Health Consultation

MOTOROLA 52ND STREET

VAPOR INTRUSION CONCERNS:
REVIEW OF INDOOR AIR DATA FROM JULY 2011 TO FEBRUARY 2016 AT OPERABLE UNIT 1

PHOENIX, MARICOPA COUNTY, ARIZONA

EPA #: AZD009004177

June 28, 2017

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Summary

INTRODUCTION

In the *Motorola 52nd Street Site: Vapor Intrusion Concerns*, the Arizona Department of Health Services' (ADHS') top priority is to ensure that the community and residents have the best information possible to safeguard their health.

The Motorola 52nd Street Superfund Site (M52) is located in the east and central portion of Phoenix, Arizona. It is a large area mixed with commercial and residential buildings. The current contaminants of concern in the area are trichloroethene (TCE) and tetrachloroethene (PCE). Actions have been taken to reduce groundwater migration and contamination, and to prevent soil exposure. The Environmental Protection Agency (EPA) has been studying the possibility of soil vapor migration from contaminated groundwater into buildings, and its impact on indoor air quality.

From April to August 2011, Freescale (a corporate successor to Motorola) conducted soil gas investigations in the area. Elevated soil gas levels of TCE, PCE, or both were found in some locations. From July 2011 to February 2016, Freescale worked with EPA to collect additional indoor air, outdoor air, and sub-slab soil gas samples to help determine if vapor intrusion was occurring. ADHS reviewed the results of all these samples in order to assess the possible health effects of exposures to indoor air contaminants.

Based on the available information, ADHS concludes the following:

CONCLUSION 1

Detected chemicals (such as PCE and TCE) in indoor air are not expected to harm people's health at the sampling schools (i.e. Brunson-Lee, Sonoran Science Academy, Headstart, and Educare).

BASIS FOR CONCLUSION

The measured indoor air levels were below the Agency for Toxic Substance and Disease Registry (ATSDR)'s health-based screening values. In addition, estimated cancer risks were within the National Contingency Plan (NCP)'s target risk range of 1 in 1,000,000 to 1 in 10,000 (10^{-6} to 10^{-4}).

CONCLUSION 2

Detected chemicals in indoor air are not expected to harm workers' health at the sampled commercial buildings.

BASIS FOR CONCLUSION

The measured indoor air levels were below the comparison values. The estimated cancer risks were within NCP's target risk range.

One commercial building was found to have an elevated TCE concentration which could pose a potential health concern. Yet, this building is not occupied and is going through a deed restriction. Freescale has committed to installing appropriate mitigation when the new property use is identified. In order to keep track of the status of the building, from time to time, EPA will

	communicate with the Arizona Department of Transportation (the owner of the property and building).
CONCLUSION 3	Breathing PCE at levels detected in indoor air at homes in the Lindon Park, McDowell Northside, and McDowell Southside areas for a year or longer is not expected to harm people's health.
BASIS FOR CONCLUSION	The measured indoor air levels were below ATSDR's screening values. In addition, the estimated cancer risks were within NCP's target risk range.
CONCLUSION 4	In the past, residents at several homes at Lindon Park, McDowell Northside and Southside might have been exposed to TCE at levels that could harm their health. The greatest concern is the potential for heart defects in children whose mothers were exposed to elevated levels of TCE during the first trimester of their pregnancies.
BASIS FOR CONCLUSION	The measured TCE concentration exceeded the concentration associated with fetal heart defects.
CONCLUSION 5	In general, exposures to TCE are not expected to cause increased cancer risks among residents in Lindon Park, McDowell Southside, and McDowell Northside areas. ADHS cannot determine whether a significant cancer risk existed in the house that had the highest measurement at the McDowell Northside residential area.
BASIS FOR CONCLUSION	Based on the available data, the estimated cancer risks did not exceed NCP's target risk range. For one of the houses, ADHS cannot determine whether a significant cancer risk existed because the exposure is intermittent. In addition, the vapor intrusion-related indoor volatile organic compounds (VOC) levels probably vary greatly over time, and only one 24-hour sample was available.
CONCLUSION 6	In homes that have systems installed to reduce the level of TCE in indoor air, current indoor TCE levels are not expected to harm residents' health.
BASIS FOR CONCLUSION	The post-mitigation indoor air samples showed that the mitigation systems have effectively reduced TCE indoor levels to meet EPA's site-specific Interim Action Level (IAL) of 1 microgram per meter cubed ($\mu g/m^3$), which is ATSDR's comparison value for TCE.
NEXT STEPS	▪ Upon request, ADHS will continue to work with EPA and the Arizona Department of Environmental Quality (ADEQ) to evaluate the potential health effects associated with a vapor intrusion exposure pathway.

- ADHS will continue to attend additional public meetings, make presentations, develop handout literature, and engage in other actions to notify the property owners and residents in the area of the findings of this health consultation.
- ADHS will notify EPA and ADEQ regarding the findings of this report and will work with both agencies to evaluate the protectiveness of remedial action plans if requested.
- ADHS will remain available to review and evaluate data provided for this site upon request.

To protect the current and future health of individuals living near the M52 Superfund site, ADHS recommends that EPA, ADEQ, and the potentially responsible parties:

- Continue taking prompt actions to eliminate soil vapor intrusion and reduce indoor air levels, so that M52 neighborhood residences are not exposed to VOCs at levels that might pose a health concern.
- Continue reducing residential exposure by using engineering controls, such as a vapor intrusion mitigation system, at residences where vapor intrusion is found to pose a potential health concern.
- Continue monitoring the levels of VOCs in sub-slab soil gas and indoor air in homes that have been mitigated to ensure the efficiency of the mitigation systems.
- Conduct as-needed periodic soil gas and indoor air VOC monitoring in homes that currently do not warrant mitigation systems to ensure that future site conditions do not pose new hazards.
- Help residents identify potential indoor air sources for VOCs such as TCE, chloroform, and BDCM.

FOR MORE INFORMATION

Please call ADHS at 602-364-3118 and ask for more information on the Motorola 52nd Street Site.

Purpose

The Environmental Protection Agency (EPA) conducted indoor air sampling at the Motorola 52nd Street Superfund site to investigate the movement of volatile organic compounds (VOCs), such as tetrachloroethene (PCE) and trichloroethene (TCE), from subsurface soil and groundwater to the indoor air of buildings (i.e. vapor intrusion). At a community meeting, the Community Information Group (CIG) members recommended the Arizona Department of Health Services (ADHS) to evaluate the indoor sampling results to see whether the indoor air concentrations of VOCs from indoor air reach levels that could be harmful to human health.

