressor facilities.

The MCDOH comments recognize there may be "data gaps and other challenges for implementing a health assessment" including "the need for monitoring soils and farm products for chemical contamination." However, there are no data showing the potential for compressor emissions to impact offsite soils and crops. In fact, the majority of chemicals constituents likely to be emitted from the proposed Sheds compressor station are semi-volatile or volatile and therefore are unlikely to deposit on soils and crops. Alternative sources of contamination, not necessarily associated with the proposed compressor station, include exhaust and lubricating oils from farm machinery, vehicular traffic, road tar debris and heating oil (EFSA 2012). Soil amendments and plant fertilizers can be a source of heavy metals in soil and plants (EFSA 2009, Perez and Anderson 2009).

8 Baseline Health and Data Gaps

In Sections VI and VII of the MCDOH comment, recommendations for framing and scoping the public health issues and potential data gaps and other challenges for implementing a health assessment are provided. However, much of this discussion seems to focus on the broader field of unconventional natural gas development (UNGD) which is often mentioned throughout the comment letter. What is conventional versus unconventional gas? Conventional oil and natural gas deposits occur in porous and permeable sandstone and carbonate reservoirs. What makes a resource unconventional is the geology. Unconventional formations are fine-grained, organic-rich, sedimentary rocks—usually shales and similar rocks (Ratner and Tiemann 2014). Unconventional oil and gas resources are difficult to reach and may require specialized drilling techniques such as hydraulic fracturing. Regardless of how they are produced or the rock they come from, unconventional oil and natural gas are essentially the same as their conventional counterparts (AER 2015). UNGD, or the development of unconventional natural gas, refers to the process of extracting the UNG along with the associated above ground facilities.

Compressor stations are used for transporting natural gas from one location to another. There is nothing unconventional about a compressor station. Over 1,200 natural gas compressor stations are used on the US interstate natural gas pipeline network to maintain a continuous flow of natural gas between supply area and consumers. **Lumping compression stations into the overall UNGD, obscures the focus of the comments which are in reference to one compressor station in Madison County and inflates that potential environmental and health impacts associated with a compressor station.**

For example, in Section VI of the comment letter, MCDOH focuses the reader on two references they say show the need for a public health perspective in the process of regulating UNGD. The two reports are “Health Impact Assessment for Shale Gas Extraction” (EHSRM 2012) and “Potential Public Health Hazards, Exposures and Health Effects from Unconventional Natural Gas Development” (Adgate et al 2014). The MCDOH comments quote from the second reference:

> “”…pollution from UNG development originates from (1) direct and fugitive emissions of methane and nonmethane hydrocarbons from the well and associated infrastructure (e.g., production tanks, valves, pipelines, and collection and processing facilities); (2) diesel engines that power equipment, trucks, and generators; (3) drilling muds, fracturing fluids, and flowback water; and (4) deliberate venting and flaring of gas and related petroleum products.” (Adgate 2014).

The comments here veer off topic. The DTI Application includes one proposed natural gas compressor station in Madison County. There is no proposed project that includes emissions from a well and associated infrastructure; drilling muds, fracturing fluids, and flow backwater; or venting and flaring of gas. MCDOH appears to have overreached and is addressing the larger topic of UNGD in general in their comments on a specific compressor station – the proposed Sheds compressor station in Madison County.

Based on their review, the MCDOH comments identify the following as data gaps:

- Baseline health studies:

    - This section of the MCDOH comments cites one reference that addresses human health questions during a shale gas boom. This section also states that "Baseline studies in relation to UNGD are needed and should be followed by health status monitoring during development and production phases". Again, it is important to remember that the DTI Application as it related to Madison County is for one natural gas compressor station, not for UNGD and related activities.

- Chemical constituents, specifically for compressor station emissions:

    - Chemical constituents for compressor station emissions are addressed in Section 1 of this response to comments. As noted in that section, typical emissions from compressor stations include common criteria pollutants (NOx, CO, VOCs, PM-10, PM-2.5, and SOx); greenhouse gases (CO2, N2O, CH4) and, in very low concentrations, hazardous air pollutants such as formaldehyde. The common theme of the DTI Application is that these pollutants have the potential to be emitted from the proposed Sheds compressor station, but at concentrations well below major source thresholds. In fact, the application states that "the pre-construction permit that will be required is known as an Air State Facility Permit". (DTI 2014). This is a state-only minor source permit.

- Chemical toxicity and chemical mixtures:

    - Chemical toxicity and chemical mixtures are addressed in Section 2 of this response to comments. As noted in that section, there is not any evidence to suggest that synergistic interactions would occur from the estimated emissions resulting from operation of the Sheds compressor station. Such interactions are rare, especially at environmentally relevant air concentrations, and the default assumptions of, at worst, summing potential health risks are conservative and appropriate as a first approximation of risks.

- Pipeline and metering station emissions:

    - This section states that "In addition to compressor stations, pipelines and metering stations also emit chemicals into the air." This comment veers off topic. The proposed natural gas compression station will connect to existing pipeline within the boundary of the site. There is no proposed pipeline development or metering station.

- Radioactive emissions from natural gas:

    - Radioactive emissions from natural gas is addressed in Section 4 of this response to comments. As noted in this section, based on review of the MCDOH comments and supporting literature, it is clear that exposure to equipment NORM

for pipeline workers or the public is already controlled, and public exposure to radon in natural gas is insignificant.

- Air dispersion modeling:
    - An air quality impact analysis using air dispersion modeling was conducted for Sheds Station Solar Taurus 70 combustion turbine as described in the DTI Application (see RR – 9 Pages 9-25 through 9-27). According to the DTI Application the modeling was completed using site specific information (proposed height of the compressor station), an EPA-approved model (AERMOD) and included five (5) years of meteorological data to predict the impacts over a five year time span utilizing the same statistics that apply to the NAAQS. As shown in Table 9.1.-15, the predicted impacts were within the NAAQS standards.

- Soil and farm products due to the increased placement of natural gas transmission infrastructure in rural farming communities:
    - Soil and farm products are addressed in Section 7 of this response to comments. As noted in that section, there are no data showing the potential for compressor emissions to impact offsite soils and crops. In fact, the majority of chemicals constituents likely to be emitted from the proposed Sheds compressor station are semi-volatile or volatile and therefore are unlikely to deposit on soils and crops.

9 Recommendations/Mitigation Measures

If the permit is granted, the MCDOH is recommending the following studies and mitigation measures:

- **Perform a baseline health study to establish the health of the surrounding community prior to construction of the compressor stations.**

  "A baseline health study would allow MCDOH to monitor and measure health impacts over time and support the development and initiation of mitigation for health consequences if any are found. A baseline study that includes air pollution monitoring would provide data to distinguish between background and additional impacts from compressor station emissions. With indoor air monitoring in residences, distinctions could be made between the use of natural gas in the home on a regular basis and the potential impact of emissions dispersing into residences. For example, a measure of spikes that might occur from cooking (short-term) would look different from longer-term spikes that result from outdoor air pollution, or nighttime spikes that might occur due to weather conditions."

The health study proposed in the MCDOH comments targeted upstream gathering line compressor stations and did not include data from interstate natural gas pipelines. The gas from these pipelines are of a higher quality and consequently will produce lower emissions than an equivalent station combusting natural gas from upstream gathering lines.

ENVIRON Comments on Baseline Health Study:
As noted in the MCDOH comments, establishing the baseline condition of the community would allow for a benchmark against which changes occurring after the compressor station was in operation could be measured. However, new data collection may not be required, and air monitoring is certainly not needed at this point in time. The need, or lack of need, for air monitoring is discussed in more detail, below.

As noted in Section 1 of this report, however, no emissions from the proposed Sheds compressor station are expected to exceed regulatory guidelines, which were developed to be protective of the public health and of the environment. Thus, conducting a baseline health assessment is of low priority, because no health effects are expected to follow from the construction or operation of the compressor station. The health study outlined in the MCDOH (2015) comments does not follow good design principles. Instead, it includes a vast and unfocused data collection effort that is unlikely to include sufficient numbers of participants from an adequately representative (i.e., not self-selected) sample of the community population to support valid conclusions. No rationale is provided for the selection of a one mile radius around the compressor as an area of concern. The proposed schedule of baseline and follow-up assessments is not explained, nor is the three year duration of follow-up. Among the outcomes of interest listed by MCDOH are cancers, COPD and heart disease. These are chronic conditions; cancer, in particular, has an induction period of decades. It is impossible that differences in cancer occurrence would be observed after three years of observation, even if there were some causal association with exposures to compressor station emissions (which is highly unlikely). As another example of the lack of thought in the MCDOH baseline study

recommendations, indoor air monitoring is called for to determine whether or not natural gas is used in the home. Questionnaires or interviews can provide this information more efficiently, for lower cost, and for a larger number of participants. It is similarly premature to implement lung function tests and to collect health diaries; resources would be more effectively used to design and recruit a valid sample of the population and collect high quality questionnaire data.

In contrast, the health study outlined in the MCDOH (2015) comments does not follow these design principles. Instead, it includes a vast and unfocused data collection effort that is unlikely to include sufficient numbers of participants from an adequately representative (i.e., not self-selected) sample of the community population to support valid conclusions. No rationale is provided for the selection of a one mile radius around the compressor as an area of concern. The proposed a schedule of baseline and follow-up assessments is not explained, nor is the three year duration of follow-up. Among the outcomes of interest listed by MCDOH are cancers, COPD and heart disease. These are chronic conditions; cancer, in particular, has an induction period of decades. It is impossible that differences in cancer occurrence would be observed after three years of observation, even if there were some causal association with exposures to compressor station emissions (which is highly unlikely). As another example of the lack of thought in the MCDOH baseline study recommendations, indoor air monitoring is called for to determine whether or not natural gas is used in the home. Questionnaires or interviews can provide this information more efficiently, for lower cost, and for a larger number of participants. It is similarly premature to implement lung function tests and to collect health diaries; resources would be more effectively used to design and recruit a valid sample of the population and collect high quality questionnaire data.

- **Perform baseline air pollution monitoring studies**

ENVIRON Comments on Baseline Air Pollution Monitoring Studies:
MCDOH is recommending that a baseline air monitoring study be conducted to provide data distinguishing background concentrations and additional impacts from the proposed Sheds compressor station. These comments only address the outdoor baseline air monitoring that MCDOH is envisioning. MCDOH recommends monitoring for air emissions such as formaldehyde, VOCs and particulate matter at residences within one mile of the proposed Sheds compressor station. This baseline air monitoring study is not be justified or needed based on the information presented in the DTI Application. The data presented in the DTI Application demonstrate that the proposed Sheds compressor station would have a limited number of potential emission points and would be classified as a minor source. Typically, construction of minor source facilities do not require pre- or post-construction air monitoring due to their size and limited impact to human health or the environment. Additionally, the concentration of formaldehyde and total hazardous air pollutants are calculated to be below 0.3 tons per year and monitoring for these constituents would not be cost effective relative to the value of the information to be gained.

Furthermore, a baseline air monitoring study could cause confusion in the community and be misinterpreted by the public. As with baseline health, it is important to note that many sources besides the proposed Sheds compressor station can effect air concentrations in a community including other sources of chemical emissions (e.g., pesticide application, industrial facilities,

gas stations, vehicles, gas stoves, fireplaces), lifestyle (e.g., occupational, driving, smoking), and airborne pollens. This could happen if the results of the study are questioned and emissions from other sources cannot be distinguished from compressor station emissions. This could lead to a false implication that the compressor station is the source of the emissions and for any concomitant health impacts associated with the emissions.

There are various mitigation strategies that could be undertaken for the proposed Sheds compressor station project. For example, DTI is proposing the use of state-or-the-art turbines, fitted with SoLoNox and oxidation catalysts to minimize emissions of NOx and reduce emissions of CO, VOC, and hazardous air pollutants (HAPS).

- **Require best practices to ensure that effective emissions control measures are kept up to date specifically mentioning that upgrades to equipment should be required for continued operation of the compressor stations and special noise abatement measures should be implemented.**

ENVIRON Comments on Best Practices:
The project proposes to use state of the art natural gas fired combustion turbines, fitted with SoLoNox and oxidations catalyst. The engines will be monitored 24 hour a day and subject to maintenance schedule to ensure the engines are running properly to reduce air emissions and comply with all permit limits.

In terms of noise abatement measures, the proposed Sheds compressor station (which includes a Solar Taurus Model 70 turbine compressor unit to be located in an acoustically insulated compressor building) will be designed to meet the NYS DEC 6 A-weighted dBA allowable incremental increase criterion (relative to existing conditions) as well as the FERC requirement of a maximum day-night sound level (L_{dn}) of 55 dBA at specified NSAs. The maximum sound level from the blowdown vent on the proposed Sheds compressor station (which will included a blow down silencer) will not exceed 60 dBA at 50 feet. For comparison, the nearest NSA in any direction is 1,300 feet from the compressor station.

- **Establish an alert system for blowdowns or other large emissions and/or noise events**

ENVIRON Comments on Alert System:
It is our understanding from DTI, that in the case of blowdowns or other large emissions and/or noise events, typically their local Management or other designated personnel contact local law enforcement, 911 and other local police/fire agencies as appropriate. In addition, their personnel notify residents in the immediate affected area door-to-door (they leave notices on the doors if no one is present).

In the area of Brookman Corners Compressor Station, DTI is participating in the Montgomery County's Hyper-Reach 911 notification system. In the event of a planned blowdown or any other activity that would warrant a call to notify the local community through the 911 system, DTI would call Montgomery County Sheriff's Office 911 Center and provide the information to be communicated. Montgomery County 911 will create the message and make the calls, based on

information DTI provides. Montgomery County is the only locale they are aware of, that offers such a service.

- **Put emergency plans in place for pipeline release events, metering station events and compressor station accidents.**

This recommendation includes provisions for training of first responders for specific scenarios related to the compressor station, training of local health providers for specific environmental exposures, and development of an evacuation plan.

ENVIRON Comments on Emergency Plans:

In their Application (RR11 – Reliability and Safety), Section 11.4 – Measure to Protect the Public, DTI discusses their safety program. This program includes:

Establish an emergency plan that provides written procedures to minimize the hazards from a gas pipeline emergency. DTI has emergency response plans in place for the existing facilities that comprise this Project. Key elements of this plan include procedures for:

- receiving, identifying and classifying emergency events (i.e., gas leakage, fires, explosions, natural disasters);
- establishing and maintaining communications with local fire, police and public officials, and coordinating emergency response;
- maintaining access to the facilities and making personnel, equipment, tools and materials available at the scene of an emergency;
- protecting people first and then property, and making both safe from actual or potential hazards; and
- emergency shutdown of system and the safe restoration of service.

Regular meetings are held with the emergency response agencies (including local fire departments) where the role of the departments with respect to pipeline fires is discussed, along with issues related to potential compressor station incidents where those facilities exist. The information exchanged between DTI and the emergency response agencies that participate in these meetings familiarizes each organization with the resources (both personnel and equipment) that can be utilized in the unlikely event that an incident occurs.

DTI will incorporate the proposed new equipment into the emergency response plans that currently cover existing facilities and will work with those first responders in the community to develop modifications to a local community's plan as necessary. DTI will continue to work with the local communities to ensure that a satisfactory plan is in place.

- **At residences within one mile of the compressor station, monitor air emissions and impacts to soil and crops**

  "To adequately protect public health it is necessary to measure air emissions at the source and to determine air pollution impacts locally. MCDOH recommends monitoring air emission such as formaldehyde, VOCs and particulate matter at residences within

one mile of the compressor station. MCDOH also recommends monitoring impacts to soil and crops within one mile of the compressor station to assess impacts on farm products."

ENVIRON Comments on Monitoring Air Emissions within 1 Mile of the Proposed Sheds Compressor Station and Impacts to Soil and Crops:

As noted above, the data presented in the DTI Application demonstrates that the proposed Sheds compressor station would have a limited number of potential emission points and would be classified as a minor source. Typically, construction of minor source facilities do not require pre- or post-construction air monitoring due to their size and limited impact to human health or the environment. Additionally, the concentration of formaldehyde and total hazardous air pollutants are calculated to be below 0.3 tons per year and monitoring for these constituents would not be cost effective relative to the value of the information to be gained. **Therefore offsite sampling is not warranted.**

- **Institute a regional health registry so that long term health effects from natural gas infrastructure can be adequately assessed**

ENVIRON Comments on a Regional Health Registry for Long Term Health Effects:

A regional health registry would collect health outcome information for a larger population than is likely to be affected by a single gas compressor station. It would not allow for specific exposures to be tied to health outcomes, nor would it support epidemiological investigations that require comparison groups. A health registry might allow for the detection of "signals" indicating potential health issues that should be investigated among the population in the region, but hypotheses of similar quality might also be generated by other means, including analyses of administratively collected data such as those compiled in birth registries, cancer registries, and hospital discharge data files.

10 Conclusions

ENVIRON has reviewed the MCDOH comment letter regarding the proposed Sheds compressor station and has identified findings in the following key categories:

- Compressor Station Emissions
- Exposures
- Health Effects
- Residents' Concerns

We found many statements and conclusions in the MCDOH comments were not substantiated by the supporting citations. These comments are detailed in Sections 1-9, above. Based on their evaluation, as outlined in the MCDOH comments, the MCDOH is recommending a number of studies and mitigation measures if the permit is granted. ENVIRON does not agree that all of these recommendations are firmly based in science and known information. Below, ENVIRON comment on our evaluation of the recommendations included in the MCDOH comments.

Baseline health study

No emissions from the proposed Sheds compressor station are expected to exceed regulatory guidelines, which were developed to be protective of the public health and of the environment. Thus, conducting a baseline health assessment is of low priority, because no health effects are expected to follow from the construction or operation of the compressor station.

Baseline air pollution monitoring studies

MCDOH is recommending that a baseline air monitoring study be conducted to provide data distinguishing background concentrations and additional impacts from the proposed Sheds compressor station. This baseline air monitoring study is not justified or needed based on the information presented in the DTI Application. The data presented in the DTI Application demonstrates that the proposed Sheds compressor station would have a limited number of potential emission points and would be classified as a minor source.

