Health Consultation

Review and Analysis of Volatile Organic Compounds (VOCs)
and Metal Exposures in Air

as part of the

MIDLOTHIAN AREA AIR QUALITY PETITION RESPONSE

MIDLOTHIAN, ELLIS COUNTY, TEXAS

NOVEMBER 17, 2016

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

A health consultation is a verbal or written response from ATSDR or ATSDR's Cooperative Agreement Partners to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This health consultation is one of a series of six health consultations being prepared by ATSDR for this site. Completion of all six health consultations concludes the health consultation process for this site, and unless additional information is obtained by ATSDR or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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HEALTH CONSULTATION

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MIDLOTHIAN AREA AIR QUALITY PETITION RESPONSE

MIDLOTHIAN, ELLIS COUNTY, TEXAS

Prepared By:

Central Branch
Division of Community Health Investigations
Agency for Toxic Substances and Disease Registry

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Abbreviations

AMCV	Air Monitoring Comparison Value
ATSDR	Agency for Toxic Substances and Disease Registry
CA	cancer
Cal EPA	California Environmental Protection Agency
CAMS	continuous air monitoring station
CREG	Cancer Risk Evaluation Guide
CV	Health Based Comparison Value
EMEG	Environmental Media Evaluation Guide
ERG	Eastern Research Group, Inc.
ESL	Effects Screening Level
HAP	Hazardous Air Pollutant
HI	Hazard Index
HQ	Hazard Quotient
H_2S	hydrogen sulfide
IUR	Inhalation Unit Risk
KM	Kaplan Meier
LOAEL	Lowest Observed Adverse Effect Level
LP	limited partnership
$\mu g/m^3$	micrograms per cubic meter
NAAQS	National Ambient Air Quality Standards
NATA	National Air Toxics Assessment
NOAEL	No Observed Adverse Effect Level
PM	particulate matter
PM_{10}	particulate matter with aerodynamic diameter of 10 microns or less
$PM_{2.5}$	particulate matter with aerodynamic diameter of 2.5 microns or less
PAC	polycyclic aromatic compound
PAH	polycyclic aromatic hydrocarbon
PSEI	Point Source Emissions Inventory
REL	Reference Exposure Level
RfC	Reference Concentration
ROS	Regression on Order Statistics
RSL	Risk Screening Level
TAMIS	Texas Air Monitoring Information System
TCEQ	Texas Commission on Environmental Quality
TDSHS	Texas Department of State Health Services
TNRCC	Texas Natural Resources Conservation Commission
TRI	Toxics Release Inventory
TSP	total suspended particulate
TXI	Texas Industries
UCL	Upper Confidence Limit
U.S. EPA	United States Environmental Protection Agency
UT-Arlington	The University of Texas at Arlington
VOC	volatile organic compound
WHO	World Health Organization
WWTP	Wastewater Treatment Plant

SUMMARY

INTRODUCTION

The Agency for Toxic Substances and Disease Registry (ATSDR) and the Texas Department of State Health Services (TDSHS) are conducting an extensive review of environmental health concerns raised by community members in Midlothian, Texas.

The goal of this review is to determine if chemical releases from local industrial facilities could have affected the health of people and animals in the area. The facilities of concern are three cement manufacturing facilities and a steel mill. ATSDR plans to achieve this goal through a series of projects. This Health Consultation documents ATSDR's findings from the project: *Review and Analysis of Volatile Organic Compounds (VOC) and Metal Exposures in Air*.

ATSDR released two health consultations in 2012 to address community members' concerns about the adequacy of the various air pollution measurements that have been collected in Midlothian and potential health implications from pollutants identified as National Ambient Air Quality Standard (NAAQS) pollutants (particulate matter (PM), ozone, sulfur dioxide, nitrogen oxides, carbon monoxide, and lead) and hydrogen sulfide (H_2S). The first health consultation identified pollutants, time frames, and locations for which the available data provide a sufficient basis for reaching health conclusions; it also identifies important gaps in the data (ATSDR 2015). The second evaluated potential exposures to pollutants identified as National Ambient Air Quality Standard (NAAQS) pollutants (particulate matter, ozone, sulfur dioxide, nitrogen oxides, carbon monoxide, and lead) and hydrogen sulfide (H_2S), and assessed their potential impacts on community health (ATSDR 2016a).

CONCLUSIONS

ATSDR reached a main conclusion and three supporting conclusions in this Health Consultation:

MAIN CONCLUSION

With the exception of sulfuric acid aerosols, no increased cancer or non-cancer risks were identified for measured and modeled ambient concentrations of volatile organic compounds, metals, or other inorganic pollutants. Estimated non-cancer risk from sulfuric acid aerosols is primarily historic due to significant emission control upgrades to the facilities that have the highest sulfuric acid aerosol emissions. However, current or future exposure to intermittently high levels of sulfuric acid aerosols may irritate the airways of area residents and cause acute respiratory symptoms in individuals with pre-existing cardiopulmonary illness, such as asthma. Children and the elderly are particularly vulnerable to adverse health outcomes from acute exposures to sulfuric acid aerosols.

BASIS FOR DECISION

ATSDR reviewed a large body of data collected at 16 locations over 30 years in the Midlothian community to evaluate potential health impacts from residential exposure to metals and VOCs from industrial emissions. These data did not cover every geographic area, time period, and pollutant of interest to the community, but most of the data were deemed sufficient for evaluating potential impacts to human health in our first health consultation. The greatest limitation for historical data was detection limit issues, which we addressed using advanced statistical methods.

To reach the main conclusion on cancer and non-cancer health risks ATSDR evaluated:

- metals, VOC, and meteorological data collected between 1981 and 2011 and the assessment of area and national databases to identify typical concentrations of individual pollutants in ambient air (see Conclusion 1);
- data modeled from emissions estimates obtained from regulatory agencies (see Conclusion 2);
- cumulative cancer and non-cancer health risk based on U.S.EPA Risk Assessment methods (see Conclusion 3); and
- scientific research from animals and humans exposed to various concentrations of these pollutants in air, and the health based comparison values derived or supported by the studies.

CONCLUSION 1

ATSDR concludes that under worst case conditions, modeled levels of sulfuric acid aerosols could harm people's health. However, sulfuric acid aerosols have never been measured in the community and the information we would need to evaluate past or current exposure is not available.

BASIS FOR DECISION

ATSDR modeled five pollutants/pollutant classes that are 1) of concern to the community; 2) emitted in greatest quantity by the facilities of interest; and 3) were not historically sampled for by the Texas Commission on Environmental Quality (TCEQ). The pollutants/pollutant classes modeled are: dioxins and furans; hydrochloric acid aerosols; mercury (vapor phase); polycyclic aromatic compounds (PACs); and sulfuric acid aerosols. Sulfuric acid aerosols were the only modeled pollutant concentrations that exceeded health based comparison values.

Substantial upgrades have occurred over the years at the facilities which emitted the most sulfur dioxide, reducing the ambient concentrations of sulfur dioxide and likely, with it the concentrations of sulfuric acid aerosols (see "*Assessing the Public Health Implications of the Criteria (NAAQS) Air Pollutants and Hydrogen Sulfide*" (ATSDR, 2016a). However, no sulfuric acid aerosols have ever been collected in the community. Thus, it is possible that exposure to sulfuric acid aerosols could have posed a health risk to sensitive populations in the community (e.g., children and the elderly) or to residents with pre-existing health conditions.

ATSDR used very conservative modeling assumptions to generate the highest potential ambient concentrations to evaluate. ATSDR assumed worst-case conditions for the modeling effort. For example, we assumed the emissions for each pollutant were the same as the highest amount ever reported by the facilities to the Toxic Release Inventory (TRI) database or to TCEQ's Point Source Emissions Inventory (PSEI), and ran emissions from different years/sites assuming the worst years occurred at the same time for individual pollutants. Furthermore, we assumed all emissions from each plant came out of the stack with the least favorable deposition pattern (e.g., shortest stack at the lowest exit velocity). We assumed these conditions would yield the highest off site concentrations of pollutants (worst-case conditions). Under these worst case conditions, only sulfuric acid aerosols exceeded current chronic health based values. At concentrations of sulfuric acid/sulfate in ambient air consistent with concentrations modeled in Midlothian, a decrease in lung capacity/volume and an increase in hospital admissions for acute respiratory illness have been observed in exposed children in other communities.

CONCLUSION 2

ATSDR concludes that measured levels of metals and volatile organic compounds (VOCs) in Midlothian are not expected to harm people's health because they are below levels of health concern.

BASIS FOR DECISION

Almost all pollutants measured historically in Midlothian are present at typical concentrations for suburban areas, thus cancer and non-cancer risk in the Midlothian community are typical of other communities in suburban areas. A few not-routinely detected pollutants in ambient air were measured at low concentrations in the 2008-2009 sampling study by University of Texas-Arlington, and were generally detected at the Tayman Drive Wastewater Treatment Plant (WWTP). These pollutants are byproducts of water chlorination, and were detected below levels associated with health effects in exposure studies.

Local influences were apparent for some pollutant classes. For example, slightly higher levels of metals that both TXI Operations and Gerdau Ameristeel report as releases were detected in monitoring stations downwind of the facilities; several trihalomethanes were detected at slightly higher concentrations at the Tayman Drive WWTP monitoring station; and pollutants typical of incomplete combustion (commonly associated with motor vehicle exhausts) were observed at monitors downwind of Interstates 67 and 287.

These findings were determined by reviewing all data available at the time this report was written. ATSDR evaluated the data for acute risks, chronic risks, and cancer risks. These are summarized, below.

Acute (short-term) risks: Benzene was the only pollutant that exceeded acute health based comparison values. Out of 1,359 valid samples, 3 had more than 29 micrograms of benzene per cubic meter of air ($\mu g/m^3$)—ATSDR's health-based comparison value (CV) for acute exposures to airborne benzene. Those three measurements were:

66 $\mu g/m^3$ on May 9, 1995, at Tayman Drive WWTP;
41 $\mu g/m^3$ on March 19, 1999, at Old Fort Worth Road; and
30 $\mu g/m^3$ on October 20, 1998 at Old Fort Worth Road.

The remaining 1,356 valid benzene measurements, or more than 99 percent of the measurements, had concentrations lower than ATSDR's screening value. The concentrations of benzene that exceeded the acute screening value were many times lower than those associated with health effects in scientific studies.

Chronic (long-term) non-cancer risks: No annual averages of individual metals and VOCs exceed chronic health based comparison values, and all are substantially lower than any concentrations associated with adverse non-cancer health outcomes in the scientific literature.

Cancer risks: Cancer risk was evaluated by the comparison of pollutant concentrations to 1-yr time frames or longer as well as a cumulative risk screening evaluation (for the latter, see Conclusion 3). Cumulative cancer risks in Midlothian from metals and VOCs were not appreciably different than cancer risks in other suburban environments, Ellis County, or the state of Texas. Many cancer-causing pollutants were present at concentrations exceeding ATSDR's conservative cancer risk evaluation guides (CREGs), which are the ambient concentrations of pollutants that could increase a population's risk by one extra case of cancer out of a million exposed people. In urban environments, many pollutants are ubiquitously present in ambient air above the CREGs because they are released from general human activities, such as driving and fueling motor vehicles, airplanes, farming, etc. Most of these pollutants are routinely sampled for in national surveillance monitoring and had similar concentrations to pollutants measured across the United States. No pollutants were present in ambient air at levels demonstrated to cause cancer in scientific studies.

Cumulative cancer risks were evaluated separately to address community concerns that residents are not exposed to pollutants one at a time (see Conclusion 3).

Section 3.0 documents in greater detail ATSDR's basis for reaching this conclusion.

CONCLUSION 3	**Based on historical data, estimated cumulative <u>cancer risks</u> calculated for monitoring sites across Midlothian are similar or lower than Ellis County or the state of Texas.** **Based on historical data, cumulative <u>non-cancer hazards</u> calculated for monitoring sites across Midlothian are similar or lower than Ellis County or the state of Texas.**

BASIS FOR DECISION

Excess lifetime cancer risks posed from existing air measurements were calculated using a continuous lifetime exposure assumption. This assumption is conservative because most people spend far more time indoors than outdoors, tend to leave home for work, school, and travel, and rarely spend a lifetime in a single residence.

Cancer: Cancer risks generated from Midlothian air sampling data are in the 10^{-5} to 10^{-6} cancer risk range for the air monitoring sites in Midlothian (risk of an additional 1 in 100,000 to 1 in 1,000,000 people developing cancer over a lifetime in a given population). For context, we compared our calculated risk to that calculated by U.S. EPA in their 2011 National Air Toxics Assessment (NATA) for Ellis County and the state of Texas.

U.S. EPA estimated total cancer risk in Ellis County for all sources (mobile and stationary) at 3.7×10^{-5} (a potential risk for 3.7 excess cancers per 100,000 people living in the area), which is lower than the general Texas state cancer risk of 4.4×10^{-5} (a potential risk for 4.4 excess cancers per 100,000 people living in Texas). The cancer risks ATSDR calculated at air monitoring stations in the Midlothian community are slightly lower than the county and state risks. The maximum long-term cancer risk calculated at any of the Midlothian monitoring stations was 2.64×10^{-5} (a potential risk for 2.64 excess cancers per 100,000 people living in the area) for the mean concentrations of all pollutants evaluated and 3.63×10^{-5} for 95% upper confidence limits (UCL) mean concentrations at the Tayman Drive WWTP station, where risk was driven by water chlorination byproducts typical of a water treatment plant.

Non-cancer: Generally the cumulative hazard for health effects other than cancer was low at all sites, but driven by manganese at sites near TXI Operations/Gerdau Ameristeel. When calculating chronic risks using the ATSDR non-cancer chronic comparison value for manganese ($0.3\ \mu g/m^3$ (ATSDR 2012d)), risks were slightly elevated at Wyatt Road and Cement Valley Road (hazard indices (HIs) of 1.07 and 1.11, respectively), but only if risk is not calculated for individual target organs but all target organs in aggregate. HIs below 1.0 indicate no increase in non-cancer risk in a community; those above have increased risk from inhalation exposure. We evaluated non-cancer risk without categorizing target organ risk as a conservative screening measure. If a detailed risk assessment had been carried out, the neurological and respiratory cumulative risk would each have resulted in an HI of less than 1, thus the risk is not considered elevated for the pollutants we evaluated.

Non-cancer risks by county, state, and across the United States were also reported in the most recent U.S. EPA National Air Toxics Assessment (NATA) review (U.S. EPA, 2011). The NATA evaluation yielded a *respiratory* hazard index of 0.95 for Ellis County, which is similar to risks calculated using the ATSDR CV of 0.3 µg/m^3 for all target organs. This level is also below 1.0, which indicates no increased risk for non-cancer hazards. According to NATA, Ellis County and Midlothian have lower non-cancer risk than the state of Texas. For reference, the state of Texas had an HI of 1.6.

NEXT STEPS

ATSDR recommends that TCEQ continue 1) monitoring organic and inorganic pollutants in locations where maximum air concentrations of site related pollutants could occur in order to quantify potential current and future risks to the community, and 2) consider an air sampling program for sulfuric acid aerosols near the northern boundary of TXI and Gerdau Ameristeel) to better quantify risks to residents from local industrial emissions, including sulfuric acid.

FOR MORE INFORMATION

If you have questions about this document or ATSDR's ongoing work on the Midlothian facilities, please call ATSDR at 1-800-CDC-INFO and ask for information about the "Midlothian, Texas evaluations." If you have concerns about your health, you should contact your health care provider.

1.0 Purpose and Statement of Issues

In July 2005, a group of residents of Midlothian, Texas, submitted a petition to the Agency for Toxic Substances and Disease Registry (ATSDR). The petitioners expressed multiple concerns, but primarily that nearby industrial facilities were emitting air pollutants at levels that were affecting their health. ATSDR accepted this petition, and the Texas Department of State Health Services (TDSHS), under a cooperative agreement with ATSDR, evaluated the data and information and prepared the response. In December 2007, TDSHS issued a public comment draft Health Consultation that attempted to address many concerns outlined in the original petition, and the public provided many comments on the draft. During the process of evaluating these public comments, the ATSDR and National Center for Environmental Health Director requested that the ATSDR and TDSHS team take a more comprehensive look at the site. As a baseline, the new evaluation includes a review of whether or not the data generated by air monitors was/is being collected in a manner that could provide data usable to address community health concerns. As outlined in its Midlothian Public Health Response Plan (ATSDR 2012a), ATSDR is completing this reevaluation in a series of projects.

Purpose of this Document

This Health Consultation documents ATSDR's findings from the project: *Assessing the public health implications of exposures to metals and volatile organic compounds (VOCs) in outdoor air*. The findings from ATSDR's first Health Consultation (ATSDR, 2015) are incorporated into this evaluation.

When reading this document, it is important to note that ATSDR's role in evaluating ambient air in Midlothian as a public health agency is different than agencies charged with addressing environmental issues. In this document, ATSDR evaluates the public health implications of the levels of air pollutants in the Midlothian area. These evaluations are not meant to address facility compliance, or lack thereof, with state and federal standards and guidance values. State and federal environmental enforcement agencies are responsible for evaluating facility adherence to existing rules and regulations.

The first ATSDR Health Consultation (ATSDR, 2015) was developed to assess the utility of existing ambient air monitoring data for addressing residential concerns regarding air emissions from four industrial facilities, while also considering additional air quality impacts from other sources (e.g., motor vehicle traffic). To evaluate these issues, ATSDR gathered relevant information on facility emissions, local meteorological conditions, and ambient air monitoring data. The findings of the first document are based on all validated ambient air monitoring data and related information available to ATSDR at the time of release. For this and subsequent pieces of the evaluation, ATSDR accessed information from multiple parties including: the petitioner, local community groups, industry and its consultants; scientists from The University of Texas at Arlington (UT-Arlington); TDSHS; the Texas Commission on Environmental Quality (TCEQ); and the U.S. Environmental Protection Agency (U.S. EPA).

The second Health Consultation documents ATSDR's findings from the project: *Assessing the public health implications of exposures to the National Ambient Air Quality Standard (NAAQS) pollutants* (particulate matter, ozone, sulfur dioxide, nitrogen oxides, carbon monoxide, and lead) and hydrogen sulfide (H_2S), and was presented at a public meeting in Midlothian in December 2012. The public comment draft of the second health consultation was released on November 16, 2012; the public comment period closed on February 18, 2013. The final draft of this document, incorporating public and peer review comments, was released on April 14, 2016.

This Health Consultation evaluates available data analyzed for metals and volatile organic compounds (VOCs) to determine potential public health implications from exposure to these pollutants in outdoor air.

2.0 Background

Midlothian is located in Ellis County, Texas, approximately 30 miles south of the Dallas-Fort Worth metropolitan area. Figure B-1 in Appendix B shows the location of Midlothian and the four industrial facilities of interest. This section provides background information on the industries previously identified to affect air quality in Midlothian, focusing on three cement plants and a steel mill currently operating in the community.

Operations at the four facilities of interest have changed over the years. Some changes have increased air emissions (e.g., increased production levels, use of different fuels in the kilns) while others have decreased air emissions (e.g., installation of pollution control devices). In some cases, changes at the facilities may have simultaneously decreased emissions of certain pollutants and increased emissions of others. These facilities emit several pollutants at rates that have consistently ranked among the highest for industrial facilities in Ellis County that submit data to TCEQ’s Point Source Emissions Inventory (PSEI). Other emission sources (e.g., motor vehicles) are acknowledged and characterized as well.

2.1 Facilities of Interest

This section presents general information on the relevant manufacturing processes for the facilities of interest in Midlothian, with a focus on the types of air emissions commonly found at cement kilns and steel mills. Please refer to the ATSDR Health Consultation *Assessing the Adequacy of the Ambient Air Monitoring Database for Evaluating Community Health Concerns* for more details about these facilities (ATSDR, 2015).

2.1.1 Air Emissions from Cement Kilns

Cement is a commercial product that is used to make concrete. While cement manufacturing facilities employ various production technologies to make their products, most facilities share some common design features. A general description of cement manufacturing follows.
Cement is typically manufactured by feeding crushed limestone, shale, and other materials into kilns that operate at very high temperatures, typically at least 2,700 degrees Fahrenheit (°F) (U.S. EPA, 1993). Facilities burn various fuels to sustain these kiln temperatures. Fuels used across industry include coal, oil, natural gas, hazardous waste, and tires. When the raw materials are heated to the temperatures achieved in the kilns, they form a material known as “clinker,” which is the solid output from the kilns that is cooled and mixed with gypsum to form the cement product.

Though the main product from the kiln is clinker, many by-products are also formed and exit the kiln in air exhaust. The primary by-product is cement kiln dust, which is a highly alkaline dust of fine particle size. Air pollution control equipment, such as baghouses and electrostatic precipitators, are typically used to reduce emissions of cement kiln dust in the exhaust air from the kilns. Cement kiln dust not collected in the controls or otherwise captured for further processing is emitted from stacks along with combustion by-products, which include carbon monoxide, nitrogen oxides, sulfur dioxide, and various volatile organic compounds (e.g., formaldehyde) and semi-volatile organic compounds (e.g., dioxins and furans).

Besides their kilns, cement manufacturing facilities have many other operations that process materials. These may include mining for limestone at on-site quarries, crushing and blending of raw materials, and other material handling processes. Air emissions from these and various other operations tend to occur at ground level and are not always vented through air pollution controls.

The processes that tend to emit organic and inorganic pollutants are summarized below (Table 1).

Table 1. Sources of organic and inorganic pollutant releases from cement kilns

Inorganics	Metals, elements, inorganic compounds	Most metals and elements emitted from cement kilns are found within the particles that are emitted as particulate matter (PM). The main exception is mercury, which is emitted as a gas from high temperature sources (i.e., the kilns). Some inorganic compounds (e.g., sulfates, hydrochloric acid, sulfuric acid) are also found in particles emitted from stacks, while other inorganic compounds (e.g., carbon monoxide, nitrogen oxides, sulfur dioxide, hydrogen sulfide) are released as gases.
Volatile/semi-volatile organic compounds (VOCs/sVOCs)	Organic (or carbon-containing) compounds with high volatility/ Organic compounds with low volatility, which include dioxins, furans, and polycyclic aromatic compounds	The high temperatures in cement kilns are expected to destroy most of the VOCs present, but some VOCs may still be found in stack emissions. These include constituents of the various raw materials and fuels and pollutants formed during the combustion of fuels. Combustion of fuels, tires, and hazardous waste can create various products of incomplete combustion and other by-products, which include a wide range of sVOCs. At cement kilns, these would be expected to be found primarily in the stack emissions.

2.1.2 Air Emissions from Steel Mills

Most steel in the United States is manufactured in either basic oxygen furnaces or in electric arc furnaces (U.S. EPA, 2000a). Electric arc furnaces are the manufacturing technology of choice at facilities that manufacture steel from scrap metal, as occurs in Midlothian. With this technology, scrap metal and sometimes alloys are loaded into the furnace. Electrical energy is then used to melt the scrap metal. During the melting process, impurities in the steel react with the air in the furnace to form various by-products that are vented to the air, typically after passing through some form of air pollution control device. These emissions can include inorganics (i.e., metals) originally found in the scrap, as well as volatile organic compounds (VOCs) that can form from the impurities present in the melting process.

After each batch of scrap metal is melted, the electric arc furnace is tilted and the contents are poured into a mold, in which the molten steel gradually cools and takes it final form. The steel then usually undergoes additional finishing processes (e.g., rolling, beam straightening) to make the final product. Slag is a solid by-product from the melting process. Steel mills employ various strategies for managing slag, including disposal and beneficial reuse.

Overall, pollutants typically emitted from steel mills that melt scrap in electric arc furnaces include particulate matter (PM) or dust, VOCs (specific VOCs generally depend on the fuels being used), carbon monoxide, nitrogen oxides, and sulfur dioxide. The PM emitted from these facilities contains various inorganics (especially chromium, iron, manganese, and nickel).

2.2 Air Emissions Sources in Midlothian

For each facility of interest, this section summarizes the industrial processes and air emissions (among other factors) to provide context for this document's technical evaluation. In preparation for our first Health Consultation, ATSDR accessed and thoroughly reviewed extensive additional information on each facility's history and TCEQ's records documenting the history of air permits and compliance status. An expanded explanation of the history and estimated air emissions (short and long term) is available in the ATSDR Health Consultation *Assessing the Adequacy of the Ambient Air Monitoring Database for Evaluating Community Health Concerns* (ATSDR, 2015).

2.2.1 Ash Grove Cement

Ash Grove Texas L.P. is a business entity that operates a Portland cement manufacturing facility located north of Midlothian, referred to in this document as "Ash Grove Cement."[1] The facility was constructed in 1965 and began operating in 1966, and has historically operated three rotary kilns to manufacture cement. The old kilns began operating in 1966, 1969, and 1972 (TNRCC, 1995). In 2013, the facility began a $150 million upgrade to decommission its two older kilns and modernize the remaining kiln to reduce emissions of oxides of nitrogen (NOx) and sulfur dioxide (SO_2). (Ash Grove, 2013). The project is complete, and two of the cement production kilns were permanently shut down in September of 2014 and were subsequently dismantled. These changes have reportedly realized a reduction in SO_2 emissions of 97% (Ash Grove, 2015).

Cement is manufactured at the Ash Grove facility by feeding limestone, shale, and other raw materials into the rotary kilns, which operate at temperatures reaching 4,000°F. Most of the raw materials used in the process are from an onsite quarry, but some materials come from offsite sources via truck and rail. The solid product from the kilns—known as clinker—is subsequently ground together with gypsum to make Portland cement (ATSDR, 2015).

Various fuels have been used at the facility over the years to fire its kilns. These fuels have included natural gas, fuel oil, coal, coke, wood chips, waste-derived fuel, and whole tires. Currently, the facility employs a combination of coal, petroleum coke, and tires to fire its kilns; natural gas was typically used only for startup of the kilns but usage has expanded in recent years. Ash Grove burned hazardous waste for fuel between 1986 and 1991 (ATSDR, 2015).

Ash Grove Cement's production processes have numerous sources of air emissions. Exhaust air from the three kilns, for example, have historically vented to the atmosphere through 150-foot tall stacks, after first passing through pollution control devices before being released to the air.

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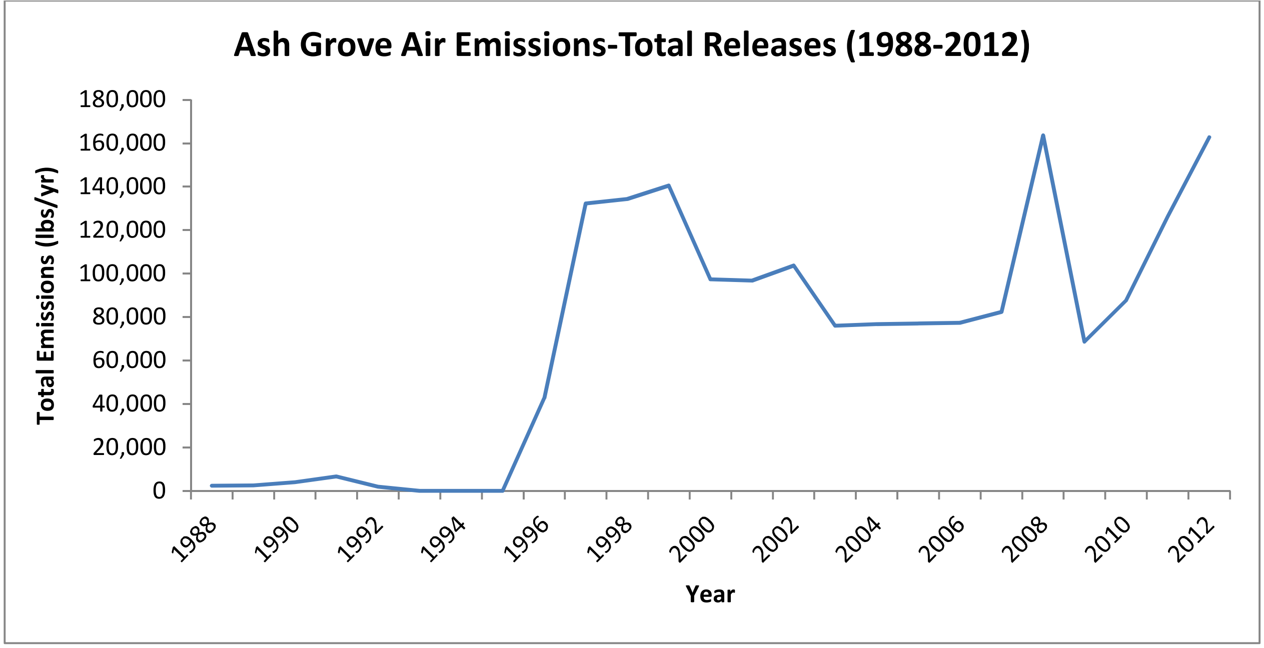
[1] This document primarily uses "Ash Grove Cement" to refer to the cement manufacturing facility located in Midlothian. Ash Grove Texas L.P. is the business entity that currently operates that facility. References to "the facility" throughout this document refer to the cement manufacturing plant, which was owned and operated by different entities over the years.

Emissions also occur from the facility's quarry activities, physical processing of raw materials (e.g., crushing, grinding, and milling), materials handling operations, stockpiles, and other storage areas. Many of these other emission sources are also equipped with air pollution controls to help reduce releases. For example, dust collectors capture PM from many of the materials handling operations. Facility-wide emissions can vary considerably with time, because Ash Grove Cement has occasionally changed its fuel sources and design of its unit operations; new equipment has been added over the years, while some older equipment has been taken out of service.

For the years in which Ash Grove Cement has reported to the Toxic Release Inventory (TRI) (1988 to 2012), total air emissions summed across all pollutants ranged from 1,923 pounds to 162,742 pounds per year (U.S.EPA, 2013a; see Figure 1). From 2000 to the present, stack emissions of sulfuric acid aerosols have accounted for more than 98 percent of the total air emissions that Ash Grove Cement has reported to TRI. During this time, emission controls have been implemented that have helped reduce impacts from sulfuric acid aerosol emissions in the community, even as emissions have increased. Other pollutants reported most frequently since 2000 include various metals (compounds of chromium, lead, manganese, and mercury) and dioxin and dioxin-like compounds. For each individual pollutant that Ash Grove Cement reported to TRI in 2008, the facility's annual air emissions did not rank among the top 100 emitters in the nationwide database. A detailed evaluation of data trends and source data strengths and limitations is presented in the first ATSDR Health Consultation, "Assessing the Adequacy of the Ambient Air Monitoring Database for Evaluating Community Health Concern, Midlothian Area Air Quality, Midlothian, Ellis County, Texas" (ATSDR, 2015).

Figure 1. Ash Grove Annual TRI Emissions (1988-2012)



Source: Toxic Release Inventory: http://www2.epa.gov/toxics-release-inventory-tri-program

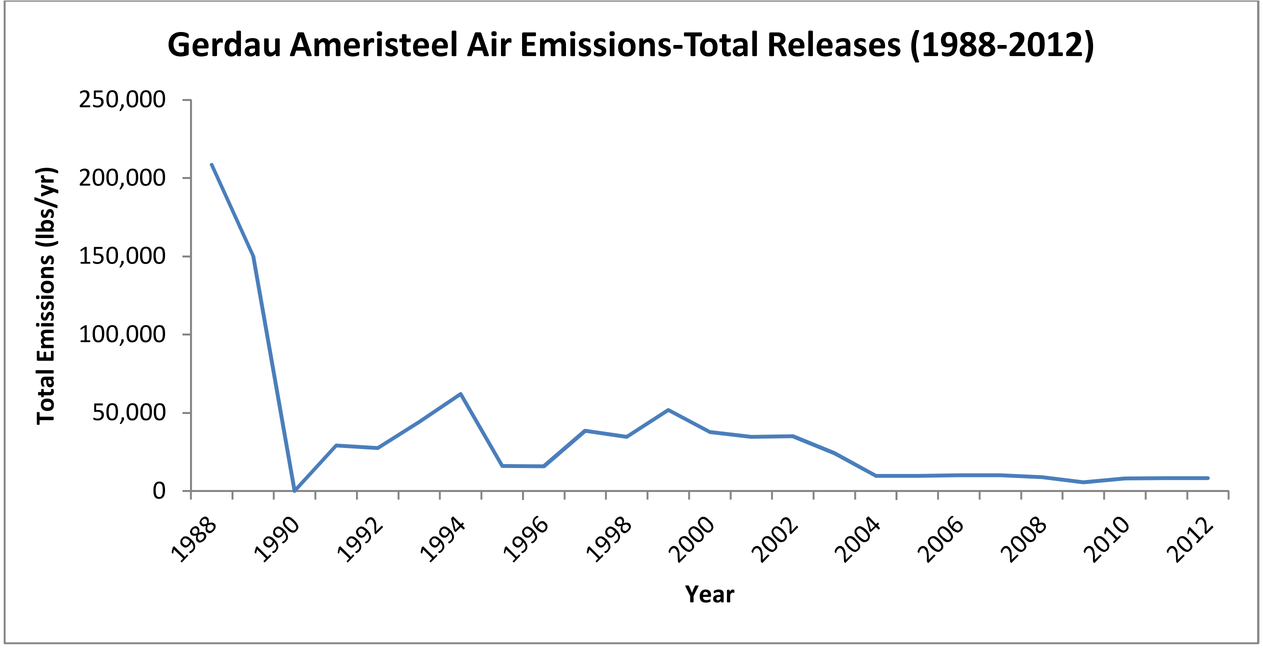
2.2.2 Gerdau Ameristeel

Gerdau Ameristeel, sometimes referred to as Chaparral Steel, operates a steel mill located southwest of Midlothian and adjacent to TXI Operations (see Section 2.2.4). The facility began operating in 1975 (TNRCC, 1995) and currently uses two electric arc furnaces and three rolling mills to melt and recycle scrap steel. The scrap steel is obtained from an automobile shredder and junkyard, also located at the facility. The two electric arc furnaces melt scrap steel, and then casting operations form the material into structural steel beams, reinforcing bars, and other shapes and forms.

Gerdau Ameristeel's production processes have multiple emission sources. Exhaust from the two furnaces passes through baghouses to remove pollutants prior to being vented to the atmosphere through three stacks ranging from 80-150 feet high. Emissions also occur from the facility's automobile shredding operation, melt shop, and scrap and slag handling. Many of these operations are also equipped with air pollution controls. As pollution controls have been installed at the site, air emissions have decreased significantly.

For the years in which Gerdau Ameristeel reported to TRI (1988 to 2012), total air emissions summed across all pollutants ranged from 8,287 pounds to 208,388 pounds per year (U.S.EPA, 2013a; see Figure 2). From 2000 to the present, air emissions of zinc compounds have accounted for 63 to 73 percent of the total air emissions that the facility reported to TRI. Other pollutants reported most frequently during this time frame are metals—particularly cadmium, chromium, copper, lead, manganese, mercury, and nickel. A detailed evaluation of data trends and source data strengths and limitations is presented in the first ATSDR Health Consultation, "Assessing the Adequacy of the Ambient Air Monitoring Database for Evaluating Community Health Concern, Midlothian Area Air Quality, Midlothian, Ellis County, Texas" (ATSDR, 2015).

Figure 2. Gerdau Ameristeel, Annual TRI Emissions (1988-2012)



Source: Toxic Release Inventory: http://www2.epa.gov/toxics-release-inventory-tri-program

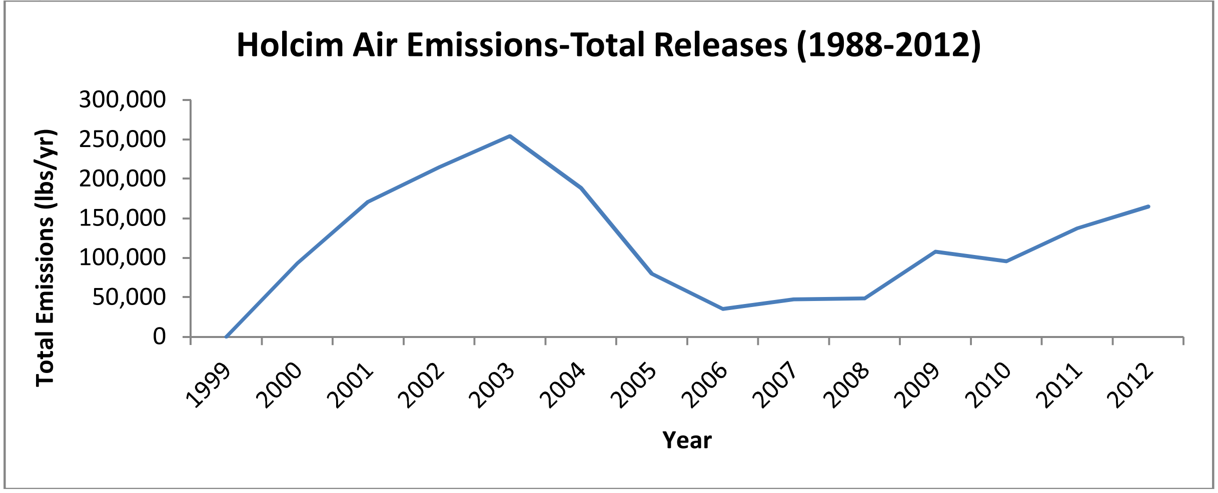
2.2.3 Holcim

Holcim Texas Limited Partnership (LP) (referred to in this document as "Holcim") is a Portland cement manufacturing facility located northeast of Midlothian that opened in 1987. Holcim operates two dry kilns that began operations in 1987 and 2000. An onsite quarry provides limestone and other raw materials used to feed the rotary kilns, which operate at temperatures reaching 3,000ºF. Raw materials are crushed and milled onsite prior to being fed to pre-heaters that precede the kilns. The solid product from the kilns, or clinker, is cooled and ground together with gypsum to make Portland cement. Since 1987, Holcim has used multiple fuels to fire its kilns. The facility was originally permitted to use coal and natural gas, but is also permitted to fire its kilns with tire chips, oil, non-hazardous liquids, non-hazardous solids, and petroleum coke.

Holcim's cement manufacturing operations emit air pollutants from multiple sources, and various measures are in place to reduce facility emissions. Both kilns now operate with pollution controls to reduce emissions of nitrogen oxides and sulfur dioxide. Process gases from the kilns eventually vent to the atmosphere through 250-foot and 273-foot tall stacks, in which the facility continuously monitors emissions of sulfur dioxide, carbon monoxide, nitrogen oxides, and ammonia. Emissions also occur from the facility's quarry activities, physical processing of raw materials, materials handling operations, and storage areas, and some of these emission sources are also equipped with baghouses to remove particulate matter from process exhaust streams (ATSDR, 2015).

For the years in which Holcim reported to TRI (2000 to 2012), total air emissions summed across all pollutants ranged from 35,247 pounds to 254,195 pounds (U.S.EPA, 2013a; see Figure 3). From 2000 to the present, the pollutants most frequently reported on Holcim's TRI reports were benzene, toluene, sulfuric acid aerosols, several metals (compounds of chromium, lead, mercury, and zinc), and dioxin and dioxin-like compounds. Over the history of Holcim's TRI reporting, benzene and toluene accounted for the largest portion of emissions, followed by sulfuric acid aerosols and xylene (U.S. EPA, 2013a). A detailed evaluation of data trends and source data strengths and limitations is presented in the first ATSDR Health Consultation, "Assessing the Adequacy of the Ambient Air Monitoring Database for Evaluating Community Health Concern, Midlothian Area Air Quality, Midlothian, Ellis County, Texas" (ATSDR, 2015).

Figure 3. Holcim Ltd., Annual TRI Emissions (2000-2012)



Source: Toxic Release Inventory: http://www2.epa.gov/toxics-release-inventory-tri-program

2.2.4 TXI Operations

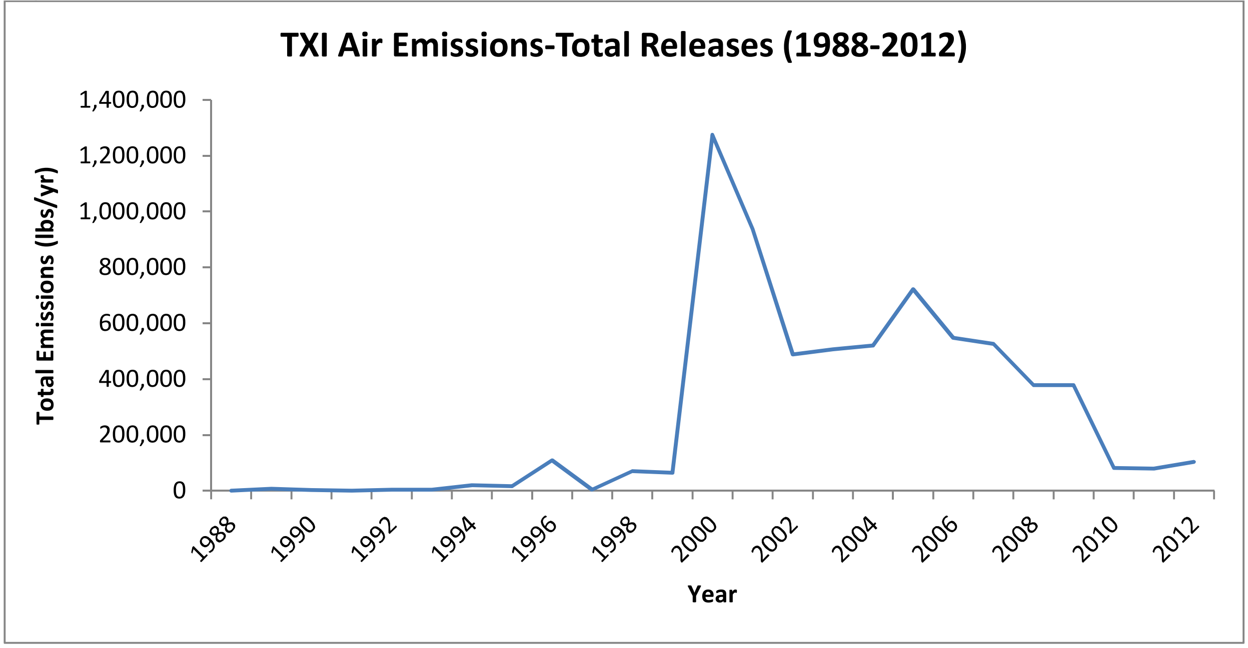
TXI Operations (TXI), the largest of the three Portland cement manufacturing facilities in Midlothian, is located southwest of the city center, adjacent to Gerdau Ameristeel. TXI opened in 1960 and for many years operated five cement kilns that came online in 1960, 1964, 1967, 1972, and 2002. Four of these were "wet kilns" and the newest is a "dry kiln." TXI has permanently shut down its wet kilns and the authority to operate these kilns has been removed from their permit. An onsite quarry provides the limestone and shale used to manufacture cement. Other raw materials are delivered via truck. The kilns are fired at temperatures that reach 2,800°F and produce clinker, which is ground together with gypsum to make the Portland cement product.

TXI has used multiple fuels to fire its kilns. The kilns were originally fired with natural gas. From this mid 70s through the late 80s, the facility was authorized to fire kilns using coal, fuel oil, petroleum coke, and waste-derived fuel, respectively. However, the only operating kiln (the dry kiln, mentioned above) is authorized to fire natural gas and coal as fuel. Though TXI was permitted to burn hazardous waste since 1987, the facility has not used this fuel continuously over the years and does not burn it now; records indicate that the facility burned hazardous waste between 1991 and 2007.

TXI has many air emission sources that are typically found at cement manufacturing facilities. Exhaust air from the active kiln passes through pollution control devices including baghouses, scrubbers, and thermal oxidizers to remove criteria pollutants and VOCs. The four previous wet kilns also had effective control technology to remove pollutants from the exhaust stream. Exhaust from kilns exit through 200-foot or 310-foot tall stacks, in which TXI continuously monitors emissions of several pollutants, including carbon monoxide, nitrogen oxides, and sulfur dioxide. The specific monitoring requirements varied across the kilns, though only a single kiln operates. In addition to pollution controls for kiln emissions, the facility has equipped a number of other process operations with baghouses and other types of dust collectors to reduce particulate emissions.

According to U.S. EPA's Biennial Reporting System database, from 1991 to 2007, TXI burned an average of approximately 56,200 tons of hazardous waste annually for purposes of energy recovery (ATSDR, 2015)—an amount roughly equivalent to burning more than 150 tons of hazardous waste per day, assuming continuous operations. Examples of the specific types of waste burned at TXI include, but are not limited to, organic liquids and sludge, waste oils, and solvents. A detailed evaluation of data trends and source data strengths and limitations is presented in the first ATSDR Health Consultation, "Assessing the Adequacy of the Ambient Air Monitoring Database for Evaluating Community Health Concern, Midlothian Area Air Quality, Midlothian, Ellis County, Texas" (ATSDR, 2015).

Figure 4. TXI Annual TRI Emissions (2000-2012)



Source: Toxic Release Inventory: http://www2.epa.gov/toxics-release-inventory-tri-program

For the years in which TXI reported to TRI (1988 to 2012), total air emissions summed across all pollutants ranged from 60 pounds to 1,274,852 pounds (U.S.EPA, 2013a; see Figure 4). Between 2000 and 2012, TXI submitted TRI reports to U.S. EPA for 64 different pollutants. Of these, the following pollutants were reported every year: sulfuric acid aerosols; and compounds of chromium, manganese, and nickel. In terms of the magnitude of pollutant emissions, sulfuric acid aerosols consistently accounted for more than 90 percent of the total air toxic emissions by the facility during this time frame. Other pollutants with the highest quantity of emissions include several VOCs (e.g., benzene, naphthalene, styrene, toluene, xylene isomers), metals (e.g., compounds of chromium, manganese, nickel, and zinc), and hydrochloric acid aerosols. TXI's estimated sulfuric acid emissions are within the top 100 highest among reporting industrial facilities nationwide (ATSDR, 2015).

2.2.5 Other Emission Sources

Air quality in Midlothian is affected by emissions from all local (and some distant) sources and not only by emissions from the four main facilities of interest. Consequently, the ambient air monitors in the area measure air pollution levels that reflect contributions from a large number of emission sources. There are typically three types of sources in any given community:

1. *Point sources:* These are emissions from industrial facilities that come out of stacks, like those mentioned for the cement and steel production facilities mentioned in previous pages.
2. *Area sources:* Smaller air pollution sources that individually do not emit enough pollutants to be considered a point source, but collectively throughout an area can account for a considerable quantity of emissions. Examples of area sources include agricultural tilling, dry cleaners, and gasoline stations.

3. *Mobile sources:* Mobile sources refer to any vehicle or equipment with a gasoline or diesel engine (e.g., on-road and off-road motor vehicles, construction equipment), as well as aircraft and recreational watercraft.

2.3 Demographics

ATSDR examines demographic data to determine the number of people who are potentially exposed to environmental contaminants and to consider the presence of sensitive populations, such as young children (age 6 years and younger), women of childbearing age (between ages 15 and 44 years), and the elderly (age 65 and older). Overall, an estimated 38,908 people live within 3 miles of any of these facilities, with some individuals being life-long residents. The main population center of Midlothian is located between the facilities of interest, although several residential developments and individual property owners are located throughout the area shown in Figure B-1 in Appendix B. Some residents live on property adjacent to one of the facilities or immediately across the highway from TXI and Gerdau Ameristeel. Approximately 7.9 percent of the population of Midlothian are children under the age of 5; 7.6 percent are older than 65; and 22 percent are women of childbearing age (Census, 2010).

2.4 Community Concerns

Since 2005, ATSDR and TDSHS have been collecting and documenting community concerns regarding the Midlothian facilities. The agencies have learned of these concerns through various means, including a door-to-door survey of residents, a community survey, and multiple public meetings and availability sessions held in Midlothian. The concerns expressed by community members have addressed many topics, including human health, animal health, and the adequacy and reliability of ambient air monitoring data collected in the Midlothian area. Concerns were summarized from written and oral communication with residents and consolidated in our Public Health Response Plan (ATSDR, 2012a). The summarized concerns related to this evaluation include:

the persistence of emissions, and the effects of continuous low level exposure to individual chemicals and/or mixtures; and

the impact on area residents, especially sensitive populations (pregnant women, infants, children, the elderly, the immune-suppressed).

These concerns are addressed in the Health Implications section of this document.

3.0 Measured Environmental Data

This section summarizes data on air pollution levels in Midlothian, including an evaluation of both measured (Section 3.0) and estimated, or “modeled” (Section 4.0) values. Taken together, the available ambient air monitoring data for the Midlothian area covered 98 VOCs collected in canisters and 58 inorganic pollutants. The inorganic pollutants were measured in one of three different size fractions in dust collected on monitor filters (TSP, PM_{10}, $PM_{2.5}$). Total suspended particulate (TSP) is a designation for all size particles in dust. PM_{10} are dust particles that are 10 micrometers (µm) or less in aerodynamic diameter ($d_{ae}<10\mu m$), and $PM_{2.5}$ are those less than 2.5

µm in aerodynamic diameter (d_{ae}<2.5µm). A detailed evaluation of TRI reporting criteria and contaminants of concern is presented in the first ATSDR Health Consultation, "Assessing the Adequacy of the Ambient Air Monitoring Database for Evaluating Community Health Concern, Midlothian Area Air Quality, Midlothian, Ellis County, Texas" (ATSDR, 2015).

Monitoring results and the output of dispersion models are reviewed separately because each has their own particular limitations and uncertainties. Monitoring results—typically generated by ambient air monitoring programs—generally are the best indicator of the amount of different air pollutants that people actually breathe, without the uncertainties associated with models. These measurements not only include air quality impacts from the local industrial sources, but will also include contributions from mobile sources, wind-blown dust, and various other factors affecting air pollution. However, ATSDR's first Health Consultation identified several gaps in the air pollution measurements in Midlothian. For instance, there are no measurements that will tell us about past air pollution levels. Models can be used to estimate what past air pollution levels might have been based on information about facility emission rates and local meteorological conditions. Section 4.0 presents results of an ATSDR modeling analysis for several pollutants for which no ambient air monitoring has been conducted or the available data are extremely limited. The modeling was conducted to derive estimates of past exposure levels and to inform decisions about the need for monitoring in the future.

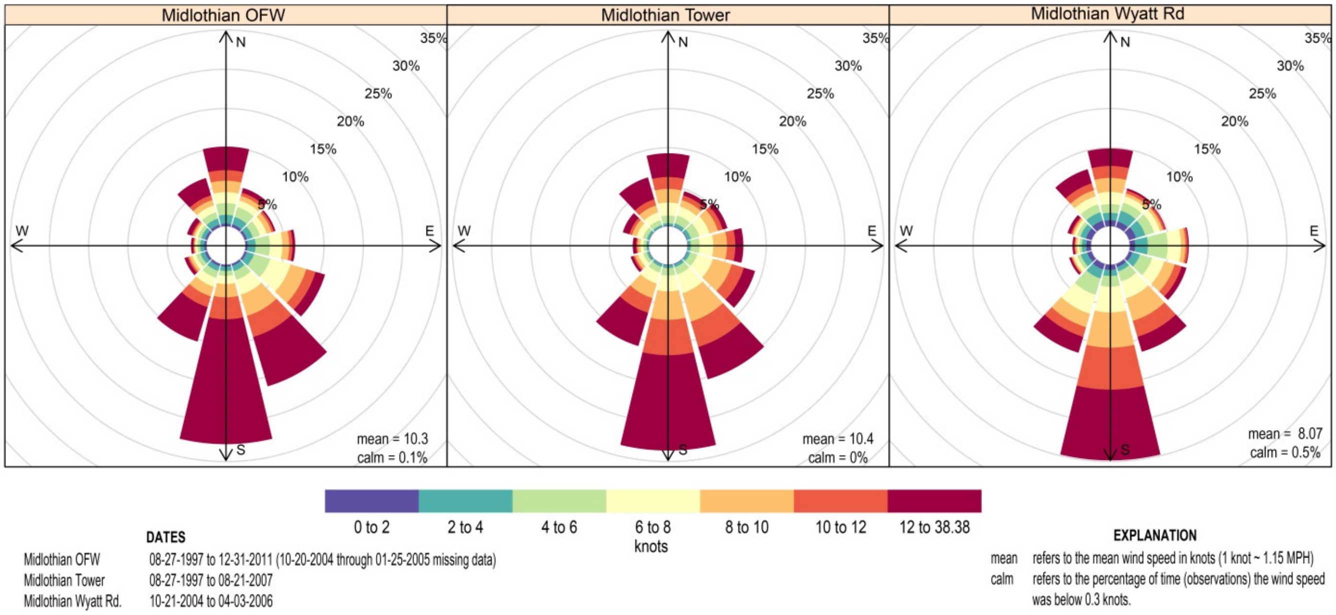
3.1 Air Monitoring

This section summarizes the measured air pollution levels for pollutants measured by monitoring equipment in Midlothian. While the summaries are organized by individual pollutants, ATSDR fully acknowledges that residents are not exposed to just one pollutant at a time—residents are instead simultaneously exposed to the complex mixture of the pollutants analyzed here. This section uses pollutant-by-pollutant summaries to provide detailed information on each substance. The health evaluation in Section 3.2.5(a,b) considers the implications of individual pollutant exposures, and Section 3.3 evaluates exposure to the complex mixture of these substances, to the extent such an evaluation can be supported by currently available science.

3.1.1 Local Climatic and Meteorological Conditions

ATSDR reviewed meteorological conditions in the Midlothian area because these factors affect how air emissions move from their sources to downwind locations. To assess the prevailing wind patterns ATSDR obtained wind speed and wind direction data for multiple meteorological stations in the Midlothian area and generated wind roses for the station at Old Fort Worth Road (OFW) (north of the border of Gerdau Ameristeel and TXI), Midlothian Tower (on TXI's property), and Wyatt Road (north of Gerdau Ameristeel). A wind rose displays the statistical distribution of wind speeds and directions observed at a meteorological station. The wind roses in Figure 5 indicate that the prevailing wind direction in the Midlothian area is largely in the wind vector of 135-215 degrees (out of the southeast, south, and southwest).

Figure 5. Wind roses depicting prevailing wind patterns in Midlothian (2001- 2011)



Data source: http://www.tceq.texas.gov/agency/data/download-data.html/#airdata

3.1.2 Review of Ambient Air Monitoring Data

This Health Consultation is based on the results of thousands of air quality measurements in the Midlothian area. The amount of monitoring data available for the Midlothian area far exceeds what ATSDR typically encounters when evaluating outdoor air quality. However, as noted in the first Health Consultation, the available data have many limitations that prevent a full characterization of outdoor air quality for all locations and time frames of interest. To review the ambient air monitoring data, this section presents: an overview of the air monitoring networks that have operated in Midlothian; the approach ATSDR used to identify the subset of pollutants that require more detailed evaluations; and the individual pollutant data summaries. Refer to Section 4.0 for modeling results that provide insights on pollutants that have not been evaluated in the monitoring programs.

Overview of Midlothian Monitoring Programs

The first Health Consultation for this site presented ATSDR's assessment of the adequacy of the ambient air monitoring database for the Midlothian area (ATSDR, 2015). Section 4.0 of that document provides highly detailed information on each monitoring network, including information on methods, data quality, monitoring locations, and sampling frequency. A general overview of the monitoring programs is presented here. The following monitoring programs have included some measurements of metals and VOCs in the Midlothian air:

- **Midlothian Ambient Air Collection and Analytical Chemical Analysis.** To fill gaps in the available environmental monitoring data identified in the public comment Health Consultation issued by TDSHS in December 2007, TCEQ funded a year-long ambient air monitoring in the Midlothian area from 2008-2009. The main goals were to (1) measure certain pollutants for the first time (e.g., hexavalent chromium) and (2) monitor at locations of potential exposure that had not been evaluated previously (e.g., several schools and parks). TCEQ, in coordination with Midlothian residents, designed the monitoring program, and URS Corporation, an environmental consulting company, implemented the program. This monitoring effort included four locations where five VOC and inorganic samples were collected quarterly, and four additional locations where five VOC and inorganic samples were collected during a single calendar quarter. Every sample collected during this program was a 24-hour average sample. All laboratory analyses were conducted by Eastern Research Group, Inc. (ERG). ATSDR has accessed the entire set of concentration measurements from this monitoring program, the quarterly data summary reports prepared by URS Corporation, and the summary report for the overall study (TCEQ, 2010).
- **TCEQ's monitoring for inorganics.** TCEQ has monitored for inorganics at multiple locations. Inorganics include metals and other chemical compounds that do not contain carbon. The coverage of these monitoring stations varied with time: just one station operated in 1981, five stations operated for different periods between 1991 and 1993, and two stations operated for most years since 2002. At all of these locations, airborne inorganics in particulate matter—both PM_{10} and $PM_{2.5}$—were collected over 24-hour average sampling periods onto filters. The majority of the sampling conducted since 2002 has occurred at some combination of the following three stations: Midlothian Tower, Old Fort Worth Road, and Wyatt Road. TCEQ maintains an electronic database of its entire history of inorganic pollutant monitoring data for the Midlothian area, which was accessed for this assessment (see http://www.tceq.texas.gov/agency/data).
- **TCEQ's VOC monitoring.** In addition to the recent VOC measurements conducted as part of the Midlothian Ambient Air Collection and Analytical Chemical Analysis (as described earlier in this list), TCEQ has conducted VOC monitoring at multiple locations in the Midlothian area since 1993. At all of these locations, integrated canister samples were collected for either 1-hour or 24-hour averaging periods. TCEQ personnel oversee sample collection and samples are analyzed at a central TCEQ laboratory. TCEQ maintains an electronic database of its entire history of VOC monitoring data for the Midlothian area, which was accessed for this assessment (see http://www.tceq.texas.gov/agency/data).

This Health Consultation considers only those monitoring data that ATSDR found to be of a known and high quality. The first Health Consultation for this site identifies the relatively few instances where ATSDR did not think certain air quality measurements should be used for health assessment purposes. Please refer to our first Health Consultation for detailed information on the monitoring, sampling, and analytical methods historically used in Midlothian. A summary of available data for this assessment is presented in Table 2, below.

Table 2. Summary of historical VOC and Metal sampling events in the Midlothian area, 1981-2012

Pollutant Class	Sampling Location	Number of Samples (N=)	Sample Duration	Sampling Period
TSP Metals	Midlothian City Hall Roof	40	24-hour	May 1981-Dec 1981
PM10 Metals	Auger Road	68	24-hour	Jan 1991-Oct 1992
	Auger Road Waste Water Treatment Plant	56	24-hour	Jan 1991-Jun 1993
	Cedar Drive	13	24-hour	Jan 1992-May 1992
	Cedar Hill Fire Department	37	24-hour	Jul 1991-Feb 1992
	Cement Valley Road	14	24-hour	Jan 1991-Jun 1993
	J.A. Vitovsky Elementary School	5	24-hour	May 2009
	Jaycee Park	20	24-hour	Dec 2008-Jul 2009
	Midlothian High School	5	24-hour	Jul 2009
	Mountain Peak Elementary School	5	24-hour	Feb 2009-Mar 2009
	Old Fort Worth Road	20	24-hour	Dec 2008-Jul 2009
	Tayman Drive Waste Water Treatment Plant	20	24-hour	Dec 2008-Jul 2009
	Triangle Park	5	24-hour	Dec 2008
	Wyatt Road (1291 E. Wyatt Road)	20	24-hour	Dec 2008-Jul 2009
	Wyatt Road (CAMS 302)	262	24-hour	Nov 1999-Jun 2004
PM2.5 Metals	Midlothian Tower	197	24-hour	May 2002-Aug 2005
	Old Fort Worth Road	321	24-hour	Sept 2005-Dec 2011
VOCs	J.A. Vitovsky Elementary School	5	24-hour	May 2009
	Jaycee Park	20	24-hour	Dec 2008-Jul 2009
	Midlothian High School	5	24-hour	Jul 2009
	Midlothian Tower	199	24-hour	Apr 2004-Aug 2007
	Midlothian Tower	316	1-hour	Aug 1999-Jul 2006
	Mountain Peak Elementary School	5	24-hour	Feb 2009-Mar 2009
	Old Fort Worth Road	766	24-hour	Mar 1997-Dec 2011
	Old Fort Worth Road	20	24-hour	Dec 2008-Jul 2009
	Tayman Drive Waste Water Treatment Plant	231	24-hour	Jan 1993-Mar 1997
	Tayman Drive Waste Water Treatment Plant	20	24-hour	Dec 2008-Jul 2009
	Triangle Park	5	24-hour	Dec 2008
	Wyatt Road (CAMS 302)	84	24-hour	Oct 2004-Mar 2006

***VOCs** are volatile organic compounds; **TSP** metals are metals in total suspended particulates (total dust);*
***PM$_{2.5}$** and **PM$_{10}$** metals are metals in dust particles ≤ 2.5 or 10 microns in aerodynamic diameter; **CAMS** is a continuous air monitoring station.*

3.2 Data Evaluation

3.2.1 Overview for identifying contaminants of concern and evaluating risk

Some general observations regarding outdoor air quality are important to understand before reading the data summaries. First, ATSDR notes that outdoor air in populated areas throughout the United States will contain trace amounts of numerous pollutants. The fact that air samples in Midlothian contained dozens of air pollutants is not unusual. It is the magnitude of the air pollution that is of greater concern for health assessment purposes. Second, measured air pollution levels in Midlothian—as with air pollution anywhere in the United States—will reflect contributions from numerous emission sources. Some of the pollutants found in the air in Midlothian are very clearly connected to the local industrial sources, but other air pollutants are not. An air sample will provide information on the levels of air pollution, but it will not indicate precisely where that pollution originated. ATSDR tries to provide context on which emission sources likely contributed to the measured air pollution levels in the sections that follow.

Before discussing health risks from exposure to air pollutants, it is important to understand:

1. Which pollutants are present;
2. The magnitude (the range) of concentrations of those pollutants;
3. How often, or the frequency, of which pollutants were detected; and
4. How long (the duration) of exposure to the levels of pollutants detected in air.

The following sections explain our process of evaluating health risks. As mentioned previously, all data collected in the community were downloaded from TCEQ by ATSDR. The data were then compared to the most conservative (lowest) health based screening levels from ATSDR, U.S.EPA, or other agencies to pinpoint those that are present at levels of potential concern to begin to understand the risk they might pose to area residents. In this document, ATSDR refers to these screening levels as "CVs", or comparison values.

3.2.2 Statistical Methods for Evaluating Measured Data

This section describes the methods we used to calculate means from censored (contaminant not-detected or ND) data. A technical description of this method is included in Appendix C. Since 1981, TCEQ monitoring stations have collected integrated 1- or 24-hour air samples that are analyzed for a specific target list of compounds, which are defined by the analytical method used. All existing TCEQ data were downloaded from the Texas Air Monitoring Information System (TAMIS) Web Interface (http://www.tceq.texas.gov/agency/data). Many of the data points in the TCEQ dataset were censored values, so the results were often below the reporting limit for individual pollutants. This was less true for metals measured in the 2000s as newer analytical methods began to yield lower (more sensitive) reporting limits.

Often in environmental sampling, and particularly in ambient air sampling, a large number of observations for a pollutant may be reported as "ND" (not-detected) or "BDL" (below the detection limit). There are a number of ways these "censored" (not-detected or zero value) data can be handled for evaluating the data to make health conclusions. Historically, researchers have approached non-detected data by assuming the pollutant is always present in air at half the detection limit of the laboratory analytical method. The substitution method mentioned above (substituting half the detection limit for censored, not detected, data) is very frequently performed for initial analyses, but has also been shown to perform poorly (U.S. EPA, 2006). The substitution method generally assumes that pollutants are always present in ambient air, and are present at least half of the concentration of the limit of detection. For example, if a pollutant was not detected in a given sample and the detection limit was 0.1 µg/m^3, the substitution limit estimate would be 0.05 µg/m^3 for that pollutant. This method becomes problematic in instances where the pollutant is never detected, or is detected a few times out of hundreds of observations; the average is then based not on real data, but on the detection limit of the individual pollutant. As a screening method, we began with averaging data this way because it tends to overestimate an averaged concentration when the censoring rate is high and the data are highly skewed (which is often the case in environmental data). If a contaminant concentration exceeded a CV, we took a look at individually reported concentrations and evaluated data using one of two, more precise methods for evaluating censored data (Lee and Helsel, 2005; Lee, 2013). The first method is called the robust regression on order statistics (ROS) approach. This approach uses the detection limit as a substitute for not-detected observations, but uses regression statistics to estimate the "spread" (mathematical distribution) of "not-detected" data. This approach appears to yield more precise estimates of means with missing data than other methods. The second method is called Kaplan-Meier (KM). The KM method uses the probabilities that the values are higher or lower than a given value (after factoring less than values) to approximate the "spread" (mathematical distribution) of the data.

Both the ROS and the KM methods have their strengths and weaknesses, and the idiosyncrasies of the data determined which method was better suited. We discuss our justification for our methods in Appendix C. In short, for the TCEQ VOC data (and particulate data where a single detection limit was given) we utilized ROS. For data where multiple detection limits were reported, such as the TCEQ PM2.5 data and the UT-Arlington data, we utilized KM. We did not calculate mean values using either KM or ROS when more than 80% were not detected. This is because these methods can yield inaccurate results when non-detected values are at greater than this rate (Lee, 2013).

3.2.3 Defining Comparison Values

ATSDR develops minimal risk levels (MRLs) based on scientific literature that evaluates exposure to specific pollutants and their associated health effects in human or animal studies. Based on the MRLs, ATSDR develops media-specific comparison values (CVs) using conservative exposure assumptions. As a result, ambient air concentrations lower than their corresponding comparison values are generally considered to be safe for even the most sensitive populations (e.g., children and the elderly) and are not expected to cause harmful health effects, but the opposite is not true. Because comparison values are often much lower than effect levels, ambient air concentrations greater than comparison values are not necessarily levels of air pollution that would present a possible public health hazard. Rather, chemicals with air concentrations higher than comparison values require further evaluation.

To select the pollutants requiring the most detailed evaluation, ATSDR considered its own health-based comparison values, as well as those published by U.S. EPA and TCEQ. Comparison values were identified for both short-term (acute) and long-term (chronic) exposure durations, and also considered both cancer and non-cancer health effects. In our evaluation, the air sampling results were compared to ATSDR Cancer Risk Evaluation Guides (CREG) and environmental media evaluation guides

(EMEGs), and U.S.EPA Regional Screening Levels (RSLs) and Reference Concentrations (RfCs). When ATSDR and U.S.EPA values were not available, we used TCEQ Air Monitoring Comparison Values (AMCVs). Please note that ATSDR has not conducted a comprehensive review of the basis of the AMCVs. These CVs are defined, below:

> ***ATSDR <u>CREGs</u>*** are concentrations of a carcinogen at which there is an elevated risk for one case of cancer in one million people exposed over a lifetime.
>
> ***ATSDR <u>EMEGs</u>*** are calculated from ATSDR minimal risk levels (MRLs) for chronic, intermediate, and acute exposures (those occurring longer than 365 days, from between 14-365 days, and 14 days of exposure or less, respectively.
>
> ***U.S. EPA <u>RfCs</u>*** are estimates of the concentrations of pollutants calculated that anyone could be exposed to for a lifetime without experiencing health effects. RfCs are for inhalational exposures and based on cancer or non-cancer health effects depending on the pollutant.
>
> ***U.S. EPA <u>RSLs</u>*** are risk-based numbers that are available for multiple exposure pathways and for chemicals with both carcinogenic and noncarcinogenic effects. The RSLs used in this analysis correspond to either a one excess risk of cancer per million exposed people (10^{-6}) for carcinogens or a Hazard Quotient (HQ) of 1 for non-carcinogens (U.S.EPA, 2013b).
>
> ***TCEQ <u>AMCVs</u>*** are chemical-specific air concentrations set to protect human health and welfare. Exposure to an air concentration at or below the AMCV is not likely to cause health effects in the general public, including sensitive subgroups such as children, the elderly, pregnant women, and people with preexisting health conditions.

In all cases, ATSDR initially considered the lowest—or the most health-protective—comparison value to determine which pollutants require the most detailed evaluation, regardless of which agency published those values. In some cases, ATSDR’s comparison values were the most protective; in other cases, the lowest values were published by U.S.EPA or TCEQ. Overall, 22 pollutants had at least one measured air concentration higher than the lowest health-based comparison value. The underlying premise in this approach is that ATSDR used the comparison values to focus its resources on the subset of pollutants having the greatest potential to contribute to adverse health effects, while assuming that the pollutants never found above health-based comparison values do not reach levels of health concern. The pollutants requiring further evaluation are reviewed in the next sub-section.

After compiling all available metals and VOC data, ATSDR then selected which subset of chemicals requires the most detailed health evaluation. The evaluation of the data occurred in three steps:

- Step 1, Initial Screening: Data were compared to the most conservative (lowest) health-based comparison value (CVs), regardless of the averaging time of the measurements (yielded 22 pollutants for further evaluation in Step 2);
- Step 2, Detailed Screening: Pollutants identified in Step 1 were compared to CVs with an averaging time consistent with the averaging time of the pollutant (yielded 13 pollutants for evaluation in Step 3);
- Step 3, Health Implications: Overarching evaluation of measured and modeled data and the cumulative risk assessment data, and incorporating spatial analysis (13 pollutants discussed). This section is presented after the modeling and risk assessment sections.