Background

Site Description: The Motorola 52nd Street Superfund Site (M52) is located in the east and central portion of Phoenix, Arizona. It is a large area mixed with commercial and residential buildings. The site is generally between 52nd Street on the east, Palm Lane on the north, 7th Avenue on the west, and Buckeye Road on the south. It has been divided into three areas called operable units (OUs) for cleanup purposes (Figure 1).

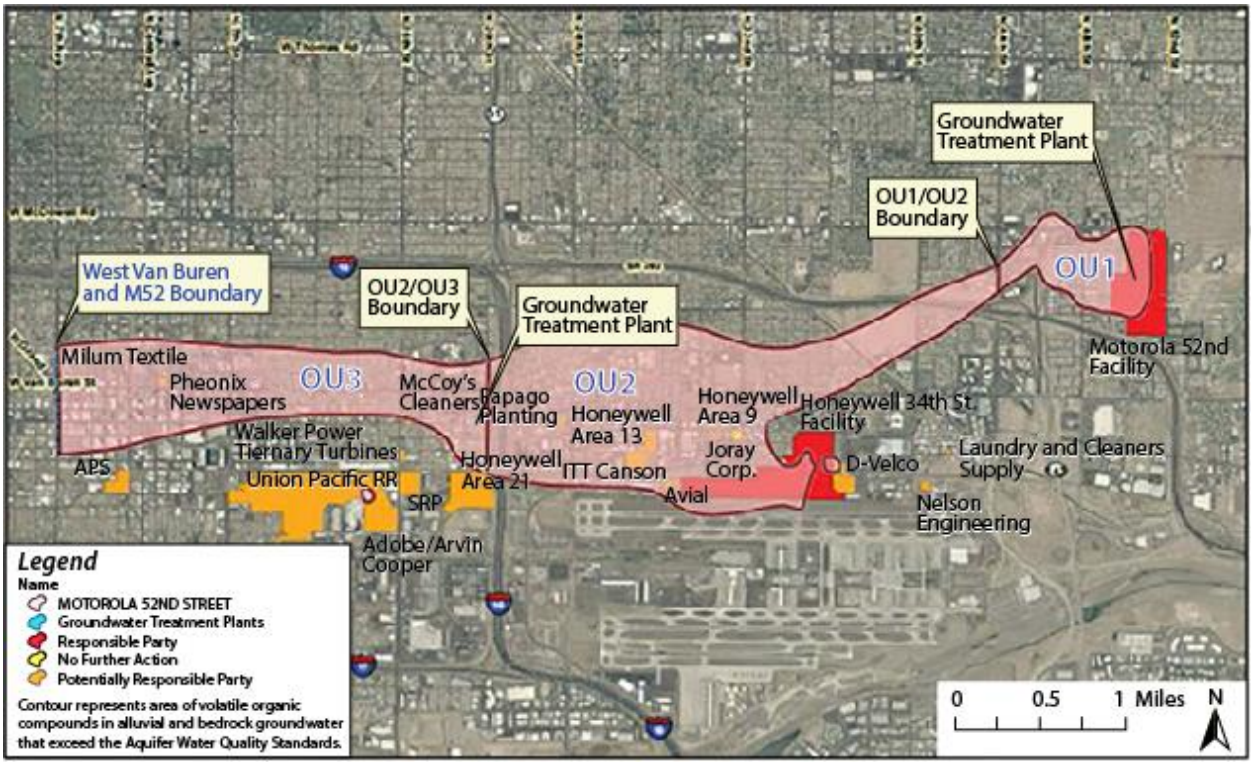

Figure 1. Site Map[1].

[1] The map is adapted from: https://clu-in.org/products/newsltrs/tnandt/view_new.cfm?issue=0815.cfm

Site History: The Motorola facility (mainly OU1) operated from 1956 to 1999. At the beginning of the operation, a septic tank and leach field were installed for domestic waste disposal, because city sewer services were not available. Industrial waste treatments and a neutralized industrial waste leach field were established for industrial wastes. In 1963, these systems were abandoned when city utilities became available and other treatment systems were installed. Since 1963, waste solvents have been collected in underground tanks or small containers, packed into drums, and staged in different areas onsite for disposal.

In 1982, Motorola reported that the 5,000 gallon underground storage tank (UST) had leaked 1,1,1-trichloroethane (TCA). In 1983, Motorola conducted a preliminary investigation, and the results indicated soil and groundwater at the facility were contaminated with high levels of TCE and TCA. The highest concentrations of contaminants were found in the courtyard area of the facility. The groundwater contamination continues to the west of the property.

Three identified primary source areas at the facility are: the courtyard, the Acid Treatment Plant (ATP), and the Southwest Parking Lot (SWPL). Chemicals known to have been released are: solvents (such as TCE, TCA, Freon and PCE), acids, cyanides, and sanitary sewage.

The site was placed on the National Priorities List (NPL) in November 1989 due to the presence of chlorinated solvents in soil and groundwater. Motorola entered into a Consent Order with the Arizona Department of Environmental Quality (ADEQ), EPA, ADHS, Arizona Department of Water Resources (ADWR), Salt River Project (SRP), and the cities of Phoenix and Scottsdale to characterize the nature and extent of contamination and recommend remedial actions.

ATSDR and ADHS Involvement:

In 1988, ATSDR completed a health assessment, and concluded that the site is not likely to pose any threats to human health because the contaminated levels at the point of extraction were below the levels of concern.

In 1992, ADHS completed a baseline risk assessment, and concluded that: *The risk of public exposure to groundwater is limited, and therefore causes no imminent health hazard.*

In 1993, ATSDR completed an update to the 1988 health assessment.

In 1996, ATSDR completed another update to the 1988 health assessment and the 1993 update to the health consultation.

In 2002, ADHS/ATSDR completed a health consultation to update the well use inventory for OU1 and OU2, and to provide an evaluation for groundwater exposure pathway in OU3. The report concluded that, based on the current usage statuses, all documented wells posed no public health hazard. Unregistered wells were not included in the evaluation.