As with baseline health, it is important to note that many sources besides the proposed Sheds compressor station can effect air concentrations in a community including other sources of chemical emissions (e.g., pesticide application, industrial facilities, gas stations, vehicles, gas stoves, fireplaces), lifestyle (e.g., occupational, driving, smoking), and airborne pollens. This could happen if the results of the study are questioned and emissions from other sources cannot be distinguished from compressor station emissions. This could lead to a false implication that the compressor station is the source of the emissions and for any concomitant health impacts associated with the emissions.

Best practices

In terms of noise abatement measures, the proposed Sheds compressor station (which includes a Solar Taurus Model 70 turbine compressor unit to be located in an acoustically insulated compressor building) will be designed to meet the NYS DEC 6 A-weighted dBA allowable incremental increase criterion (relative to existing conditions) as well as the FERC requirement of a maximum day-night sound level (L_{dn}) of 55 dBA at specified NSAs. The maximum sound level from the blowdown vent on the proposed Sheds compressor station (which will include a blow down silencer) will not exceed 60 dBA at 50 feet. For comparison, the nearest NSA in any direction is 1,300 feet from the compressor station.

Emergency plans

In the DTI Application (RR11 – Reliability and Safety), Section 11.4 – Measure to Protect the Public, DTI discusses their safety program. This program includes establishing an emergency plan that provides written procedures to minimize the hazards from a gas pipeline emergency. This plan is further described in Section 9 of this response to comments.

Alert system for blowdowns or other large emissions and/or noise events

DTI has a plan for alerting local law enforcement, 911, other local police/fire agencies as appropriate and nearby residents. This plan is discussed further in Section 9 of this response to comments.

Monitoring Air Emissions within 1 Mile of the Proposed Sheds Compressor Station and Impacts to Soil and Crops

The data presented in the DTI Application demonstrates that the proposed Sheds compressor station would have a limited number of potential emission points and would be classified as a minor source. Typically, construction of minor source facilities do not require pre- or post-construction air monitoring due to their size and limited impact to human health or the environment. Additionally, the concentration of formaldehyde and total hazardous air pollutants are calculated to be below 0.3 tons per year and monitoring for these constituents would not be cost effective relative to the value of the information to be gained. Therefore offsite sampling is not warranted.

Regional Health Registry for Long Term Health Effects

A regional health registry would collect health outcome information for a larger population than is likely to be affected by a single gas compressor station. It would not allow for specific exposures to be tied to health outcomes, nor would it support epidemiological investigations that require comparison groups. A health registry might allow for the detection of “signals” indicating potential health issues that should be investigated among the population in the region, but hypotheses of similar quality might also be generated by other means, including analyses of administratively collected data such as those compiled in birth registries, cancer registries, and

hospital discharge data files. However, for the above-mentioned reasons, establishment of a health registery is not warranted for this project.

11 References

Adgate, JA, Goldstein BA and Mckenzie LM. 2014. Potential Public Health Hazards, Exposures and Health Effects from Unconventional Natural Gas Development Environmental Science and Technology. Environmental Science & Technology. 48:8307-8320. dx.doi.org/10.1021/es404621d.

AER. 2015. What is Unconventional Oil and Gas? Alberta Energy Regulator. http://www.aer.ca/about-aer/spotlight-on/unconventional-regulatory-framework/what-is-unconventional-oil-and-gas.

Alves-Pereira M and Branco C. 1999. Vibroacoustic Diseases: The Need for a New Attitude Towards Noise. Proceedings of the International Conference on Public Participation & Information Technologies, 340–347.http://www.citidep.pt/papers/articles/alvesper.htm.

Amdur M. 1960. The Response of Guinea Pigs to Inhalation of Formaldehyde and Formic Acid Alone and with a Sodium Chloride Aerosol. Int J Air Poll, 3(4), 201–220.

ATSDR. 1999. Toxicological Profile for Formaldehyde. Agency for Toxic Substances and Disease Registry. United States Department of Health and Human Services. http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=220&tid=39.

ATSDR. 2007. Toxicological Profile for Benzene. Agency for Toxic Substances and Disease Registry. United States Department of Health and Human Services. http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=40&tid=14.

Brook RD, Rajagopalan S, Pope CA, Brook JR, Bhatnagar A, Diez-Roux AV, et al. 2010. Particulate Matter Air Pollution and Cardiovascular Disease: An Update to the Scientific Statement from the American Heart Association. Circulation, 121, 2331–2378. doi:10.1161/CIR.0b013e3181dbece1.

Brown D, Weinberger B, Lewis C, and Bonaparte H. 2014. Understanding Exposure from Natural Gas Drilling Puts Current Air Standards to the Test. Reviews on Environmental Health. doi:10.1515/reveh-2014-0002.

CHPNY. 2014. Compendium of Scientific, Medical, and Media Findings Demonstrating Risks and Harms of Fracking (Unconventional Gas and Oil Extraction). Concerned Health professionals of New York. Physicians Scientists & Engineers for Health Energy, 1–70. http://www.psehealthyenergy.org/site/view/1180.

Crofton KM, Craft ES, Hedge JM, Gennings C, Simmons J E, Carchman, et al. 2005. Thyroid-Hormone-Disrupting Chemicals: Evidence for Dose-Dependent Additivity or Synergism. Environmental Health Perspectives, 113(11), 1549–1554. doi:10.1289/ehp.8195.

Darrow L, Klein M, Sarnat J, Mulholland J, Strickland M, Sarnat S, and Tolbert P. 2011. The Use of Alternative Pollutant Metrics in Time-Series Studies of Ambient Air Pollution and Respiratory Emergency Department Visits. J Expo Sci Environ Epidemiol, 21(1), 10–19. doi:10.1038/jes.2009.49.

DTI. 2014. Abbreviated Application for a Certificate of Public Convenience and Necessity. Dominion Transmission, Inc. New Market Project, filed June 2, 2014.

EFSA. 2009. Scientific Opinion of the Panel on Contaminants in the Food Chain on a request from the European Commission on cadmium in food. The EFSA Journal (2009) 980, 1-139.

EFSA. 2012. Scientific Opinion on Mineral Oil Hydrocarbons in Food. Panel on Contaminants in the Food Chain. EFSA Journal, 10(6), 185pp. doi:10.2903/j.efsa.2012.2704.

EHSRM. 2012. Health Impact Assessment of Shale Gas Extraction: Workshop Summary - Workshop On The Health Impact Assessment Of New Energy Sources: Shale Gas Extraction. Sponsored By Roundtable On Environmental Health Sciences, Research, And Medicine April 30–May 1, 2012, House Of Sweden, 2900 K Street NW, Washington, DC.

ERG & SEC. 2011 City of Fort Worth Natural Gas Air Quality Study: Final Report. Eastern Research Group, Inc. and Sage Environmental Consulting, LP. http://www.edf.org/sites/default/files/9235_Barnett_Shale_Report.pdf.

Ethridge S. 2009. Health Effects Review of Ambient Air Monitoring Data Collected by Wolf Eagle Environmental Engineers and Consultants for DISH, TX. Texas Commission on Environmental Quality. Interoffice Memorandum. October 27.

FERC. 2013. An Interstate Natural Gas Facility on My Land? What Do I Need to Know. Federal Energy Regulation Commission. http://www.ferc.gov/for-citizens/citizen-guides/citz-guide-gas.pdf.

FERC. 2014. Notice of Intent to Prepare an Environmental Assessment for the Proposed New Market Project, Request for Comments on Environmental Issues and Notice of Public Scoping Meeting. Letter Dated September 18, 2014. Federal Energy Regulation Commission. Docket No. CP14-497-000. Received by the Madison County Department of Health.

HEI. 2007. Traffic-Related Air Pollution: A Critical Review of the Literature on Emissions, Exposure, and Health Effects. Health Effects Institute. Boston, Massachusetts.

HEI. 2010. Panel on the Health Effects of Traffic-Related Air Pollution. Traffic-Related Air Pollution: A Critical Review of the Literature on Emissions, Exposure, and Health Effects. HEI Special Report 17. Health Effects Institute. Boston, Massachusetts.

IAOGP. 2008. Guidelines for the management of naturally occurring radioactive material (NORM) in the oil & gas industry. International Association of Oil & Gas Producers, Report No. 412, September. http://www.ogp.org.uk/pubs/412.pdf.

IARC. 2012. Benzene. IARC Monographs 100-F. International Agency for the Registry of Cancer. http://monographs.iarc.fr/ENG/Monographs/vol100F/mono100F-24.pdf.

Jonker D, Woutersen R, Van Bladeren PJ, Til HP, and Feron VJ. 1990. Subacute (4-wk) Oral Toxicity of a Combination of Four Nephrotoxins in Rats: Comparison with the Toxicity of the Individual Compounds. Food and Chemical Toxicology, 28(9), 623-631.

Jonker D, Woutersen R, Van Bladeren PJ, Til HP, and Feron VJ. 1993. Subacute (4-wk) Oral Toxicity of a Combination of Four Nephrotoxins in Rats: Comparison with the Toxicity of the

Individual Compounds. Food and Chemical Toxicology, 31(9), 125–136. doi:10.1016/0278-6915(93)90126-J.

Jonker D, Woutersen R, and Feron VJ. 1996. Toxicity of Mixtures of Nephrotoxicants with Similar or Dissimilar Mode of Action. Food and Chemical Toxicology, 34, 1075–1082. doi:10.1016/S0278-6915(97)00077-X.

Kirk JL, Muir DCG, Gleason A, Wang X, Lawson G, Frank RA, Lehnherr I, and Wrona F. 2014. Atmospheric deposition of mercury and methylmercury to landscapes and waterbodies of the Athabasca oil sands region. Environmental Science & Technology: 48, 7374-7383.

Kortenkamp A, Backhaus T, Faust M. 2009. State of the Art Report on Mixture Toxicity (Vol. Contract N, pp. 1–391). doi:http://ec.europa.eu/environment/chemicals/pdf/report_Mixture%20toxicity.pdf.

MCDOH. 2015. Environmental Health Study Design. Georgetown Gas Compressor Station. Madison County Department of Health. PowerPoint slides. February.

McKenzie LM, Witter RZ, Newman LS, and Adgate JL. 2012. Human Health Risk Assessment of Air Emissions from Development of Unconventional Natural Gas Resources. The Science of the Total Environment, 424, 79–87. doi:10.1016/j.scitotenv.2012.02.018.

Meek MEB, Boobis AR, Crofton KM, Heinemeyer G, Raaij, M, and Vickers C. 2011. Risk Assessment of Combined Exposure to Multiple Chemicals: A WHO/IPCS Framework. Regulatory Toxicology and Pharmacology, 60, S1–S14. doi:10.1016/j.yrtph.2011.03.010.

Mills N, Tornqvist M, Gonzalez, M et al. 2007. Ischemic and Thrombotic Effects of Dilute Diesel-Exhaust Inhalation in Men with Coronary Heart Disease. The New England Journal of Medicine, 357(11), 609–619. doi:10.1056/NEJMoa1109071

Nadal M, Schuhmacher M, and Domingo JL. 2003. Metal pollution of soils and vegetation in an area with petrochemical industry. Science of the Total Environment: 321, 59-69.

NYDEC. 2013. Region 7 Air Quality Data. New York State Department of Environmental Conservation. http://www.dec.ny.gov/chemical/29317.html

Orrechio S. 2010. Contamination from polycyclic aromatic hydrocarbons (PAHs) in the soil of a botanic garden localized next to a former manufacturing gas plant in Palermo (Italy) Journal of Hazardous Materials: 180:590-601.

PADEP. 2010a. Emission Inventory. Pennsylvania Department of Environmental Protection. http://www.dep.state.pa.us/dep/deputate/airwaste/aq/emission/emission_inventory.htm.

PADEP. 2010b. Southwestern Pennsylvania Marcellus Shale Short-Term Ambient Air Sampling Report. Pennsylvania Department of Environmental Protection. http://www.dep.state.pa.us/dep/deputate/airwaste/aq/aqm/docs/Marcellus_SW_11-01-10.pdf

PADEP. 2011. 2011 Unconventional Natural Gas Emissions Inventory by Source Type (Tons per Year). Pennsylvania Department of Environmental Protection. http://www.dep.state.pa.us/dep/deputate/airwaste/aq/emission/marcellus/Unconventional_Natural_Gas_Emissions-Source.xlsx

PADEP. 2012. Air Emissions Inventory Data for the Unconventional Natural Gas Industry. http://www.portal.state.pa.us/portal/server.pt/community/emission_inventory/21810/marcellus_inventory/1829967.

Perez AL, Anderson KA. 2009. Soil-diffusive gradient in thin films partition coefficients estimate metal bioavailability to crops at fertilized field sites. Environmental toxicology and chemistry / SETAC;28(10):2030-2037. doi:10.1897/08-637.1.

Perma-Fix Environmental Services. 2015. Technologically Enhanced Naturally Occurring Radioactive Materials. Beaver, Pennsylvania. doi:10.1080/15563650902997849.

Pope CA, Muhlestein JB, May HT, Renlund DG, Anderson JL, and Horne BD. 2006. Ischemic heart disease events triggered by short-term exposure to fine particulate air pollution. Circulation, 114, 2443–2448. doi:10.1161/CIRCULATIONAHA.106.636977.

Ratner M and Tiemann M. 2014. An Overview of Unconventional Oil and Natural Gas: Resources and Federal Actions. Congressional Research Service. http://fas.org/sgp/crs/misc/R43148.pdf

Steinzor N, Subra W, and Sumi L. 2012. Gas Patch Roulette: How Shale Gas Development Risks Public Health in Pennsylvania (pp. 1–51). www.earthworksaction.org.

Steinzor N, Subra W, and Sumi L. 2013. Investigating Links between Shale Gas Development and Health Impacts through a Community Survey Project in Pennsylvania. New Solutions: 23(1): 55-84.

Subra W. 2009. Results of Health Survey of Current and Former DISH/Clark, Texas Residents. Earthworks' Oil and Gas Accountability Project. http://www.earthworksaction.org/files/publications/DishTXHealthSurvey_FINAL_hi.pdf.

SWPA-EHP. 2013. Health Issues and Concerns Related to Unconventional Gas Development. Southwest Pennsylvania Environmental Health Project. www.environmentalhealthproject.org.

TCEQ. 2010. Barnett Shale Formation Area Monitoring Projects. Texas Commission on Environmental Quality. Doc number BS0912-FR. http://www.tceq.state.tx.us/assets/public/implementation/barnett_shale/2010.01.27-BarnettShaleMonitoringReport.pdf.

TCEQ. 2015. About Effects Screening Levels (ESLs). Texas Commission on Environmental Quality. https://www.tceq.texas.gov/toxicology/esl.

TDSHS. 2010. Tests Indicate Exposures in Dish Similar to U.S. Population. DISH, Texas Exposure Investigation DISH, Denton County, Texas. Texas Department of State Health Services. May 12.

TOXNET. 2015. Hazardous Substance Data Bank, Search Term "Benzene." http://toxnet.nlm.nih.gov/cgi-bin/sis/search2/f?./temp/~g7oNWu:1.

TransCanada. 2005. Blowdown Notification. http://www.transcanada.com/docs/Our_Responsibility/Blowdown_Notification_Factsheet.pdf

UNESCO. 2005. The precautionary principle. United Nations Educational, Scientific, and Cultural Organization. Paris, France. http://unesdoc.unesco.org/images/0013/001395/139578e.pdf.

USEPA. 1973. Assessment of Potential Radiological Health Effects from Radon in Natural Gas. United States Environmental Protection Agency. doi:EPA 520/1-73-004.

USEPA. 1989. Risk Assessment Guidance for Superfund. Volume 1: Human Health Evaluation Manual (Part A). Interim Final. Office of Emergency and Remedial Response. EPA-540/1-89/002. Washington, D.C. December.

USEPA. 1996. Technology Transfer Network 1996 National-Scale Air Toxics Assessment. United States Environmental Protection Agency. http://www.epa.gov/airtoxics/nata/sab/appendix-f.pdf.

USEPA. 2000. Methylene Chloride (Dichloromethane). United States Environmental Protection Agency. http://www.epa.gov/airtoxics/hlthef/methylen.html.

USEPA. 2005. Technology Transfer Network Air Toxics: 2005 National-Scale Air Toxics Assessment. United States Environmental Protection Agency. http://www.epa.gov/airtoxics/nata2005/tables.html.

USEPA. 2009. Benzene, TEACH Chemical Summary. Toxicity and Exposure Assessments for Children's Health. United States Environmental Protection Agency. http://www.epa.gov/teach/chem_summ/BENZ_summary.pdf.

USEPA. 2013a. EPA Needs to Improve Air Emissions Data for the Oil and Natural Gas Production Sector. Office of the Inspector General. United States Environmental Protection Agency. February 20. http://www.epa.gov/oig/reports/2013/20130220-13-P-0161.pdf.

USEPA. 2013b. National Air Toxics Assessments. http://www.epa.gov/airtoxics/natamain/.

USEPA. 2014a. Glossary. "Reference Concentration: (RfC)." http://www.epa.gov/risk_assessment/glossary.htm.

USEPA. 2014b. National Ambient Air Quality Standards (NAAQS). United States Environmental Protection Agency. http://www.epa.gov/air/criteria.html.

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

Wellenius GA, Burger MR, Coull BA, Schwartz J, Sus HH, Koutrakis P, Schlaug G, Gold DR, Mittleman MA. 2012. Ambient Air Pollution and the Risk of Acute Ischemic Stroke. Archives of Internal Medicine: 172(3):229-34.

WHO. 2011. Burden of Disease from Environmental Noise: Quantification of Healthy Life Years Lost in Europe. World Health Organization & JRC European Commission. Copenhagen, Denmark.

Appendix: Resumes of Key Project Team Members

Debra A. Kaden, PhD | Senior Manager

Boston, Massachusetts
+ 1 617 946 6110 | dkaden@environcorp.com

Dr. Debra A. Kaden has more than 25 years' experience in toxicology and environmental health sciences, with emphasis in the area of air toxics. She is a senior practitioner in ENVIRON's Occupational Health and Safety practice. Debra is a member of the International Society for Exposure Science—where she sits on the council—as well as a member of the Society of Toxicology (SOT) and the Society for Risk Analysis (SRA), and serves as president of the New England chapter of SRA. Debra has authored more than 25 peer-reviewed publications in toxicology and environmental health sciences. She has spearheaded critical reviews of the state of science to identify research priorities for understanding exposure and health effects of mobile source air toxics, diesel exhaust and electric and magnetic fields. Debra also has organized and convened workshops and conferences on scientific topics relevant to air pollution.