3.2.4 Initial Screening (Step 1)

ATSDR compared the highest ambient air concentration of a pollutant measured in the various monitoring programs (generally 24 hour samples or less) to the lowest state or federal health-based comparison value (CV), regardless of whether it was an acute, intermediate, or chronic value. Only benzene exceeded any acute CV, and only on three separate days in thousands of days of sampling. Given this observation, we focused on chronic risk evaluation. No pollutants were included for further evaluation unless they were detected at least 20% of the time (see the Data Analysis (Section 3.2.2) for more information on the rationale for this data requirement). Any individual sample that exceeded this initial screening was analyzed more closely. Those that did not exceed this value were not evaluated further because they were detected below comparison values that are believed to be "safe" levels of exposure and were many times lower than those known of suspected of causing adverse health effects. Twenty-two organic and inorganic pollutants exceeded a health based comparison value at one of the area air sampling stations. These pollutants include (See Appendices D and E for the full evaluation at each sampling site):

Metals/inorganics

Arsenic
Cadmium
Chlorine
Chromium
Chromium VI (Hexavalent chromium)
Cobalt
Manganese
Nickel

VOCs/organics

Acrolein
Acrylonitrile
Benzene
Bromodichloromethane
1,3-Butadiene
Carbon Tetrachloride
Chloroform
Dicromochloromethane
Ethylbenzene
Ethylene dichloride
Methyl tert butyl ether
Tetrachloroethylene
Trichloroethylene
1,2,4-Trimethylbenzene

3.2.5 Detailed Screening (Step 2)

Descriptive statistics were generated for the pollutants identified in Step 1, and the data were compared to health based comparison values specific to the sampling time frames. For example, instead of comparing 24-hour average samples to a chronic health based comparison value for cancer because it was the lowest CV as was done in Step 1, we calculated long-term averages to estimate long term exposures (all years). So, 24-hour sampling data were compared to acute health-based comparison values, and annually averaged data were compared to chronic health-based comparison values, etc.

Pollutants that were present at least 20% of the time and had measured data exceeding health based comparison values were evaluated further in Step 2. Of the 22 pollutants identified in Step 1, three metals (arsenic, cadmium, and manganese) and nine VOCs (acrolein, acrylonitrile, benzene, bromodichloromethane, 1-3-butadiene, carbon tetrachloride, chloroform, dibromochloromethane, and ethylene dichloride) were selected for further evaluation. This additional evaluation included a discussion of potential health effects for each of the 12 pollutants, as well as the modeled pollutants exceeding health based comparison values. See Appendices D and E for the full presentation of summary data at each sampling site.

3.2.5a Pollutants selected for further evaluation-VOCs

Acrolein

Acrolein is a volatile chemical used in some industries to make other products, and it also is emitted to the air from combustion of various fossil fuels (ATSDR, 2007a). The Midlothian facilities have never reported acrolein emissions to TRI, suggesting that the quantities of acrolein released by these facilities have consistently fallen below the reporting thresholds.

The only ambient air sampling for acrolein in the Midlothian area took place during the 2008-2009 study, when multiple 24-hour average samples were collected at seven locations. During this time, acrolein was reportedly detected in 83 out of the 86 samples at concentrations ranging from 0.14 $\mu g/m^3$ to 5.7 $\mu g/m^3$. This highest concentration was greater than 3.2 $\mu g/m^3$ —TCEQ's effects screening level for acute exposures to airborne acrolein. All other measurements were below this value. At the three stations with the greatest number of samples, average concentrations ranged from 0.69 $\mu g/m^3$ to 0.94 $\mu g/m^3$. These average concentrations are all considerably higher than U.S.EPA's Reference Concentration, or 0.021 $\mu g/m^3$. However, TCEQ reported that the average acrolein concentrations at the Midlothian monitoring sites fell within the range of average acrolein concentrations that had recently been observed during U.S.EPA's Schools Monitoring Initiative (TCEQ, 2010).

Since the 2008-2009 study was completed, U.S.EPA has reported on difficulties associated with measuring ambient air concentrations of acrolein. Specifically, recent research found that air pollution measurements of acrolein using stainless steel canisters (i.e., the method that was used in Midlothian) can be biased high for various reasons (U.S.EPA, 2010a). This finding, which was not published at the time the 2008-2009 study was completed, complicates efforts to interpret these results, due to the likelihood of a positive bias in the sampling results.

Health effects possible from exposure to acrolein

Acute exposure: Volunteers exposed to increasing levels of acrolein vapors for 35 minutes reported statistically significant nose irritation at 597 $\mu g/m^3$, throat irritation at 987 $\mu g/m^3$, and a decrease in respiratory rate at 1377 $\mu g/m^3$ (Weber-Tschopp et al. 1977; U.S. EPA, 2003). No statistically significant difference was observed between controls and subjects exposed to 390 $\mu g/m^3$. In the same study, constant exposure to 688 $\mu g/m^3$ acrolein for 40 minutes resulted in reports of mild nose irritation shortly after onset of exposure, while throat irritation was reported after 10 minutes. Based on the nose and throat irritation and a decrease in respiratory rate in humans exposed to acrolein, an acute-duration CV of 6.7 $\mu g/m^3$ has been calculated from the lowest observed adverse effect level (LOAEL) of 688 $\mu g/m^3$ (Weber-Tschopp et al., 1977; U.S. EPA, 2003a).

Intermediate or subchronic exposure: Feron et al. (1978) exposed rats, hamsters, and rabbits for six hours/day, five days/week for 13 weeks to 0; 900; 3,200 or 11,000 $\mu g/m^3$ acrolein in a whole-body exposure chamber. Tissue changes of the nasal cavity, lung, larynx, and trachea were observed from the various levels of exposure. Changes described as "slightly affected" were found in the nasal cavity of 1 of 12 rats exposed to 900 $\mu g/m^3$. Severity increased at the higher levels of exposure. No nasal lesions were reported in hamsters or rabbits at 900 µg/m^3. The severity of nasal lesions was concentration-related in all 3 species, most clearly so in the rat. In the 11,000 µg/m^3 groups of all three species, slightly to markedly increased lesions were reported in the nasal cavity and trachea; moderate to marked effects were seen in the bronchi and lungs of rats and rabbits (but not hamsters). The human equivalent concentration (a concentration calculated to take into account the differences in animal and human body size, respiration rate, and exposure duration) of the LOAEL concentration is 20 µg/m^3 (U.S. EPA, 2003a). Even if we assumed the measured concentration were accurate and not overestimating true measurements, average acrolein concentrations (from 0.69 µg/m^3 to 0.94 µg/m^3) in Midlothian are substantially lower than the LOAEL.

There are very few studies of the potential for acrolein to cause cancer. No human studies of acrolein exposure alone have been conducted, and a handful of rat and hamster studies have inconclusive results about whether or not acrolein exposure causes cancer. One study suggested weak associations between exposure and adrenal cortical tumors, but this study could not be replicated (U.S. EPA, 2003a).

Given the fact that the averages are well below acute and chronic health effect levels, this pollutant is not expected to harm people's health.

Acrylonitrile

Acrylonitrile is a chemical used in the manufacture of plastics and rubber. It is emitted to the air by industrial facilities that produce and use the chemical and by facilities that manage wastes that contain the chemical (ATSDR, 1990). Over the history of TRI reporting in Midlothian, the highest annual air releases from the facilities for acrylonitrile was 7 pounds, as self-reported by Ash Grove Cement in 1990.

The routine ambient air monitoring conducted by TCEQ has not measured concentrations of acrylonitrile. The first time this pollutant was measured in samples from Midlothian was during the 2008-2009 study, when 24-hour average air samples were collected from seven locations throughout the area and subsequently analyzed for acrylonitrile. The following paragraphs summarize these data:

Annual average concentrations. Three stations had at least 20 samples collected during an 8-month time frame in 2008-2009, and the measured concentrations were evaluated as indicators of annual average concentrations. At the Old Fort Worth Road monitoring site, acrylonitrile was never detected, and the average concentration at that site is likely beneath the detection limit. The detection limit for all sites was at or below the lowest health-based screening value for cancer endpoints (0.015 µg/m^3, an ATSDR CREG). This pollutant was measured above the detection limit three times at Jaycee Park (max = 0.25 µg/m^3) and four times at the Tayman Drive Wastewater Treatment Plant (max = 0.12 µg/m^3), but was not detected frequently enough at or above the CREG to constitute a chronic cancer risk. For non-cancer endpoints, even the highest estimates of average concentrations using the half detection limit substitution method (0.28 µg/m^3) are lower than the lowest health-based screening value for chronic exposures (2 µg/m^3, an U.S.EPA Reference Concentration). To be conservative, this pollutant and any other pollutant detected above the CREG was included in the cumulative risk assessment presented in Section 3.3.

24-hour average concentrations. Between 2008 and 2009, 86 24-hour average air samples were collected in the Midlothian area and analyzed for acrylonitrile. Only 12 of these resulted in detectable acrylonitrile concentrations, which ranged from 0.037 µg/m^3 to 0.29 µg/m^3. All of these values are considerably lower than 220 µg/m^3—the lowest health-based comparison value for acute inhalation exposures to acrylonitrile (ATSDR acute EMEG).

Health effects possible from exposure to acrylonitrile

Acute exposure: Workers in a synthetic rubber manufacturing plant exposed to concentrations of 34,750 to 217,200 µg/m^3 acrylonitrile for less than an hour experienced airway irritation, headaches, nausea, and stress (anxiety and apprehension) (U.S. EPA, 1991). They also experienced low grade anemia (decrease in red blood cells), leukocytosis (increase in white blood cell count that usually indicates an inflammatory response in the body), kidney irritation, and mild jaundice, which subsided when their exposure ceased (U.S. EPA, 1991). Human volunteers exposed acutely (8 hours) to acrylonitrile at concentrations of 5,400-10,900 µg/m^3 exhibited no adverse effects (U.S. EPA, 1991). ***These values are thousands of times higher than the highest acute concentration detection in Midlothian. Thus, exposures to the acute levels of acrylonitrile detected in Midlothian are not expected to harm people's health.***

Chronic exposure: The lowest concentration of exposure to acrylonitrile that has resulted in chronic non-cancer health effects that was used to determine U.S. EPA's RfC of 2 µg/m^3 is 1,900 µg/m^3 acrylonitrile (human equivalent dose to effects observed in a rat study) (U.S. EPA, 1991). This value is thousands of times higher than the highest detection in Midlothian.

Cancer is generally considered to be the most sensitive chronic exposure health outcome for acrylonitrile, and has been studied in animals and humans. Animal studies indicate that whole body exposures can result in tumors of the nervous system, digestive system, and ear canal. Of 12 studies evaluating cancer risk in humans, five suggested associations between cancer (particularly lung) and exposure to acrylonitrile. All of the studies had significant limitations such as methodology, definition and/or size of the population, existence of exposure to other carcinogens, and duration of the follow-up period (WHO, 2000). A long term epidemiological investigation by O'Berg (1980) is the most robust study to provide evidence of acrylonitrile as a human lung carcinogen, and is the basis of U.S.EPA's cancer inhalation unit risk value (IUR). Out of 1345 workers exposed to acrylonitrile, a total of 43 cases of cancer occurred versus 37.1 expected. Ten cases of lung cancer were observed versus 7.2 expected, based on the company rates (U.S. EPA, 1991). The 8-hour time-weighted average work day exposure was 33,000 µg/m^3. At an air concentration of 1 µg acrylonitrile per m^3, the lifetime risk is estimated to be 2×10^{-5} (an increased risk of two cases per 100,000 people). Interestingly, no lung tumors have been observed in animals, and no nervous system tumors have been observed in humans. ***Since no long term acrylonitrile concentrations exceed health based guidelines, and all concentrations are far below those noted in the epidemiologic literature to cause health effects acrylonitrile concentrations measured in the community are not expected to harm people's health.***

Benzene

Benzene is an organic compound that is emitted from many sources, including as a by-product from combustion of coal, oil, gasoline, and other fuels. Emissions from on-road motor vehicles accounts for a significant portion of the benzene released to the air every year in the United States (U.S.EPA, 2014). In Midlothian, the three cement manufacturing facilities—Ash Grove Cement, Holcim, and TXI—have all emitted benzene to the air, according to data available from the TRI and PSEI emission inventories. According to the emission inventories, the years with the highest reported benzene emissions were 1996 (based on data reported by TXI) and 2001-2004.

Between 1993 and 2011, ambient air monitoring for benzene was conducted at nine locations throughout the Midlothian area. At eight of these sites, 24-hour average samples were collected at set frequencies. In contrast, the Midlothian Tower site adopted a different schedule, including both 1-hour average and 24-hour average sampling events. The following paragraphs summarize data trends for different exposure durations and compare observed concentrations to health-based screening values:

Annual average concentrations. Only four of the nine monitoring stations that measured ambient air concentrations of benzene did so over time frames longer than one calendar year. Table 3 summarizes the annual average benzene levels observed at these four stations. The annual average levels of benzene between 1993 and 2000 ranged from 0.70 to 2.6 µg/m^3. These annual average concentrations were generally higher than the levels observed since 2000. The highest annual average concentration observed during this time was at the Tayman Drive Wastewater Treatment Plant (WWTP) monitoring station. Since 2000, the annual average concentrations ranged from 0.48 µg/m^3 to 0.80 µg/m^3. In several years, measurements simultaneously occurred at multiple stations—Midlothian Tower, Old Fort Worth Road, and Wyatt Road. The annual average benzene concentrations did not differ considerably across these sites in those years. At the one site with the longest period of record (Old Fort Worth Road), annual average benzene concentrations in recent years are roughly half as low as the annual average benzene concentrations observed at this site during the late 1990s.

Table 3 also presents the lowest health-based comparison values that ATSDR used to identify contaminants of concern. Every annual average concentration of benzene calculated for Midlothian was found to exceed ATSDR's CREG value for cancer endpoints (0.13 µg/m^3). However, it is not uncommon for benzene concentrations to exceed this screening value: a recent U.S.EPA assessment of air toxics in the United States found that annual average benzene concentrations exceeded this screening value at 152 out of the 154 trend sites used to characterize long term changes in outdoor air quality (U.S.EPA, 2014). According to this U.S.EPA assessment, the median annual average benzene concentration across the 154 trend sites in 2010 was 0.80 µg/m^3—higher than the benzene levels measured in Midlothian the same year.

In terms of non-cancer endpoints, none of the annual average benzene concentrations observed in Midlothian was found to exceed 9.6 µg/m^3, which is the lowest health-based screening value for chronic inhalation exposures based on health effects other than cancer (ATSDR chronic EMEG).

24-hour average concentrations. Between 1993 and 2011, 1,359 different 24-hour average air samples were collected for benzene. Of these sampling events, 1,348 resulted in detectable benzene concentrations, while only 11 resulted in non-detect observations. Out of the 1,359 samples, 3 had measured concentrations greater than 29 µg/m^3—ATSDR's health-based comparison value for acute exposures to airborne benzene. Those three measurements were: 66 µg/m^3 on May 9, 1995, at Tayman Drive WWTP; 41 µg/m^3 on March 19, 1999, at Old Fort Worth Road; and 30 µg/m^3 on October 20, 1998 at Old Fort Worth Road. The remaining 1,356 benzene measurements, or more than 99 percent of the measurements, had concentrations lower than ATSDR's corresponding screening value.

1-hour average concentrations. Between 1999 and 2006, 316 different 1-hour average samples were collected for benzene. These were all collected at the Midlothian Tower monitoring station, and they were only collected during the spring and summer months around sunrise and in the mid-afternoon. All samples had measured benzene concentrations less than 29 µg/m^3. The highest 1-hour measurement collected at this site was 14 µg/m^3 on September 10, 2004.

Table 3. Annual average benzene concentrations at selected monitoring sites, 1993-2011[a]

Year	Annual Average Benzene Concentrations (µg/m^3)[d]			
	Midlothian Tower	Old Fort Worth Rd	Wyatt Rd	Tayman Drive WWTP
Lowest screening value for cancer endpoints = 0.13 µg/m^3, ATSDR CREG				
Lowest screening value for non-cancer endpoints = 9.6 µg/m^3, ATSDR chronic EMEG				
1993	—[c]	—	—	1.25
1994	—	—	—	0.86
1995	—	—	—	2.62
1996	—	—	—	0.74
1997	—	1.15[b]	—	0.70[b]
1998	—	1.79	—	—
1999	—	1.47	—	—
2000	—	1.18	—	—
2001	—	0.70	—	—
2002	—	0.64	—	—
2003	—	0.70	—	—
2004	0.54[b]	0.64[b]	0.80[b]	—
2005	0.58	—	0.61	—
2006	0.51	0.51[b]	0.70[b]	—
2007	0.61[b]	0.64	—	—
2008	—	0.64	—	—
2009	—	0.51	—	—
2010	—	0.48	—	—
2011	—	0.48[b]	—	—

Notes: [a] Data were downloaded from TCEQ's Texas Air Monitoring Information System (TCEQ, 2013). The table presents data for only those monitoring sites that operated for at least one full calendar year.

[b] Monitoring site did not operate during the entire calendar year. Annual average concentrations are based on all valid measurements during the months when the site operated.

[c] Monitoring data were not collected at these sites during these years.

[d] When calculating annual averages, non-detect observations were replaced with concentrations equal to one-half the detection limit.

Health effects possible from exposure to benzene

The most sensitive health endpoint that indicates that benzene is harming the body is changes in blood cells, particularly the suppression of the body's production of white blood cells (acute and chronic exposure). There are five kinds of white blood cells produced in the blood marrow, and they fight off assault from infectious diseases and other substances foreign to the body. Thus, significant long term exposure to benzene can increase a person's chance of infection and developing cancer.

Acute exposures: Acute exposure to benzene concentrations over 960,000 µg/m^3 have been reported to cause drowsiness, dizziness, headaches, tremors, confusion, and loss of consciousness. In most cases, these symptoms are reversible with the cessation of exposure (ATSDR, 2007c).

The lowest acute observed adverse effect level for benzene in a mouse study used by ATSDR to derive our acute health-based guideline was 33,000 µg/m^3, and was based on the decrease in production of a type of white blood cells (lymphocytes). The mice were exposed for 6 hours a day for 6 consecutive days. The LOAEL was then adjusted to a human equivalent concentration to yield an adjusted human LOAEL of 8,145 µg/m^3. Then this value was divided by an uncertainty factor warranted by 1) using a LOAEL instead of a no observed adverse effect level (NOAEL); 2) extrapolating from a mouse study to humans; and 3) adjusting for human variability. Dividing 8,145 µg/m^3 by the uncertainty factor of 300 yields the ATSDR acute CV of 29 µg/m^3 (ATSDR, 2007c). ***Since the lowest adverse effect level in scientific studies is hundreds of time higher that the highest acute value measured in Midlothian, concentrations of benzene measured in the community are not expected to harm people's health.***

Chronic exposures: The study ATSDR's chronic health based comparison value was derived from was an occupational study of 250 shoe and clothing production workers in Tianjin, China. In the study, the critical effect (most sensitive) was again the depression of the production of lymphocytes (B cells). The study determined that workers exposed for one month to benzene concentrations as low as 1800 µg/m^3 had statistically significant decreases in white blood cells and blood platelets. Other studies have found depression of white blood cells at levels between 7,200 and 24,300 µg/m^3 (ATSDR, 2007c). U.S.EPA used another study of workers in Shanghai, China to derive the reference concentration for lifetime exposure by dividing an adjusted LOAEL of 8,700 µg/m^3 by an uncertainty factor of 1,000, yielding the chronic non-cancer RfC of 9 µg/m^3 (U.S EPA, 2003b).

The kind of cancer generally observed in people exposed to high levels of benzene in occupational settings is leukemia, a cancer of the blood or blood forming tissue in the body. Benzene is widely recognized as carcinogenic to humans. There are many studies that indicate that leukemia risk is elevated with increasing concentrations of ambient benzene in air (all studies reviewed for this analysis indicate that long term exposure concentrations were above 1 part per million (3,200 µg/m^3)) (WHO, 2000). The National Cancer Institute of the U.S. National Institutes of Health and the Chinese Academy of Preventative Medicine have been conducting a comprehensive epidemiological study of 75,000 benzene-exposed and 36,000 non benzene-exposed workers employed for 15 years in 700 factories in China. Employee work histories were linked to benzene exposure data in order to derive individual time-specific estimates for each worker (U.S EPA, 2003b). This large cohort mortality study produced a significantly elevated risk of blood/blood forming tissue tumors in workers exposed to benzene at an average of less than 32,000 µg/m^3. U.S.EPA has calculated the target cancer risk ranges as presented in Table 4.

Table 4. U.S.EPA cancer risk ranges and corresponding benzene concentrations

Risk Level	Concentration
10^{-4} (1 in 10,000)	13.0 to 45.0 µg/m^3
10^{-5} (1 in 100,000)	1.3 to 4.5 µg/m^3
10^{-6} (1 in 1,000,000)	0.13 to 0.45 µg/m^3

Source: U.S. EPA, 2003b

Most annual averaged benzene concentrations in Midlothian fall in the 10^{-6} (0.000001) risk range, with three years being in the 10^{-5} (0.00001) risk range. The added risk is very small compared to typical lifetime risks for people living in the United States, which the American Cancer Society (http://www.cancer.org) estimates to be one in two men (0.5) and one in three women (0.33). Benzene risks for each site can be found in Appendix G.

Although benzene concentrations in Midlothian exceed ATSDR's cancer health based comparison values at times, they are within U.S.EPA's target risk range, never exceeded chronic non-cancer risk values and are hundreds of times below levels known to cause cancer and non-cancer health effects. Furthermore, benzene concentrations in Midlothian are not notably different than benzene concentrations found in Ellis County, Texas, and throughout the United States. Thus, chronic benzene concentrations measured at Midlothian monitors are not expected to harm people's health.

Bromodichloromethane

In industry, bromodichloromethane was previously used for many purposes (e.g., as a fire retardant, fire extinguishing agent, and a solvent). Currently, its primary industrial use is in certain chemical reactions, and it is most often associated with being a byproduct of water chlorination (ATSDR, 1989). The TRI database does not have information on air emissions of bromodichloromethane, because the chemical is not included in the TRI reporting requirements. Therefore, the history of this chemical's emissions from the Midlothian facilities is not known.

The routine ambient air monitoring conducted by TCEQ has not measured concentrations of bromodichloromethane. The first time this pollutant was measured in samples from Midlothian was during the 2008-2009 study, when 24-hour average air samples were collected from seven locations throughout the area and subsequently analyzed for bromodichloromethane. The following paragraphs summarize these data:

Annual average concentrations. Three stations had at least 20 samples collected during an 8-month time frame in 2008-2009, and the measured concentrations were evaluated as indicators of annual average concentrations. At Old Fort Worth Road and Jaycee Park, bromodichloromethane was detected in only two and three samples, respectively. The half detection limit substitution-averaged concentrations at these sites were 0.016 $\mu g/m^3$ and 0.022 $\mu g/m^3$, respectively. These average values were calculated by replacing non-detect observations with concentrations of one-half the detection limit, and are both lower than the lowest health-based comparison value for cancer endpoints (0.07 $\mu g/m^3$, a U.S.EPA risk screening level).

In contrast, bromodichloromethane was detected in half of the samples collected at the Tayman Drive WWTP. The average concentration at this location (0.15 $\mu g/m^3$) was nearly 10 times higher than the values calculated for the other two sites and also higher than the health-based comparison value for cancer endpoints. Although the monitoring program was not designed to quantify air quality impacts from the water treatment facility, emissions from the water treatment operations may account for the higher concentrations that were consistently observed at this site.

For non-cancer endpoints, the highest estimate of average concentrations (0.15 $\mu g/m^3$) is lower than the lowest health-based screening value for chronic inhalation exposures (67 $\mu g/m^3$, a TCEQ Effects Screening Level).

24-hour average concentrations. Between 2008 and 2009, 86 24-hour average air samples were collected in the Midlothian area and analyzed for bromodichloromethane. The chemical was detected in 17 of these samples, with 0.67 µg/m^3 being the highest result. All of these values are considerably lower than 671 µg/m^{3}which is the lowest health-based comparison value for acute inhalation exposures to bromodichloromethane (a TCEQ effects screening level).

Health effects possible from exposure to bromodichloromethane
There are no supporting studies that indicate that bromodichloromethane is harmful when inhaled from outdoor air at the levels measured in Midlothian. Studies of acute and chronic exposure in animals are generally conducted by administering oral doses by gavage to study animals at high doses (orally administered in solution, directly into their stomachs). Only two mice inhalation studies were located that were conducted for sub-acute durations of 7 and 21 days, respectively (Torti et al., 2001). These studies indicated that the liver and kidneys are the target organs of exposure to bromodichloromethane. The lowest observed adverse effect level in these studies was 67,000 µg/m^3 and the no observed adverse effect level was 20,000 µg/m^3. The latter is 30,000 times the highest concentration detected in any sample in Midlothian (DWI, 2010).

Available data are inadequate to evaluate bromodichloromethane for human carcinogenicity, though it is known that laboratory-controlled ingestion exposure is associated with liver, kidney, and intestinal cancer in rats and mice (ATSDR, 1989). Some studies indicate the presence of cancer in humans with ingestion exposure to trihalomethanes like bromodichloromethane, but the studies could not differentiate the effects of bromodichloromethane from the hundreds of other byproducts in chlorinated water (NTP, 2011). There are no studies that demonstrate a relationship between inhalation exposure and cancer in animals or humans.

The major route of exposure to trihalomethanes like bromodichloromethane is through drinking tap water and bathing, since these chemicals are used to kill bacteria in the drinking water supply. Water treatment facilities are required to analyze treated water to ensure chlorination byproducts are present at safe levels. These data, if available, will be analyzed in ATSDR's health consultation titled, "*Review and Analysis of Volatile Organic Compounds and Metal Exposures from Air Emissions in Media Other than Air.*"

Drinking chlorinated water is the most likely route of exposure to bromodichloromethane. Since measured concentrations are far below those observed in studies to cause health effects, bromodichloromethane measured in Midlothian monitors is not expected to harm people's health.

1,3-Butadiene
1,3-Butadiene is a chemical emitted during certain industrial processes, such as rubber and plastic manufacturing. Automobile exhaust is a constant source of 1,3-butadiene release into the air (ATSDR, 2012b). Other sources of 1,3-butadiene include cigarette smoke and the smoke of wood fires. Of the four Midlothian facilities, only TXI has submitted TRI reports for 1,3-butadiene. According to the TRI submissions, the highest amount of air releases occurred in 1996, when stack emissions from TXI peaked at nearly 14,000 pounds of the chemical.

Between 1993 and 2011, ambient air monitoring for 1,3-butadiene was conducted at nine locations throughout the Midlothian area: 24-hour average samples were collected at all of these sites, and the

Midlothian Tower site also included some 1-hour average sampling. The following paragraphs summarize data trends for different exposure durations and compare observed concentrations to health-based screening values:

Annual average concentrations. Only four of the nine monitoring stations that measured ambient air concentrations of 1,3-butadiene did so over time frames longer than one calendar year. Table 5 summarizes the annual average 1,3-butadiene levels observed at these four stations. Between 1993 and 1997, the monitoring primarily occurred at the Tayman Drive WWTP, where annual average concentrations ranged from 0.20 µg/m^3 to 0.71 µg/m^3. Most of these annual average concentrations were higher than those observed from 1998 to 2011, which ranged from 0.27 µg/m^3 to 0.31 µg/m^3.

Between 2004 and 2007, 1,3-butadiene measurements simultaneously occurred at multiple stations throughout the Midlothian area. During this time, the annual average 1,3-butadiene concentrations were highly similar across the monitoring sites, suggesting a ubiquitous source. At the one monitoring site with the longest period of record (Old Fort Worth Road), annual average 1,3-butadiene concentrations changed little between 1998 and 2011.

Table 5 also presents the lowest health-based comparison values that ATSDR used to identify contaminants of concern. Every annual average concentration of 1,3-butadiene observed for the Midlothian monitoring sites was higher than ATSDR's CREG value for cancer endpoints (0.03 µg/m^3). However, it is not uncommon for 1,3-butadiene concentrations to exceed this screening value: a recent U.S.EPA assessment of air toxics in the United States found that annual average 1,3-butadiene concentrations exceeded this screening value at 76 of 137 trend sites used to characterize long term changes in outdoor air quality (U.S.EPA, 2014). According to ATSDR, mean concentrations of 1,3-butadiene in the air in cities and suburban areas ranges from 0.1 to 2 µg/m^3; the average background concentration of 0.13 µg/m^3 has been estimated. Within the general population, smokers (and individuals exposed to secondhand smoke) and individuals inhaling smoke from wood fires are likely to be exposed to higher levels of 1,3-butadiene (ATSDR, 2012b).

In terms of non-cancer endpoints, none of the annual average 1,3-butadiene concentrations observed in Midlothian exceeded U.S. EPA reference concentration of 2 µg/m^3, which is the lowest health-based chronic duration screening value for health effects other than cancer.

24-hour average concentrations. Between 1993 and 2011, more than 1,300 24-hour average air samples were collected for 1,3-butadiene. Of these sampling events, 189 resulted in detectable 1,3-butadiene concentrations, with the remainder being non-detects. None of the measured 1,3-butadiene concentrations in Midlothian was greater than 510 µg/m^3—a TCEQ effects screening level. The highest 24-hour measurement was 0.75 µg/m^3, collected at Tayman Drive WWTP on January 31, 1993.

1-hour average concentrations. Between 1999 and 2006, more than 300 1-hour average samples were collected for 1,3-butadiene. These were all collected at the Midlothian Tower monitoring station, and they were only collected during the spring and summer months around sunrise and in the mid-afternoon. All samples measured 1,3-butadiene concentrations less than 510 µg/m^3. The highest 1-hour measurement collected at this site was 0.38 µg/m^3 on September 6, 2003.

Table 5. Annual average 1,3-butadiene concentrations at selected monitoring sites, 1993-2011[a]

Year	Annual Average 1,3-Butadiene Concentrations (µg/m^3)[d]			
	Midlothian Tower	Old Fort Worth Rd	Wyatt Rd	Tayman Drive WWTP
Lowest screening value for cancer endpoints = 0.03 µg/m^3, ATSDR CREG				
Lowest screening value for non-cancer endpoints = 2 µg/m^3, U.S.EPA RfC				
1993	—[c]	—	—	0.20
1994	—	—	—	0.62
1995	—	—	—	0.58
1996	—	—	—	0.66
1997	—	0.58[b]	—	0.71[b]
1998	—	0.27	—	—
1999	—	0.29	—	—
2000	—	0.27	—	—
2001	—	0.29	—	—
2002	—	0.29	—	—
2003	—	0.29	—	—
2004	0.29[b]	0.29[b]	0.24[b]	—
2005	0.29	—	0.29	—
2006	0.29	0.31[b]	0.31[b]	—
2007	0.29[b]	0.27	—	—
2008	—	0.27	—	—
2009	—	0.29	—	—
2010	—	0.31	—	—
2011	—	0.31[b]	—	—

Notes: [a] Data were downloaded from TCEQ's Texas Air Monitoring Information System (TCEQ, 2013). The table presents data for only those monitoring sites that operated for at least one full calendar year.

[b] Monitoring site did not operate during the entire calendar year. Annual average concentrations are based on all valid measurements during the months when the site operated.

[c] Monitoring data were not collected at these sites during these years.

[d] When calculating annual averages, non-detect observations were replaced with concentrations equal to one-half the detection limit.

Health effects possible from exposure to these levels of 1,3-butadiene

1,3-Butadiene is emitted in motor vehicle exhaust, so is always present in outdoor air. High, short-term exposures can result in irritation of the eyes, nasal passages, throat, and lungs. Long term exposures have been shown to cause leukemia in workers exposed to high concentrations for long periods of time.

Acute exposure: Acute inhalation exposures to 1,3-butadiene have resulted in fetal effects and reproductive effects at levels as low as 88,500 µg/m^3. These effects include skeletal defects in offspring, retarded fetal growth, decreases in maternal weight gain, and deformities in the sperm of mice, rats, and rabbits. Health outcomes reported in the scientific literature differ: some studies report serious effects at low levels, while others report no adverse effects. Toxicity is highly variable from one animal species to another, so the same dose resulting in health effects in one species may not in another. These issues precluded ATSDR from calculating acute CVs in the newest version of the toxicological profile for 1,3-butadiene (ATSDR, 2012b). Regardless, the highest concentrations in Midlothian are tens of thousands of times lower than concentrations resulting in any adverse effects in any animal study identified at the time of this report (ATSDR, 2012b; U.S. EPA, 2002). ***Since the lowest adverse effect level in scientific studies is thousands of times higher than the highest acute value measured in Midlothian, acute duration concentrations of 1,3-butadiene measured in the community are not expected to harm people's health.***

Chronic exposure: Chronic-duration exposures results in increased lung weight/lung cell changes, mammary tumors, and kidney damage in rats; and reproductive damage (to testes and ovaries), liver cell death, abnormal over production of the tissue in the stomach, lung, and heart cells, and destruction of the sense of smell in mice. The most sensitive health outcome, or the outcome caused at the lowest concentration, was damage to ovaries of mice, which was observed at exposure to 13,800 µg/m^3 for 6 hours/day for 2 years; complete destruction of oocytes (eggs) and follicles was also observed. For many reasons, particularly for the different ways the various lab animals break down (metabolize) 1,3-butadiene, ATSDR did not calculate a chronic CV. However, U.S.EPA derived an RfC of 2 µg/m^3 for chronic exposure to 1,3-butadiene for non-cancer health effects (U.S. EPA, 2002).

Similar to benzene, the kind of cancer generally observed in people exposed to high levels of 1,3-butadiene in occupational settings is leukemia, a cancer of the blood or blood forming tissue in the body. 1,3-Butadiene is widely recognized as carcinogenic to humans. There are many studies that indicate that leukemia is elevated in workers who are consistently exposed for long periods of time to 1,3-butadiene, but few have quantified the exposures. Those studies that have suggest that levels of approximately 11,000 µg/m^3 are associated with an elevated risk of developing leukemia for polymer production workers exposed for 20 years or more (ATSDR, 2012b). Other studies suggest that workers exposed to 1,3-butadiene could also develop other kinds of cancer, but those studies are difficult to interpret because the workers were exposed to chemical mixtures that included many other pollutants (ATSDR, 2012b). The lowest concentration of 1,3-butadiene reported in the scientific literature where cancer was detected is 13,800 µg/m^3 for mice exposed for 6 hours/day for 2 years (NTP, 1993). These concentrations are 1,500 times higher than the highest annual average of 1,3-butadiene in the Midlothian monitoring data. U.S. EPA's target cancer risk ranges for 1,3-butadiene are as follows:

Table 6. U.S.EPA cancer risk ranges and corresponding 1,3-butadiene concentrations

Risk Level	Concentration
10^{-4} (1 in 10,000)	3 µg/m^3
10^{-5} (1 in 100,000)	0.3 µg/m^3
10^{-6} (1 in 1,000,000)	0.03 µg/m^3

Source: U.S. EPA, 2002

Annual averaged 1,3-butadiene concentrations in Midlothian fall in the 10^{-5} (0.00001) cancer risk range. The added risk is very small compared to typical lifetime risks for people living in the United States, which the American Cancer Society (http://www.cancer.org) estimates to be one in two men (0.5) and one in three women (0.33). 1,3-Butadiene risks for each site can be found in Appendix G.

Although 1,3-butadiene concentrations in Midlothian at times exceed ATSDR's cancer health based comparison values, they are within U.S.EPA's target risk range, never exceed chronic non-cancer risk values and are thousands of times below levels known to cause cancer and non-cancer health effects. Furthermore, 1,3-butadiene concentrations in Midlothian are not notably different than 1,3-butadiene concentrations found in Ellis County, Texas, and throughout the United States. Thus,

chronic 1,3-butadiene concentrations measured at Midlothian monitors are not expected to harm people's health.

Carbon Tetrachloride

Carbon tetrachloride is a synthetic chemical that was previously used in many applications, such as refrigeration and in aerosol cans. However, most industrial and commercial uses of the chemical have been phased out in recent decades due to concerns about how carbon tetrachloride affects the ozone layer (ATSDR, 2005a). Ash Grove Cement is the only Midlothian facility that reported carbon tetrachloride to TRI. This reporting only occurred in 1989 and 1991, and the air emissions of carbon tetrachloride reported in both years were less than 100 pounds.

Between 1993 and 2011, ambient air monitoring for carbon tetrachloride was conducted at nine locations throughout the Midlothian area. 24-Hour average samples were collected at all of these sites and 1-hour average sampling was also included at the Midlothian Tower site. The following paragraphs summarize data trends for different exposure durations and compare observed concentrations to health-based screening values:

Annual average concentrations. Only four of the nine monitoring stations that measured ambient air concentrations of carbon tetrachloride did so over time frames longer than one calendar year. Table 7 summarizes the annual average carbon tetrachloride levels observed at these four stations. Over the period of record, annual average concentrations of carbon tetrachloride ranged from 0.50 $\mu g/m^3$ to 1.95 $\mu g/m^3$. In several years, measurements simultaneously occurred at multiple stations. However, the annual average carbon tetrachloride concentrations did not differ considerably from one site to the next. At the site with the longest period of record (Old Fort Worth Road), annual average carbon tetrachloride concentrations were relatively constant between 1997 and 2011, with only minor variability between years.

Table 7 also presents the lowest health-based comparison values that ATSDR used to identify contaminants of concern. Every annual average concentration of carbon tetrachloride calculated for Midlothian was found to exceed ATSDR's CREG value of 0.17 $\mu g/m^3$ for cancer endpoints. It is not uncommon for carbon tetrachloride concentrations to exceed this screening value. A recent U.S.EPA assessment of air toxics in the United States found that annual average carbon tetrachloride concentrations exceeded this screening value at 109 of 116 trend sites used to characterize long term changes in outdoor air quality (U.S.EPA, 2014). According to this U.S.EPA assessment, the median annual average carbon tetrachloride concentration across the 116 trend sites in 2010 was 0.63 $\mu g/m^3$—identical to the annual average carbon tetrachloride concentration measured in Midlothian the same year.

In terms of non-cancer endpoints, none of the annual average carbon tetrachloride concentrations observed in Midlothian was found to exceed 13 $\mu g/m^3$, which is the lowest health-based chronic duration screening value for health effects other than cancer (a TCEQ effects screening level).

24-hour average concentrations. Between 1993 and 2011, 1,307 24-hour average air samples from the Midlothian area were analyzed for carbon tetrachloride. Of these sampling events, 1,178 resulted in detectable carbon tetrachloride concentrations, with 129 non-detects. Out of the 1,307 valid samples, none had measured concentrations greater than TCEQ's health-based comparison value for acute exposures to airborne carbon tetrachloride (126 µg/m^3). The highest 24-hour measurement was 27 µg/m^3, collected at Tayman Drive WWTP on September 24, 1996.

1-hour average concentrations. Between 1999 and 2006, 316 1-hour average samples were collected for carbon tetrachloride. These were all collected at the Midlothian Tower monitoring station and they were only collected during the spring and summer months around sunrise and in the mid-afternoon. All samples measured carbon tetrachloride concentrations less than 126 µg/m^3. The highest 1-hour measurement collected at this site was 2.8 µg/m^3 on July 1, 2000.

Table 7. Annual average carbon tetrachloride concentrations at selected monitoring sites, 1993-2011[a]

Year	Annual Average Carbon Tetrachloride Concentrations (µg/m^3)[d]			
	Midlothian Tower	Old Fort Worth Rd	Wyatt Rd	Tayman Drive WWTP
Lowest screening value for cancer endpoints = 0.20 µg/m^3, ATSDR CREG				
Lowest screening value for non-cancer endpoints = 13 µg/m^3, TCEQ AMCV/ESL (long-term)				
1993	—[c]	—	—	0.69[b]
1994	—	—	—	1.95[b]
1995	—	—	—	0.88
1996	—	—	—	1.26
1997	—	0.95[b]	—	0.57[b]
1998	—	0.76	—	—
1999	—	0.88	—	—
2000	—	1.01	—	—
2001	—	0.69	—	—
2002	—	0.63	—	—
2003	—	0.63	—	—
2004	0.63[b]	0.63[b]	0.57[b]	—
2005	0.69	—	0.69	—
2006	0.57	0.63[b]	0.50[b]	—
2007	0.57[b]	0.63	—	—
2008	—	0.57	—	—
2009	—	0.57	—	—
2010	—	0.63	—	—
2011	—	0.63[b]	—	—

Notes: [a] Data were downloaded from TCEQ's Texas Air Monitoring Information System (TCEQ, 2013). The table presents data for only those monitoring sites that operated for at least one full calendar year.

[b] Monitoring site did not operate during the entire calendar year. Annual average concentrations are based on all valid measurements during the months when the site operated.

[c] Monitoring data were not collected at these sites during these years.

[d] When calculating annual averages, non-detect observations were replaced with concentrations equal to one-half the detection limit.

Health effects possible from exposure to carbon tetrachloride

Carbon tetrachloride can cause adverse outcomes to the kidney and liver. It can also affect the nervous system if exposure is high enough. Generally, health effects from acute exposures will dissipate after exposure ceases unless severe damage has been done to the organs from exposure. Liver damage caused by exposure to carbon tetrachloride has been observed to be worse in people who consume alcohol.

Acute exposure: Acute inhalation and oral exposures to high levels of carbon tetrachloride have been observed primarily to damage the liver (swollen, tender liver, changes in enzyme levels, and jaundice) and kidneys (nephritis, nephrosis, and proteinurea) of humans at levels of exposure greater than 63,000 µg/m^3 (U.S EPA, 2010b), which is the NOAEL for humans and the LOAEL for rats. Depression of the central nervous system has also been reported. Symptoms of acute exposure in humans include headache, weakness, lethargy, nausea, and vomiting (U.S. EPA, 2010b), but these symptoms were reported at exposures of nearly 252,000 µg/m^3 (ATSDR, 2005a). No symptoms have been reported at levels as low as those in Midlothian, and the highest acute (24-hour) average concentration detected in Midlothian was over 2,000 times lower than the LOAEL of 63,000 µg/m^3, noted above. ***Since the lowest adverse effect level in scientific studies is thousands of times higher than the highest acute value measured in Midlothian, acute duration concentrations of carbon tetrachloride measured in the community are not expected to harm people's health.***

Chronic exposure: The liver and kidney are the most prominent targets of carbon tetrachloride in subchronic and chronic inhalation studies of laboratory animals. Liver effects (centrilobular fatty degeneration, necrosis, fibrosis, cirrhosis, hepatitis, and regenerative activity) were observed in animals exposed to carbon tetrachloride concentrations as low as 12,600 µg/m^3. Kidney damage was reported less frequently at higher concentrations than those causing liver damage. Cancer in humans has not been directly linked to carbon tetrachloride exposures, mostly because occupational exposures are complicated by the presence of significant quantities of other air pollutants (U.S.EPA, 2000b). Liver cancer has been reported in laboratory animals exposed chronically to carbon tetrachloride at air concentrations of 157,500 µg/m^3, but not in humans (ATSDR, 2005a). This concentration was used to derive the U.S. EPA cancer slope factor for evaluating ambient air data, and is many thousands of times higher than the highest annual averaged level of carbon tetrachloride in the community. U.S. EPA's target cancer risk ranges for carbon tetrachloride are as follows:

Table 8. U.S.EPA cancer risk ranges and corresponding carbon tetrachloride concentrations

Risk Level	Concentration
10^{-4} (1 in 10,000)	17 µg/m^3
10^{-5} (1 in 100,000)	1.7 µg/m^3
10^{-6} (1 in 1,000,000)	0.17 µg/m^3

Source: U.S. EPA, 2010b

Annual averaged carbon tetrachloride concentrations in Midlothian generally fall in the 10^{-6} (0.00001) cancer risk range. The added risk is very small compared to typical lifetime cancer risks for people living in the United States, which the American Cancer Society (http://www.cancer.org) estimates to be one in two men (0.5) and one in three women (0.33). Carbon tetrachloride risks for each site can be found in Appendix G.

Since chronic exposures to carbon tetrachloride are substantially lower than those observed to have caused health effects in scientific studies, and since levels of carbon tetrachloride are typical of those across the United States, long-term exposure to levels of carbon tetrachloride measured in Midlothian are not expected to harm people's health.

Chloroform

Chloroform is an organic chemical that is used to produce other products. Chloroform is emitted to the air by industrial facilities that produce and use the chemical, and also by facilities that manage wastes that contain the chemical. Chloroform may also be released to the air from a large number of sources related to its manufacture and use; it is also formed in the chlorination of drinking water, wastewater, and swimming pools. Pulp and paper mills, hazardous waste sites, and sanitary landfills are also sources of air emissions (ATSDR, 1997). Ash Grove Cement and TXI are the only two Midlothian facilities that have reported chloroform releases to TRI. The reported releases occurred in different years between 1989 and 2007, and never amounted to more than 10 pounds of self-reported emissions per year.

Between 1993 and 2011, ambient air monitoring for chloroform was conducted at nine locations throughout the Midlothian area. 24-Hour average samples were collected at all of these sites and 1-hour average sampling was included at the Midlothian Tower site The following paragraphs summarize data trends for different exposure durations and compare observed concentrations to health-based screening values:

Annual average concentrations. Only four of the nine monitoring stations that measured ambient air concentrations of chloroform did so over time frames longer than one calendar year. Table 9 summarizes the annual average chloroform levels observed at these four stations. Using the half detection limit substitution method for non-detects, annual average concentrations of chloroform ranged from 0.10 µg/m^3 to 1.22 µg/m^3, with the lowest levels observed in the most recent 5 years of data. Evaluating only detected data, averages for all samples were not nearly so high: 0.08 µg/m^3 at Tayman Drive (range: 0.06-0.12 µg/m^3 annual averages from 1993-1996); 0.05 µg/m^3 at Old Fort Worth Road (annual averages 0.06 µg/m^3 (1997) and 0.06 µg/m^3 (2007)); and 0.03 µg/m^3 at Midlothian Tower (0.07 µg/m^3 in 2007). This comparison of substituted versus censored data averaging demonstrates how substitution methods can inflate estimated averages. Concentration comparisons using the two methods showed the substitution method overestimated annual averages by between 2 and 20 times over what measured data estimated using censoring averaging methods. In several years, measurements simultaneously occurred at multiple stations—Midlothian Tower, Old Fort Worth Road, and Wyatt Road. The annual average chloroform concentrations were highly consistent across these sites between 2004 and 2006. At the one site with the longest period of record (Old Fort Worth Road), annual average chloroform concentrations in recent years (0.10–0.29 µg/m^3) are lower than the levels that were observed at this station in the late 1990s (0.44–0.78 µg/m^3).

Table 9 also presents the lowest health-based comparison values that ATSDR used to identify contaminants of concern. Every annual average concentration of chloroform calculated for Midlothian was found to exceed ATSDR's CREG value for cancer endpoints (0.04 µg/m^3). For reference on the magnitude of these concentrations, typical background concentrations of chloroform usually range between 0.1 and 10 µg/m^3 in outdoor air. In the early 1990s, U.S.EPA determined that the United States average background concentration was 0.2 µg/m^3 (U.S.EPA, 2000c) and between 0.17 and 43.9 µg/m^3 in indoor air (NTP, 2011), which are also above the ATSDR CREG.

In terms of non-cancer endpoints, none of the annual average chloroform concentrations observed in Midlothian exceeded the long term TCEQ air monitoring comparison value of 9.7 µg/m^3, which is the lowest health-based chronic duration screening value for health effects other than cancer.

24-hour average concentrations. Between 1993 and 2011, 1,361 24-hour average air samples in Midlothian were analyzed for chloroform. Of these sampling events, 545 resulted in detectable chloroform concentrations, and 816 were non-detects. Every chloroform sampling result in Midlothian was less than the lowest identified health-based comparison value for acute exposures to airborne chloroform of 97.3 µg/m^3 (a TCEQ effects screening level). The highest 24-hour measurement was 1.27 µg/m^3, collected at Old Fort Worth Road on August 25, 2003.

1-hour average concentrations. Between 1999 and 2006, 316 1-hour average samples were collected for chloroform. These were all collected at the Midlothian Tower monitoring station, and they were only collected during the spring and summer months around sunrise and in the mid-afternoon. All samples had measured chloroform concentrations less than 97.3 µg/m^3. The highest 1-hour measurement collected at this site was 1.90 µg/m^3 on September 6, 2003.

Table 9. Annual average chloroform concentrations at selected monitoring sites, 1993-2011[a]

Year	Annual Average Chloroform Concentrations (µg/m^3)[d]			
	Midlothian Tower	Old Fort Worth Rd	Wyatt Rd	Tayman Drive WWTP
Lowest screening value for cancer endpoints = 0.04 µg/m^3, ATSDR CREG				
Lowest screening value for non-cancer endpoints = 9.7 µg/m^3, TCEQ AMCV (Long Term)				
1993	—[c]	—	—	0.58
1994	—	—	—	0.29
1995	—	—	—	0.83
1996	—	—	—	1.17
1997	—	0.78[b]	—	1.22 [b]
1998	—	0.44	—	—
1999	—	0.49	—	—
2000	—	0.49	—	—
2001	—	0.49	—	—
2002	—	0.49	—	—
2003	—	0.49	—	—
2004	0.44[b]	0.44[b]	0.39[b]	—
2005	0.44	—	0.49	—
2006	0.49	0.49[b]	0.49[b]	—
2007	0.24[b]	0.24	—	—
2008	—	0.10	—	—
2009	—	0.10	—	—
2010	—	0.15	—	—
2011	—	0.29[b]	—	—

Notes: [a] Data were downloaded from TCEQ's Texas Air Monitoring Information System (TCEQ, 2013). The table presents data for only those monitoring sites that operated for at least one full calendar year.

[b] Monitoring site did not operate during the entire calendar year. Annual average concentrations are based on all valid measurements during the months when the site operated.

[c] Monitoring data were not collected at these sites during these years.

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[d] When calculating annual averages, non-detect observations were replaced with concentrations equal to one-half the detection limit.

Health effects possible from exposure to chloroform

The predominant pathway of human exposure to chloroform is through exposure to public water supplies. Chloroform is the most predominant trihalomethane in treated water, and is a byproduct of water disinfection (U.S.EPA, 2001a). Ingestion and inhalation of, and dermal contact with chlorinated water while drinking tap water, bathing, or swimming in chlorinated pools can be substantial. For example, two college swimmers were evaluated for chloroform uptake during a two-hour swim practice. Over the course of their swim, levels of chloroform as high as 371 µg/m^3 were detected in their exhaled breath. The researchers theorized this was the result of both inhalation and dermal exposure (NTP, 2011).

Like carbon tetrachloride, chloroform can cause adverse outcomes to the kidney and liver. It can also affect the nervous system if exposure is high enough. Generally, health effects from acute exposures will dissipate after exposure ceases unless severe damage has been done to the organs from exposure.

<u>Acute exposure:</u> The most recent summary of toxicological research on chloroform is from the World Health Organization (WHO) from 2004. The lowest concentration reported to result in measureable adverse health effects is 9,800 µg/m^3 in certain strains of mice and rats, which caused changes in nasal cavity cell growth. This concentration is thousands of times higher than the highest concentration of chloroform measured in Midlothian.

In general, chloroform affects humans in similar ways as laboratory animals. Chloroform was used in the past as a medical anesthetic, and people were commonly exposed to extremely high doses (12–73 g/m^3-or 12,000,000-73,000,000 µg/m^3 chloroform). Using chloroform as an anesthetic was discontinued because it was associated with deaths due to heart and breathing failures. Many people who came through the anesthesia experienced a number of neurological and liver symptoms including nausea, vomiting, prostration, jaundice, and coma due to liver dysfunction. WHO (2004) also reports that 1-hour exposure at less than 250,000 µg/m^3 has been reported to cause discomfort. ***Since acute chloroform levels measured in Midlothian are substantially lower than those that have been observed to cause acute health effects in scientific studies, exposure to chloroform levels measured in Midlothian are not expected to harm people's health.***

<u>Chronic exposure:</u> Chronic studies of laboratory animals show evidence of liver and kidney damage with long term inhalation exposures to high levels of chloroform. The toxicity to the animal varies significantly with the type and sex of the animal. For example, female mice in these studies did not appear to develop tumors on their livers and kidneys, whereas male mice did. Furthermore a type of lab mouse called a "BDF1" mouse appears to be more sensitive to exposures than "F344" mice. Regardless, no effects were identified in animals with less exposure than 142,000 µg/m^3 in these studies (WHO, 2004).

There are few chronic studies of human exposures where health outcomes can be attributable only to chloroform, and no reliable human studies evaluating cancer outcomes have been identified. One study reported jaundice in workers exposed for four months after exposure to 80,000–160,000 µg/m^3 for less than 4 months while another study reported elevated rates of hepatitis in workers exposed to 10,000-1,000,000 µg/m^3 for 1-4 years (WHO, 2004). U.S. EPA's inhalation unit risk for chloroform exposure and ATSDR's CREG were derived in the 1990s based on liver cancer in female mice dosed orally with chloroform and not from an inhalation exposure study (U.S. EPA, 2001a). ATSDR's calculation of cancer risk from exposure to chloroform at the various air monitoring sites ranged from the 10^{-6} (0.000001) to 10^{-7} (0.0000001) risk range, which suggests no increased cancer risk from long term exposure to chloroform (lifetime risk for the average American is 0.33-0.5 (33% chance for females to 50% chance for males of developing cancer)). ***Given that chloroform is measured at concentrations across all monitoring sites for all years that are well below those known to cause adverse health effects and that concentrations are typical of suburban environmental exposures across the United States, long-term averaged chloroform levels measured in Midlothian are not expected to harm people's health.***

Dibromochloromethane

In industry, dibromochloromethane was previously used for many purposes (e.g., as a fire extinguishing agent, refrigerator fluid, and spray can propellants). It is also formed as a byproduct when drinking water is chlorinated (ATSDR, 2005b). The TRI database does not have information on air emissions of dibromochloromethane, because the chemical is not included in the TRI reporting requirements. Therefore, the history of dibromochloromethane emissions from the Midlothian facilities is not fully known, though this chemical is not typically associated with cement and steel manufacturing.

The routine ambient air monitoring conducted by TCEQ has not measured concentrations of dibromochloromethane. The first time this pollutant was measured in samples from Midlothian was during the 2008-2009 study, when 24-hour average air samples were collected from seven locations throughout the area and subsequently analyzed for dibromochloromethane. The following paragraph summarizes these data:

Annual average concentrations. Three stations had at least 20 samples collected during an 8-month time frame in 2008-2009 and the measured concentrations were evaluated as indicators of annual average concentrations. At Jaycee Park, dibromochloromethane was detected in 1 out of 22 samples, with an annual average concentration of 0.009 µg/m^3. At Old Fort Worth Road, dibromochloromethane was detected in 2 out of 20 samples, with an annual average concentration of 0.001 µg/m^3. Both of these annual average concentrations were calculated by replacing non-detect observations with one-half the detection limit, and both averages were lower than the lowest health-based comparison values for cancer endpoints (0.10 µg/m^3, a U.S.EPA risk screening level) and for non-cancer endpoints (2 µg/m^3, a TCEQ effects screening level).

At Tayman Drive WWTP, dibromochloromethane was detected in 14 out of 24 samples collected. After replacing non-detects with concentrations of one-half the detection limits, the average dibromochloromethane concentration for this site was 0.19 µg/m^3. This average value is higher than the lowest health-based comparison value for cancer endpoints (0.09 µg/m^3) but lower than the value for non-cancer endpoints (2 µg/m^3).

24-hour average concentrations. Between 2008 and 2009, 86 different 24-hour average air samples were collected in the Midlothian area and analyzed for dibromochloromethane. The highest concentration measured was 0.66 µg/m^3 in a sample collected from the Tayman Drive WWTP station. Every measured dibromochloromethane concentration was considerably lower than the lowest health-based comparison value for acute inhalation exposures to dibromochloromethane of 20 µg/m^3 (a TCEQ effects screening level).

Health effects possible from exposure to dibromochloromethane
Most people receive their greatest dibromochloromethane exposure from drinking chlorinated water or from breathing it while bathing in chlorinated water. Slight elevations at Tayman Drive WWTP are most likely the result of water treatment processes and not emissions from the facilities of interest. Exposures to high levels can result in central nervous system, liver, and kidney health effects, but the liver is the most sensitive organ. No inhalation studies exist for dibromochloromethane in animals or humans. Most studies of health effects are oral dosing of animals to high levels of dibromochloromethane (ATSDR, 2005b). Health effects occur in these animals at doses hundreds of thousands of times the doses from inhalation of Midlothian levels of this pollutant.

Drinking chlorinated water is the most likely route of exposure to dibromochloromethane. Since measured concentrations are far below those observed in studies to cause health effects, dibromochloromethane measured in Midlothian monitors is not expected to harm people's health.

Ethylene Dichloride
Ethylene dichloride, also referred to as 1,2-dichloroethane or 1,2-DCA, is a synthetic chemical that is currently used primarily to make other chemicals and plastics. It is emitted to the air by industrial facilities that produce and use the chemical and by facilities that manage wastes that contain the chemical. None of the Midlothian facilities has reported releases of 1,2-DCA to TRI. This most likely means that any amounts of this chemical that the facilities use and release into the environment fall below thresholds that would trigger reporting to TRI.

Between 1993 and 2011, ambient air monitoring for 1,2-DCA was conducted at nine locations throughout the Midlothian area. 24-Hour average samples were collected at all of these sites and 1-hour average sampling was also included at the Midlothian Tower site. The following paragraphs summarize data trends for different exposure durations and compare observed concentrations to health-based screening values:

Annual average concentrations. Only four of the nine monitoring stations that measured ambient air concentrations of 1,2-DCA did so over time frames longer than one calendar year. It is difficult to estimate the actual annual average air concentrations of this chemical in Midlothian, because ethylene dichloride was detected in fewer than 16 percent of the samples that have been collected to date. Using substitution methods (assuming nondetects were one half the measurement detection limit) ATSDR calculated annual averages. However, these averages are likely to be overestimated.

The lowest screening value for cancer endpoints is 0.04 µg/m^3, an ATSDR CREG. Detection limits of between 0.008 µg/m^3 and 0.04 µg/m^3 were achieved for the sampling sites in the 2008-2009 study in Midlothian, and none of the samples collected during that time frame had measured concentrations above these detection limits. Therefore, even though the many non-detects prevent a reliable estimate of the annual average concentrations for 1,2-DCA, the data from the 2008-2009 study indicate that the annual average value concentrations were less than the lowest screening value for cancer endpoints.

Prior to 2008, all laboratory analyses for 1,2-DCA were conducted by TCEQ, and the reporting limit for those analyses was 0.04 µg/m^3. Using the half detection limit substitution methods, 1,2-DCA was detected most frequently at the Tayman Drive WWTP site, where the highest estimated annual average concentration was higher than ATSDR's CREG (0.18 µg/m^3). However, using the ROS method, the highest annual mean concentration was 0.05 µg/m^3, which is substantially lower than the substitution method average. It is possible that emissions from the water treatment plant contributed to these measured concentrations because estimated annual average concentrations of 1,2-DCA were considerably lower at the other monitoring stations (Midlothian Tower and Old Fort Worth Road) and was not detected at all at Wyatt Road. Typical concentrations of 1,2-DCA in the United States reportedly range from 0.05-1.0 µg/m^3 (U.S. EPA, 2000d) in urban environments, similar to the ranges detected in Midlothian.

In terms of non-cancer endpoints, even though annual average concentrations cannot be reliably calculated due to the numerous non-detects, it is clear from the magnitude of the detection limits that annual average levels of 1,2-DCA at the Midlothian sampling locations could not have been greater than the lowest health-based screening value for health effects other than cancer of 4 µg/m^3 (a TCEQ effects screening level).

24-hour average concentrations. Between 1993 and 2011, 1,361 24-hour average air samples were collected in the Midlothian area and analyzed for 1,2-DCA. Of these, 213 resulted in detectable concentrations of 1,2-DCA, and the rest were non-detects. None of the measured concentrations exceeded the lowest health-based comparison value for acute inhalation exposures to airborne 1,2-DCA of 16 µg/m^3 (a TCEQ effects screening level). The highest 24-hour measurement was 1.9 µg/m^3 which was collected at Tayman Drive WWTP on June 24, 1993.

1-hour average concentrations. Between 1999 and 2006, 316 1-hour average samples were collected for 1,2-DCA at the Midlothian Tower monitoring station during the spring and summer months around sunrise and in the mid-afternoon. Out of 316 valid samples, only 8 had detectable concentrations of 1,2-DCA. The highest 1-hour average concentration was 0.36 µg/m^3, collected on August 15, 2003, which was well below the lowest health-based comparison value (a TCEQ effects screening level) for acute inhalation exposures (162 µg/m^3).

Health effects possible from exposure to ethylene dichloride

1,2-DCA affects the central nervous system, liver, and kidneys at high exposures. There are very few studies of humans exposed to 1,2-DCA and most of what is known about it is from intentional or accidental poisoning by ingestion of pure 1,2-DCA. In those instances, the exposed individuals died from circulatory system failure (ATSDR, 2001; NRC, 2008).

<u>Acute exposure:</u> The studies that exist on health outcomes from exposure to 1,2-DCA show that humans generally experience central nervous system and gastrointestinal effects from acute exposures. Animal studies have also identified effects that occur in the liver and kidney of various animal species at levels over 4,000,000 µg/m^3. Workers who survived exposure to short term high levels (greater than 304,000 µg/m^3) of 1,2-DCA experienced a range of neurological symptoms including dizziness, headache, and weakness, as well as gastrointestinal symptoms such as nausea, vomiting, and stomach cramps (ATSDR, 2001; NRC, 2008). These concentrations were nearly a million times as high as the highest 1-hour concentration measured in Midlothian (0.36 µg/m^3). ***Since levels of 1,2-DCA in***

Midlothian were substantially lower than any concentrations linked with health effects in scientific studies, exposure to these acute (short-term) concentrations are not expected to harm people's health.

Chronic exposure: Symptoms of chronic and subchronic exposures are similar to those observed in acute studies of exposure. Some workers exposed to 40,500 µg/m^3 or more of 1,2-DCA in air for up to 8 months experienced dizziness, sleepiness, a strange taste in their mouths, dry mouth, nausea, vomiting, constipation, and gastric pain. However, it should be noted that these workers were also exposed to benzene (the mixture they were exposed to was 80% 1,2-DCA and 20% benzene). No studies could be found that identified a relationship between inhaling 1,2-DCA and developing cancer in humans. However, one inhalation study and some dermal and ingestion studies indicate that animals who are dosed with 1,2-DCA on their skin or by gavage (orally, directly into their stomachs) have developed cancerous tumors on their skin and in their bodies (stomach, circulatory system, mammary (breast) tissue, lung, liver, kidneys, etc.) (ATSDR, 2001; Nagano et al., 2006; NRC, 2008). Oral exposure studies of rats are the basis of the U.S. EPA inhalation unit risk (IUR) and the ATSDR CREG. Based on the IUR, the cancer risk range for 1,2-DCA was in the 10^{-6} cancer risk range at Tayman Drive, and lower at other sites, where it was detected in a small number of samples. ***Long-term concentrations of 1,2-DCA detected across all monitoring sites for all years are well below those known to cause adverse health effects. Thus, exposure to these concentrations of 1,2-DCA is not expected to harm people's health.***

3.2.5b Pollutants selected for further evaluation-Metals

Metals present in ambient air are measured in suspended dust particles. Generally, suspended particles are measured in three sizes ("size fractions"). These include particles that are 2.5 microns (µm) in size ("aerodynamic diameter") which is represented as particulate matter that is 2.5 µm or smaller ($PM_{2.5}$); particles that have an aerodynamic diameter of 10 microns or less are called PM_{10} (and include $PM_{2.5}$); or metals measured in total dust, with particles of any aerodynamic diameter, called Total Suspended Particles (TSP). In Midlothian, metals in PM_{10} and $PM_{2.5}$ were measured and reported. Inhaling coarse particles can contribute to ingestion exposure due to entrapment in the mucosal lining of the upper airways and being swallowed. Inhaled fine particles (typically 2.5 µm or smaller) can lodge deep in the lungs and penetrate the gas exchange region of the lungs (respiratory bronchioles, alveolar ducts, and alveoli) and cross directly into the blood stream. Thus, generally, the smaller the particle, the more easily the body is affected by the inorganic pollutant. TCEQ has measured metals in Midlothian in all three size fractions in different sampling locations over different time periods.

Arsenic

Arsenic is a naturally occurring metal that is found in soil and many types of rock. Arsenic is released to the atmosphere by industrial facilities that process mineral ores and by facilities that burn coal and other fuels containing trace amounts of arsenic. The Midlothian facilities have never reported arsenic emissions to TRI, suggesting that the quantities of arsenic used or manufactured at these facilities have consistently fallen below the reporting thresholds. Nonetheless, all four facilities likely have emitted some quantities of arsenic, as supported by data in the PSEI inventory.

Arsenic is present in ambient air as a component of particulate matter. The arsenic measurements that ATSDR determined to be of known and high quality were first collected in 2001. All available measurements are 24-hour average samples, and the majority of these were collected once every six days. The following paragraphs summarize data trends for different particle size fractions and exposure durations and compare observed concentrations to health-based comparison values.

Arsenic- PM_{10} Measurements

Annual average PM_{10} concentrations. The station with the longest duration of arsenic monitoring was Wyatt Road (January 2001–June 2004). There were four stations that had at least 20 samples collected during an 8-month time frame in 2008-2009. Although arsenic was never detected in the Wyatt Road samples, the detection limit was 1000 times higher than the ATSDR Cancer Risk Evaluation Guide of 0.0002 µg/m^3. This was not true in the 2008-2009 study, which had substantially lower detection limits. Table 10 shows that the average arsenic levels observed in 2008-2009 did not vary considerably from one location to the next.

Every average concentration of arsenic presented in Table 10 is higher than ATSDR's Cancer Risk Evaluation Guide. However, it is not uncommon for arsenic concentrations to exceed this screening value. A recent U.S.EPA assessment of air toxics in the United States found that annual average arsenic concentrations in PM_{10} exceeded this screening value at 23 out of 27 trend sites used to characterize long term changes in outdoor air quality (U.S.EPA, 2014). According to this U.S.EPA assessment, the median annual average arsenic concentration in PM_{10} across the trend sites in 2010 was 0.00061 µg/m^3, which falls within the range of arsenic concentrations measured in Midlothian during the 2008-2009 study.

To screen the data for non-cancer health concerns, ATSDR compared the average concentrations in Table 10 to the long term TCEQ Air Monitoring Comparison Value of 0.07 µg/m^3. No annual averages for any sites exceeded this screening value.

The Texas Natural Resource Conservation Commission (TNRCC, now known as TCEQ) conducted an air quality study in Midlothian in the early 1990s. In the first Health Consultation for this site, ATSDR expressed some data quality concerns about the old TNRCC study. ATSDR noted that arsenic was detected in fewer than 4 percent of samples collected during that earlier study, but the detection limit in the study was above the ATSDR CREG (ATSDR 2015).

24-hour average PM_{10} concentrations. Between 2001 and 2009, 304 24-hour average PM_{10} air samples were collected in the Midlothian area and analyzed for arsenic. The highest arsenic concentration in PM_{10} recorded among these samples was 0.012 µg/m^3. This measurement, and every other arsenic PM_{10} concentration, is considerably lower than the lowest health-based comparison value that ATSDR identified for acute inhalation exposure to arsenic (9.9 µg/m^3, a TCEQ air monitoring comparison value). ATSDR did not review the basis of the TCEQ AMCV for arsenic.

Table 10. Average arsenic concentrations in PM_{10}, 2008-2009

Year	Average Concentration (µg/m³), by Monitoring Station[c]			
	2008-2009 URS Study[a]			
	Old Fort Worth Rd	Jaycee Park	Wyatt Rd	Tayman Drive WWTP
Lowest screening value for cancer endpoints = 0.0002 µg/m³, ATSDR CREG				
Lowest screening value for non-cancer endpoints = 0.07 µg/m³, TCEQ's (Long-Term) AMCV				
2009	***0.0006*** [b]	***0.0006*** [b]	***0.0010*** [b]	***0.0005*** [b]

Notes: NM = not measured

Numbers in bold, italic font are average concentrations that exceed the health-based comparison value for cancer endpoints: 0.0002 µg/m³ (ATSDR's CREG). None of these average concentrations exceeded the lowest comparison value for chronic exposure derived for non-cancer endpoints: 0.07 µg/m³ (TCEQ's Long-Term AMCV/ESL).

[a] 2008-2009 URS study data were accessed from TCEQ's website (http://www.tceq.state.tx.us/implementation/tox/research/Midlothian.html).

[b] The 2008-2009 URS study had air quality measurements from December 2008 through July 2009. The average concentrations for the four stations sampled most frequently are presented in the table. Average concentrations listed for 2009 are based on measurements throughout the program, even though some of the measurements were collected in 2008.

[c] When calculating annual averages, non-detect observations were replaced with concentrations equal to one-half the detection limit.

Arsenic- $PM_{2.5}$ Measurements

Annual average $PM_{2.5}$ concentrations. Only two stations in the Midlothian area measured arsenic in the $PM_{2.5}$ size fraction. This monitoring occurred at Midlothian Tower between May 2002 and August 2005, and at Old Fort Worth Road beginning in September 2005 and continues today. The highest annual average arsenic concentrations in $PM_{2.5}$ observed at these stations were 0.0014 µg/m³ at Midlothian Tower in 2004 and 0.0012 µg/m³ at Old Fort Worth Road in 2007. The annual average concentrations calculated for these two sites exceeded ATSDR's CREG comparison value for arsenic (0.0002 µg/m³), but did not exceed the screening value developed for chronic exposure and non-cancer endpoints (0.07 µg/m³).

24-hour average $PM_{2.5}$ concentrations. Between 2002 and 2011, 578 24-hour average $PM_{2.5}$ air samples were collected in the Midlothian area and analyzed for arsenic. The highest arsenic concentration in $PM_{2.5}$ observed among these samples was 0.0098 µg/m³ from a sample collected at TCEQ's Midlothian Tower monitoring station in 2004. All measurements of arsenic in $PM_{2.5}$ were lower than the lowest health-based comparison value that ATSDR identified for acute inhalation exposure to arsenic (9.9 µg/m³, a TCEQ air monitoring comparison value).