In 2010, the Arizona Cancer Registry at ADHS reviewed the age adjusted cancer rates of primary sites of concern and all invasive cancer cases combined from the M52 Study Area and compared them with the age adjusted rates among Arizona residents for the same time period (2001-2006). This comparison found:

- Age adjusted cancer incidence rates from the M52 study area and the State of Arizona showed no significant difference between the two rates for: kidney, liver, lung, leukemia, non-Hodgkin lymphoma and prostate.
- The M52 study area had lower age adjusted cancer rates than the State of Arizona cancer rates for all cancers combined and thyroid cancer.

On April 3, 2014, ADHS attended the Community Information Group (CIG) meeting for the M52 Superfund site, and presented on the health consultation process and the findings of the 2010 Arizona Cancer Registry report.

Statement of Issues

The current contaminants of concern in the area are TCE and PCE.

Currently, public drinking water supply wells are not impacted by the site. The drinking water supplied by the City of Phoenix distribution system is primarily from surface water (98%) and limited groundwater (2%) from areas outside of the M52 site.

Some of the wells near residential areas have measured levels of TCE and PCE. TCE and PCE can volatilize and move from contaminated groundwater through air pockets in the soil into buildings. The vapors may accumulate in homes and other occupied buildings to levels that may cause health problems. This type of movement of contaminants into a building is called *vapor intrusion* (VI). Figure 2 shows a simple conceptual model of the VI pathway. Metals such as lead and arsenic do not cause indoor vapor problems because they do not evaporate. VOCs (such as PCE) or semi-VOCs (such as phenol, which can be found in mouthwashes) can easily become vapors and get into the indoor air.

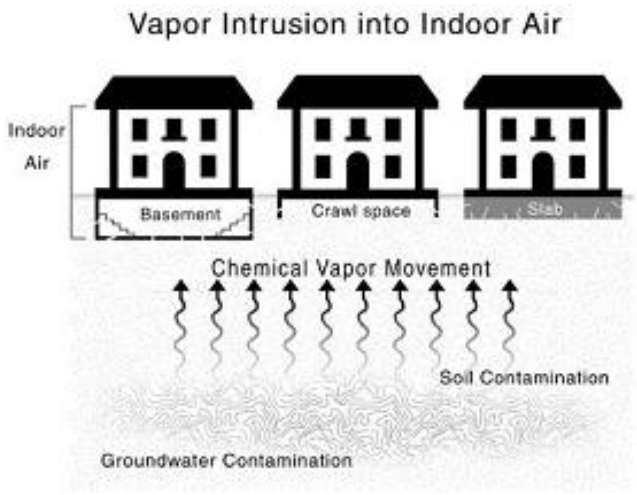

Figure 2 Vapor Intrusion Pathway, which refers to the movement of volatile chemicals from a contaminated subsurface into overlaying buildings or structures. (This picture is adapted from: (http://www.epa.gov/region07/factsheets/2010/faq_about_vapor_intrusion_201002.htm)

In 1992, ADEQ conducted soil gas studies in the residential area west of the facility. ADHS conducted an evaluation of the indoor and outdoor exposure pathways as a part of the baseline risk assessment for the Motorola 52nd Street facility. ADHS determined (based on the then-current understanding of TCE and PCE health risks) that both the indoor and outdoor exposure pathways were below the risk screening level for all locations.

EPA periodically re-evaluates the actions that have been taken at Superfund sites. EPA has been studying the possibility of soil vapor migration from contaminated groundwater into buildings and its impact on indoor air quality. Since then, EPA's understanding of the health risks of TCE and PCE, and the process of how they volatilize and can enter buildings that overlay contamination, has evolved. From April to August 2011, Freescale (a corporate successor to Motorola) conducted additional soil gas investigation in the area to re-evaluate whether there is a need to conduct indoor air samplings in this neighborhood.

A total of 79 soil gas samples were collected at 5 feet and 15 feet below the ground surface (bgs). In general, the measured concentrations were higher at 15 feet bgs because it is closer to the source of contamination in groundwater or bedrock. In some locations, soil gas levels exceeded screening values for TCE, PCE, or both. Therefore, from July 2011 to February 2016, Freescale worked with EPA to collect additional indoor air, outdoor air, and sub-slab soil gas samples beneath the slab foundation of the building to help determine if vapor intrusion was occurring.

In this health consultation, ADHS reviewed the results from indoor air, outdoor air, and the sub-slab soil gas samples. ADHS assessed the possible health effects based on the exposures to indoor air concentrations.

Discussion

General Assessment Methodology

ADHS generally follows a three-step methodology to assess public health issues related to environmental exposures. First, ADHS obtains representative environmental data for the site of concern and compiles a comprehensive list of site-related contaminants. Second, ADHS identifies exposure pathways, and then uses health-based comparison values to find those contaminants that do not have a realistic possibility of causing adverse health effects. For the remaining contaminants, ADHS reviews recent scientific studies to determine if exposures are sufficient to impact public health.

Available Environmental Data

ADHS reviewed the sub-slab and indoor and outdoor air sampling results provided by EPA.

In July and October 2011, Freescale conducted indoor air and sub-slab soil gas sampling activities in the areas with the highest chemical concentrations in soil gas (i.e. 50th Street,

Willetta Street, and the Monterey Village apartments.) In February 2012, additional samples were collected from homes, commercial buildings, and schools sampled in 2011. Freescale also collected samples from residences adjacent to those that had elevated TCE concentrations during the 2011 sampling events. Further samples were taken in the area at residences, schools, and commercial buildings approximately semiannually through July 2015. A sampling event solely of residences where mitigation systems have been installed was conducted in February 2016.

Sub-slab soil gas samples were collected from 2" to 6" below surface. Indoor air samples were collected near or at the same locations as the sub-slab samples. Indoor air samples were collected immediately prior to sub-slab samples to ensure that there were no interferences from the sub-slab sampling activity. Indoor air samples were collected from the location of highest use in the residences using certified Summa canisters. 24-hour samples were collected from a breathing zone of three (3) to seven (7) feet. Meteorological conditions and any unusual residential conditions were noted.

Outdoor samples were collected approximately one hour before the collection of the indoor air samples. The outdoor sample collection lasted approximately the same time period as the indoor air samples. Samples were collected from four (4) locations bounding the sampling neighborhoods. Indoor and outdoor air samples were analyzed for nine VOCs by EPA method TO-15 SIM.

Exposure Pathway Analysis

Identifying exposure pathways is important in a health consultation because adverse health impacts can only happen if people are exposed to contaminants. The presence of a contaminant in the environment does not necessarily mean that people are actually coming into contact with that contaminant. Exposure pathways have been divided into three categories: completed, potential, and eliminated.