EDUCATION

1997 Postdoctoral Fellowship, Harvard Medical School

1984 Postdoctoral Fellowship, New York University

1983 PhD, Toxicology, Massachusetts Institute of Technology

1978 SM, Toxicology, Massachusetts Institute of Technology

1978 SB, Life Sciences, Massachusetts Institute of Technology

EXPERIENCE

- Planned, developed and managed complex, multi-faceted research projects on exposure to and health effects of air pollutants, including ozone, particulate matter, aldehydes, benzene, 1,3-butadiene, and other air toxics. Programs included international, multi-center research efforts. Promoted the understanding of health effects of exposure to air toxics. Developed calls for applications, managed review of proposals, negotiated scientific scope and budget of studies, managed studies and programs, and communicated results to a broad group of stakeholders.
- Spearheaded critical review of the state of science to identify research priorities for understanding exposure and health effects of mobile source air toxics, diesel exhaust and electric and magnetic fields. Helped secure new funding sources, defined scope of research, identified and recruited experts, developed innovative approaches to disseminating and applying results. Coordinated writing assignments, bringing projects to fruition despite short performance periods, and limited budgets.
- Managed peer reviews of research reports, and developed draft commentaries that synthesized scientific findings and highlighted their policy implications.
- Organized and convened research workshops and conferences on scientific topics relevant to exposure and health effects of air pollution.

CREDENTIALS

Awards and Honors

Sigma Xi Undergraduate Research Award

Cabot Corporation Solar Energy Fellowship

Debra A. Kaden, PhD

Professional Affiliations and Activities

International Society of Exposure Science

Society of Toxicology

Society for Risk Assessment, New England Chapter

Peer reviewer for the following journals:

- Cancer Research
- Critical Reviews in Toxicology
- Chemical and Biological Interactions
- Environmental Health Perspectives
- Human Genetics
- Mutation Research

Grant reviewer for the following panels:

- California Air Resources Board
- European Commission Directorate General Twelve
- United States Army
- US Environmental Protection Agency

Founder and President, DakTox, LLC, 2009-2010

Member, International Society of Exposure Science, 2008-present

Elected Member of Executive Council, International Society of Exposure Science, 2008-present

Advisor, World Health Organization Indoor Air Quality Working Group, 2008-2010

Member, Board of Directors, George and Elizabeth Sanborn Foundation for the Treatment and Cure of Cancer, Arlington MA, 1998-present, President, Board of Directors, 2003-2006

Member, Diesel Epidemiology Working Group. Health Effects Institute. 2000-2002.

Scientific Advisory Committee, South Coast Air Quality Management District Multiple Air Toxics Exposure Study (MATES) II and III, 2001-2008

Member, Society of Toxicology, 1991-present

Principal Scientist, The Health Effects Institute, Boston MA, 2003-2009; Senior Scientist, 1997-2003; Staff Scientist, 1990-1997

Senior Scientist, META System/Cambridge Environmental, Cambridge, MA, 1987-1989

Postdoctoral Fellow, Cancer Genetics, Dana Farber Cancer Institute, Harvard Medical School, 1984-1987

Postdoctoral Fellow, Environmental Medicine, New York University Medical Center, 1983-1984

Meeting and Symposium Leadership

Rapporteur, Beyond Science and Decisions: Issue Identification to Dose-Response Assessment. March 16-18 2010 Workshop. Austin TX.

Debra A. Kaden, PhD

Organizer and Symposium Co-Chair. "The Relationships Among Surrogate Measures of Exposure to Air Pollution in Developed Countries" at International Society of Environmental Epidemiology (ISEE)/ International Society of Exposure Analysis (ISEA) Joint Annual Meeting, Pasadena CA. October 13, 2008. Abstracts published in Epidemiology: November 2008 - Volume 19 - Issue 6 - p S26 2008.

Organizer, Conference Session "Examining Exposure to Air Toxics in Potential Hot Spots" at Health Effects Institute Annual Conference. Philadelphia PA. April 27-29, 2008.

Co-Organizer and Symposium Co-Chair, "Understanding Air Toxics Exposure Distributions and their Implication for Health Risk" at International Society for Exposure Analysis (ISEA) Annual Meeting. Durham NC. October 15, 2007.

Co-Organizer, Workshop "Health Effects Associated with Exposure to Mobile Source Air Toxics (MSATs)" Washington DC. May 15, 2006.

Organizer, Conference Session "Transboundry Migration of Air Pollution" at Celebrating 25 Years of Trusted Science for Better Air Quality Decisions: Health Effects Institute Annual Conference. San Francisco CA, April 10, 2006.

Organizer. Workshop "Border Crossings" at Celebrating 25 Years of Trusted Science for Better Air Quality Decisions: Health Effects Institute Annual Conference. San Francisco CA, April 6, 2006.

Organizer. Workshop "Mobile Source Air Toxics" at Celebrating 25 Years of Trusted Science for Better Air Quality Decisions: Health Effects Institute Annual Conference. San Francisco CA, April 7, 2006.

Member, Organizing Committee. International Symposium on Butadiene, Isoprene and Chloroprene. 2005

Organizer, "Air toxics Investigators Workshop" at Health Effects Institute Annual Conference. Baltimore, MD. April 16, 2005.

Co-Organizer and session chair, "Community Exposure to Air Toxics" at International Society of Exposure Analysis (ISEA) Annual Meeting. November 2, 2005

Program Co-Coordinator, Health Effects Institute Annual Conference. Baltimore, MD. April 17-19, 2005. http://www.healtheffects.org/Archive/AnnConf2005.htm

Organizer, Conference Session "Air Toxics Exposure and Health Effects" at Health Effects Institute Annual Conference. Baltimore, MD. April 17, 2005.

Organizer, Endiottt House 2004 Air Quality Symposium: Air Toxics (Health Effects). Endicott House, August 4-5, 2004

Organizer, "Diesel Markers/Air Toxics Investigators Workshop" at Health Effects Institute Annual Conference. Boston, MA. May 2, 2004.

Program Co-Coordinator, Health Effects Institute Annual Conference. Boston, MA. May 2-4, 2004. http://www.healtheffects.org/Archive/AnnConf2004.htm

Organizer, Conference Session "Living on the Edge: New Approaches in Assessing Exposure" at Health Effects Institute Annual Conference. Boston, MA. May 2-4, 2004.

Program Co-Coordinator "Air Pollution: Integrating Exposure and Effects" Health Effects Institute Annual Conference Seattle WA, April 28-30, 2002. http://www.healtheffects.org/Archive/AnnConf2002.htm

Organizer, Conference Session "Understanding Source Contribution to Exposure" at Air Pollution: Integrating Exposure and Effects: Health Effects Institute Annual Conference Seattle WA. April 30, 2002. http://www.healtheffects.org/Archive/AnnConf2002.htm

Debra A. Kaden, PhD

Organizer, Health Effects Institute's Diesel Signature Workshop. Baltimore MD. December 2-6, 2002. http://pubs.healtheffects.org/getfile.php?u=298

Co-Organizer, Health Effects Institute Mobile Source Air Toxics Research Needs Workshop. 2001.

Co-Organizer. Planning Committee for EPA Local Air Toxics Assessment and Reductions Training workshop November 14-15 2001. 2001.

Co-Organizer Health Effects Institute Workshop on Mobile Source Air Toxics: Exposure and Risk. Washington DC. February 8, 2000. http://www.healtheffects.org/Airtoxics/airtoxics-agenda.html

Organizer Mini-Symposium on "Emerging Technologies in Molecular Biology and Their Application to Environmental Health Issues" at Exploring Exposure and Risk Issues: Health Effects Institute Annual Conference. Atlanta, GA. April 9-11, 2000. http://www.healtheffects.org/Archive/AnnConf2000.htm

Organizer, Conference session "Approaches to Improving Assessment of Exposure to Air Pollutants" at Exploring Exposure and Risk Issues: Health Effects Institute Annual Conference. Atlanta, GA. April 9-11, 2000. http://www.healtheffects.org/Archive/AnnConf2000.htm

Member, Program Committee and Chair, Poster Session. International Symposium: Evaluation of Butadiene, Isoprene, and Chloroprene. September 12-14 2000, London UK.

Member, Editorial Committee, International Symposium: Evaluation of Butadiene, Isoprene, and Chloroprene. September 12-14 2000, London UK.

Program Co-Coordinator "Air Pollution: Understanding Air Toxics and Particles" Health Effects Institute Annual Conference San Diego, CA May 9-12, 1999. http://www.healtheffects.org/Archive/AnnConf1999.htm

Organizer, Conference session "Mechanistic and Cross-Species Comparisons of Butadiene Toxicity" at Air Pollution: Understanding Air Toxics and Particles; Health Effects Institute Annual Conference Sand Diego, CA May 10, 1999. http://www.healtheffects.org/Archive/AnnConf1999.htm

Organizer, Conference session "Transitional Epidemiologic Study in Butadiene-Exposed Czech Workers" at Air Pollution: Understanding Air Toxics and Particles; Health Effects Institute Annual Conference Sand Diego, CA May 10, 1999. http://www.healtheffects.org/Archive/AnnConf1999.htm

Member of Program Committee and Session Moderator. EPA's Urban Air Toxics Strategy 1999 Urban Air Toxics Summer Symposium. Endicott House, Dedham, MA July 8-9, 1999.

RESEARCH OVERSIGHT

Meng RQ, Hackfeld LC, Hodge RP, Wisse LA, Redetzke DL, Walker VE. 2010. Mutagenicity of Stereochemical Configurations of 1,3-Butadiene Epoxy Metabolites in Human Cells. HEI Research Report 150. Health Effects Institute, Boston, MA. http://pubs.healtheffects.org/view.php?id=344

Cahill, Thomas M, M Judith Charles, and Vincent Y Seaman. 2010.

Development and Application of a Sensitive Method to Determine Concentrations of Acrolein and Other Carbonyls in Ambient Air. HEI Research Report 149. Health Effects Institute, Boston, MA. http://pubs.healtheffects.org/view.php?id=340

Zielinska B, Samy S, McDonald JD, Seagrave J. 2010. Atmospheric Transformation of Diesel Emissions. HEI Research Report 147. Health Effects Institute, Boston, MA. http://pubs.healtheffects.org/view.php?id=339

Walker VE, Walker DM, Meng Q, McDonald JD, Scott BR, Bauer MJ, Seilkop SK, Claffey DJ, Upton PB, Powley MW, Swenberg JA, Henderson RF. 2009. Genotoxicity of 1,3-Butadiene and Its Epoxy Intermediates. HEI Research Report 144. Health Effects Institute, Boston, MA. http://pubs.healtheffects.org/view.php?id=324

Harrison RM, Delgado-Saborit JM, Baker SJ, Aquilina N, Meddings C, Harrad S, Matthews I, Vardoulakis S, Anderson HR. 2009. Measurement and Modeling of Exposure to Selected Air Toxics for Health Effects Studies and Verification by Biomarkers. HEI Research Report 143. Health Effects Institute, Boston, MA. http://pubs.healtheffects.org/view.php?id=329

Turpin BJ, Weisel CP, Morandi M, Colome S, Stock T, Eisenreich S, Buckley B. 2007. Relationships of Indoor, Outdoor, and Personal Air (RIOPA): Part II. Analyses of Concentrations of Particulate Matter Species. HEI Research Report 130; NUATRC Research Report 10. Health Effects Institute, Boston MA, and Mickey Leland National Urban Air Toxics Research Center, Houston TX. http://pubs.healtheffects.org/view.php?id=276

Delzell E, Sathiakumar N, Graff J, Macaluso M, Maldonado G, Matthews R. August 2006. An Updated Study of Mortality Among North American Synthetic Rubber Industry Workers. Research Report 132. Health Effects Institute, Boston MA. http://pubs.healtheffects.org/view.php?id=263

Weisel CP, Zhang J, Turpin BJ, Morandi MT, Colome S, Stock TH, Spektor DM, and Others. November 2005. Relationships of Indoor, Outdoor, and Personal Air (RIOPA): Part I. Collection Methods and Descriptive Analyses. HEI Research Report 130; NUATRC Research Report 7. Heath Effects Institute, Boston MA; Mickey Leland National Urban Air Toxics Research Center, Houston TX. http://pubs.healtheffects.org/view.php?id=31

Cohen BS, Heikkinen MSA, Hazi Y, Gao H, Peters P, Lippmann M. 2004. Field Evaluation of Nanofilm Detectors for Measuring Acidic Particles in Indoor and Outdoor Air. Research Report 121. Health Effects Institute, Boston MA. http://pubs.healtheffects.org/view.php?id=99

Geyh AS, Hering S, Kreisberg N, John W. 2004. Evaluation of a Personal and Microenvironmental Aerosol Speciation Sampler (PMASS). Research Report 122. Health Effects Institute, Boston MA. http://pubs.healtheffects.org/view.php?id=98

Albertini RJ, Srám RJ, Vacek PM, Lynch J, Nicklas JA, van Sittert NJ, Boogaard PJ, Henderson RF, Swenberg JA, Tates AD, Ward Jr JB, Wright M and others. 2003. Biomarkers in Czech Workers Exposed to 1,3-Butadiene: A Transitional Epidemiologic Study. Research Report 116. Health Effects Institute, Boston MA. http://pubs.healtheffects.org/view.php?id=33

Henderson RF, Barr EB, Belinsky SA, Benson JM, Hahn FH, and Ménache MG. 2000. 1,3-Butadiene: Cancer, Mutations, and Adducts. Part I: Carcinogenicity of 1,2,3,4-Diepoxybutane. HEI Research Report 92 Part I. Health Effects Institute, Cambridge, MA.

Recio L, Saranko CJ, and Steen A-M. 2000. 1,3-Butadiene: Cancer, Mutations, and Adducts. Part II: Roles of Two Metabolites of 1,3-Butadiene in Mediating Its in Vivo Genotoxicity. HEI Research Report 92 Part II. Health Effects Institute, Cambridge, MA.

Walker VE and Meng Q. 2000. 1,3-Butadiene: Cancer, Mutations, and Adducts. Part III: In Vivo Mutation of the Endogenous hprt Genes of Mice and Rats by 1,3-Butadiene and Its Metabolites. HEI Research Report 92 Part III. Health Effects Institute, Cambridge, MA.

Blair IA, Oe T, Kambouris S, and Chaudhary AK. 2000. 1,3-Butadiene: Cancer, Mutations, and Adducts. Part IV: Molecular Dosimetry of 1,3-Butadiene

HEI Research Report 92 Part IV. Health Effects Institute, Cambridge, MA.

Swenberg JA, Christova-Gueorguieva NI, Upton PB, Ranasinghe A, Scheller N, Wu K-Y, Yen T-Y, and Hayes R. 2000. 1,3-Butadiene: Cancer, Mutations, and Adducts. Part V: Hemoglobin Adducts as Biomarkers of 1,3-Butadiene Exposure and Metabolism HEI Research Report 92 Part V. Health Effects Institute, Cambridge, MA.

Grosovsky AJ, Sasaki JS, Arey J, Eastmond DA, Parks KK, and Atkinson R. 1999. Evaluation of The Potential Health Effects of the Atmospheric Reaction Products of Polycyclic Aromatic Hydrocarbons. HEI Research Report 84 Health Effects Institute, Cambridge, MA.

Pinkerton KE, Weller BL, Ménache MG, and Plopper CG. 1998. Consequences of Prolonged Inhalation of Ozone on F344/N Rats: Collaborative Studies. Part XIII: Changes in Lung Structure and Enzyme Activities in Rats Exposed to Ozone for Different Time Periods. . HEI Research Report 65 Part XIII. Health Effects Institute, Cambridge, MA.

Harkema JR, Catalano PJ, and Hotchkiss JA. 1997. Consequences of Prolonged Inhalation of Ozone on F344/N Rats: Collaborative Studies. Part XII: Atrophy of Bone in Nasal Turbinates . HEI Research Report 65 Part XII. Health Effects Institute, Cambridge, MA.

Gennings C, Carter Jr. WH, Dawson K. 1996. Using the Parallel Coordinate Axis System to Analyze Complex Mixtures: Determining Biological Activity and Interactions Among Components. In: Communications 4. Theoretical Approaches to Analyzing Complex Mixtures. Health Effects Institute, Cambridge MA.

Catalano PJ, Chang LY, Harkema JR, Kaden DA, Last JA, Mellick PW, Parks WC, Pinkerton KE, Radhakrishnamurthy B, Ryan LM, and Szarek JL 1995. Consequences of Prolonged Inhalation of Ozone on F344/N Rats: Collaborative Studies. Part XI: Integrative Summary. HEI Research Report 65 Part XI. Health Effects Institute, Cambridge, MA.

Catalano, Paul J, John Rogus, and Louise M Ryan.1995. Consequences of Prolonged Inhalation of Ozone on F344/N Rats: Collaborative Studies. Part X: Robust Composite Scores Based on Median Polish Analysis. HEI Research Report 65 Part X. Health Effects Institute, Cambridge, MA.

Pinkerton KE, Ménache MG, and Plopper CG. 1995. Consequences of Prolonged Inhalation of Ozone on F344/N Rats: Collaborative Studies. Part IX: Studies of Changes in Lung Structure and Enzyme Activities in Rats After Prolonged Exposure to Ozone. HEI Research Report 65 Part IX. Health Effects Institute, Cambridge, MA.

Chang LY, Stockstill BL, Ménache MG, Mercer RR, and Crapo JD. 1995. Consequences of Prolonged Inhalation of Ozone on F344/N Rats: Collaborative Studies. Part VIII: Studies of Changes in Lung Structure and Enzyme Activities in Rats After Prolonged Exposure to Ozone. HEI Research Report 65 Part VIII. Health Effects Institute, Cambridge, MA.

Boorman GA, Catalano PJ, Jacobson BJ, Kaden DA, Mellick PW, Nauss KM, and Ryan LM. 1995. Consequences of Prolonged Inhalation of Ozone on F344/N Rats: Collaborative Studies. Part VI: Background and Study Design. HEI Research Report 65 Part VI. Health Effects Institute, Cambridge, MA.

Leikauf GD, Zhao Q, Zhou S, and Santrock J. 1995. Activation of Eicosanoid Metabolism in Human Airway Epithelial Cells by Products of Ozonolysis in Membrane Fatty Acids. . HEI Research Report 71. Health Effects Institute, Cambridge, MA.