Table 11. Average arsenic concentrations in $PM_{2.5}$, 2002-2011

Average Concentration (µg/m^3), by Monitoring Station		
Lowest screening value for cancer endpoints = 0.0002 µg/m^3, ATSDR CREG		
Lowest screening value for non-cancer endpoints = 0.07 µg/m^3, TCEQ's (Long-Term) AMCV		
Year	**Midlothian OFW**	**Midlothian Tower**
2002	†	***0.00111***
2003	†	***0.00131***
2004	†	***0.00144***
2005	*	*
2006	***0.00115***	†
2007	***0.00116***	†
2008	*	†
2009	*	†
2010	*	†
2011	†	†

Numbers in bold, italic font are average concentrations that exceed the health-based comparison value for cancer endpoints: 0.0002 µg/m^3 (ATSDR's CREG). None of these average concentrations exceeded the lowest comparison value for chronic exposure derived for non-cancer endpoints: 0.07 µg/m^3 (TCEQ's Long-Term AMCV/ESL).

--- † Monitor Site Not Active; * greater than 80% non-detect;
Data source: TCEQ, 2013

Health effects possible from exposure to arsenic

Most data on human health effects resulting from arsenic exposure come from occupational studies of workers at smelters and chemical plants. These workers generally have exposure pathways beyond inhalation (dermal or oral exposures) and generally are exposed to other pollutants in addition to arsenic, so evaluating the inhalation pathway alone can be challenging (ATSDR, 2007b; U.S.EPA, 2012).

Acute exposure: Acute (short-term) high-level exposure to arsenic dust or fumes has resulted in gastrointestinal effects (nausea, diarrhea, abdominal pain) and central and peripheral nervous system disorders (U.S.EPA, 2012). However, ambient concentrations of arsenic were not measured in these studies and the exposures resulting in these effects are unknown. It is known that ingestion of arsenic can cause these effects at doses of 0.05 mg/kg/day or greater. The equivalent concentrations in air to produce these types of health effects are likely to be higher than 100 µg/m^3 (ATSDR, 2007b). In animal studies, subtle health effects (increased susceptibility to bacteria) were observed in mice at levels above 271 µg/m^3 (ATSDR, 2007b). This lowest acute LOAEL is over 27,000 times higher than the highest 24-hour average of arsenic in Midlothian. ***Given that measured arsenic concentrations in the community are well below levels associated with acute health effects, acute exposure to arsenic is not expected to harm people's health.***

Chronic exposure: Chronic (long-term) inhalation exposure to inorganic arsenic of humans is associated with irritation of the skin and mucous membranes and effects in the brain and nervous system. Non-cancer symptoms including cardiovascular (like Reynaud's phenomenon and numbness in fingers, heart arrhythmia, congestive heart failure, etc.), dermal effects (dermatitis and discoloration, like blackfoot disease), and neurological effects have been demonstrated to occur in workers exposed chronically to greater than or equal to 360 µg/m^3, 78 µg/m^3, and 310 µg/m^3, respectively. The most sensitive endpoint in workers exposed for many years is the development of cancer. Long term inhalation exposure (>30 years) has been shown to be strongly associated with lung cancer at levels as low as 50 µg/m^3 (ATSDR, 2007b). U.S. EPA's target cancer risk ranges for arsenic are as follows:

Table 12. U.S.EPA cancer risk ranges and corresponding arsenic concentrations

Risk Level	Concentration
10^{-4} (1 in 10,000)	0.02 µg/m^3
10^{-5} (1 in 100,000)	0.002 µg/m^3
10^{-6} (1 in 1,000,000)	0.0002 µg/m^3

Source: U.S. EPA, 1998

Concentrations of arsenic in Midlothian correspond with the 10^{-5} (0.00001) to 10^{-6} (0.000001) cancer risk range. The added risk is very small compared to typical lifetime risks for people living in the United States, which the American Cancer Society (http://www.cancer.org) estimates to be one in two men (0.5) and one in three women (0.33). Arsenic risks for each site can be found in Appendix G.

The levels of arsenic in air are far below levels associated with the development of cancer in occupational studies (over 7,500 times lower) or experiencing acute or long-term non-cancer health effects (over 15,000 times lower) in the scientific literature. Furthermore, risk from arsenic exposure in Midlothian does not appear to be substantially different from national reference sites in other cities. Thus, chronic exposure to the levels of arsenic measured in ambient air are not expected to harm people's health.

Cadmium

Cadmium is a naturally occurring metal found in the earth's crust. Cadmium is also emitted to the air from steel mills, other metal production facilities, and facilities that burn coal and other fuels containing trace amounts of cadmium. Of the four facilities in Midlothian, the only facility to report cadmium emissions to TRI was Gerdau Ameristeel, which reported air releases from 2000 to 2010. During this time frame, the highest reported cadmium emissions from the facility occurred in 2002. No TRI data for cadmium emissions are available for earlier years.

Cadmium is present in ambient air as a component of particulate matter. The cadmium measurements that ATSDR determined to be of known and high quality were first collected in 2001. All available measurements are 24-hour average samples, and the majority of these were collected once every six days. The following paragraphs summarize data trends for different particle size fractions and exposure durations and compare observed concentrations to health-based comparison values.

Cadmium-PM_{10} Measurements

Annual average PM_{10} concentrations. The stations with the longest duration of cadmium monitoring were Wyatt Road (January 2001–June 2004) and four stations that had at least 20 samples collected during an 8-month time frame in 2008-2009. Table 13 summarizes the average cadmium concentrations in PM_{10} measured at these sampling stations.

Table 13. Average cadmium concentrations in PM$_{10}$, 2001-2009

Year	**Average Concentration (µg/m^3), by Monitoring Station**				
	TCEQ[a]	**2008-2009 URS Study[b]**			
	Wyatt Rd	**Old Fort Worth Rd**	**Jaycee Park**	**Wyatt Rd**	**Tayman Drive WWTP**
Lowest screening value for cancer endpoints = 0.0006 µg/m^3, ATSDR CREG					
Lowest screening value for non-cancer endpoints = 0.005 µg/m^3, WHO					
2001	***0.00100***	---	---	---	---
2002	***0.00109***	---	---	---	---
2003	***0.00100***	---	---	---	---
2004	***0.00079*** [c]	---	---	---	---
2005	---	---	---	---	---
2006	---	---	---	---	---
2007	---	---	---	---	---
2008	---	---	---	---	---
2009	---	0.00015 [d]	0.00015 [d]	0.00044 [d]	0.00014 [d]

Notes: --- not measured

Numbers in bold, italic font are average concentrations that exceed the health-based comparison value for cancer endpoints: 0.0006 µg/m^3 (ATSDR's CREG). No annual averages exceeded the lowest health-based comparison value for non-cancer endpoints: 0.005 µg/m^3 (WHO Guideline).

[a] TCEQ data were downloaded from TAMIS: accessed from TCEQ's website: http://www.tceq.state.tx.us/implementation/tox/research/Midlothian.html.

[b] 2008-2009 URS study data were accessed from TCEQ's website.

[c] In 2004, TCEQ's CAMS 302 site only operated from January through June.

[d] The 2008-2009 URS study had air quality measurements from December 2008 through July 2009. The average concentrations for the four stations sampled most frequently are presented in the table. Average concentrations listed for 2009 are based on measurements throughout the program, even though some of the measurements were collected in 2008.

Annual averages were calculated using the half detection limit substitution method for non-detected data. No average cadmium concentrations from the 2008-2009 ambient air monitoring study exceeded ATSDR's Cancer Risk Evaluation Guide (CREG) concentration (0.0006 µg/m^3). However, TCEQ's Wyatt Road monitoring station exceeded this value in every year between 2001 and 2004. Cadmium was detected above the method detection limit in only 3 of 196 samples during this period and the annual averages are based on half the detection limit of cadmium (0.001 µg/m^3 at the time) and not on actual measurements. Calculating annual averages based on half of the detection limit overestimated the concentrations displayed in Table 13. Whether or not the actual measurements would have exceeded the CREGs had the detection limits been more sensitive is unknown. The Wyatt Road station is located closest to Gerdau Ameristeel, which had the only self-reported cadmium emissions of all facilities in the area. All average cadmium concentrations shown in Table 13 were lower than the lowest health-based comparison value for evaluating non-cancer endpoints associated with chronic exposures of 0.005 µg/m^3 (a WHO Guideline).

TNRCC conducted an air quality study in Midlothian in the early 1990s, but in the first Health Consultation for this site, ATSDR expressed some data quality concerns about the old TNRCC study. ATSDR noted that cadmium was detected in fewer than 10 percent of samples collected for that study, presumably due to the fact that the earlier sampling had a relatively high cadmium detection limit (0.008 µg/m^3) (ATSDR 2012c).

For additional insights into the magnitude of the average cadmium concentrations, ATSDR accessed all annual average cadmium concentrations that TCEQ measured in the state of Texas in calendar year 2011. Across the four TCEQ-operated stations during that year, the average cadmium concentrations ranged from 0.0007 µg/m^3 to 0.0027 µg/m^3. As Table 13 shows, three of the four monitoring stations in Midlothian had average cadmium concentrations that fall within the statewide range. The average cadmium concentration at the Wyatt Road monitor from the 2008-2009 study (0.0044 µg/m^3) is higher than what was most recently measured at monitoring stations throughout the state. This is likely due to influences from the Gerdau Ameristeel plant (see Figures 24 and 25 in Section 3.4 for more information on potential sources of this pollutant).

24-hour average PM_{10} concentrations. Between 2001 and 2009, 304 24-hour average PM_{10} air samples were collected in the Midlothian area and analyzed for cadmium, and cadmium was found above detection limits in every sample. The highest cadmium concentration in PM_{10} recorded among these samples was 0.004 µg/m^3, based on a sample collected at TCEQ's Wyatt Road station on May 8, 2002. Even if we assumed that 0.004 µg/m^3 was the long term average concentration, the cancer risk would still be within the 10^{-6} range. All measurements were lower than the lowest health-based comparison value that ATSDR identified for acute inhalation exposure to cadmium (0.1 µg/m^3, a TCEQ air monitoring comparison value).

Cadmium-$PM_{2.5}$ Measurements

Annual average $PM_{2.5}$ concentrations. Only two stations in the Midlothian area have measured cadmium in the $PM_{2.5}$ size fraction. This monitoring occurred at Midlothian Tower between May 2002 and August 2005, and at Old Fort Worth Road between September 2005 and December 2011 and continues today. Averaging the data annually, the same issues with the substitution method arise as with the historical PM_{10} data. Cadmium was only detected in 13 of 197 samples at Midlothian Tower and in 2 of 321 samples at Old Fort Worth Road. Using the substitution method, at Midlothian Tower the highest annual average cadmium concentration in $PM_{2.5}$ was 0.0027 µg/m^3 in 2005 (the concentrations detected in the 13 samples ranged from 0.004 to 0.01 µg/m^3). Similarly, at Old Fort Worth Road, the highest annual average based on the substitution method was 0.0024 µg/m^3, also in 2005 (the concentrations in the 2 samples were 0.004 and 0.008 µg/m^3). Given the small number of observations where cadmium was detected and that detection limits were higher than the ATSDR CREG, it is difficult to determine whether or not the CREG would have been exceeded if detection limits would have been lower.

ATSDR also identified a peculiar result when examining the cadmium concentrations. Of all samples collected and analyzed for cadmium, only Old Fort Worth Road had both PM_{10} and $PM_{2.5}$ cadmium on the same days. On these days concentrations of cadmium in $PM_{2.5}$ were higher than the annual average values for cadmium in PM_{10}. This likely reflects some type of measurement bias because the $PM_{2.5}$ average values should be lower than the PM_{10} average values. The reason for this anomaly is unclear, but suggests that the $PM_{2.5}$ cadmium measurements have a positive bias or that the PM_{10} cadmium measurements have a negative bias or some combination of the two (Table 14).

Table 14. Comparison of simultaneously sampling of PM_{10} and $PM_{2.5}$ cadmium measurements at Old Fort Worth Road

Date	Average Concentration (µg/m^3)	
	PM_{10}[a]	$PM_{2.5}$[b]
12/8/2008	0.000194	0.00293
3/2/2009	0.000092	0.00003
5/7/2009	0.000169	BDL
7/6/2009	0.000076	0.00182

BDL: Pollutant not quantified above the limit of detection ("below detection limit")
[a] TCEQ data were downloaded from TAMIS (http://www.tceq.state.tx.us/implementation/tox/research/Midlothian.html).
[b] 2008-2009 URS study data were accessed from TCEQ's website (http://www.tceq.state.tx.us/implementation/tox/research/Midlothian.html).

24-hour average $PM_{2.5}$ concentrations. Between 2002 and 2011, 578 24-hour average $PM_{2.5}$ air samples were collected in the Midlothian area and analyzed for cadmium. The highest cadmium concentration in $PM_{2.5}$ observed was 0.0106 µg/m^3 in a sample collected at TCEQ's Midlothian Tower monitoring station in 2005. This was the only measurement that exceeded the lowest health-based comparison value that ATSDR identified for acute inhalation exposure to cadmium (0.03 µg/m^3).

Health effects possible from exposure to cadmium
Cadmium can damage the respiratory tract, including the nasal passages and the lungs as well as the kidneys. These effects have been observed in animals and humans. Cadmium is also known to be a cancer-causing pollutant.

Acute exposure: Cadmium exposure in air can cause a broad range of impacts to the lining of the airways, lungs, and kidneys with increasing severity with increasing concentrations. Acute studies of cadmium exposure are generally reported for lab animals, and for accidental high exposure occupational case studies. Some studies have documented a delayed onset of fatal symptoms from high occupational exposures for as little as a single exposure for five hours. Exposure to lower concentrations can cause less serious health effects. For example, rats exposed to cadmium oxide dust for two to three hours at 400 µg/m^3 experienced increased cell production in lung's air exchange sacs (the alveoli) and total lung weight (ATSDR, 2012c). The concentration associated with these effects (400 µg/m^3) is 100,000 times the highest 1-hour concentration in PM_{10} and 38,000 times the highest 24-hour concentration detected in $PM_{2.5}$. The ATSDR acute minimum risk level (MRL) of 0.03 ug/m3 is based on a rat study conducted over two weeks at an LOAEL exposure of 88 µg/m^3. The researchers noted irritation and inflammation of the alveoli in the lungs as the most sensitive adverse health effect associated with exposure. ***Since short-term cadmium concentrations are substantially lower than concentrations known to cause acute health effects, short-term exposures to the cadmium concentrations detected in Midlothian are not expected to harm people's health.***

Chronic exposure: Chronic or subchronic cadmium exposures can cause similar health outcomes to the body as acute exposures, but over a longer time period to lower concentrations. Animal studies noted mild neurological effects at 20 µg/m^3, damage to throat tissue in rats at 22 µg/m^3, immune response activation in rat alveoli at 98 µg/m^3, and mortality in 75% of test rats at day 45 in a study of inhalation exposure to 90 µg/m^3 of cadmium oxide. Similarly, increased mortality was observed in rats exposed to 30 µg/m^3 of cadmium for 18 months. For cancer in humans, occupational exposure to 100 µg/m^3 cadmium oxide over 6 months was the lowest cadmium exposure concentration where lung cancer was reported over 6 months to 45 years of cadmium oxide occupational exposure. In rats, the lowest exposure concentration where lung cancer was detected was 30 µg/m^3 over 18 months (ATSDR, 2012c). All of these values are at least 8,100 times higher than the highest annual average concentration detected in Midlothian.

***The levels of cadmium in air are far below levels associated with the development of cancer in occupational and animal studies (over 7,500 times lower) or experiencing acute or long-term non-cancer health effects (over 5,000 times lower) in the scientific literature. Since long-term ambient concentrations of cadmium in Midlothian are substantially lower than those known to cause health effects, long-term exposures to concentrations detected in Midlothian are not expected to harm people's health*.**

Manganese

Manganese is a naturally occurring element that is used in steel production. It is also found in trace amounts in soils, coal, and other resources throughout the United States. According to the TRI and PSEI emission inventory data, all four industrial facilities in Midlothian have emitted manganese to the air at some time during their history. Between 1988 and 2010, the highest reported manganese emissions occurred in 1988 and 1989, attributable to emissions from Gerdau Ameristeel. However, between 2004 and 2009, emissions from TXI accounted for more than half of the manganese emissions that the four facilities reported to U.S.EPA. According to TRI data, the total estimated emissions of manganese summed across the four facilities has decreased by almost ten-fold between 1988 and 2010.

Manganese is present in ambient air as a component of particulate matter. The measurements of manganese that ATSDR determined to be of known and high quality were first collected in 2001. All available measurements are 24-hour average samples, and the majority of these were collected once every six days. The following paragraphs summarize data trends for different particle size fractions and exposure durations and compare observed concentrations to health-based comparison values.

Manganese-PM_{10} Measurements

Annual average PM_{10} concentrations. The stations with the most comprehensive manganese monitoring were Wyatt Road (January 2001–June 2004) and four stations that had at least 20 samples collected during an 8-month time frame in 2008-2009. Table 15 summarizes the average manganese concentrations in PM_{10} measured at these sampling stations. As the table shows, no monitoring conducted in Midlothian had average concentrations of manganese in PM_{10} greater than the chronic ATSDR comparison value of 0.30 µg/m^3.

The Wyatt Road station is located closest to Gerdau Ameristeel and TXI, which have typically had the highest self-reported manganese emissions of all facilities in the area. It should also be noted that the typical concentration of manganese in urban environments in the United States is 0.04 µg/m^3 (ATSDR, 2012d), comparable to those measured in Midlothian.

TNRCC conducted an air quality study in Midlothian in the early 1990s. Although ATSDR expressed some data quality concerns about the old TNRCC study in the first Health Consultation for this site, ATSDR noted that the highest average manganese concentration observed during the study was 0.046 µg/m^3 based on 5 months of sampling at a location along Cement Valley Road (ATSDR 2015). That observation is consistent with the range of average concentrations observed between 2001 and 2009.

24-hour average PM_{10} concentrations. Between 2001 and 2009, 304 24-hour average PM_{10} air samples were collected in the Midlothian area and analyzed for manganese. The highest manganese concentration in PM_{10} recorded among these samples was 0.171 µg/m^3 from a sample collected at TCEQ's Wyatt Road station on April 15, 2003. However, all measurements are considerably lower than 2 µg/m^3, which is the lowest health-based comparison value that ATSDR identified for acute inhalation exposure to manganese (a TCEQ air monitoring comparison value).

Table 15. Average manganese concentrations in PM_{10}, 2001-2009

Year	Average Concentration (µg/m^3), by Monitoring Station				
	TCEQ[a]	2008-2009 URS Study[b]			
	CAMS 302-Wyatt Road	OFW Road	Jaycee Park	Wyatt Road	TD-WTP
Chronic screening value for non-cancer endpoints = 0.30 µg/m^3, ATSDR cEMEG					
2001	0.043	---	---	---	---
2002	0.033	---	---	---	---
2003	0.045	---	---	---	---
2004	0.056[c]	---	---	---	---
2005	---	---	---	---	---
2006	---	---	---	---	---
2007	---	---	---	---	---
2008	---	---	---	---	---
2009	---	0.017[d]	0.009[d]	0.059[d]	0.011[d]

Notes: --- not measured

Numbers in bold, italic font are average concentrations that exceeded the most protective (lowest) health-based comparison value for chronic exposures: 0.3 µg/m^3 (ATSDR's Minimal Risk Level).

[a] TCEQ data were downloaded from TAMIS. (http://www.tceq.state.tx.us/implementation/tox/research/Midlothian.html)

[b] 2008-2009 URS study data were accessed from TCEQ's website (http://www.tceq.state.tx.us/implementation/tox/research/Midlothian.html).

[c] In 2004, TCEQ's CAMS 302 site only operated from January through June.

[d] The 2008-2009 URS study had air quality measurements from December 2008 through July 2009. The average concentrations for the four stations sampled most frequently are presented in the table. Average concentrations listed for 2009 are based on measurements throughout the program, even though some of the measurements were collected in 2008.

Manganese-$PM_{2.5}$ Measurements

Annual average $PM_{2.5}$ concentrations. Only two stations in the Midlothian area have measured manganese in the $PM_{2.5}$ size fraction. This monitoring occurred at Midlothian Tower between May 2002 and August 2005, and at Old Fort Worth Road between September 2005 and December 2011 and continues today. At Midlothian Tower, the highest annual average manganese concentration in $PM_{2.5}$ was 0.0033 µg/m^3. Similarly, at Old Fort Worth Road, the highest annual average was 0.0066 µg/m^3 (Table 16). None of these annual average concentrations exceeded the ATSDR health-based comparison value for chronic inhalation exposures to manganese (0.30 µg/m^3).

24-hour average $PM_{2.5}$ concentrations. Between 2002 and 2011, 578 different 24-hour average $PM_{2.5}$ air samples were collected in the Midlothian area and analyzed for manganese. The highest manganese concentration in $PM_{2.5}$ observed among these samples was 0.039 µg/m^3, based on a sample collected at TCEQ's Old Fort Worth Road monitoring station in 2007. The entire set of manganese measurements in $PM_{2.5}$ were considerably lower than the lowest health-based comparison value that ATSDR identified for acute inhalation exposure to manganese (2 µg/m^3).

Table 16. Average Manganese Concentrations in $PM_{2.5}$, 2002-2011

Average Concentration (µg/m^3), by Monitoring Station		
Lowest screening value for non-cancer endpoints = 0.30 µg/m^3, ATSDR cEMEG		
Year	**Midlothian OFW**	**Midlothian Tower**
2002	---	0.00168
2003	---	0.00173
2004	---	0.00194
2005	0.00619	0.00331
2006	0.00595	---
2007	0.00602	---
2008	0.00657	---
2009	0.00457	---
2010	0.00563	---
2011	---	---

Numbers in bold, italic font are average concentrations that exceeded the most protective (lowest) health-based comparison value for chronic exposures: 0.3 µg/m^3 (ATSDR's Minimal Risk Level).

--- † Monitor Site Not Active; * greater than 80% non-detect;
Data source: TCEQ, 2013

Health effects possible from exposure to manganese

As mentioned previously, manganese is a naturally occurring element that is used in steel production. It is also found in trace amounts in soils, coal, and other resources throughout the United States. Manganese is an essential nutrient for neurological function and intake from dietary sources is necessary to maintain normal health. At high concentrations, manganese is a known neurotoxin and causes neuromotor and neuropsychological deficits. Most of these studies are occupational, but some studies have evaluated non-occupational exposures to manganese from environmental exposures. Some non-occupational studies have suggested decreased neuromotor function from relatively low ambient exposures while others found no associations (ATSDR, 2012d). Since manganese is found in abundance in leafy green vegetables, rice, legumes, and some fruit it is very difficult to distinguish the relative contribution of inhalational exposure versus dietary exposure. Dietary uptake of manganese is by far the most significant contribution of manganese to the body.

The occupational study, which is the basis of the ATSDR CV and U.S. EPA RfC, evaluated exposure for respirable manganese particles (≤5 µm). Respirable particles are able to travel past the nose and upper respiratory system to enter the lungs. The finer the particle, the more potential it has to enter the blood stream or directly affect the brain through olfactory uptake. In Midlothian, dust particles less than 2.5 microns in aerodynamic diameter and particles less than 10 microns in aerodynamic diameter were evaluated.

Acute exposure: No human studies of acute manganese exposure were identified for this assessment. Two of seven studies of acute exposures in animals demonstrated mild health effects (genetic changes in brain tissue) at 710 µg/m^3 in rats (ATSDR, 2012d). This concentration is 12,000 times higher than the highest concentrations identified in the Midlothian area. ***Since short-term concentrations of manganese in Midlothian air data do not exceed the TCEQ acute health based comparison value and are below levels known to result in acute health effects, manganese exposure to short-term air concentrations in Midlothian is not expected to harm people's health.***

Chronic exposure: Chronic human exposure to excessive manganese via inhalation is primarily associated with neurological effects. Occupational studies have found deficits in motor skills (such as finger tapping, reaction time, hand-eye coordination, etc.) in workers with chronic manganese exposures between 27-1590 µg/m^3 (ATSDR, 2012d; Lucchini et al., 1995; Lucchini et al., 1999) The lowest of these concentrations (27 µg/m^3) is over 450 times the highest annual average of manganese detected in Midlothian. There is no evidence that manganese causes cancer.

Manganese exposure in Midlothian is typical of manganese concentrations found across the United States. Furthermore, long-term concentrations reported in air monitoring programs are below those known to cause health effects. Therefore, the levels of manganese measured in Midlothian are not expected to harm people's health.

3.3 Multi-pollutant Risk Evaluation

Residents in Midlothian have expressed concern about cumulative health risks from the combination of all the different pollutants present in their outdoor air. To evaluate multi-pollutant risk, non-cancer and cancer health effects were assessed through standard risk assessment screening methodology. Whereas the previous section discussed risks from individual pollutants, this section presents the total hazard calculated for cancer and non-cancer effects from all combined uncensored data (all pollutants detected in at least 20% of samples). Our averaging approach for long term exposure and our rationale for using a 20% censorship rate were presented in the data analysis section (Section 3.2.2). We believe our assessment was conservative, yet realistic, because we used upper bound estimates of contaminant concentration means and assumed both VOC and metal sampling occurred simultaneously at each monitoring site, even if it did not. We summed risks from all pollutants and all dates for each sampling location and included all data that could reasonably be extrapolated to chronic exposure. The sites sampled for only five consecutive days during the 2008-2009 UT-Arlington Study were not included.

A sample size of five is too small to generate reliable statistics, and chronic risk cannot be extrapolated from five consecutive samples. Acute risks were evaluated in the previous section. No significant chronic risks were identified in the measured monitoring program.

The health based comparison values used in the non-cancer and cancer risk equations that follow were derived by ATSDR, U.S. EPA, California EPA, and TCEQ. In each case chronic exposure has been defined as "continuous exposure over a lifetime". For the purposes of risk assessment, the assumptions are 24 hour/day exposure over a 70 year lifetime. While assuming residents are exposed continuously over 70 years may be an overestimation of risk, we considered this assumption a conservative initial screening of exposure for community members. Furthermore, for the initial screening assessment, we did not calculate risk based on the individual target organ or body system it would affect—we assumed that they influence of the pollutants were all cumulative in the body. For example, in reality, some pollutants only affect the brain while others affect the lungs. Calculating risk based on the individual organs impacted by individual pollutants would result in lower risk than calculating total risk.

Evaluating multi chemical exposures--non-cancer
The likelihood of non-cancer health hazards can be evaluated with the calculation of hazard quotients and hazard indices. A hazard quotient is the ratio of the potential exposure to the substance and the level at which no adverse effects are expected:

$HQ\ (unitless) = air\ concentration\ (\mu g/m^3) \div health\ based\ non\text{-}cancer\ comparison\ value\ (\mu g/m^3)$

In short, hazard quotients are calculated by dividing ambient air concentrations of pollutants by the appropriate health based comparison values that represent no increase in health effects (ATSDR, 2005c; TCEQ, 2006; U.S. EPA, 2005). If the HQ calculated is equal to or less than 1, then no adverse health effects are expected as a result of exposure. If the HQ is greater than 1, then further evaluation is warranted. To estimate a total non-cancer hazard posed by more than one pollutant, the HQs are simply summed, yielding a hazard index, or "HI" (ATSDR, 2005c).

$HI = HQ_{pollutant\ 1} + HQ_{pollutant\ 2} + HQ_{pollutant\ 3} + HQ_{pollutant\ 4} \ldots\ldots etc.$

Evaluating multi chemical exposures-cancer
As was done for HQ calculations, excess cancer risk can be calculated using a ratio of measured concentrations in air to air concentrations that represent a 10^{-6} cancer risk (the risk of 1 excess cancer per one million people exposed to the same contaminant concentration over a lifetime), or by multiplying a cancer unit risk factor by the concentration of pollutant measured in air. A unit risk factor is the amount of risk posed by the specific concentration unit in air (usually per 1 $\mu g/m^3$ of the pollutant in air). The calculation yields the relative increase of cancer risk from exposure to individual pollutants, or if summed, the cumulative increased cancer risk to multiple pollutants (ATSDR, 2005c; TCEQ, 2006; U.S. EPA, 2005).

$Cancer\ Risk = [air\ concentration\ (\mu g/m^3) \div health\ based\ cancer\ comparison\ value\ (\mu g/m^3)]*10^{-6}$
or
$ER = CSF\ (or\ IUR)\ x\ air\ concentration\ (\mu g/m^3)$

where

ER = estimated risk (unitless)
CSF/IUR = cancer slope factor $(mg/kg/day)^{-1}$ *or inhalation unit risk* $(\mu g/m^3)^{-1}$

ATSDR and U.S.EPA cancer-based CVs and contaminant concentrations were used to calculate cancer risk for each pollutant present in at least 20% of samples collected at each site in this investigation. The specific values used in our screening analysis assumed constant, 24 hour a day/7 day a week exposure over a 70 year lifetime.

The cancer risks for individual pollutants in the data set were summed to yield cumulative cancer risk by monitoring location. Ninety-five percent confidence intervals were generated for each of the contaminants where at least 20% of the samples were above the detection limit. This allows us to assess possible uncertainty in the mean from sampling variability (which can be judged by the width of the confidence interval). U.S.EPA Risk Assessment Guidance suggests that an exposure point concentration (EPC) be used that is believed to be representative of typical site concentrations to evaluate risk. The most commonly used EPC is the 95% upper confidence limit (UCL) of the mean, which is the 95th percent confidence limit of the average concentration calculated for each pollutant at the site (U.S.EPA, 2007). The advantage of using the entire confidence interval (both upper and lower confidence limits) over the EPC method is that it conveys the overall precision in our estimates and allows us to convey the overall uncertainty from the measurement of the pollutants. ATSDR calculated cancer and non-cancer risk using mean and UCL of the 95th percent confidence limits of the averages for each pollutant in the multi-pollutant risk evaluation.

To give context to our own risk calculations, we compared our cumulative risk values to risk calculated by U.S.EPA. In 2011, U.S.EPA released its National-Scale Air Toxics Assessment (NATA) for modeled emissions across the United States from the year 2005 (U.S. EPA, 2011). The purpose of NATA is to identify and prioritize air toxics, emission source type, and locations that are of greatest potential concern in terms of contributing to population risk. Also presented in the report are locations throughout the United States that have elevated cancer and non-cancer risk from exposure to pollutants listed on the hazardous air pollutants (HAPs) list. In the 2011 report, 177 HAPs were included and cancer and non-cancer risks were calculated by county and state. Ellis County cancer risk ranked 48th highest out of 254 Texas counties and 751st highest in all 3223 United States counties where cancer risk was modeled. Total cancer risk in Ellis County for all sources (mobile and stationary) was estimated at 3.7×10^{-5} (a potential risk of about four excess cancers per 100,000 people living in the area), and is about the same as or slightly lower than the general Texas state cancer risk of 4.4×10^{-5} (a potential risk for about four excess cancers per 100,000 people living in the area). The cancer risks ATSDR calculated at air monitoring stations in the community are slightly lower than the county and state risks. The maximum long-term cancer risk calculated at any of the Midlothian monitoring stations was 2.64×10^{-5} (a potential risk for 2.64 (or about 3) excess cancers per 100,000 people living in the area) for the mean concentrations of all pollutants evaluated and 3.63 (or about 4) x 10^{-5} for the UCL mean concentrations at the Tayman Drive WWTP station, where risk was driven by possible water chlorination byproducts typical of a water treatment plant (see Appendix G for a full list of pollutants and their corresponding risks). The findings of ATSDR's risk evaluation for cancer is consistent with cancer registry data in that both suggest that cancer risk (presented here) and the number of cancer cases reported in Midlothian are comparable to Ellis County and the state of Texas. Cancer registry data are presented in greater detail in our Health Consultation titled "*Evaluation of Health Outcome Data for the Midlothian Area"* (ATSDR, 2015).

It is not unusual for cumulative risk in ambient air to pose cancer risks higher than the increased risk of one in one million (10^{-6}) people developing cancer. An evaluation of national air monitoring data determined that concentrations of acetaldehyde, arsenic, benzene, 1,3-butadiene, and carbon tetrachloride individually exceeded 10^{-6} cancer risk at most monitoring sites across the country (McCarthy et al., 2009). These pollutants are generally ubiquitous and found commonly in outdoor air.

Non-cancer hazards by county, state, and across the United States were also reported in the 2011 U.S.EPA NATA document. The NATA evaluation yielded a respiratory hazard index of 0.95 for Ellis County. This level is below 1.0, which indicates no increased risk for non-cancer hazards. For reference, the state of Texas had a HI of 1.6 (living in Texas increased a person's risk of experiencing irritating non-cancer respiratory effects by 60%). With 1 being the worst, the Ellis County HI ranked 55th out of 254 counties in Texas, and 1,013th of 3,223 counties in the United States (U.S.EPA, 2011). In Midlothian, two short term air monitoring sites north of Gerdau Ameristeel and TXI had the highest non-cancer risk, driven by potential manganese exposure‒a pollutant released by both facilities at a similar range of pounds per year. These sites are the URS Wyatt Road location (0.82 for the mean HI; 1.07 for the mean 95%UCL HI) and the Cement Valley Road location (HIs of 0.80 and 1.11, respectively). Thus, our assessment yielded a slightly elevated non-cancer risk at the URS Wyatt Road (7% increase in risk) and Cement Valley Road (11% increase in risk) sites for 20 and 13 samples, respectively, but not at other sites. However, as noted in Section 3.2.5b, the average concentration of manganese in this area is typical of what has been noted in ambient air across the United States. A summary of the total cancer and non-cancer risks for all sampling locations are presented in Table 17.

Appendix G presents pollutant-specific contributions to the total risks. Cancer risks appear typical of the county and state but are in the top 20% of risks calculated across the United States. The non-cancer health risks are slightly higher in certain parts of Midlothian, and unlike cancer risks, appear to be highly localized to air monitoring stations near TXI/Gerdau Ameristeel. Non-cancer health risks exceed those calculated for Ellis County and Texas at sites closest to Gerdau Ameristeel and not other community monitoring locations. The non-cancer health risk is driven almost exclusively by manganese.

Table 17. Estimated cancer (CA) risk and Non-cancer Hazard Index (HI) for pollutants at air monitoring sites in Midlothian, TX

URS Study Monitoring Site Name	Mean CA[a] Risk	Mean HI [b]	UCL[c] CA Risk	UCL HI
Jaycee Park-Metals	3.36E-06	0.25	4.30E-06	0.32
Jaycee Park-VOCs	1.32E-05	0.13	1.52E-05	0.15
Jaycee Park-Total Risk	**1.66E-05**	**0.39**	**1.95E-05**	**0.47**
OFW-Metals	3.98E-06	0.33	5.15E-06	0.40
OFW-VOCs	1.31E-05	0.16	1.49E-05	0.19
OFW-Total Risk	**1.71E-05**	**0.48**	**2.00E-05**	**0.59**
Tayman Dr WWTP-Metals	3.14E-06	0.34	3.85E-06	0.46
Tayman Dr WWTP-VOCs	2.33E-05	0.16	3.25E-05	0.21
Tayman Dr WWTP-Total Risk	**2.64E-05**	**0.49**	**3.63E-05**	**0.67**
Wyatt Road-Metals	7.33E-06	0.82	9.59E-06	1.07

Wyatt Road-VOCs	N/A	N/A	N/A	N/A
Wyatt Road-Total Risk	**7.33E-06**	**0.82**	**9.59E-06**	**1.07**
Historical Monitoring Site Name	**Mean CA Risk**	**Mean HI**	**UCL CA Risk**	**UCL HI**
OFW Rd-Metals	4.97E-08	0.32	5.58E-08	0.40
OFW Rd -VOCs	1.12E-05	0.22	1.29E-05	0.29
OFW Rd -Total Risk	**1.13E-05**	**0.54**	**1.30E-05**	**0.69**
Midlothian Tower-Metals	5.61E-06	0.28	6.31E-06	0.35
Midlothian Tower-VOCs	8.87E-06	0.19	9.51E-06	0.23
Midlothian Tower-Total Risk	**1.45E-05**	**0.47**	**1.58E-05**	**0.58**
Tayman Dr WWTP-Metals	N/A	N/A	N/A	N/A
Tayman Dr WWTP-VOCs	2.16E-05	N/A	3.10E-05	N/A
Tayman Dr WWTP-Total Risk	**2.16E-05**	**N/A**	**3.10E-05**	**N/A**
Wyatt Road-Metals	1.74E-07	0.41	2.02E-07	0.47
Wyatt Road-VOCs	8.87E-06	0.14	9.52E-06	0.15
Wyatt Road-Total Risk	**9.04E-06**	**0.55**	**9.72E-06**	**0.62**
Early 1990s Monitoring Site Name	**Mean CA Risk**	**Mean HI**	**UCL CA Risk**	**UCL HI**
Auger Road-Metals[d]	2.83E-09	0.43	1.35E-07	0.74
Cedar Drive-Metals	1.77E-06	0.27	9.18E-07	0.46
Cedar Hill Fire Dept-Metals		0.06		0.07
Cement Valley Rd-Metals	2.68E-06	0.80	2.95E-06	**1.11**
Tayman Dr. WWTP-Metals		0.22		0.53

[a] *CA=abbreviation for cancer;*

[b] *HI= hazard index, a cumulative indicator of excess non-cancer hazard*

[c] *UCL: Upper confidence limit average*

[d] *Barium, Beryllium, and Strontium only had 4 samples in this analysis; all other metals had 68*

A number of limitations should be noted with this evaluation. Although the risks calculated for individual and aggregated pollutants are not markedly different than other major metropolitan areas (McCarthy, et al., 2009; U.S.EPA, 2011), localized impacts like those observed from manganese near TXI/Gerdau Ameristeel may not be reflected in large scale county and state risk assessment activities. Further, ATSDR could only estimate risk in the community where data have been collected. Thus, the available data may over- or under-predict total risk for other parts of the community. The NATA data presented here were intended to give context to risk values calculated with measured data in the community and were based on emission rates from various sources throughout the community. Lastly, the emissions data used in the 2011 report were from the 2005 National Emissions Inventory, and the data used for the ATSDR cumulative health evaluation include data that were collected before, during, and after the 2005 time frame. We made assumptions that the data collected represent chronic conditions, assuming time frames as small as 8 months (URS data) were representative of conditions for a year or longer. With all limitations considered, the health risk modeled by U.S.EPA, and estimated by ATSDR are similar for Ellis County/Midlothian.

3.4 Spatial Analysis of Step 2 Pollutant List

Generally, there are some pollutants with clear relationships with the facilities or with the vehicular traffic on highways, and there are other pollutants that were measured at similar concentrations at most of the community sampling sites. We evaluated the spatial trends of contaminants of concern using several different assessment tools. These included the generation of:

Polar Plots: These plots displaying conditional probabilities were used to examine the relationship of wind direction and wind speed on pollutant concentration. The output is scaled to a polar coordinate system, which is essentially a circular axis. Wind direction data are placed in bins on the polar axis that correspond to the direction in degrees from which the wind originated, with north at 0 degrees, south at 180 degrees, east at 90 degrees and west at 270 degrees. Polar plots show wind speeds for any given direction in bins or compartments that are a proportional distance from the center of the plot, with higher wind speeds occurring further from the center. These plots will indicate the direction and the wind speed where contaminant concentrations are higher (the redder the area) or lower (the bluer the area) and can indicate potential sources. To normalize the plots, we plotted *probability* (from 0 to 1) of the pollutant concentration in the top 25% of concentrations for the site when there was a particular wind direction and speed. These figures are called conditional probability function plots and are mapped to illustrate the relationship of the highest ambient concentrations to the direction of the potential source.

Wind Roses: We generated wind roses for the highest (top 10%) and lowest (bottom 10%) pollutant concentration days to compare the effect of wind direction on ambient concentrations of pollutants.

Kruskal-Wallis statistical analysis: After substituting detection limit values for non-detects (the Kruskal-Wallis test uses ranks so substitution in this case will not affect the results), we used the Kruskal-Wallis test to test for differences in the distribution of pollutant concentrations when grouped into eight major wind directions. A low p-value ($p \leq 0.05$) indicates significant differences in one or more wind directions' pollutant concentrations compared to the other directions. We report median levels grouped by wind direction, but the Kruskal-Wallis analysis tests all quantiles in the data. In addition, if a pollutant's Kruskal-Wallis test was significant, we performed pairwise Wilcoxon rank sum tests (using Holm's method to adjust for multiple comparisons) on the data and examined boxplots to identify which wind directions could be different from the rest. This method was used to supplement the interpretation of the wind roses and the polar plots previously generated.

3.4.1. Spatial Evaluation of VOCs

Acrylonitrile

Acrylonitrile has not been routinely monitored for by TCEQ. The first time this pollutant was quantified in ambient air was in the 2008-2009 UT-Arlington air investigation. Unfortunately, there were too few data points to plot conditional probability for this pollutant.

The Midlothian facilities release little, if any, acrylonitrile. The largest reported release was 7 lbs from Ash Grove in 1990. Acrylonitrile is a known constituent of car exhaust, therefore these monitors may be influenced by Highway 67. Wind roses for the highest and lowest concentrations were only generated for pollutants present at least 80% of the time. Acrylonitrile was censored in all datasets, so no wind rose plots were created. The Kruskal-Wallis statistical analysis showed no statistically significant associations between concentration and wind direction because of the low frequency of detection of the pollutant in area monitors (Table 18).

Table 18. Wind direction and p-value results for tests of significance for concentration of acrylonitrile in air and wind direction*¥

Monitoring Location	Number of Observations	p.value†
Jaycee Park	20	0.59
Old Fort Worth Road	20	0.27
Tayman Drive WWTP-URS	20	0.28

**** Wind direction is the direction from which the wind is blowing;***

¥ Sites with 5 or less samples were not included in this table; and

† p values of ≤0.05 are considered statistically significant

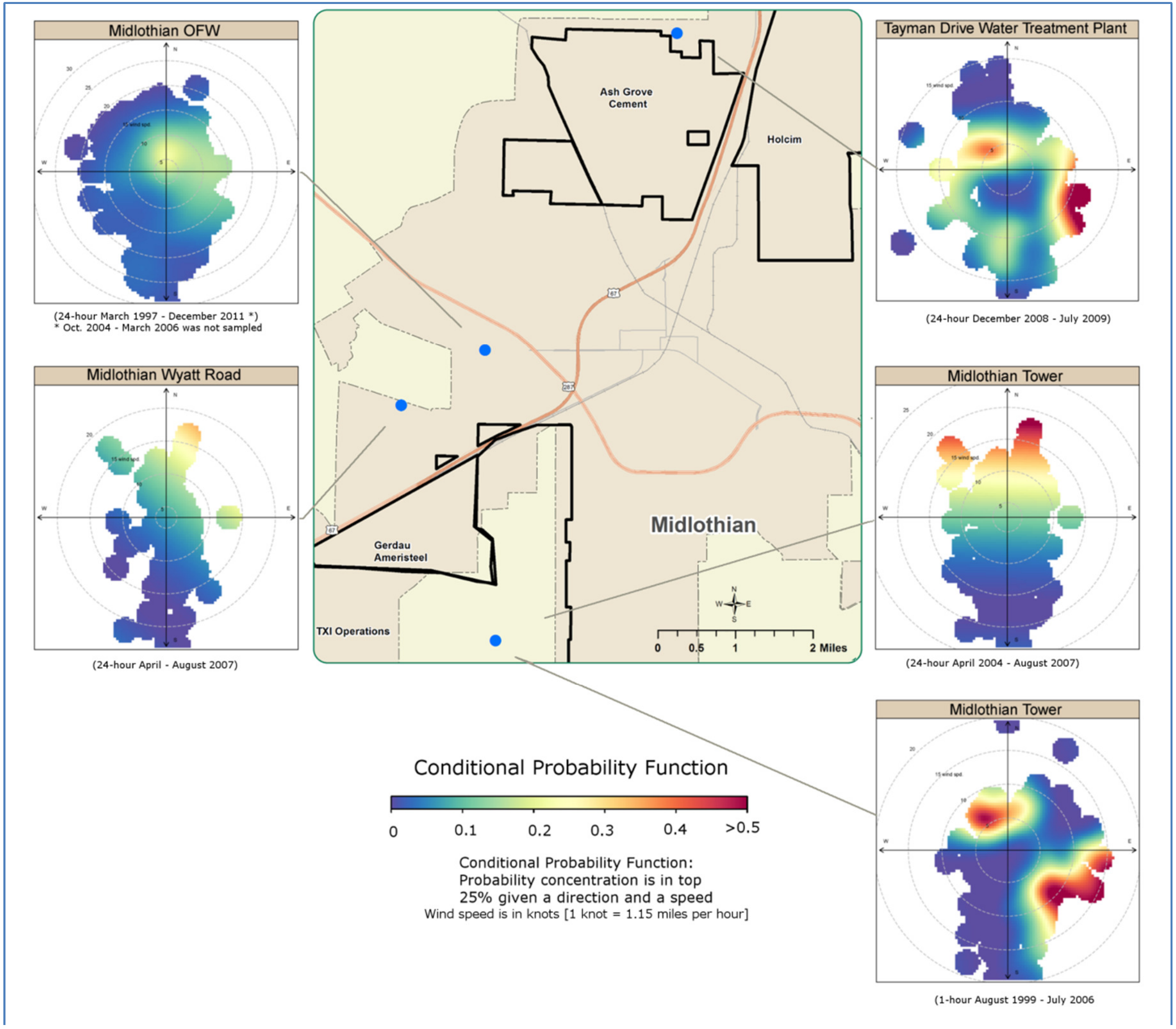
Given these observations, ATSDR concludes the acrylonitrile has no identifiable industrial source, but could be present in the community as a constituent of car exhaust.

Benzene

Benzene is a naturally occurring and man-made compound found in air throughout the world, and is a major constituent of oil and gasoline. Therefore, it is present in car exhaust, oil and gas operations, as well as many industrial processes. For many years, benzene has been measured in air at every station in Midlothian where VOCs were sampled. Furthermore, benzene has been reported in emissions inventories by all three cement plants in the area. The highest emission years were 1996 (TXI) and 2001-2004 (Holcim).

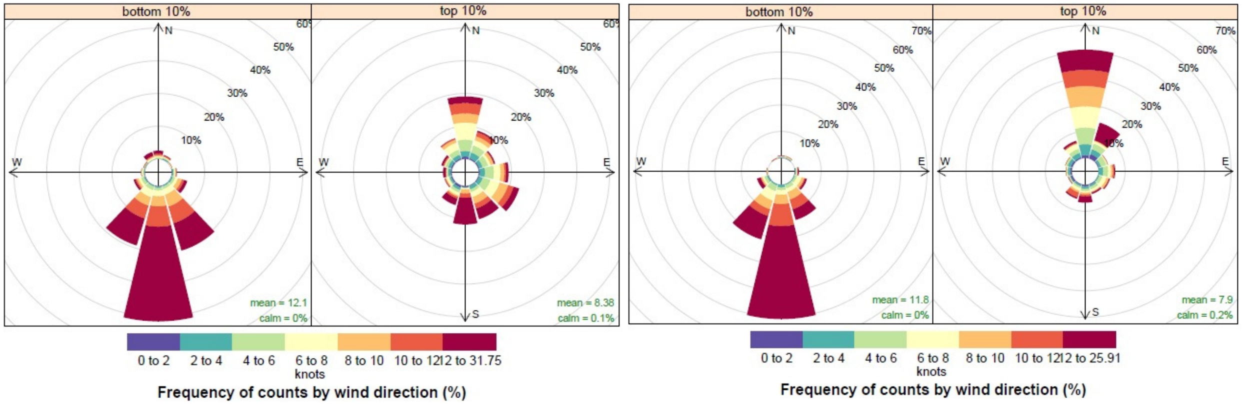
Polar plot maps indicate that generally, benzene concentrations are highest when wind is blowing from the direction of roadways and Highways 67 and 287 (Figure 6). However, local influences may be observed in some cases, such as at Midlothian Tower with 1-hour samples and at the Tayman Drive WWTP. The Midlothian Tower site is directly adjacent to a road that serves as an access route to a large quarry as well as a large loading dock. It is possible that vehicle exhausts as well as quarry operations could affect measured benzene concentrations at this location. It is not clear if there is an onsite source of benzene at the Tayman Drive WWTP, but there are open faced settling basins, bioreactors, and storage facilities on site. There is also a road on the east side of the property and a facility access road surrounding the remainder of the property.

Figure 6. Polar plot maps for various monitoring sites, Benzene



Wind roses were also generated for high and low concentration days to further evaluate the influence of area sources on VOC monitors in the community (Figure 7). The longest running monitors confirm that benzene concentrations in ambient air appear to be influenced in large part by mobile sources (e.g., automobiles on nearby roads and highways).

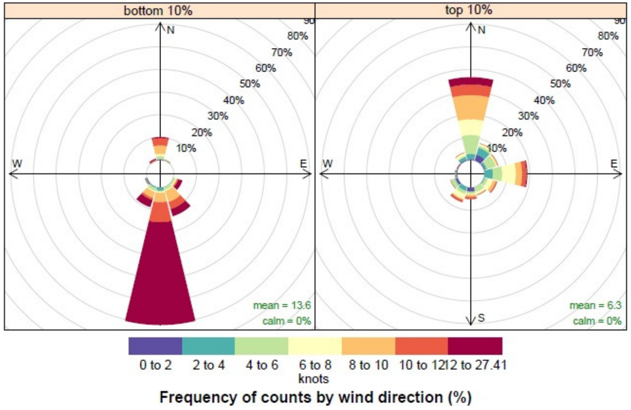
Figure 7. Wind Roses of wind direction by lowest (bottom 10%) and highest (top 10%) average concentrations of benzene



Old Fort Worth Road (1997-2011)

Midlothian Tower (2004-2007)

Wyatt Road (2004-2006)



The Kruskal-Wallis statistical analysis showed statistically significant associations between concentration and wind direction in monitors at Midlothian Old Fort Worth Road, Midlothian Tower, Midlothian Wyatt Road, and Midlothian Tayman Drive (Table 19). Comparisons of pairs of wind directions ("pairwise comparisons") and boxplot graphs shows that winds from the south and southwest resulted in lower concentrations, although pairwise comparison did not detect a difference at Tayman Drive. Although the UT-Arlington 2008-2009 data did not have statistically significant relationships with wind direction, the statistical tests indicate similar findings to the longer running monitors: concentrations of benzene are greatest when the wind is blowing from the roadways and highways in the community.

Table 19. Associations (p-value) between benzene concentration in air and wind direction*¥

Monitoring Location	Number of Observations	p.value†
Old Fort Worth Rd	766	<0.001
Midlothian Tower	199	<0.001
Midlothian Wyatt Rd	84	0.01
Tayman Dr WWTP	231	0.01
Jaycee Park	20	0.21
Old Fort Worth Rd-URS	20	0.39
Tayman Dr WWTP-URS	20	0.70

***** Wind direction is the direction from which the wind is blowing;*

¥ Sites with 5 or less samples were not included in this table; and

† p values of ≤0.05 are considered statistically significant

Given these observations, ATSDR concludes that benzene is likely present in the community as a constituent of car exhaust.

Bromodichloromethane

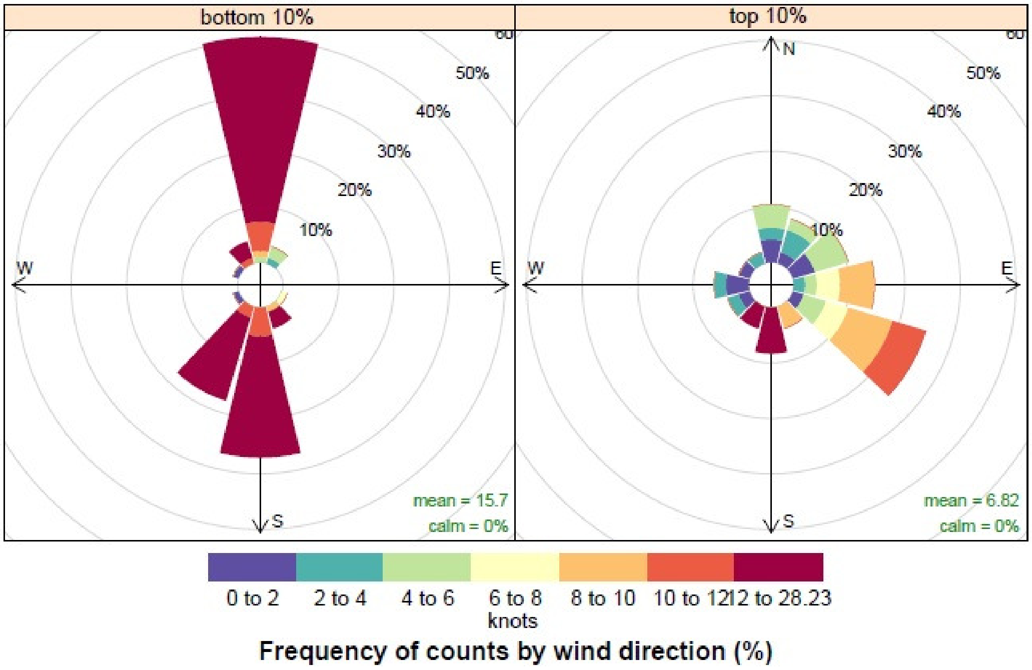
Bromodichloromethane was not historically sampled in Midlothian and was quantified in ambient air for the first time in the 2008-2009 UT-Arlington Air Investigation. In that study, the pollutant was detected infrequently, two to three times at two sites (Old Fort Worth Road and Jaycee Park) and in half of the samples collected at the Tayman Drive WWTP. Given that this pollutant is a common byproduct of water chlorination, it is ATSDR's opinion that the water treatment plant is the likely source of the pollutant in ambient air. There are a number of potential sources of bromodichloromethane on the property that could impact the air monitor (see aerial map, below (Figure 8)). As was the case with acrylonitrile, there were too few observations to generate conditional probability plots of wind direction and ambient concentrations.

Figure 8. Aerial View of the Tayman Drive Wastewater Treatment Plant

Source: Google Maps (www.maps.google.com)

Wind roses were also generated for high and low concentration days to evaluate the influence of the Tayman Drive WWTP. The wind rose suggests a short range source predominantly to the east/southeast (Figure 9), which indicates the influence of onsite storage tanks located to the east and southeast of the monitor (Figure 8, above).

Figure 9. Wind Rose of wind direction by lowest (bottom 10%) and highest (top 10%) average concentrations of bromodichloromethane at Tayman Drive WWTP.



The Kruskal-Wallis statistical analysis showed no statistically significant associations between concentration and wind direction because of the low frequency of detection of the pollutant in area monitors (Table 20).

Table 20. Wind direction and p-value result of tests of significance for concentration of bromodichloromethane in air and wind direction*¥

Monitoring Location	Number of Observations	p.value†
Tayman Dr. WWTP	20	0.15
Jaycee Park	20	0.28
Old Fort Worth Road	20	0.42

***** *Wind direction is the direction from which the wind is blowing;*

¥ ***Sites with 5 or less samples were not included in this table; and***

† p values of ≤0.05 are considered statistically significant

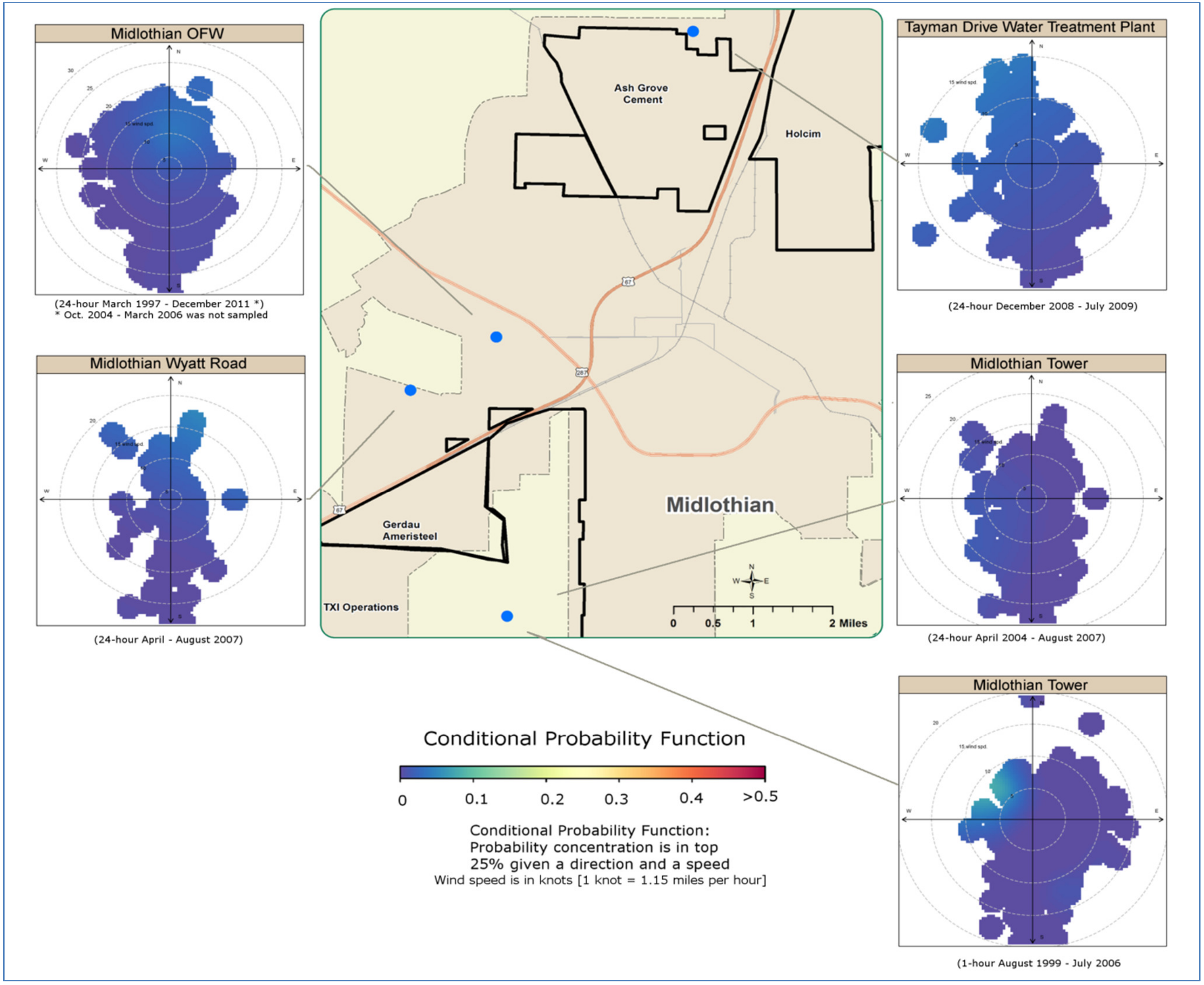
Given these observations, ATSDR concludes the bromodichloromethane is likely present in the community as a constituent of water chlorination at the Tayman Drive WWTP.

1,3-Butadiene

Like benzene, 1,3-butadiene is a common air pollutant emitted from automobiles. Of the Midlothian facilities of interest, TXI is the only facility that has reported the release of 1,3-butadiene in sufficient enough quantity to warrant reporting of the pollutant. The highest emissions year of 1,3-butadiene at TXI was in 1996 (14,000 lbs). Also like benzene, 1,3-butadiene has been measured at every site where VOCs have been sampled for in the community.

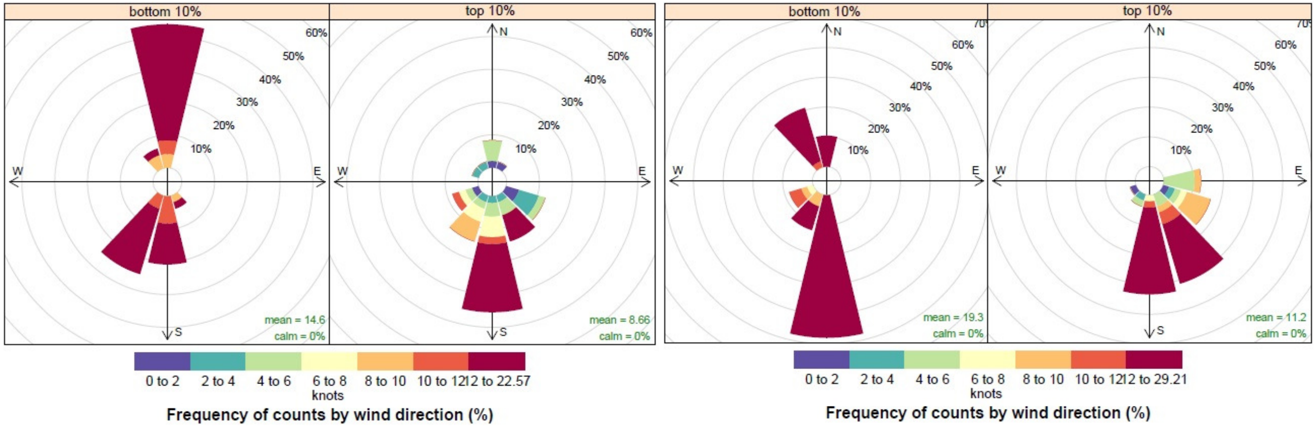
Polar plot maps indicate that 1,3-butadiene is a ubiquitous pollutant and that high concentration days have no specific directionality (Figure 10). However, as in the case of benzene, local influences may be observed in some cases (see Midlothian Tower with 1-hour samples, and a weak suggestion of influence from Highways 67 and 287 at Old Fort Worth Road and Wyatt Road).

Figure 10. Polar plot maps for various monitoring sites, 1,3-Butadiene

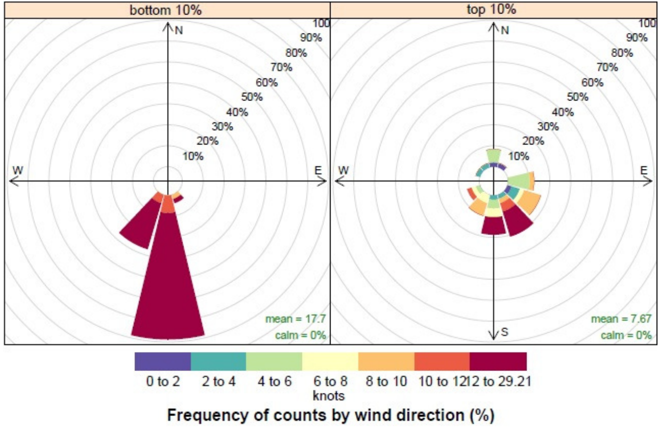


Wind roses were generated for high and low concentration days to further evaluate the influence of area sources on VOC monitors in the community (Figure 11). Unfortunately, for the longest running stations, 1,3-butadiene was not detected above the detection limit more than 20% of the time, so comparison wind roses were not generated (Old Fort Worth Road, Midlothian Tower, Tayman Drive WWTP, and Wyatt Road).

Figure 11. Wind Roses of wind direction by lowest (bottom 10%) and highest (top 10%) average concentrations of 1,3-butadiene


Old Fort Worth Road (2008-2009) *Tayman Drive WWTP (2008-2009)*

Jaycee Park (2008-2009)



The Kruskal-Wallis statistical analysis only found significant effects from wind direction at Midlothian Old Fort Worth Road (OFW) location (Table 21). At the Old Fort Worth Road location, the boxplots of concentration versus wind direction did not reveal a strong effect, and the post-hoc comparisons of the concentration and wind direction only revealed that the levels were lower when the winds were from the south. The data do not lead us to conclude that there is major source of 1,3-butadiene in the community.

Table 21. Associations (p-value) between 1,3-butadiene concentrations in air and wind direction*¥

Monitoring Location	Number of Observations	p.value†
Midlothian OFW	766	0.001
Midlothian Tower	199	0.257
Midothian Wyatt Road	84	0.231
Tayman Dr WWTP	231	0.252
Jaycee Park-URS	20	0.131
Tayman Dr WWTP-URS	20	0.147
Old Fort Worth Road-URS	20	0.394

***** Wind direction is the direction from which the wind is blowing;**

¥ Sites with 5 or less samples were not included in this table; and

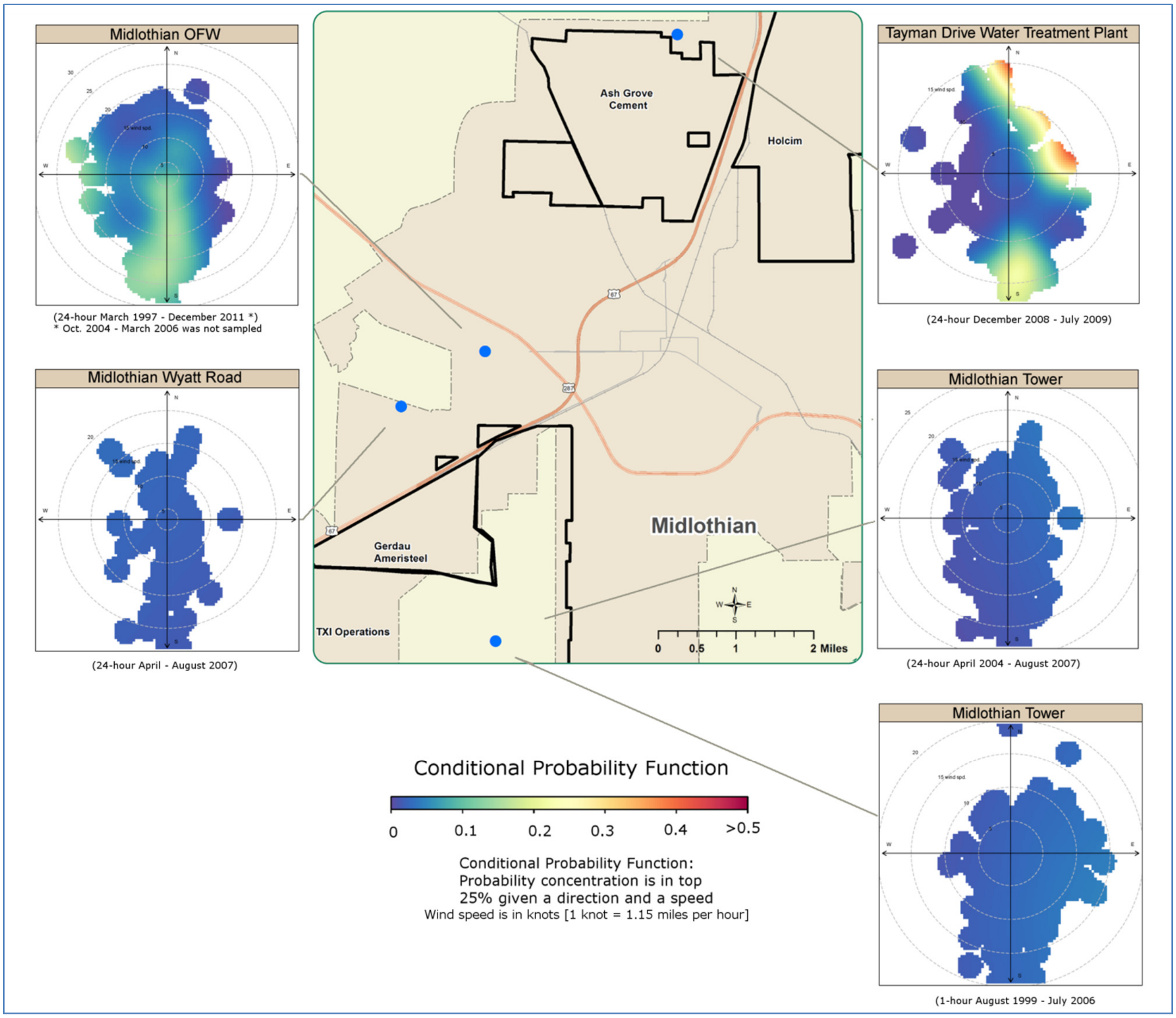
† p values of ≤0.05 are considered statistically significant

Given these observations, ATSDR concludes the 1,3-butadiene is likely present in the community as a persistent ambient air pollutant, without a major emissions source in the community.

Carbon Tetrachloride

Carbon tetrachloride is a common air pollutant in the United States. Of the Midlothian facilities of interest, Ash Grove is the only facility that has reported the release of carbon tetrachloride in sufficient enough quantity to warrant reporting of the pollutant. The highest emissions years of 1,3-butadiene at Ash Grove were in 1989 and 1991 (<100 lbs). Like benzene and 1,3-butadiene, carbon tetrachloride has been measured at every site where VOCs have been sampled for in the community. Polar plot maps of the top 25% of ambient concentrations weakly indicate that carbon tetrachloride concentrations may be influenced by sources at the boundary of TXI and Gerdau Ameristeel as well as to the south and northwest of the Tayman Drive monitor (Figure 12). The intersection of small roadways are to the northeast of the Tayman Drive monitor, and waste bioreactors at the wastewater treatment plant and Ash Grove are south of the Tayman Drive monitor.