There are five elements considered in the evaluation of exposure pathways:

1) *a source of contamination*: a chemical release, landfills, and others.
2) *an environmental media transport*: the way the contaminant is transported from the source, such as soil or groundwater.
3) *a point of exposure*: a place where people come into physical contact with the chemical, e.g., soil, air, groundwater, surface water, sediment, or food.
4) *a route of exposure*: how people come into physical contact with the chemical, e.g., breathing, drinking, eating, touching.
5) *a receptor population*: a group of people likely to come into physical contact with site-related chemicals.

Completed pathways exist when all five elements are present and indicate that exposure to a contaminant has occurred in the past and/or is occurring presently. In a *potential exposure pathway*, one or more elements of the pathway cannot be identified, but it is possible that the element might be present or might have been present. In *eliminated pathways*, at least one of the five elements is or was missing, and will never be present. Completed and potential pathways, however, may be eliminated when they are unlikely to be significant.

ADHS further evaluated the completed and potential exposure pathways to determine whether realistic exposures are sufficient in magnitude, duration or frequency to result in adverse health effects (Table 1).

Table 1. Exposure Analysis for Vapor Intrusion Exposure Pathway

Exposure Pathway Elements					Time frame	Type of Exposure Pathway
Source	Media	Point of exposure	Route of exposure	Potentially exposed population		
Contaminated Groundwater	Soil gas/ Indoor Air	Buildings over contaminated groundwater	Inhalation	Residents/ School staff & students/ commercial building workers	Past	Completed
					Current	Completed
					Future	Potential

Description of Health-based Comparison Values for Indoor Air Samples

Health-based comparison values (CVs) are screening tools used to evaluate environmental data relevant to exposure pathways. The comparison values are quite conservative, and usually include uncertainty factors that account for the most sensitive populations. Adverse health effects are not expected to occur if an exposure concentration/dose is below a CV. However, an exposure concentration/dose at or above the CV does not mean adverse effects will occur: rather, it means that there is a need to conduct a site-specific exposure scenario evaluation. The health risk for an individual depends on individual human factors (e.g. personal habits, occupation, and/or overall health), and site-specific environmental exposure factors (e.g. duration and amount of exposure.) Therefore, CVs should not be used to predict the occurrence of adverse health effects without looking at site-specific conditions. CVs are only used to help determine which contaminants need to be evaluated in more detail.

ADHS typically uses CVs as follows: if a contaminant is never found at levels greater than its CV, ADHS concludes the levels of corresponding contamination do not pose a risk to human health. If, however, a contaminant is found at levels that are greater than its CV, ADHS designates the pollutant as a *chemical of interest*, and examines potential human exposures in greater detail.

ADHS follows an environmental guideline hierarchy (Appendix A) for selecting health-based CVs. ADHS first uses screening values developed by ATSDR, such as Minimal Risk Levels (MRLs), Environmental Media Evaluation Guides (EMEGs), and Cancer Risk Evaluation Guides (CREGs) developed by ATSDR. If ATSDR screening values are not available, ADHS then uses screening values developed by EPA, such as Regional Screening Levels (RSLs) and Reference Concentrations (RFCs). If none of these CVs are available, ADHS makes use of other CVs, such as Chronic Ambient Air Guidelines (CAAGs) and Vapor Intrusion Screening Levels (VISLs). A description of these CVs can be found on page 16 and in Appendix B. The potential for exposed persons to experience adverse health effects depends on many factors such as 1) the amount

of chemical to which a person is or has been exposed; 2) the length of time a person is exposed; 3) the route by which a person is exposed (i.e. inhalation, ingestion, or dermal absorption); 4) the health condition of the person; 5) the nutritional status of the person; and 6) if the person is exposed to other chemicals (e.g. chemicals in the work place or chemicals in cigarettes).

Comparison to Health-based Comparison Values

Table 2 summarizes the results of indoor air samples collected from four schools, seven commercial buildings, and three residential areas (Lindon Park, McDowell Northside, McDowell Southside). The indoor air levels were compared to health-based CVs for cancer and non-cancer health effects. Where indoor air values exceeded these CVs, the potential for adverse health effects is further discussed below in the Public Health Implications Section. The identified chemicals (regardless of the source) are TCE, PCE, chloroform, and bromodichloromethane.

Table 2. A summary of the measured chemical concentrations in micrograms per cubic meter (µg/m^3) of indoor air samples collected from two schools and three residential areas: Lindon Park, McDowell Northside, and McDowell Southside from July 2011 to February 2016

Schools (Brunson-Lee, Sonoran Science Academy, Headstart, and Educare)

Chemical	Detected frequency	Detected range (µg/m^3)	Comparison value (µg/m^3)	Source of CV	Number of Samples Exceeds CV	Is it a Chemical of Interest?
1,1-Dichloroethene	0/50	ND[9]	79 200	EMEG[1] RfC[2]	0 0	No
1,1,2-Trichlorotrifluoroethane (F113)	48/50	ND – 0.89	20,000	CAAG[3]	0 0	No
cis-1,2-Dichloroethene	6/50	ND – 0.45	63	VISL[4]	0	No
1,1,1-Trichloroethane	0/50	ND	3,800 5,000	EMEG RfC	0	No
Trichloroethene (TCE)	11/50	ND – 0.58	2.1 2 0.22	EMEG RfC CREG[5]	0 3	**Yes**
Tetrachloroethene (PCE)	30/50	ND – 1.7	41 40 3.8	MRL RfC CREG	0 0 0	No
Chlorobenzene	2/50	ND – 0.22	52	RSL-nc[6]	0	No
Chloroform	30/32	ND – 0.63	98 0.03	EMEG CREG	0 29	**Yes**
Bromodichloromethane (BDCM)	1/27	ND – 0.2	0.076	RSL-c[7]	1	**Yes**