Harkema JR, Morgan KT, Gross EA, Catalano PJ, and Griffith WC. 1994. Consequences of Prolonged Inhalation of Ozone on F344/N Rats: Collaborative Studies. Part VII: Effects on the Nasal Mucociliary Apparatus. HEI Research Report 65 Part VII. Health Effects Institute, Cambridge, MA.

Harkema JR and Mauderly JL. 1994. Consequences of Prolonged Inhalation of Ozone on F344/N Rats: Collaborative Studies. Part V: Effects on Pulmonary Function. HEI Research Report 65 Part V. Health Effects Institute, Cambridge, MA.

Parks W and Roby J. 1994. Consequences of Prolonged Inhalation of Ozone on F344/N Rats: Collaborative Studies. Part IV: Effects on Expression of Extracellular Matrix Genes. HEI Research Report 65 Part IV. Health Effects Institute, Cambridge, MA.

Radhakrishnamurthy B. 1994. Consequences of Prolonged Inhalation of Ozone on F344/N Rats: Collaborative Studies. Part III: Effects on Complex Carbohydrates of Lung Connective Tissue. HEI Research Report 65 Part III. Health Effects Institute, Cambridge, MA.

Szarek JL. 1994. Consequences of Prolonged Inhalation of Ozone on F344/N Rats: Collaborative Studies. Part II: Mechanical Properties, Responses to Bronchoactive Stimuli, and Eicosanoid Release in Isolated Large and Small Airways. HEI Research Report 65 Part II. Health Effects Institute, Cambridge, MA.

Last JA, Gelzleichter TR, Harkema J, and Hawk S. 1994. Consequences of Prolonged Inhalation of Ozone on F344/N Rats: Collaborative Studies. Part I: Content and Cross-Linking of Lung Collagen. HEI Research Report 65 Part I. Health Effects Institute, Cambridge, MA.

Fennell TR. 1994. Development of Methods for Measuring Biological Markers of Formaldehyde Exposure. HEI Research Report 67. Health Effects Institute, Cambridge, MA.

Giese RW and Vouros P. 1993. Methods Development Toward the Measurement of Polyaromatic Hydrocarbon–DNA Adducts by Mass Spectrometry. HEI Research Report 61. Health Effects Institute, Cambridge, MA.

PEER-REVIEW AND COMMENTARY OVERSIGHT

Schauer JJ, Lough GC, Shafer MM, Christensen WF, Arndt MF, DeMinter JT, Park J-S. March 2006. Characterization of Metals Emitted from Motor Vehicles. Research Report 133. Health Effects Institute, Boston MA http://pubs.healtheffects.org/view.php?id=150

Koutrakis P, Suh HH, Sarnat JA, Brown KW, Coull BA, Schwartz J. December 2005. Characterization of Particulate and Gas Exposures of Sensitive Subpopulations Living in Baltimore and Boston. Research Report 131. Health Effects Institute, Boston MA. http://pubs.healtheffects.org/view.php?id=91

Hering S, Kreisberg N, John W. 2003. A Personal Particle Speciation Sampler. Research Report 114. Health Effects Institute, Boston MA. http://pubs.healtheffects.org/view.php?id=103

PUBLICATIONS & PRESENTATIONS

Presentations

Invited speaker. "Beyond Science and Decisions: From Problem Formulation to Dose Response" at Society for Risk Analysis, New England Chapter meeting. Lexington MA. July 19, 2010.

Invited Speaker, "Mobile Source Air Toxics: Understanding Health Effects" at Coordinating Research Council (CRC) Mobile Source Air Toxics Workshop. Phoenix Phoenix, AZ, December 1-3, 2008.

Invited Speaker, "Mobile Source Air Toxics: A Critical Review of the Literature on Exposure and Health Effect" at Northern Transportation and Air Quality Summit, Baltimore, MD August 14, 2008.

Invited Speaker. Health Canada Border Air Quality Workshop. HEI Research Program 2007

Invited Speaker. Mickey Leland National Urban Air Toxics Research Center (NUATRC) meeting. 2007

Invited Speaker, "Mobile Source Air Toxics: Understanding Health Effects" at Coordinating Research Council (CRC) Mobile Source Air Toxics Workshop. 2006

Debra A. Kaden, PhD

Invited Speaker "Panel Findings in Selected MSATs: Aldehydes" at Workshop on Health Effects Associated with Exposure to Mobile Source Air Toxics (MSATs). Washington DC. May 15, 2006.

Invited Speaker, "Mobile Source Air Toxics Overview" at Southern Transportation and Air Quality Summit. Charleston SC. August 23-25, 2005.

Invited Speaker. "Mobile Source Air Toxics" at Joint Texas Commission on Environmental Quality (TCEQ)/National Urban Air Toxics Research Center (NUATRC) Annual Workshop, Air Toxics: What We Know and What We Don't Know. Houston, TX. 2005

Invited Speaker. "Mobile Source Air Toxics: Potential Health Effects "at Workshop associated with Transportation Research Board Annual Meeting. Baltimore, MD. January 9, 2005.

Invited Speaker, "HEI Program on Air Toxics and Accountability Research" at Office of Air and Radiation Workshop on Measuring Program Results. Environmental Measurements for Program Development. Rosslyn VA. December 7-8, 2004.

Invited speaker. Air Toxics: The HEI Research Program. Endicott House, August 4-5, 2004

Invited Speaker "Source Signatures for Motor Vehicle Emissions" at MARAMA-MANE-VU Science Meeting. Baltimore, MD. January 27-29, 2004.

Invited Speaker, "Overview of HEI Activities on Diesel Exhaust" at SAE International Truck and Bus Meeting: Health and Safety Aspects of Vehicle Emissions. Detroit MI November 18, 2003.

Invited Speaker, "Source Signatures for Motor Vehicle Emissions" at International Commission on Environmental Cooperation Second Workshop on Methodologies to Assess vehicle Exhaust Exposure. Montreal, Quebec. September 29-30, 2003.

Invited Speaker, "Current and Future Research on Mobile Source Air Toxics" at UCLA workshop "Issues in the Assessment of Health Impacts of Gasoline Emissions in California" June 12-13, 2001

Invited Speaker: Toxic Emissions From Motor Vehicles: Health Effect Issues, SAE Government/Industry Conference. 2000

Invited Speaker, The Health Effects Institute: Air Toxics Research Program" at the Manufactures of Emission Control Association (MECA) Meeting, March 23, 1999.

Invited Speaker and Workshop co-Chair, International Society of Environmental Epidemiology (ISEE)/International Society of Exposure Analysis (ISEA) Joint Annual Meeting. Athens, Greece. September 5-8, 1999.

Peer-reviewed Publications

Health Effects Institute Panel on the Health Effects of Traffic-Related Air Pollution. 2010. Traffic-Related Air Pollution: A Critical Review of the Literature on Emissions, Exposure, and Health Effects. Health Effects Institute, Boston MA.

Bird MG, Greim H, Kaden DA, Rice JM, and Snyder R. 2010. Benzene 2009 – Health Effects and Mechanisms of bone Marrow Toxicity: Implications for t-AML and the Mode of Action Framework. Chemical and Biological Interactions. 184(1-2):3-6.

Health Effects Institute Air Toxics Review Panel. 2007. Mobile-Source Air Toxics: A Critical Review of the Literature on Exposure and Health Effects. Special Report 16. Health Effects Institute, Boston MA.

Van Atten C, Brauer M, Funk T, Gilbert NL, Graham L, Kaden D, Miller PJ, Rojas Bracho L, Wheeler A, and White RH. 2005 Assessing Population Exposures to Motor Vehicle Exhaust. Reviews on Environmental Health 20(3):195-214.

Health Effects Institute. 2003. Improving Estimates of Diesel and Other Emissions for Epidemiologic Studies. Communication 10. Health Effects Institute, Boston MA.

Diesel Epidemiology Working Group. 2002. Research Directions to Improve Estimates of Human Exposure and Risk from Diesel Exhaust. Special Report. Health Effects Institute, Boston MA.

Health Effects Institute. 1999. A Partnership to Examine Emerging Health Effects: EC/HEI Workshop on 1,3-Butadiene. Communication 6. Health Effects Institute, Cambridge MA.

Kaden DA, Warren J, Ryan L, Boorman G, and Mellick P. 1996. The NTP/HEI collaborative ozone project on the health effects of chronic ozone inhalation. Inhalation Toxicology 8:213-227.

Catalano P, Ryan LM, and Kaden DA. 1996. Statistical aspects of the NTP/HEI collaborative ozone project on the health effects of chronic ozone inhalation. Inhalation Toxicology 8:229-249.

Collaborative Ozone Project Group. 1995. Consequences of prolonged inhalation of ozone of F344/N rats: Collaborative studies. Part IV, Background and project design. Research Report Number 65. Health Effects Institute, Cambridge, MA.

Collaborative Ozone Project Group. 1995. Consequences of prolonged inhalation of ozone of F344/N rats: Collaborative studies. Part XI, Integrative summary. Research Report Number 65. Health Effects Institute, Cambridge, MA.

Health Effects Institute. 1993. Research Priorities for Mobile Air Toxics. Communication 2. Health Effects Institute, Cambridge MA.

Murphy JC, Kaden DA, Warren J, and Sivak A. 1993. Power frequency electric and magnetic fields: A review of genetic toxicology. Mutation Res 296:221-240.

EMF Research Planning Committee. 1993. Do Electric or Magnetic Fields Cause Adverse Health Effects? HEI's Research Plan to Narrow the Uncertainties. Special Report. Health Effects Institute, Cambridge MA.

Health Effects Institute. 1992. New Methods in Ozone Toxicology: Abstracts of Six Pilot Studies. Communication 1. Health Effects Institute, Cambridge MA.

Kaden DA, Bardwell L, Anisowitz A, Skopek TR, and Sager R. 1989. High frequency of large spontaneous deletions of DNA in tumor-derived CHEF cells. Proc Natl Acad Sci,USA 86:2306-2310.

Kaden DA, Gadi IK, Bardwell L, Gelman R, and Sager R. 1989. Spontaneous mutation rates of tumorigenic and non-tumorigenic Chinese hamster embryo fibroblast cell lines. Cancer Res 49:3374-3379.

Kaden DA, Call K, Leong PM, Komives EA, and Thilly WG. 1987. Killing and mutation of human lymphoblast cells by aflatoxin B1: Evidence for an inducible repair response. Cancer Res 47:1993-2001.

DeLuca JG, Kaden DA, Komives EA, and Thilly WG. 1984. Mutation of Xeroderma pigmentosum lymphoblast cells by far ultraviolet light. Mutation Res 128:47-57.

Penman BW, Kaden DA, Liber HL, Skopek TR, Hites RA, and Thilly WG. 1980. Perylene is a more potent mutagen than benzo(a)pyrene for S. typhimurium. Mutation Res 77:271-277.

Kaden DA, Hites RA, and Thilly WG. 1979. Mutagenicity of soot and associated polycyclic aromatic hydrocarbons to Salmonella typhimurium. Cancer Res 39:4152-4159.

Skopek TR, Liber HL, Kaden DA, and Thilly WG. 1979. Mutation of human cells by kerosene soot. J Natl Cancer Inst 63:309-312.

Krishnan S, Kaden DA, Thilly WG, and Hites RA. 1979. Cyano-arenes in soot: Synthesis and mutagenicity of cyanonaphtalenes. Env Sci Tech 13:1532-1534.

Poss R, Thilly WG, and Kaden DA. 1979. Methylmethacrylate is a weak mutagen for Salmonella typhimurium. J Bone Joint Surg 61-A:1203-1208.

Skopek TR, Liber HL, Kaden DA, and Thilly WG. 1978. Relative sensitivities in forward and reverse mutation assays in Salmonella typhimurium. Proc Natl Acad Sci USA 75:4470-4473.

DeLuca JG, Kaden DA, Krolewski JJ, Skopek TR, and Thilly WG. 1977. Comparative mutagenicity of ICR-191 to Salmonella typhimurium and diploid human lymphoblasts. Mutation Res 46:11-18.

DeLuca JG, Krolewski JJ, Skopek TR, Kaden DA, and Thilly WG. 1977. 9-Aminoacridine: A frameshift mutagen for Salmonella typhimurium TA1537, inactive at the hgprt locus in human lymphoblasts. Mutation Res 42:327-33.

Book Chapters and Monographs Book Chapters, Reports, and Conference Proceedings

Murphy JC, Kaden DA, Warren J, and Sivak A. 1993. Electric and magnetic fields: Genetic toxicity data. In: "Electricity and Magnetism in Biology and Medicine." Blank M (ed), San Francisco Press Inc., San Francisco CA. pp 506-508.

Mauderly JL, Rosenkranz HS, Garte SJ, Froines J, Heinrich U, Kaden DA, Lavoie E, Lewtas J, and Salmeen IT. 1993. Research Priorities to Reduce Uncertainties in Risk Assessment for Polycyclic Organic Matter. In: "Research Priorities for Mobile Air Toxics." Health Effects Institute, Cambridge MA. pp 90-107.

Crouch EAC, Kaden DA, Green LC, and Lash TL. Addenda to Health Risk Assessment for the W.R. Grace & Co. Property, Cambridge, Massachusetts. Cambridge Environmental Inc. August, 1989.

Crouch EAC, Kaden DA, Green LC, and Lash TL. Addendum to Health Risk Assessment for Boston Gas Property, 100 Commercial Street, Malden, Massachusetts. Cambridge Environmental Inc. June, 1989.

Crouch EAC, Green LC, and Kaden DA. Health Risk Assessment for Proposed Waste–to–Energy Facility, Orange County, Florida. Environmental Health and Toxicology Group, Meta Systems Inc. May, 1989.

Crouch EAC, Baer SN, Kaden DA, and Green LC. Health Risk Characterization for Parcel 3, Cambridge Center. Environmental Health and Toxicology Group, Meta Systems Inc. April, 1989.

Crouch EAC, Kaden DA, and Green LC. Comments on Administrative Order Index No. II CERCLA-80217. Environmental Health and Toxicology Group, Meta Systems Inc. November, 1988.

Crouch EAC and Kaden DA. Health Risk Assessment for Boston Gas Property, 100 Commercial Street, Malden, Massachusetts. Environmental Health and Toxicology Group, Meta Systems Inc. October, 1988.

Charnley G and Kaden DA. Vinylidene Chloride: Evaluation of Carcinogenic Potential. Environmental Health and Toxicology Group, Meta Systems Inc. October, 1988.

Kaden DA and Baer SN. Chemical Fact Sheets for SARA Title III. Environmental Health and Toxicology Group, Meta Systems Inc. July, 1988.

Kaden DA, Crouch E, and Green LC. Comments on Section 40.545 (4) (d) of the Massachusetts Contingency Plan. Environmental Health and Toxicology Group, Meta Systems Inc. May, 1988.

Green LC, Kaden DA, Lash TL, and Tannenbaum SR. Comments on the ATSDR Toxicological Profile for Trichloroethylene. Environmental Health and Toxicology Group, Meta Systems Inc. April, 1988.

Kaden DA and Green LC. Spontaneous Hepatocellular Neoplasms and Activation of Cellular Oncogenes in B6C3F1 Mice. Environmental Health and Toxicology Group, Meta Systems Inc. December, 1987.

Skopek TR, Andon BM, Kaden DA, and Thilly WG. 1981. Mutagenic activity of 42 coded compounds using 8-azaguanine-resistance as a genetic marker in Salmonella typhimurium. In: "Evaluations for Short-Term Tests for Carcinogens. Report for the International Collaborative Program," deSerres FJ; Ashby J, eds. Elsevier/North Holland, Inc., Amsterdam. pp. 371-375.

Kaden DA, Andon BM, Li LL, Hites RA, and Thilly WG. 1980. Mutagenicity of kerosene soot, diesel soot, and air particulates to Salmonella typhimurium. In: "Proceedings of the Conference on Health Effects of Energy Production." Atomic Energy of Canada, Ltd., Chalk River, Ontario.

Thilly WG, DeLuca JG, Furth EE, Hoppe IV HH, Kaden DA, Krolewski JJ, Liber HL, Skopek TR, Slapikoff SA, Tizard RJ, and Penman BW. 1980. Gene locus mutation assays in diploid human lymphoblast lines. In: "Chemical Mutagens: Principles and Methods for Their Detection," Vol. 6, Hollaender A; deSerres F, eds. Plenum Press, New York. pp. 331-364.

Kaden DA and Thilly WG. 1979. Mutagenic activity of fossil fuel combustion products. In: "Proceedings of the Conference on Carbonaceous Particles in the Atmosphere," Novakov T, ed. National Science Foundation, Washington, DC pp. 193-198.

Kaden DA and Thilly WG. 1978. Genetic toxicology of kerosene soot. In: "Unregulated Diesel Emissions and Their Potential Health Effects," Powel SF, ed. Department of Transportation, Washington, D.C., pp. 612-623.

Other Selected Publications

Health Effects Institute, 1999. A Partnership to Examine Emerging Health Effects: EC/HEI Workshop on 1,3-Butadiene. Communication 6. Health Effects Institute, Cambridge MA.

Health Effects Institute,1999. Program Summary: Research on Air Toxics. Health Effects Institute, Cambridge MA.

Health Effects Institute. 1995. Program Summary: Research on Benzene and 1,3-Butadiene. Health Effects Institute, Cambridge MA.

Health Effects Institute.1993. Research Priorities for Mobile Air Toxics. Communication 2. Health Effects Institute, Cambridge MA.

Timothy M. Kelly, PhD, PE | Senior Manager

Arlington, Virginia
+1 703 516 2368 | tkelly@environcorp.com

Dr. Timothy M. Kelly has more than 20 years' experience in the permitting and modeling of new and modified industrial facilities. As a recognized expert in environmental engineering, he provides technical review, client development and project management for the power, solid waste, manufacturing, pulp and paper, oil and gas and industrial sectors. He is a strategic manager for key clients, and has prepared multi-disciplinary permit applications and presented at conferences, workshops and regulatory meetings. Tim has focused on air quality modeling and specialized in permitting and regulatory issues as a proven air quality business leader. He has managed or led numerous air permitting and auditing projects for the refining, petrochemical, power, wood products, manufacturing, pulp and paper, pipeline, and oil and gas industries, primarily in Virginia, Florida, North Carolina and South Carolina. He has supported the development of air quality services (e.g., permitting, auditing, modeling, control technology evaluations, regulatory applicability analyses, etc.), in addition to greenhouse gas program development and sustainability reporting, for primarily industrial clients. Tim has employed a variety of EPA-approved dispersion models (i.e., AERMOD, ISCST3, CALPUFF and CALINE3) in numerous evaluations of industrial sources.