Figure 12. Polar plot maps for various monitoring sites, Carbon Tetrachloride



(24-hour March 1997 - December 2011 *)
* Oct. 2004 - March 2006 was not sampled

(24-hour April - August 2007)

(24-hour December 2008 - July 2009)

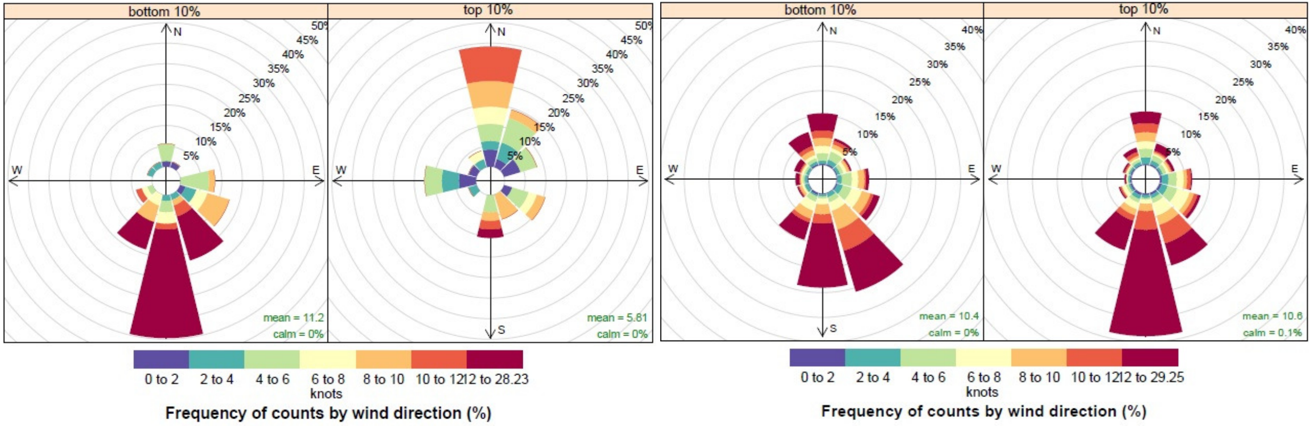
(24-hour April 2004 - August 2007)

(1-hour August 1999 - July 2006)

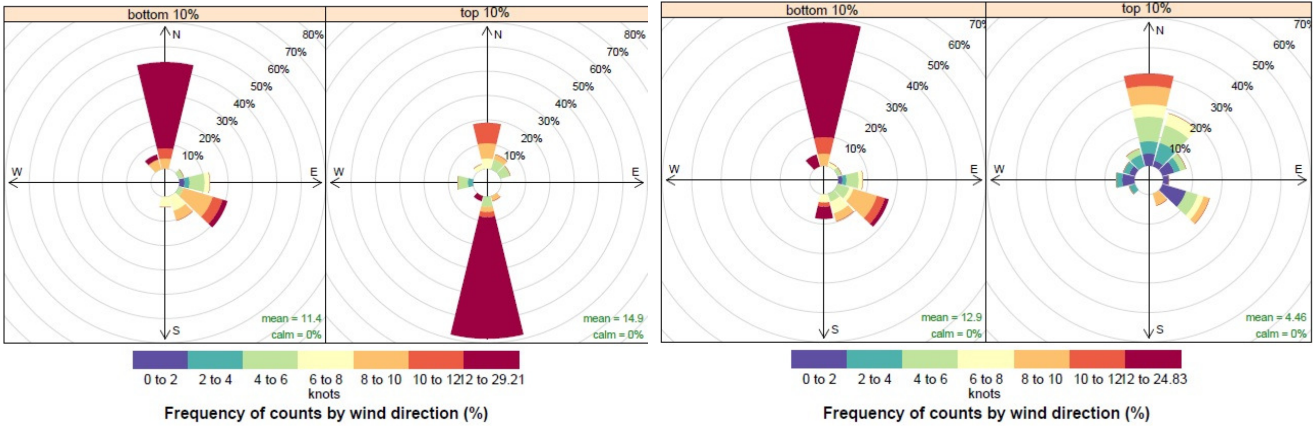
Conditional Probability Function:
Probability concentration is in top 25% given a direction and a speed
Wind speed is in knots [1 knot = 1.15 miles per hour]

Wind roses were generated for high and low concentration days to further evaluate the influence of area sources on VOC monitors in the community. Wind roses were generated for all of the stations that ran eight months or longer in the community. Longer running monitors, such as Old Fort Worth Road CAMs (1997-2011), Wyatt Road (2004-2006), and Midlothian Tower (2004-2007), seem to indicate a weak source in the direction of the property boundary between TXI and Gerdau Ameristeel. The URS data collected in 2008-2009 shows a much clearer pattern for Old Worth Road in this regard. Historical sampling show the influence a southern source, possibly Ash Grove, on the Tayman Drive WWTP monitor (1993-1997), but this pattern does not exist for the 2008-2009 data. In the URS study, however, Jaycee Park data also seem to indicate that Ash Grove could contribute to ambient concentrations of carbon tetrachloride at its location (Figure 13).

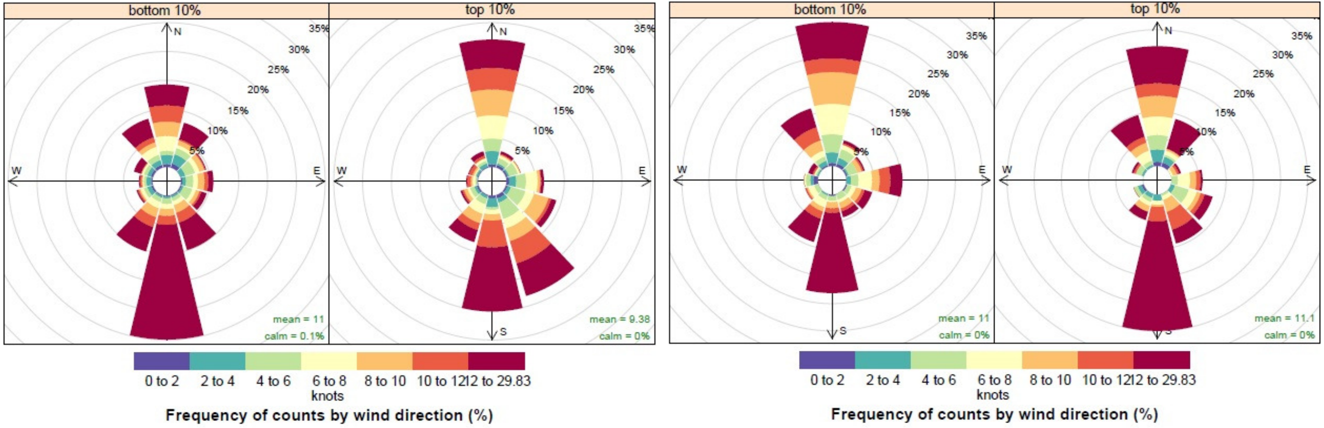
Figure 13. Wind Rose of wind direction by lowest (bottom 10%) and highest (top 10%) average concentrations of carbon tetrachloride


Jaycee Park (2008-2009) *Old Fort Worth Rd (1997-2011)*

Old Fort Worth Road (2008-2009) *Tayman Drive WWTP (2008-2009)*

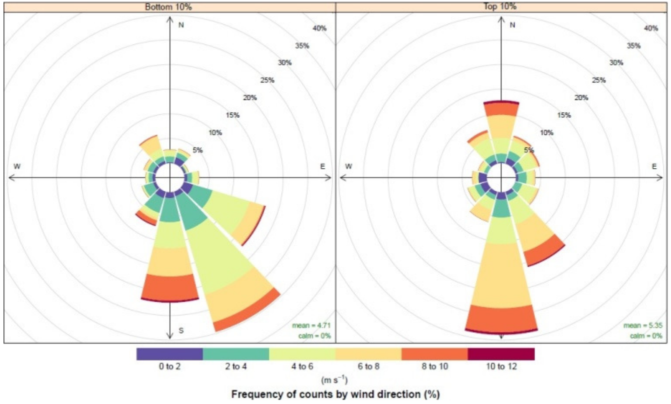


(Figure 15, continued)



Midlothian Tower (2004-2007) *Wyatt Road (2004-2006)*

Tayman Drive WWTP (1993-1997)



The Kruskal-Wallis statistical analysis showed a statistically significant association at the long running Old Fort Worth Road monitor, but nowhere else (Table 22). The boxplots of concentration versus wind direction did not reveal a strong effect, and the post-hoc comparisons of the concentration and wind direction did not reveal a significant pattern, this indicating that there is no major source of carbon tetrachloride identified by these sampling data and, as in many U.S. cities, carbon tetrachloride is a persistent pollutant in the community.

Table 22. Associations (p-value) between carbon tetrachloride concentrations in air and wind direction[*¥]

Monitoring Location	Number of Observations	p.value[†]
Old Fort Worth Road-CAMs	766	0.03
Midlothian Tower	199	0.08
Tayman Dr WWTP	231	0.19
Jaycee Park-URS	20	0.38
Old Fort Worth Road-URS	20	0.44
Tayman Dr WWTP-URS	20	0.53
Wyatt Road	84	0.78

**** Wind direction is the direction from which the wind is blowing;***
[¥] Sites with 5 or less samples were not included in this table; and
† p values of ≤0.05 are considered statistically significant

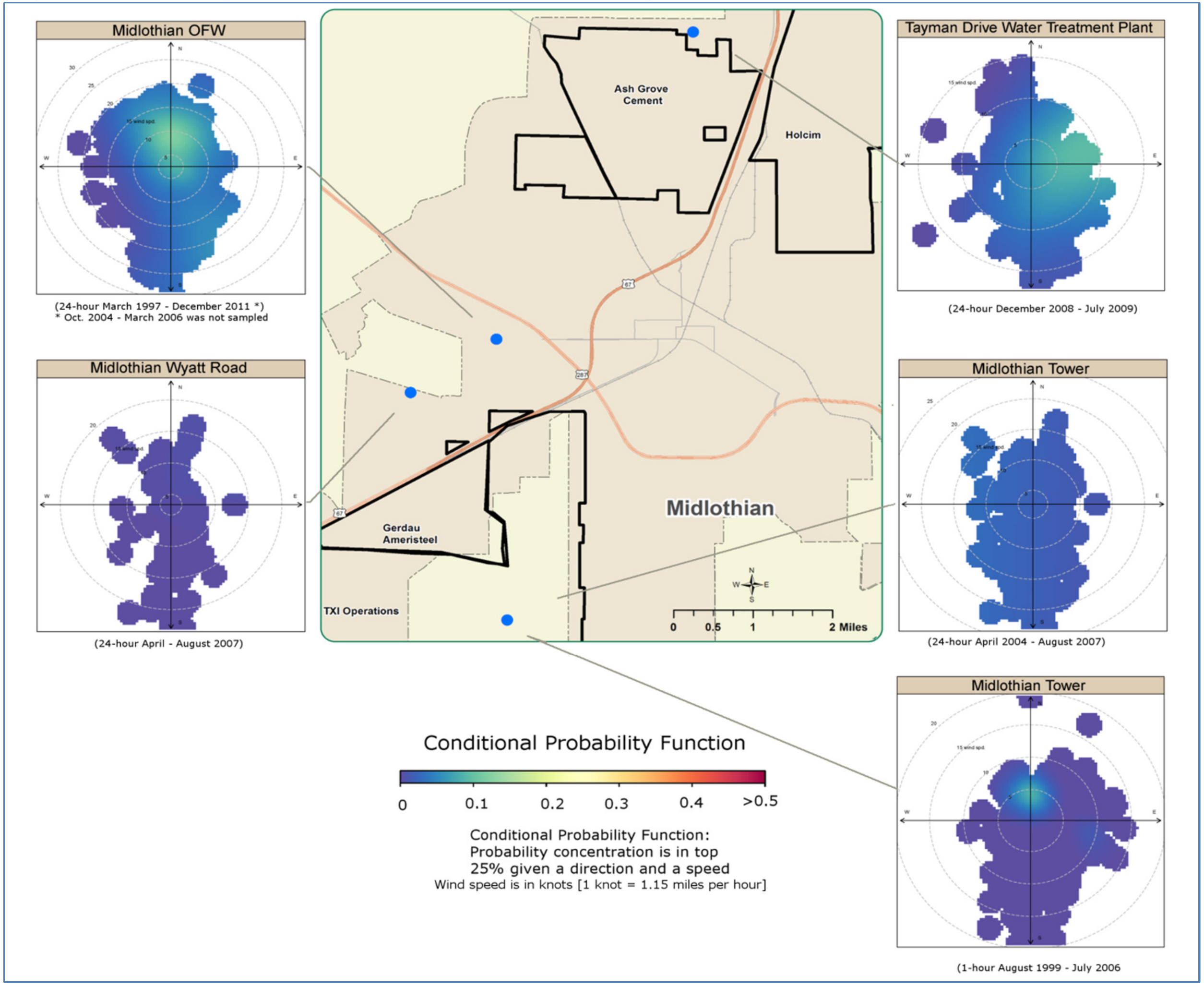
Given these observations, ATSDR concludes the carbon tetrachloride is likely present in the community as a persistent pollutant which may also be emitted in small quantities from roadways and industrial sources in the community.

Chloroform

Chloroform is also a very commonly detected pollutant in ambient air across the United States. It is released from industrial processes as well as from water chlorination activities. In Midlothian, two of the four facilities of interest have reported releases to the Toxics Release Inventory (Ash Grove Cement and TXI), but never for more than 10 lbs of the pollutant over a year.

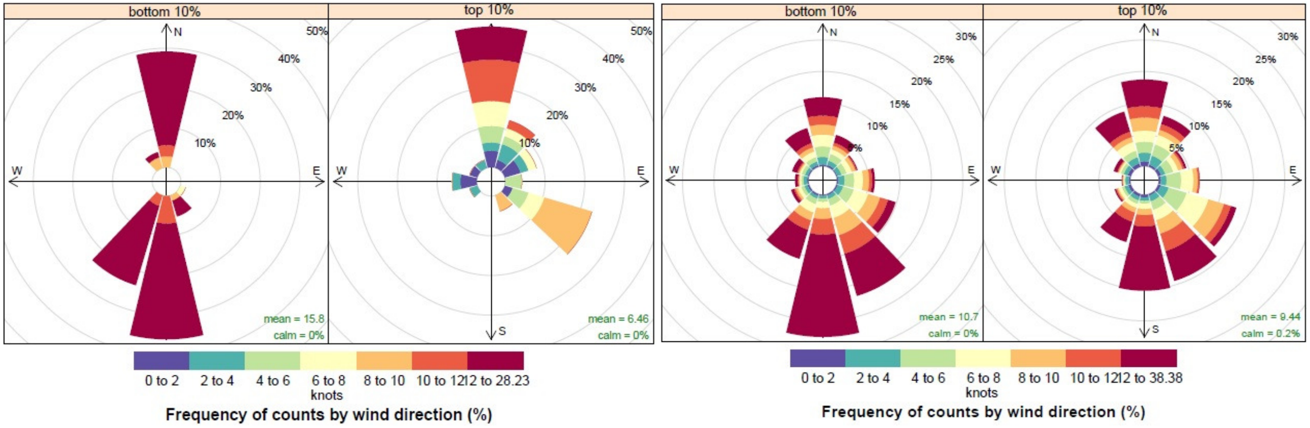
Polar plots indicated that no obvious patterns between ambient concentration and wind direction with the exception of a weak source north of Old Fort Worth Road (1997-2011) and at Tayman Drive for historical (1993-1997) (Figure 14). The detection of chloroform at Tayman Drive could be the result of chlorination activities at the Tayman Drive WWTP.

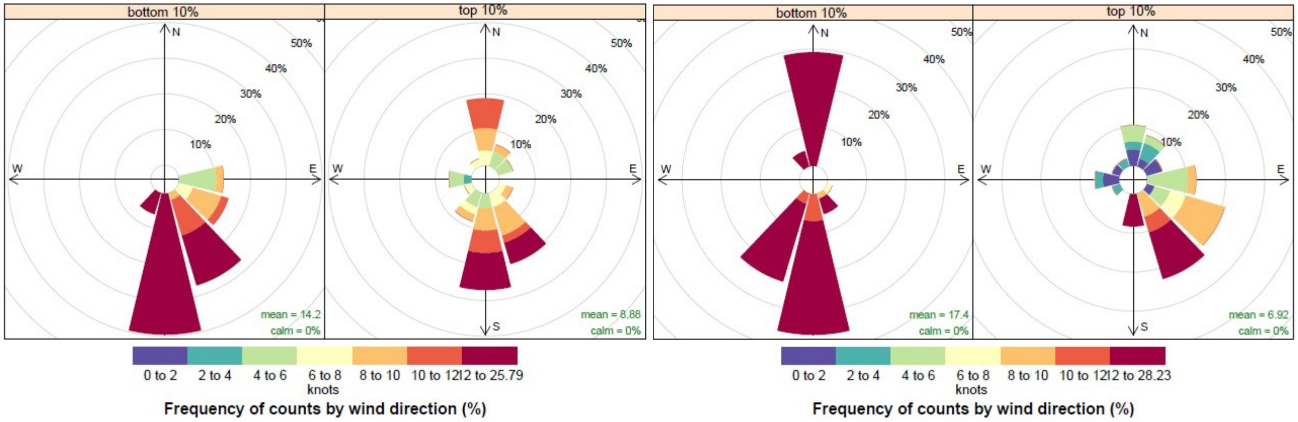
Figure 14. Polar plot maps for various monitoring sites, Chloroform

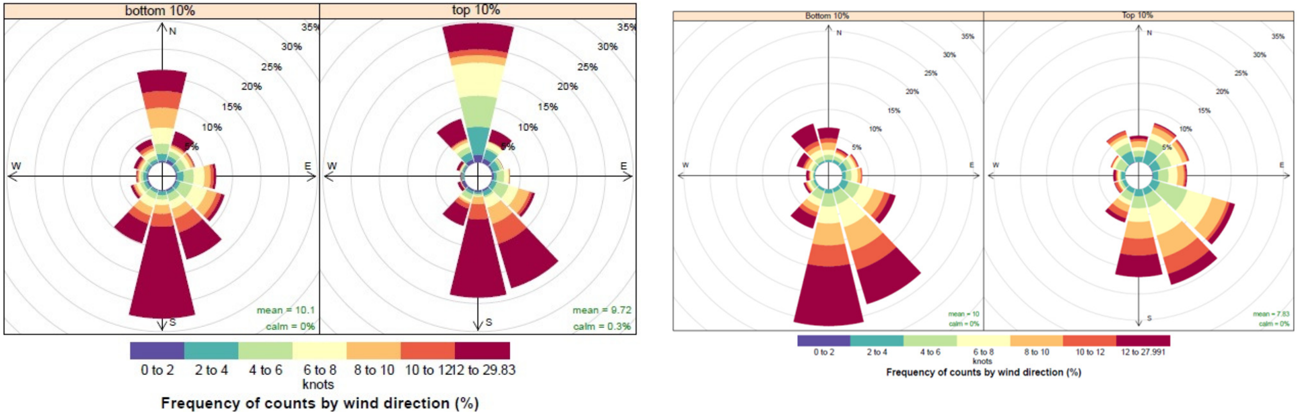


Ambient concentrations of chloroform and their relationship to wind direction was further evaluated in wind roses that ATSDR generated for the highest 10% of concentrations and the lowest 10% of concentrations (Figure 15). The wind roses show weak associations with wind direction, with a possible minor source to the north Jaycee Park and the Old Fort Worth URS sites (2008-2009); and a source to the southeast/south-southeast at the Tayman Drive WWTP URS site (2008-2009). There is no clear pattern at the long term monitors at Midlothian Tower, Old Fort Worth Road, and Tayman Drive WWTP.

Figure 15. Wind Rose of wind direction by lowest (bottom 10%) and highest (top 10%) average concentrations of chloroform


Jaycee Park (2008-2009) *Old Fort Worth Rd (1997-2011)*


Old Fort Worth Rd (2008-2009) *Tayman Drive WWTP (2008-2009)*


Midlothian Tower (2004-2007) *Tayman Dr WWTP (1993-1997)*

The Kruskal-Wallis statistical analysis showed a statistically significant association at the long running Old Fort Worth Road monitor, but nowhere else (Table 23). Much of the data are below the limit of detection, however, the Kruskal-Wallis test detected differences because other quantiles were slightly different across the wind direction categories. Judging from the boxplots, the overall effect of wind direction on concentration was small. Pairwise comparisons of concentration by wind direction only found the South concentrations were significantly lower than the North concentrations. There is no evidence of a major source of chloroform in the community. Chloroform is found at consistent concentrations throughout Midlothian over time and location, again indicating a ubiquitous source.

Table 23. Associations (p-value) between chloroform concentrations in air and wind direction[*¥]

Monitoring Location	Number of Observations	p.value[†]
Midlothian OFW	766	0.02
Tayman Dr WWTP-URS	20	0.08
Jaycee Park-URS	20	0.22
Tayman Dr WWTP	231	0.36
Midlothian Wyatt Road	84	0.60
Old Fort Worth Road-URS	20	0.63
Midlothian Tower	199	0.83

**** Wind direction is the direction from which the wind is blowing;***

¥ Sites with 5 or less samples were not included in this table; and

† p values of ≤0.05 are considered statistically significant

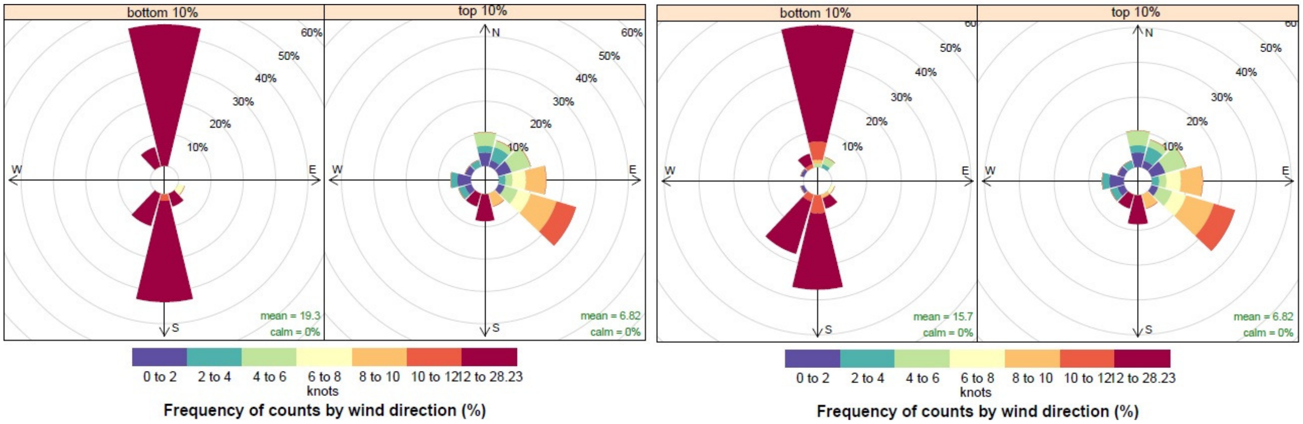
Given these observations, ATSDR concludes that chloroform is commonly detected in the community as it is across the United States, but localized sources may also influence ambient concentrations of chloroform. A local source may be influencing the Tayman Drive WWTP monitor (chloroform is a byproduct of water chlorination) and there may be a possible minor source north of the Midlothian Tower monitoring station.

Dibromochloromethane

Dibromochloromethane is a byproduct of water chlorination. It has never been reported by the Midlothian facilities of interest because it is not a pollutant that has reporting requirements. Thus, whether or not the facilities handle it in unknown. This pollutant was never analyzed in monitoring efforts until the 2008-2009 UT-Arlington air investigation. During that investigation, it was detected in three samples out of 40 at Old Fort Worth Road and Jaycee Park stations. Tayman Drive WWTP, on the other hand, had 14/24 detects of the pollutant. More than likely, this was an onsite source. Given that this pollutant is a common byproduct of water chlorination, it is ATSDR's opinion that the Tayman Drive WWTP is the likely source of the pollutant in ambient air. As with bromodichloromethane, there are a number of potential sources of dibromochloromethane on the property that could impact the air monitor. There were not enough data to generate conditional probability polar plots for this pollutant.

Wind roses were generated for high and low concentration days to evaluate the influence of the Tayman Drive WWTP. Similar to bromodichloromethane, the monitor suggests a short range source which is predominantly to the east/southeast. The wind roses of top concentration days for the two chlorination byproducts show very similar patterns for the direction of potential sources, which are likely onsite storage tanks to the east and southeast of the monitor (Figure 16).

Figure 16. Wind Rose of wind direction by lowest (bottom 10%) and highest (top 10%) average concentrations of dibromochloromethane and bromodichloromethane at Tayman Dr WWTP


Dibromochloromethane *Bromodichloromethane*

The Kruskal-Wallis statistical analysis showed no statistically significant associations between concentration and wind direction. However, this test has low sensitivity because of the small number of samples the pollutant in area monitors (Table 24).

Table 24. Wind direction and p-value result of tests of significance for concentration of dibromochloromethane in air and wind direction[*¥]

Monitoring Location	Number of Observations	p.value[†]
Tayman Dr WWTP	20	0.096
Old Fort Worth Road	20	0.368
Jaycee Park	20	0.426

**** Wind direction is the direction from which the wind is blowing;***
[¥] *Sites with 5 or less samples were not included in this table; and*
[†] *p values of ≤0.05 are considered statistically significant*

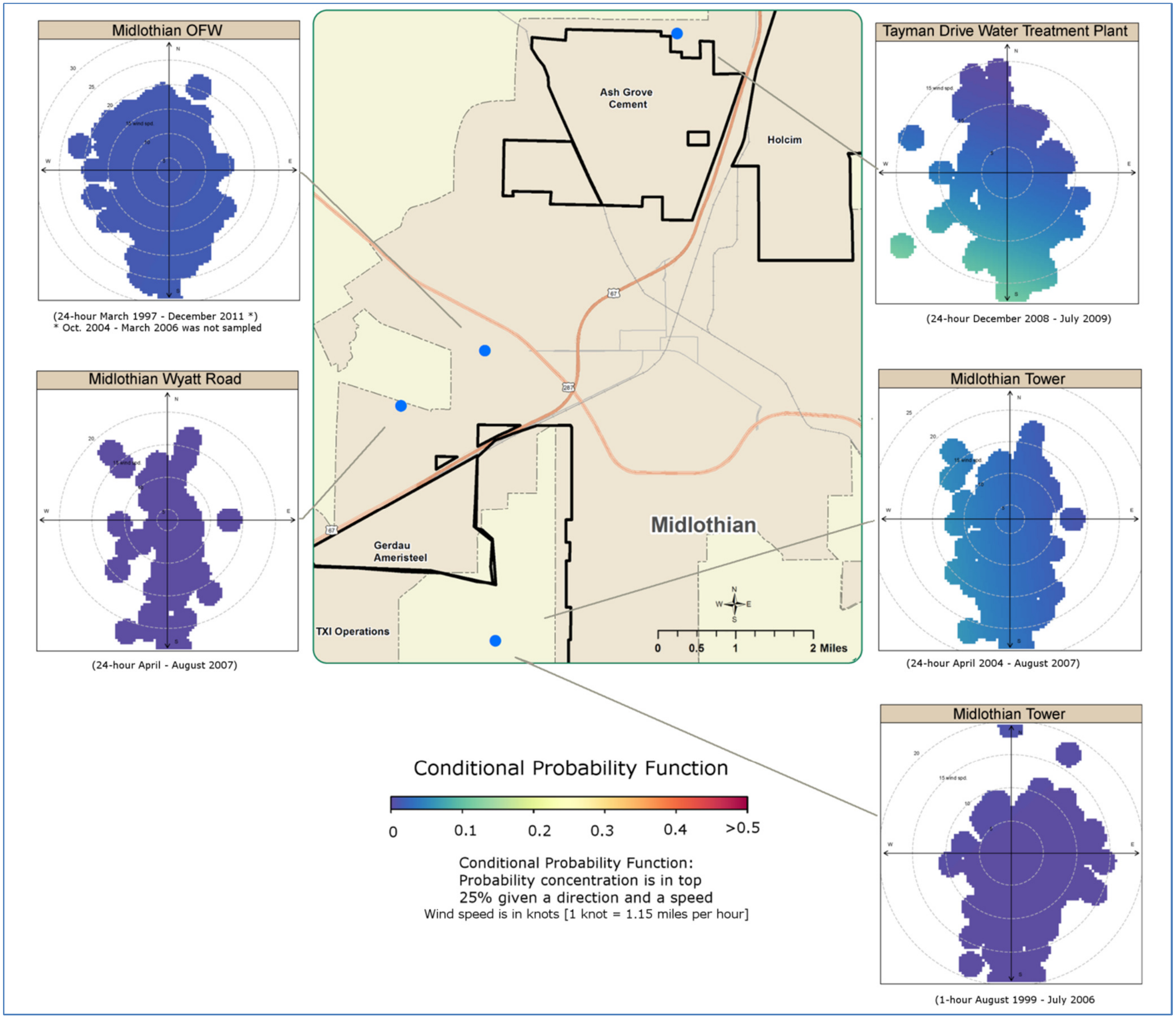
Given these observations, ATSDR concludes the dibromochloromethane is likely present in the community as a chlorination byproduct from the Tayman Drive WWTP.

Ethylene Dichloride (1,2-Dichloroethane or 1,2-DCA)

1,2-DCA is used to make other synthetic chemicals or plastics. It has never been reported by the Midlothian facilities of interest. The only site where this pollutant was detected in more than 20% of samples was at the Tayman Drive WWTP air monitor (1993-1997).

Polar plots are inconclusive because 1,2-DCA was only detected in a very small number of samples at most of the sites (Figure 17). The only site with more than 20% detects is Tayman Drive WWTP, which weakly indicates a source to the south in the 1993-1997 data set.

Figure 17. Polar plot maps for various monitoring sites, Ethylene Dichloride (1,2-Dichloroethane)



Comparison wind roses could not be generated for high and low concentration days at any site because there was insufficient data at monitoring sites for 1,2-DCA. The Kruskal-Wallis statistical analysis showed no statistically significant associations between concentration and wind direction because of the low frequency of detection of the pollutant in area monitors (Table 25).

Table 25. Wind direction and p-value result of tests of significance for concentration of 1,2-dichloroethane in air and wind direction*¥

Monitoring Location	Number of Observations	p.value†
Jaycee Park-URS	20	0.27
Old Fort Worth Road-URS	20	0.27
Tayman Dr WWTP-URS	20	0.26
Tayman Drive CAMS	231	0.09
Old Fort Worth Road-CAMs	766	0.89
Midlothian Tower	199	0.69
Wyatt Road	84	NA

***** Wind direction is the direction from which the wind is blowing;***
¥ Sites with 5 or less samples were not included in this table; and
† p values of ≤0.05 are considered statistically significant

Due to the general lack of ambient measurements, ATSDR cannot make conclusions about the source of the 1,2-DCA in ambient air.

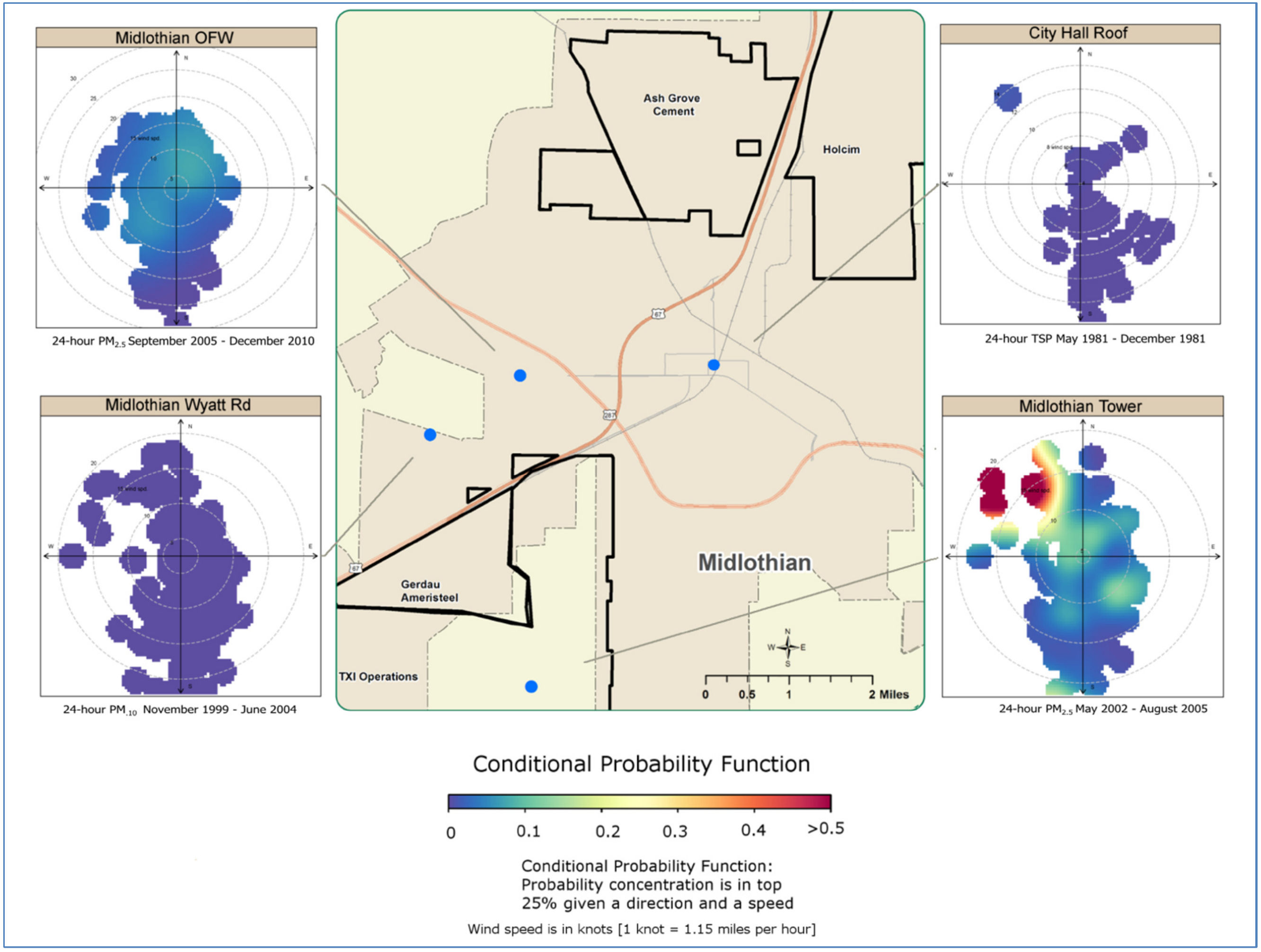
3.4.2. Spatial Evaluation of Metals

Arsenic

Arsenic is naturally occurring in soil and airborne dust, and is also released from industrial facilities. The Midlothian facilities did not report arsenic emissions to the Toxic Release Inventory, most likely because their emissions were not high enough to meet reporting requirements. In Midlothian, historical detection limits were substantially higher than cancer comparison values. Thus, arsenic was “not detected” or present at levels “below the limit of detection” in all samples except the UT-Arlington air investigation conducted in 2008-2009, when the detection limit was low enough to quantify arsenic at concentrations below the ATSDR CREG of 0.0002 µg/m^3. As noted earlier, concentrations of arsenic detected in Midlothian during the 2008-2009 study were consistent across all sites, indicating a ubiquitous source.

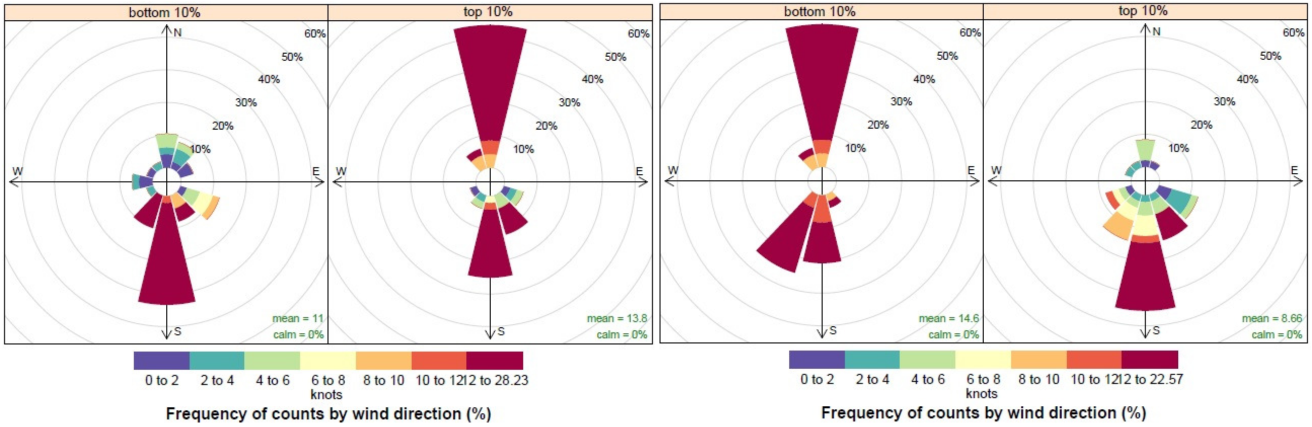
Polar plots for arsenic in the PM_{10} fraction of dust are inconclusive because arsenic was only detected in a very small number of samples at long running sites because of high detection limits. Even with lower detection limits, the 2008-2009 study had only four monitors with 20 samples collected at each site and did not have enough observations to create conditional probability polar plots. Of longer term monitoring sites, only the $PM_{2.5}$ plots indicate a source to the northwest at Midlothian Tower within the upper quartile of detections of the metal in ambient air (Figure 18).

Figure 18. Polar plot maps for various monitoring sites, Arsenic



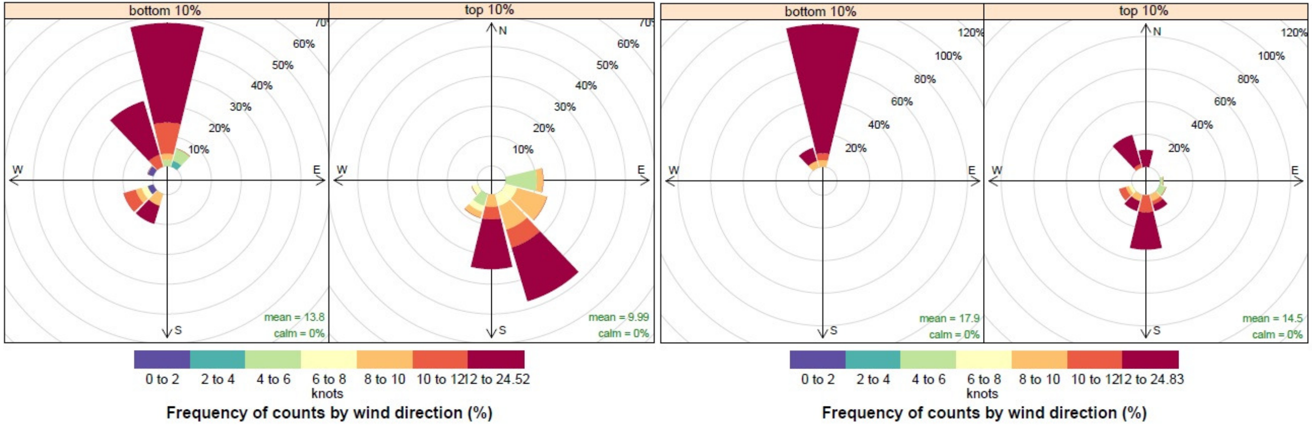
Wind roses were generated for high and low concentration days to further evaluate the influence of area sources. Sufficient data were only available to create wind rose comparisons for four URS stations (PM_{10}) and for Midlothian Tower ($PM_{2.5}$). Generally, there are weak indications that sources to the north contributed higher concentrations of arsenic at Jaycee Park and more contributions were made by sources south of the remainder of the 2008-2009 study sites (all PM_{10}). The wind rose for Midlothian Tower ($PM_{2.5}$) indicates that concentrations of arsenic are highest when winds are blowing from the north and northwest but also show a strong signal from the north when ambient concentrations are lowest (see Figure 19).

Figure 19. Wind Rose of wind direction by lowest (bottom 10%) and highest (top 10%) average concentrations of arsenic



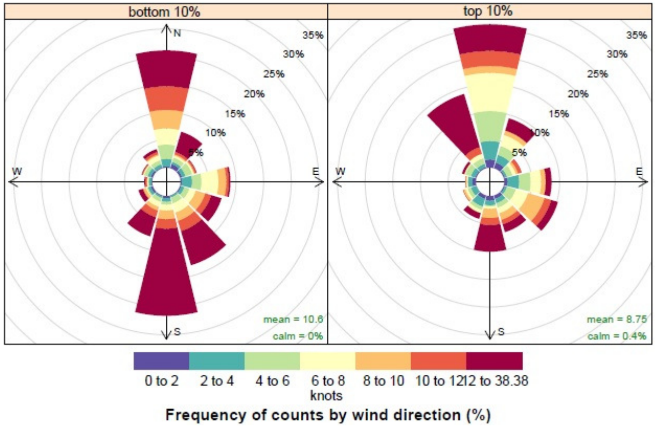
Jaycee Park (2008-2009)

Old Fort Worth Road (2008-2009)



Tayman Drive WWTP (2008-2009)

Wyatt Road (2008-2009)



Midlothian Tower, $PM_{2.5}$ (2002-2005)

The Kruskal-Wallis statistical analysis showed no statistically significant associations between concentration and wind direction in the PM_{10} data because of the small number of samples collected in the 2008-2009 study. On the other hand, the $PM_{2.5}$ data demonstrated borderline significance for Old Fort Worth Road and statistical significance with northerly source(s) at the Midlothian Tower location

(Table 26). Boxplots did not reveal large differences in the concentrations by wind direction, and the pairwise comparisons were significant only when comparing concentrations when winds were from the north and south.

Table 26. Wind direction and p-value result of tests of significance for concentration of arsenic in air and wind direction*¥

PM10 Monitoring Location	Number of Observations	p.value†
Wyatt Road-URS	20	0.07
Old Fort Worth Road-URS	20	0.16
Tayman Dr WWTP-URS	20	0.19
Jaycee Park-URS	20	0.35
PM2.5 Monitoring Location	**Number of Observations**	**p.value†**
Midlothian Tower	197	0.0063
Midlothian OFW	321	0.0566

**** Wind direction is the direction from which the wind is blowing;***
¥ Sites with 5 or less samples were not included in this table; and
† p values of ≤0.05 are considered statistically significant

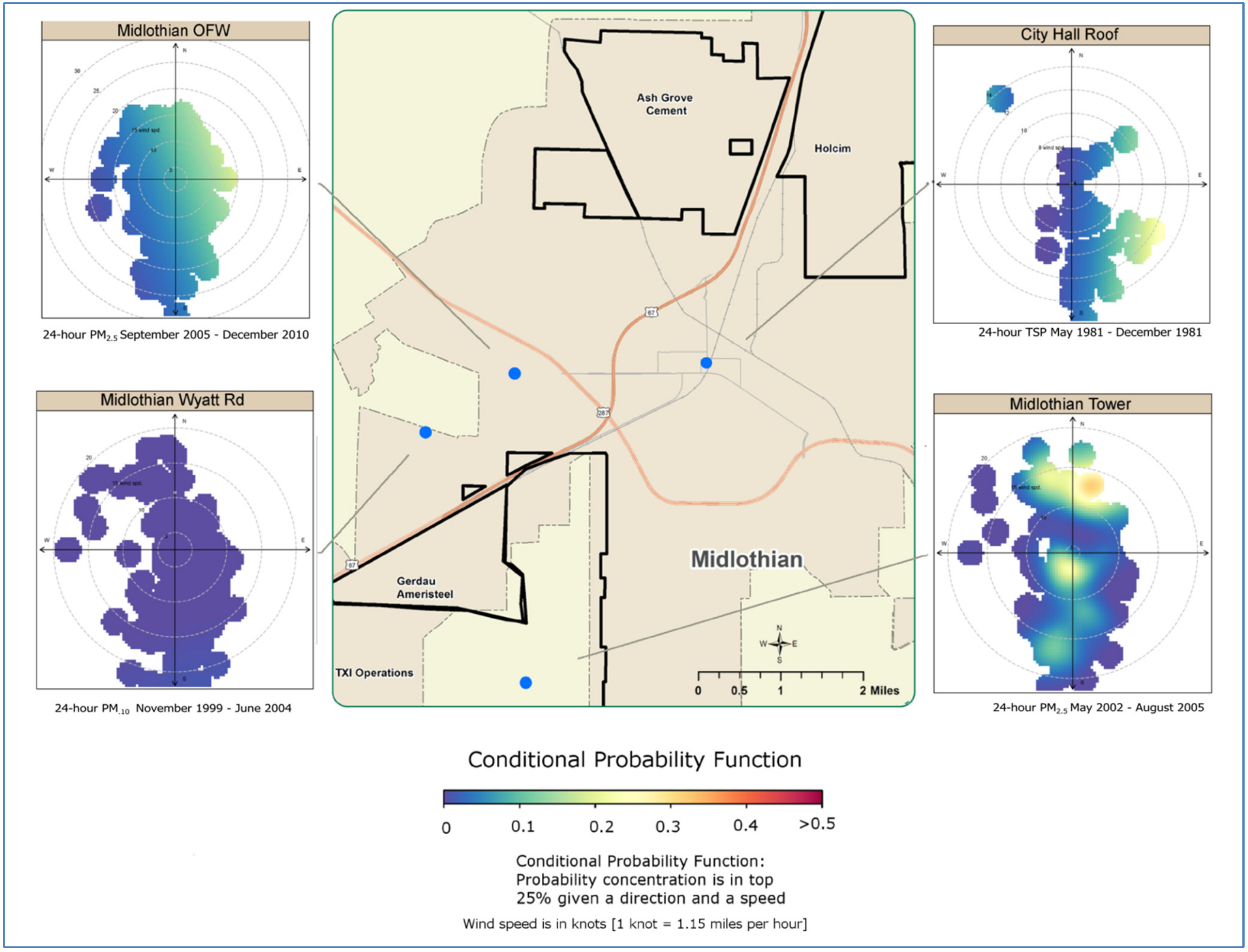
It is possible that there are contributions from industrial and naturally occurring sources to ambient arsenic concentrations in Midlothian. However, among the possible sources of airborne arsenic in the community, none stand out as the sole (or even the major) contributor. Arsenic concentrations in the Midlothian community are similar to those across the United States.

Cadmium

Cadmium is another commonly found metal in soil and air and can be released in trace amounts by industrial activity, such as steel mills and other metal production facilities. Although none of the cement plants in Midlothian report emissions of cadmium to the toxic release inventory, Gerdau Ameristeel has consistently reported cadmium emissions from their Midlothian steel mill. Cadmium has been measured in PM_{10} and $PM_{2.5}$ dust sizes in Midlothian. Data collected during the 2008-2009 UT-Arlington study has lower detection limits than earlier studies, and subsequently a greater percentage of detected cadmium samples. No monitoring stations have more than 20% detects outside of the 2008-2009 study.

Polar plots of cadmium at area sampling locations indicate an influence of emissions from the direction of Gerdau Ameristeel (Figure 20). However, only three individual measured concentrations exceeded any health based comparison value (the ATSDR CREG) and, if averaged appropriately over a time period greater than a year, a chronic average would not exceed this health based comparison value. Thus, even though Gerdau Ameristeel locally influences metal concentrations at surrounding monitoring stations, those contributions do not necessarily pose a threat to residents living nearby.

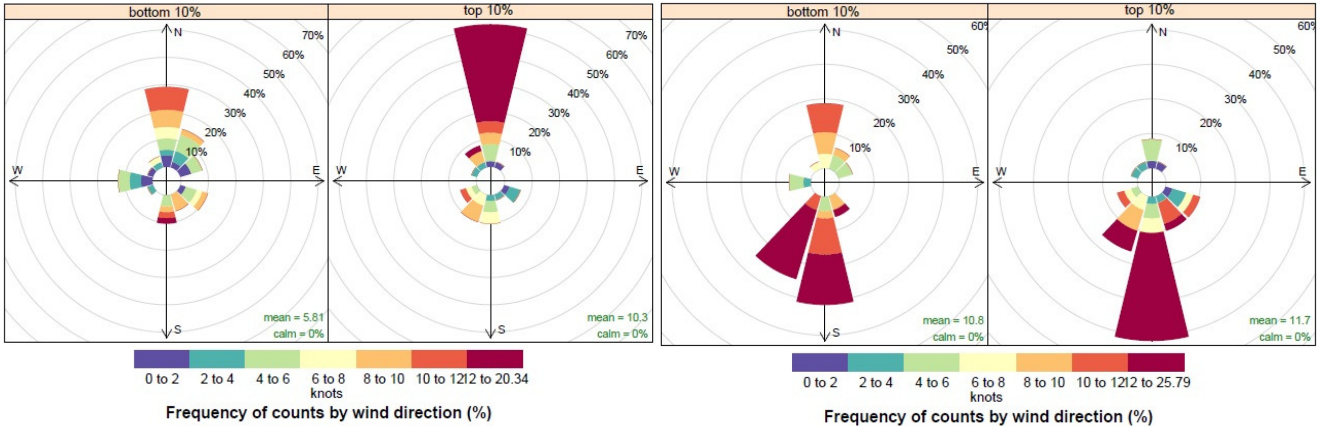
Figure 20. Polar plot maps for various monitoring sites, Cadmium



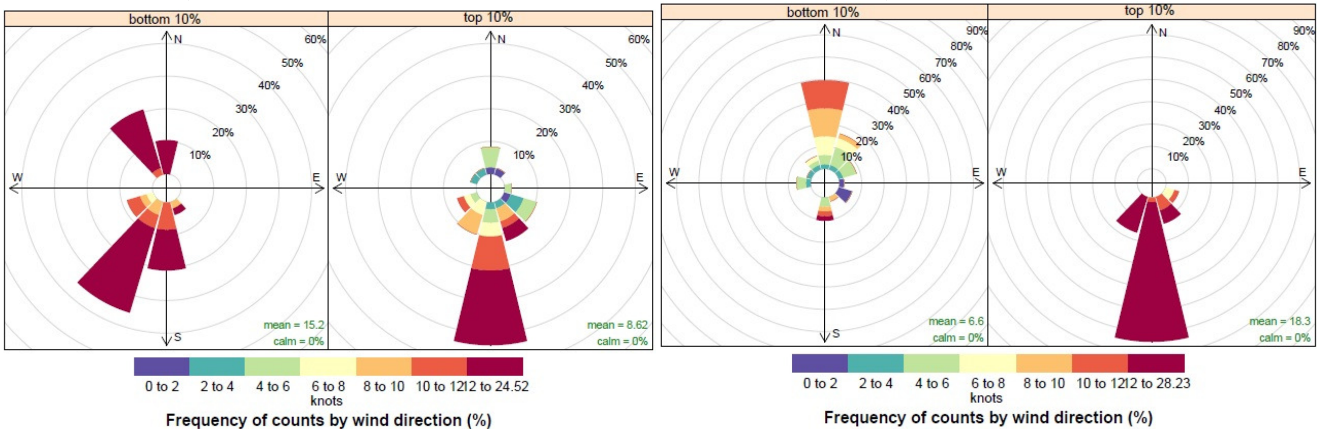
Wind roses were generated for high and low concentration days to further evaluate the influence of area sources. Sufficient data were only available to create wind rose comparisons for four URS stations (PM_{10}). The wind roses show a clear relationship between Gerdau Ameristeel and impacts at the Wyatt Road sampling site on high cadmium concentration days in the 2008-2009 UT-Arlington study (Figure 21). The trends at the other sites are not conclusive.

Figure 21. Wind Rose of wind direction by lowest (bottom 10%) and highest (top 10%) average concentrations of cadmium

Jaycee Park (2008-2009) *Old Fort Worth Road (2008-2009)*



Tayman Dr WWTP (2008-2009) *Wyatt Road (2008-2009)*



The Kruskal-Wallis test showed no statistically significant associations between concentration and wind direction in the PM_{10} data because of the small number of samples collected in the 2008-2009 study. There were not sufficiently detected data to perform these analyses on the historical PM_{10} data or the $PM_{2.5}$ data (Table 27).

Table 27. Wind direction and p-value result of tests of significance for concentration of cadmium in air and wind direction*¥

PM10 Monitoring Location	Number of Observations	p.value†
Old Fort Worth Road-URS	20	0.08
Wyatt Road-URS	20	0.12
Jaycee Park-URS	20	0.22
Tayman Dr WWTP-URS	20	0.23

**** Wind direction is the direction from which the wind is blowing;***
¥ Sites with 5 or less samples were not included in this table; and
† p values of ≤0.05 are considered statistically significant

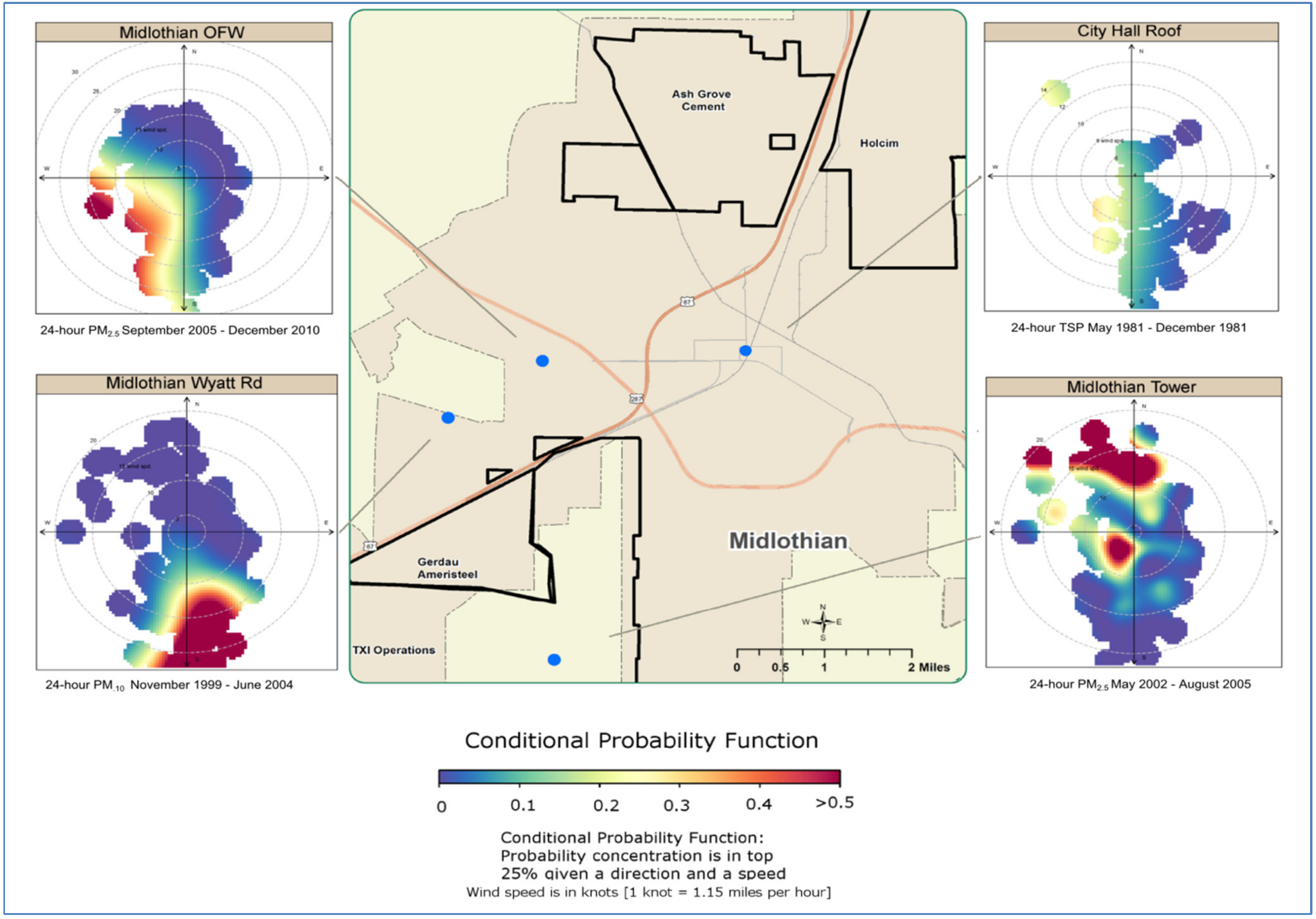
In summary, the spatial evaluation of cadmium concentrations at monitoring sites suggest a local influence from the steel mill or the area immediately north of Gerdau Ameristeel.

Manganese

Manganese, like arsenic and cadmium, is a naturally occurring element found in the soil and air as well as in emissions from industrial facilities, like steel mills. All four facilities of concern in Midlothian have reported emissions of manganese to reporting inventories. In Midlothian, manganese has been measured in PM_{10} and $PM_{2.5}$ air for as long as metals have been quantified there. Generally, it has been measured at concentrations typical for the United States.

There were not enough observations to create polar plots of the 2008-2009 URS manganese data. However, polar plots of manganese at area sampling locations show the consistently clear influence of emissions from the direction of Gerdau Ameristeel (Figure 22). As is true for cadmium, ambient concentrations of manganese never exceeded the ATSDR chronic health based comparison value. Thus, even though Gerdau Ameristeel locally influences manganese concentrations at surrounding monitoring stations, those contributions do not necessarily pose a threat from manganese exposure to residents living nearby.

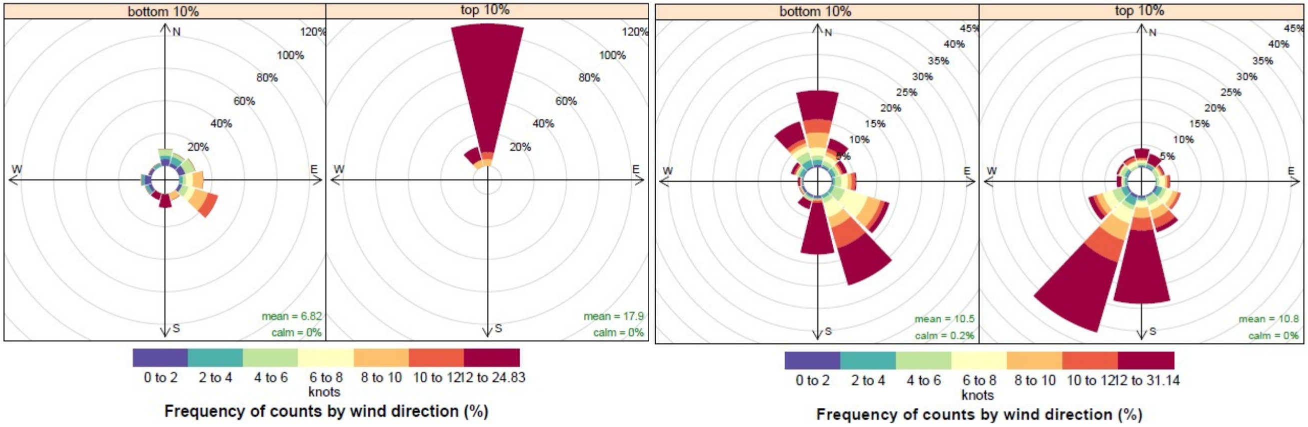
Figure 22. Polar plot maps for various monitoring sites, Manganese



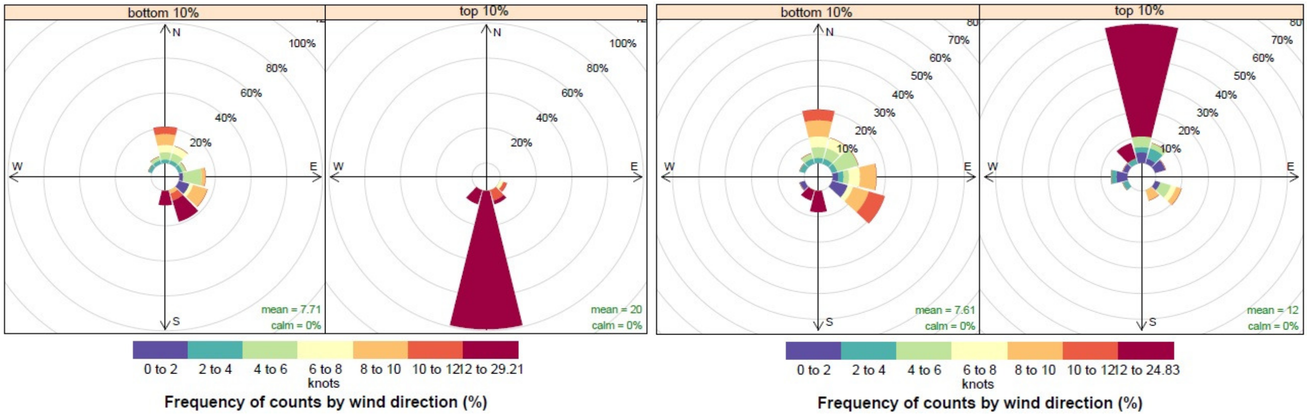
As with all other pollutants, wind roses were generated for high and low concentration days to further evaluate the influence of area sources. Sufficient data were available to create wind rose comparisons for four URS stations (PM_{10}) and two long running $PM_{2.5}$ monitors. As with the polar plots, wind roses show a clear relationship between Gerdau Ameristeel and impacts at Old Fort Worth Road, Midlothian Tower, and Wyatt Road sampling sites on high manganese concentration days for all data collected at those sites. Ash Grove appears to influence the Jaycee Park monitoring site for the 2008-2009 air sampling study as well (Figure 23).

Figure 23. Wind Rose of wind direction by lowest (bottom 10%) and highest (top 10%) average concentrations of manganese

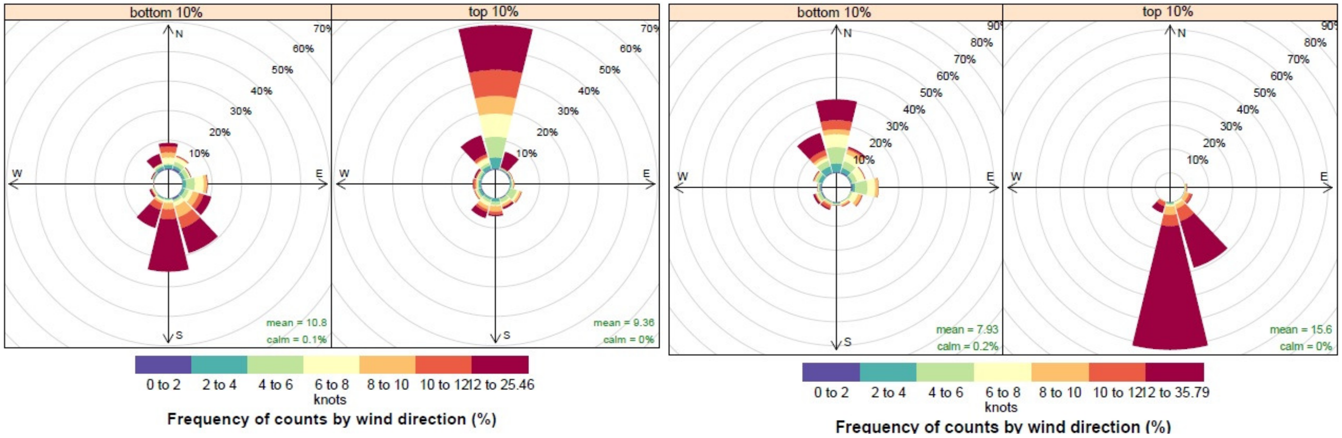
Jaycee Park (2008-2009) *Old Fort Worth Road, $PM_{2.5}$ (2005-2010)*



Old Fort Worth Road (2008-2009) *Tayman Drive (2008-2009)*



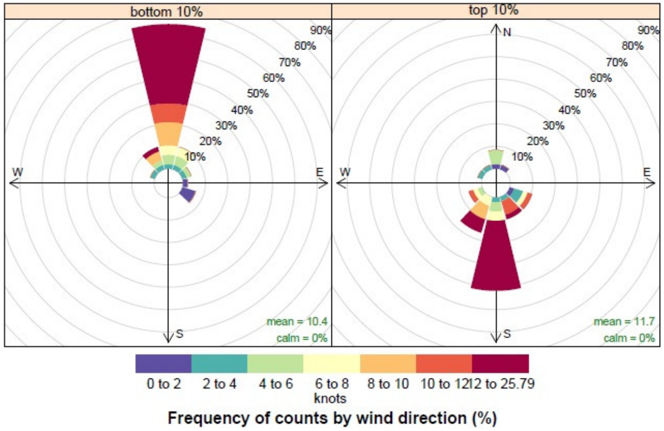
(figure 23, continued)



Midlothian Tower, $PM_{2.5}$ (2002-2005)

Wyatt Road (2004-2006)

Wyatt Road (2008-2009)



The Kruskal-Wallis test showed statistically significant associations between concentration and wind direction at sites near Gerdau Ameristeel (Table 28).

Table 28. Wind direction and p-value result of tests of significance for concentration of manganese in air and wind direction*¥

PM_{10} Monitoring Location	**Number of Observations**	**p.value†**
Wyatt Rd-CAMS	262	3.99E-22
Old Fort Worth Road-URS	20	0.03
Wyatt Road-URS	20	0.05
Jaycee Park-URS	20	0.21
Tayman Dr WWTP-URS	20	0.34
$PM_{2.5}$ Monitoring Location	**Number of Observations**	**p.value†**
Old Fort Worth Road-CAMS	321	2.67E-08
Midlothian Tower	197	0.12

***** *Wind direction is the direction from which the wind is blowing;*

¥ ***Sites with 5 or less samples were not included in this table; and***

† p values of ≤0.05 are considered statistically significant

In summary, the spatial evaluation of manganese concentrations at monitoring sites suggest a local influence from the steel mill on the area immediately north of Gerdau Ameristeel and south of Ash Grove.

4.0 Environmental Data-Modeling Data

For the pollutants reviewed in the previous section, ATSDR based its conclusions on ambient air monitoring data—or direct measurements of levels of air pollution in the Midlothian area. This could not be done for the site-related pollutants for which no ambient air monitoring data are available, which include acetaldehyde, formaldehyde, dioxins, furans, and certain acid aerosols. As noted in the first Health Consultation, ATSDR conducted a modeling analysis to estimate what past air pollution levels might have been for these substances.

Air dispersion models use information about facilities, their emissions, local land uses, and weather patterns to estimate air pollution. The model results are estimated air pollution levels that are generated from a scientific understanding of how emissions move from a source through the outdoor air to other locations. Numerous dispersion models are available and these vary in complexity and their ability to evaluate specific air quality scenarios. Although the field of air dispersion modeling has advanced in recent decades, modeling is not a perfect science. Results generated by air dispersion models have uncertainties and limitations. The main sources of uncertainty in this assessment are the model inputs for facility emission rates and inherent limitations in air dispersion models—uncertainties are likely greater for the estimated short-term peak air concentrations, due to lack of hourly-average emissions data. ATSDR generally made assumptions to err on the side of protecting public health, while not making the modeling exercise unrealistically conservative. For instance, emissions data used in the modeling were generally based on the highest levels that the individual facilities have reported to date.

Appendix F presents detailed information on the modeling that ATSDR conducted for the four Midlothian facilities. Our modeling included acetaldehyde, dioxins/furans, formaldehyde, hydrochloric acid, PAHs, and sulfuric acid. The inorganic pollutants included in the modeling (hydrochloric acid, sulfuric acid, and vapor-phase mercury) were those for which no air monitoring has been conducted, but that are reported in the Midlothian facilities' emission reports. The semi-volatile organic compounds included in the modeling (dioxins, furans, and polycyclic aromatic hydrocarbons (PAHs)) are also reported in substantial quantities among the area facilities, but have not been sampled for in ambient air. Two VOCs, acetaldehyde and formaldehyde, were also included in our modeling effort as they have not been sampled for in ambient air. Our modeling estimated how air quality impacts of several pollutants at locations throughout the Midlothian area. Table 29 summarizes modeling results for pollutants for which no ambient air monitoring data are available. This list presents the highest air concentrations predicted by the models, which were generally found to occur in the immediate vicinity of the industrial facilities with the highest emissions.

Table 29. Modeling results for pollutants not previously monitored for in ambient air

Modeled Pollutant	Highest annual average concentration	Lowest cancer-based screening level	Lowest non-cancer based screening level	Above Chronic Screening Level?	Highest 24-hr average concentration	Lowest acute screening level	Above Acute Screening Level?
Acetaldehyde	0.058 μg/m^3	0.5 μg/m^3[a] (CREG)[b]	9 μg/m^3 (RfC)[c]	NO	0.20 μg/m^3	90 μg/m^3 (TCEQ ESL)[d]	NO
Formaldehyde	.034 μg/m^3	0.08 μg/m^3 (CREG)	3.3 μg/m^3 (TCEQ ESL)	NO	0.17 μg/m^3	15 μg/m^3 (TCEQ ESL)	NO
Mercury Vapor	0.021 μg/m^3	N/A	0.025 μg/m^3 (TCEQ ESL)	NO	0.067 μg/m^3	0.25 μg/m^3 (TCEQ ESL)	NO
Dioxins/Furans[+]	9.30E-11 μg/m^3	3.0E-8 μg/m^3 (U.S.EPA RSL)[e]	3.0E-8 μg/m^3 (TCEQ ESL)	NO	3.0E-10 μg/m^3	None	NO[†]
PAHs	0.00004 μg/m^3	0.00087 μg/m^3 (U.S.EPA RSL)	0.003 μg/m^3 (TCEQ AMCV)	NO	0.00017 μg/m^3	0.03 μg/m^3 (TCEQ AMCV)[f]	NO
Hydrochloric Acid Aerosols	0.15 μg/m^3	N/A	8.4 μg/m^3 (TCEQ ESL)	NO	0.64 μg/m^3	190 μg/m^3 (TCEQ ESL)	NO
Sulfuric Acid Aerosols	**3.56 μg/m^3**	**N/A**	**1.0 μg/m^3 (U.S.EPA RSL)**	**YES**	**15.45 μg/m^3**	**None**	**N/A**

N/A = not applicable

[a] *μg/m^3 = micrograms of pollutant per meter cubed of air*

[b] *CREG = ATSDR Cancer Risk Evaluation Guide*

[c] *RfC = U.S. EPA Reference Concentration*

[d] *TCEQ ESL = Texas Commission on Environmental Quality Effects Screening Levels*

[e] *U.S. EPA RSL = United States Environmental Protection Agency Risk-Based Screening Levels*

[f] *TCEQ AMCV = Texas Commission on Environmental Quality Air Monitoring Comparison Value*

[+] *See Appendix for congeners of Dioxins/Furans included in this assessment and the subset of PAHs included in this assessment.*

[†] *Acute screening levels are generally higher than cancer and non-cancer chronic values. Since this level is orders of magnitude below those values, no acute hazard exists.*

NOTE: The basis of the TCEQ AMCVs and ESLs have not been reviewed by ATSDR

ATSDR assumed worst-case conditions for the modeling effort. For example, we assumed the emissions for each pollutant was the same as the highest amount ever reported by the facilities to the TRI database or to TCEQ's Point Source Emissions Inventory (PSEI). Furthermore, we assumed all emissions from each plant came out of the stack with the least favorable deposition pattern (e.g., shortest stack at the lowest exit velocity). We assumed these conditions would yield the highest off site concentrations of pollutants (worst-case conditions). Even under these worst case conditions, only sulfuric acid aerosols exceeded current chronic health based values. Since emission rates reflect the highest year of emissions for all four facilities, the emission rates used for each facility were from two different years (2002 TRI for Ash Grove, and 2000 PSEI and TRI data for Holcim and TXI, respectively, and no data reported for Gerdau). Our conservative assumptions make it likely that sulfuric acid exposures are lower than calculated. Furthermore, strides have been taken or are currently underway by the facilities of interest to reduce emissions of sulfur dioxide. However, to be protective of public health we believe this approach is appropriate to evaluate past exposure and estimate worst case current exposures. Please see Appendix F for modeling methodology, assumptions, and maps.