Lindon Park Area Residences

Chemical	Detected Frequency	Detected Range (µg/m^3)	Comparison Value (CV) (µg/m^3)	Source of CV	Number of Samples Exceeds CV	Is it a Chemical of Interest?
1,1-Dichloroethene	1/67	ND[9]– 0.31	79 200	EMEG[1] RfC[2]	0 0	No
1,1,2-Trichlorotrifluoroethane (CFC-113)	51/51	0.46 – 0.75	20,000	CAAG[3]	0 0	No
Cis-1,2-Dichloroethene	2/67	ND – 0.15	63	VISL[4]	0	No
1,1,1-Trichloroethane	17/67	ND – 2.9	3,800 5,000	EMEG RfC	0 0	No
Trichloroethene (TCE)	31/67	ND – 25	2.1 2 0.22	EMEG RfC CREG[5]	0 0 5	**Yes**
Tetrachloroethene (PCE)	42/52	ND – 3.2	41 40 3.8	MRL RfC CREG	0 0 0	**No**
Chloroform	41/41	0.21 – 8.4	98 0.03	EMEG CREG	0 39	**Yes**
Chlorobenzene	2/54	ND – 0.26	52	RSL-nc[6]	0	No
Bromodichloromethane	32/38	ND – 3.8	0.076	RSL-c[7]	30	**Yes**

McDowell Northside Residences

Chemical	Detected Frequency	Detected Range (µg/m^3)	Comparison Value (CV) (µg/m^3)	Source of CV	Number of samples Exceeds CV	Is it a Chemical of Interest?
1,1-Dichloroethene	0/85	ND[9]	79 200	EMEG[1] RfC[2]	0 0	No
1,1,2-Trichlorotrifluoroethane	80/80	0.44 – 0.72	20,000	CAAG[3]	0	No

Chemical	Detected Frequency	Detected Range (µg/m^3)	Comparison Value (CV) (µg/m^3)	Source of CV	Number of samples Exceeds CV	Is it a Chemical of Interest?
(CFC-113)						
Cis-1,2-Dichloroethene	1/85	ND – 5.8	63	VISL[4]	0	No
1,1,1-Trichloroethane	4/85	ND – 6.3	3,800 5,000	EMEG RfC	0 0	No
Trichloroethene (TCE)	57/85	ND – 7.9	2.1 2 0.22	EMEG RfC CREG[5]	2 2 23	**Yes**
Tetrachloroethene (PCE)	59/85	ND – 5.3	41 40 3.8	MRL RfC CREG	0 0 3	**Yes**
Chlorobenzene	0/80	ND	52	RSL-nc[6]	0	No
Chloroform	39/39	0.4 – 14	98 0.03	EMEG CREG[5]	0 21	**Yes**
Bromodichloromethane	32/36	ND – 6.6	0.076	RSL-c[7]	17	**Yes**

McDowell Southside Residences

Chemical	Detected Frequency	Detected Range (µg/m^3)	Comparison Value (CV) (µg/m^3)	Source of CV	Number of samples Exceeds CV	Is it a Chemical of Interest?
1,1-Dichloroethene	11/116	ND[9] – 1.1	79 200	EMEG[1] RfC[2]	0 0	No
1,1,2-Trichlorotrifluoroethane (F113)	114/114	0.39 – 0.85	20,000	CAAG[3]	0	No
Cis-1,2-Dichloroethene	4/116	ND – 0.2	63	VISL[4]	0	No
1,1,1-Trichloroethane	9/116	ND – 0.84	3,800 5,000	EMEG RfC	0 0	No

Chemical	Detected Frequency	Detected Range (µg/m^3)	Comparison Value (CV) (µg/m^3)	Source of CV	Number of samples Exceeds CV	Is it a Chemical of Interest?
Trichloroethene (TCE)	69/116	ND – 3.8	2.1 2 0.22	EMEG RfC CREG[5]	4 4 55	**Yes**
Tetrachloroethene (PCE)	103/116	ND – 37	41 40 3.8	MRL RfC CREG	0 0 8	**Yes**
Chlorobenzene	10/116	ND – 0.35	52	RSL-nc[6]	0	No
Chloroform	40/40	0.38 – 51	98 0.043	EMEG CREG[5]	0 40	**Yes**
Bromodichloromethane	35/38	ND – 12	0.076	RSL-c[7]	35	**Yes**

Commercial Buildings

Chemical	Detected frequency	Detected range (µg/m^3)	Comparison value[8] (µg/m^3)	Source of CV	Number of Samples Exceeds CV	Is it a Chemical of Interest?
1,1-Dichloroethene	0/38	ND[9]	316 800	EMEG[1] RfC[2]	0 0	No
1,1,2-Trichlorotrifluoroethane (F113)	38/38	0.42 – 1.2	80,000	CAAG[3]	0 0	No
cis-1,2-Dichloroethene	4/38	ND – 0.42	252	VISL[4]	0	No
1,1,1-Trichloroethane	2/38	ND – 0.85	15,200 20,000	EMEG RfC	0 0	No
Trichloroethene (TCE)	30/38	ND – 8.6	8.4 8 0.88	EMEG RfC CREG[5]	1 1 19	**Yes**
Tetrachloroethene (PCE)	33/38	ND – 7.6	164 160 15.2	MRL RfC CREG	0 0 0	No
Chlorobenzene	4/38	ND – 0.22	208	RSL-nc[6]	0	No
Chloroform	21/21	0.18 – 2.0	392 0.16	EMEG CREG	0 21	**Yes**

Chemical	Detected frequency	Detected range ($\mu g/m^3$)	Comparison value[8] ($\mu g/m^3$)	Source of CV	Number of Samples Exceeds CV	Is it a Chemical of Interest?
Bromodichloromethane (BDCM)	4/21	ND – 0.56	0.304	RSL-c[7]	3	**Yes**

1. EMEG: Environmental Media Evaluation Guide, developed by ATSDR, represents concentrations of substances in water, soil, and air to which humans might be exposed during a specific period of time (acute, intermediate or chronic) without experiencing adverse health effects.
2. RfC: Reference Concentration, developed by US EPA, is an estimate, considering uncertainty or safety factors, of the daily lifetime air concentration of a substance that is unlikely to cause harm in humans.
3. CAAG: Chronic Ambient Air Guideline, developed by Maine Center for Disease Control and Prevention: http://www.maine.gov/dhhs/mecdc/environmental-health/eohp/air/documents/06aags.pdf
4. VISL: Vapor Intrusion Screening Levels, developed by New Jersey Department of Environmental Protection: http://www.nj.gov/dep/srp/guidance/vaporintrusion/vig_update_tables.pdf
5. CREG: Cancer Risk Evaluation Guide, developed by ATSDR, is a media-specific comparison value that is used to identify concentrations of cancer causing substances that are unlikely to result in an increase of cancer rates in an exposed population after a lifetime of exposure.
6. RSL-nc: Regional Screening Levels for non-carcinogenic chemicals, developed by US EPA, are risk-based concentrations derived from standardized equations combining exposure information assumptions with EPA toxicity data. The values are considered to be protective for humans (including sensitive population) over a lifetime.
7. RSL-c: Regional Screening Levels for carcinogenic chemicals, developed by US EPA, are risk-based concentrations derived from standardized equations combining exposure information assumptions with EPA toxicity data. The values are considered to be protective for humans (including sensitive population) over a lifetime.
8. The comparison values were adjusted based on the length of a workday, assuming 8 hours/day and 5 days/week, for commercial buildings.
9. ND: non-detected