EDUCATION

2001 PhD, Civil and Environmental Engineering, Florida State University

1994 MS, Civil Engineering, Florida State University

1992 BSE, Environmental Engineering, University of Florida

EXPERIENCE

- In advance of anticipated air permitting support for a potential combined cycle project in 2014, formulated a strategy to address BACT for multiple combustion turbine (CT) vendors and models. Specifically, the client was interested in an air permitting approach that would envelope several different CT vendors and models to provide them with "optionality" and to not be tied to one CT vendor once the permit is issued. A draft and final report outlined our strategy to ultimately present to the Virginia DEQ to obtain their concurrence on this approach.
- Evaluated the potential health impact of a proposed Poultry Litter-to-Energy Facility in Shenandoah Valley, Virginia. Conducted complex terrain (AERMOD) modelling of a proposed incinerator to determine the maximum ambient air quality impacts for a network of receptors.
- Prepared a complete RACT application for the existing landfill, mixing basins and biosolids areas. Work included the preparation of cost estimates and engineering design for an air stripper and carbon absorption units to remove volatile organic compounds and hazardous air pollutants. The RACT analysis was submitted to the Colorado Department of Public Health and Environment and the APCD.
- Performed air quality permitting and compliance issues for a marine services company and prepared an air emission inventory and a minor source air permit application.
- Prepared and negotiated numerous Title V permits for various types of facilities, including cogeneration, paper, chemical, refinery, glass manufacturing, and surface coating operations. As part of the Title V permit application, developed equipment inventories (significant and insignificant) and emissions calculations (point and fugitive); conducted rigorous regulatory applicability analyses; and determined compliance status with each applicable regulations.

Timothy M. Kelly, PhD, PE

- Prepared reports and permit applications for a batch chemical manufacturing plant. Numerous state permits were updated to capture equipment revisions and modifications and outdated or erroneous permit conditions. This project required extensive effort to identify equipment and manufacturing operations that were inconsistent with current permits, re-estimate batch emissions, prepare and submit revised permit applications, and negotiate permit conditions with permit writers.
- Conducted compliance auditing of numerous industrial facilities, including large chemical plants, pharmaceutical plants, automobile parts manufacturers, and TSDFs. Audits, which identified deficiencies and recommended corrective action, covered all media, including air, RCRA, SARA, water/waste-water, and pollution prevention.
- Prepared state permit applications for batch specialty chemical and pharmaceutical manufacturing plants using batch permitting procedures outlined by the NJDEP. These projects involved the development of products with emissions estimates to represent a wide variety of chemical products. These permits allowed great flexibility in operations for the manufacturing plants without requiring permit modifications. In addition, these permits often allowed the facilities to operate as "synthetic minor" facilities, avoiding additional regulatory requirements such as Title V and MACT.
- Prepare modeling to support a risk based application for a glass manufacturing facility. Work included AERMOD modeling, collecting relevant site data and supporting the risk assessment for the facility.
- As environmental engineer for the NAS Cecil Field Installation Restoration Program, responsible for air quality permitting and basewide compliance issues. Contributed to the preparation of an annual emission inventory and a Title V air permit application.
- Served as the Project Engineer for the preparation of a workplan for a stack test of the facility's wood waste incinerator at the landfill. Involved with the gathering, interpretation, and preparation of data for the workplan and preparing documents for submittal to USEPA and DEQ. Other activities include preparing the renewal of the Title V application and NSPS compliance.
- With E & E, prepared a CAA Title V air permit application for this 1,000-acre facility. The project included compilation of source information, consultation with representatives of involved agencies, and electronic submission of the application form.
- Prepared an air pollution applicability analysis for a federal fuel depot. The project included an air emission analysis and estimation of emissions associated with the removal and installation of diesel fuel ASTs at the site.
- Managed preparation of the Title V permit application and led the development of the emission inventory and ensured that it was consistent with application requirements and followed FDEP guidance for the grouping of entire process lines into single emission categories. This enabled the facility to limit the number of emission units, reduce the level of effort required for inventory development, and more easily track emissions based on chemical usage. It also significantly reduced the monitoring and record-keeping requirements for the Title V application. Filed a construction permit application for two new process lines to be located in a site expansion area.
- Prepared a compliance assurance monitoring (CAM) plan for this Title V source. Conducted an air emissions inventory that included a PTE/PSD evaluation.
- Prepared a combined new construction/Title V renewal permit application for a major boat manufacturer. Included a regulatory applicability analysis that included compliance with the MACT NESHAP (40 CFR 63, Subpart VVV).
- Prepared two construction permit applications for this Title V source. Conducted an air emissions inventory that was included in the Title V permit modification application.

Timothy M. Kelly, PhD, PE

- Prepared a modelling study utilizing the AERMOD-Prime/ISCST3 model to determine impacts from a petroleum refinery including the remediation of a TCE spill. Conducted water to air transfer calculations for input into the model.
- Conducted a post-wide air emissions survey including over 100 building locations. The facility's O&M plan was also updated and the Clean Air Act General Duty Clause evaluated with respect to its applicability to the facility.
- Served as project manager for the design, construction and air quality permitting for a large scale remediation project.
- Was hired by a regional solid waste authority to design and develop a Landfill Gas to Energy project for its Subtitle D landfill. Duties included air quality permitting, the design of the facility's overall landfill gas collection system including a phased construction approach, as well as the development of construction level documents for the construction of the initial phase. Designed interim remediation measures to control the offsite migration of landfill gas in the Authority's sanitary sewer system. Landfill gas collected was sent via pipeline to an adjacent property where a new industrial end user was constructing an aluminum smelter.
- Served as project manager to determine the feasibility of utilizing the landfill gas from Spartanburg County Wellford Landfill to fuel a boiler at Milliken's Dewey Plant. Services also included air permitting, sampling and analysis of the LFG to determine its quality for the designated end use, review the operation of the existing active gas extraction system and the performance of an LFG extraction pump test to establish a sound basis for the recommendation to Milliken & Company. An active LFG extraction system was designed, based on the results of the pump test, and will supply landfill gas for LFGTE.

Prior to joining ENVIRON, Tim held the following positions.

- Golder Associates Inc. – Richmond, Virginia
  - Dr. Kelly was a senior engineer in Golder's Richmond, Virginia office. He is a registered Professional Engineer (P.E.) in Virginia, South Carolina, North Carolina, Florida and Missouri. He joined Golder Associates as a Senior Engineer, working on the design and engineering analysis for projects such as air pollution compliance, permitting and modelling, solid waste landfill design, groundwater remediation and modelling, environmental compliance audits and storm water/NPDES permitting. Dr. Kelly has been extensively involved in client development and air quality permitting of compressed gas manufacturing facilities, pulp and paper mills, breweries, chemical plants, cement plants, oil refineries, and electrical generation facilities.
- Joyce Engineering, Inc. – Richmond, Virginia
  - As a senior technical consultant, he managed technical staff, provided project management and prepared engineering analysis for projects such as landfill design, groundwater remediation and modelling, air pollution permitting and modelling, environmental compliance audits and storm water/NPDES permitting. Dr. Kelly worked on solid waste management projects, air pollution control and modelling, contaminant hydrogeology and modelling, remediation and environmental compliance projects.
- URS Corporation – Richmond, Virginia and Tallahassee, Florida
  - As a senior engineer, he managed air projects for the office and performed projects relating to CERCLA and RCRA as well as hazardous waste compliance and permitting. As the geoenvironmental group manager, he was responsible for team profitability and project management.
- Ecology and Environment – Tallahassee, Florida
  - Dr. Kelly oversaw the FDEP Petroleum remediation section. In this role, Dr. Kelly reviewed and approved remedial action plans and corrective action reports to satisfy the requirements of the FDEP petroleum program.

Timothy M. Kelly, PhD, PE

- Law Engineering and Environmental Services – Atlanta, Georgia and Tallahassee, Florida
  - As a senior engineer, he performed engineering analysis of civil, environmental and geotechnical projects. He was also responsible for environmental and engineering projects in the Atlanta, Georgia and Tallahassee, Florida locations.
- Amec E&I (formerly ABB Environmental Services) – Tallahassee, Florida
  - As a project engineer, he managed federal and commercial projects pertaining to groundwater and soil remediation, air permitting and modelling and performed engineering analysis for civil, environmental and geotechnical projects.

CREDENTIALS

Professional Engineer: Florida, Missouri, North Carolina, Maryland, South Carolina and Virginia

PUBLICATIONS & PRESENTATIONS

Kelly, T.M. and J. Wright. Can Hazardous Waste Sites be Breached by Future Climate Change?. Journal of Environmental Engineering, May (2005)

Whitlock, Ian and T.M. Kelly. Relationship Between Subsurface Landfill Gas and Arsenic Mobilization in Groundwater. Groundwater Monitoring and Remediation, Spring (2010)

Kelly, T.M., A.D. Dzurik and D. Leszczynska. 1998. Water and Soil Contamination from Auto Salvage Facilities and their Regulations. Proceeding of the Fourth International Symposium and Exhibition on Environmental Contamination in Central and Eastern Europe. Warsaw, Poland.

Kelly, T.M., A.D. Dzurik and D. Leszczynska. 1999. Stormwater Runoff Effects of Florida's Automobile Salvage Yards. Proceedings of the 1999 ASCE Water Resources Planning and Management Conference. Tempe, Arizona.

Caspary, J.R., T.M. Kelly and K.S. Tawfiq. 1999. Containment and Control of Low-Level Radioactive and Industrial Wastes at the Jacksonville Naval Air Station Superfund Site. Proceedings of the 1999 ASCE Conference. Orlando, Florida.

Kelly, T.M., M. Annable and J. Caspary. 2000. Remediation of Fuel Site SS-15B—the Former Flightline Pumphouses. Proceedings of 2000 Florida Remediation Conference. Orlando, Florida.

Kelly, T.M. and J. Wright. 2002. Air Sparging Performance Evaluation in Florida. National Ground Water Association, Proceedings from the Petroleum Remediation Conference. Atlanta, Georgia.

Kelly, T.M. 2001. Determination of Factors that Influence Wetting Front Instability in Unsaturated Porous Media. Ph.D. dissertation, Florida State University, Tallahassee, Florida.

Elizabeth A. Miesner | Principal

San Francisco, California
+ 1 415 796 1938 | emiesner@environcorp.com

Liz Miesner has over 26 years of experience conducting and managing environmental health assessments. She has managed and conducted exposure/risk assessments for numerous Comprehensive Environmental Response, Compensation and Liability Act (CERCLA-Superfund), Resource Conservation and Recovery Act (RCRA) and other hazardous waste sites involving the evaluation of human health risks from exposure to contaminants detected in soil, sediment, soil gas, air, groundwater and surface water. She has evaluated many of these sites for potential vapor migration from the subsurface to indoor/ambient air. She has conducted risk assessments of air toxic emissions in support of projects conducted under California's "Air Toxics Hot Spots" bill (AB2588) and Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65) and in support of environmental impact reports (EIRs). In addition to chemical risk assessment, she has evaluated both non-chemical and cumulative (community) health impacts and has been actively involved in the emerging field of health impact assessments (HIAs).

EDUCATION

1987 MS, Environmental Health Science (Environmental Health Management/Air Pollution), Harvard School of Public Health

1980 BS, Psychobiology, University of California, Los Angeles

EXPERIENCE

Site Exposure/Risk Assessment:

- Prepared and implemented numerous ambient/indoor air monitoring plans to evaluate potential vapor intrusion into a building or sources within a building. Monitoring includes volatile organic compounds (including chlorinated compounds, formaldehyde and methane), semi-volatile organic compounds (including polychlorinated biphenyls), and air quality parameters collected in over 100 buildings including commercial/industrial buildings, homes, schools, and daycares.
- Developed a risk-based remediation strategy for redevelopment of a former 200-acre refinery located in Hercules, California to residential and park use. Work included development of sampling, risk and remediation strategies, evaluation of site data, and presentations/negotiations with the San Francisco Regional Water Quality Control Board (SFRWQCB).
- For a fuel terminal in Southern California, managed and conducted a human health risk assessment for both onsite and offsite areas. Petroleum products currently or historically stored at the terminal included leaded gasoline, unleaded gasoline, gasoline additives, jet fuel, diesel, ethanol, and transmix (i.e., a mixture of gasoline, diesel and jet fuel). Chemicals of concern in groundwater and soil gas included benzene/toluene, ethylbenzene/xylene (BTEX), methyl tert-butyl ether (MTBE), tertiary amyl methyl ether (TAME), and tertiary Butyl Alcohol (TBA).
- For a former electronic and communication equipment facility in Mountain View, California, managed and conducted a human health risk assessment to evaluate potential exposure to future onsite residents after redevelopment of the property. The objective of the risk assessment was to develop risk-based concentrations (RBCs) for volatile chemicals (including chlorinated solvents) identified in subsurface soil and groundwater at the site. The site-specific RBCs were designed to be protective for future residents who may be exposed to volatile chemicals via inhalation while living at the site. Work also included design and implementation of a

soil gas sampling plan and a sampling plan for monitoring of natural attenuation parameters for chlorinated solvents in groundwater. The project included coordination/negotiations with the United States Environmental Protection Agency (USEPA) Region 9.

- For a former aerospace facility in Burbank, California, provided strategic risk assessment services for the client, the developer of the property. Future land uses for the site included retail, office, hotel, and restaurant facilities. Work on the project included evaluation of previous site investigations and risk assessments, strategy development with the developer and their law firm, negotiations/interactions with the current property owner consultants and the city of Burbank consultants, meetings with future site occupants, and evaluation of potential Proposition 65 issues.
- For the Port of Oakland, conducted risk assessment related activities for the redevelopment of the Ninth Avenue Terminal (bulk storage terminal). Conducted human health risk assessment activities, oversaw ecological risk assessment activities, interacted/coordinated with Port Environmental Department, the Port Real Estate Department, the Port's lawyers, other Port environmental consultants, the developer, and the developer's consultants. Responsible for presenting the Port's risk assessment work plans to the San Francisco Regional Water Quality Control Board (SFRWQCB).
- For an 800-acre residential redevelopment project on a former oil field production area, assisted the client in development of health risk-based site-specific cleanup concentrations for total petroleum hydrocarbons (TPH in the gasoline, diesel and residual ranges) in soils to be remediated at the site.
- Updated and revised risk assessments previously prepared for a former pesticide plant in Richmond, CA. The goal of the project was to fulfill the requirements of the SFRWQCB for investigation and corrective action at the site. The risk assessment addressed potential risks to human health and ecological receptors due to potential exposure to chemicals present in ground water, surface water, and sediment. As part of this assessment, evaluated the potential risk reduction corresponding to four remedial alternative and/or environmental controls including long-term monitoring, institutional controls, soil/sediment excavation, capping, and installation of a concrete lining.
- Managed site characterization/remediation activities, and prepared a human health risk assessment in support of a RCRA Part B Permit modification and EIR for a proposed land-use change for a manufacturing facility in San Jose, California. This risk assessment required evaluation of potential impacts from soil (facility operations and former agricultural land use) and groundwater contamination as well as from current and future facility emissions from on-going operations to the proposed future commercial/residential land development.
- As part of a RCRA Corrective Action at a refinery in the Midwest US, worked with the client and state agency to develop a cost-effective approach to assessing potential onsite and offsite human health and ecological risk to determine if additional corrective measures were needed and to support the risk communication program for the community. Chemicals of concern included BTEX, polyaromatic hydrocarbons (PAHs), metals and TPH in soil, groundwater and surface water.
- Managed and conducted baseline risk assessments for numerous CERCLA - Superfund and other hazardous waste sites involving the evaluation of human health risks from exposure to contaminants detected in soil, sediment, air, groundwater, and surface water. Sites evaluated include waste disposal sites, lead smelters, and an optical lens manufacturing facility.
- Performed preliminary risk assessments to be used in the support of interim action decisions at Superfund sites, developed air, soil and groundwater risk-based concentrations for use in screening sites for further evaluation and focusing the development of remedial alternatives, and determined potential health risks associated with selected site remedial actions.

Elizabeth A. Miesner

- Managed and conducted screening human health risk assessments of potentially contaminated sites at the Marine Corps Station El Toro for the Southwest Division Naval Facilities Engineering Command (Navy-SWDIV). The assessments used risk-based concentrations to support cleanup decision-making and focus efforts on sites posing the greatest risks. Conducted a well-specific risk assessment for the evaluation of volatile organic compounds in the regional groundwater plume.
- Managed and conducted a human health risk assessment for the Navy-SWDIV at the Naval Weapons Station Seal Beach. Provided senior technical oversight and review for Navy-SWDIV of human health risk assessments conducted at the Marine Corps Base, Camp Pendleton.
- Managed and conducted a human health risk assessment for the Navy-SWDIV for Operable Unit 5 of the former Naval Air Station (NAS) Alameda. The risk assessment included evaluation of soil, groundwater and soil gas data to assess potential exposures to current onsite Coast Guard personnel and potential future onsite residential redevelopment. The chemicals of concern for this assessment were polyaromatic hydrocarbons in soil and volatile organic chemicals in groundwater.
- Managed and conducted a screening human health risk assessments for sites included in the West/Annexes/Basewide Operable Unit at Travis Air Force Base. The purpose of these assessments was to prioritize sites for further investigation or to eliminate those sites requiring no further action based on initial site field sampling results.
- Managed and conducted risk assessments for seven manufactured gas plant (MGP) sites in accordance with California's Preliminary Endangerment Assessment (PEA) guidance. Results from the risk assessments supported recommendations for different institutional controls and remedial action alternatives. The risk assessments were used as a basis for negotiations with the state on appropriate remedial actions for each site.
- On behalf of a private development client, presented comments before the San Francisco Department of Public Health, Health Commission regarding potential health risks to the surrounding community from naturally accurring asbestos during grading activities.
- On behalf of a northern California University, presented to and met with parents of children in the onsite daycare facility to communicate the potential for exposures/risk and the effectiveness of mitigation measures regarding movement of stockpiled soil near the facility.
- For mediation, prepared an expert declaration for a transportation agency regarding cleanup goals for arsenic in soil in paved and unpaved areas along a bus way, bike path, and pedestrian walkway constructed along a former railroad right-of-way.
- In support of litigation, reconstructed potential past exposures to benzene for identified individuals living in proximity to oil fileds located in Southern California.
- Assisted the Commonwealth of Australia in the evaluation of human health risks due to contaminated soils and groundwater at the former Cockatoo Island Dockyard and in the preparation of technical responses to critical reports received in relation to the arbitration between the former tenant and the Commonwealth.
- Senior reviewer for a health risk assessment of soil and groundwater contamination at the Towrah Lakes Project located in North Cronulla, Australia. The assessment, which was conducted for Australian Housing and Land, evaluated the potential human health risks to construction workers and users of a proposed lake and wetland.