Sulfuric Acid

Sulfuric acid and other inorganic acids in solution have been used to pickle steel (i.e. remove scale and oxides from the metal surface) as part of the finishing process in the steel industry. Sulfuric acid in air is formed from sulfur dioxide released when coal, oil, and gas are burned. It is removed from air by rain and is generally a major component of acid rain (ATSDR, 1999).

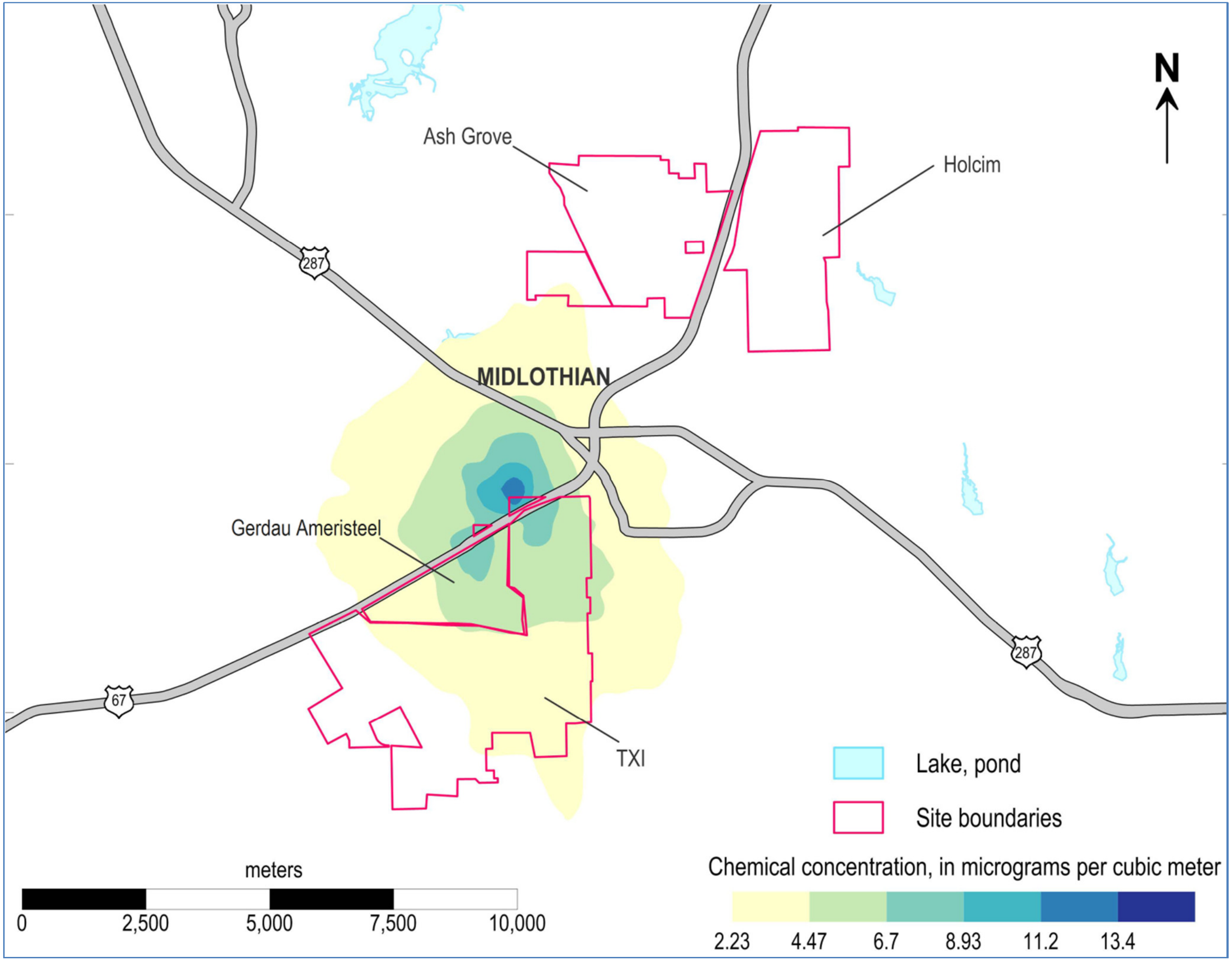
Gerdau Ameristeel did not report sulfuric acid emissions to state or federal reporting databases for any year prior to the modeling, most likely because sulfuric acid in solution does not have to be reported unless it is emitted in aerosol form. All three cement plants reported releases of sulfuric acid aerosols, some years in substantial quantities. For example, the highest release year at TXI was in 2000 when over one million pounds of sulfuric acid was released (1,261,000 lbs). Sulfuric acid at cement plants is typically produced as a by-product of combustion of kiln fuel. Sulfur in the fuels are emitted as multiple oxides of sulfur, including some that form sulfuric acid aerosols in the stacks and in the ambient air.

Health effects possible from exposure to sulfuric acid aerosols

Sulfuric acid/sulfuric acid aerosols are recognized eye, nose, and throat irritants that can have a significant impact on respiratory health. Individuals with compromised respiratory health/pre-existing respiratory conditions are at higher risk from experiencing adverse health effects from exposure.

Acute exposure: There are many studies evaluating acute health effects of sulfuric acid exposures in animals and humans. The lowest observed adverse effect level identified for acute exposure was 50 $\mu g/m^3$. At lower acute concentrations humans and animals experienced mild health effects, including difficulty clearing the lungs of particles that were ≤ 3.5 µm in aerodynamic diameter at 50 $\mu g/m^3$ (rabbit), decreased lung volume (humans) at 70 $\mu g/m^3$, and subtle immune system impacts at 75 $\mu g/m^3$ (rabbit) (WHO, 2000). The highest modeled 1-hour concentration was 27.4 $\mu g/m^3$ and the highest 24-hour average modeled concentration was 15.5 $\mu g/m^3$ (Figure 24). **Short-duration emissions in this range could reach levels that could result in breathing difficulties in sensitive populations, including those that could experience the exacerbation of pre-existing respiratory effects (e.g., children and asthmatics).** Non-cancer health outcome data (including some respiratory health outcomes) are presented in our Health Consultation titled, "*Evaluation of Health Outcome Data for the Midlothian Area*" (ATSDR, 2016b).

Figure 24. Highest Modeled 24-hour Average for Sulfuric Acid Aerosols (μg/m^3)



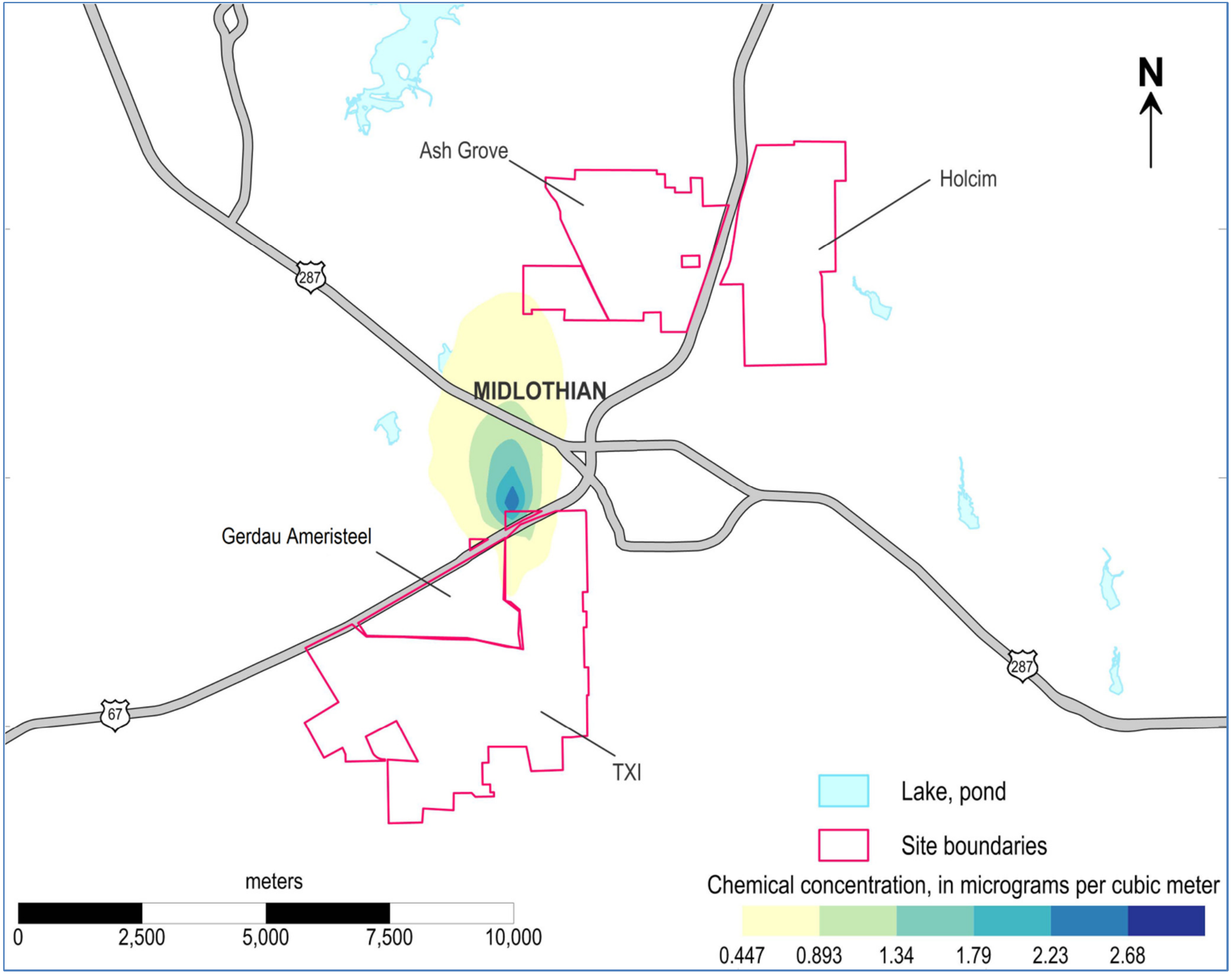
Chronic exposure: There are a number of studies that have indicated that chronic exposure to low levels of sulfuric acid can negatively affect sensitive individuals. It appears that when the hydrogen atoms in sulfate dusts contact water (including mucosa and fluids in the lungs) they become hydrogen ions (H+), which is believed to be the basis of adverse human health effects (Cal EPA, 2001). Sulfate concentrations of 6.6 μg/m^3 in ambient air have been associated with statistically significant detriments to lung capacity in tests for exposed children (forced expiratory volume (FEV) and forced vital capacity (FVC)). A study of asthmatic children determined that there was a linear association between lung capacity tests (peak flow), use of rescue medications (inhalers), and chest symptoms to ambient sulfate concentrations down to 1 μg/m^3, but lower concentrations were not measured. While evaluating hospital admissions, Thurston et al. (1997) hypothesized that the effect level for exposure to sulfates could be as low as 2 μg/m^3 (Cal EPA, 2001).

The California EPA Reference Exposure Level (REL) of 1 μg/m^3 is used as a screening level for long term exposure by the U.S.EPA. This screening level is based on a monkey exposure study with a

LOAEL of 380 µg/m^{3}and applying an uncertainty factor of 300. California EPA acknowledges the relatively low "margin of safety" in their REL given the low concentrations of sulfate that have produced adverse effects documented in asthmatic children (Cal EPA, 2001). Further, in the Chronic Toxicity Summary, California EPA identified asthmatic children as the most critically sensitive human population for exposure to sulfuric acid (or sulfate). Of the constituents of PM_{10}, there is some indication that sulfuric acid is most highly correlated with hospital admissions for respiratory symptoms (Cal EPA, 2001).

The highest annual average of sulfuric acid aerosols that was modeled in Midlothian was 3.56 µg/m^3 which is comparable to chronic low level exposure studies like those mentioned above (see Figure 25). The greatest impacted neighborhoods are predicted to be north of the boundary of TXI Operations and Gerdau Ameristeel.

Figure 25. Highest Modeled Annual Average for Sulfuric Acid Aerosols (µg/m^3)



There are a number of studies that indicate that high occupational exposures to sulfuric acid aerosols can cause laryngeal (throat) and lung cancers. The International Agency for Research on Cancer concluded that there is sufficient evidence that sulfuric acid is a human carcinogen (IARC, 2012).

Exposures to sulfates and sulfuric acid aerosols at low concentrations have been associated with decreased lung capacity/volume and increased hospital admissions for people with cardiopulmonary diseases, such as asthma. The concentrations of sulfuric acid aerosols modeled in Midlothian may be harmful to sensitive populations (e.g., children, the elderly, and residents with compromised respiratory health (asthma, emphysema, etc.)). Ambient air sampling in the area of impact (near the northern boundary of TXI and Gerdau Ameristeel) should be conducted to determine if sulfuric acid aerosols measured in air could cause harm.

5.0 General Summary of Health Implications

As discussed in previous sections, the exposures to individual air pollutants at the concentrations measured in Midlothian are unlikely to result in adverse health effects. The pollutants discussed were generally present at concentrations many times lower than those that have been associated with adverse health effects in the scientific literature. Many pollutants exceeded conservative cancer health based guidelines, but that is generally the case in suburban environments for many ubiquitous airborne pollutants.

Of all air pollutants modeled, our evaluation indicated that sulfuric acid aerosols could present the greatest risk of harm to area residents, especially those with pre-existing conditions that could be exacerbated by ambient exposures. Additional air sampling is needed to determine if acid aerosols are at potentially harmful levels and if emission reduction is needed.

The cumulative chemical exposure evaluation indicates that there may be a slight increase of non-cancer risk from manganese exposure at locations immediately downwind of TXI and Gerdau Ameristeel, but the hazard is similar to the risk individuals in urban or suburban environments are likely to experience. Cancer risk is consistent with Ellis County and the state of Texas, thus no differences in cancer are anticipated from ambient contaminant concentrations evaluated.

Limitations

When reviewing metals data, two observations regarding average concentrations should be noted. First, 2008-2009 measurements were collected during a time when the cement manufacturing industry experienced decreased production (USGS, 2011) and during a time when no facilities in the Midlothian were burning hazardous waste. However, ATSDR believes those data are still useful for understanding which areas in Midlothian appear to have relatively higher air concentrations of various metals. It should be noted that while no data were collected between 1986 and 1991 when Ash Grove was burning hazardous waste, there were data collected downwind of TXI when it was burning hazardous waste (intermittently from 1991-2007). Second, while we critically reviewed metal concentrations prior to 2001, due to data limitations noted in our first Health Consultation evaluating the historical sampling in Midlothian, these data were not used to calculate annual averages. Further, although enforcement agencies require stack testing and other proof of emissions, our modeling relies on facility-reported data in emissions databases.

Generally, over time, laboratory analytical detection limits have become more sensitive, allowing pollutants to be measured at lower concentrations. Thus, recent data with a greater proportion of uncensored observations (more detected data) are more reliable to evaluate exposure than older data with higher detection limits. For example, the URS dataset from 2008-2009 had more sensitive detection limits than previous efforts to quantify PM_{10} and VOCs, and consequently less non-detects. $PM_{2.5}$ data have historically had more sensitive detection limits and had a greater percentage of quantified metals than PM_{10} particulate analyses conducted in the 1990s. As described previously, we addressed the challenges of assessing historical risk of censored data through the use of regression on order statistics (ROS). However, assessing exposure and health implications based on actual measurements is preferable to that based on estimated means calculated from censored datasets.

Child Health Considerations

In communities with air pollution issues, the many physical differences between children and adults demand special emphasis. Children could be at greater risk than adults from certain kinds of exposure to hazardous substances. Children frequently play outdoors, especially during the summertime or afterschool during the warm months, which can increase their exposure potential. Further, a child's lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. Further, children are dependent on adults for their general wellbeing. Thus, adults need as much information as possible to make informed decisions regarding their children's health.

When preparing this health consultation, ATSDR considered these and other children's health concerns. We consistently utilized the most conservative screening values available to be as health-protective as possible for children and other sensitive individuals. Where available, we evaluated studies that reviewed health outcomes in children from exposure to air pollutants. In our modeling assessment, we determined that sulfuric acid aerosols could pose an increased risk to children's respiratory health. We recommend TCEQ consider quantifying exposures of sulfuric acid aerosols in the community to better understand risks to children and other sensitive individuals.

6.0 Conclusions and Recommendations

Conclusions

Exposure to intermittently high levels of sulfuric acid aerosols may irritate the airways of area residents and cause acute respiratory symptoms in individuals with pre-existing cardiopulmonary illness, such as asthma. Children and the elderly are particularly vulnerable to adverse health outcomes from acute exposures to sulfuric acid aerosols. No increased cancer or non-cancer risk was identified for measured and modeled ambient concentrations of volatile organic compounds, metals, or other inorganic pollutant.

1. ATSDR modeled five pollutants/pollutant classes that 1) are a community concern ; 2) are emitted in greatest quantity by the facilities of interest; and 3) have never been sampled for historically by TCEQ. These include: dioxins and furans; hydrochloric acid aerosols; mercury (vapor phase); polycyclic aromatic compounds (PACs); and sulfuric acid aerosols. With the exception of sulfuric acid aerosols, no other modeled pollutant concentrations exceeded health based comparison values.

   ATSDR concludes that worst-case modeled concentrations of sulfuric acid aerosols estimate levels of sulfuric acid aerosols that could harm the health of sensitive individuals (e.g., children, the elderly, or residents with pre-existing health conditions), but no measured data exist to determine whether or not a threat existed in the past or currently exists.

2. Almost all pollutants measured historically in Midlothian are present at typical concentrations for large metropolitan areas. A few not-routinely detected pollutants in ambient air were measured at low concentrations in the 2008-2009 sampling study by University of Texas-Arlington, generally at the Tayman Drive WWTP. These pollutants are often byproducts of water chlorination and are not present at levels that have been observed to cause health effects in exposure studies.

   Local influences were apparent for some pollutant classes. For example, slightly higher levels of metals were detected in monitoring stations downwind of TXI and Gerdau Ameristeel; a couple of trihalomethanes were detected at slightly higher concentrations at the water treatment plant monitoring station; and pollutants typical of incomplete combustion of gasoline were observed at monitors near Interstates 67 and 287.

   ATSDR concludes that reviewed measured levels of metals and volatile organic compounds (VOCs) are not expected to harm people's health because they are below levels of health concern.

3. Based on historically measured data, cumulative cancer risks in Midlothian are *not* substantially different than Ellis County or the state of Texas. Based on historically measured data, cumulative non-cancer risk is similar or lower than Ellis County or the state of Texas. Manganese drove non-cancer risk at monitors downwind of TXI/Gerdau Ameristeel, but ambient concentrations of manganese are not substantially different in Midlothian than they are across the United States in suburban environments.

Recommendations

ATSDR recommends that community focused air investigations continue and that sulfuric acid aerosols be included in these investigations. ATSDR recommends sampling of acid aerosols in the area of impact (near the northern boundary of TXI and Gerdau Ameristeel) to better quantify risks to residents from local industrial emissions, including sulfuric acid.

7.0 Public Health Actions

General:

ATSDR continued its investigation of impacts from area facilities on community health, focusing on pollutant concentrations in other media besides air and on health outcomes in animals and human.

ATSDR met with residents to present the findings in this Health Consultation and other Health Consultations and to answer questions from residents.

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Appendix A. Glossary of Terms

This glossary defines words used by ATSDR in communications with the public. It is not a complete dictionary of environmental health terms. For additional questions or comments, call ATSDR's toll-free telephone number, 1-888-42-ATSDR (1-888-422-8737).

Ambient air
Outdoor air.

Cement kiln
A high-temperature industrial oven where limestone and other raw materials are combined to form clinker, which is later used to make cement.

Cement kiln dust
A fine dust that is carried by the exhaust air from cement kilns, most of which is collected at cement manufacturing facilities by air pollution control equipment.

Concentration
The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other media.

Continuous emission monitoring
The continuous measurement of the amount of pollutants leaving a source (typically, a stack) over time.

Criteria pollutant
Six common air pollutants—carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide—for which EPA has developed National Ambient Air Quality Standards.

Deposition
The settling of air pollutants to the Earth's surface, both in wet form (e.g., pollutants brought to the ground in rainfall) or dry form (e.g., pollutants reaching the ground when it is not raining or snowing).

Detection limit
The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.

Emissions
Pollutants released into the air from smokestacks, vents, and other industrial processes. Emissions can also occur from motor vehicles, household activities, and natural sources.

Emission inventory
A listing, by source, of the amount of air pollutants released into the air within a given area. Examples include EPA's Toxics Release Inventory, EPA's National Emissions Inventory, and TCEQ's Point Source Emissions Inventory.

Exposure
Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term (acute exposure), of intermediate duration, or long-term (chronic exposure).

Inorganic pollutant (metal, element, inorganic compound)
Chemical substances of a mineral nature that are not typically made up of linked carbon atoms. Most inorganic pollutants considered in this Health Consultation are found in airborne particles.

Organic compound (VOCs, SVOCs)
An organic compound is any member of a large class of gaseous, liquid, or solid chemical compounds whose molecules contain carbon.

Particulate matter
Small solid particles and aerosols found in air, including dust, smoke, mist, and fumes. Different subsets of particulate matter are defined based on the size of the particles.

Pollutant
A substance introduced into the environment that adversely affects the usefulness of a resource or the health of humans, animals, or ecosystems. Pollutants can come from many types of sources: industry, motor vehicles, agricultural, and nature.

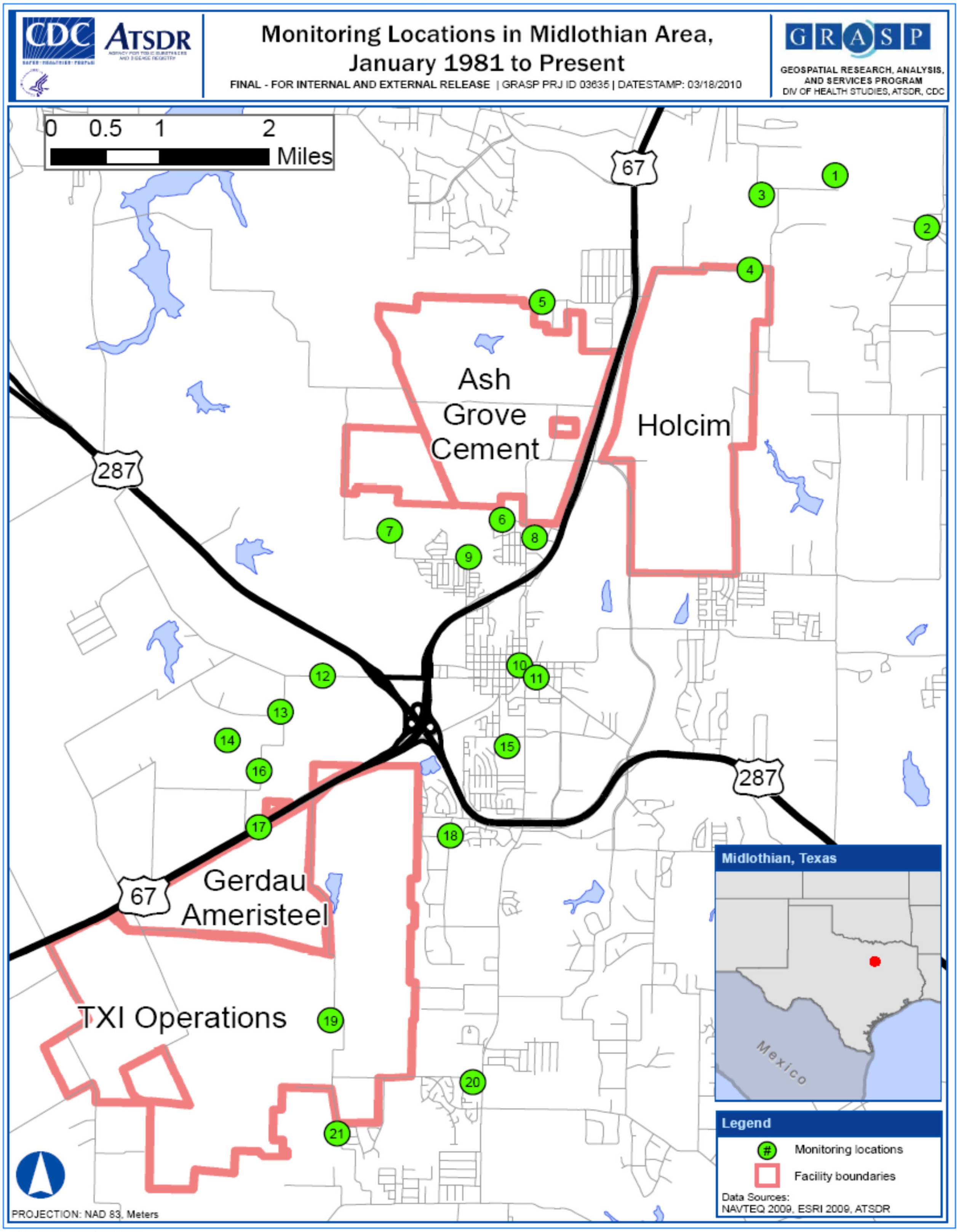
Semi-volatile organic compound (SVOC)
Organic compounds that evaporate slowly at room temperature. These pollutants can be found in the air as gases and bound to particulate matter.

Valid data
Environmental measurements generated by instruments or reported by laboratories that have met certain quality assurance and quality control criterion. Rejected data are not considered valid.

Volatile organic compound (VOC)
Any organic compound that evaporates readily at room temperature. VOCs tend to be found in air as gases. When in the air, these pollutants participate in the chemical reactions that form ozone.

Appendix B. Area Monitoring Locations

Figure B-1. All Historical Air Monitoring Locations in Midlothian



MAP AUTHOR: JR HENRY

Site name for corresponding ID#s shown on this page can be found in the following table.

Table B-1. List of Air Monitoring Sites Correlation with Figure B-1.

Location (Figure 6)	EPA Site Number	TCEQ Site Number	Station Name	Pollutants Measured	Sampling Duration	Time Frame
1	48-139-0011	N/A	Hidden Valley	PM_{10}	24-hour	9/92 - 10/93
2	48-139-0006	N/A	Gorman Road	PM_{10}	24-hour	3/92 - 4/93
3	48-139-0014	N/A	Box Crow	PM_{10}	24-hour	11/93 - 1/95
4	N/A	N/A	Holcim facility boundary	$PM_{2.5}$	Continuous	1/06 - present
5	48-139-0007	N/A	Tayman Drive Water Treatment Plant	PM_{10}	24-hour	3/92 - 12/96
				22 inorganics (PM_{10})	24-hour	12/08 - 7/09
				109 VOCs	24-hour	1/93 - 3/97
				60 VOCs	24-hour	12/08 - 8/09
6	N/A	N/A	Jaycee Park	22 inorganics (PM_{10})	24-hour	12/08 - 7/09
				60 VOCs	24-hour	12/08 - 7/09
7	48-139-0013	N/A	Auger Road Water Treatment	PM_{10}	24-hour	1/91 - 1/92
						1/93 - 11/94
				16 inorganics (PM_{10})	24-hour	1/91 - 12/91
						2/93 - 6/93
8	N/A	N/A	J.A. Vitovsky Elementary School	22 inorganics (PM_{10})	24-hour	5/09
				60 VOCs	24-hour	5/09
9	48-139-0004	N/A	Auger Road	PM_{10}	24-hour	1/91 - 1/93
				16 inorganics (PM_{10})	24-hour	1/91 - 10/92
10	48-139-0001	N/A	City Hall Roof	TSP	24-hour	5/81 - 12/84
				56 inorganics (TSP)	24-hour	5/81 - 12/81
				Lead	24-hour	5/81 - 12/81
						1/83 - 12/83
11	N/A	N/A	Triangle Park	22 inorganics (PM_{10})	24-hour	12/08
				60 VOCs	24-hour	12/08

Location (Figure 6)	EPA Site Number	TCEQ Site Number	Station Name	Pollutants Measured	Sampling Duration	Time Frame
12	48-139-0016	CAMS 52/137	Old Fort Worth (OFW) Road	PM_{10}	24-hour	11/94 - 6/04
				$PM_{2.5}$	24-hour	9/05 - present
					Continuous	4/06 - present
				88 inorganics ($PM_{2.5}$)	24-hour	9/05 - present
				22 inorganics (PM_{10})	24-hour	12/08 - 7/09
				88 VOCs	24-hour	3/97 - 10/04
						4/06 - present
				60 VOCs	24-hour	12/08 - 7/09
				Sulfur compounds	Continuous	8/97 - present
				Nitrogen oxides	Continuous	3/03 - 10/04
						1/05 - present
				Ozone	Continuous	4/06 - present
13	48-139-0005	N/A	Cement Valley Road	PM_{10}	24-hour	1/92 - 6/92
				16 inorganics (PM_{10})	24-hour	1/92 - 5/92
14	48-139-0017	CAMS 302	CAMS 302 - Wyatt Road	PM_{10}	24-hour	11/99 - 6/04
				$PM_{2.5}$	Continuous	8/00 - 3/06
				25 inorganics (PM_{10})	24-hour	1/01 - 6/04
				109 VOCs	24-hour	10/04 - 3/06
				Sulfur compounds	Continuous	10/04 - 3/06
				Nitrogen oxides	Continuous	10/04 - 3/06
15	N/A	N/A	Midlothian High School	22 inorganics (PM_{10})	24-hour	7/09
				60 VOCs	24-hour	7/09
16	N/A	N/A	Wyatt Road	22 inorganics (PM_{10})	24-hour	12/08 - 7/09
17	48-139-0012	N/A	Gerdau Ameristeel	PM_{10}	24-hour	1/96 - 12/98
				Lead	24-hour	1/93 - 8/98
18	48-139-0084	N/A	Cedar Drive	PM_{10}	24-hour	1/92 - 10/94
				16 inorganics (PM_{10})	24-hour	1/92 - 8/92
						2/93 - 6/93
				Sulfur compounds	Continuous	8/85 - 12/85
						3/86 - 7/86

Location (Figure 6)	EPA Site Number	TCEQ Site Number	Station Name	Pollutants Measured	Sampling Duration	Time Frame
19	48-139-0015	CAMS 94/158/160	Midlothian Tower	PM$_{10}$	24-hour	10/94 - 6/04
				PM$_{2.5}$	Continuous	2/00 - 12/06
				PM$_{2.5}$	24-hour	5/02 - 8/05
				70 inorganics (PM$_{2.5}$)	24-hour	5/02 - 8/05
				105 VOCs	1-hour	8/99 - 10/99
						5/00 - 10/00
						5/01 - 7/01
						5/02 - 10/02
						7/03 - 10/03
						6/04 - 9/04
						5/05 - 10/05
						5/06 - 7/06
				105 VOCs	24-hour	4/04 - 8/07
				Sulfur compounds	Continuous	8/97 - 8/07
				Nitrogen oxides	Continuous	10/00 - 8/07
				Ozone	Continuous	8/97 - 8/07
20	48-139-0008	N/A	Mountain Peak Elementary School	22 inorganics (PM$_{10}$)	24-hour	2/09 - 3/09
				60 VOCs	24-hour	2/09 - 3/09
21	48-139-0008	N/A	Mountain Creek	PM$_{10}$	24-hour	3/92 - 4/93

**Note: only data from sites measuring "inorganics" and "VOCs" were assessed in this document. An analysis of criteria pollutants can be found at the ATSDR Midlothian site (http://www.atsdr.cdc.gov/HAC/pha/MidlothianAreaAirQuality/MidlothianTX_NAAQS_HC_Final_04-14-2016_508.pdf)*

Appendix C: Quantitative Methods for Data Analysis

Calculation of Means from Censored Data

C.1 Ambient Data Evaluated

C.1.1 TCEQ VOC Data

TCEQ monitoring stations collected integrated 24-hour whole air samples that were analyzed for a suite of compounds. TCEQ data were downloaded from the Texas Air Monitoring Information (TAMIS) Web Interface. 24-hour sample results for the target list "Canister Parameters" were queried for each site.

To estimate the mean concentration and to compare to comparison values, ATSDR used robust regression on order Statistics (ROS) (Lee and Helsel, 2005; Helsel, 2012). This method is implemented by the R package ***NADA*** function *cenros* (Lee, 2013).

ROS was used for compounds when at least 20% of the samples were not censored. Gilliom and Helsel (1986) demonstrated that expected errors from ROS approached a level that exceeded the parameter values being estimated when censoring levels were at 80%, and would be expected to be higher when censoring exceeded that level. ROS was chosen in favor of the reverse Kaplan-Meier method because the single reporting limit in the data would result in effectively substituting the reporting limit for the non-detected data (see Helsel 2012, p. 93). See Technical Description of Kaplan-Meier method below for further explanation (Section C.2.2).

Because there is uncertainty in estimating an average from sample data, we computed 2-sided 95% confidence limits using the ROS imputed values and the nonparametric percentile bootstrap intervals. Percentile bootstrap methods recommended by Helsel (2012) and 1999 sample replicates were used in the bootstrap.

At the Midlothian Tower location, 1-hour sampling was conducted on a sporadic basis from 1999 – 2006. Since these data were not collected with a regular frequency (as was the case with the 24-hour samples) we could not calculate a representative mean as the data were too sparse over this time period.

C.1.2 TCEQ PM_{10} and TSP Data

Similar to the VOC data, there was only one detection limit reported in the TCEQ PM_{10} and TSP data. Therefore, we elected to use the ROS method for computing mean values (Section C.2.1). We also used the percentile bootstraps to compute 2-sided 95% confidence limits for the mean estimates.

C.1.3 TCEQ $PM_{2.5}$ and URS Data

Individual detection limits were reported for much of the TCEQ PM2.5 and for the URS data. Therefore, we elected to calculate means using Non Detects and Data Analysis (NADA) for R statistical package's *cenfit* method. This method uses reverse Kaplan-Meier (KM) estimates to calculate the sample mean (Lee and Helsel 2007). We elected to use the KM estimates because multiple censoring limits were present in the data and KM estimates do not require that the dataset is large and fits a known distribution shape (normal, log-normal, etc.). Instead, KM methods use the probabilities that the data are above or below a given value to estimate a mean (a mean, by definition, is the sum of values multiplied by their probabilities). More technical details on KM methods are presented in "Technical Description of Kaplan-Meier estimation" (Section C.2.2.). To address the uncertainty of our estimated mean, we computed 2-sided 95% percentile bootstrap confidence limits.

C.2 Identifying Means and Estimation of Trends in Contaminants of Concern

An important caveat with the TCEQ data is that many reported values are below what is termed the *detection limit*. The detection limit is a value such that it is high enough to have a 99% confidence that it does not include zero. TCEQ reports values less than the detection limit, and uses these data in summary statistical calculations (after replacing zeros with half the reporting limit). This "substitution method" has been shown to perform poorly (U.S. EPA, 2006). Although detection limit information was extracted from TAMIS, in some cases the detection limits exceeded the values reported in the TAMIS datasets, and which were reported without qualifiers. ATSDR considered the following options for dealing with non-detected data:

1. Analyzing the TCEQ TAMIS dataset using the detection limits, which would involve a process of replacing reported data from TCEQ data with censored values ("<detection limit"). Con: This method would not allow summary statistics to be calculated for all pollutants.
2. Consider all the reported values as valid, and consider all zero values with less than detection limit. Con: This approach would result in some datasets with the maximum censoring level having concentrations that are higher than the reported data. In available statistical methods for dealing with left-censored data, these data points would be eliminated, which would bias the reported summary statistics. It would also lead to what has been termed "insider censoring" which would bias subsequent statistical analysis (Helsel 2005).
3. Use the reporting limit (<0.01) for the TCEQ data that were reported as 0. When this censoring level is below the lowest detected value, the ROS method imputes values that are less than the lowest detected values (and also even higher than the reporting limit of 0.01), but generally less than the minimum of the detected values. This is because the regression is done on the plotting positions of the data and not on their quantitative values.

ATSDR elected to use option 3 because we believe the pollutant could not be present at levels higher than the detection limit and because this method would be less likely to yield inflated averages.

For contaminants that had maximum readings higher than the chronic comparison value, the time series was visualized using the R package ***openair*** (Carslaw and Ropkins 2013). We used ***openair*** functions *polarPlot* and *polarFrequency* to examine the relationship of wind direction and wind speed on concentration of contaminants of concern. Both of these functions create output scaled to a polar coordinate system, which is essentially a circular axis. Wind direction data are placed in bins on the polar axis that correspond to the direction in degrees from which the wind originated, with North at 0 degrees, South at 180 degrees, East at 90 degrees and West and 270 degrees. Wind speeds for any given direction in bins or compartments that are a proportional distance from the center of the plot, with higher wind speeds occurring further from the center. In the polar frequency plot, each bin is shaded to indicate the calculated mean (average) of the concentrations. In contrast to *polarFrequency,* the function *polarPlot* uses a

Generalized Additive Model (GAM) smoother to the surface of the average concentration (Wood 2006). These resulting plots are shown in the document main body in Section 3.4, "Spatial Analysis".

C.2.1 Technical Description of ROS

The robust ROS method is a method that uses linear regression of the Wiebull-type plotting positions of the uncensored log-transformed data to estimate a set of values for the censored observations. The general steps in ROS are as follows (Lee and Helsel 2005):

1. Data are log-transformed.
2. For the censored data, the exceedance probability (E_j) of exceeding the *j*th censoring limit (E_j) is calculated using the following equation:

   $$E_j = E_{j+1} + \left(\frac{A_j}{\left[A_j + B_j\right]}\right)\left(1 - E_{j+1}\right)$$

   Where: A_j is the total number of uncensored observations greater than or equal to the *jth* censoring limit and less than to the next highest censoring limit.

   B_j is equal to the total number of censored and uncensored observations less than the *j*th censoring limit.

3. The plotting position, *p(i)* is calculated for the uncensored observations using the rank (r_i):

   $$p(i) = \left(1 - E_j\right) + \frac{\left(E_j - E_{j+1}\right)r_i}{\left(A_j + 1\right)}$$

   Where r_i is the rank of the observation between j and j+1.

4. The plotting position of the censored values are calculated using the total number of censored values in the range of j and j+1 (C_j):

   $$p(i) = \frac{\left(1 - E_j\right) r_i}{\left(C_j + 1\right)}$$

5. A regression model is formed using the uncensored observations and the normal quantiles of the uncensored plotting positions.
6. Concentrations are estimated from the plotting positions of the censored data. The imputed values are exponentiated and are combined with the untransformed uncensored data.

The combined set of estimated and uncensored values is then retransformed and summary statistics are then calculated on the combined dataset.

C.2.2 Technical Description of Kaplan-Meier Estimation

Kaplan-Meier methods are more commonly applied to survival (right-censored data) in studies involving time to a certain event but can be used for left-censored sampling data (Lee and Helsel 2007). In general, KM methods create an estimate of the empirical cumulative distribution (ECDF). This is estimated using the following formula:

$$1 - F = \prod_{j=1}^{k} \frac{b_j - d_j}{b_j}$$

Where b_j is the number of observations both uncensored and censored below each uncensored observation.

The value d_j is the number of detected values at the concentration. The probability that a value exceeds the next highest detected concentration when given the data below that concentration is:

$$\frac{b_j - d_j}{b_j}.$$

The CDF probability (F) of a given observation (k^{th} highest) when the data are ordered from lowest to the highest is equal to one minus the product of $j= 1$ to k probabilities. The CDF can be used to calculate the arithmetic mean of the distribution by multiplying the area under the curve of the value by the CDF function (mathematically, this is equivalent of taking sum of the values multiplied by their probability).

We can then calculate the probability that x is greater than a given value (the Survivor function), which is the mirror image of the CDF (because the probability of $X \geq x$ is equal to 1 minus the probability $X \leq x$). Survivor functions are used for either right-censored data or left-censored data that has been transformed by subtracting their value from some constant that is higher than their values.

The ECDF is actually an estimate of the CDF. By taking the area under the ECDF curve multiplied by the values, we also estimate the mean. KM estimates are positively biased in the case of a singularly censored data set – by singularly censored we mean that no values (detected or undetected) are reported less than 1 detection limit. This is because KM methods are empirical (that is uses the ECDF) it cannot estimate probabilities beyond the range of the data it is given.

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Appendix D: Measured Data Summaries: VOCs

Table D-1. Old Fort Worth Road Monitoring Station VOCs (all units are µg/m3): Only VOCs detected >20% of the time are shown

Pollutant	Mean[†]	Chronic CV[¶]	Chronic CV source	Exceeds chronic CV (yes/no)?
Acetylene	0.64 (0.58–0.69)	2660	AMCV[a]	No
Benzene	**0.82 (0.69–0.98)**	**0.13**	**CREG[b]**	**YES**
n-Butane	3.12 (2.83–3.49)	19000	AMCV	No
Carbon Tetrachloride	**0.57 (0.55–0.59)**	**0.17**	**CREG**	**YES**
Chloroform	**0.05 (0.04–0.05)**	**0.04**	**CREG**	**YES**
Chloromethane	1.27 (1.24–1.29)	103	AMCV	No
Cyclohexane	0.13 (0.10–0.15)	344	AMCV	No
Cyclopentane	0.09 (0.05–0.13)	344	AMCV	No
Dichlorodifluoromethane	2.61 (2.57–2.64)	98.9	RfC[c]	No
Dichloromethane	0.14 (0.13–0.16)	101	CREG	No
2,2-Dimethylbutane	0.06 (0.05–0.09)	352	AMCV	No
2,3-Dimethylpentane	0.15 (0.09–0.215)	348	AMCV	No
Ethylbenzene	0.26 (0.16–0.38)	0.96	SL - Ca[d]	No
Ethylene	0.77 (0.73–0.82)	6080	AMCV	No
m-Ethyltoluene	0.15 (0.08–0.24)	123	AMCV	No
o-Ethyltoluene	0.06 (0.03–0.09)	123	AMCV	No
p-Ethyltoluene	0.09 (0.05–0.15)	123	AMCV	No
n-Heptane	0.27 (0.16–0.39)	348	AMCV	No
n-Hexane	1.39 (0.77–2.36)	670	AMCV	No
Isobutane	1.77 (1.66–1.88)	19000	AMCV	No
Isopentane	2.29 (1.86–2.83)	23600	AMCV	No
Isoprene	0.08 (0.06–0.09)	5.57	AMCV	No
Methyl Chloroform	0.07 (0.06–0.09)	5110	AMCV	No
Methyl Ethyl Ketone	0.18 (0.13–0.25)	5010	RfC	No
Methyl Tert-Butyl Ether	0.79 (0.31–1.48)	9.37	SL - Ca	No
Methylcyclohexane	0.29 (0.16–0.46)	1610	AMCV	No
Methylcyclopentane	0.42 (0.21–0.77)	258	AMCV	No
2-Methylheptane	0.05 (0.03–0.07)	350	AMCV	No
2-Methylhexane	0.38 (0.23–0.55)	307	AMCV	No
2-Methylpentane	0.83 (0.59–1.12)	300	AMCV	No
3-Methylhexane	0.45 (0.28–0.66)	307	AMCV	No
3-Methylpentane	0.64 (0.59–0.69)	352	AMCV	No
n-Pentane	1.49 (1.20–1.89)	1000	RfC	No
Propane	6.18 (5.77–6.63)	N/A	N/A-asphyxiant	No

n-Propylbenzene	0.07 (0.04–0.96)	123	AMCV	No
Propylene	0.59 (0.54–0.64)	2930	cREL	No
Tetrachloroethylene	0.06 (0.046–0.08)	3.87	CREG	No
Toluene	1.57 (1.04–2.23)	301	cEMEG	No
Trichlorofluoromethane	1.59 (1.57–1.62)	2810	AMCV	No
1,2,4-Trimethylbenzene	0.24 (0.14–0.39)	6.88	RfC	No
1,3,5-Trimethylbenzene	0.07 (0.04–0.1)	123	AMCV	No
2,2,4-Trimethylpentane	0.24 (0.18–0.31)	350	AMCV	No
2,3,4-Trimethylpentane	0.08 (0.06–0.1)	350	AMCV	No
m/p Xylene	0.86 (0.47–1.4)	608	AMCV	No
o-Xylene	0.27 (0.15–0.42)	608	AMCV	No

† numbers in the parenthesis indicate the confidence interval of the arithmetic mean
¶ CV= health based comparison value
***a** AMCV= TCEQ Air Monitoring Comparison Value*
***b** CREG= ATSDR Cancer Risk Evaluation Guide*
***c** RfC= U.S. EPA Reference Concentration*
***d** SL-Ca= U.S. EPA Residential air screening level for cancer effects*
NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Table D-2. Midlothian Tower Monitoring Station VOCs (all units are µg/m3): Only VOCs detected >20% of the time are shown

Pollutant	Mean[†]	Chronic CV[¶]	Chronic CV Source	Exceeds chronic CV (yes/no)?
Acetylene	0.53 (0.47–0.58)	2660	AMCV[a]	No
Benzene	**0.56 (0.52–0.60)**	**0.13**	**CREG[b]**	**YES**
n-Butane	2.58 (2.31–2.88)	19000	AMCV	No
Carbon Tetrachloride	**0.60 (0.58–0.62)**	**0.17**	**CREG**	**YES**
Chloroform	0.03 (0.027–0.04)	0.04	CREG	No
Chloromethane	1.29 (1.25–1.33)	103	AMCV	No
Cyclohexane	3.27 (2.56–4.21)	344	AMCV	No
Cyclopentane	0.66 (0.49–0.89)	344	AMCV	No
Dichlorodifluoromethane	2.57 (2.51–4.21)	98.9	RfC[c]	No
Dichloromethane	0.13 (0.079–0.19)	101	CREG	No
2,2-Dimethylbutane	0.14 (0.09–0.204)	352	AMCV	No
2,3-Dimethylbutane	0.31 (0.20–0.47)	349	AMCV	No
2,4-Dimethylpentane	0.41 (0.29–0.57)	348	AMCV	No
Ethylbenzene	0.13 (0.11–0.15)	0.96	SL - Ca[d]	No
Ethylene	0.67 (0.62–0.73)	6080	AMCV	No
m-Ethyltoluene	0.04 (0.03–0.05)	123	AMCV	No

n-Heptane	0.05 (0.04–0.07)	348	AMCV	No
n-Hexane	3.27 (2.43–4.39)	670	AMCV	No
Isobutane	1.75 (1.30–2.52)	19000	AMCV	No
Isopentane	1.44 (1.18–1.85)	23600	AMCV	No
Isoprene	0.15 (0.10–0.21)	5.57	AMCV	No
Methylcyclopentane	4.86 (3.63–6.59)	258	AMCV	No
Methyl Ethyl Ketone	0.21 (0.15–0.30)	5010	RfC	No
2-Methylhexane	0.26 (0.20–0.32)	307	AMCV	No
2-Methylpentane	2.30 (1.71–3.13)	300	AMCV	No
3-Methylhexane	0.17 (0.13–0.21)	307	AMCV	No
3-Methylpentane	1.79 (1.32–2.49)	352	AMCV	No
Methyl Tert-Butyl Ether	0.06 (0.04–0.08)	9.37	SL - Ca	No
n-Pentane	0.82 (0.70–0.96)	1000	RfC	No
Propane	5.82 (5.18–6.52)	N/A	N/A- asphyxiant	No
n-Propylbenzene	0.03 (0.03–0.04)	123	AMCV	No
Propylene	0.46 (0.42–0.51)	2930	cREL	No
Toluene	0.56 (0.49–0.64)	301	cEMEG	No
Trichlorofluoromethane	1.55 (1.51–1.59)	2810	AMCV	No
1,2,4-Trimethylbenzene	0.07 (0.05–0.1)	6.88	RfC	No
2,2,4-Trimethylpentane	0.08 (0.06–0.1)	350	AMCV	No
m/p Xylene	0.26 (0.23–0.30)	608	AMCV	No
o-Xylene	0.08 (0.06–0.09)	608	AMCV	No

† *numbers in the parenthesis indicate the confidence interval of the arithmetic mean*

¶ *CV= health based comparison value*

a *AMCV= TCEQ Air Monitoring Comparison Value*

b *CREG= ATSDR Cancer Risk Evaluation Guide*

c *RfC= U.S. EPA Reference Concentration*

d *SL-Ca= U.S. EPA Residential air screening level for cancer effects*

NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Table D-3. Midlothian Tower Monitoring Station Acute (1-hr) VOCs (all units are µg/m3): All pollutants, regardless of frequency of detection

Pollutant	Max	Acute CV¶	Acute CV Source	Does Max exceed Acute CV?
Acetylene	3.01	26600	AMCV[a]	No
Benzene	13.80	29	aEMEG[b]	No
Bromomethane	0.43	116	AMCV	No
1,3-Butadiene	0.38	510	AMCV	No
n-Butane	10.70	219000	AMCV	No
1-Butene	2.29	115000	AMCV	No
Butyl Acetate	0.05	35200	AMCV	No
Butyraldehyde	0.91	7960	AMCV	No
Carbon Tetrachloride	2.77	126	AMCV	No
Chlorobenzene	1.06	460	AMCV	No
Chloroform	1.90	97.3	AMCV	No
2-Chloropentane	0.04	1050	AMCV	No
Cyclohexane	19.70	3440	AMCV	No
Cyclopentane	9.98	3440	AMCV	No
Cyclopentene	0.14	8080	AMCV	No
n-Decane	0.82	10200	AMCV	No
1,1-Dichloroethane	0.04	4050	AMCV	No
1,1-Dichloroethylene	0.04	714	AMCV	No
1,2-Dichloropropane	0.46	231	aEMEG	No
m-Diethylbenzene	0.44	2530	AMCV	No
p-Diethylbenzene	0.99	2530	AMCV	No
2,3-Dimethylbutane	3.67	3490	AMCV	No
2,3-Dimethylpentane	1.11	3480	AMCV	No
2,4-Dimethylpentane	2.38	3480	AMCV	No
Ethylbenzene	2.95	21700	aEMEG	No
Ethylene	4.29	574000	AMCV	No
m-Ethyltoluene	4.47	1230	AMCV	No
o-Ethyltoluene	1.72	1230	AMCV	No
p-Ethyltoluene	2.36	1230	AMCV	No
n-Heptane	1.43	3480	AMCV	No
3-Hexanone	0.04	123	AMCV	No
Isobutane	5.28	78400	AMCV	No
Isobutyraldehyde	10.80	2950	AMCV	No

Isopentane	19.20	201000	AMCV	No
Isoprene	1.34	55.7	AMCV	No
3-Methyl-1-Butene	0.23	22900	AMCV	No
2-Methyl-1-Pentene	0.03	1720	AMCV	No
4-Methyl-1-Pentene	0.03	1720	AMCV	No
2-Methyl-2-Butene	0.83	7460	AMCV	No
2-Methyl-3-Hexanone	0.19	126	AMCV	No
Methyl Isobutyl Ketone	0.04	819	AMCV	No
Methylcyclohexane	2.37	16100	AMCV	No
Methylcyclopentane	41.40	2580	AMCV	No
2-Methylheptane	1.17	3500	AMCV	No
3-Methylheptane	1.21	3500	AMCV	No
3-Methylhexane	2.21	3070	AMCV	No
3-Methylpentane	13.50	3520	AMCV	No
n-Nonane	0.53	10500	AMCV	No
n-Octane	0.75	3500	AMCV	No
n-Pentane	19.80	201000	AMCV	No
1-Pentene	0.95	7460	AMCV	No
Styrene	0.51	21300	aEMEG	No
1,1,2,2-Tetrachloroethane	1.03	68.7	AMCV	No
Tetrachloroethylene	2.78	1360	aEMEG	No
Toluene	11.50	3770	aEMEG	No
1,1,2-Trichloroethane	0.55	546	AMCV	No
Trichloroethylene	0.75	537	AMCV	No
1,2,4-Trimethylbenzene	6.78	1230	AMCV	No
2,3,4-Trimethylpentane	1.78	3500	AMCV	No
n-Undecane	6.33	3520	AMCV	No
Vinyl Chloride	0.03	1280	aEMEG	No
o-Xylene	3.39	7380	AMCV	No

¶ CV= health based comparison value
a *AMCV= TCEQ Air Monitoring Comparison Value*
b *aEMEG= ATSDR Acute Environmental Media Evaluation Guide*
NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Table D-4. Tayman Drive Wastewater Treatment Plant Monitoring Station VOCs (all units are µg/m3): VOCs detected >20% of the time

Pollutant	Mean[†]	Chronic CV[¶]	Chronic CV Source	Exceeds chronic CV (yes/no)?
Benzene	**1.35 (0.949–2.03)**	**0.13**	**CREG[a]**	**YES**
Bromomethane	0.023 (0.020–0.027)	11.60	AMCV[b]	No
n-Butane	3.86 (3.35–4.52)	19000.00	AMCV	No
Carbon Tetrachloride	**0.98 (0.65–1.4)**	**0.17**	**CREG**	**YES**
Chlorobenzene	0.17 (0.11–0.24)	46.00	AMCV	No
Chloroform	**0.084 (0.074–0.095)**	**0.04**	**CREG**	**YES**
Cyclohexane	0.13 (0.080–0.19)	344.00	AMCV	No
Cyclopentane	0.045 (0.036–0.056)	344.00	AMCV	No
n-Decane	0.16 (0.082–0.27)	1020.00	AMCV	No
Dichloromethane	0.2 (0.16–0.24)	101.00	CREG	No
2,3-Dimethylbutane	0.36 (0.25–0.49)	349.00	AMCV	No
2,3-Dimethylpentane	0.065 (0.042–0.093)	348.00	AMCV	No
Ethylbenzene	0.33 (0.27–0.41)	0.96	SL - Ca[c]	No
Ethylene Dichloride	**0.093 (0.070–0.12)**	**0.04**	**CREG**	**YES**
n-Heptane	0.22 (0.18–0.27)	348.00	AMCV	No
n-Hexane	0.72 (0.52–1.0)	670.00	AMCV	No
Isobutane	1.87 (1.59–2.24)	19000.00	AMCV	No
Isopentane	2.43 (2.15–2.74)	23600.00	AMCV	No
Isoprene	0.1 (0.05–0.17)	5.57	AMCV	No
Methyl Chloroform	1.42 (1.14–1.76)	5110.00	AMCV	No
Methylcyclohexane	0.25 (0.11–0.51)	1610.00	AMCV	No
Methylcyclopentane	0.28 (0.17–0.47)	258.00	AMCV	No
2-Methylheptane	0.061 (0.046–0.078)	350.00	AMCV	No
2-Methylpentane	0.49 (0.042–0.078)	300.00	AMCV	No
3-Methylheptane	0.056 (0.042–0.072)	350.00	AMCV	No
3-Methylhexane	0.11 (0.081–0.13)	307.00	AMCV	No
3-Methylpentane	0.57 (0.42–0.56)	352.00	AMCV	No
n-Pentane	1.65 (1.39–1.83)	1000.00	RfC[d]	No
n-Propylbenzene	0.04 (0.034–0.07)	123.00	AMCV	No
Propylene	1.5 (1.12–1.93)	2930.00	cREL[e]	No
Styrene	0.15 0.10–0.19)	469.00	AMCV	No

Tetrachloroethylene	0.24 (0.20–0.28)	3.87	CREG	No
Toluene	1.5 (1.28–1.79)	301.00	cEMEG[f]	No
Trichloroethylene	0.16 (0.11–0.22)	0.24	CREG	No
Trichlorofluoromethane	1.59 (1.40–1.92)	2810.00	AMCV	No
1,2,4-Trimethylbenzene	0.28 (0.19–0.38)	6.88	RfC	No
1,3,5-Trimethylbenzene	0.11 (0.083–0.15)	123.00	AMCV	No
2,2,4-Trimethylpentane	0.14 (0.11–0.17)	350.00	AMCV	No
m/p Xylene	0.54 (0.43–0.69)	608.00	AMCV	No
o-Xylene	0.39 (0.31–0.50)	608.00	AMCV	No

¶ CV= health based comparison value
***a** CREG= ATSDR Cancer Risk Evaluation Guide*
***b** AMCV= TCEQ Air Monitoring Comparison Value*
***c** SL-Ca= SL-Ca= U.S. EPA Residential air screening level for cancer effects*
***d** RfC= U.S. EPA Reference Concentration*
***e** cREL= California EPA chronic reference exposure level*
***f** cEMEG= ATSDR Chronic Environmental Media Evaluation Guide*
NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Table D-5. Wyatt Road Monitoring Station VOCs (all units are µg/m3): VOCs detected >20% of the time

Pollutant	Mean[†]	Chronic CV[¶]	Chronic CV Source	Exceeds chronic CV (yes/no)?
Acetylene	0.67 (0.59–0.74)	2660	AMCV[a]	No
Benzene	**0.66 (0.60–0.72)**	**0.13**	**CREG[b]**	**YES**
n-Butane	3.29 (2.79–3.79)	19000	AMCV	No
Carbon Tetrachloride	**0.63 (0.61–0.66)**	**0.17**	**CREG**	**YES**
Chloromethane	1.19 (1.15–1.24)	103	AMCV	No
Dichlorodifluoromethane	2.47 (2.38–2.55)	98.9	RfC[c]	No
Dichloromethane	0.07 (0.054–0.089)	101	CREG	No
Ethylbenzene	0.10 (0.080–0.13)	0.96	SL - Ca[d]	No
Ethylene	0.78 (0.70–0.87)	6080	AMCV	No
n-Hexane	0.24 (0.18–0.30)	670	AMCV	No
Isobutane	2.07(1.57–2.83)	19000	AMCV	No
Isopentane	1.90 (1.55–2.29)	23600	AMCV	No
Methyl Ethyl Ketone	0.15 (0.079–0.23)	5010	RfC	No
2-Methylhexane	0.07 (0.045–0.087)	307	AMCV	No
2-Methylpentane	0.20 (0.14–0.26)	300	AMCV	No
3-Methylhexane	0.08 (0.06–0.1)	307	AMCV	No
3-Methylpentane	0.15 (0.11–0.19)	352	AMCV	No

Methyl Tert-Butyl Ether	0.13 (0.089–0.17)	9.37	SL - Ca[e]	No
n-Pentane	0.75 (0.58–0.93)	1000	RfC	No
n-Propylbenzene	0.04 (0.02–0.06)	123	AMCV	No
Propylene	0.46 (0.41–0.52)	2930	cREL[f]	No
Toluene	0.63 (0.52–0.75)	301	cEMEG[g]	No
Trichlorofluoromethane	1.64 (1.58–1.71)	2810	AMCV	No
1,2,4-Trimethylbenzene	0.08 (0.06–0.1)	6.88	RfC	No
2,2,4-Trimethylpentane	0.12 (0.097–0.14)	350	AMCV	No
m/p Xylene	0.27 (0.21–0.31)	608	AMCV	No
o-Xylene	0.08 (0.06–0.1)	608	AMCV	No

† *numbers in the parenthesis indicate the confidence interval of the arithmetic mean*
¶ CV= health based comparison value
a *AMCV= TCEQ Air Monitoring Comparison Value*
b *CREG= ATSDR Cancer Risk Evaluation Guide*
c *U.S. EPA Residential air screening level for cancer effects*
d *RfC= U.S. EPA Reference Concentration*
e *SL-Ca= U.S. EPA Residential air screening level for cancer effects*
f *cREL= California EPA chronic reference exposure level*
g *cEMEG= ATSDR Chronic Environmental Media Evaluation Guide*
NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

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Table D-6. URS VOCs-Jaycee Park Monitoring Station (all units in $\mu g/m^3$)

Pollutant	Mean[†]	Chronic CV[¶]	Chronic CV Source	Exceeds chronic CV (yes/no)?
Acetonitrile	0.35 (0.24–0.47)	60.00	RfC[a]	No
Acetylene	0.44 (0.36–0.53)	2660	AMCV[b]	No
Acrolein	**0.76 (0.59–0.97)**	**0.02**	**RfC**	**YES**
Benzene	**0.64 (0.53–0.75)**	**0.13**	**CREG[c]**	No
Bromomethane	0.06 (0.05–0.06)	11.6	AMCV	No
1,3-Butadiene	0.03 (0.02–0.03)	0.033	CREG	No
Carbon Disulfide	1.87 (0.085–3.18)	700	RfC	No
Carbon Tetrachloride	**0.73 (0.67–0.80)**	**0.017**	**CREG**	**YES**
Chloroethane	0.05 (0.04–0.06)	10000	RfC	No
Chloroform	**0.12 (0.098–0.14)**	**0.04**	**CREG**	**YES**
Chloromethane	1.55 (1.43–1.67)	103	AMCV	No

p-Dichlorobenzene	0.04 (0.04–0.05)	12000	cEMEG[d]	No
Dichlorodifluoromethane	2.91 (2.74–3.06)	98.9	RfC	No
Dichloromethane	0.37 (0.28–0.46)	101	CREG	No
Ethylbenzene	0.14 (0.10–0.18)	0.96	SL - Ca[e]	No
Methyl Ethyl Ketone	1.45 (1.15–1.76)	5010	RfC	No
Methyl Isobutyl Ketone	0.11 (0.091–0.14)	81.9	AMCV	No
Methyl Methacrylate	0.16 (0.12-0.24)	11700	RfC	No
n-Octane	0.07 (0.06–0.08)	350	AMCV	No
Propylene	0.31 (0.28-0.45)	2930	cREL[f]	No
Styrene	0.07 (0.05–0.1)	469	AMCV	No
Tetrachloroethylene	0.10 (0.074–0.13)	3.87	CREG	No
Toluene	0.52 (0.45–0.60)	301	cEMEG	No
1,1,1-Trichloroethane	0.09 0.09–0.1)	5110	AMCV	No
Trichlorofluoromethane	1.59 (1.52–1.67)	2810	AMCV	No
Trichlorotrifluoroethane	0.87 (0.81–0.93)	30000	RfC	No
1,2,4-Trimethylbenzene	0.13 (0.11–0.15)	6.88	RfC	No
1,3,5-Trimethylbenzene	0.05 (0.04–0.06)	123	AMCV	No
Vinyl chloride	0.02 (0.02–0.02)	0.11	CREG	No
m,p-Xylene	0.32 (0.22–0.44)	608	AMCV	No
o-Xylene	0.13 (0.10–0.17)	608	AMCV	No

† *numbers in the parenthesis indicate the confidence interval of the arithmetic mean*
¶ CV= health based comparison value
a *RfC= U.S. EPA Reference Concentration*
b *AMCV= TCEQ Air Monitoring Comparison Value*
c *CREG= ATSDR Cancer Risk Evaluation Guide U.S. EPA Residential air screening level for cancer effects*
d *cEMEG= ATSDR Chronic Environmental Media Evaluation Guide*
e *SL-Ca= U.S. EPA Residential air screening level for cancer effects*
f *cREL= California EPA chronic reference exposure level*
NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Table D-7. URS VOCs-Old Fort Worth Road Monitoring Station (all units in $\mu g/m^3$)

Pollutant	Mean[†]	Chronic CV[¶]	Chronic CV Source	Exceeds chronic CV (yes/no)?
Acetonitrile	0.31 (0.22–0.40)	60	RfC[a]	No
Acetylene	0.47 (0.39–0.54)	2660	AMCV[b]	No
Acrolein	**0.94 (0.59–1.5)**	**0.02**	**RfC**	**YES**
Benzene	**0.68 (0.60–076)**	**0.13**	**CREG[c]**	**YES**
Bromomethane	0.06 (0.049–0.062)	11.6	AMCV	No

1,3-Butadiene	0.03 (0.021–0.031)	0.033	CREG	No
Carbon Disulfide	0.34 (0.066–0.85)	700	RfC	No
Carbon Tetrachloride	**0.69 (0.622–0.76)**	**0.017**	**CREG**	**YES**
Chloroethane	0.04 (0.03–0.04)	10000	RfC	No
Chloroform	**0.10 (0.089–0.12)**	**0.04**	**CREG**	**YES**
Chloromethane	1.48 (1.37–1.61)	103	AMCV	No
p-Dichlorobenzene	0.04 (0.03–0.04)	12000	cEMEG[d]	No
Dichlorodifluoromethane	2.90 (2.73–3.06)	98.9	RfC	No
Dichloromethane	0.53 (0.30–0.86)	101	CREG	No
Ethylbenzene	0.13 (0.04–0.25)	0.96	SL – Ca[e]	No
Methyl Ethyl Ketone	1.41 (1.16–1.67)	5010	RfC	No
Methyl Isobutyl Ketone	0.09 (0.07–0.10)	81.9	AMCV	No
Methyl Methacrylate	0.08 (0.06–0.12)	11700	RfC	No
n-Octane	0.08 (0.08–0.09)	350	AMCV	No
Propylene	0.31 (0.272–0.347)	2930	cREL[f]	No
Styrene	0.13 (0.044–0.26)	469	AMCV	No
Tetrachloroethylene	0.10 (0.08–0.12)	3.87	CREG	No
Toluene	0.60 (0.47–0.74)	301	cEMEG	No
1,1,1-Trichloroethane	0.09 (0.09–0.1)	5110	AMCV	No
Trichloroethylene	0.05 (0.05–0.07)	0.24	CREG	No
Trichlorofluoromethane	1.72 (1.55–1.97)	2810	AMCV	No
Trichlorotrifluoroethane	0.87 (0.81–0.93)	30000	RfC	No
1,2,4-Trimethylbenzene	0.12 (0.09–0.15)	6.88	RfC	No
1,3,5-Trimethylbenzene	0.05 (0.04–0.06)	123	AMCV	No
Vinyl chloride	0.01 (0.01–0.02)	0.11	CREG	No
m,p-Xylene	0.30 (0.19–0.45)	608	AMCV	No
o-Xylene	0.13 (0.09–017)	608	AMCV	No

† *numbers in the parenthesis indicate the confidence interval of the arithmetic mean*
¶ CV= health based comparison value
a *RfC= U.S. EPA Reference Concentration*
b *AMCV= TCEQ Air Monitoring Comparison Value*
c *CREG= ATSDR Cancer Risk Evaluation Guide U.S. EPA Residential air screening level for cancer effects*
d *cEMEG= ATSDR Chronic Environmental Media Evaluation Guide*
e *SL-Ca= U.S. EPA Residential air screening level for cancer effects*
f *cREL= California EPA chronic reference exposure level*
NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Table D-8. URS VOCs-Tayman Drive Wastewater Treatment Plant Monitoring Station (all units in $\mu g/m^3$)

Pollutant	Mean[†]	Chronic CV[¶]	Chronic CV Source	Exceeds chronic CV (yes/no)?
Acetonitrile	0.26 (0.18–0.34)	60	RfC[a]	No
Acetylene	0.43 (0.35–0.50)	2660	AMCV[b]	No
Acrolein	**0.75 (0.56–0.99)**	**0.02**	**RfC**	**YES**
Acrylonitrile	**0.05 (0.04–0.1)**	**0.015**	**CREG[c]**	**YES**
Benzene	**0.60 (0.52–0.68)**	**0.13**	**CREG**	**YES**
Bromodichloromethane	**0.19 (0.12–0.30)**	**0.07**	**SL - Ca[d]**	**YES**
Bromoform	0.14 (0.11–0.20)	0.91	CREG	No
Bromomethane	0.05 (0.05–0.06)	11.6	AMCV	No
1,3-Butadiene	0.02 (0.12–0.30)	0.0332	CREG	No
Carbon Disulfide	5.24 (2.95–7.90)	700	RfC	No
Carbon Tetrachloride	**0.73 (0.63–0.82)**	**0.017**	**CREG**	**YES**
Chloroethane	0.05 (0.04–0.07)	10000	RfC	No
Chloroform	**0.19 (0.14–0.25)**	**0.04**	**CREG**	**YES**
Chloromethane	1.52 (1.36–1.67)	103	AMCV	No
Dibromochloromethane	**0.21 (0.13–0.30)**	**0.10**	**SL - Ca**	**YES**
p-Dichlorobenzene	0.04 (0.03–0.05)	12000	cEMEG[e]	No
Dichlorodifluoromethane	2.93 (2.71–3.16)	98.9	RfC	No
Dichloromethane	0.31 (0.26–0.36)	101	CREG	No
Ethylbenzene	0.12 (0.091–0.16)	0.955	SL - Ca	No
Methyl Ethyl Ketone	1.30 (1.07–1.54)	5010	RfC	No
Methyl Isobutyl Ketone	0.10 (0.081–0.13)	81.9	AMCV	No
Methyl Methacrylate	0.19 (0.13–0.28)	11700	RfC	No
n-Octane	0.07 (0.06–0.07)	350	AMCV	No
Propylene	0.28 (0.223–0.32)	2930	cREL[f]	No
Styrene	0.17 (0.062–0.365)	469	AMCV	No
Tetrachloroethylene	0.11 (0.074–0.155)	3.87	CREG	No
Toluene	0.52 (0.41–0.68)	301	cEMEG	No
1,1,1-Trichloroethane	0.10 (0.89–0.10)	5110	AMCV	No
Trichlorofluoromethane	1.60 (1.5–1.7)	2810	AMCV	No
Trichlorotrifluoroethane	0.91 (0.84–0.98)	30000	RfC	No
1,2,4-Trimethylbenzene	0.12 (0.085–0.16)	6.88	RfC	No
1,3,5-Trimethylbenzene	0.04 (0.03–0.05)	123	AMCV	No

Vinyl chloride	0.02 (0.02–0.02)	0.112	CREG	No
m,p-Xylene	0.27 (0.16–0.40)	608	AMCV	No
o-Xylene	0.11 (0.08–0.17)	608	AMCV	No