Uncertainty and Variability of Indoor Air Measurements

Volatile organic compounds (VOCs), such as PCE, TCE, and chloroform, are found in common household products and can be emitted as gases into the air as a source of indoor air contamination. Examples include: paints, paint strippers, cleaning supplies, air fresheners, cigarette smoke, dry-cleaned clothes, furniture, and new carpeting. Over the past ten years, there has been a phase-out of TCE from common household products. However, TCE is still present in some gun cleaning products, pepper spray formulations, and arts and crafts products. This might explain why some of the indoor air samples taken in the OU1 residences found various VOCs when very little of those particular VOCs were found in sub-slab soil gas samples. In those situations, vapor intrusion might not be an important source of the detected VOCs, and a sub-slab depressurization (mitigation) system would not reduce indoor air VOCs.

The concentration of indoor air contaminants can vary temporally and spatially. The indoor air levels of VOCs can vary because of indoor air pressure changes due to the use of heating and air conditioning systems and seasonal phenomena. The ability of soil gas to enter homes is dependent on many factors such as the type of building construction, number and size of cracks

in the building foundation/basement, and type of soil below and around the buildings (EPA 2012.)

During the winter months, fresh air exchange is reduced because homes are closed more tightly. A "stack effect" commonly results due to the indoor to outdoor air temperature differential as well as the operation of many types of heating systems (EPA 2012). The stack effect tends to cause more sub-slab soil gas to enter homes at a greater rate during winter months. Therefore, the indoor PCE and TCE concentrations resulting from vapor intrusion can be expected to vary throughout the year, and might be higher or lower than what was observed during any individual sampling event. EPA attempted to take indoor air samples in hotter and colder months to account for the temporal variation.

Chloroform and BDCM are common disinfection byproducts (trihalomethanes), which can be formed when chlorine or bromine interacts with the natural organic materials found in water during water treatment (CDC 2016). General population exposure to DBPs can occur primarily through ingesting chlorinated water or inhaling the water vapor. EPA implemented health based limits for trihalomethanes in drinking water in 2002 and tightened these limits in 2012. Therefore, off-gassing of chloroform and BDCM from tap water should be noted as one potential contributor to air concentrations at sampling locations.

Public Health Implications*: This section will provide general toxicological information and site-specific exposure evaluation for each contaminant of interest. The evaluation is based on indoor air data collected from July 2011 to February 2016. As conditions in buildings change, possible health impacts from exposures can change.*

Tetrachloroethene (Tetrachloroethylene, Perchloroethylene, PCE, PERC)

Non-Cancer Health Effects:

ATSDR established an acute Minimum Risk Level[2] (MRL) of 41 µg/m^3 (ATSDR 2014) for PCE. The highest measured PCE levels found in schools, commercial buildings, and the three residential areas were 1.7 µg/m^3, 7.6 µg/m^3 and 37 µg/m^3, respectively. Therefore, the measured indoor PCE levels are not expected to present a short-term public health concern.

ATSDR established a chronic MRL of 41 µg/m^3. This value was determined based on PCE-induced color vision loss from occupational exposures. A significant decrease in color vision was observed in dry cleaners exposed to a mean concentration of 49,000 µg/m^3. This value was converted to an equivalent continuous exposure concentration of 11,600 µg/m^3 in order to derive the chronic MRL. EPA established a Reference Concentration[3] (RfC) of 40 µg/m^3. An RfC is an estimate of a continuous inhalation exposure to the human population (including the sensitive population) that is unlikely to have harmful effects during a lifetime of exposure. It is

[2] Minimal risk level (MRL) is an ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to cause measurable noncancerous adverse health effects.

[3] Reference concentration (RfC) is an US EPA estimate of a continuous inhalation exposure concentration (including uncertainty and safety factors) to people (including sensitive population) that is unlikely to cause harm to humans.

generally developed by first determining the most sensitive target organ, and then identifying either a No Observed Adverse Effect Level[4] (NOAEL) or the Lowest Observed Adverse Effect Level[5] (LOAEL). PCE has two LOAELs: 1) 15,000 μg/m^3 for neurotoxicity observed in workers involving color vision changes (Cavalleri et al. 1994), and 2) 56,000 μg/m^3 for neurotoxicity involving reaction time and cognitive effects in workers (Echeverria et al. 1995). After applying an uncertainty factor of 1,000, the midpoint of these two values was chosen as the RfC for PCE (EPA IRIS 2015).

The highest measured PCE level found in the schools, commercial buildings, and residences from areas of Lindon Park, McDowell North and McDowell South did not exceed the RfC; therefore, the measured indoor PCE levels are not expected to present a long-term, non-cancerous public health concern.

Cancer Health Effects:

The US Department of Health and Human Services (DHHS) has determined that PCE may reasonably be anticipated to be a human carcinogen (NTP 2011). The International Agency for Research on Cancer (IARC) has classified PCE as a Group 2A carcinogen: probably carcinogenic to humans due to limited evidence in humans and sufficient evidence in animals (IARC 1995). EPA classified PCE as "*likely to be carcinogenic to humans*" by all routes of exposure based on increased tumor incidences in animal studies, and suggestive association between PCE exposure and cancer from epidemiologic studies (EPA IRIS 2015). In 2012, EPA determined the Inhalation Unit Risk (IUR) to be 2.6 ×10^{-7} per μg/m^3 based on the mouse liver tumor data from the JISA (1993) bioassay. The IUR is the excess lifetime cancer risk estimated to result from continuous exposure to a substance at a concentration of 1 μg/m^3 in air.

The highest measured PCE levels found in the schools, commercial buildings, and residences at Lindon Park Area did not exceed their respective comparison values for cancerous health effects (Table 2); therefore, the measured indoor PCE levels do not present a long-term cancerous public health concern at school or Lindon Park area.