Elizabeth A. Miesner

Air Toxics Risk Assessments:

- Managed the preparation of a RCRA Part B Hazardous Waste Treatment and Storage permit for a manufacturing facility in Richmond, California. Units being permitted included two drum storage facilities, eight above ground tanks, and a hazardous waste incinerator.
- Managed and conducted a human health risk assessment in support of a Resource Consevation and Recovery Act (RCRA) Part B Permit and EIR for a commercial waste treatment, storage, and disposal facility in East Palo Alto, California.
- Managed and conducted a human health risk assessment in support of an EIR for a landfill expansion in Manteca, California where the key issues were landfill gas emissions and diesel exhaust.
- Managed and conducted a human health risk assessment in support of a RCRA Part B Permit for a recycling facility in Reedley, California which focused on solvent emissions and potential exposures to onsite and offsite populations.
- Managed and conducted a human health risk assessment in support of a RCRA Part B Permit for air emissions from a commercial waste treatment, storage, and disposal facility in Chandler, Arizona.
- Managed and conducted a human health risk assessment to evaluate potential exposures to surrounding sensitive populations due to air emissions (stationary and mobile) from an operating rock quarry. The assessment included potential offsite exposure to naturally occurring crystalline silica in quarry soil during blasting and other activities that may lead to fugitive emissions.
- For a mining facility in California, evaluated potential offsite exposures to metals in mining materials due to facility emissions, offsite pipeline spills and windblown dust from an evaporation pond. The assessment included evaluation of compliance with California's Proposition 65.
- Managed and conducted a screening health risk assessment in support of an EIR to evaluate potential off-site impacts due to incremental diesel particulate emissions from the Oakland Army Base area redevelopment program. The project evaluated the dispersion of incremental diesel emissions from trucks, trains and ships and the estimated incremental risks to surrounding populations.
- In support of an EIR for the Candlestick Point-Hunters Point Shipyard Phase II Redevelopment Project, which encompasses approximately 700 acres, prepared ambient air quality risk assessments to evaluate the impact of construction-related diesel particulate matter, chemicals bound to airborne PM_{10}, toxic air contaminatns from stationary sources in Research and Development Areas; and $PM_{2.5}$ analysis of traffic/vehicular emissions.
- For an Office/R&D/Medical Clinic Project in Redwood City, California evaluated potential health impacts from onsite operational emsisions and construction activities on onsite and offsite receptors and surrounding sources (stationary and mobile) on onsite sensitive receptors. The evaluation was used to assest in planning the location for an onsite daycare facility.
- On behalf of a northern California University, presented to and met with parents of children in the onsite daycare facility to communicate the potential for exposures/risk regarding demolition/construction activities in nearby buildings.
- In response to comments received on an EIR for a proposed hospital, evaluated potential health risks from diesel exhasust emissions due to its location proximate to a major freeway in Northern California. The evaluation assessed risk based on both height and distance of air intakes from the freeway.
- For a mixed-use development located adjacent to a freeway in Northern California, conducted a risk assessment to address toxic air contaminants (TACs) associated with vehicle emissions, conducted refined site-

specific modeling, and provided justification for the selection of a significance threshold in response to defeciences in their EIR as identified by the Court.

- Prepared screening-level multi-pathway health risk assessments under the "Air Toxics Hot Spots" bill (AB2588) for air emissions from the South Bayside System Authority and Union Sanitary District municipal wastewater treatment facilities for submittal to the Bay Area Air Quality Management District.
- Prepared a multi-pathway health risk assessment under the "Air Toxics Hot Spots" bill (AB2588) for air emissions from an electronics manufacturing facility in Fullerton, California for submittal to the South Coast Air Quality Management District.
- Conducted a comprehensive technical review of a human health risk assessment and related documents for a lead/sulfide smelter located in Boolaroo, Australia for the New South Wales Department of Planning (DoP). The risk assessment presented a preliminary assessment of the potential lead risk from smelter air emissions to populations in Boolaroo and the surrounding communities. The review included comparing the assessment techniques with current international trends, providing guidance to the DoP as to the suitability of the methodology used, and providing recommendations as to the acceptability of the risk assessment.
- On behalf of a city in Northern California, gave a presentation to the local community on conducting a human health risk assessment for airborne emissions with focus on refinery emissions.
- On behalf of a paint manufacturer, identified products containing California Proposition 65 materials and prepared screening risk-based target concentrations (RBTCs) for compliance with Proposition 65 for volatile emissions from paint (resident and commercial worker), nonvolatile respirable aerosol during spray painting (commercial) and nonvolatile respirable dust during sanding (resident and commercial worker).
- For an asphalt manufacturer, conducted a screening level analysis for two facilities to determine whether California Proposition 65 warnings were needed due to offsite facility emissions.

Community Health/Health Impact Assessments (HIAs)

- On behalf of a property development company prepared a white paper on HIAs for their internal use and for the edification of the local city council. Reviewed and critically evaluated an HIA prepared for their redevelopment project by the University of California, Berkeley Health Impact Group.
- On behalf of a private oil and gas client reviewed and critically evaluated an HIA prepared for their distribution project in the Western United States.
- On behalf of a private oil and gas client reviewed and critically evaluated an HIA addressing hydraulic fracturing in Maryland.
- On behalf of a private goods movement client, prepared a white paper and fact sheet for edification of internal staff and to assist in responding to community comments. Conducted a critical evaluation of the clients current way of addressing health in their EIRs, health risk assessments, and related community programs and identified both overlap and data gaps in addressing key HIA issues.
- Invited by the Southern California Association of Governments to speak on "Health Risk Assessments and Health Impact Assessments" at their meeting in Los Angeles, CA on January 31, 2011.
- Participated in the 2011 HIA of America's Workshop held in Oakland, California.
- Co-authored a written review of the 2011 National Academy of Sciences report on HIA, Improving Health in the United States, the Role of Health Impact Assessment.

- Co-chaired a symposium session "Health Impact Assessments – A Broader View of Public Health" at the Society of Risk Analysis 2012 World Congress held in Sydney, Australia.
- Co-authored and presented a talk titled "The Intersection of Health Impact Assessment and Human Health Risk Assessment" at the Society of Risk Analysis 2012 World Congress held in Sydney, Australia.
- Co-authored and presented a talk titled "Hydraulic Fracturing and Community Health" at the 23rd Annual International Conference on Soil, Water, Energy and Air held in San Diego, California in March 2013.
- Attended a 4-day HIA training course put on by the San Francisco Department of Public Health (2011).
- Attended an invitation-only HIA training by the University of California, Los Angeles School of Public Health (2011).

Prior to joining ENVIRON, Liz held the following positions:

- Risk Assessment Specialist, CH2M Hill
  - Managed and conducted numerous health risk assessments for CERCLA and other hazardous waste sites.
  - Technical coordinator for human health risk assessment in the Bay Area Region.
- Research Assistant, Department of Environmental Science and Physiology, Harvard School of Public Health
  - Supervised field operations for a large air pollution/health study, collected and analyzed air samples, and assisted in designing a field study to determine total human exposure to particulates.
- Graduate Teaching Assistant, Department of Biostatistics, Harvard School of Public Health
  - Prepared lectures, conducted weekly review sessions, and evaluated student performance for a graduate course in introductory biostatistics.
- Intern, Monsanto Company
  - Compiled and statistically analyzed data to evaluate the relationship between quantitative results from toxicity, mutagenicity, and carcinogenicity tests of potentially toxic substances.
- Staff Research Associate, Department of Psychology, University of California, Los Angeles
  - Organized and executed experiments that investigated the sexual differentiation of the nervous system and the development of related behaviors.

CREDENTIALS

Professional Affiliations and Activities

Air and Waste Management Association (AWMA)

Association for Environmental Health and Sciences (AEHS)

- Scientific Advisory Board Member for West Coast Conference (2007 to present)

Interstate Technology and Regulatory Council (ITRC)

- Risk Assessment Team Member (2012-14)

National Society for Risk Analysis (SRA)

Northern California Chapter of the Society for Risk Analysis (NCCSRA)

- Treasurer (1998-99), President-elect (2000), President (2001), Councilor/Past President (2002)

Elizabeth A. Miesner

Northern California Chapter of the Society of Toxicology (NorCal SOT)

- Councilor (2002-04), Web Site Coordinator (2002-04)

Society of Environmental Toxicology and Chemistry (SETAC)

PUBLICATIONS & PRESENTATIONS

Miesner, E. 2014. Invited Panel Member: The Future of Human Health Risk Assessment: What to Expect by 2020. 24rd Annual AEHS Meeting and West Coast Conference on Soil, Water, Energy, and Air. March 17-20. San Diego, California.

Kaden, D., Sulsky, S., Dell, L., Hall, L., and Miesner, E. 2013. Understanding Cumulative Impacts in Assessing Community Exposure and Health. Poster presented at Environment and Health – Bridging South, North, East and West. Sponsored by the International Society for Environmental Epidemiology (ISEE), the International Society of Indoor Air Quality and Climate (ISIAQ), and the International Society of Exposure Science (ISES). August 19-23. Basel, Switzerland.

Miesner, E. 2013. Comparing California's Safer Consumer Product (SCP) Regulation with Europe's Registration, Evaluation, Authorization and Restriction of Chemical's (REACH) Regulation. Presented at the 2nd Safer Products Summit. April 2-4. San Francisco, California.

Miesner, E., Hall, L., Harris, A., and Kaden, D. 2013. Hydraulic Fracturing and Community Health. Presented at the 23rd Annual AEHS Meeting and West Coast Conference on Soil, Water, Energy, and Air. March 18-21. San Diego, California.

Miesner, E. 2012. Co-chair symposium session "Health Impact Assessments – A Broader View of Public Health". SRA World Congress on Risk 2012. July 18-20. Sydney, Australia.

Miesner, E.and Hall, L. 2012. The Intersection of Health Impact Assessment and Human Health Risk Assessment. SRA World Congress on Risk 2012. July 18-20. Sydney, Australia.

Keinath, M., Caviness, G., and Miesner, E. 2011. Air Toxics Risk Assessment: The Impact of Applying Age Sensitivity Factors. Poster presentation at the 2011 Annual Northern California Chapter of the Society of Environmental Toxicology and Chemistry (NorCal SETAC) Meeting. May 4-5. California State University, Sacramento, California.

Miesner, E. 2011. Invited Panel Member: Green Chemistry in California - Where is it Now? Where is it Going? Los Angeles County Bar Association, 25th Annual Environmental Law Super Symposium: The Greening of California—Achieving Green Goals in a Time of Limited Financial Resources. April 28. Los Angeles, California.

Caviness, G., Miesner, E., Louie, J., and Posson, M. 2011. Impact of Applying Age Sensitivity Factors (ASFs) on Risk Characterization. Poster Presentation at the 21st Annual International Conference on Soil, Water, Energy, and Air. March 14-17. San Diego, California.

Miesner, E. 2011. Chairperson workshop session ""California Goes Green – California's Green Chemistry Initiative" and talk titled "Toxics Information Clearing House – Identification of Hazard Traits, Endpoints and Other Relevant Data". 21st Annual AEHS Meeting and West Coast Conference on Soil, Water, Energy, and Air. March 14. San Diego, CA.

Miesner E. and Lester J. 2011. Invited Speaker: Health Risk Assessments and Health Impact Assessments. Southern California Association of Governments, Los Angeles, California, January 31.

Miesner, E. 2009. Vapor Intrusion – Influence of Ambient and Indoor Air Sources. Presented at the 19th Annual AEHS Meeting and West Coast Conference on Soils, Sediments, and Water, San Diego, CA.

Elizabeth A. Miesner

Miesner, E. 2008. Invited Speaker. Presentation on "Cost Effective Evaluation of Vapour Intrusion: Human Health Risks from Subsurface Chlorinated Solvents" at Air & Waste Management Association (AWMA) Conference – Vapour Intrusion: Understanding Scientific, Technical, and Legal Issues and Solutions. September 8-10. Toronto, ON, Canada.

Miesner, E. and C. Serlin. 2007. Vinyl Chloride in Indoor Air – Vapor Intrusion versus Indoor Sources. Presented at the 17th Annual AEHS Meeting and West Coast Conference on Soils, Sediments, and Water. March 19-22. San Diego, California.

Bowie, T., D. Daugherty, M. Keinath, E. Miesner, C. Stubbs. 2006. Validation of the Johnson and Ettinger Vapor Intrusion Model Applied to Commercial Buildings. Presented at AIHCE 2006, Chicago, IL. May.

Miesner, E. 2006. Moderator for Sessions on Risk Assessment/Human Health and Perchlorate. 16th Annual AEHS Meeting and West Coast Conference on Soils, Sediment and Water. March 13-16. San Diego, California.

Cline, P., C.A. Lawrence, and E. Miesner. 1997. Risk Analysis: Natural Attenuation Alternative for Trichloroethene. Proceedings of the Fourth International In Situ and On-Site Bioremediation Symposium. Volume 3, pp. 213-218. Battelle Press.

Kirkendall, V., D. Caniparoli and E. Miesner. 1992. Risk Assessment Methodology: The California Experience (Air Toxics). Presented at the Pacific Northwest Air and Waste Management Association 1992 Annual Conference and Exhibition, Bellevue, Washington.

Miesner, E., C. St. Hilaire, R. McDonald, R. Scofield, and G. Van Gelder. 1989. An evaluation of conservative assumptions and methodology in residential and occupational inhalation exposure assessments. Presented at the Society for Risk Analysis 1989 Annual Meeting, San Francisco, California.

Miesner, E.A., S.N. Rudnick, F.C. Hu, J.D. Spengler, L. Preller, H. Ozkaynak, and W. Nelson. 1989. Particulate and nicotine sampling in public facilities and offices. Journal of the Air and Waste Management Association, 39, No. 12, 1577-1582.

Bottjer, S.W., K.A. Halsema, S.A. Brown, and E.A. Miesner. 1989. Axonal connections of a forebrain nucleus involved with vocal learning in zebra finches. Journal of Comparative Neurology, 279 (2):312-26.

McCarthy, J., E. Miesner, and J.D. Spengler. 1988. Environmental Concentrations of ETS. Chapter 6, Environmental Tobacco Smoke: A Compendium of Technical Information. Draft. Indoor Air Division. Office of Atmospheric and Indoor Air Programs. Office of Air and Radiation. United States Environmental Protection Agency.

Miesner, E.A., S.N. Rudnick, L. Preller, F.C. Hu, J.D. Spengler, H. Ozkaynak, and W. Nelson. 1988. Aerosol and ETS sampling in public facilities and offices. Paper #88-76.4. Presented at the 81st Annual Meeting of the Air Pollution Control Association, Dallas, Texas. June.

Bottjer, S.W., E.A. Miesner, and A.P. Arnold. 1986. Changes in neuronal number, density and size account for increases in volume of song-control nuclei during song development in zebra finches. Neuroscience Letters, 67, 263-268.

Miesner, E.A., S.W. Bottjer, and A.P. Arnold. 1984. Afferent input to a forebrain nucleus involved in song learning in zebra finches. Society of Neuroscience Abstracts 10-401.

Bottjer, S.W., E.A. Miesner, and A.P. Arnold. 1984. Forebrain lesions disrupt development but not maintenance of song in passerine birds. Science. 224, 901-903.

Bottjer, S.W., E.A. Miesner, and A.P. Arnold. 1983. Developmental changes in effects of lesions in forebrain song-control nuclei of passerine birds. Society of Neuroscience Abstracts,

Daniel J. Price, RG | Principal Consultant

St. Louis, Missouri
+ 1 314 513 1970 | dprice@environcorp.com

Daniel J. Price is a geologist with over 25 years' experience dedicated to technical and cost-effective environmental site investigation, characterization, remediation and liability management. Daniel has successfully managed a variety of projects, from property transaction due diligence site assessments to full-scale RCRA facility investigations, CERCLA remedial investigations, interim response actions, and remediation. More recently, his practice has focused on assisting clients in accurately assessing environmental liabilities related to owned and legacy properties.

EDUCATION

1981 BS, Geology, Missouri State University

EXPERIENCE

Missouri Brownfields/Voluntary Cleanup Program (BVCP)

- Assisted a client with taking a site in southeastern Missouri through the BVCP. The site has been operating since the 1970's and releases over the years has resulted in impacts to soil and groundwater from hexavalent chromium and nickel related to chrome plating operations. The site investigation phase is complete and interim remedial actions have been implemented to remove some of the mass of hexavalent chromium in groundwater in advance of a performing a Tier I Risk Assessment in accordance with the Missouri Risk-based Corrective Action Guidance Document. Interim action consisted of the installation of an extraction well. During the first month of extraction well operation approximately 95 pounds of hexavalent chromium were removed.
- Served as project manager for a project seeking closure under the BVCP related to a groundwater impact from metals, specifically hexavalent chromium. The site investigation consisted of multiple phases based on the findings from each subsequent phase. The dissolved metals impact to groundwater was documented as migrating offsite in the unconsolidated zone and present within the shallow fractured dolomite bedrock beneath the site. Additional investigation activities are planned to delineate horizontal and vertical extent of the groundwater impact.
- Served as project manager for site characterization under the BVCP for a former ink manufacturing facility. Investigation of potential source areas resulted in the identification of minimal impacts to soil and groundwater at levels appropriate for site use. Received a Certificate of Completion for the site in April 2012.
- Provided project management, site characterization and remediation at a former tar plant associated with a manufactured gas plant (MGP) in Kansas City, Missouri, under the BVCP. Led a team providing technical consulting, site characterization and remediation services for this former owner. Remediation efforts included the excavation of a tar well and tar separator and associated impacted soil. All excavated material was properly disposed off-site. Groundwater impact was determined to be commingled with impacts from the adjacent MGP; therefore, remedial actions were postponed until all actions were complete at the adjacent MGP. Assisted the former owner in settlement negotiations with the current property owner and obtained a favorable financial settlement for the client covering the estimated costs of the future groundwater remedial action. The site obtained a Certificate of Completion for the soil portion of the project during my involvement.
- Served as project manager for site characterization at a former MGP in St. Louis, Missouri. This former MGP/Coke Plant was sold by the client to an entity that continued the coking operations for several years. However, due to bankruptcy the environmental liability returned to the client. USEPA Region VII was threatening to take the site into Superfund and recover costs from past viable owners. The USEPA contractor had developed a site investigation work plan based on minimal site knowledge that was excessive and quite costly. Evaluation of

all historical data available and presentation of that data using a Geographic Information System (GIS) convinced the USEPA that a much smaller scale investigation was sufficient. The investigation was conducted under the BVCP for approximately half the costs of the USEPA contractor quote and the results satisfied the regulators.