† numbers in the parenthesis indicate the confidence interval of the arithmetic mean
¶ CV= health based comparison value
***a** RfC= U.S. EPA Reference Concentration*
***b** AMCV= TCEQ Air Monitoring Comparison Value*
***c** CREG= ATSDR Cancer Risk Evaluation Guide U.S. EPA Residential air screening level for cancer effects*
***d** SL-Ca= U.S. EPA Residential air screening level for cancer effects*
***e** cEMEG= ATSDR Chronic Environmental Media Evaluation Guide*
***f** cREL= California EPA chronic reference exposure level*
NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

URS Sites with 5 observations

Table D-9. URS VOCs-JA Vitovsky Elementary School Monitoring Station (all units in µg/m^3)

Pollutant	Max†	Acute CV¶	Acute CV source
Acrylonitrile	0.29	220	aEMEG [a]
Acetonitrile	0.71	N/A	N/A[b]
Acetylene	0.46	26600	AMCV
Acrolein	2.10	3.2	AMCV[c]
Benzene	0.90	29	aEMEG
Bromomethane	0.10	116	AMCV
1,3-Butadiene	0.03	510	AMCV
Carbon Disulfide	5.61	6200	aREL[d]
Carbon Tetrachloride	0.74	126	AMCV
Chloroethane	0.06	39600	aEMEG
Chloroform	0.12	97.3	AMCV
Chloromethane	1.83	1030	AMCV
p-Dichlorobenzene	0.06	60.1	aEMEG
Dichlorodifluoromethane	3.01	49500	AMCV
Dichloromethane	0.67	2080	aEMEG
Ethylbenzene	0.15	22000	aEMEG
Methyl Ethyl Ketone	1.57	13000	aREL
Methyl Isobutyl Ketone	0.17	819	AMCV
Methyl Methacrylate	0.39	N/A	N/A
n-Octane	0.08	3500	AMCV

Propylene	0.56	N/A	N/A
Styrene	0.50	21300	AMCV
Tetrachloroethylene	0.13	1360	aEMEG
Toluene	1.03	3770	aEMEG
1,1,1-Trichloroethane	0.11	9250	AMCV
Trichlorofluoromethane	1.71	28100	AMCV
Trichlorotrifluoroethane	1.10	N/A	N/A
1,3,5-Trimethylbenzene	0.05	1230	AMCV
1,2,4-Trimethylbenzene	0.14	1230	AMCV
Vinyl chloride	0.02	1300	aEMEG
m,p-Xylene	0.40	7380	AMCV
o-Xylene	0.15	7380	AMCV

Note: Descriptive Statistics were not generated for this dataset because of the small number of observations (N=5)

† No mean reported (only 5 observations)

¶ CV= health based comparison value

***a** aEMEG= ATSDR Acute Environmental Media Evaluation Guide*

***b** N/A= There is no acute CV available for this pollutant*

***c** AMCV= TCEQ Air Monitoring Comparison Value*

***d** aREL= California EPA acute reference exposure level*

NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Table D-10. URS VOCs-Midlothian High School Monitoring Station (all units in $\mu g/m^3$)

Pollutant	Max†	Acute CV¶	Acute CV Source
Acetonitrile	0.33	N/A	N/A[a]
Acetylene	0.41	26600	AMCV[b]
Acrolein	1.88	3.2	AMCV
Benzene	0.44	29	aEMEG[c]
Bromomethane	0.06	116	AMCV
1,3-Butadiene	0.02	510	AMCV
Carbon Disulfide	12.70	6200	aREL[d]
Carbon Tetrachloride	0.98	126	AMCV
Chloroethane	0.07	39600	aEMEG
Chloroform	0.23	97.3	AMCV
Chloromethane	2.46	1030	AMCV
p-Dichlorobenzene	0.04	60.1	aEMEG
Dichlorodifluoromethane	3.67	49500	AMCV
Dichloromethane	0.34	2080	aEMEG

Ethylbenzene	0.11	22000	aEMEG
Methyl Ethyl Ketone	1.77	13000	aREL
Methyl Isobutyl Ketone	0.16	819	AMCV
Methyl Methacrylate	1.27	N/A	N/A
n-Octane	0.08	3500	AMCV
Propylene	0.33	N/A	N/A
Styrene	0.04	21300	aEMEG
Tetrachloroethylene	0.10	1360	aEMEG
Toluene	0.65	3770	aEMEG
1,1,1-Trichloroethane	0.09	9250	AMCV
Trichlorofluoromethane	1.90	28100	AMCV
Trichlorotrifluoroethane	0.90	N/A	N/A
1,2,4-Trimethylbenzene	0.17	1230	AMCV
1,3,5-Trimethylbenzene	0.05	1230	AMCV
m,p-Xylene	0.25	7380	AMCV
o-Xylene	0.11	7380	AMCV

Note: Descriptive Statistics were not generated for this dataset because of the small number of observations (N=5)

† *No mean reported (only 5 observations)*

¶ CV= health based comparison value

a *N/A= There is no acute CV available for this pollutant*

b *AMCV= TCEQ Air Monitoring Comparison Value*

c *aEMEG= ATSDR Acute Environmental Media Evaluation Guide*

d *aREL= California EPA acute reference exposure level*

NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Table D-11. URS VOCs-Mountain Peak Elementary School Monitoring Station (µg/m^3)

Chemical Name	Max†	Acute CV¶	Acute CV Source
Acetonitrile	0.21	N/A	N/A[a]
Acetylene	0.45	26600	AMCV[b]
Acrolein	1.56	3.2	AMCV
Acrylonitrile	0.06	220	aEMEG[c]
Benzene	0.53	29	aEMEG
Bromomethane	0.05	116	AMCV
1,3-Butadiene	0.03	510	AMCV
Carbon Disulfide	2.22	6200	aREL[d]
Carbon Tetrachloride	0.60	126	AMCV
Chloroethane	0.12	39600	aEMEG
Chloroform	0.08	97.3	AMCV

Chloromethane	1.33	1030	AMCV
Dichlorodifluoromethane	2.43	49500	AMCV
Dichloromethane	0.25	2080	aEMEG
Ethylbenzene	0.95	22000	aEMEG
Methyl Ethyl Ketone	1.87	13000	aREL
Methyl Isobutyl Ketone	0.09	819	AMCV
Methyl Methacrylate	0.43	N/A	N/A
n-Octane	0.09	3500	AMCV
Propylene	0.37	N/A	N/A
Styrene	0.04	21300	aEMEG
1,1,2,2-Tetrachloroethane	0.02	68.7	AMCV
Tetrachloroethylene	0.06	1360	aEMEG
Toluene	0.48	3770	aEMEG
1,1,1-Trichloroethane	0.09	9250	AMCV
1,1,2-Trichloroethane	0.02	546	AMCV
Trichlorofluoromethane	1.35	28100	AMCV
Trichlorotrifluoroethane	0.86	N/A	N/A
1,2,4-Trimethylbenzene	0.25	1230	AMCV
1,3,5-Trimethylbenzene	0.09	1230	AMCV
m,p-Xylene	3.24	7380	AMCV
o-Xylene	0.82	7380	AMCV

Note: Descriptive Statistics were not generated for this dataset because of the small number of observations (N=5)

† No mean reported (only 5 observations)

¶ CV= health based comparison value

***a** N/A= There is no acute CV available for this pollutant*

***b** aEMEG= ATSDR Acute Environmental Media Evaluation Guide*

***c** AMCV= TCEQ Air Monitoring Comparison Value*

***d** aREL= California EPA acute reference exposure level*

NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Table D-12. URS VOCs-Triangle Park Monitoring Station (all units in µg/m^3)

Pollutant	Max†	Acute CV¶	Acute CV Source
Acetylene	1.82	26600	AMCV[a]
Acrolein	0.37	3.2	AMCV
Benzene	1.18	29	aEMEG[b]
Bromomethane	0.06	116	AMCV
1,3-Butadiene	0.21	510	AMCV
Carbon Disulfide	0.75	6200	aREL[c]

Carbon Tetrachloride	0.87	126	AMCV
Chloroethane	0.05	39600	aEMEG
Chloroform	0.11	97.3	AMCV
Chloromethane	1.65	1030	AMCV
Dichlorodifluoromethane	2.98	49500	AMCV
Dichloromethane	0.75	2080	aEMEG
Ethylbenzene	0.24	22000	aEMEG
Methyl Ethyl Ketone	0.95	13000	aREL
Methyl Isobutyl Ketone	0.08	819	AMCV
Methyl Methacrylate	0.24	N/A	N/A[d]
n-Octane	0.13	3500	AMCV
Propylene	1.19	N/A	N/A
Styrene	0.07	21300	aEMEG
Tetrachloroethylene	1.01	1360	aEMEG
Toluene	1.64	3770	aEMEG
1,1,1-Trichloroethane	0.11	9250	AMCV
Trichlorofluoromethane	1.55	28100	AMCV
Trichlorotrifluoroethane	0.77	N/A	N/A
1,2,4-Trimethylbenzene	0.25	1230	AMCV
1,3,5-Trimethylbenzene	0.08	1230	AMCV
m,p-Xylene	0.60	7380	AMCV
o-Xylene	0.24	7380	AMCV

Note: Descriptive Statistics were not generated for this dataset because of the small number of observations (N=5)

† No mean reported (only 5 observations)

¶ CV= health based comparison value

***a** AMCV= TCEQ Air Monitoring Comparison Value*

***b** aEMEG= ATSDR Acute Environmental Media Evaluation Guide*

***c** aREL= California EPA acute reference exposure level*

***d** N/A= There is no acute CV available for this pollutant*

NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Appendix E: Measured Data Summaries: Metals

Table E-1. Midlothian Old Fort Worth Road Monitoring Station PM2.5 Metals (all units are µg/m3): for metals detected >20% of the time

Pollutant	Mean[†]	Chronic CV[¶]	Chronic CV source	Exceeds chronic CV (yes/no)?
Aluminum	0.10 (0.082–0.12)	5	AMCV[a]	No
Ammonium Ion	1.02 (0.95–1.11)	70	cEMEG[b]	No
Chlorine	0.026 (0.019–0.033)	0.15	cEMEG	No
Chromium	0.0011 (0.0010–0.0014)	0.01	AMCV	No
Copper	0.0050 (0.0041–0.0060)	1	AMCV	No
Lead	0.0041 (0.0038–0.0047)	0.15	NAAQS[c]	No
Manganese	0.0054 (0.0049–0.0060)	0.3	cEMEG	No
Nickel	0.001 (0.00078–0.0014)	0.01	SL-NCa[d]	No
Vanadium	0.00087 (0.00081–0.00093)	0.05	AMCV	No
Zinc	0.0013 (0.0013–0.0014)	5	AMCV	No

† numbers in the parenthesis indicate the confidence interval of the arithmetic mean
¶ CV= health based comparison value
***a** AMCV= TCEQ Air Monitoring Comparison Value*
***b** cEMEG= ATSDR Chronic Environmental Media Evaluation Guide*
***c** NAAQS= U.S. EPA National Ambient Air Quality Standards*
***d** SL-NCa= U.S. EPA Residential air screening level for non-cancer effects*
NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Table E-2. Midlothian Tower Monitoring Station PM2.5 Metals (all units are µg/m3): Only Metals detected >20% of the time

Pollutant	Mean[†]	Chronic CV[¶]	Chronic CV Source	Exceeds chronic CV?
Aluminum	0.053 (0.036–0.073)	5	AMCV[a]	No
Ammonium Ion	1.29 (1.17–1.42)	70	cEMEG[b]	No
Arsenic	0.0013 (0.0012–0.0014)	**0.00023**	**CREG[c]**	**Yes**
Chlorine	0.012 (0.0077–0.018)	0.15	cEMEG	No
Chromium	0.0012 (0.00094–0.0015)	0.01	AMCV	No
Copper	0.0038 (0.0033–0.0044)	1	AMCV	No
Manganese	0.0020 (0.0018–0.0023)	0.3	cEMEG	No
Nickel	0.00072 (0.00066–0.00084)	0.01	SL-NCa[d]	No
Selenium	0.0011 (0.0010–0.0011)	0.2	AMCV	No
Vanadium	0.0012 (0.0011–0.0014)	0.05	AMCV	No
Zinc	0.016 (0.012–0.019)	5	AMCV	No

† numbers in the parenthesis indicate the confidence interval of the arithmetic mean
¶ CV= health based comparison value

__a__ AMCV= TCEQ Air Monitoring Comparison Value
__b__ cEMEG= ATSDR Chronic Environmental Media Evaluation Guide
__c__ CREG= ATSDR Cancer Risk Evaluation Guide
d SL-NCa= U.S. EPA Residential air screening level for non-cancer effects
NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Table E-3. Wyatt Road Monitoring Station PM10 Metals (all units are µg/m3): Only Metals detected >20% of the time

Pollutant	Mean†	Chronic CV	Chronic CV Source	Exceeds chronic CV?
Aluminum	0.20 (0.17–0.23)	5	AMCV[a]	No
Chromium	0.0055 (0.0049–0.0061)	0.01	AMCV	No
Copper	0.017 (0.015–0.019)	1	AMCV	No
Manganese	0.043 (0.038–0.048)	0.3	cEMEG[b]	No
Molybdenum	0.0040 (0.0040–0.0041)	5	AMCV	No
Vanadium	0.0020 (0.0018–0.0021)	0.05	AMCV	No
Zinc	0.10 (0.084–0.12)	5	AMCV	No

† numbers in the parenthesis indicate the confidence interval of the arithmetic mean
¶ CV= health based comparison value
__a__ AMCV= TCEQ Air Monitoring Comparison Value
__b__ cEMEG= ATSDR Chronic Environmental Media Evaluation Guide
NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Table E-4. 1990s PM10 Metals (all units are µg/m3): Only Metals detected >20% of the time

Pollutant	Station Name	Mean†	Chronic CV¶	Chronic CV Source	Exceeds chronic CV?
Aluminum	Auger Road	0.66 (0.065–1.21)	5	AMCV[a]	No
Beryllium	Auger Road	0.00006	0.00042	CREG[b]	No
Chromium	Auger Road	0.0079 (0.0062–0.010)	0.1	RfC[c]	No
Manganese	Auger Road	0.0053 (0.0056–0.010)	0.3	cEMEG[d]	No
Nickel	Auger Road	0.0040 (0.0039–0.0071)	0.02	RfC	No
Aluminum	Cedar Drive	0.39 (0.085–1.09)	5	AMCV	No
Cadmium	**Cedar Drive**	0.00099 (0.00042–0.00051)	**0.00056**	**CREG**	**Yes**
Chromium	Cedar Drive	0.0012 (0.00063–0.0024)	0.1	RfC	No
Manganese	Cedar Drive	0.013 (0.0066–0.015)	0.05	RfC	No
Nickel	Cedar Drive	0.00083 (0.0011–0.0024)	0.02	RfC	No
Chromium	Cedar Hill Fire Dept	0.0037 (0.0031–0.0043)	0.1	RfC	No
Manganese	Cedar Hill Fire Dept	0.0067 (0.0048–0.0094)	0.05	RfC	No

Aluminum	Cement Valley Rd	0.19 (0.12–0.24)	5	AMCV	No
Cadmium	**Cement Valley Rd**	0.0013 (0.0005–0.0014)	**0.00056**	**CREG**	**Yes**
Chromium	Cement Valley Rd	0.0056 (0.0032–0.0069)	0.1	RfC	No
Lead	Cement Valley Rd	0.024 (0.010–0.043)	0.15	NAAQS[e]	No
Manganese	**Cement Valley Rd**	0.052 (0.027–0.068)	**0.05**	**RfC**	**Yes**
Nickel	Cement Valley Rd	0.0047 (0.0028–0.0069)	0.02	RfC	No
Aluminum	Auger Rd WWTP	0.12 (0.077–0.16)	5	AMCV	No
Chromium	Auger Rd WWTP	0.0063 (0.0071–0.01)	0.1	RfC	No
Manganese	Auger Rd WWTP	0.0026 (0.0049–0.0086)	0.05	RfC	No
Nickel	Auger Rd WWTP	0.0025 (0.0049–0.0073)	0.02	RfC	No

† numbers in the parenthesis indicate the confidence interval of the arithmetic mean
¶ CV= health based comparison value
***a** AMCV= TCEQ Air Monitoring Comparison Value*
***b** CREG= ATSDR Cancer Risk Evaluation Guide*
***c** RfC= U.S. EPA Reference Concentration*
***d** cEMEG= ATSDR Chronic Environmental Media Evaluation Guide*
***e** NAAQS= U.S. EPA National Ambient Air Quality Standards*
NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Table E-5. City Hall Monitoring Station TSP Metals (all units are µg/m3): Only Metals detected >20% of the time

Pollutant	Mean†	Chronic CV¶	Chronic CV Source	Exceeds chronic CV?
Aluminum	0.68 (0.54–0.82)	5	AMCV[a]	No
Copper	0.016 (0.014–0.019)	1	AMCV	No
Manganese	0.043 (0.039–0.048)	0.3	cEMEG[b]	No
Vanadium	0.0024 (0.0019–0.0029)	0.05	AMCV	No
Zinc	0.057 (0.0440.057)	5	AMCV	No

† numbers in the parenthesis indicate the confidence interval of the arithmetic mean
¶ CV= health based comparison value
***a** AMCV= TCEQ Air Monitoring Comparison Value*
***b** cEMEG= ATSDR Chronic Environmental Media Evaluation Guide*
NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Table E-6. URS PM10 Metals (all units are µg/m3): Only Metals detected >20% of the time – Jaycee Park Monitoring Station

Pollutant	Mean†	Chronic CV¶	Chronic CV Source	Exceeds chronic CV?
Aluminum	0.088	5	AMCV[a]	No
Antimony	0.00041 (0.00032–0.00051)	0.5	AMCV	No

Pollutant	Mean[†]	Chronic CV[¶]	Chronic CV Source	Exceeds chronic CV?
Arsenic	0.00058 (0.00044–0.00074)	**0.00023**	**CREG[b]**	**Yes**
Barium	0.0077 (0.0063–0.0091)	0.5	AMCV	No
Beryllium	0.0000049 (0.0000037–0.0000065)	0.00042	CREG	No
Cadmium	0.00015 (0.00012–0.00018)	0.00056	CREG	No
Chromium III	0.0021 (0.0019–0.0023)	0.01	AMCV	No
Chromium VI	0.000016 (0.0000094–0.000024)	0.000083	CREG	No
Cobalt	0.000094 (0.000073–0.00012)	0.00027	SL-Ca[c]	No
Copper	0.0063 (0.0045–0.0086)	1	AMCV	No
Lead	0.0026 (0.0020–0.0033)	0.15	NAAQS[d]	No
Manganese	0.0091 (0.0065–0.012)	0.3	cEMEG[e]	No
Mercury	0.000057 (0.000019–0.00012)	0.03	cREL[f]	No
Molybdenum	0.00033 (0.00024–0.00046)	5	AMCV	No
Nickel	0.0010 (0.00080–0.0012)	0.01	SL-Ca	No
Selenium	0.00073 (0.00056–0.00091)	0.2	AMCV	No
Uranium	0.000018 (0.000014–0.000023)	0.04	RfC[g]	No
Vanadium	0.0010 (0.00073–0.0013)	0.05	AMCV	No
Zinc	0.023 (0.016–0.032)	5	AMCV	No

† numbers in the parenthesis indicate the confidence interval of the arithmetic mean
¶ CV= health based comparison value
***a** AMCV= TCEQ Air Monitoring Comparison Value*
***b** CREG= ATSDR Cancer Risk Evaluation Guide*
***c** SL-Ca= U.S. EPA Residential air screening level for cancer effects*
***d** NAAQS= U.S. EPA National Ambient Air Quality Standards*
***e** cEMEG= ATSDR Chronic Environmental Media Evaluation Guide*
***f** cREL= California EPA chronic reference exposure level*
***g** RfC= U.S. EPA Reference Concentration*
NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Table E-7. URS PM10 Metals (all units are µg/m3): Only Metals detected >20% of the time – Old Fort Worth Road Monitoring Station

Pollutant	Mean[†]	Chronic CV[¶]	Chronic CV Source	Exceeds chronic CV?
Aluminum	0.13 (0.11–0.15)	5	AMCV[a]	No
Antimony	0.00045 (0.00035–0.00057)	0.5	AMCV	No
Arsenic	**0.00058 (0.00046–0.00072)**	**0.00023**	**CREG[b]**	**Yes**
Barium	0.0098 (0.0081–0.012)	0.5	AMCV	No
Beryllium	0.0000058 (0.0000043–0.0000074)	0.00042	CREG	No
Cadmium	0.00015 (0.00012–0.00019)	0.00056	CREG	No

Pollutant	Mean†	Chronic CV¶	Chronic CV Source	Exceeds chronic CV?
Chromium III	0.0028 (0.0025–0.0032)	0.01	AMCV	No
Chromium VI	0.000055 (0.000029–0.000086)	0.000083	CREG	No
Cobalt	0.00012 (0.000098–0.00015)	0.00027	SL-Ca[c]	No
Copper	0.0085 (0.0067–0.011)	1	AMCV	No
Lead	0.0038 (0.0028–0.0050)	0.15	NAAQS[d]	No
Manganese	0.017 (0.012–0.022)	0.3	cEMEG[e]	No
Mercury	0.000086 (0.000039–0.00014)	0.03	cREL[f]	No
Molybdenum	0.00040 (0.0033–0.00047)	5	AMCV	No
Nickel	0.0010 (0.00086–0.0012)	0.02	RfC[g]	No
Selenium	0.00081 (0.00065–0.00097)	0.2	AMCV	No
Uranium	0.000024 (0.000020–0.000030)	0.04	RfC	No
Vanadium	0.0013 (0.00098–0.0017)	0.05	AMCV	No
Zinc	0.031 (0.023–0.039)	5	AMCV	No

† numbers in the parenthesis indicate the confidence interval of the arithmetic mean
¶ CV= health based comparison value
***a** AMCV= TCEQ Air Monitoring Comparison Value*
***b** CREG= ATSDR Cancer Risk Evaluation Guide*
***c** SL-Ca= U.S. EPA Residential air screening level for cancer effects*
***d** NAAQS= U.S. EPA National Ambient Air Quality Standards*
***e** cEMEG= ATSDR Chronic Environmental Media Evaluation Guide*
***f** cREL= California EPA chronic reference exposure level*
***g** RfC= U.S. EPA Reference Concentration*
NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Table E-8. URS PM10 Metals (all units are µg/m3): Only Metals detected >20% of the time –Tayman Drive WWTP Monitoring Station

Pollutant	Mean†	Chronic CV¶	Chronic CV Source	Exceeds chronic CV?
Aluminum	0.12 (0.097–0.14)	5	AMCV[a]	No
Antimony	0.00045 (0.00033–0.00058)	0.5	AMCV	No
Arsenic	**0.00051 (0.00042–0.00060)**	**0.00023**	**CREG[b]**	**Yes**
Barium	0.0076 (0.0062–0.0091)	0.5	AMCV	No
Beryllium	0.0000047 (0.0000034–0.0000063)	0.00042	CREG	No
Cadmium	0.00014 (0.00012–0.00017)	0.00056	CREG	No
Chromium III	0.0020 (0.0019–0.0022)	0.01	AMCV	No
Chromium VI	0.000018 (0.0000097–0.000035)	0.000083	CREG	No
Cobalt	0.00010 (0.000089–0.00012)	0.00027	SL-Ca[c]	No
Copper	0.041 (0.023–0.064)	1	AMCV	No

Lead	0.0036 (0.0026–0.0051)	0.15	NAAQS[d]	No
Manganese	0.000026 (0.000015–0.000040)	0.3	cEMEG[e]	No
Mercury	0.00029 (0.00025–0.00032)	0.03	cREL[f]	No
Molybdenum	0.00029 (0.00025–0.00032)	5	AMCV	No
Nickel	0.0016 (0.00091–0.0025)	0.02	RfC[g]	No
Selenium	0.00074 (0.00058–0.00090)	0.2	AMCV	No
Uranium	0.000028 (0.000021–0.000035)	0.04	RfC	No
Vanadium	0.0011 (0.00081–0.0014)	0.05	AMCV	No
Zinc	0.019 (0.015–0.023)	5	AMCV	No

† *numbers in the parenthesis indicate the confidence interval of the arithmetic mean*
¶ CV= health based comparison value
a *AMCV= TCEQ Air Monitoring Comparison Value*
b *CREG= ATSDR Cancer Risk Evaluation Guide*
c *SL-Ca= U.S. EPA Residential air screening level for cancer effects*
d *NAAQS= U.S. EPA National Ambient Air Quality Standards*
e *cEMEG= ATSDR Chronic Environmental Media Evaluation Guide*
f *cREL= California EPA chronic reference exposure level*
g *RfC= U.S. EPA Reference Concentration*
NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Table E-9. URS PM10 Metals (all units are µg/m3): Only Metals detected >20% of the time – Wyatt Road Monitoring Station

Pollutant	Mean[†]	Chronic CV[¶]	Chronic CV Source	Exceeds chronic CV?
Aluminum	0.27 (0.21–0.33)	5	AMCV[a]	No
Antimony	0.00054 (0.00045–0.00062)	0.5	AMCV	No
Arsenic	0.0011 (0.00083–0.0013)	**0.00023**	**CREG[b]**	**Yes**
Barium	0.013 (0.011–0.015)	0.5	AMCV	No
Beryllium	0.000012 (0.0000090–0.000016)	0.00042	CREG	No
Cadmium	0.00046 (0.00028–0.00068)	0.00056	CREG	No
Chromium III	0.0053 (0.0042–0.0065)	0.01	AMCV	No
Chromium VI	0.00007 (0.000037–0.00012)	0.000083	CREG	No
Cobalt	0.00023 (0.00018–0.00028)	0.00027	SL-Ca[c]	No
Copper	0.022 (0.018–0.027)	1	AMCV	No
Lead	0.016 (0.0094–0.025)	0.15	NAAQS[d]	No
Manganese	0.063 (0.045–0.085)	0.3	cEMEG[e]	No
Mercury	0.0001 (0.000049–0.00017)	0.03	cREL[f]	No
Molybdenum	0.0010 (0.00073–0.0013)	5	AMCV	No
Nickel	0.00080 (0.00065–0.00094)	0.02	RfC[g]	No

Selenium	0.00080 (0.00065–0.00094)	0.2	AMCV	No
Uranium	0.000052 (0.000037–0.000072)	0.04	RfC	No
Vanadium	0.0024 (0.0018–0.0029)	0.05	AMCV	No
Zinc	0.15 (0.082–0.22)	5	AMCV	No

† *numbers in the parenthesis indicate the confidence interval of the arithmetic mean*
¶ CV= health based comparison value
a *AMCV= TCEQ Air Monitoring Comparison Value*
b *CREG= ATSDR Cancer Risk Evaluation Guide*
c *SL-Ca= U.S. EPA Residential air screening level for cancer effects*
d *NAAQS= U.S. EPA National Ambient Air Quality Standards*
e *cEMEG= ATSDR Chronic Environmental Media Evaluation Guide*
f *cREL= California EPA chronic reference exposure level*
g *RfC= U.S. EPA Reference Concentration*
NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

For the remaining air monitoring stations in this Appendix, only 5 observations were available, and no observations exceeded acute health based comparison values.

Table E-10. URS PM10 Metals (all units are µg/m3): Only Metals detected >20% of the time – JA Vitovsky Monitoring Station

Pollutant	Max	Acute CV[¶]	Acute CV Source
Aluminum	0.13	50	AMCV[a]
Antimony	0.00047	5	AMCV
Arsenic	0.00081	9.9	AMCV
Barium	0.0064	5	AMCV
Beryllium	0.000005	N/A	
Cadmium	0.00018	0.03	aEMEG[b]
Chromium III	0.0032	0.1	AMCV
Chromium VI	0.000021	0.1	AMCV
Cobalt	0.000095	0.20	AMCV
Copper	0.0088	10	AMCV
Lead	0.0023	0.15	NAAQS[c]
Manganese	0.015	2.0	AMCV
Mercury	0.000015	0.6	aREL[d]
Molybdenum	0.00036	50	AMCV
Nickel	0.0015	0.2	aREL
Selenium	0.0015	2	AMCV
Uranium	0.000012	N/A	

Vanadium	0.0026	0.5	AMCV
Zinc	0.026	50	AMCV

Note: Descriptive Statistics were not generated for this dataset because of the small number of observations (N=5)
¶ CV= health based comparison value
***a** AMCV= TCEQ Air Monitoring Comparison Value*
***b** aEMEG= ATSDR Acute Environmental Media Evaluation Guide*
***c** NAAQS= U.S. EPA National Ambient Air Quality Standards*
***d** aREL= California EPA acute reference exposure level*
NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Table E-11. URS PM10 Metals (all units are µg/m3): Only Metals detected >20% of the time – Midlothian High School Monitoring Station

Pollutant	Max	Acute CV¶	Source_Acute
Aluminum	0.15	50	AMCV[a]
Antimony	0.00072	5	AMCV
Arsenic	0.00076	0.20	AMCV
Barium	0.023	5	AMCV
Beryllium	0.000005	N/A	
Cadmium	0.000098	0.03	aEMEG[b]
Chromium III	0.0021	0.1	AMCV
Chromium VI	0.000039	0.1	AMCV
Cobalt	0.00014	0.20	AMCV
Copper	0.01	10	AMCV
Lead	0.0034	0.15	NAAQS[c]
Manganese	0.0064	2.0	AMCV
Mercury	0.000015	0.6	aREL[d]
Molybdenum	0.00037	50	AMCV
Nickel	0.00078	0.2	aREL
Selenium	0.00083	2	AMCV
Uranium	0.000013	N/A	
Vanadium	0.00068	0.5	AMCV
Zinc	0.02	50	AMCV

Note: Descriptive Statistics were not generated for this dataset because of the small number of observations (N=5)
¶ CV= health based comparison value
***a** AMCV= TCEQ Air Monitoring Comparison Value*
***b** aEMEG= ATSDR Acute Environmental Media Evaluation Guide*
***c** NAAQS= U.S. EPA National Ambient Air Quality Standards*
***d** aREL= California EPA acute reference exposure level*
NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Table E-12. URS PM10 Metals (all units are µg/m3): Only Metals detected >20% of the time – Mountain Peak Elementary School Monitoring Station

Pollutant	Max	Acute CV¶	Acute CV Source
Aluminum	0.16	50	AMCV[a]
Antimony	0.00039	5	AMCV
Arsenic	0.00034	9.9	AMCV
Barium	0.01	5	AMCV
Beryllium	0.000012	N/A	
Cadmium	0.00013	0.03	aEMEG[b]
Chromium III	0.0021	0.1	AMCV
Cobalt	0.00015	0.1	AMCV
Copper	0.0054	0.20	AMCV
Chromium VI	0.000039	10	AMCV
Lead	0.0025	0.15	NAAQS[c]
Manganese	0.019	2.0	AMCV
Mercury	0.00034	0.6	aREL[d]
Molybdenum	0.00089	50	AMCV
Nickel	0.0012	0.2	aREL
Selenium	0.00096	2	AMCV
Uranium	0.000044	N/A	
Vanadium	0.0014	0.5	AMCV
Zinc	0.014	50	AMCV

Note: Descriptive Statistics were not generated for this dataset because of the small number of observations (N=5)

¶ CV= health based comparison value

***a** AMCV= TCEQ Air Monitoring Comparison Value*

***b** aEMEG= ATSDR Acute Environmental Media Evaluation Guide*

***c** NAAQS= U.S. EPA National Ambient Air Quality Standards*

***d** aREL= California EPA acute reference exposure level*

NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Table E-13. URS PM10 Metals (all units are µg/m3): Only Metals detected >20% of the time – Triangle Park Monitoring Station

Pollutant	Max	Acute CV¶	Acute CV Source
Aluminum	0.091	50	AMCV[a]
Antimony	0.0014	5	AMCV
Arsenic	0.00077	9.9	AMCV
Barium	0.024	5	AMCV
Beryllium	0.000007	N/A	
Cadmium	0.00059	0.03	aEMEG[b]
Chromium III	0.0019	0.1	AMCV
Chromium IV	0.000031	0.1	AMCV
Cobalt	0.00011	0.20	AMCV
Copper	0.019	10	AMCV
Lead	0.006	0.15	NAAQS[c]
Manganese	0.015	2.0	AMCV
Mercury	0.00021	0.6	aREL[d]
Molybdenum	0.00057	50	AMCV
Nickel	0.00096	0.2	aREL
Selenium	0.0012	2	AMCV
Uranium	0.000027	N/A	
Vanadium	0.0014	0.5	AMCV
Zinc	0.046	50	AMCV

Note: Descriptive Statistics were not generated for this dataset because of the small number of observations (N=5)
¶ CV= health based comparison value
***a** AMCV= TCEQ Air Monitoring Comparison Value*
***b** aEMEG= ATSDR Acute Environmental Media Evaluation Guide*
***c** NAAQS= U.S. EPA National Ambient Air Quality Standards*
***d** aREL= California EPA acute reference exposure level*
NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Appendix F. ATSDR Modeling Analysis

For numerous air pollutants considered in this Health Consultation, ATSDR based its conclusions on ambient air monitoring data—the direct measurements of levels of air pollution in the Midlothian area. This could not be done for the site-related pollutants for which no ambient air monitoring data are available.

For insights into these and other pollutants with no air monitoring data, ATSDR conducted its own air dispersion modeling analysis. Air dispersion models can be used to estimate air pollution levels based on facility configurations, emission rates, local meteorological conditions, and other factors. This appendix describes the air dispersion modeling analysis that ATSDR conducted. All model input files used for this dispersion modeling effort are available in electronic format from ATSDR, upon request. Note that the modeling described in this appendix was designed to characterize the combined air quality impacts from all four industrial facilities in the Midlothian area, but does not account for influences from any other sources.

Model selection. Modeling was performed using the AERMOD model, version number 11103. AERMOD was chosen because it is designated as a “recommended model” in EPA’s Guideline on Air Quality Models (EPA, 2005). AERMOD has been widely used for modeling how pollutants move from industrial facilities through the air to offsite locations. This model can be used for evaluating many different types of emission sources, including point, area, and volume sources. AERMOD can also be used to assess air pollution levels in all types of terrain, including flat terrain and complex terrain.

Pollutants. A previous Health Consultation reviewed the modeling that ATSDR conducted for carbon monoxide (see ATSDR’s Health Consultation entitled: *Assessing the public health implications of exposures to the National Ambient Air Quality Standard (NAAQS) pollutants* (ATSDR 2015). This appendix reviews the modeling that ATSDR conducted for the following pollutants for which no air monitoring data are available: acetaldehyde, dioxins, formaldehyde, furans, hydrochloric acid aerosols, mercury vapor, polycyclic aromatic hydrocarbons, and sulfuric acid aerosols. Figures F-4 through F-10 shows modeled maximum annual averages for these pollutants, and Figures F-11 through F-17 shows their respective modeled maximum 24-hour averages.

Facilities and sources to model. The modeling focused on emissions from Ash Grove Cement, Gerdau Ameristeel, Holcim, and TXI. For the pollutants considered in the modeling, the overwhelming majority of emissions that the facilities reported to TRI and to the state emission inventory come from either kiln stacks (at the cement manufacturing facilities) or furnace stacks (at the steel mill). This is consistent with the knowledge that industrial emissions of many of these pollutants are dominated by fuel combustion sources and other high temperature sources. ATSDR’s approach was to model emissions from one stack per facility, with the stack selected being the one expected to have the least favorable dispersion (i.e., the shortest kiln or furnace stack with the lowest exit velocity). For each facility, ATSDR allocated 100 percent of the facility-wide emissions to the one stack selected for modeling. In other words, 100 percent of each facility’s emissions for a given pollutant were considered in the model—they were just assumed to be emitted from the stack that would lead to the highest offsite air quality impacts. Although some facilities have ground-level emissions source of the selected pollutants (e.g., exhaust from trucks and small engines), these account for an extremely small fraction of the facility's overall inventories. The tables at the end of this protocol list the stack parameters and emission rates for the facilities of interest. Building downwash was not considered, primarily because the stacks are considerably higher than the nearby buildings and structures. Furthermore, no residents live within an area where building downwash would be expected to have notable air quality impacts.

Meteorological data. AERMOD, like most refined dispersion models, requires inputs that characterize local meteorological conditions. These are typically hourly observations of wind speed, wind direction, temperature, and other parameters. For this modeling, ATSDR used the electronic meteorological data sets that TCEQ has already processed for modeling applications in Ellis County in Texas. The meteorological data used were those for "medium" surface roughness, which is appropriate for rural and suburban areas. The specific data set processed by TCEQ and widely used in modeling applications in this area includes surface meteorological data from the Dallas–Fort Worth Airport for calendar years 1985, 1987, 1988, 1989, and 1990. These were processed with upper air data from Stephenville, Texas. The five individual year datasets were combined into a single file for input to the model.

Terrain data. Elevation data for the Midlothian area were obtained from the National Elevations Dataset available from the U.S. Geological Survey. These data were used to assign elevations to every location where air pollution was modeled and to make more realistic assessments for how local terrain affects atmospheric dispersion.

Receptor grid. In the field of dispersion modeling, "receptors" refer to the locations where models estimate air pollution levels. These can be assigned to any geographic area of interest. The proposed receptor grid for this modeling application was selected to help pinpoint locations with maximum impact from the primary stack at an individual facility. It is standard practice to have a high concentration of receptors in areas where one expects air pollution levels to be highest, with fewer receptors in other areas. This approach helps ensure the highest air pollution levels are identified, while saving computational time. The receptor grid for this modeling is depicted in Figures F-1, F-2, and F-3, and included three tiers of receptors:

Fine grid for near-field receptors. The most receptors were placed in the immediate vicinity of the four facilities. Specifically, receptors were placed at 100-meter intervals along the facility boundaries and at regular spacing to a distance 1 kilometer from the facility boundary. Concentrations were not modeled for locations within the facility boundaries. Figures F-1 and F-2 show the near-field receptor grid.

Intermediate grid receptors. At distances between 1 and 5 kilometers from the facility boundaries, receptors were placed at 500-meter intervals. Figure F-3 shows these receptors.

Coarse grid for far-field receptors. At locations between 5 and 10 kilometers from the facilities, receptors were placed at 1,000-meter intervals. Figure F-3 shows the locations of these receptors. Modeling was not conducted for locations more than 10 kilometers away from the facility boundaries. The outputs from the modeling confirmed that this modeling domain was adequate and that higher air quality impacts for the selected pollutants did not occur at locations further downwind.

Model inputs and emission rates. Table F-1 lists all of the model inputs for the individual facilities. For the stacks considered in the analysis, the table lists the geographic coordinates, the stack height and diameter, and the temperature and velocity of the emissions from the stack. These parameters are all taken from publicly available Emission Inventory Questionnaire data. Pollutant-specific emission rates used in the modeling (and shown in Table F-1) are the highest annual emissions levels documented in the facility's history of TRI reporting or in selected years of TCEQ's Point Source Emission Inventory (PSEI). The emissions data shown in the table are the total amounts of pollutants released over the course of the year. For purposes of modeling, these values were used to calculate emission rates, which were assumed to remain constant throughout the year.

Model outputs and averaging times. The model was run with 5 years of meteorological data, and pollutant concentrations were calculated for each receptor. These concentrations represent the combined air quality impact from all four Midlothian facilities, not considering contributions from other sources (e.g., motor vehicles). The highest air quality impacts were generally observed at locations immediate north of the Gerdau Ameristeel and TXI facilities. Table F-2 lists the highest predicted pollutant concentrations for different averaging periods.

Uncertainties and limitations. As with any data considered in its public health evaluations, ATSDR considered the uncertainties and limitations of these modeling results. The model inputs for stack parameters are based on direct observations of facility conditions, and these are believed to be highly accurate. The meteorological data used in the model are based on observations at the Dallas–Fort Worth Airport. Although this location is approximately 30 miles away from Midlothian, the prevailing wind directions observed in the meteorological data set are highly similar to those encountered in the Midlothian area (ATSDR, 2015, pp. 77-78).

The main source of uncertainty is likely associated with the emissions data. It should be noted that ATSDR took steps to ensure that the highest annual emissions were modeled. For example, for each facility, the highest pollutant emissions rate from all of the TRI data and from selected years of PSEI data were considered in the assessment. Further, even though the highest emissions occurred during different years across the four facilities, the modeling assumed the highest annual emissions from all four facilities occurred at the same time. ATSDR notes that TRI data are self-reported and the accuracy of these numbers is not known.

Despite efforts to ensure that the modeling is based on health-protective assumptions, another limitation in the emissions data is that the assessment is based on annual emissions, which were assumed to remain constant throughout the year. In reality, emissions will vary from one hour to the next, and short-term fluctuations in emissions are not captured in the modeling analysis (but short-term fluctuations in the local meteorological conditions are addressed). The reason that short-term fluctuations in emissions are not captured is because no hourly emissions data are available to support such an assessment. Therefore, it is possible that some actual short-term pollutant concentrations were higher than the worst-case levels predicted by the model.

References

(U.S. EPA). United States Environmental Protection Agency. 2005. Guideline on Air Quality Models. Code of Federal Regulations, Chapter 40, Part 51, Appendix W. November 9, 2005.

Table F-1. Model Input Parameters (see notes on next page for further details on the data reported in the table)

Input Parameters	Facility			
	Ash Grove Cement	Gerdau Ameristeel	Holcim	TXI Operations
Stack modeled	"Kiln #1"	"Baghouse A"	"Kiln #1"	"Kiln #4"
UTM-North (zone 14)	3,599,875 meters	3,592,800 meters	3,599,176 meters	3,593,584.25 meters
UTM-East (zone 14)	687,419 meters	684,525 meters	690,633 meters	685,435.55 meters
Stack height	150 feet	80 feet	273 feet	200 feet
Stack diameter	10.5 feet	11.9 feet	13.5 feet	9 feet
Exit temperature	350 ºF	150 ºF	233 ºF	383 ºF
Exit velocity	31 feet/second	5.9 feet/second	56 feet/second	37.43 feet/second
Formaldehyde emissions	12,633 lb/year	No data	No data	No data
Source of data	2007 PSEI data	NA	NA	NA
Mercury vapor emissions	85.34 lb/year	750.97 lb/year	59 lb/year	38.3 lb/year
Source of data	2008 TRI data	2006 TRI data	2004 TRI data	2000 TRI data
Hydrochloric acid emissions	44,526 lb/year	No data	31,105 lb/year	52,528 lb/year
Source of data	1999 TRI data	NA	2003 TRI data	1998 TRI data
Sulfuric acid emissions	101,520 lb/year	No data	157,969 lb/year	1,260,518 lb/year
Source of data	2002 TRI data	NA	2000 PSEI data	2000 TRI data
Dioxin/furan emissions	0.000882 gram/year	0.0015215 gram/year	0.0028665 gram/year	0.0015337 gram/year
Source of data	2000 TRI data	2007 TRI data	2001 TRI data	2002 TRI data
Acetaldehyde emissions	No data	No data	84,827 lb/year	No data
Source of data	NA	NA	2009 TRI data	NA
PAH emissions	No data	No data	No data	13.8 lb/year
Source of data	NA	NA	NA	2000 TRI data

Notes: The stack parameters are all taken from data documented on the facility's Emission Inventory Questionnaires for years 2000, 2007, 2010. Stack parameters are not expected to change considerably from one year to the next. In each case, the stack modeled is the kiln or furnace stack expected to have the highest air quality impacts. For purposes of the modeling, 100 percent of the facility's pollutant-specific emissions were assumed to be emitted from these stacks.

The emissions data represent the highest annual emission rates that were available from TRI or from selected years of PSEI. The entries shown above are the highest annual emissions over the entire period of record. ATSDR's modeling assumed that emissions occurred at these rates over the entire period considered in the modeling analysis.

ATSDR selected the pollutants for modeling based on evaluations documented in the first Health Consultation and other factors. All pollutants selected have emissions data from some combination of the four facilities. For certain pollutants and facilities, no emissions data have been documented in TRI or the years of PSEI data that ATSDR reviewed. In those cases, the table lists "No data" under the field for emissions data and "NA" (not applicable) under the field for source of emissions data.

The emissions data for “dioxins and furans” are the highest annual release that the facilities reported to TRI for the category “dioxin and dioxin-like compounds.” This category includes 17 individual dioxins and furans that are summed together and reported under this one listing. As a protective assumption in the health evaluation, ATSDR is assuming that 100 percent of the reported emissions are the most toxic congener (2,3,7,8-tetrachlorodibenzo-p-dioxin, or 2,3,7,8-TCDD).

The emissions data for “xylenes” are the sum of emissions data for the three xylene isomers: m-xylene, o-xylene, and p-xylene. In their TRI data, some facilities report emissions of the individual isomers, and other facilities report for all three chemicals combined.

The emissions data for “PAHs” are based on TRI reporting data submitted for the chemical category “polycyclic aromatic compounds.” This category includes 21 individual PAHs that are summed together and reported under the PACs listing. As a protective assumption in the health evaluation, ATSDR is assuming that 100 percent of the reported PACs emissions are the most toxic chemical within this category (benzo(a)pyrene).

Table F-2. Highest Pollutant Concentrations Estimated across All Receptors Considered in the Modeling (see notes at end of table for further explanation of reported values)[d]

Averaging Time	Highest Estimated Formaldehyde Concentration	
	Parts per billion (ppb)	Micrograms per cubic meter (µg/m^3)
1-hour	0.27	0.33
24-hour	0.14	0.17
Annual average	0.028	0.035
5-year average	0.025	0.031
Averaging Time	**Highest Estimated Mercury Vapor Concentration**	
	Parts per billion (ppb)	**Micrograms per cubic meter (µg/m^3)**
1-hour	NA[a]	0.17
24-hour	NA	0.067
Annual average	NA	0.021
5-year average	NA	0.017
Averaging Time	**Highest Estimated Hydrochloric Acid Concentration**	
	Parts per billion (ppb)	**Micrograms per cubic meter (µg/m^3)**
1-hour	NA[a]	1.15
24-hour	NA	0.64
Annual average	NA	0.15
5-year average	NA	0.13
Averaging Time	**Highest Estimated Sulfuric Acid Concentration**	
	Parts per billion (ppb)	**Micrograms per cubic meter (µg/m^3)**
1-hour	NA[a]	27.35
24-hour	NA	15.45
Annual average	NA	3.56
5-year average	NA	3.06
Averaging Time	**Highest Estimated Dioxin/Furan Concentration[b]**	
	Parts per billion (ppb)	**Micrograms per cubic meter (µg/m^3)**
1-hour	NA[a]	7.6 x 10^{-10}
24-hour	NA	3.0 x 10^{-10}
Annual average	NA	9.3 x 10^{-11}
5-year average	NA	7.9 x 10^{-11}
Averaging Time	**Highest Estimated Acetaldehyde Concentration**	
	Parts per billion (ppb)	**Micrograms per cubic meter (µg/m^3)**
1-hour	0.92	0.51
24-hour	0.36	0.20
Annual average	0.058	0.032
5-year average	0.050	0.028
Averaging Time	**Highest Estimated PAH Concentration[c]**	

	Parts per billion (ppb)	Micrograms per cubic meter ($\mu g/m^3$)
1-hour	NA[a]	0.00030
24-hour	NA	0.00017
Annual average	NA	0.00004
5-year average	NA	0.00003

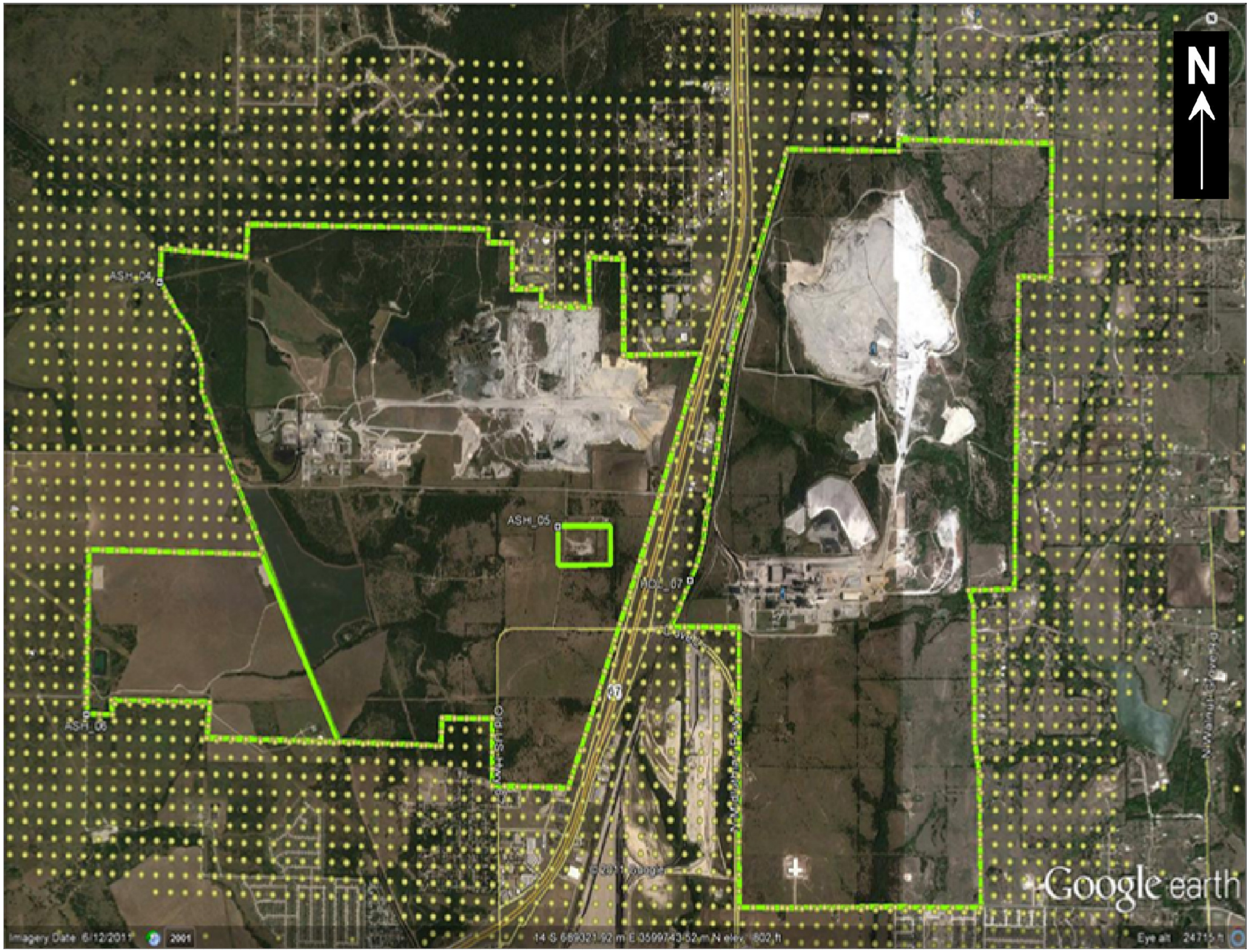
[a] NA = Not applicable. Concentrations for this pollutant are typically expressed in micrograms per cubic meter.

[b] The emission rate used as an input was the sum of emissions for the 17 dioxin and furan congeners that are subject to reporting under the TRI “dioxin and dioxin-like compounds” chemical category.

[c] The emission rate used as an input was the sum of emissions for the 21 individual PAHs that are subject to reporting under the TRI “polycyclic aromatic compounds” chemical category.

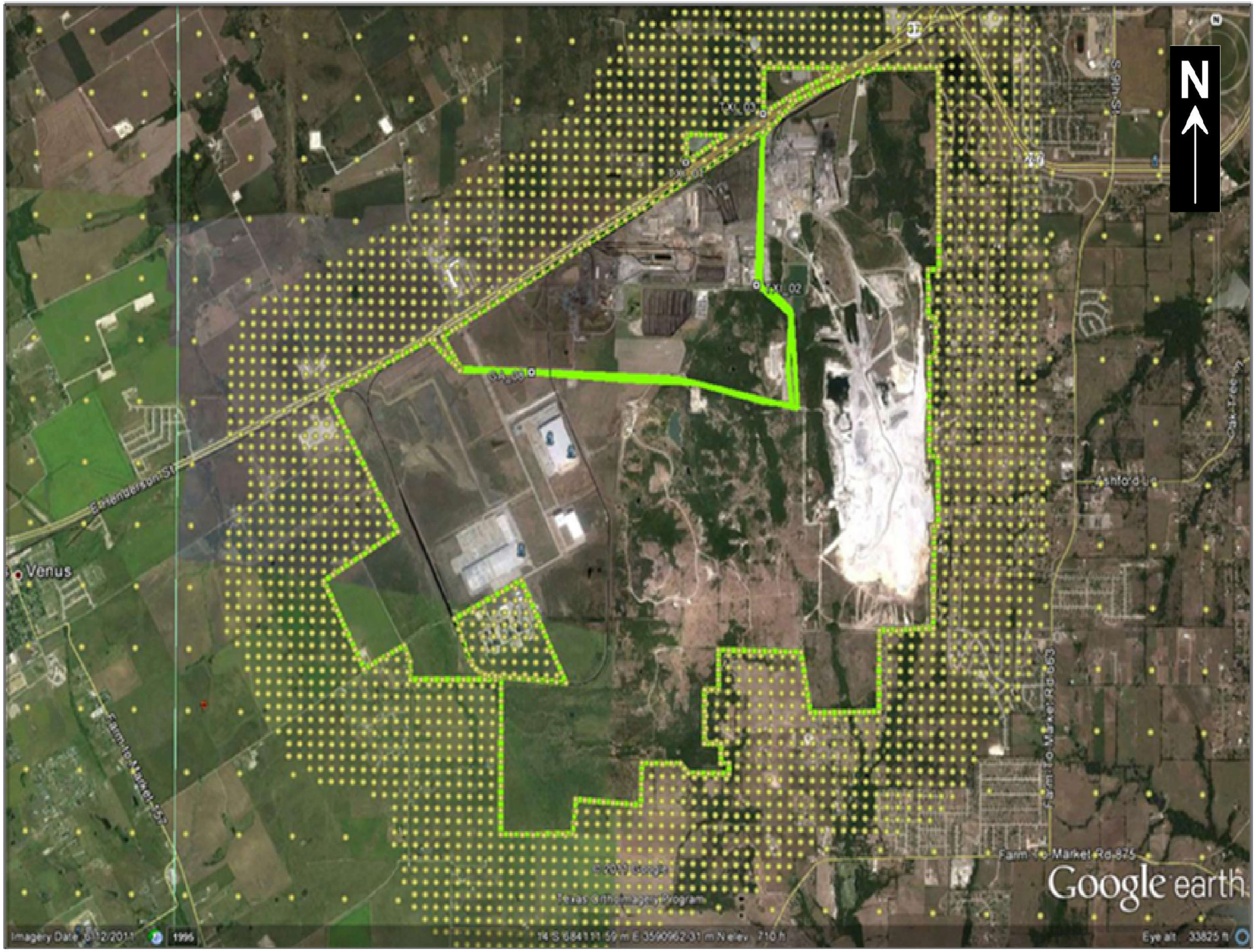
[d] The concentrations presented in the table are the highest estimated off-site concentrations for each pollutant across all receptors. The receptors where the highest estimated concentration occurred were not the same for every pollutant and averaging time. The locations of the highest air quality impacts were generally downwind from the facility with the highest emissions.

Figure F-1. Aerial Photograph Showing Near-Field Receptor Grid near Ash Grove Cement and Holcim



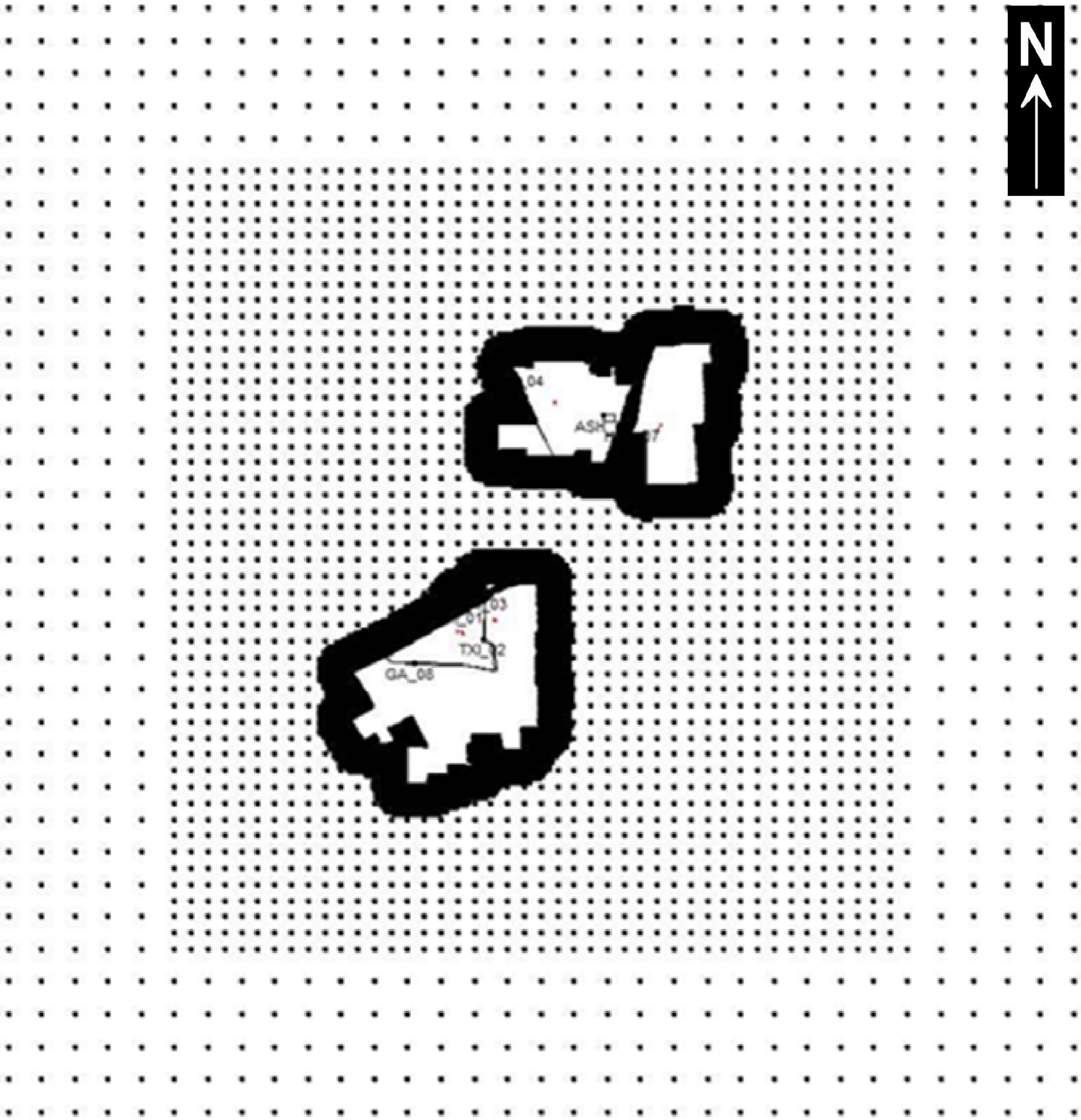
Note: Map shows placement of near-field receptors in the vicinity of the Ash Grove Cement and Holcim facilities. The near-field receptors are placed along the property lines and at 100-meter intervals and appear in the map as green dots. No receptors are placed within the facility boundaries.

Figure F-2. Aerial Photograph Showing Near-Field Receptor Grid near Gerdau Ameristeel and TXI Operations



Note: Map shows placement of near-field receptors in the vicinity of the Gerdau Ameristeel and TXI Operations facilities. The near-field receptors are placed along the property lines and at 100-meter intervals and appear in the map as green dots. No receptors are placed within the facility boundaries. Some intermediate-range receptors (placed at 500-meter intervals) are also displayed.

Figure F-3. Illustration Showing Entire Receptor Grid for Modeling Domain



Note: Map shows proposed placement of all receptors. The far-field receptors at 1,000-meter intervals appear around the exterior of the illustration. The intermediate range receptors at 500-meter intervals are also visible. The near-field receptors at 100-meter intervals are also displayed, but they appear as a shaded area rather than individual points due to their close proximity when displaying the entire modeling domain.