The highest measured PCE concentrations at McDowell Northside (9.3 μg/m^3) and Southside (37 μg/m^3) exceeded ATSDR's CREG. ADHS estimated the potential cancer risks using the highest detected PCE concentration as a potential worst-case situation (37 μg/m^3). The estimated cancer risk is 4 × 10^{-6} (Appendix D). This represents about 4 possible extra cancer cases in a population of 1,000,000 over a lifetime.

EPA has established a target risk range of 1 in 1,000,000 to 1 in 10,000 (10^{-6} to 10^{-4}) for hazardous waste sites. Based on the available data, the estimated cancer risks did not exceed the EPA target risk range. The actual risk is likely to be less because exposure is likely to be intermittent. For example: the residential exposure is not likely to be 24 hours a day, 7 days a week, and 52 weeks a year.

[4] No Observed Adverse Effect Level (NOAEL): the highest tested level of a substance that has been reported to have no adverse/harmful health effects in animal or human studies

[5] Lowest Observed Adverse Effect Level (LOAEL): the lowest tested level of a substance that has been reported to cause adverse/harmful health effects in animals or human studies

Trichloroethene (TCE)

Non-Cancer Health Effects

Exposure to high levels (> 300,000 μg/m^3) can irritate the eyes and respiratory tract, and can cause dizziness, headache, sleepiness, nausea, confusion, blurred vision, and fatigue. ATSDR has not developed an acute inhalation MRL for TCE due to lack of proper information (ATSDR 2014).

Both human epidemiologic data and animal studies showed that exposure to TCE can cause non-cancerous adverse effects to the central nervous system, kidney, liver, immune system, male reproductive system, and the developing fetus. The most sensitive effects are developmental, kidney, and immunological (EPA IRIS 2015). The US EPA determined an inhalation RfC of 2 μg/m^3 based on immunological effect (decreased thymus weight in adult mice), and critical heart effect (increased cardiac malformation in rat fetuses) from oral exposure studies (EPA IRIS 2015). ATSDR adopted the value of 2.1 μg/m^3 as its chronic inhalation MRL (ATSDR 2014). EPA derived the exposure levels that may be expected to cause the same effects in humans (i.e. human equivalent concentration, HEC). The HECs are 21 μg/m^3 for fetal heart malformation with an uncertainty factor of 10, and 190 μg/m^3 for immunological effects with an uncertainty factor of 100 (EPA IRIS 2015). Depending on the exposure dose and length, the immunological and kidney effects could potentially occur in children and adults. EPA also derived a HEC of 30 μg/m^3 (with a lower confidence) based on the 1988 NTP study. That is, there is a 5% chance of developing kidney damage when people are exposed to TCE above 30 μg/m^3.

The highest measured TCE indoor air concentration in schools (0.58 μg/m^3) did not exceed EPA's RfC of 2 μg/m^3. Therefore, the measured indoor TCE levels do not present a non-cancerous public health concern to school staff.

One of the commercial buildings was found to have TCE concentrations above the comparison value. It is going through the process of a deed restriction. It is still an unoccupied building with plans to be sold and used as a parking lot. Freescale has committed to install appropriate mitigation when the new property use is identified. In order to keep track of the status of the building, from time to time, EPA communicates with Arizona Department of Transportation (the owner of the property and building) to keep track of the status of the building.

The highest measured TCE indoor air concentrations exceeded the ATSDR's chronic EMEG and EPA RfC of 2 μg/m^3 in 16 homes. The highest measured TCE indoor air level (25 μg/m^3) was detected in a residence at the Lindon Park area in October 2014. The second highest measured TCE indoor air level was detected in a residence at the McDowell Northside area in February 2012. These values were slightly above the HEC that reported fetal heart malformations (EPA IRIS 2015). Thus, there is a potential for developmental effects if a woman was exposed to this level during the three week window of critical fetal heart development in the first trimester of pregnancy. A mitigation system was installed in both homes, and post-mitigation samples indicated that the TCE indoor level has been reduced to less than 1.5 μg/m^3.

EPA installed mitigation systems in 16 homes (Table 3) that may be potentially impacted by vapor intrusion. The goal is to ensure that the TCE indoor air concentration is below 2 μg/m^3. The selection criteria were in-home sub-slab TCE concentrations 1,000 μg/m^3 or higher, indoor

air TCE data above 1-1.5 µg/m^3, written consent/access from the home property/owner, and the subsurface TCE soil vapor concentrations between 5'-15' below ground surface (bgs) from the vicinity of the building/homes that were above those residential EPA Superfund soil gas screening levels in effect at the time of sampling for the M52 site.

After installation of the mitigation system, EPA monitors indoor air for a minimum of 2 years. Homeowners were taught how to read the mitigation gauge and were given contact information to call if the gauge is not in the typical position. In 2013, the initial post mitigation indoor air sample results indicated that 1 of the 16 homes had TCE concentration of 4 µg/m^3, and the remaining homes had TCE concentrations reduced to less than 2 µg/m^3. The owner of the home with the elevated TCE concentration agreed to system upgrades and additional suction points were installed. The home owner also moved chemicals from an indoor storage to an outdoor storage shed. As a result, the TCE indoor air results have decreased to less than 2 µg/m^3 (Table 3).

Table 3. Trichloroethene (TCE) indoor air concentrations before and after installation of mitigation systems.

	Mitigation Location	Description	Sample Type	Sample Date	TCE (µg/m^3)
Lindon Park	1		Indoor Air	07/25/11	1.4
	1	Post-mitigation sample	Indoor Air	10/28/14	5.8
	1	Post-mitigation sample	Indoor Air	02/24/15	ND
	1	Post-mitigation sample	Indoor Air	02/25/16	ND
	1		Indoor Air	07/25/11	0.31
	1	Post-mitigation sample	Indoor Air	10/28/14	0.38
	1	Post-mitigation sample	Indoor Air	02/26/16	0.40
McDowell Northside	2		Indoor Air	08/16/12	0.72
	2		Indoor Air	02/21/13	1.8
	2		Indoor Air Duplicate	02/21/13	1.1
	2	Post-mitigation sample	Indoor Air	08/20/13	4
	2	Post-mitigation sample	Indoor Air	02/12/14	0.33
	2	Post-mitigation sample	Indoor Air Duplicate	02/12/14	0.31
	2	Post-mitigation sample	Indoor Air	02/24/15	0.17
	2	Post-mitigation sample	Indoor Air	02/25/16	0.27