- Performed an investigation under the BVCP at a property encompassing a former quarry that had been backfilled with debris and soil prior to commercial redevelopment. The purpose of the investigation was to assess potential contamination to soil and groundwater at the site resulting from fill material. No impact was defined to soil or groundwater within the quarry though a soil excavation was required at an area of the site that formerly housed a junkyard. The work conducted satisfied the BVCP and a Certificate of Completion was issued.
- An investigation conducted under the BVCP revealed surface and subsurface soil impacts from metals and semi-volatile organic compounds (SVOCs) at a site in southwest Missouri. Activities were undertaken to minimize exposure to the contaminants including: capping the area with asphalt, constructing storm water controls and installation of a fence. The BVCP issued a Certificate of Completion with Activity Use Limitations (AULs).

Site Solutions (Other Regulatory Programs)

- Managed a team conducting an investigation and implementing a remediation effort of a release of petroleum solvents at a facility in Toronto, Ontario. The release was well defined and limited in extent. The remedial effort consisted of in-situ chemical oxidation (ISCO) via direct push injection of activated persulfate in areas with less impact and via soil mixing of the reagent in source areas. An 80 to 90 percent reduction in hydrocarbon concentrations in groundwater was achieved over the majority of the property. Two areas of limited extent will require additional targeted soil excavation and additional ISCO injections in groundwater to achieve the site specific clean-up objectives.
- Conducted an assessment of the appropriateness of monitored natural attenuation (MNA) as an acceptable groundwater remedy for a container manufacturer located in Spartanburg, South Carolina. The assessment was prompted by a request from the South Carolina Department of Health and Environmental Control (DHEC) to justify the selection of MNA as the appropriate means of remediation for groundwater at the facility. The assessment included a review of all existing groundwater data and biodegradation modeling. The results of the model illustrated that the lateral extent of chlorinated volatile organic compounds in groundwater beneath the site was stable and would not migrate offsite.
- Performed a review and evaluation of available documentation to assess the main factors that may have contributed to the presence of landfill gas at a site that contained a former non-registered landfill and an onsite engineered cell where larger (greater than 6 inches) material from the former landfill was placed. Subsequently provided an expert witness report opining on the requirements of the B/VCP related to such a site and proper investigative techniques that would have been appropriate to assess the potential presence of landfill gas in the subsurface.
- Served as project manager for an interim indoor air sampling program in Olathe, Kansas for an industrial client that is a PRP at a former chemical recycling site. This effort focused on the collection of seasonal indoor air samples at 83 residences located adjacent to and immediately surrounding the former chemical recycling site. The project involved direct communication with the public by the project team on the client's behalf. The successful community interaction, in part due to training that included role playing, resulted in no complaints from the residents to the client or USEPA. Another key component to the success of the project was the development of an enhanced communications database used not only to track correspondence with residents but also to manage analytical data. The database was constructed to allow direct input all relevant data to the client's Environmental Data Management System.
- Served as project manager for closure of a Treatment, Storage, and Disposal Facility (TSDF) at a Heat Transfer Unit Manufacturing Facility in Camdenton, Missouri. This TSDF closure project required a detailed site geologic

evaluation, excavation and proper disposal of contaminated soil, and indoor air monitoring to assess possible preferential flow mechanisms. Evaluation of the data demonstrated that the former TSDF was not the sole source of the observed ground water impact, resulting in a savings of more than $100,000 to the client as the offsite ground water liabilities were assumed by another party. The soil removal action eliminated onsite sources of ground water and indoor air impacts. Collection of indoor air quality samples to verify the residual contamination left in soil immediately next to the building posed no excess risk to workers allowed the facility to achieve compliance with the RCRA Corrective Action Environmental Indicator (EI) – Current Human Exposures Under Control. Prepared the EI for the Missouri Department of Natural Resources (MDNR) and obtained approval from MDNR and USEPA Region VII.

- Served as project manager for an investigation at a veterinary pharmaceutical facility in Iowa. The investigation included a geophysical survey that resulted in the identification of conductive and magnetic anomalies. Investigation of these anomalies required the installation of test pits. Based upon what little was known about the waste disposed in the area excavation activities required Level B Personnel Protective Equipment (PPE). Results from the excavation activities indicated that the buried material could remain in place with implementation of a deed restriction.
- Served as project manager for a CERCLA investigation at a former ordinance plant for the United States Army Corp of Engineers (USACE) in St. Louis, Missouri. The work was conducted under a performance-based contract (PBC) with the USACE to take a former ordinance plant through the CERCLA process from Remedial Investigation (RI) through Remedy In-Place (RIP). Contaminants at the site include metals and PCBs in shallow soil and chlorinated volatile organic compounds (CVOCs) in ground water. The work also included indoor air sampling at an adjacent home. Both the Vapor Intrusion (VI) Work Plans and the RI Work Plan were completed in an expedited manner to ensure that field activities were implemented as early as possible. The VI and RI field work were completed on time and under budget.
- Produced a risk transfer product that provided the client with an incentivized price guarantee to achieve regulatory closure for known groundwater contamination at two former musical instrument manufacturing facilities in Wisconsin. In order to accurately assess and value the characterization and remedial costs the findings from multiple previous investigations were assessed, site visits were conducted, and interviews were conducted with those most knowledgeable about historic releases and investigative activities at the sites.
- Served as the project manager for investigation of a release from a former Underground Storage Tank (UST) at an active facility located in St. Joseph, Missouri, that had formerly operated as an MGP. The intent of the investigation was to differentiate groundwater contamination associated with the gasoline UST release from groundwater contamination associated with former MGP activities. Unfortunately, the groundwater plumes were commingled to an extent were differentiation was not possible. However, negotiations with the UST trust fund did result in partial funding for the investigation and following remedial action through the fund.
- Served in a senior consultant capacity for review and evaluation of a Corrective Measures Study (CMS) and Risk Transfer (RT) proposal for a former MGP site in West Palm Beach, Florida. The purpose was to ensure that the selected remedy was appropriate and more importantly that the RT proposal was within the legitimate range of costs for this type of work. The ENVIRON team independently calculated remedial costs to verify those presented in the CMS. Based on our conclusions ENVIRON recommended the client proceed to the next phase with the RT company.
- Implemented a sampling program to characterize potential contamination at 28 natural gas compressor stations along pipelines in Kansas and Missouri under a United States Environmental Protection Agency (USEPA) Administrative Order of Consent. The sampling program was successfully completed in four weeks in large part due to detailed planning and scheduling in the upfront portion of the project. Initial sampling activities were comprehensive enough to limit the need for additional follow-up delineation sampling at only four sites.

- As the project manager for the Supplemental Site Investigation (SSI) of the Comprehensive Investigation/ Corrective Action Study (CI/CAS) at a former refinery and current pipeline and distribution terminal in Kansas City, Kansas, proposed and implemented a scope of work designed to minimize costs to the client and expedite closure of the site. Successfully negotiated with the Kansas Department of Health and the Environment (KDHE) a 20 percent reduction in the ground water monitoring locations requiring sampling, expediting abandonment of obsolete wells and thereby reducing annual monitoring costs by more than a third.
- Managed a Focused Phase II Environmental Site Assessment (ESA) and semi-annual groundwater sampling event at glass manufacturing facility in Tennessee. The Focused Phase II ESA included the abandonment and replacement of three existing monitoring wells, the installation of one new monitoring well and the collection of soil samples from the new well soil boring.
- Directed initial activities related to a RCRA Facility Investigation (RFI) project at a manufacturing facility located in the lead mining area of southwest Missouri. Historical activities at the site included lead smelting and battery production. Prior to completion of the RFI Work Plan and commencement of the investigation; negotiations with the regulatory agencies (MDNR and USEPA Region VII) resulted in less costly investigative efforts through the use of historical data and acceptance of the future use of geostatistics in assessing the data.
- Developed a sampling program to characterize, in place, lead-contaminated soil for disposal at a former firing range at the former Richards-Gebaur AFB in Kansas City, Missouri as part of the base closure and redevelopment. The plan was accepted by the agencies and allowed for the impacted soil to be directly loaded into trucks for disposal as either special or hazardous waste based on the in-place characterization results which eliminated the need for double handling of the material (excavate, stockpile, load into trucks) resulting in a savings to the client of more than $200,000.
- Served as project manager/primary author of a hydrogeologic evaluation at a former MGP in St. Louis, Missouri. A hydrogeologic evaluation was required to support the findings of a Baseline Risk Assessment conducted by a previous consultant. The evaluation demonstrated the hydrologic relationship between ground water and an urban creek at the property boundary.
- Primary author of and Engineering Evaluation/Cost Analysis (EE/CA) for seven Areas of Concern (AOCs) at the former Richards-Gebaur AFB in Kansas City, Missouri, under the Base Realignment and Closure (BRAC) program. Served as lead presenter at the public meeting where the options and selected remedial actions documented in the EE/CA were presented to the public and the Restoration Advisory Board (RAB). Public comments received were minimal.
- Served as project manager for a routine landfill gas monitoring project at a close landfill located at the former Chanute Air Force Base in Rantoul, Illinois. Landfill gasses were measured using a Landtec GEM200. Quarterly reports produced in association with the monitoring tracked trends in landfill gas generation.
- Provided senior review for various Phase II site assessments/investigations at industrial and commercial facilities throughout the United States and select locations in Canada and Brazil.

Due Diligence

- Conducted several due diligence projects for a venture capital firm related to potential acquisition of specialty chemical and performance materials sector companies. The work included Phase I ESAs and limited compliance reviews at acquisition target companies with facilities in North America, Europe and Asia.
- Performed a review and completed a white paper that evaluates certain environmental and business risks associated with injection of nonhazardous oilfield wastes (NOW) including naturally-occurring radioactive material (NORM) (Class II wells) as well as nonhazardous industrial solid wastes (NID, Class I wells) into salt caverns and the caprock above a salt dome. The work included interviews with various federal and state

regulators, literature review and review of data provided by the client. The whitepaper supported an ongoing due diligence review of the company, including performance of a Phase I ESA conducted by another consultant.

- Provided an evaluation of environmental liabilities associated with the acquisition of a natural gas company that provides service to residential and commercial customers in the Midwest and New England. The evaluation consisted of a desktop review of documentation provided by the client and obtained from the regulatory agencies. Environmental liabilities identified were related to the historic operation of manufactured gas plants (MGPs). The evaluation allowed the company to allocate the appropriate amount of funds for future investigative and remedial actions at the five sites being acquired and the 15 non-transferred sites with legacy environmental liabilities.
- Conducted a due diligence assessment and limited compliance review for the potential purchaser of the mid-stream assets of a mid-size oil and gas production company. The assets evaluated were located in the Eagleford Shale play in West Texas and included 11 Gas Gathering Systems (GGSs) each consisting of one or more compressor stations. The entire GGS network consists of 619 miles of pipeline. Sour gas (Hydrogen Sulfide or H_2S) produced from wells in three of the GGSs required a heightened level of health and safety precautions.
- Provided an evaluation of environmental liabilities associated with the potential acquisition of a manufacturing company with 15 facilities in United States and Europe. The evaluation consisted of a desktop review of documentation provided by the client including and assessment of their accruals related to environmental liabilities.
- Conducted a due diligence assessment and limited compliance review at three steel pipe manufacturer locations in West Texas. Pipe was being manufactured for oil and gas drilling needs and consisted of machining and warehousing.
- Directed a project to assess environmental liabilities associated with industrial properties (most had historically been steel foundries). A total of 11 properties located in five states were assessed. The assessment include a review of company files, performing site visits, conducting interviews with site personnel, and a review of historic fire insurance maps. The assessment provided a range of costs for environmental liabilities for each site that were used by the owner to more accurately establish property values.
- Managed a team that conducted due diligence assessments at 11 short line railroad companies located primarily in the southern United States. In addition to providing the client with our standard Phase I ESA report for each of the 11 companies, a reasonable and reasonable worst case environmental liability cost estimate based on the findings was provided for each of the 11 companies.
- Served as the project manager for a Phase I and Phase II ESA program associated with the Lambert St. Louis International Airport expansion program. A buyout of adjacent commercial, industrial and residential parcels was required to obtain the land necessary for expansion. Over 50 small to large commercial business were located in the buyout area. Commercial businesses that required Phase II follow-up assessments included a dry cleaner, a recreational vehicle (RV) dealership, and a heavy equipment dealership.
- Conducted and managed due diligence activities related to the acquisition of a chain of specialty chemical and compressed gas retail stores throughout the Midwest.
- Managed a team of auditors conducting a due diligence assessment of an 800-mile long crude oil pipeline in Oklahoma and Texas. The work involved site visits to all pumping stations and a review of aerial photography along the entire length of the route to identify any areas of disturbance that could be indicative of a release.
- Provided Phase I ESA services for proposed telecommunication cellular tower locations throughout the St. Louis metropolitan area. These assessments also included an archeological assessment.

- Conducted, managed or provided senior review of deliverables for Phase I ESAs at numerous industrial and commercial facilities in the retail sector, multi-family residential sector, and manufacturing sector. Types of businesses included printing and publishing, metal recycling, aviation maintenance, petroleum and natural gas, healthcare, telecommunications, electric utilities and automotive.

Compliance Assistance

- Managed an Environmental, Health and Safety (EHS) assessment conducted at a plate steel facility in Santiago, Chile. Operations involve steel plate processing, primarily consisting of: cutting, bending (pressing), and rolling activities. The assessment evaluated site compliance with respect to general permitting requirements for the purpose of assessing the impact of adding a new large scale welding operation process onsite.
- Conducted a Health, Safety, Environmental and Security (HSES) business assessment for a large chemical company at two facilities in South America. The facilities are bulk storage terminals that were being considered for lease or acquisition. Assessment at the facilities located in Sao Paulo, Brazil and Cartagena, Colombia included a site tour, review of HSES documentation and permits, and interviews with site HSES personnel.
- Assisted a client with permitting and other compliance matters related to a new construction and demolition material recovery facility to be located in the St. Louis, Missouri, metropolitan area. Specifically the assistance consisted of preparing and submitting to MDNR a request for an exemption from the requirements to obtain a permit to construct and operate a solid waste processing facility in accordance with provisions of the Missouri Solid Waste Management Regulations; evaluating the potential applicability of industrial stormwater and air emissions permitting requirements; and identification of additional local requirements that may be applicable.

Sustainability and Energy Management

- Worked with ENVIRON in the United Kingdom (UK) to provide energy audits and Carbon Reduction Commitment (CRC) registration support for a United States (US) based manufacturing company with facilities in the UK.
- Assisted a specialty chemical manufacturing client with a Life Cycle Assessment (LCA) of their chemical catalog.

CREDENTIALS

Registrations and Certifications

Registered Geologist, Missouri (No. 0480)

Professional Affiliations and Activities

American Society for Testing and Materials (ASTM), Subcommittee D18.26 on Hydraulic Fracturing

Engineers Club – St. Louis

PUBLICATIONS & PRESENTATIONS

Fracking – Real World Examples; Presented to the Illinois State Bar Association, Springfield, Illinois; September 2013.

Zero Discharge Water Management for Hydrofracturing Activities – A Brief Synopsis of the Concept; Presented to the ASTM Subcommittee D18.26 on Hydraulic Fracturing, Jacksonville, Florida; January 2013.

Site Assessment Training Program; Developed and conducted a training program for a confidential client's staff of non-groundwater professionals consisting of engineers and attorneys. The training material covered basic groundwater concepts, natural attenuation, methods for assessing environmental issues at a site related to historical releases, and common remedial alternatives. December, 2011.

ENVIRON

Sandra I. Sulsky, MPH, PhD | Prinicipal

Amherst, Massachusetts
+1 413 835 4362 | ssulsky@environcorp.com

With over 20 years as a consultant epidemiologist, Dr. Sulsky has designed, analyzed and overseen the successful execution of large, records-based epidemiological studies of occupational injury and disability as well as evaluations of the effectiveness of work place health and safety interventions and outcomes of health care. She has authored or co-authored critical reviews of the epidemiological literature on topics including human health effects of exposures to specific occupational chemicals and work place physical activities. Dr. Sulsky has been involved in identifying and developing the scientific base needed to support tobacco product regulation for the last six years. Her expertise as a methodologist has provided a flexible platform for work supporting industry and government clients, and she has provided litigation support in numerous toxic tort cases alleging occupational or environmental causes of disease in individual and class actions. Sandy has taught several courses as an adjunct associate professor at the University of Massachusetts Amherst, and has served as an invited expert panelist for the Canadian national and Ontario provincial government.

EDUCATION

2000 PhD, Epidemiology, University of Massachusetts Amherst

1993 MPH, Epidemiology, Boston University

1985 BS, Psychology and Sociology, University of Massachusetts Amherst

SELECTED PROJECT EXPERIENCE

- Directed a study to describe major injuries occurring during Army Basic Combat Training, to identify individual and training-related risk factors for injury, and to support an economic analysis of the direct costs of medical care to the Army due to the treatment of injuries.
- Conducted an investigation to assess the efficacy of an outside-the-boot ankle brace in reducing risk of ankle injury in 220,000 Army Paratrooper trainees, and to identify unintended risks associated with ankle brace use during training for the US Army.
- Directed a literature review on the association between occupational carbon disulfide (CS_2) exposure and heart disease.
- Comprehensively reviewed and summarized the epidemiological literature to assess the association between occupation and carpal tunnel syndrome (CTS).
- Designed and implemented a series of case-control studies to elucidate the independent contributions of occupational factors and sociodemographic characteristics to the causation of knee-related injuries and disabilities among enlisted personnel in the US Army.
- Developed and employed methodology for linking US Army and VA databases to describe the natural history of disability in the Army.
- Directed a retrospective cohort study of over one million active-duty US Army personnel to investigate delayed-onset, disabling effects of vaccination against anthrax.
- Co-authored a comprehensive review of the human health risks associated with low level exposures to manganese.