Figure F-4. ***Acetaldehyde*** **-Highest Modeled Annual Average for Pollutants Never Sampled in Air (µg/m^3)**

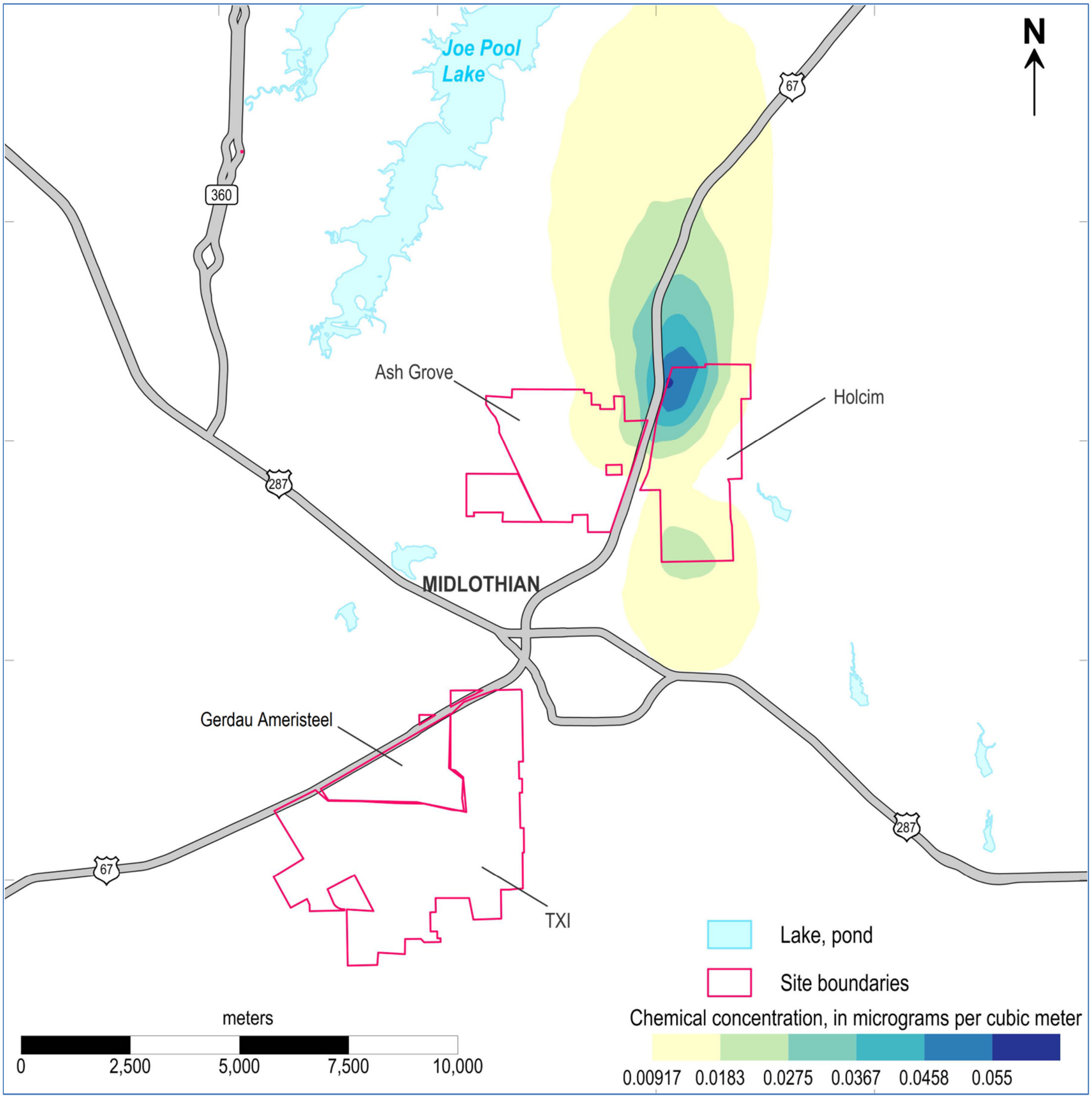


Figure F-5. ***Dioxins/Furans*** **-Highest Modeled Annual Average for Pollutants Never Measured in Air (µg/m^3)**

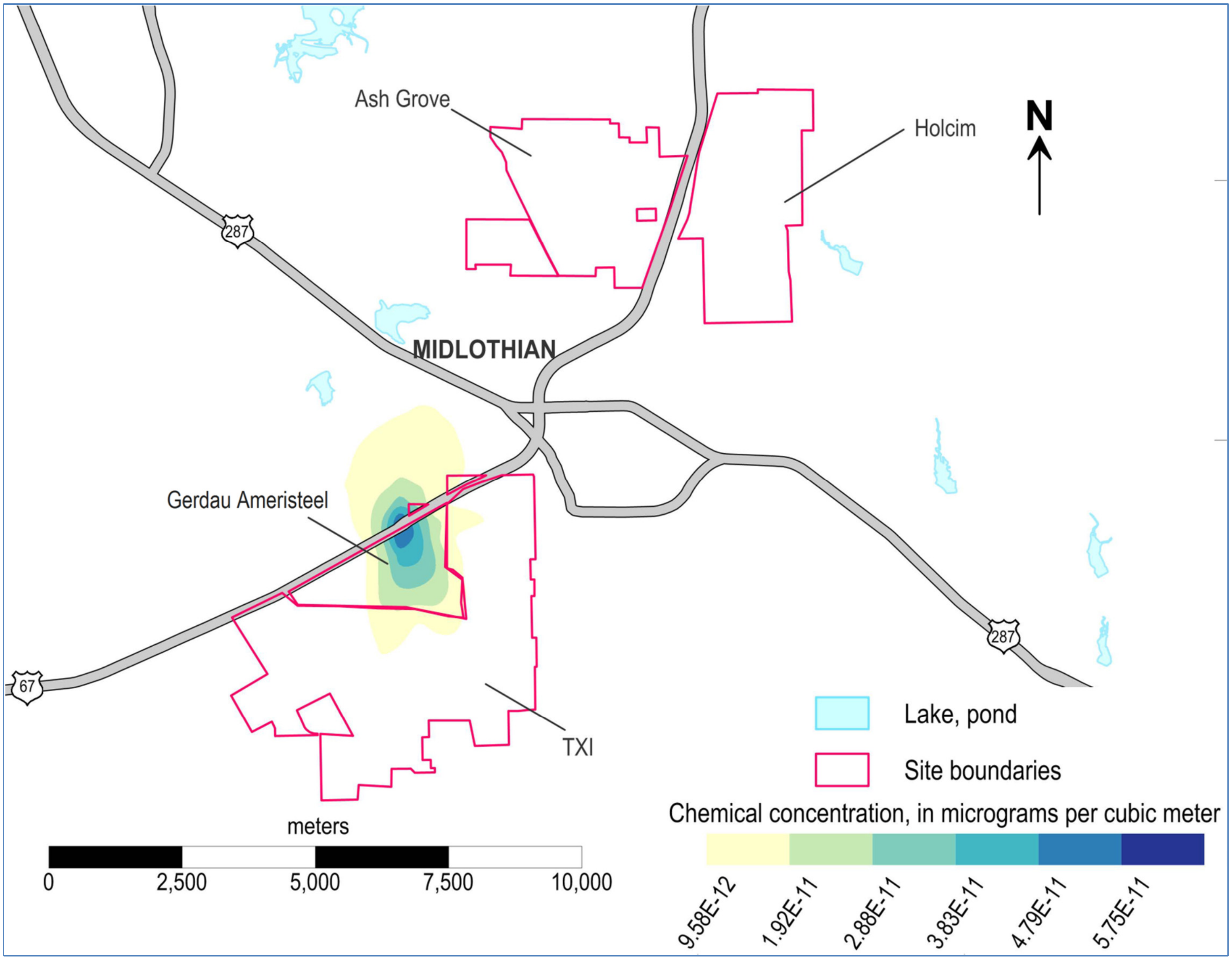


Figure F-6. *Formaldehyde* -Highest Modeled Annual Average for Pollutants Never Measured in Air (µg/m^3)

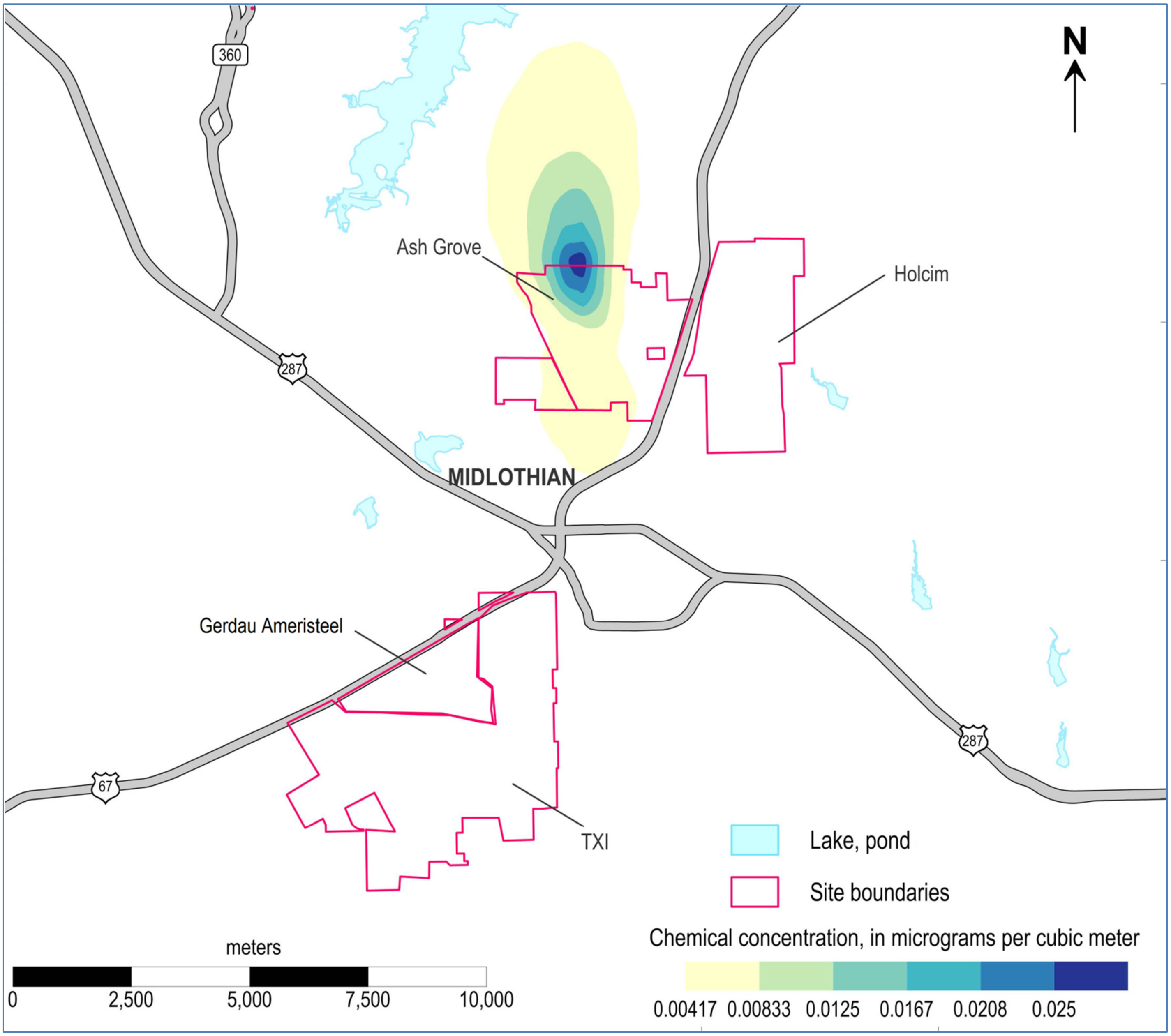


Figure F-7. ***Hydrochloric Acid Aerosols*** **-Highest Modeled Annual Average for Pollutants Never Measured in Air (µg/m^3)**

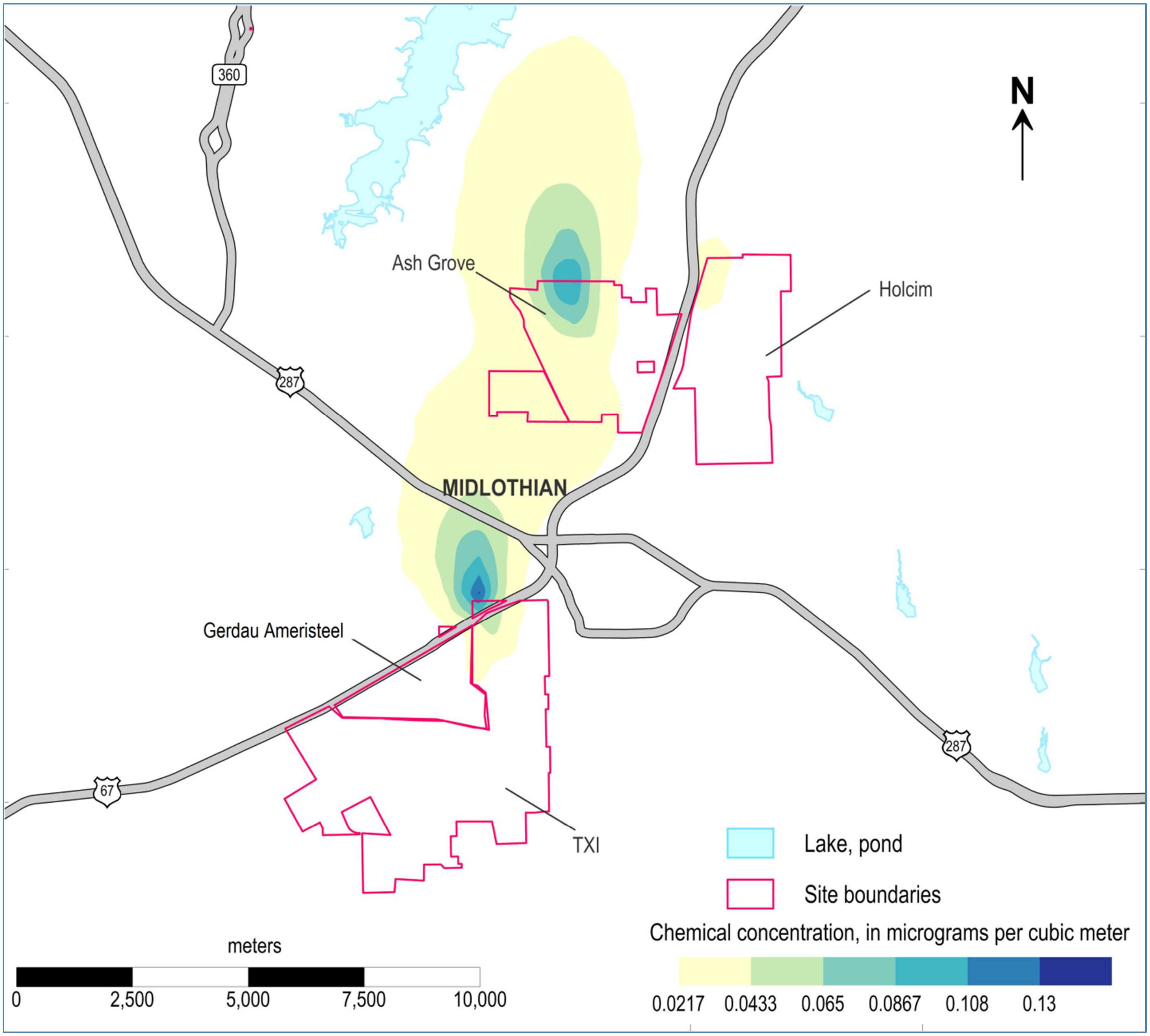


Figure F-8. *Vapor Phase Mercury*- Highest Modeled Annual Average for Pollutants Never Measured in Air ($\mu g/m^3$)

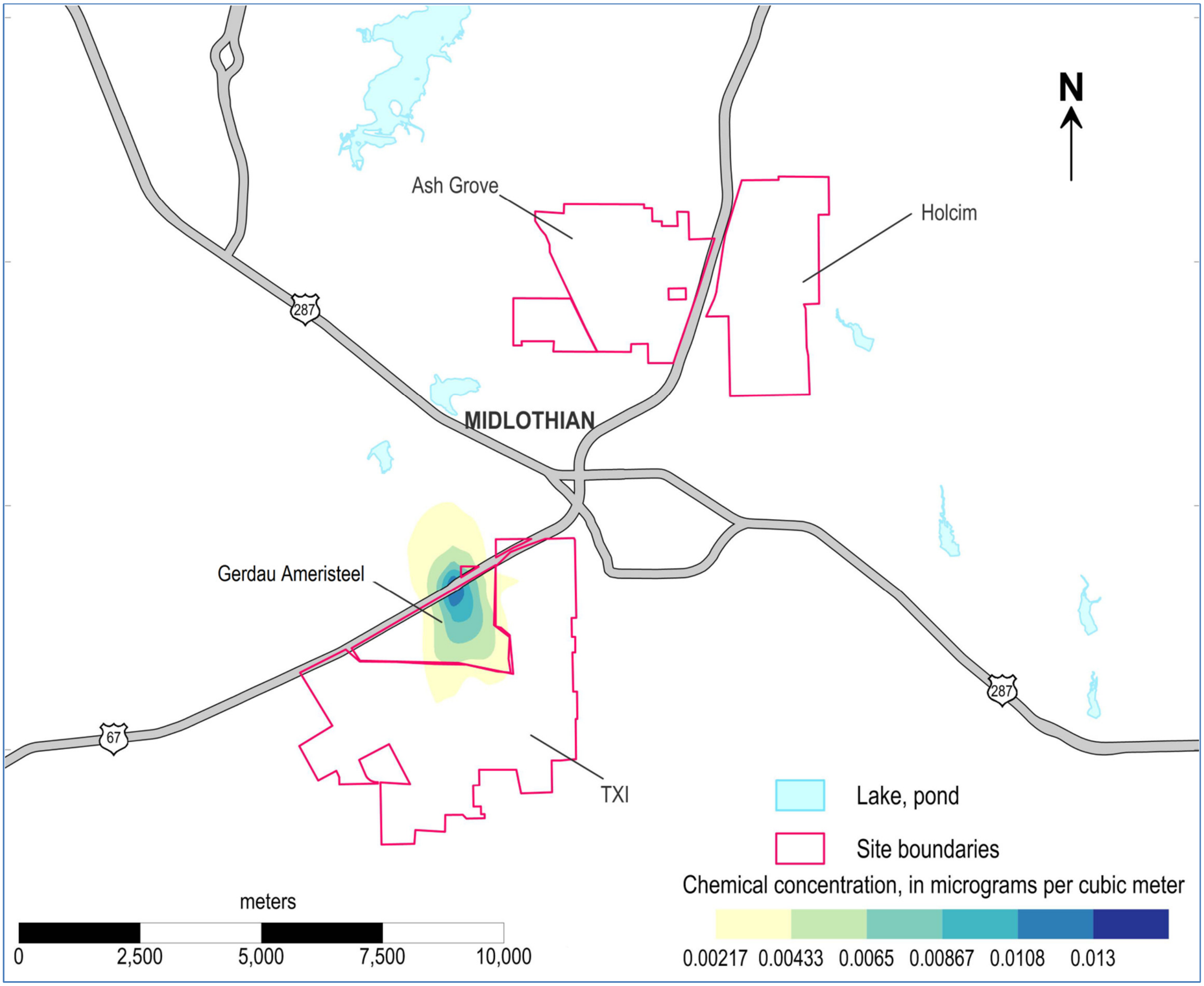


Figure F-9. ***Polycyclic Aromatic Hydrocarbons (PAHs)*****- Highest Modeled Annual Average for Pollutants Never Measured in Air (µg/m³)**

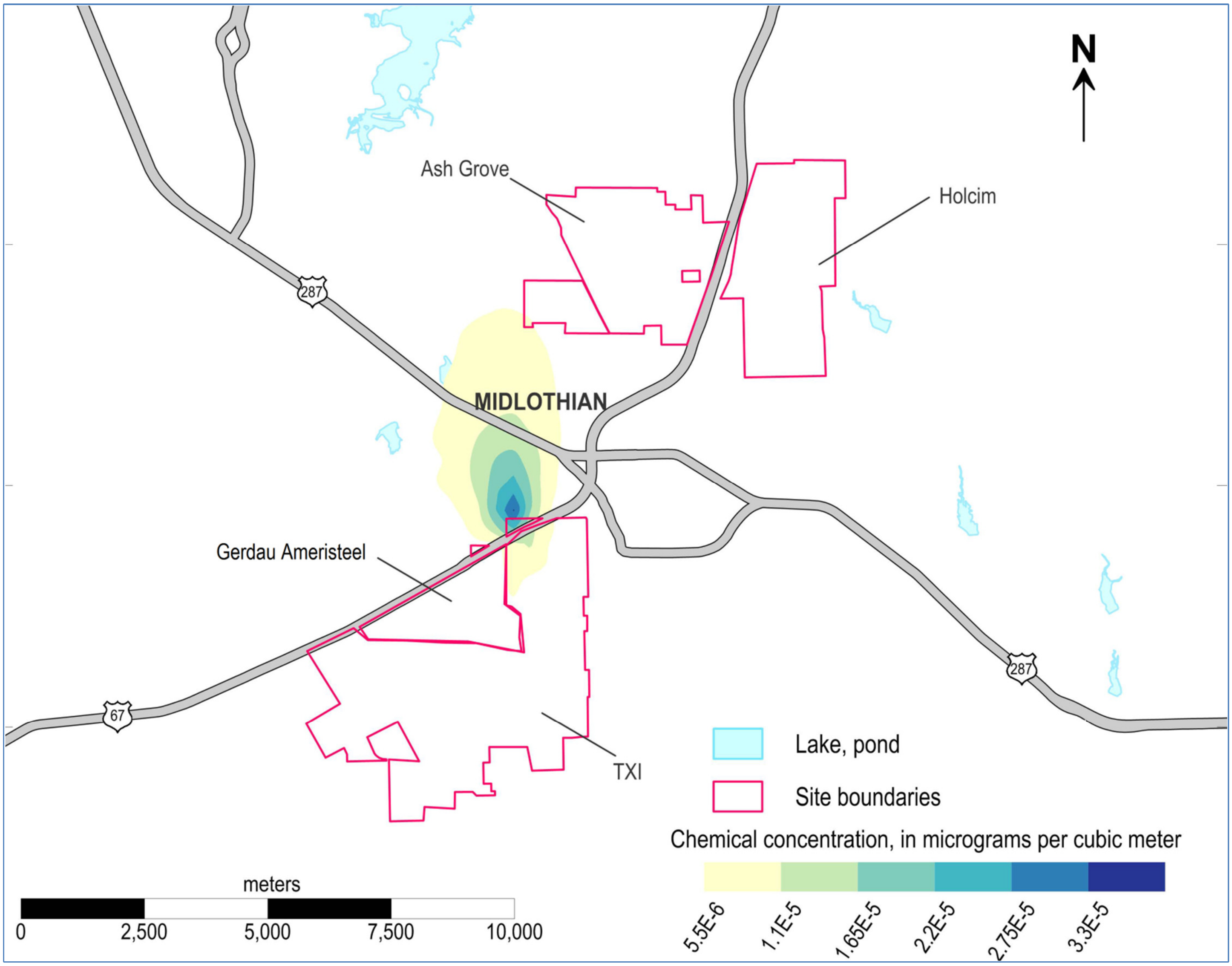


Figure F-10. ***Sulfuric Acid Aerosols*****- Highest Modeled Annual Average for Pollutants Never Measured in Air (μg/m^3)**

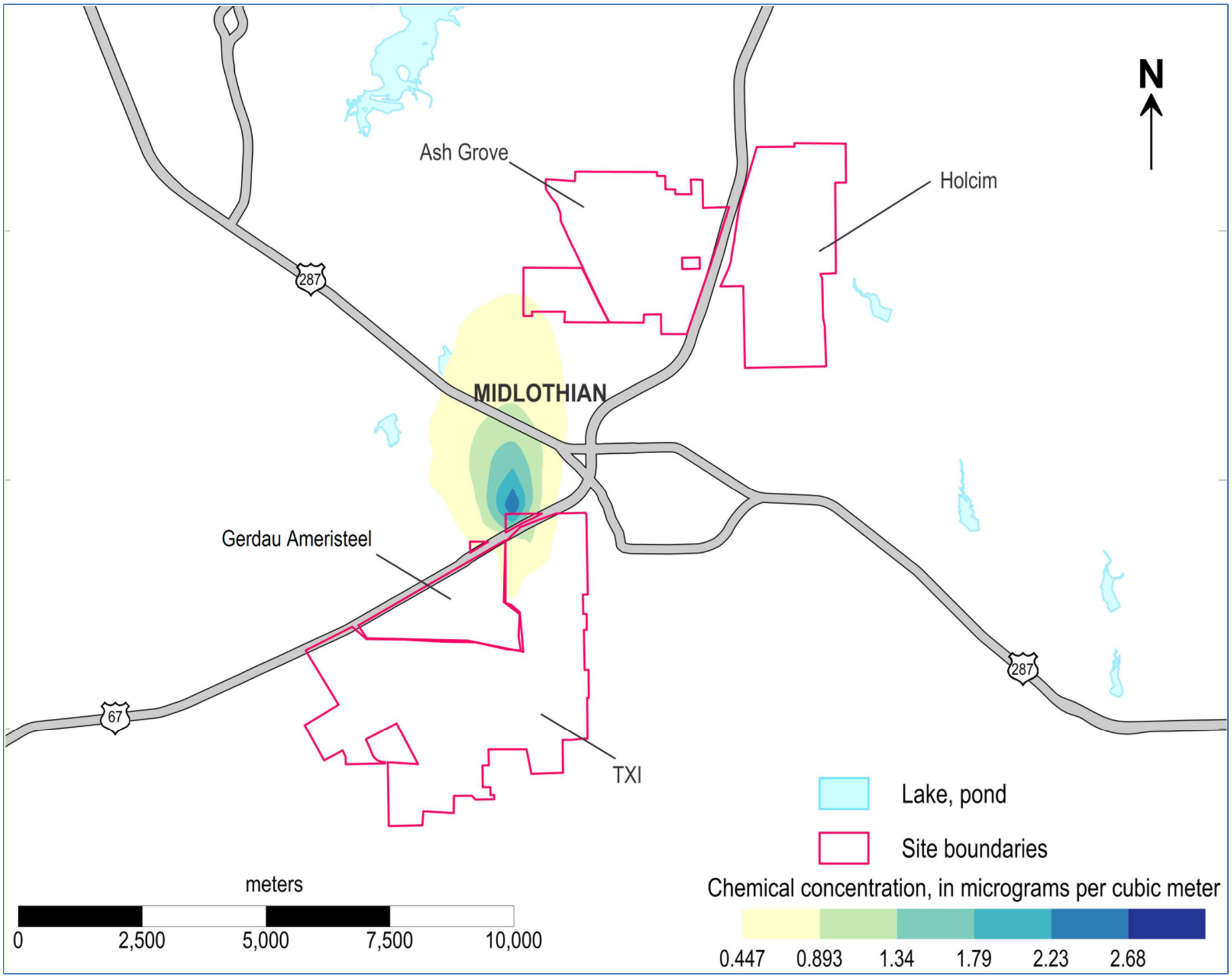


Figure F-11. ***Acetaldehyde*****- Highest Modeled 24-hour Average for Pollutants Never Measured in Air (µg/m^3)**

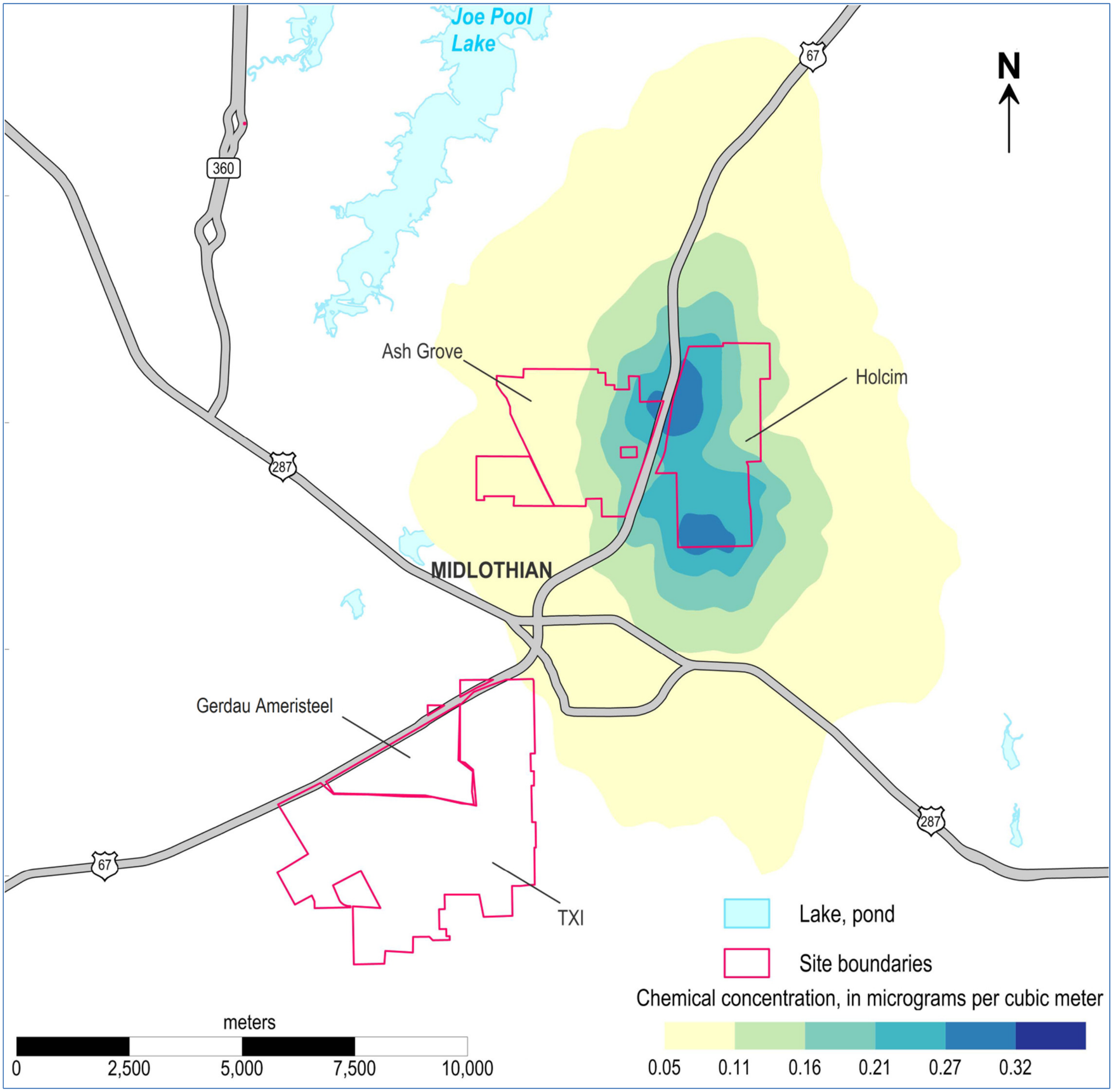


Figure F-12. ***Dioxin/Furans*- Highest Modeled 24-hour Average for Pollutants Never Measured in Air (µg/m^3)**

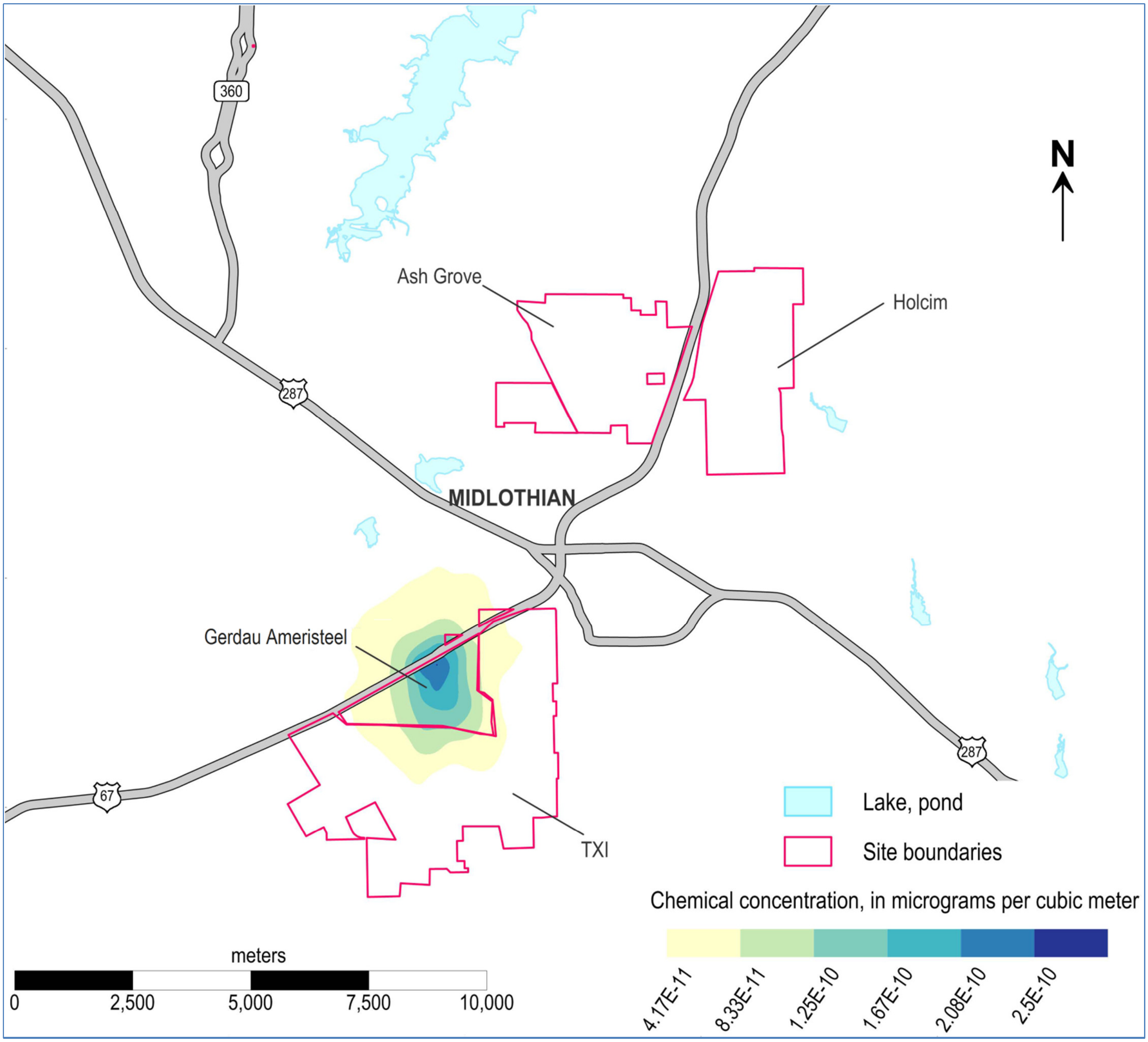


Figure F-13. ***Formaldehyde*****- Highest Modeled 24-hour Average for Pollutants Never Measured in Air (µg/m³)**

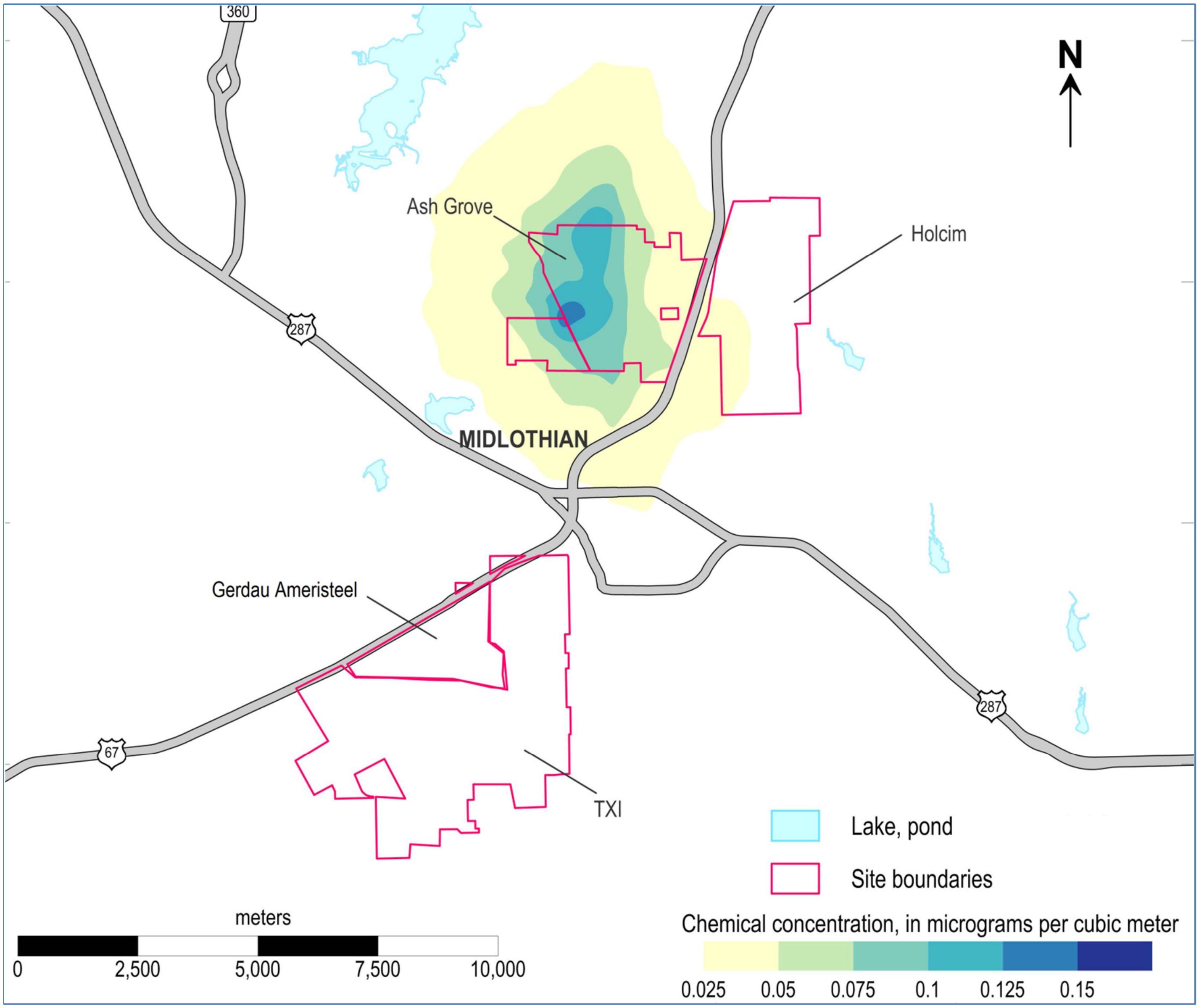


Figure F-14. ***Hydrochloric Acid Aerosols*** **- Highest Modeled 24-hour Average for Pollutants Never Measured in Air (μg/m^3)**

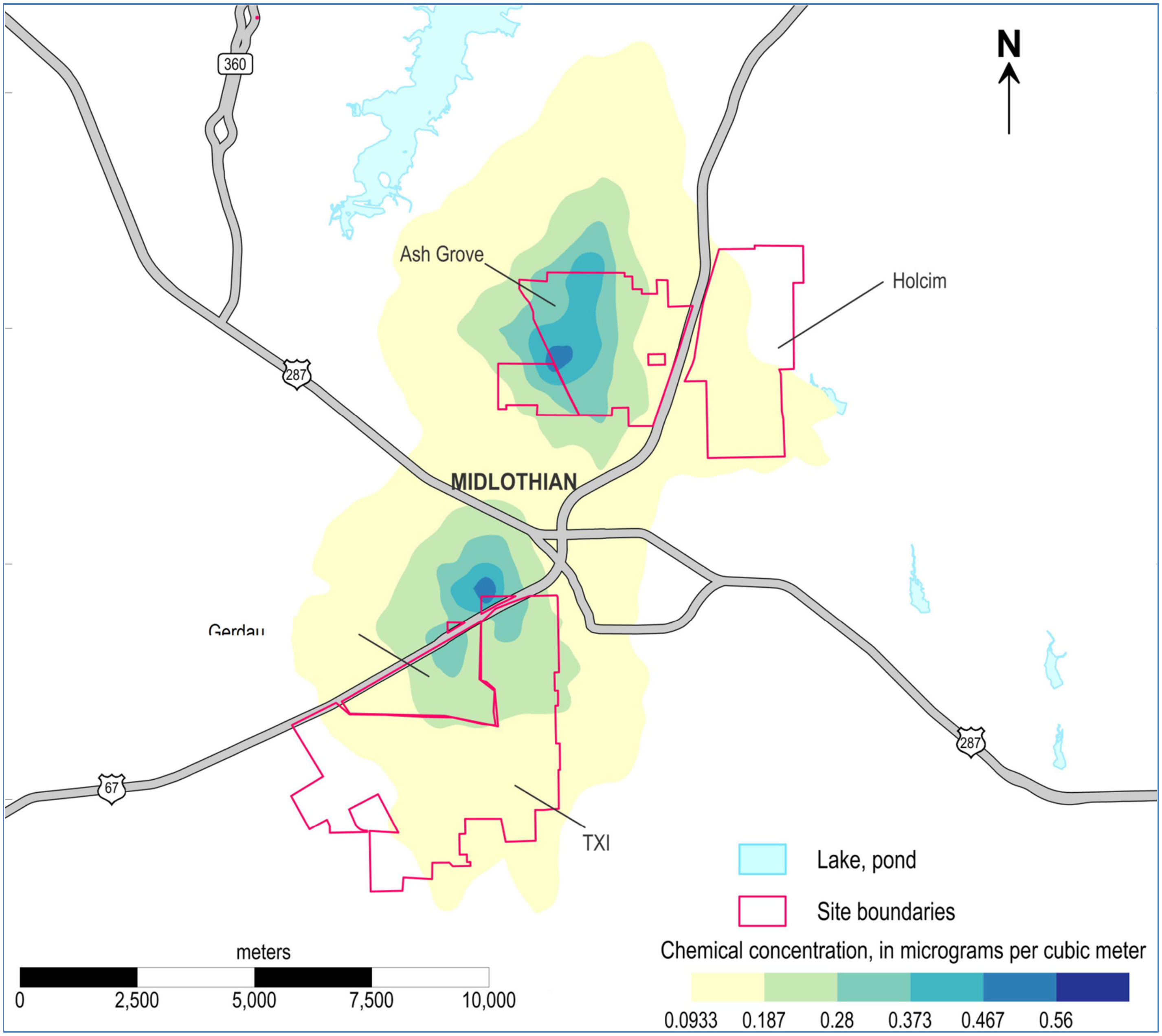


Figure F-15. ***Vapor Phase Mercury*-Highest Modeled 24-hour Average for Pollutants Never Measured in Air (µg/m^3)**

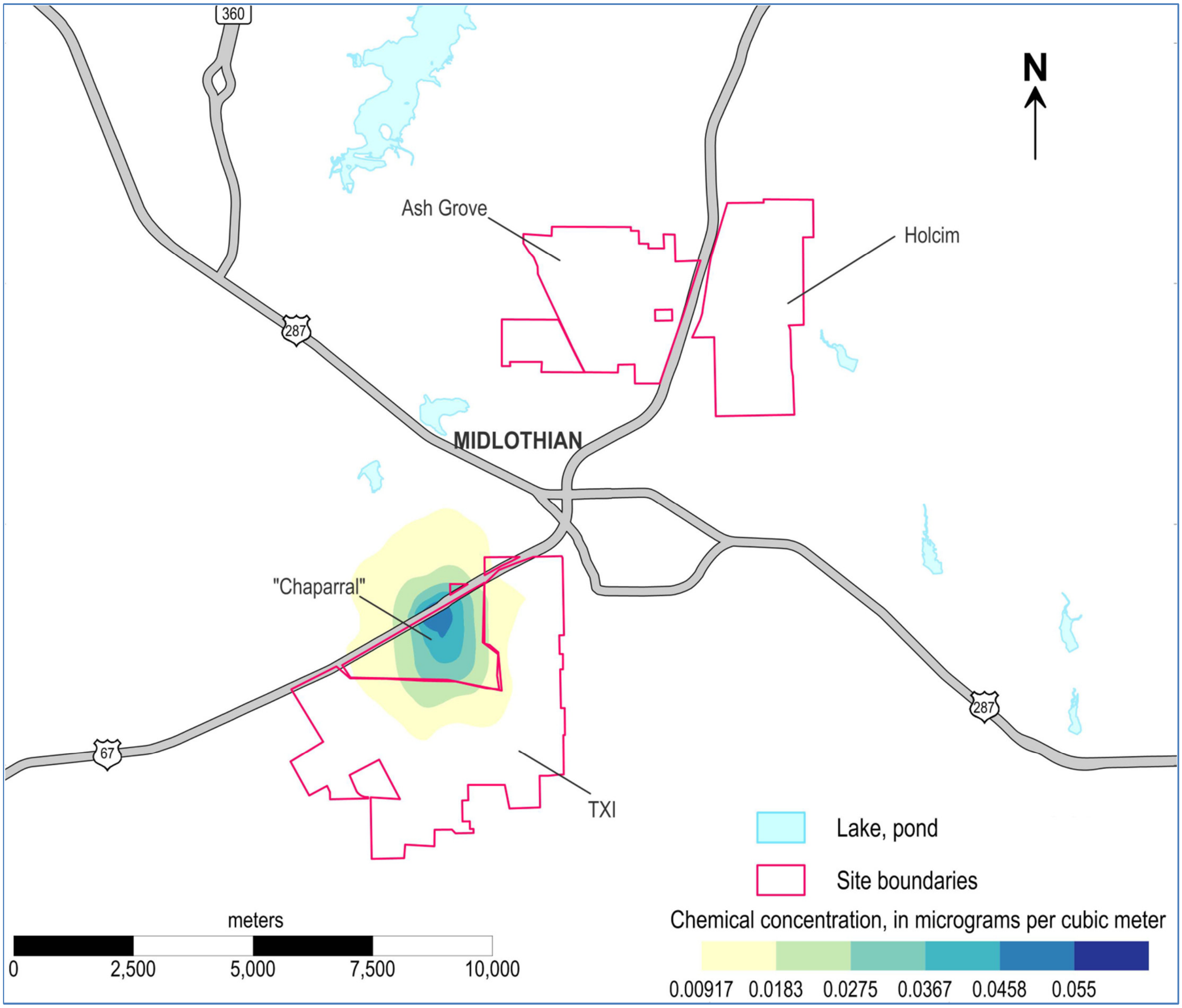


Figure F-16. ***Polycyclic Aromatic Hydrocarbons (PAHs)*****-Highest Modeled 24-hour Average for Pollutants Never Measured in Air (µg/m^3)**

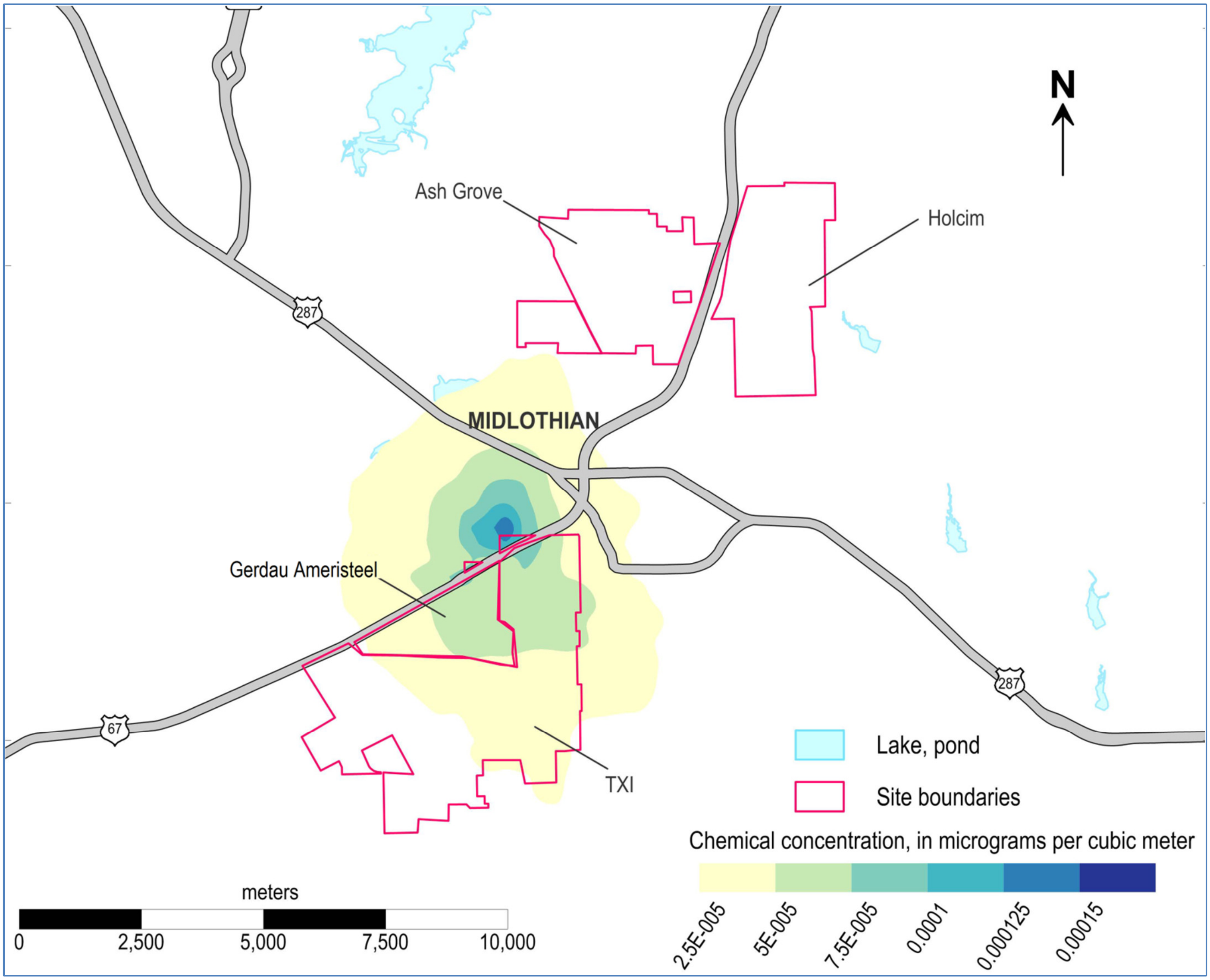
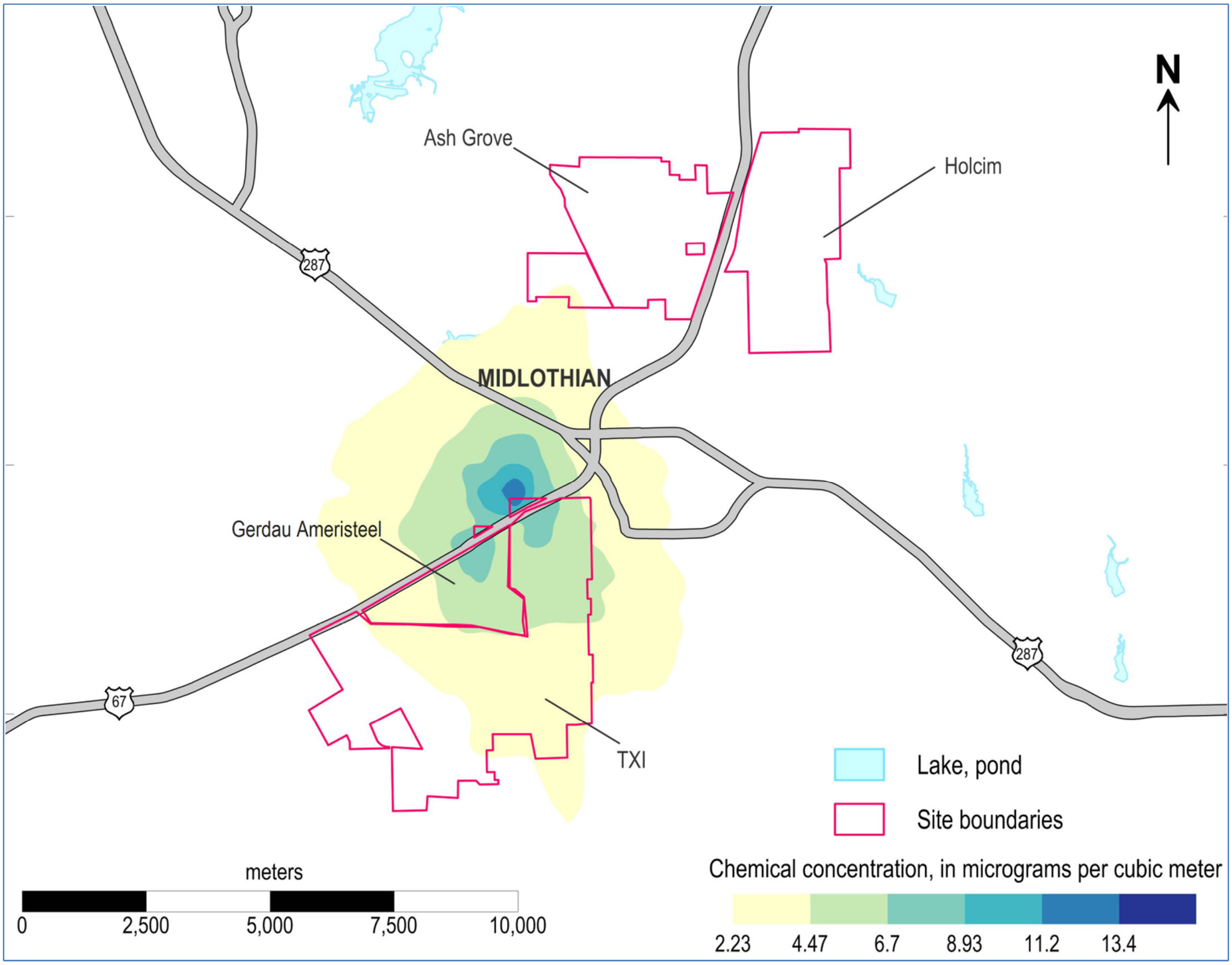


Figure F-17. ***Sulfuric Avid Aerosols*****-Highest Modeled 24-hour Average for Pollutants Never Measured in Air (µg/m^3)**



Appendix G: Multi-chemical Health Evaluation

Table G-1. Risk Calculations for Midlothian Old Fort Worth Road-VOCs[a]

Chemical Name	Mean CA[b] Risk	Mean HQ[c]	95% UCL[d] CA Risk	95% UCL HQ	N[e]=	Chronic CV[f]	Cancer CV	CV Source	Units
Acetylene		0.00024		0.00026	745	2662		AMCV[g]	µg/m^3
Benzene	6.39E-06	0.08521	7.68E-06	0.10240	766	9.6	0.128	cEMEG[h]; CREG[i]	µg/m^3
n-Butane		0.00016		0.00018	766	19017		AMCV	µg/m^3
1-Butene					766				µg/m^3
Carbon Tetrachloride	3.38E-06	0.00574	3.49E-06	0.00593	766	100	0.17	RfC[j]; CREG	µg/m^3
Chloroform	1.07E-06	0.00047	1.19E-06	0.00052	766	98	0.043	RfC; CREG	µg/m^3
Chloromethane		0.01411		0.01433	412	90		RfC	µg/m^3
Cyclohexane		0.00002		0.00003	766	6000		RfC	µg/m^3
Cyclopentane		0.00025		0.00036	766	344		AMCV	µg/m^3
Dichlorodifluoromethane		0.02610		0.02640	412	100		RfC	µg/m^3
Dichloromethane	1.43E-09	0.00041	1.55E-09	0.00045	766	347	100	RfC; CREG	µg/m^3
2,2-Dimethylbutane		0.00018		0.00025	766	352		AMCV	µg/m^3
2,3-Dimethylpentane		0.00043		0.00062	766	349		AMCV	µg/m^3
Ethane					713			simple asphyxiant	µg/m^3
Ethylbenzene	2.69E-07	0.00100	3.98E-07	0.00148	766	260	0.97	cEMEG; SL-Ca[k]	µg/m^3
Ethylene		0.00013		0.00013	745	6080		AMCV	µg/m^3
m-Ethyltoluene		0.00122		0.00193	766	123		AMCV	µg/m^3
p-Ethyltoluene		0.00075		0.00118	766	123		AMCV	µg/m^3
o-Ethyltoluene		0.00048		0.00073	766	123		AMCV	µg/m^3
n-Heptane		0.00077		0.00113	766	348		AMCV	µg/m^3
n-Hexane		0.00207		0.00352	766	670		AMCV	µg/m^3
Isobutane		0.00009		0.00010	766	19017		AMCV	µg/m^3
Isopentane		0.00010		0.00012	765	23607		AMCV	µg/m^3
Isoprene (2-methyl-1,3-butadiene)		0.01257		0.01455	766	6		AMCV	µg/m^3
Methyl Chloroform (1,1,1-Trichloroethane)		0.00001		0.00002	766	5000		RfC	µg/m^3
Methylcyclohexane		0.00018		0.00029	766	1606		AMCV	µg/m^3
Methylcyclopentane		0.00163		0.00298	766	258		AMCV	µg/m^3
Methyl Ethyl Ketone		0.00004		0.00005	174	5000		RfC	µg/m^3
2-Methylheptane		0.00014		0.00021	766	350		AMCV	µg/m^3
2-Methylhexane		0.00021		0.00180	766	307		AMCV	µg/m^3

3-Methylhexane		0.00147		0.00215	766	307		AMCV	µg/m^3
2-Methylpentane		0.00278		0.00373	766	300		AMCV	µg/m^3
3-Methylpentane		0.00180		0.00276	766	352		AMCV	µg/m^3
Methyl Tert-Butyl Ether	8.39E-08	0.00438	1.57E-07	0.00822	540	180	9.4	AMCV; SL - CA	µg/m^3
n-Pentane		0.00149		0.00189	766	1000		RfC	µg/m^3
Propane					745			N/A-asphyxiant	µg/m^3
n-Propylbenzene		0.00007		0.00010	766	1000		RfC	µg/m^3
Propylene		0.00020		0.00021	745	3000		RfC	µg/m^3
Tetrachloroethylene	1.63E-08	0.00155	2.14E-08	0.00204	765	40	3.8	RfC; CREG	µg/m^3
Toluene		0.00523		0.00743	766	300		cEMEG	µg/m^3
Trichlorofluoromethane		0.00227		0.00231	766	700		RfC	µg/m^3
1,2,4-Trimethylbenzene		0.03486		0.05529	766	7		RfC	µg/m^3
1,3,5-Trimethylbenzene		0.00059		0.00092	766	123		AMCV	µg/m^3
2,2,4-Trimethylpentane		0.00069		0.00091	766	350		AMCV	µg/m^3
2,3,4-Trimethylpentane		0.00023		0.00031	766	350		AMCV	µg/m^3
m/p Xylene		0.00862		0.01380	766	100		RfC	µg/m^3
o-Xylene		0.00268		0.00428	766	100		RfC	µg/m^3
Total Risk	**1.12E-05**	**0.22365**	**1.29E-05**	**0.28830**					

[a] VOC = *volatile organic compound*

[b] CA= *Cancer*

[c] HQ = *hazard quotient (non-cancer health risk). An HQ of less than one means there is no increased risk from exposure. Greater than one means there is an increased risk from exposure.*

[d] 95% UCL = *the upper 95% confidence limit of the mean. This is a mean for which we believe exceeds the true mean concentration 95% of the time and is a conservative estimate used for screening purposes.*

[e] N = *number of samples used in the calculation*

[f] CV = *health based comparison value*

[g] AMCV = *TCEQ Air Monitoring Comparison Value*

[h] cEMEG = *ATSDR Chronic Environmental Media Evaluation Guide*

[i] CREG = *ATSDR Cancer Risk Evaluation Guide*

[j] RfC = *U.S. EPA Reference Concentration*

[k] SL – CA = *U.S. EPA Residential Screening Level for Cancer*

NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Table G-2. Risk Calculations for Midlothian Old Fort Worth Road- $PM_{2.5}$[a]

Chemical Name	Mean CA[b] Risk	Mean HQ[c]	95% UCL[d] CA Risk	95% UCL HQ	N[e]=	Chronic CV[f]	Cancer CV	CV Source	Units
Aluminum		0.020		0.025	321	5		RfC[g]	µg/m³
Chlorine		0.171		0.221	321	0.15		RfC	µg/m³
Chromium III (CrVI for nCa)		0.011		0.014	321	0.1		RfC	µg/m³
Copper		0.005		0.006	321	1		AMCV[h]	µg/m³
Lead	4.97E-08	0.028	5.58E-08	0.031	321	0.15	0.000012	CalEPA IUR[i]	µg/m³
Manganese		0.018		0.021	321	0.05		RfC	µg/m³
Nickel (Oxide)		0.050		0.068	321	0.02		RfC	µg/m³
Vanadium		0.009		0.009	321	0.1		RfC	µg/m³
Zinc		0.004		0.005	321	5		AMCV	µg/m³
Total Risk	**4.97E-08**	**0.316**	**5.58E-08**	**0.399**					

[a] PM2.5 = *particulate matter with an aerodynamic diameter of 2.5 microns or smaller*

[b] CA= *Cancer*

[c] HQ = *hazard quotient (non-cancer health risk). An HQ of less than one means there is no increased risk from exposure. Greater than one means there is an increased risk from exposure.*

[d] 95% UCL = *the upper 95% confidence limit of the mean. This is a mean for which we believe exceeds the true mean concentration 95% of the time and is a conservative estimate used for screening purposes.*

[e] N = *number of samples used in the calculation*

[f] CV = *health based comparison value*

[g] RfC = *U.S. EPA Reference Concentration*

[h] AMCV = *TCEQ Air Monitoring Comparison Value*

[i] CalEPA IUR = *California EPA Inhalation Unit Risk*

NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Table G-3. Risk Calculations for Midlothian Tower-VOCs[a]

Chemical Name	Mean CA[b] Risk	Mean HQ[c]	95% UCL[d] CA Risk	95% UCL HQ	N[e]=	Chronic CV[f]	Cancer CV	CV Source	Units
Acetylene		0.00020		0.00022	199	2662		AMCV[g]	µg/m^3
Benzene	4.38E-06	0.05833	4.68E-06	0.06240	199	9.6	0.128	cEMEG[h]; CREG[i]	µg/m^3
n-Butane		0.00014		0.00015	199	19017		AMCV	µg/m^3
1-Butene					199				µg/m^3
Carbon Tetrachloride	3.55E-06	0.00604	3.66E-06	0.00622	199	100	0.17	RfC[j]; CREG	µg/m^3
Chloroform	8.05E-07	0.00035	1.01E-06	0.00044	199	98	0.043	RfC; CREG	µg/m^3
Chloromethane		0.01433		0.01478	199	90		RfC	µg/m^3
Cyclohexane		0.00055		0.00070	199	6000		RfC	µg/m^3
Cyclopentane		0.00192		0.00260	199	344		AMCV	µg/m^3
Dichlorodifluoromethane		0.02570		0.02620	199	100		RfC	µg/m^3
Dichloromethane	1.25E-09	0.00036	1.93E-09	0.00056	199	347	100	AMCV; CREG	µg/m^3
2,2-Dimethylbutane		0.00039		0.00058	199	352		AMCV	µg/m^3
2,3-Dimethylbutane		0.00088		0.00134	199	349		AMCV	µg/m^3
2,3-Dimethylpentane		0.00030		0.00039	199	348		AMCV	µg/m^3
2,4-Dimethylpentane		0.00118		0.00164	199	348		AMCV	µg/m^3
Ethane					199			asphyxiant	µg/m^3
Ethylbenzene	1.32E-07	0.00049	1.54E-07	0.00057	199	260	0.97	cEMEG; SL-CA[k]	µg/m^3
Ethylene		0.00011		0.00012	199	6080		AMCV	µg/m^3
m-Ethyltoluene		0.00032		0.00043	198	123		AMCV	µg/m^3
n-Heptane		0.00014		0.00019	199	348		AMCV	µg/m^3
n-Hexane		0.00488		0.00655	199	670		AMCV	µg/m^3
Isobutane		0.00009		0.00013	199	19017		AMCV	µg/m^3
Isopentane		0.00006		0.00008	199	23607		AMCV	µg/m^3
Isoprene		0.02500		0.03550	199	6		AMCV	µg/m^3
Methylcyclopentane		0.01884		0.02550	199	258		AMCV	µg/m^3
Methyl Ethyl Ketone		0.00004		0.00006	199	5000		RfC	µg/m^3
2-Methylhexane		0.00084		0.00106	199	307		AMCV	µg/m^3
3-Methylhexane		0.00056		0.00069	199	307		AMCV	µg/m^3
2-Methylpentane		0.00767		0.01043	199	300		AMCV	µg/m^3

3-Methylpentane		0.00509		0.00707	199	352		AMCV	µg/m³
Methyl Tert-Butyl Ether	6.01E-09	0.00031	8.29E-09	0.00043	199	180	9.4	AMCV; SL - CA	µg/m³
n-Pentane		0.00082		0.00096	199	1000		RfC	µg/m³
Propane					199			simple asphyxiant	µg/m³
n-Propylbenzene		0.00003		0.00004	199	1000		RfC	µg/m³
Propylene		0.00015		0.00017	199	3000		RfC	µg/m³
Toluene		0.00187		0.00213	199	300		cEMEG	µg/m³
Trichlorofluoromethane		0.00221		0.00227	199	700		RfC	µg/m³
1,2,4-Trimethylbenzene		0.01036		0.01393	199	7		RfC	µg/m³
2,2,4-Trimethylpentane		0.00023		0.00028	199	350		AMCV	µg/m³
m/p Xylene		0.00263		0.00304	199	100		RfC	µg/m³
o-Xylene		0.00075		0.00091	199	100		RfC	µg/m³
Total Risk	**8.87E-06**	**0.19418**	**9.51E-06**	**0.23075**					

[a] VOC = *volatile organic compound*

[b] CA= *Cancer*

[c] HQ = *hazard quotient (non-cancer health risk). An HQ of less than one means there is no increased risk from exposure. Greater than one means there is an increased risk from exposure.*

[d] 95% UCL = *the upper 95% confidence limit of the mean. This is a mean for which we believe exceeds the true mean concentration 95% of the time and is a conservative estimate used for screening purposes.*

[e] N = *number of samples used in the calculation*

[f] CV = *health based comparison value*

[g] AMCV = *TCEQ Air Monitoring Comparison Value*

[h] cEMEG = *ATSDR Chronic Environmental Media Evaluation Guide*

[i] CREG = *ATSDR Cancer Risk Evaluation Guide*

[j] RfC = *U.S. EPA Reference Concentration*

[k] SL – CA = *U.S. EPA Residential Screening Level for Cancer*

NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Table G-4. Risk Calculations for Midlothian Tower- $PM_{2.5}$[a]

Chemical Name	Mean CA[b] Risk	Mean HQ[c]	95% UCL[d] CA Risk	95% UCL HQ	N[e]=	Chronic CV[f]	Cancer CV	CV Source	Units
Aluminum		0.0105		0.0145	197	5		RfC[g]	µg/m^3
Arsenic	5.57E-06	0.0853	6.26E-06	0.0960	197	0.015	0.00023	CREG[h]	µg/m^3
Chlorine		0.0820		0.1227	197	0.15		RfC	µg/m^3
Chromium III (*CrVI for nCa)		0.0116		0.0151	197	0.1		RfC	µg/m^3
Copper		0.0038		0.0044	197	1		AMCV[i]	µg/m^3
Lead	4.46E-08	0.0248	5.08E-08	0.0282	197	0.15	0.000012	CalEPA IUR[j]	µg/m^3
Manganese		0.0066		0.0075	197	0.05		RfC	µg/m^3
Nickel		0.0362		0.0422	197	0.02		RfC	µg/m^3
Selenium		0.0001		0.0001	197	20		RfC	µg/m^3
Vanadium		0.0121		0.0137	197	0.1		RfC	µg/m^3
Zinc		0.0031		0.0038	197	5		AMCV	µg/m^3
Total Risk	**5.61E-06**	**0.2760**	**6.31E-06**	**0.3857**					

Risk for pollutants without CVs could not be calculated and are not displayed here.

[a] PM2.5 = *particulate matter with an aerodynamic diameter of 2.5 microns or smaller*

[b] CA= *Cancer*

[c] HQ = *hazard quotient (non-cancer health risk). An HQ of less than one means there is no increased risk from exposure. Greater than one means there is an increased risk from exposure.*

[d] 95% UCL = *the upper 95% confidence limit of the mean. This is a mean for which we believe exceeds the true mean concentration 95% of the time and is a conservative estimate used for screening purposes.*

[e] N = *number of samples used in the calculation*

[f] CV = *health based comparison value*

[g] RfC = *U.S. EPA Reference Concentration*

[h] AMCV = *TCEQ Air Monitoring Comparison Value*

[i] CalEPA IUR = *California EPA Inhalation Unit Risk*

NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Table G-5. Risk Calculations for Tayman Drive Wastewater Treatment Plant-VOCs[a]

Chemical Name	Mean CA[b] Risk	Mean HQ[c]	95% UCL[d] CA Risk	95% UCL HQ	N[e]=	Chronic CV[f]	Cancer CV	CV Source	Units
Benzene	1.04E-05	0.14063	1.57E-05	0.21250	229	9.6	0.13	cEMEG[g]; CREG[h]	µg/m³
Bromomethane		0.00460		0.00530	169	5		RfC[i]	µg/m³
n-Butane		0.00020		0.00024	137	19017		AMCV[j]	µg/m³
1-Butene					137				µg/m³
Carbon Tetrachloride	5.75E-06	0.00977	8.53E-06	0.01450	177	100	0.17	RfC; CREG	µg/m³
Chlorobenzene		0.00348		0.00490	231	50		RfC	µg/m³
Chloroform	1.95E-06	0.00086	2.21E-06	0.00097	231	98	0.043	CREG	µg/m³
Cyclohexane		0.00002		0.00003	137	6000		RfC	µg/m³
Cyclopentane		0.00013		0.00016	137	344		AMCV	µg/m³
n-Decane		0.00016		0.00027	137	1018		AMCV	µg/m³
Dichloromethane	1.99E-09	0.00057	2.39E-09	0.00069	231	347	100	AMCV; CREG	µg/m³
2,3-Dimethylbutane		0.00103		0.00142	137	349		AMCV	µg/m³
2,3-Dimethylpentane		0.00019		0.00026	137	348		AMCV	µg/m³
Ethylbenzene	3.42E-07	0.00128	4.27E-07	0.00159	231	260	0.97	cEMEG; SL-CA[k]	µg/m³
Ethylene Dichloride (1,2-dichloroethane)	2.44E-06	0.01324	3.16E-06	0.01714	231	7	0.038	RfC; CREG	µg/m³
n-Heptane		0.00064		0.00078	137	348		AMCV	µg/m³
n-Hexane		0.00107		0.00152	137	670		AMCV	µg/m³
Isobutane		0.00010		0.00012	137	19017		AMCV	µg/m³
Isopentane		0.00010		0.00012	137	23607		AMCV	µg/m³
Isoprene		0.01717		0.03067	137	6		AMCV	µg/m³
Methyl Chloroform (1,1,1-Trichloroethane)		0.00028		0.00035	151	5000		RfC	µg/m³
Methylcyclohexane		0.00016		0.00031	137	1606		AMCV	µg/m³
Methylcyclopentane		0.00110		0.00187	137	258		AMCV	µg/m³
2-Methylheptane		0.00017		0.00022	137	350		AMCV	µg/m³
3-Methylheptane		0.00016		0.00020	137	350		AMCV	µg/m³
3-Methylhexane		0.00034		0.00043	137	307		AMCV	µg/m³
2-Methylpentane		0.00164		0.00188	137	300		AMCV	µg/m³
3-Methylpentane		0.00163		0.00315	137	352		AMCV	µg/m³
n-Pentane		0.00165		0.00184	137	1000		RfC	µg/m³

1-Pentene					137				μg/m³
Propane					70			N/A-asphyxiant	μg/m³
n-Propylbenzene		0.00004		0.00005	137	1000		RfC	μg/m³
Propylene		0.00050		0.00064	70	3000		RfC	μg/m³
Styrene		0.00017		0.00023	229	850		cEMEG	μg/m³
Tetrachloroethylene	6.34E-08	0.00603	7.47E-08	0.00710	231	40	3.8	RfC; CREG	μg/m³
Toluene		0.00500		0.00597	231	300		cEMEG	μg/m³
Trichloroethylene	6.71E-07	0.08050	9.38E-07	0.11250	231	2	0.24	RfC; CREG	μg/m³
Trichlorofluoromethane		0.00227		0.00276	231	700		RfC	μg/m³
1,2,4-Trimethylbenzene		0.03943		0.05300	137	7		RfC	μg/m³
1,3,5-Trimethylbenzene		0.00092		0.00120	137	123		AMCV	μg/m³
2,2,4-Trimethylpentane		0.00040		0.00049	110	350		AMCV	μg/m³
m/p Xylene		0.00542		0.00690	191	100		RfC	μg/m³
o-Xylene		0.00391		0.00495	231	100		RfC	μg/m³
Total Risk	**2.16E-05**	**0.34695**	**3.10E-05**	**0.49921**					

[a] VOC = *volatile organic compound*

[b] CA= *Cancer*

[c] HQ = *hazard quotient (non-cancer health risk). An HQ of less than one means there is no increased risk from exposure. Greater than one means there is an increased risk from exposure.*

[d] 95% UCL = *the upper 95% confidence limit of the mean. This is a mean for which we believe exceeds the true mean concentration 95% of the time and is a conservative estimate used for screening purposes.*

[e] N = *number of samples used in the calculation*

[f] CV = *health based comparison value*

[g] cEMEG = *ATSDR Chronic Environmental Media Evaluation Guide*

[h] CREG = *ATSDR Cancer Risk Evaluation Guide*

[i] RfC = *U.S. EPA Reference Concentration*

[j] AMCV = *TCEQ Air Monitoring Comparison Value*

[k] SL – CA = *U.S. EPA Residential Screening Level for Cancer*

NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Table G-6. Risk Calculations for Wyatt Road-VOCs[a]

Chemical Name	Mean CA[b] Risk	Mean HQ[c]	95% UCL[d] CA Risk	95% UCL HQ	N[e]=	Chronic CV[f]	Cancer CV	CV Source	Units
Acetylene		0.00025		0.00028	84	2662		AMCV[g]	µg/m^3
Benzene	5.04E-06	0.06823	5.50E-06	0.07448	84	9.6	0.13	cEMEG[h]; CREG[i]	µg/m^3
n-Butane		0.00017		0.00020	84	19017		AMCV	µg/m^3
1-Butene					84				µg/m^3
Carbon Tetrachloride	3.71E-06	0.00631	3.87E-06	0.00658	84	100	0.17	RfC[j]; CREG	µg/m^3
Chloromethane		0.01322		0.01378	84	90		RfC	µg/m^3
Dichlorodifluoromethane		0.02470		0.02550	84	100		RfC	µg/m^3
Dichloromethane	7.03E-10	0.00020	8.84E-10	0.00025	84	347	100	AMCV; CREG	µg/m^3
Ethane					84			N/A-asphyxiant	µg/m^3
Ethylbenzene	1.06E-07	0.00040	1.33E-07	0.00050	84	260	0.97	cEMEG; SL-CA[k]	µg/m^3
Ethylene		0.00013		0.00014	84	6080		AMCV	µg/m^3
n-Hexane		0.00035		0.00045	84	670		AMCV	µg/m^3
Isobutane		0.00011		0.00015	84	19017		AMCV	µg/m^3
Isopentane		0.00008		0.00010	84	23607		AMCV	µg/m^3
Methyl Ethyl Ketone		0.00003		0.00005	84	5000		RfC	µg/m^3
2-Methylhexane		0.00021		0.00028	84	307		AMCV	µg/m^3
3-Methylhexane		0.00026		0.00035	84	307		AMCV	µg/m^3
2-Methylpentane		0.00066		0.00086	84	300		AMCV	µg/m^3
3-Methylpentane		0.00043		0.00053	84	352		AMCV	µg/m^3
Methyl Tert-Butyl Ether	1.35E-08	0.00071	1.79E-08	0.00093	84	180	9.4	AMCV; SL-CA	µg/m^3
n-Pentane		0.00075		0.00093	84	1000		RfC	µg/m^3
Propane					84			N/A-asphyxiant	µg/m^3
n-Propylbenzene		0.00004		0.00006	84	1000		RfC	µg/m^3
Propylene		0.00015		0.00017	84	3000		RfC	µg/m^3
Toluene		0.00210		0.00251	84	300		cEMEG	µg/m^3
Trichlorofluoromethane		0.00234		0.00244	84	700		RfC	µg/m^3
1,2,4-Trimethylbenzene		0.01129		0.01390	84	7		RfC	µg/m^3
2,2,4-Trimethylpentane		0.00034		0.00041	84	350		AMCV	µg/m^3
m/p Xylene		0.00266		0.00314	84	100		RfC	µg/m^3
o-Xylene		0.00077		0.00097	84	100		RfC	µg/m^3
Total Risk	**8.87E-06**	**0.13690**	**9.52E-06**	**0.14995**					

Table G-6, Continued

[a] VOC = *volatile organic compound*

[b] CA= *Cancer*

[c] HQ = *hazard quotient (non-cancer health risk). An HQ of less than one means there is no increased risk from exposure. Greater than one means there is an increased risk from exposure.*

[d] 95% UCL = *the upper 95% confidence limit of the mean. This is a mean for which we believe exceeds the true mean concentration 95% of the time and is a conservative estimate used for screening purposes.*

[e] N = *number of samples used in the calculation*

[f] CV = *health based comparison value*

[g] AMCV = *TCEQ Air Monitoring Comparison Value*

[h] cEMEG = *ATSDR Chronic Environmental Media Evaluation Guide*

[i] CREG = *ATSDR Cancer Risk Evaluation Guide*

[j] RfC = *U.S. EPA Reference Concentration*

[k] SL – CA = *U.S. EPA Residential Screening Level for Cancer*

NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Table G-7. Risk Calculations for Wyatt Road-PM$_{10}$[a]

Chemical Name	Mean CA[b] Risk	Mean HQ[c]	95% UCL[d] CA Risk	95% UCL HQ	N[e]=	Chronic CV[f]	Cancer CV	CV Source	Units
Aluminum		0.039		0.045	196	5		AMCV[g]	µg/m^3
Calcium					196				µg/m^3
Chromium		0.055		0.061	196	0.1		AMCV	µg/m^3
Copper		0.017		0.019	196	1		AMCV	µg/m^3
Iron					196				µg/m^3
Lead	1.74E-07	0.097	2.02E-07	0.112	196	0.15	1.2E-05	CalEPA IUR[h]	µg/m^3
Magnesium					196				µg/m^3
Manganese		0.142		0.161	196	0.05		RfC[j]	µg/m^3
Molybdenum		0.001		0.001	196	5		AMCV	µg/m^3
Vanadium		0.039		0.043	196	0.05		AMCV	µg/m^3
Zinc		0.020		0.024	196	5		AMCV	µg/m^3
Total Risk	**1.74E-07**	**0.410**	**2.02E-07**	**0.466**					

[a] PM10 = *particulate matter with an aerodynamic diameter of 10 microns or smaller*

[b] CA= *Cancer*

[c] HQ = *hazard quotient (non-cancer health risk). An HQ of less than one means there is no increased risk from exposure. Greater than one means there is an increased risk from exposure.*

[d] 95% UCL = *the upper 95% confidence limit of the mean. This is a mean for which we believe exceeds the true mean concentration 95% of the time and is a conservative estimate used for screening purposes.*

[e] N = *number of samples used in the calculation*

[f] CV = *health based comparison value*

[g] AMCV = *TCEQ Air Monitoring Comparison Value*

[h] CalEPA IUR = *California EPA Inhalation Unit Risk*

[i] RfC = *U.S. EPA Reference Concentration*

NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Table G-8. Risk Calculations (URS) Jaycee Park-VOCs[a]

Chemical Name	Mean CA[b] Risk	Mean HQ[c]	95% UCL[d] CA Risk	95% UCL HQ	N[e]=	Chronic CV[f]	Cancer CV	CV Source	Units
Acetonitrile		0.005883		0.00790	22	60		RfC[g]	µg/m^3
Acetylene		0.000163		0.00020	22	2662		AMCV[h]	µg/m^3
Benzene	4.90E-06	0.066354	5.78E-06	0.07823	22	9.6	0.13	cEMEG[i]; CREG[j]	µg/m^3
Bromomethane		0.011160		0.01264	22	5		RfC	µg/m^3
1,3-Butadiene	7.94E-07	0.013100	9.76E-07	0.01610	22	2	0.033	RfC; CREG	µg/m^3
Carbon Disulfide		0.002671		0.00454	22	700		RfC	µg/m^3
Carbon Tetrachloride	4.31E-06	0.007330	4.69E-06	0.00798	22	100	0.17	RfC; CREG	µg/m^3
Chloroethane (ethyl chloride)		0.000005		0.00001	22	10000		RfC	µg/m^3
Chloroform	2.67E-06	0.001173	3.14E-06	0.00138	22	98	0.043	RfC; CREG	µg/m^3
Chloromethane		0.017222		0.01856	22	90		RfC	µg/m^3
p-(1,4)-Dichlorobenzene	2.00E-07	0.000735	2.48E-07	0.00091	22	60	0.22	cEMEG; SL-CA[k]	µg/m^3
Dichlorodifluoromethane		0.029100		0.03060	22	100		RfC	µg/m^3
Dichloromethane (methylene chloride)	3.69E-09	0.001063	4.62E-09	0.00133	22	347	100	AMCV; CREG	µg/m^3
Ethylbenzene	1.39E-07	0.000519	1.81E-07	0.00068	22	260	0.97	cEMEG; SL-CA	µg/m^3
Methyl Ethyl Ketone		0.000290		0.00035	22	5000		RfC	µg/m^3
Methyl Isobutyl Ketone		0.001390		0.00172	22	82		AMCV	µg/m^3
Methyl Methacrylate		0.000233		0.00034	22	700		RfC	µg/m^3
n-Octane		0.000208		0.00023	22	350		AMCV	µg/m^3
Propylene		0.000103		0.00012	22	3000		RfC	µg/m^3
Styrene		0.000088		0.00012	22	850		cEMEG	µg/m^3
Tetrachloroethylene	2.63E-08	0.002498	3.39E-08	0.00323	22	40	3.8	RfC; CREG	µg/m^3
Toluene		0.001743		0.00199	22	300		cEMEG	µg/m^3
1,1,1-Trichloroethane		0.000019		0.00002	22	5000		RfC	µg/m^3
Trichlorofluoromethane		0.002271		0.00239	22	700		RfC	µg/m^3
Trichlorotrifluoroethane (1,1,2-Trichloro-1,1,2-trifluoroethane)		0.000029		0.00003	22	30000		RfC	µg/m^3
1,3,5-Trimethylbenzene		0.000400		0.00046	22	123		AMCV	µg/m^3
1,2,4-Trimethylbenzene		0.018714		0.02186	22	7		RfC	µg/m^3
Vinyl chloride	1.49E-07	0.000164	1.74E-07	0.00019	22	100	0.11	RfC; CREG	µg/m^3
m,p-Xylene		0.003240		0.00443	22	100		RfC	µg/m^3

o-Xylene		0.001300		0.00165	22	100		RfC	µg/m^3
Total Risk	**1.32E-05**	**0.1891704**	**1.52E-05**	**0.22016**					

[a] VOC = *volatile organic compound*

[b] CA= *Cancer*

[c] HQ = *hazard quotient (non-cancer health risk). An HQ of less than one means there is no increased risk from exposure. Greater than one means there is an increased risk from exposure.*

[d] 95% UCL = *the upper 95% confidence limit of the mean. This is a mean for which we believe exceeds the true mean concentration 95% of the time and is a conservative estimate used for screening purposes.*

[e] N = *number of samples used in the calculation*

[f] CV = *health based comparison value*

[g] RfC = *U.S. EPA Reference Concentration*

[h] AMCV = *TCEQ Air Monitoring Comparison Value*

[i] cEMEG = *ATSDR Chronic Environmental Media Evaluation Guide*

[j] CREG = *ATSDR Cancer Risk Evaluation Guide*

[k] SL – CA = *U.S. EPA Residential Screening Level for Cancer*

NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Table G-9. Risk Calculations (URS) Jaycee Park- PM$_{10}$[a]

Chemical Name	Mean CA[b] Risk	Mean HQ[c]	95% UCL[d] CA Risk	95% UCL HQ	N[e]=	Chronic CV[f]	Cancer CV	CV Source	Units
Aluminum		0.0175		0.02220	20	5		RfC[g]	µg/m^3
Antimony		0.0008		0.00104	20	0.5		AMCV[h]	µg/m^3
Arsenic	2.52E-06	0.0386	3.20E-06	0.04913	20	0.015	0.000230	RfC; CREG[i]	µg/m^3
Barium		0.0155		0.01832	20	0.5		RfC	µg/m^3
Beryllium	1.15E-08	0.0002	1.55E-08	0.00033	20	0.02	0.000420	RfC (NCA[j]); CREG	µg/m^3
Cadmium	2.61E-07	0.0146	3.16E-07	0.01770	20	0.01	0.000560	RfC; CREG	µg/m^3
Chromium		0.0209		0.02310	20	0.1		RfC	µg/m^3
CrVI	1.87E-07	0.0002	2.87E-07	0.00024	24	0.1	0.000083	RfC; CREG	µg/m^3
Cobalt	3.48E-07	0.0157	4.37E-07	0.01967	20	0.006	0.000270	RfC; SL – CA[k]	µg/m^3
Copper		0.0063		0.00856	20	1		AMCV	µg/m^3
Lead	3.08E-08	0.0171	4.01E-08	0.02227	20	0.15	0.000012	SL (NCA)[l]; CalEPA IUR[m]	µg/m^3
Manganese		0.0302		0.04100	20	0.05		RfC	µg/m^3
Mercury		0.0003		0.00059	20	0.2		cEMEG	µg/m^3
Molybdenum		0.0001		0.00009	20	5		AMCV	µg/m^3
Nickel		0.0505		0.06150	20	0.02		RfC	µg/m^3
Selenium		0.0000		0.00454	20	0.2		AMCV	µg/m^3
Uranium		0.0004		0.00057	20	0.04		cEMEG	µg/m^3
Vanadium		0.0204		0.02640	20	0.05		AMCV	µg/m^3
Zinc		0.0045		0.00644	20	5		AMCV	µg/m^3
Total Risk	**3.36E-06**	**0.2538**	**4.30E-06**	**0.32368**					

[a] PM10 = *particulate matter with an aerodynamic diameter of 10 microns or smaller*

[b] CA= *Cancer*

[c] HQ = *hazard quotient (non-cancer health risk). An HQ <1 means there is no increased risk from exposure. An HQ>1 means there is an increased risk from exposure.*

[d] 95% UCL = *the upper 95% confidence limit of the mean. This is a mean for which we believe exceeds the true mean concentration 95% of the time and is a conservative estimate used for screening purposes.*

[e] N = *number of samples used in the calculation*

[f] CV = *health based comparison value*

[g] RfC = *U.S. EPA Reference Concentration*

[h] AMCV = *TCEQ Air Monitoring Comparison Value*

[i] CREG = *ATSDR Cancer Risk Evaluation Guide*

[j] NCA = *Non-Cancer Health Effects*

[k] SL – CA = *U.S. EPA Residential Screening Level for Cancer*

[l] SL (NCA) = *U.S. EPA Residential Screening Level for Noncancer effects*

[m] CalEPA IUR = *California EPA Inhalation Unit Risk*

Table G-10. Risk Calculations (URS) Old Fort Worth Road-VOCs[a]

Chemical Name	Mean CA[b] Risk	Mean HQ[c]	95% UCL[d] CA Risk	95% UCL HQ	N[e]=	Chronic CV[f]	Cancer CV	CV Source	Units
Acetonitrile		0.005083		0.006583	20	60		RfC[g]	μg/m^3
Acetylene		0.000176		0.000204	20	2662		AMCV[h]	μg/m^3
Benzene	5.20E-06	0.070417	5.86E-06	0.079375	20	9.6	0.13	cEMEG[i]; CREG[j]	μg/m^3
Bromomethane		0.011100		0.012500	20	5		RfC	μg/m^3
1,3-Butadiene	7.88E-07	0.013000	9.39E-07	0.015500	20	2	0.033	RfC; CREG	μg/m^3
Carbon Disulfide		0.000479		0.001209	20	700		RfC	μg/m^3
Carbon Tetrachloride	4.08E-06	0.006930	4.46E-06	0.007590	20	100	0.17	RfC; CREG	μg/m^3
Chloroethane (ethyl chlroide)		0.000004		0.000004	20	10000		RfC	μg/m^3
Chloroform	2.40E-06	0.001051	2.77E-06	0.001214	20	98	0.043	RfC; CREG	μg/m^3
Chloromethane		0.016444		0.017889	20	90		RfC	μg/m^3
p-(1,4)-Dichlorobenzene	1.71E-07	0.000628	2.11E-07	0.000775	20	60	0.22	cEMEG; SL-Ca[k]	μg/m^3
Dichlorodifluoromethane		0.029000		0.030600	20	100		RfC	μg/m^3
Dichloromethane	5.27E-09	0.001519	8.61E-09	0.002481	20	347	100	AMCV; CREG	μg/m^3
Ethylbenzene	1.33E-07	0.000496	1.82E-07	0.000681	20	260	0.97	cEMEG; SL-Ca	μg/m^3
Methyl Ethyl Ketone		0.000282		0.000334	20	5000		RfC	μg/m^3
Methyl Isobutyl Ketone		0.001066		0.001293	20	82		AMCV	μg/m^3
Methyl Methacrylate		0.000120		0.000170	20	700		RfC	μg/m^3
n-Octane		0.000242		0.000260	20	350		AMCV	μg/m^3
Propylene		0.000103		0.000116	20	3000		RfC	μg/m^3
Styrene		0.000148		0.000304	20	850		cEMEG	μg/m^3
Tetrachloroethylene	2.68E-08	0.002550	3.26E-08	0.003100	20	40	3.8	RfC; CREG	μg/m^3
Toluene		0.002007		0.002463	20	300		cEMEG	μg/m^3
1,1,1-Trichloroethane		0.000019		0.000021	20	5000		RfC	μg/m^3
Trichloroethylene	2.23E-07	0.026750	3.02E-07	0.036250	20	2	0.24	RfC; CREG	μg/m^3
Trichlorofluoromethane		0.002457		0.002814	20	700		RfC	μg/m^3
Trichlorotrifluoroethane (1,1,2-Trichloro-1,1,2-trifluoroethane)		0.000029		0.000031	20	30000		RfC	μg/m^3
1,2,4-Trimethylbenzene		0.016714		0.021429	20	7		RfC	μg/m^3
1,3,5-Trimethylbenzene		0.000367		0.000454	20	123		AMCV	μg/m^3
Vinyl chloride	1.28E-07	0.000141	1.62E-07	0.000178	20	100	0.11	RfC; CREG	μg/m^3
m,p-Xylene		0.002970		0.004490	20	100		RfC	μg/m^3

o-Xylene		0.001250		0.001680	20	100		RfC	µg/m^3
Total Risk	**1.31473E-05**	**0.213543**	**1.49E-05**	**0.251992**					

[a] VOC = *volatile organic compound*

[b] CA= *Cancer*

[c] HQ = *hazard quotient (non-cancer health risk). An HQ of less than one means there is no increased risk from exposure. Greater than one means there is an increased risk from exposure.*

[d] 95% UCL = *the upper 95% confidence limit of the mean. This is a mean for which we believe exceeds the true mean concentration 95% of the time and is a conservative estimate used for screening purposes.*

[e] N = *number of samples used in the calculation*

[f] CV = *health based comparison value*

[g] RfC = *U.S. EPA Reference Concentration*

[h] AMCV = *TCEQ Air Monitoring Comparison Value*

[i] cEMEG = *ATSDR Chronic Environmental Media Evaluation Guide*

[j] CREG = *ATSDR Cancer Risk Evaluation Guide*

[k] SL – C = *U.S. EPA Residential Screening Level for Cancer*

NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Table G-11. Risk Calculations (URS) Old Fort Worth Road-PM$_{10}$[a]

Chemical Name	Mean CA[b] Risk	Mean HQ[c]	95% UCL[d] CA Risk	95% UCL HQ	N[e]=	Chronic CV[f]	Cancer CV	CV Source	Units
Aluminum		0.02540		0.02980	20	5		RfC[g]	µg/m^3
Antimony		0.00091		0.00113	20	0.5		AMCV[h]	µg/m^3
Arsenic	2.53E-06	0.03880	3.1E-06	0.04760	20	0.015	0.0002	RfC; CREG[i]	µg/m^3
Barium		0.01964		0.02320	20	0.5		RfC	µg/m^3
Beryllium	1.37E-08	0.00029	1.74E-08	0.00037	20	0.02	0.0004	RfC; CREG	µg/m^3
Cadmium	2.73E-07	0.01530	3.36E-07	0.01880	20	0.01	0.0006	RfC; CREG	µg/m^3
Chromium (HQ=CrVI)		0.02820		0.03180	20	0.1		RfC	µg/m^3
Cobalt	4.56E-07	0.02050	5.74E-07	0.02583	20	0.006	0.0003	RfC; SL - CA[j]	µg/m^3
Copper		0.00848		0.01060	20	1		AMCV	µg/m^3
Hexavalent Chromium	6.63E-07	0.00055	1.06E-06	0.00088	20	0.1	0.00008	RfC; CREG	µg/m^3
Lead	4.56E-08	0.02533	6.05E-08	0.03360	20	0.15	0.00001	SL-NCA[k]; CalEPA IUR[l]	µg/m^3
Manganese		0.05700		0.07400	20	0.05		RfC	µg/m^3
Mercury		0.00043		0.00073	20	0.2		cEMEG	µg/m^3
Molybdenum		0.00008		0.00009	20	5		AMCV	µg/m^3
Nickel		0.05150		0.06100	20	0.02		RfC	µg/m^3
Selenium		0.00004		0.00483	20	0.2		AMCV	µg/m^3
Uranium		0.00061			20	0.04		cEMEG	µg/m^3
Vanadium		0.02640		0.03400	20	0.05		AMCV	µg/m^3
Zinc		0.00614		0.00788	20	5		AMCV	µg/m^3
Total Risk	**3.98E-06**	**0.32560**	**5.15E-06**	**0.40614**					

[a] PM10 = *particulate matter with an aerodynamic diameter of 10 microns or smaller*

[b] CA= *Cancer*

[c] HQ = *hazard quotient (non-cancer health risk). An HQ < 1 means there is no increased risk from exposure. An HQ > 1 means there is an increased risk from exposure.*

[d] 95% UCL = *the upper 95% confidence limit of the mean. This is a mean for which we believe exceeds the true mean concentration 95% of the time and is a conservative estimate used for screening purposes.*

[e] N = *number of samples used in the calculation*

[f] CV = *health based comparison value*

[g] RfC = *U.S. EPA Reference Concentration*

[h] AMCV = *TCEQ Air Monitoring Comparison Value*

[i] CREG = *ATSDR Cancer Risk Evaluation Guide*

[j] SL – CA = *U.S. EPA Residential Screening Level for Cancer*

[k] SL (NCA) = *U.S. EPA Residential Screening Level for Noncancer effects*

[l] CalEPA IUR = *California EPA Inhalation Unit Risk*

Table G-12. Risk Calculations (URS) Tayman Drive Wasterwater Treatment Plant-VOCs[a]

Chemical Name	Mean CA[b] Risk	Mean HQ[c]	95% UCL[d] CA Risk	95% UCL HQ	N[e]=	Chronic CV[f]	Cancer CV	CV Source	Units
Acetonitrile		0.00427		0.00562	22	60		RfC[g]	µg/m^3
Acetylene		0.00016		0.00019	22	2662		AMCV[h]	µg/m^3
Acrylonitrile	3.37E-06	0.02530	7.13E-06	0.05350	22	2	0.015	RfC; CREG[i]	µg/m^3
Benzene	4.58E-06	0.06198	5.25E-06	0.07104	22	9.6	0.13	cEMEG[j]; CREG	µg/m^3
Bromodichloromethane	2.91E-06		4.53E-06		22		0.066	SL - CA[k]	µg/m^3
Bromoform	1.58E-07		2.21E-07		22		0.91	CREG	µg/m^3
Bromomethane		0.01084		0.01228	22	5		RfC	µg/m^3
1,3-Butadiene	6.55E-07	0.01080	8.00E-07	0.01320	22	2	0.033	RfC; CREG	µg/m^3
Carbon Disulfide		0.00749		0.01129	22	700		RfC	µg/m^3
Carbon Tetrachloride	4.28E-06	0.00728	4.83E-06	0.00821	22	100	0.17	RfC; CREG	µg/m^3
Chloroethane		0.00001		0.00001	22	10000		RfC	µg/m^3
Chloroform	4.51E-06	0.00198	5.88E-06	0.00258	22	98	0.043	RfC; CREG	µg/m^3
Chloromethane		0.01689		0.01856	22	90		RfC	µg/m^3
p-Dichlorobenzene (1,4-Dichlorobenzene)	1.79E-07	0.00066	2.48E-07	0.00091	22	60	0.22	cEMEG; SL-CA	µg/m^3
Dibromochloromethane	2.30E-06		3.37E-06		22		0.09	SL-CA	µg/m^3
Dichlorodifluoromethane		0.02930		0.03160	22	100		RfC	µg/m^3
Dichloromethane	3.05E-09	0.00088	3.56E-09	0.00103	22	347	100	AMCV; CREG	µg/m^3
Ethylbenzene	1.27E-07	0.00047	1.67E-07	0.00062	22	260	0.97	cEMEG; SL-CA	µg/m^3
Methyl Ethyl Ketone		0.00026		0.00031	22	5000		RfC	µg/m^3
Methyl Isobutyl Ketone		0.00126		0.00157	22	82		AMCV	µg/m^3
Methyl Methacrylate		0.00027		0.00040	22	700		RfC	µg/m^3
n-Octane		0.00019		0.00021	22	350		AMCV	µg/m^3
Propylene		0.00009		0.00011	22	3000		RfC	µg/m^3
Styrene		0.00020		0.00043	22	850		cEMEG	µg/m^3
Tetrachloroethylene	2.87E-08	0.00273	4.08E-08	0.00388	22	40	3.8	RfC; CREG	µg/m^3
Toluene		0.00174		0.00225	22	300		cEMEG	µg/m^3
1,1,1-Trichloroethane		0.00002		0.00002	22	5000		RfC	µg/m^3
Trichlorofluoromethane		0.00229		0.00243	22	700		RfC	µg/m^3
Trichlorotrifluoroethane (1,1,2-Trichloro-1,1,2-trifluoroethane)		0.00003		0.00003	22	30000		RfC	µg/m^3

1,2,4-Trimethylbenzene		0.01657		0.02300	22	7		RfC	µg/m^3
1,3,5-Trimethylbenzene		0.00035		0.00044	22	123		AMCV	µg/m^3
Vinyl chloride	1.64E-07	0.00018	1.71E-07	0.00019	22	100	0.112	RfC; CREG	µg/m^3
m,p-Xylene		0.00267		0.00394	22	100		RfC	µg/m^3
o-Xylene		0.00109		0.00146	22	100		RfC	µg/m^3
Total Risk	**2.33E-05**	**0.20823**	**3.26E-05**	**0.27129**					

[a] VOC = *volatile organic compound*

[b] CA= *Cancer*

[c] HQ = *hazard quotient (non-cancer health risk). An HQ of less than one means there is no increased risk from exposure. Greater than one means there is an increased risk from exposure.*

[d] 95% UCL = *the upper 95% confidence limit of the mean. This is a mean for which we believe exceeds the true mean concentration 95% of the time and is a conservative estimate used for screening purposes.*

[e] N = *number of samples used in the calculation*

[f] CV = *health based comparison value*

[g] RfC = *U.S. EPA Reference Concentration*

[h] AMCV = *TCEQ Air Monitoring Comparison Value*

[i] CREG = *ATSDR Cancer Risk Evaluation Guide*

[j] cEMEG = *ATSDR Chronic Environmental Media Evaluation Guide*

[k] SL – C = *U.S. EPA Residential Screening Level for Cancer*

NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Table G-13. Risk Calculations (URS) Tayman Drive Wastewater Treatment Plant-PM_{10}[a]

Chemical Name	Mean CA[b] Risk	Mean HQ[c]	95% UCL[d] CA Risk	95% UCL HQ	N[e]=	Chronic CV[f]	Cancer CV	CV Source	Units
Aluminum		0.02340		0.02780	20	5		RfC[g]	µg/m^3
Antimony		0.00089		0.00114	20	0.5		AMCV[h]	µg/m^3
Arsenic	2.23E-06	0.03420	2.63E-06	0.04033	20	0.015	0.000230	RfC; CREG[i]	µg/m^3
Barium		0.01514		0.01814	20	0.5		AMCV	µg/m^3
Beryllium	1.11E-08	0.00023	1.5E-08	0.00032	20	0.02	0.000420	RfC (NCA)[j]; CREG	µg/m^3
Cadmium	2.52E-07	0.01410	3E-07	0.01680	20	0.01	0.000560	cEMEG[k]; CREG	µg/m^3
Chromium		0.02040		0.02160	20	0.1		RfC-CrVI[l]	µg/m^3
Cobalt	3.85E-07	0.01733	4.44E-07	0.02000	20	0.006	0.000270	RfC; SL - CA[m]	µg/m^3
Copper		0.04110		0.06280	20	1		AMCV	µg/m^3
Hexavalent Chromium	2.22E-07	0.00018	4E-07	0.00033	20	0.1	0.000083	cEMEG; CREG	µg/m^3
Lead	4.36E-08	0.02420	6.02E-08	0.03347	20	0.15	0.000012	SL-NCA[n]; CalEPA IUR[o]	µg/m^3
Manganese		0.03833		0.04900	20	0.05		RfC	µg/m^3
Mercury		0.00013		0.00020	20	0.2		cEMEG	µg/m^3
Molybdenum		0.00006		0.00006	20	5		AMCV	µg/m^3
Nickel		0.07750		0.12700	20	0.02		RfC	µg/m^3
Selenium		0.00372		0.00446	20	0.2		AMCV	µg/m^3
Uranium		0.00069		0.00088	20	0.04		cEMEG	µg/m^3
Vanadium		0.02160		0.02740	20	0.05		AMCV	µg/m^3
Zinc		0.00382		0.00460	20	5		AMCV	µg/m^3
Total Risk	**3.14E-06**	**0.33703**	**3.85E-06**	**0.45634**					

[a] PM10 = *particulate matter with an aerodynamic diameter of 10 microns or smaller*

[b] CA= *Cancer*

[c] HQ = *hazard quotient (non-cancer health risk). An HQ < 1 means there is no increased risk from exposure. An HQ > 1 means there is an increased risk from exposure.*

[d] 95% UCL = *the upper 95% confidence limit of the mean. This is a mean for which we believe exceeds the true mean concentration 95% of the time and is a conservative estimate used for screening purposes.*

[e] N = *number of samples used in the calculation*

[f] CV = *health based comparison value*

[g] RfC = *U.S. EPA Reference Concentration*

[h] AMCV = *TCEQ Air Monitoring Comparison Value*

[i] CREG = *ATSDR Cancer Risk Evaluation Guide*

[j] NCA = *Noncancer health effects*

[k] cEMEG = *ATSDR Chronic Environmental Media Evaluation Guide*

[l] RfC-CrVI = U.S. EPA Reference Concentration for Chromium VI-used for screening purposes only. Most Cr is less toxic Cr III in Midlothian (TCEQ, 2010).

Table G-13, continued

[m] SL – CA = *U.S. EPA Residential Screening Level for Cancer*
[n] SL (NCA) = *U.S. EPA Residential Screening Level for Noncancer effects*
[o] CalEPA IUR = *California EPA Inhalation Unit Risk*
NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Table G-14. Risk Calculations (URS) Wyatt Road PM$_{10}$[a]

Chemical Name	Mean CA[b] Risk	Mean HQ[c]	95% UCL[d] CA Risk	95% UCL HQ	N[e]=	Chronic CV[f]	Cancer CV	Chronic CV Source	Units
Aluminum		0.0540		0.06720	24	5		RfC[g]	µg/m^3
Antimony		0.0011		0.00126	24	0.5		AMCV[h]	µg/m^3
Arsenic	4.61E-06	0.0707	5.61E-06	0.08600	24	0.015	0.00023	RfC; CREG[i]	µg/m^3
Barium		0.0258		0.03020	24	0.5		RfC	µg/m^3
Beryllium	2.90E-08	0.0006	3.81E-08	0.00080	24	0.02	0.00042	RfC (NCA[j]); CREG	µg/m^3
Cadmium	8.16E-07	0.0457	1.22E-06	0.06850	24	0.01	0.00056	RfC; CREG	µg/m^3
Chromium (HQ=CrVI)		0.0533		0.06470	24	0.1		RfC	µg/m^3
Cobalt	8.48E-07	0.0382	1.06E-06	0.04783	24	0.006	0.00027	RfC; SL - CA[k]	µg/m^3
Copper		0.0220		0.02660	24	1		AMCV	µg/m^3
Hexavalent Chromium	8.43E-07	0.0007	1.37E-06	0.00114	24	0.1	0.000083	RfC; CREG	µg/m^3
Lead	1.90E-07	0.1053	2.86E-07	0.15867	24	0.15	0.000012	SL-NCA[l]; CalEPA IUR[m]	µg/m^3
Manganese		0.2110		0.27800	24	0.05		RfC	µg/m^3
Mercury		0.0005		0.00086	24	0.2		cEMEG[n]	µg/m^3
Molybdenum		0.0002		0.00027	24	5		AMCV	µg/m^3
Nickel		0.1080		0.13200	24	0.02		RfC	µg/m^3
Selenium		0.0040		0.00470	24	0.2		AMCV	µg/m^3
Uranium		0.0013		0.00181	24	0.04		cEMEG	µg/m^3
Vanadium		0.0476		0.05940	24	0.05		AMCV	µg/m^3
Zinc		0.0294		0.04480	24	5		AMCV	µg/m^3
Total Risk	**7.33E-06**	**0.8193**	**9.59E-06**	**1.07473**					

[a] PM10 = *particulate matter with an aerodynamic diameter of 10 microns or smaller*

[b] CA= *Cancer*

[c] HQ = *hazard quotient (non-cancer health risk). An HQ of less than one means there is no increased risk from exposure. Greater than one means there is an increased risk from exposure.*

[d] 95% UCL = *the upper 95% confidence limit of the mean. This is a mean for which we believe exceeds the true mean concentration 95% of the time and is a conservative estimate used for screening purposes.*

[e] N = *number of samples used in the calculation*

[f] CV = *health based comparison value*

[g] RfC = *U.S. EPA Reference Concentration*

[h] AMCV = *TCEQ Air Monitoring Comparison Value*

[i] CREG = *ATSDR Cancer Risk Evaluation Guide*

Table G-14, continued

[j] NCA = *Noncancer health effects*

[k] SL – CA = *U.S. EPA Residential Screening Level for Cancer*

[l] SL (NCA) = *U.S. EPA Residential Screening Level for Noncancer effects*

[m] CalEPA IUR = *California EPA Inhalation Unit Risk*

[n] cEMEG = *ATSDR Chronic Environmental Media Evaluation Guide*

NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Table G-15. Risk Calculations (Early 1990s) Various Sites-PM$_{10}$[a]

Pollutant	Site Name	Mean CA[b] Risk	Mean HQ[c]	95% UCL[d] CA Risk	95% UCL HQ	N[e]=	Chronic CV[f]	Cancer CV	CV Source	Units
Aluminum*	Auger Road		0.133		0.242	4	5		RfC[g]	µg/m^3
Beryllium*	Auger Road	2.83E-09	0.003	1.35E-07	0.003	4	0.02	0.00042	RfC; CREG[h]	µg/m^3
Chromium III (CrVI CV for nCa)	Auger Road		0.079		0.104	68	0.1		RfC	µg/m^3
Manganese	Auger Road		0.018		0.033	63	0.05		RfC	µg/m^3
Nickel	Auger Road		0.201		0.356	68	0.02		RfC	µg/m^3
only 4 samples	**Total Risk**	**2.83E-09**	**0.433**	**1.35E-07**	**0.738**					

Pollutant	Site Name	Mean CA Risk	Mean HQ	95% UCL CA Risk	95% UCL HQ	n=	Chronic CV	Cancer CV	CV Source	Units
Aluminum	Cedar Drive		0.08		0.22	6	5		RfC	µg/m^3
Cadmium	Cedar Drive	1.77E-06	0.10	9.18E-07	0.05	14	0.01	0.00056	RfC; CREG	µg/m^3
Chromium III (CrVI CV for nCa)	Cedar Drive		0.01		0.02	14	0.1		RfC	µg/m^3
Manganese	Cedar Drive		0.04		0.05	14	0.05		RfC	µg/m^3
Nickel	Cedar Drive		0.04		0.12	14	0.02		RfC	µg/m^3
	Total Risk	**1.77E-06**	**0.27**	**9.18E-07**	**0.46**					

Pollutant	Site Name	Mean CA Risk	Mean HQ	95% UCL CA Risk	95% UCL HQ	n=	Chronic CV	Cancer CV	CV Source	Units
Chromium III (CrVI CV for nCa)	Cedar Hill FD		0.04		0.04	37	0.1		RfC	µg/m^3
Manganese	Cedar Hill FD		0.02		0.03	37	0.05		RfC	µg/m^3
	Total Risk	**N/A**	**0.06**	**N/A**	**0.07**					

Pollutant	Site Name	Mean CA Risk	Mean HQ	95% UCL CA Risk	95% UCL HQ	n=	Chronic CV	Cancer CV	CV Source	Units
Aluminum	Cement Valley Rd		0.04		0.05	3	5		RfC	µg/m^3
Cadmium	Cement Valley Rd	2.39E-06	0.13	2.43E-06	0.14	13	0.01	0.00056	RfC; CREG	µg/m^3
Chromium III (CrVI CV for nCa)	Cement Valley Rd		0.06		0.07	13	0.1		RfC	µg/m^3
Lead	Cement Valley Rd	2.86E-07	0.16	5.21E-07	0.29	13	0.15	0.000012	SL-NCA[i]; CalEPA IUR[j]	µg/m^3

Manganese	Cement Valley Rd		0.17		0.23	13	0.05		RfC	µg/m³
Nickel	Cement Valley Rd		0.24		0.34	13	0.02		RfC	µg/m³
	Total Risk	**2.68E-06**	**0.80**	**2.95E-06**	**1.11**					

Pollutant	Site Name	Mean CA Risk	Mean HQ	95% UCL CA Risk	95% UCL HQ	n=	Chronic CV	Cancer CV	CV Source	Units
Aluminum	Tayman Dr WWTP		0.02		0.03	3	5		RfC	µg/m³
Chromium III (CrVI CV for nCa)	Tayman Dr WWTP		0.06		0.10	56	0.1		RfC	µg/m³
Manganese	Tayman Dr WWTP		0.01		0.03	56	0.05		RfC	µg/m³
Nickel	Tayman Dr WWTP		0.13		0.37	56	0.02		RfC	µg/m³
	Total Risk	**N/A**	**0.22**	**N/A**	**0.53**					

[a] PM10 = *particulate matter with an aerodynamic diameter of 10 microns or smaller*

[b] CA= *Cancer*

[c] HQ = *hazard quotient (non-cancer health risk). An HQ of less than one means there is no increased risk from exposure. Greater than one means there is an increased risk from exposure.*

[d] 95% UCL = *the upper 95% confidence limit of the mean. This is a mean for which we believe exceeds the true mean concentration 95% of the time and is a conservative estimate used for screening purposes.*

[e] N = *number of samples used in the calculation*

[f] CV = *health based comparison value*

[g] RfC = *U.S. EPA Reference Concentration*

[h] CREG = *ATSDR Cancer Risk Evaluation Guide*

[i] SL (NCA) = *U.S. EPA Residential Screening Level for Noncancer effects*

[j] CalEPA IUR = *California EPA Inhalation Unit Risk*

NOTE: ATSDR did not evaluate the basis of the TCEQ AMCVs and ESLs

Table G-16. Risk Calculations City Hall-TSP[a]

Pollutant	Mean CA[b] Risk	Mean HQ[c]	95% UCL[d] CA Risk	95% UCL HQ	N[e]=	Chronic CV[f]	Cancer CV	CV Source	Units
Aluminum		0.14		0.16	40	5		RfC[g]	µg/m^3
Copper		0.02		0.02	40	1		AMCV[h]	µg/m^3
Lead	1.92E-06		2.17E-06	1.21	94	0.15	0.000012	SL-NCA[i];CalEPA IUR[j]	µg/m^3
Manganese		0.14		0.48	40	0.05		AMCV	µg/m^3
Vanadium		0.02		0.03	40	0.1		RfC	µg/m^3
Zinc		0.01		0.01	40	5		AMCV	µg/m^3
Total Risk	**1.92E-06**	**0.33**	**2.17E-06**	**1.91**					

[a] PM10 = *particulate matter with an aerodynamic diameter of 10 microns or smaller*

[b] CA= *Cancer*

[c] HQ = *hazard quotient (non-cancer health risk). An HQ of less than one means there is no increased risk from exposure. Greater than one means there is an increased risk from exposure.*

[d] 95% UCL = *the upper 95% confidence limit of the mean. This is a mean for which we believe exceeds the true mean concentration 95% of the time and is a conservative estimate used for screening purposes.*

[e] N = *number of samples used in the calculation*

[f] CV = *health based comparison value*

[g] RfC = *U.S. EPA Reference Concentration*

[h] CREG = *ATSDR Cancer Risk Evaluation Guide*

[i] SL (NCA) = *U.S. EPA Residential Screening Level for Noncancer effects*

[j] CalEPA IUR = *California EPA Inhalation Unit Risk*

Appendix H: Public Comments and Response to Public Comments

Response to Public Comments

General Comments

Comment 1A: *My comments will be brief. I could spend many hours reviewing the details of each report but my comments will not change the outcome. ATSDR has been reviewing data in Midlothian for the past ten years. Citizens have become weary of commenting on the lack of quality information ATSDR is using to come up with their conclusions. TCEQ air monitoring is insufficient to make accurate determinations and modeling does not reflect real life. Many of the original petitioners have given up and will no longer participate in this process.*

Citizens who live in and downwind of Midlothian are well aware of the health impacts of poor air quality. Door to door interviews with citizens would give a true to life picture of what is going on in neighborhoods where no monitoring takes place. Soil and water sampling would reveal better information. But again, using only existing data and modeling is insufficient.

Response 1A: ATSDR reviewed a very large and scientifically robust dataset to address community exposures in Midlothian. Data back to 1981 were reviewed, and measurements from 21 monitoring locations were evaluated. This is a much larger and more complete dataset than most ATSDR has an opportunity to review. Our first health consultation for the site, released for public comment in 2012 and released final in 2015, addressed the value of existing data for health assessment purposes and we determined that much of the data were appropriate and useful for such an assessment. We do, however, acknowledge that there are places and timeframes where we lack data or the necessary information to model estimated air concentrations. The reviewer is correct when observing that modeling does not reflect "real life"—in the instance of this health consultation on metals and VOCs, the modeling represents a much worse release scenario than occurs in real life. We modeled worst case annual emissions from all four facilities as if they occurred simultaneously, which they did not. Furthermore, we assumed worst case meteorological conditions occurred during that period and that the lowest release point for each site was where all releases occurred. These assumptions do overestimate releases that occur at the facilities, but we wanted to make these assumptions to estimate the worst possible conditions. Door to door surveys are helpful in gathering health concerns, but those have been well documented over the time of ATSDR's investigation in Midlothian. Historically, TCEQ attempted to locate many of their monitoring stations in locations based on modeling areas of highest impact or due to residential concerns. While not every neighborhood was sampled (it is simply not feasible to do so), those that were, were believed to be the most highly impacted of neighborhoods from industrial exposures. Since air deposition of pollutants is believed to be the main avenue for any soil or water contamination in the community, extensive air sampling in areas of highest modeled impact was conducted. Historical sampling for other media than air will be discussed in a separate health consultation.

Comment 2A: *Once again, this report is based on modeling (educated guessing) and inadequate TCEQ monitoring. As I have reported in previous comments, there are gaps in monitoring, complete years where there is no air monitoring at all and those are years when hazardous waste was being experimented with as fuel. There is a cluster of Downs Syndrome babies born in Ellis County in the years following that gap. There is no monitoring at all for many hazardous air pollutants. Methods used to monitor certain pollutants are known to underestimate pollution levels. Methods used to monitor certain pollutants are not capable of measuring concentrations near the health protective levels. TCEQ's monitoring was scheduled in advance so that industry knew what day they would be monitored. Leaving out one hazardous fuel source would alter the results.*

There is a synergistic effect of multiple pollutants, sometimes producing new compounds and different health effects. Current monitoring methods cannot address these concerns. I understand ATSDR did consider multiple pollutant exposure through modeling. Modeling is educated guessing and is not real life.

Response 2A: As mentioned in the previous comment, ATSDR modeled a worst case scenario to assess potential impacts to the community that likely overestimated actual emissions into the community. Again, these included: 1) Assuming the highest emissions for the pollutant modeled occurred simultaneously at all facilities; 2) Assuming the stack height was the lowest on the property of the facility, which results in higher ground level estimated air concentrations; and 3) assuming worst case meteorological conditions (i.e., those that would result in conditions that would worst impact the surrounding community).

The reviewer is correct in stating that not every pollutant was measured in every area of the community over the entire 30 year monitoring period. That type of monitoring is not feasible, however TCEQ made an effort to locate monitoring sites in parts of the community demonstrated to be most likely to be impacted by industrial emissions, and in some cases, sited a monitor to address community concerns in areas that may not have been in the highest impacted area. This monitoring was conducted generally for pollutants classes that were released in greatest quantity from the sites of interest to residents. For a few pollutants released by the facilities that had not been historically monitored or for pollutants of concern to residents, ATSDR modeled worst case releases for emissions reported back to 1986. Of these, and only under worst case assumptions (but not under actual release conditions), ATSDR identified the potential of sulfuric acid aerosols to have been a potential irritant to residents. However, releases of sulfur compounds has greatly decreased at all the facilities of interest over time as the facilities have upgraded their processes to include better environmental controls. Thus, it is likely that air quality will continue to improve and that these pollutants will cause less of a health risk in the future.

The multi-pollutant risk assessment was also very conservative, and to calculate risk, we used the upper 95% confidence limit of the ***measured*** mean pollutant concentration over the sampling period. This means we used the highest range of the average within reason for all the pollutants measured to estimate human health impacts. We believe this is also a very conservative approach for estimating risk to residents from historical exposures to air pollutants. We also used the actual measured "average" to calculate "real life" estimates of risk. So, in summary, we estimated average and upper bound risk estimates and did not find a substantially elevated risk for the pollutants measured over the 30 year monitoring period for the data available for ATSDR review.

Comment 3A: *The TCEQ Air Monitoring is routinely conducted every six days and is not indicative of what is actually released on other days. We all know when monitoring day rolls around. The state placed a monitor on my property for approximately a year and there were no results listed in the report like other residents.*

Response 3A: ATSDR addressed the 1 in 6 day sampling in two ways in our first health consultation on the adequacy of the database. (see http://www.atsdr.cdc.gov/HAC/pha/MidlothianAreaAirQuality/MidlothianAreaAirQuality_HC_

Final_07-28-2015_508.pdf) Conclusion 5 in that health consultation states: "The available air pollution measurements and facility-specific emission measurements provide no evidence that the Midlothian facilities alter their emissions on days when 1-in-6 day samples are collected." To arrive at this conclusion, ATSDR evaluated two lines of evidence—continuous PM ambient air monitoring data and continuous emission monitoring data—to evaluate this concern. Continuous monitoring of particulates or criteria pollutants did not demonstrate any trends of reduced concentrations on days between the discrete 1 in 6 day sampling schedule, nor did releases of pollutants measured directly from the stacks of the facilities (continuous emissions monitoring).

ATSDR presented all data collected within the 30 year period of 1981 to 2011. No datasets were excluded. However, data presented in this Health Consultation are only VOC and metals data. Criteria pollutant data (NAAQS) and data collected in soil and other media are discussed in two other health consultations.

Comment 4A: *We know Cesium-137 was melted down at Chaparral Steel and contaminated the adjoining Kemp Ranch, but there is no testing of soil in ATSDR's study, nor is there state testing of water where two forms of Plutonium were found in addition to the Plutonium in their CKD and soil by the U. S. EPA. HELLO !!!!!!!!*

Response 4A: The Health Consultations released for public comment were on air sampling for VOCs and metals and for human and animal health outcome data. The Health Consultation on other media, including all available sampling of soil and water, addresses this issue.

Comment 5A: *As a general issue of concern in the draft health consultation, the reader is led to believe the air quality may have caused adverse health effects in the past when air monitoring in the Midlothian area indicates acceptable air quality. Further, air quality in Midlothian is better than most monitored areas of the country. This could lead to undue anxiety for the citizens of Midlothian.*

Response 5A: ATSDR generally agrees that the historical data indicate acceptable air quality, acknowledging in Conclusion 2 on Page 3 "ATSDR concludes that measured levels of metals and volatile organic compounds (VOCs) in Midlothian are not expected to harm people's health because they are below levels of health concern." The only pollutant that we state may have posed such a risk, sulfuric acid aerosols, has never been measured in residential air. ATSDR modeled this pollutant to understand possible historical risks to area residents, and states that while this pollutant could have posed a risk, it was only under "worst case conditions". These conditions were explained as follows (p.3 para 3):
"*ATSDR used very conservative modeling assumptions to generate the highest potential ambient concentrations to evaluate. ATSDR assumed worst case conditions for the modeling effort. For example, we assumed the emissions for each pollutant were the same as the highest amount ever reported by the facilities to the Toxic Release Inventory (TRI) database or to TCEQ's Point Source Emissions Inventory (PSEI), and ran emissions from different years/sites assuming the worst years occurred at the same time for individual pollutants. Furthermore, we assumed all emissions from each plant came out of the stack with the least favorable deposition pattern (e.g., shortest stack at the lowest exit velocity). We assumed these conditions would yield the highest off site concentrations of pollutants (worst-case conditions). Under these worst case conditions, only sulfuric acid aerosols exceeded current chronic health based values.*"

Comment 6A: *We also note that the level of any given screening value does not constitute a bright line where health effects are expected to occur. On the contrary, these screening values are set at a level that protects the general population as well as sensitive subpopulations, incorporating an adequate margin of safety. Therefore, the simple fact that ambient air at a community monitoring site or modeled value exceeded a given screening value does not indicate (1) that citizens were actually exposed to that concentration, (2) that the concentrations measured at that monitor constitute unsafe exposures, or (3) that health effects would be expected from exposure to that concentration. The [commenter] looks forward to continuing to work with ATSDR to address the findings and recommendations made in this report and to sharing additional data and information that will produce the best possible product for the public and for policymakers.*

Response 6A: We also noted this distinction (p. 23, "Defining Comparison Values"): *"As a result, ambient air concentrations lower than their corresponding comparison values are generally considered to be safe and not expected to cause harmful health effects, but the opposite is not true. Because comparison values are often much lower than effect levels, ambient air concentrations greater than comparison values are not necessarily levels of air pollution that would present a possible public health hazard. Rather, chemicals with air concentrations higher than comparison values require further evaluation."* Thank you for your comment.

Comment 7A: *The document lacks proper explanation that it is evaluating ambient air concentrations, not exposure concentrations. Actual exposure will depend on the locations where citizens travel during the day and their physical activity during those times. A considerable amount of research has been conducted that shows most people typically spend the majority of their day (~90%) inside, not outside, a finding quoted by the EPA when discussing indoor air issues. It has also been shown that indoor air quality is typically worse than outdoor air quality. These are important factors that ATSDR should consider.*

Response 7A: ATSDR makes it clear from the beginning of the document that our assessment of risk is very much based on outdoor air measurements of speciated data. We do not refer to the concentrations as "exposure concentrations", but "air measurements" or "air modeling estimates". While the reviewer's point is well taken about indoor air quality, this document was written to address the additional burden of exposure residents experience as a result of the environmental emissions from the facilities of concern. The risk assessment expressly states that an assumption of continuous exposure is an overestimate of risk, but that this assumption is part of an initial screening process. Further, ATSDR must rely on air measurements as indicators of exposure.

To make this conservative assumption clear, we have added language to Conclusion 3. We hope this helps the reader understand that our assumptions are that they are exposed to the outdoor air continuously for a lifetime, and in spite of this assumption we did not find an elevation of long-term risk.

Comment 8A: *The document concludes that all pollutants, except sulfuric acid, were found to be either monitored or modeled at concentrations below levels of health concern. As stated by ATSDR, the conclusion for sulfuric acid is based solely on modeled concentrations from* *emissions data rather than measured concentrations. While modeled data can be useful, it does not depict reality. In this case, the worst-case scenario was used. Using worst-case scenario assumptions is an extremely conservative approach that is not reflective of real-life scenarios. Therefore, it is inappropriate to base a conclusion on a scenario that does not exist in actuality. In addition, it is stated that the sulfuric acid aerosol estimates were only slightly higher than the screening values, which would not indicate that health effects would be expected – as stated above, screening values do not constitute a bright line and have an ample margin of safety built in.*

Response 8A: See responses 2A and 5A, which address the conservative assumptions of our modeling approach. For screening purposes, ATSDR uses a conservative approach for modeling and risk assessment. A more refined evaluation occurs (in this instance, a review of toxicological data) if the conservative estimate exceeds health based comparison values (CVs). Although we generally agree that health based CVs allow for a margin of safety (i.e., they are many times lower than known human effect levels), the CV for chronic exposure to sulfuric acid *does not* have a large margin of safety (see http://oehha.ca.gov/air/chronic_rels/pdf/sulfuric.pdf for a more thorough explanation). The California REL, which is also used as a USEPA RfC, is 1 µg/m^3. Studies of adverse respiratory effects in asthmatic children exposed to low µg/m^3 levels of sulfates shows that exposures like those modeled in Midlothian, could put a small segment of the community (children, the elderly, and residents with compromised respiratory health (asthma, emphysema, etc.) at risk for the exacerbation of pre-existing health conditions (http://oehha.ca.gov/air/chronic_rels/pdf/sulfuric.pdf).

Comment 9A: Throughout the document, when describing the pollutants evaluated, it would be helpful if chemical abstract service numbers (CAS Numbers) were given as pollutants have multiple names.

Response 9A: Where there are two well-known names of a pollutant, we give both names in the text. We do not believe the general public will find added value in listing CAS numbers.

Comment 10A: The document utilizes several ambient comparison values developed by the TCEQ; however, some of the values used are not correct. The TCEQ has two different types of screening values, effects screening levels (ESLs) and air monitoring comparison values (AMCVs). ESLs are developed for air permitting purposes and take into account multiple emission sources while AMCVs are developed specifically for use in evaluating ambient air monitoring data. Therefore, it is inappropriate to use an ESL when an AMCV is available (for more detailed information, please see http://www.tceq.texas.gov/toxicology/faqs/common-questions-about-tceq-toxicity-factors). The following should be updated in the evaluation:

Pollutant	CV Used in Document ($\mu g/m^3$)	Correct TCEQ AMCV ($\mu g/m^3$)	Notes
Acrolein	3.7	11	The short-term AMCV is the value that should be used
Acrylonitirle	40	1,100	The short-term AMCV is the value that should be used
Benzene (noncancer)	4.5	280	The value used for the noncancer screening is a cancer-based value. For screening noncancer, the listed chronic value should be used
Bromodichloromethane (noncancer)	671 (short-term); 67 (long-term)	700 (short-term); 70 (long-term)	The short- and long-term AMCVs should be updated to be correct
Carbon Tetrachloride (noncancer)	126	130	The short-term AMCV should be updated to be correct
Chloroform (noncancer)	97.3 (short-term); 9.7 (long-term)	100 (short-term); 10 (long-term)	The short- and long-term AMCVs should be updated to be correct
Dibromodichloromethane	19.6 (short-term); 1.96 (long-term)	20 (short-term); 2 (long-term)	The short- and long-term AMCVs should be updated to be correct
Ethylene Dichloride (noncancer)	162	160 (1-hr) & 16 (24-hr)	The short-term AMCV should be updated to be correct; in addition to the 1-hr value, TCEQ has a 24-hr value, which is more appropriate for comparison with 24-hr average concentrations
Arsenic (noncancer)	0.1	9.9	The short-term AMCV is the value that should be used

Response 10A: Thank you for your comments. All CVs were current at the time the report was drafted, but during the review process some CVs were updated by TCEQ or other agencies. The changes recommended did not identify any new exceedences not noted originally. Note that:

the acrolein value should read “3.2 $\mu g/m^3$” in lieu of “3.7 $\mu g/m^3$“ for the TCEQ effects screening level, which has been revised.

the ESL for dibromochloromethane was not changed because TCEQ has rounded 1.96 to 2 $\mu g/m^3$ and 19.6 to 20 $\mu g/m^3$ since the report was written.

the ESL for acrylonitrile is no longer the most conservative acute value and this value has been changed to 220 $\mu g/m^3$ (ATSDR acute EMEG).

the ESL for benzene is no longer the most conservative chronic non-cancer value and this value has been changed to 9.6 $\mu g/m^3$ (ATSDR chronic EMEG).

the establishment of a 24-hour value for ethylene dichloride changed the ESL from 40 to 4 $\mu g/m^3$, which has been incorporated into the text.

the ESL for dibromochloromethane has been changed to units in $\mu g/m^3$, thus the values in the document have been changed to 20 $\mu g/m^3$ and 2 $\mu g/m^3$, respectively, as suggested by the reviewer.

some values changed slightly since the document was drafted. The CVs were updated in the text and appendices accordingly.

For some comparison values corrected by the reviewer, ATSDR converted the TCEQ AMCV/ESL table available at the time the report was written, which presented values in ppb. These values are correct, and will not be changed even though the September 2015 ESL table shows the original ppb ESL next to a **rounded** µg/m^3 ESL. For bromodichloromethane, carbon tetrachloride, and chloroform, our conversion of current ESLs are correct:

Bromodichloromethane (molecular weight of 163.83): ESL=10/100 ppb for short and long term levels, respectively
Carbon tetrachloride (molecular weight of 153.81): ESL= 20 ppb for short term
Chloroform (molecular weight of 119.37): ESLs = 2/20 ppb for short and long term levels, respectively
Ethylene Dichloride or 1,2-dichloroethane (molecular weight 98.96): ESL = 40 ppb for short term (1 hr) level

Using the following equation for converting ppb to µg/m^3:

µg/m^3 = (ppb value)(molecular weight) ÷ 24.45 (volume of 1 mole of gas at 25˚C and 1 atm)*

The converted concentrations of these pollutants are what we use in our current draft:
Bromodichloromethane: ESLs of 10/100 ppb are equivalent to 67/671 µg/m^3
Carbon tetrachloride: ESL of 20 ppb is equivalent to 126 µg/m^3
Chloroform: ESLs of 2/20 ppb are equivalent to 9.7/97.3 µg/m^3
Ethylene Dichloride or 1,2-dichloroethane: ESL of 40 is equivalent to 162 µg/m^3

TCEQ chose to round these 70/700 µg/m^3; 130 µg/m^3; 10/100 µg/m^3; and 160 µg/m^3 respectively, but the conversions under standard temperature and pressure are lower than the rounded value and will remain in the document.

Comment 11A: ***Page 34:*** *Background concentrations for 1,3-butadiene are stated as ranging from 0.1 – 2 µg/m3. All averages are within the background range, even though the ATSDR CREG is 0.04 µg/m3. More emphasis should be given to the fact that the measured concentrations are within typical background for this compound.*

Response 11A: We believe we clearly state that 1,3-butadiene is present in Midlothian at levels that are within typical ranges of 1,3-butadiene locally and nationally. This section states: "Every annual average concentration of 1,3-butadiene observed for the Midlothian monitoring sites was higher than ATSDR's CREG value for cancer endpoints (0.04 µg/m^3). However, ***it is not uncommon for 1,3-butadiene concentrations to exceed this screening value***: a recent U.S.EPA assessment of air toxics in the United States found that annual average 1,3-butadiene concentrations exceeded this screening value at 76 of 137 trend sites used to characterize long term changes in outdoor air quality (U.S.EPA, 2014). According to ATSDR, mean concentrations of 1,3-butadiene in the air in cities and suburban areas ranges from 0.1 to 2 µg/m^3...". Furthermore, in the summary for the discussion of this pollutant, we state, "***…*** *1,3-butadiene concentrations in Midlothian* ***are not notably different than concentrations found in***

***Ellis County, Texas, and throughout the United States**. Thus, chronic 1,3-butadiene concentrations measured at Midlothian monitors are below levels that harm people's health."*

Comment 12A: ***Page 37:*** *The text states that USEPA calculated the average background concentration for carbon tetrachloride is 0.63 µg/m3, which is the same average concentration in Midlothian. The Midlothian average is identical to average background, even though the ATSDR CREG is 0.19 µg/m3. More emphasis should be given to the fact that the measured concentrations are within typical background for this compound.*

Response 12A: We believe we clearly state that carbon tetrachloride is present in Midlothian at levels that are within typical ranges of carbon tetrachloride locally and nationally. This section states: *"Every annual average concentration of carbon tetrachloride calculated for Midlothian was found to exceed ATSDR's CREG value of 0.19 µg/m^3 for cancer endpoints. **It is not uncommon for carbon tetrachloride concentrations to exceed this screening value.** A recent U.S.EPA assessment of air toxics in the United States found that annual average carbon tetrachloride concentrations exceeded this screening value at 109 of 116 trend sites used to characterize long term changes in outdoor air quality (U.S.EPA, 2014). According to this U.S.EPA assessment, the median annual average carbon tetrachloride concentration across the 116 trend sites in 2010 was 0.63 µg/m^3—identical to the annual average carbon tetrachloride concentration measured in Midlothian the same year."* Furthermore, in the summary for the discussion of this pollutant, we state, "*Since chronic exposures to carbon tetrachloride are substantially lower than those observed to have caused health effects in scientific studies, **and since levels of carbon tetrachloride are typical of those across the United States**, long-term exposure to levels of carbon tetrachloride....".*

Comment 13A: ***Page 40-41:*** Background concentrations for chloroform are stated as ranging from 0.1 – 10 µg/m3, with an average background concentration of 0.2 µg/m3. All averages are within the background range, even though the ATSDR CREG is 0.049 µg/m3. More emphasis should be given to the fact that the measured concentrations are within typical background for this compound.

Response 13A: We believe we clearly state that chloroform is present in Midlothian at levels that are within typical ranges of chloroform locally and nationally. This section states: *"Every annual average concentration of chloroform calculated for Midlothian was found to exceed ATSDR's CREG value for cancer endpoints (0.049 µg/m^3). For reference on the magnitude of these concentrations, typical background concentrations of chloroform usually range between 0.1 and 10 µg/m^3 in outdoor air. In the early 1990s, U.S.EPA determined that the United States average background concentration was 0.2 µg/m^3 (U.S.EPA, 2000c) and between 0.17 and 43.9 µg/m^3 in indoor air (NTP, 2011), **which are also above the ATSDR CREG**."* Furthermore, in the summary for the discussion of this pollutant, we state, "*Given that chloroform is measured at concentrations across all monitoring sites for all years that are well below those known to cause adverse health effects **and that concentrations are typical of suburban environmental exposures across the United States**, long-term averaged chloroform levels....".*

Comment 14A: ***Page 43:*** *Heading states Dibromodichloromethane, but the text states dibromochloromethane. Text should be fixed to reflect correct pollutant.*

Response 14A: Thank you. This misspelling has been corrected.

Comment 15A: ***Page 46:*** *Text states that "No studies could be found that identified a relationship between inhaling 1,2-DCA and developing cancer." The authors may want to read the following study: Nagano et al. 2006, Carcinogenicity and chronic toxicity in rats and mice exposed by inhalation to 1,2-dichloroethane for two years. J Occup Health. 48(6): 424-36.*

Response 15A: Thank you. This study was added to the tox section on 1,2-DCA and the reference has been added.

Comment 16A: ***Page 47-48:*** *Text states CalEPA REL of 0.015 µg/m3 will be used, but table states TCEQ AMCV of 0.01 µg/m3 used. Text/table should be updated to reflect the correct value used in the evaluation.*

Response 16A: Thank you. This correction has been made.

Comment 17A: *This 2015 report relies on a flawed air dispersion modeling methodology and modeling results analysis to incorrectly imply that non-cancer health risk from sulfuric acid emissions may be elevated, and that sulfuric acid emissions could have resulted in historic irritation, or future irritation, to a limited subset of Midlothian residents. A detailed analysis of the flaws in the air dispersion modeling analysis will be provided at a later date, but some examples of the flaws are: the use of a grossly outdated version of the AERMOD model; over-exaggerated emission rates; and meteorological data that does not correspond to the time period of the emissions data.*

Response 17A: The version of AERMOD used was the most up to date version of the software at the time of the modeling of facility emissions (2011: http://www3.epa.gov/ttn/scram/models/aermod/aermod_mcb5.txt). We have no reason to believe the use of that version adversely affects the conclusions and recommendations we have drawn on data collected through 2011.

Emission rates were obtained from the Toxics Release Inventory and the TCEQ Point Source Emissions Inventory, which are facility-reported emissions data bases.

Regarding the meteorological input files for AERMOD, the reviewer is directed to the Clean Air Act (1999) **40 CFR Ch. I, Pt. 51, App. W, Section 9.3.1** (pp. 415-416) http://www3.epa.gov/scram001/guidance/guide/appw_99.pdf which states, "Five years of representative meteorological data should be used when estimating concentrations with an air quality model. Consecutive years from the most recent, readily available 5-year period are preferred. The meteorological data may be data collected either onsite or at the nearest National Weather Service (NWS) station. If the source is large, e.g., a 500MW power plant, the use of 5 years of NWS meteorological data or at least 1 year of site-specific data is required." Note that while recent data is preferred, it is not required.

Comment 18A: *The errors in the modeling results analysis are even more egregious. For example, the chronic risk analysis for sulfuric acid emissions uses a health risk screening value published by USEPA Region 3 as a point of comparison (a value that can no longer be found on* *the Region 3 website) to the modeled high annual average air concentration. ATSDR used the screening value in its risk assessment without any analysis of the scientific validity or applicability of the screening value to such a risk assessment. Further, the location of the modeled high annual average concentration used by ATSDR in its flawed analysis is on property where there are no people to be chronically exposed. Thus, there are no data to suggest that people could have or may be exposed to sulfuric acid emissions above regulatory levels of concern.*

Response 18A: The basis of our health opinion is presented in the toxicological review of sulfuric acid aerosols beginning on page 90 of this document. This health opinion is ***not*** based solely on USEPA's reference concentration for sulfuric acid (which is not an outdated R3 value, but is, as of November 2015, still listed as 1 µg/m^3: http://semspub.epa.gov/work/03/2220589.pdf), but on the existing toxicological database of exposure and resulting health effects. Existing studies indicate that reduced lung capacity and the exacerbation of asthma can occur in children exposed to sulfate/sulfuric acid aerosol concentrations in the low microgram per cubic meter range. The lack of data mentioned by the reviewer in the last sentence of comment 18A is the basis of ATSDR's recommendation for sampling of this pollutant in ambient air.

Comment 19A: *Finally, ATSDR's statements regarding the potential irritation of Midlothian residents associated with sulfuric acid emissions are likewise egregious. For example, if one assumed that ATSDR's modeling was valid, the highest modeled 1-hour ambient air concentration for sulfuric acid aerosols is 27.35 micrograms per cubic meter (µg/m^3) as reported in Table F-2. The generally recognized acute health exposure endpoint for sensitive individuals, the Acute Exposure Guideline Level 1 (which for sulfuric acid is based on irritation), is 200 ug/m3—a value well above ATSDR's highest modeled ambient air concentration.*

Response 19A: ATSDR disagrees that the AEGL-1 is a "generally recognized acute health exposure endpoint for sensitive individuals". From the NOAA website (http://response.restoration.noaa.gov/oil-and-chemical-spills/chemical-spills/resources/acute-exposure-guideline-levels-aegls.html) , the AEGL-1 is defined as *"the airborne concentration (expressed as ppm or mg/m^3) of a substance above which it is predicted that* ***the general population****, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic nonsensory effects*." An effect level for the general population is not protective of sensitive individuals. The basis of our concern is presented in the "*Health effects possible from exposure to sulfuric acid aerosols*" section of this document (pp 90-91), which includes studies of sulfate/sulfuric acid exposures and their effect on asthmatic children.

Comments on Conclusions and Recommendations

Comment 1B: *"Exposure to intermittently high levels of sulfuric acid aerosols may irritate the airways of area residents and cause acute respiratory symptoms in individuals with pre-existing cardiopulmonary illness, such as asthma. Children and the elderly are particularly vulnerable to adverse health outcomes from acute exposures to sulfuric acid aerosols. No elevated cancer or non-cancer risk was identified for measured and modeled ambient concentrations of volatile organic compounds, metals, or other inorganic pollutants."*

"ATSDR concludes that worst-case modeled concentrations of sulfuric acid aerosols estimate levels of sulfuric acid aerosols that could harm the health of sensitive individuals (e.g., children, the elderly, or residents with pre-existing health conditions), but no measured data exist to determine whether or not a threat existed in the past or currently exists."
The only pollutant of concern ATSDR has identified is sulfuric acid aerosols. It is convenient that no data exists. Do you have the authority to demand that monitoring for sulfuric acid begin around the facilities in Midlothian?

Response 1B: ATSDR is an advisory agency and does not have the authority to demand any kind of air sampling be conducted. Enforcement agencies, such as TCEQ and USEPA, have the authority to require such sampling and have required it in the past from these facilities. Thus, ATSDR recommended that TCEQ consider conducting or requiring the facilities of interest to conduct this type of monitoring.

Comment 2B: *"…slightly higher levels of metals were detected in monitoring stations downwind of TXI and Gerdau Ameristeel;.."*
Please consider the following: "Assessing risk for metals in ambient air is difficult for a variety of reasons….

Metals have been associated with a wide range of environmental and health effects including respiratory and pulmonary disorders (Prieditis 2001), neurotoxicity, and cancer (Monn 1999). High concentrations of metals in the environment, especially near industrial facilities, are thus a cause for concern.

Human exposures to airborne metals are usually to metal-bearing particulates, which necessitates measurements of particle sizes in the breathing zone of receptors of concern to achieve accurate estimates of deposition rates in the respiratory tract. (Overview of Airborne Metals Regulations, Exposure Limits, Health Effects, and Contemporary Research, Dec. 3, 2010, Andrea Geiger and John Cooper, Cooper Environmental Services LLC)"

Response 2B: While it is true that metals *can* be a cause for concern in sufficient quantity, whether or not they *are* cause for concern depends on the concentration of the metal in question. While metals were detected in air measured by area monitors in Midlothian, ATSDR did not find that the concentrations of metals measured presented an elevated cancer or non-cancer health risk. These pollutants were not measured at levels that approached health effect levels in human and animal studies as reported in the scientific literature. Further, particulate measurements in two size fractions have been conducted (particulate matter 10 micrometers in aerodynamic diameter or less (PM10) and finer particulate matter 2.5 micrometers in aerodynamic diameter or less (PM2.5)) and the toxicological implications of the particle size for the various metals was considered in our assessment.

Comment 3B: *"ATSDR recommends that TCEQ continue 1) monitoring organic and inorganic pollutants in locations where maximum air concentrations of site related pollutants could occur in order to quantify potential current and future risks to the community, and 2) consider an air sampling program for sulfuric acid aerosols."*

This is weak language. ATSDR recommends that TCEQ, who is inherently lax in their responsibility, and you ask them to "consider" sampling. This will never happen unless they are required to take these steps.

<u>Response 3B:</u> ATSDR is not an enforcement agency and cannot require an enforcement agency to take action. We are an advisory agency and make recommendations based on our assessment of the potential public health implications of the data we review in communities. It is our hope that TCEQ implements a sampling program for this pollutant as a compliment to their robust sampling network, but that decision lies within their enforcement program.

Comment 4B: *"ATSDR recommends that community focused air investigations continue and that sulfuric acid aerosols be included in these investigations. ATSDR recommends sampling of acid aerosols to better quantify risks to residents from local industrial emissions, including sulfuric acid."*

Again, this is weak language. Please amend to include stronger language to mandate TCEQ follow your recommendations.

<u>Response 4B:</u> See Responses 1B and 3B.

Comment 5B: ATSDR Recommendations
ATSDR recommends that TCEQ should continue to conduct community air monitoring and add sulfuric acid as an analyte to see if it is actually a problem. Routine air monitoring by TCEQ (and its predecessor agency, TNRCC) began in the Midlothian area in 1981 and has continued through to the present time. Overall, the air monitoring data from the Midlothian area compose an impressively rich data set. While copious amounts of air quality data were reviewed for the health consultation, the draft report fails to put into context the overall air quality in Midlothian. Monitored air toxics concentrations in Midlothian are not only acceptable and in compliance with federal regulations, but are much lower than concentrations measured in many other areas of the nation.

<u>Response 5B:</u> ATSDR acknowledges the robust, long term sampling network in Midlothian. ATSDR is not a regulatory agency, and objectively evaluates ambient air data regardless of the state of compliance with state and federal regulations. Further, for each pollutant identified as a contaminant of concern, we present "typical" concentrations in the United States for reference.

Comment 6B: *Regarding the recommendation to add sulfuric acid as an analyte, TCEQ currently measures VOCs, hydrogen sulfide (H2S), nitrogen oxides (NOX), ozone (O3), speciated metals measured as particulate matter less than 2.5 micrometers in diameter (PM2.5), PM2.5, and sulfur dioxide (SO2) at the Midlothian OFW monitoring site. In effect, by currently measuring SO2, the TCEQ is also monitoring for sulfuric acid. According to the USEPA, the National Ambient Air Quality Standard (NAAQS) for SO2 is designed to protect against exposure to the entire group of sulfur oxides (SOX). SO2 is the component of greatest concern and is used as the indicator for the larger group of gaseous SOX. Other gaseous SOX (e.g., sulfur trioxide and sulfuric acid) are found in the atmosphere at concentrations much lower than SO2. In August, 2015, the USEPA promulgated a rule directing state and tribal air agencies to provide data to characterize current air quality in areas with large sources of SO2 emissions*

(emissions greater than 2,000 tons per year or more of SO2). Industries located in Midlothian emit less than 2,000 tons per year SO2 and are therefore not subject to this rule. In other words, SO2 emissions from these industries are not classified as large sources and are not considered to be of concern. Based on the information presented by ATSDR, the TCEQ does not agree that there is a need for ambient air monitoring for sulfuric acid in Midlothian.

Response 6B: ATSDR disagrees that the SO_2 NAAQS is designed to protect against sulfuric acid aerosols. While it is a precursor of sulfates (a secondary PM), SO_2 is a gaseous pollutant, and sulfuric acid aerosols are fine particles. Thus, the SO_2 NAAQS is designed to protect against gaseous sulfur compounds, such as those noted by the reviewer. It is more likely that the $PM_{2.5}$ NAAQS considers sulfates, but $PM_{2.5}$ has not been evaluated for sulfates in Midlothian. A U.S. EPA assessment of the Houston "Supersite" air quality reported that $PM_{2.5}$ was comprised of up to 40% sulfates in the Houston metropolitan area (see http://www3.epa.gov/ttn/amtic/sshouston.html). While we know Midlothian and Dallas/Ft. Worth may have a different chemical profile for fine particles than Houston and we also agree that sulfur dioxide levels are substantially lower than they have been historically in Midlothian, we believe it would be valuable to conduct a short term analysis of this pollutant in $PM_{2.5}$ to estimate what portion of fine particulate is made up of sulfates as a health protective measure. This is particularly true if we consider that maximum 24-hour concentrations of PM ranged from 42.2-52.1 $\mu g/m^3$ from 2000-2011 at four area criteria pollutant monitoring stations in Midlothian; 40% of these values are higher than ATSDR's estimated 24-hour maximum modeled concentration of sulfuric acid aerosols (15.5 $\mu g/m^3$) presented in this document (see the ATSDR, 2016a *Health Consultation: Assessing the Public Health Implications of the Criteria (NAAQS) Air Pollutants and Hydrogen Sulfide* for additional details).

Sulfur dioxide is not a surrogate for sulfuric acid aerosol concentrations in air. The conversion of sulfur dioxide to sulfuric acid is dependent on various factors, including: the presence of hydrocarbons and nitrogen oxides, presence of different catalysts (like metallic salts), the presence of ammonia, the presence of adsorbent particles (like soot and metal oxide particles), the intensity of solar radiation, and temperature and humidity. Further, ATSDR has evaluated sites where sulfur dioxide was not a threat to human health, but concluded that sulfuric acid aerosols posed a public health hazard (e.g., http://www.atsdr.cdc.gov/hac/pha/pha.asp?docid=1047&pg=0).

Comment 7B: *It should also be noted that, as the state environmental agency, the role of TCEQ is to protect our state's public health and natural resources. Therefore, TCEQ considers protection of public health not only when evaluating ambient air data, but also when issuing air (or other media) authorizations. We use methods and models that are protective of public health with an adequate margin of safety.*

Response 7B: Thank you for your comment.