Sandra I. Sulsky, MPH, PhD

CREDENTIALS

Awards and Honors

Graduate School Fellowship, University of Massachusetts, 1997

Academic Achievement Award, School of Public Health and Health Sciences, University of Massachusetts, 1996

Bachelor of Science, *cum laude*, University of Massachusetts, 1985

Psi Chi, National Merit Association for psychology students, 1983

Professional Affiliations and Activities

Member, American College of Epidemiology

- Chair, Awards Committee 2012-2015
- Member, Nominating Committee 2011 and 2013
- Chair, Task Force on Promoting Creativity, 2012
- Panelist representing consultancies, Career Mentoring workshop, 2009, 2010, 2011
- Chair, Admissions Committee 2006- 2009
- Vice-Chair, Admission Committee 2004-2005
- Elected Member, Board of Directors 2006-2009
- Member, Policy Committee 2002-2007
- Member, Program Planning Committee, 2003, 2004, 2013

Member, Society for Epidemiologic Research

Peer reviewer for the following journals:

- American Journal of Infection Control
- Annals of Epidemiology
- Disability and Health Journal
- International Archives of Occupational and Environmental Medicine
- Journal of Occupational and Environmental Medicine
- Journal of Safety Research (Editorial Board)
- Occupational and Environmental Medicine

Invited participant, Ontario (Canda) Population Studies Research Network Intervention Workshop, January 21 & 22, 2013

Expert panelist for the Canadian government's Networks of Centres of Excellence (NCE) Program mid-term review of the Allergy, Genes and Environment Network (AllerGen), October 2008

Senior Epidemiologist, Applied Epidemiology, Inc., 1999-2003

Field Consultant, Massachusetts Department of Public Health, Bureau of Health Statistics and Evaluation, Boston, 1997-2001

Sandra I. Sulsky, MPH, PhD

Research Assistantships, Department of Biostatistics and Epidemiology, University of Massachusetts at Amherst, 1995-1999

Research Associate, Epidemiology Resources, Inc., Newton, MA, 1991-1995

Project Coordinator, USDA Human Nutrition Research Center on Aging, Tufts University, Boston, 1987-1991

Research Study Coordinator, USDA Human Nutrition Research Center on Aging, Tufts University, Boston, 1985-1987

ACADEMIC APPOINTMENTS

Adjunct Associate Professor, Department of Epidemiology, School of Public Health and Health Sciences, University of Massachusetts at Amherst, 2010–present

Adjunct Assistant Professor, Department of Epidemiology, School of Public Health and Health Sciences, University of Massachusetts at Amherst, 2003-2010.

OTHER ACTIVITIES

Chair, Town of Amherst (Massachusetts) Board of Health, 2007-2008

Member, Amherst Board of Health, 2004-2010

SCIENTIFIC PRESENTATIONS

Bachand AM, Sulsky SI. Estimatating the potential effect of modified risk tobacco products (MRTPs) on population mortality: A dynamic population model. Annual meeting of the Tobacco Merchants Association (TMA-VII), Richmond, VA, May 2012

Bachand AM, Sulsky SI. Changes in tobacco-related mortality due to reduced exposure products: A dynamic population model to estimate the potential efficacy of tobacco harm reduction approaches. 3rd North American Congress of Epidemiology:Montreal, Canada, June 21-24, 2011.

Bachand A, Curtin G, Swauger JE, Sulsky SI. Development of a dynamic simulation model to estimate population mortality effects resulting from the availability of smokeless tobacco products. American College of Epidemiology Annual Meeting: Improving Reality: the Role of Modeling in Epidemiology. San Francisco, CA, September 13-14, 2010 (Ann Epidemiol 20 (9):P70, 2010).

Sulsky SI, Bachand A, Swauger JE, Curtin G. Assessment and application of the multistate life tables approach to modeling population harm reduction with smokeless tobacco. American College of Epidemiology Annual Meeting: Improving Reality: the Role of Modeling in Epidemiology. San Francisco, CA, September 13-14, 2010 (Ann Epidemiol 20 (9):P69, 2010).

Sulsky SI, Luippold RS, Bookhart BK, Corral M, Piech CT. The effect of anemia in hypertensive patients with chronic kidney disease: Hospital costs and lengths of stay. National Kidney Foundation (NKF) 2008 Spring Clinical Meetings, Dallas, Texas, April 2-6, 2008.

Sulsky SI, Parsons W, Amoroso PJ. Disability discharge among United States Army personnel vaccinated against anthrax (1998-2005). The Force Health Protection Conference, Louisville, KY, August 6-10, 2007.

Sulsky SI, Parsons W, Amoroso PJ. Effective Use of Administrative Data for Evaluation Research: The Parachute Ankle Brace. The Force Health Protection Conference, Louisville, KY, August 6-10, 2007.

Sandra I. Sulsky, MPH, PhD

Zilberberg MD, Luippold RS, Sulsky S, Shorr AF. Prolonged Acute Mechanical Ventilation, Hospital Resource Utilization and Mortality in a US Cohort. The Society of Critical Care Medicine's 36th Critical Care Congress, Orlando, FL, February 17-21, 2007 (Crit Care Med 2006;34:A126)

Sulsky S, Luippold RS, Raut M, Zilberberg MD. Evaluation of hospitalization outcomes and costs of anemia among hospitalized patients with Chronic Obstructive Pulmonary Disease. CHEST 2006: 72nd Annual International Scientific Assembly of the American College of Chest Physicians, Salt Lake City, Utah, October 21-26, 2006 (Chest 2006 130: 185S).

Birk T, Sulsky S, Cohen L, Luippold R, Heidenreich M, Nunes A. Needlestick injuries among health care workers - effectiveness and economic implications of safety-engineered medical devices. A quality-based critical review of the literature. The 28th International Congress on Occupational Health (ICOH) "Renewing a century of commitment to a healthy, safe & productive working life", Milan, Italy, June 11-16, 2006.

Sulsky SI, Amoroso PJ, Schmidt M. Effectiveness evaluation using a large administrative database. American College of Epidemiology Annual Scientific Sessions, Boston, MA, September 11-14, 2004.

Sulsky S, Burch M, Mundt KA. Scientific evidence, public health policy and occupational exposure limits. EPICOH, Barcelona, Spain, September 11-13, 2002. (La Medicina del Lavoro 2002;93(5):441)

Bigelow C, Mundt KA, Sulsky SI. Attribution of Risk and Apportionment of Disease. 2001 Congress of Epidemiology, Toronto, Canada, June 13-16, 2001. (American Journal of Epidemiology 2001;153(11):S255)

Sulsky SI, Amoroso PJ, Mundt KA. Risk factors for occupational disability resulting from knee injuries in the United States Army. National Occupational Injury Research Symposium, Morgantown, WV, October 15-17, 1997.

PUBLICATIONS

Bulzacchelli MT, Sulsky SI, Rodriguez-Monguio R, Karlsson LH, Hill (MAJ) OT. Injury During U.S. Army Basic Combat Training: A Systematic Review of Risk Factor Studies. Am J Prev Med 2014; 47(6) 813-822.

Sulsky SI, Karlsson LH, Bulzacchelli MT, Luippold RS, Rodriguez-Monguio R, Bulathsinhala L, Hill (MAJ) OT. Methodological Challenges of Using U.S. Army Administrative Data to Identify a Cohort of Basic Combat Trainees and Descriptive Analysis of Trends in Characteristics That Are Potential Risk Factors for Training-Related Injury. Military Medicine 2014. 179(12):1487.

Curtin GM, Sulsky SI, Van Landingham C, Marano KM, Graves MJ, Ogden MW, Swauger JE. Measures of initiation and progression to increased smoking among current menthol compared to non-menthol cigarette smokers based on data from four U.S. government surveys. Regul Toxicol Pharmacol. 2014 Nov.; 70(2):446-456. Epub Aug 9.

Sulsky SI, Fuller WG, Vandingham C, Ogden MW, Swauger JE, Curtin GM. Evaluating the association between menthol cigarette use and the likelihood of being a former versus current smoker. Regul Toxicol Pharmacol. 2014; Oct. 1; 70(1):231-24. Epub 2014 Jul 11.

Curtin GM, Sulsky SI, Van Landingham C, Marano KM, Graves MJ, Ogden MW, Swauger JE. Patterns of menthol cigarette use among current smokers, overall and within demographic strata, based on data from four U.S. government surveys. RegulToxicol Pharmacol. 2014; Oct. 1; 70(1):189-196. Epub 2014 Jul 2.

Curtin GM, Sulsky SI, Van Landingham C, Marano KM, Graves MJ, Ogden MW, Swauger JE. Primary measures of dependence among menthol compared to non-menthol cigarette smokers in the United States. Regul Toxicol Pharmacol. 2014; Aug;69(3):451-66.

Sandra I. Sulsky, MPH, PhD

Bachand AM, Sulsky SI. A dynamic population model for estimating all-cause mortality due to lifetime exposure history. Regulatory Toxicology and Pharmacology 67 (2013) 246-251.

Hiatt RA, Sulsky S, Aldrich MC, Kreiger N, Rothenberg R. Promoting innovation and creativity in epidemiology for the 21st century. Annals of Epidmology. 23 (2013) 452-54.

Sulsky SI, Carlton L, Bochmann F, Ellegast R, Glitsch U, Hartmann B, Pallapies D, Seidel D, Sun Y. Epidemiological evidence for work load as a risk factor for osteoarthritis of the hip: a systematic review. PLoS One 2012; 7(2):e31521.

Sulsky SI, Kreiger N, McKeown RE. Not continuing along previous lines: exploring how new directions emerge in epidemiologic research. Annals Epidmiology. 2012; 22(5):369-71.

Sulsky SI, Luippold RS, Garman P, Hughes H, Boyko EJ, Maynard C, Amoroso PJ. Disability among US Army Veternas vaccinated against Anthrax. Vaccine 2012;30:6150-6156.

Luippold RS, Sulsky SI, Amoroso PJ. Effectiveness of an external ankle brace in reducing parachuting-related ankle injuries. Injury Prevention. 2011 Feb;17(1):58-61. Epub 2010 Nov 11.

Sulsky SI, Luippold RS, Garman P, Hughes H, Amoroso PJ. Risk of disability for US Army personnel vaccinated against anthrax, 1998-2005. Vaccine 2011; 29(35):6035-41.

Santamaria AB, Sulsky SI. Risk Assessment of an Essential Element: Manganese. Journal of Toxicology & Environmental Health, Part A. 2010;73:128-55.

Gelbke H, Göen T, Mäurer M, Sulsky SI. A Review of Health Effects of Carbon Disulfide in Viscose Industry and a Proposal for an Occupational Exposure Limit. Critical Reviews in Toxicology 2009; 39(S2):1-126.

Zilberberg MD, Luippold RS, Sulsky SI, Shorr AF. Prolonged acute mechanical ventilation, hospital resource utilization, and mortality in the United States. Critical Care Medicine 2008; 36(3):724-30.

Schmidt MD, Sulsky SI, Amoroso PJ. Effectiveness of an outside-the-boot ankle brace in reducing parachuting related injuries. Injury Prevention 2005; 11:163-168.

Sulsky SI, Grabenstein JD, Delbos RG. Disability among US Army personnel vaccinated against anthrax. Journal of Occupational and Environmental Medicine 2004; 46(10):1065-1075.

Sulsky SI. On occupational health and safety research in the US Army: Comparability with civilian employee cohorts. Journal of Occupational and Environmental Medicine 2003; 45(3):220-1.

Mundt DJ, Dell LD, Luippold RS, Sulsky SI, Skillings A, Gross R, Cox KI, Mundt KA. Cause-specific mortality among Kelly Air Force Base civilian employees, 1981-2001. Journal of Occupational and Environmental Medicine 2002; 44(11):989-996.

Sulsky SI, Mundt KA, Bigelow C, Amoroso PJ. Risk factors for occupational knee-related disability among enlisted women in the US Army. Occupational and Environmental Medicine 2002; 59:601-607.

Sulsky SI, Hooven FH, Burch MT, Mundt KA. A critical review of the epidemiological literature on the potential cardiovascular effects of occupational carbon disulfide exposure. International Archives of Occupational and Environmental Health 2002; 75:365-380.

Dimberg LA, Striker J, Nordanlycke-Yoo C, Nagy L, Mundt KA, Sulsky SI. Mental health insurance claims among spouses of frequent business travellers. Occupational and Environmental Medicine 2002; 59:175-181.

Dimberg LA, Mundt KA, Sulsky SI, Liese BH. Deep venous thrombosis (DVT) associated with corporate air travel. Journal of Travel Medicine 2001; 8(3):127-32.

Sandra I. Sulsky, MPH, PhD

Zapka JG, Luckman R, Sulsky SI, Goins KV, Bigelow C, Mazor K. A cancer control knowledge, attitudes and perceived skills among medical students. Journal of Cancer Education 2000: 15:73-78.

Sulsky SI, Mundt KA, Bigelow C, Amoroso PJ. Case-control study of discharge from the US Army for disabling occupational knee injury: The role of gender, race/ethnicity, and age. American Journal of Preventive Medicine 2000; 18(3S):103-111.

Lanes SF, Sulsky S, Walker AM, Isen J, Grier CE 3rd, Lewis BE, Dreyer NA. A cost density analysis of benign prostatic hyperplasia. Clinical Therapeutics 1996; 18(5):993-1004.

Walker AM, Funch DP, Sulsky SI, Dreyer NA. Patient factors associated with strut fracture in Björk-Shiley 60 degree convexo-concave heart valves. Circulation 1995; 92(11):3235-39.

Walker AM, Funch DP, Sulsky SI, Dreyer NA. Manufacturing characteristics associated with strut fracture in Björk-Shiley 60 degree convexo-concave heart valves. Journal of Heart Valve Disease 1995; 4(6):640-48.

Jacques PF, Sulsky SI, Perrone GA, Jenner J, Schaefer EF. Effect of vitamin C supplementation on lipoprotein cholesterol, apolipoprotein and triglyceride concentrations. Annals of Epidemiology 1995; 5:52-59.

Jacques PF, Sulsky SI, Perrone GA, Schaefer EJ. Ascorbic acid and plasma lipids. Epidemiology 1994; 5:19-26.

Jacques PF, Sulsky SI, Sadowski JA, Phillips JCC, Rush D, Willett WC. Comparison of micronutrient intake measured by a dietary questionnaire and biochemical indicators of micronutrient status. American Journal of Clinical Nutrition 1993; 57:182-89.

Taylor A, Jacques PF, Nadler D, Morrow F, Sulsky SI, Shepard D. Relationship between ascorbic acid consumption and levels of total and reduced ascorbic acid in lens, aqueous humor and plasma. Current Eye Research 1991; 10:751-59.

Sulsky SI, Jacques PF, Otradovec CL, Hartz SC, Russell RM. Influence of cigarette smoking on biochemical markers of nutritional status. Journal of Nutritional Medicine 1990; 1:187-94.

Sulsky SI, Jacques PF, Otradovec CL, Hartz SC, Russell RM. Descriptors of alcohol consumption among noninstitutionalized, nonalcoholic elderly. Journal of the American College of Nutrition 1990; 9:326-31.

Jacques PF, Sulsky S, Hartz SC, Russell RM. Moderate alcohol intake and nutritional status in nonalcoholic elderly subjects. American Journal of Clinical Nutrition 1989; 50:875-83.

Book Chapters and Monographs

Sulsky SI, Birk T, Cohen LC, Luippold RS, Heidenreich MJ, Nunes A. Effectiveness of measures to prevent needlestick injuries among employees in health professions. Published by Hauptverband der gewerblichen Berufsgenossenschaften - BGIA-Report, February 2006: 116 pages; ISBN:3-88383-696-6.

Sulsky SI, Mastroberti MA, Schmidt MD. Quality based critical review of the epidemiological literature on carpal tunnel syndrome and occupation. Published by Hauptverband der gewerblichen Berufsgenossenschaften - BGIA-Report, 2/2005e July 2005: 89 pages; ISBN:3-88383-681-8.

Book Reviews

Sulsky, S. I. Book review. *Musculoskeletal Disorders and the Workplace.* Appl Occup Environ Hyg 2003;18(5): 403.

Sulsky SI. Book review: *Work and Unseen Chronic Illness: Silent Voices.* Applied Occupational and Environmental Hygiene 2002; 17(7):519.

Sandra I. Sulsky, MPH, PhD

Other Selected Publications

Ward C, Sulsky SI. Monitoring the safety of dietary supplements and novel foods: looking beyond the recent GAO report. Update: A Publication of the Food and Drug Law Institute (FDLI). 2013. September/October.

Bachand A, Sulsky SI. Critique of "Quantifying the effects of promoting smokeless tobacco as a harm reduction strategy in the USA" by Mejia AB, Ling PM, Glantz SA. letter to Tobacco Control 2010. Tobacco Control, published online January 5, 2011.

Sulsky SI, Luippold RS, Amoroso PJ. Parachute Ankle Brace Effectiveness Evaluation. USArmy Research Institute of Environmental Medicine (Technical Report T10-02, May 2010: 65 pages).

Sulsky S, Mundt KA, Bigelow C, Amoroso PJ, Fisher D. Knee-related injuries and disabilities in the US Army, 1980-1997. US Army Research Institute of Environmental Medicine (Technical Report no. T00-24, September 2000: 143 pages).

Taylor A, Jacques PF, Morrow F, Sulsky S, Shepard D. Relationship between ascorbic acid intake and levels of total and reduced ascorbic acid in human lens aqueous humor and plasma. Investigations in Ophthalmology & the Visual Sciences 1991; 32:723.

Sulsky SI, Jacques PF, Jacob RA, Hartz SC. Influence of cigarette smoking on biochemical markers of nutritional status. FASEB Journal 1988; 2 (5):1435.