	Mitigation Location	Description	Sample Type	Sample Date	TCE (µg/m^3)
McDowell Northside	3		Indoor Air	10/05/11	0.53
	3		Indoor Air	02/22/12	3.8
	3		Indoor Air	08/15/12	0.3
	3	Post-mitigation sample	Indoor Air	08/20/13	0.86
	3	Post-mitigation sample	Indoor Air	02/12/14	0.7
	3	Post-mitigation sample	Indoor Air	02/25/15	0.35
	3	Post-mitigation sample	Indoor Air	02/25/16	0.53
McDowell Northside	4		Indoor Air	10/05/11	0.42
	4		Indoor Air	02/21/12	2.6
	4		Indoor Air	08/17/12	ND
	4	Post-mitigation sample	Indoor Air	08/21/13	0.55
	4	Post-mitigation sample	Indoor Air	02/11/14	0.29
	4	Post-mitigation sample	Indoor Air	02/24/15	ND
	4	Post-mitigation sample	Indoor Air	02/26/16	0.65
McDowell Northside	5		Indoor Air	02/23/12	24
	5	Post-mitigation sample	Indoor Air	07/17/12	0.89
	5	Post-mitigation sample	Indoor Air	02/19/13	1.3
	5	Post-mitigation sample	Indoor Air	02/11/14	0.47
	5	Post-mitigation sample	Indoor Air Duplicate	02/11/14	0.52
	5	Post-mitigation sample	Indoor Air	02/27/16	0.36
McDowell Northside	6		Indoor Air	02/23/12	5.1
	6		Indoor Air Duplicate	02/23/12	3.9
	6	Post-mitigation sample	Indoor Air	07/17/12	0.25
	6	Post-mitigation sample	Indoor Air	02/19/13	0.30
	6	Post-mitigation sample	Indoor Air	02/11/14	0.27
	6	Post-mitigation sample	Indoor Air	02/25/16	1.1
McDowell	7		Indoor Air	02/24/12	7.6

	Mitigation Location	Description	Sample Type	Sample Date	TCE (µg/m^3)
Northside	7		Indoor Air – EPA	02/24/12	9.3
	7	Post-mitigation sample	Indoor Air	02/21/13	0.19
	7	Post-mitigation sample	Indoor Air	02/11/14	0.59
	7	Post-mitigation sample	Indoor Air	02/24/15	0.18
	7	Post-mitigation sample	Indoor Air	02/25/16	0.22
McDowell Northside	8		Indoor Air	02/22/12	12
	8		Indoor Air – EPA	02/22/12	10
	8	Post-mitigation sample	Indoor Air	07/17/12	1.2
	8	Post-mitigation sample	Indoor Air Duplicate	07/17/12	1.1
	8	Post-mitigation sample	Indoor Air – EPA	07/17/12	1.1
	8	Post-mitigation sample	Indoor Air	08/15/12	2.4
	8	Post-mitigation sample	Indoor Air	02/20/13	0.87
	8	Post-mitigation sample	Indoor Air	02/12/14	0.53
	8	Post-mitigation sample	Indoor Air	02/26/16	0.42
McDowell Northside	9		Indoor Air	02/24/12	14
	9	Post-mitigation sample	Indoor Air	08/21/13	0.43
	9	Post-mitigation sample	Indoor Air-EPA	08/21/13	0.52
	9	Post-mitigation sample	Indoor Air-EPA Dup.	08/21/13	0.55
	9	Post-mitigation sample	Indoor Air	02/11/14	0.38
	9	Post-mitigation sample	Indoor Air	02/24/15	0.26
	9	Post-mitigation sample	Indoor Air	02/25/16	0.22
McDowell Northside	10	Post-mitigation sample	Indoor Air	02/19/13	0.43
	10	Post-mitigation sample	Indoor Air	02/11/14	0.45
	10	Post-mitigation sample	Indoor Air	02/24/15	0.31
	10	Post-mitigation	Indoor Air	02/25/16	ND

	Mitigation Location	Description	Sample Type	Sample Date	TCE (µg/m^3)
		sample			
	10	Post-mitigation sample	Indoor Air Duplicate	02/25/16	0.32
McDowell Northside	11		Indoor Air	10/05/11	2.4
	11		Indoor Air Duplicate	10/05/11	2.1
	11	Post-mitigation sample	Indoor Air	07/17/12	0.56
	11	Post-mitigation sample	Indoor Air	02/20/13	ND
	11	Post-mitigation sample	Indoor Air	02/11/14	0.25
	11	Post-mitigation sample	Indoor Air	02/25/16	0.16
	11	Post-mitigation sample	Indoor Air Duplicate	02/25/16	0.17
McDowell Northside	12		Indoor Air	10/05/11	1.3
	12	Post-mitigation sample	Indoor Air	07/17/12	0.53
	12	Post-mitigation sample	Indoor Air	02/19/13	0.95
	12	Post-mitigation sample	Indoor Air	02/11/14	0.33
	12	Post-mitigation sample	Indoor Air	06/10/15	0.34
	12	Post-mitigation sample	Indoor Air	02/25/16	0.16
McDowell Northside	13		Indoor Air Duplicate	02/24/12	3.6
	13		Indoor Air	02/24/12	3.7
	13	Post-mitigation sample	Indoor Air	07/17/12	0.36
	13	Post-mitigation sample	Indoor Air	02/19/13	0.15
	13	Post-mitigation sample	Indoor Air	02/11/14	0.18
	13	Post-mitigation sample	Indoor Air	02/25/16	0.26
McDowell Northside	14		Indoor Air	10/05/11	0.28
	14	Post-mitigation sample	Indoor Air	07/17/12	1.1
	14	Post-mitigation sample	Indoor Air	02/20/13	0.24
	14	Post-mitigation sample	Indoor Air Duplicate	02/20/13	0.22

	Mitigation Location	Description	Sample Type	Sample Date	TCE (µg/m^3)
	14	Post-mitigation sample	Indoor Air	02/11/14	0.2
	14	Post-mitigation sample	Indoor Air	02/25/16	0.3
McDowell Northside	15		Indoor Air	07/17/12	2.6
	15		Indoor Air	08/15/12	0.86
	15		Indoor Air – EPA	08/15/12	0.83
	15	Post-mitigation sample	Indoor Air	02/20/13	0.17
	15	Post-mitigation sample	Indoor Air	08/20/13	3.1
	15	Post-mitigation sample	Indoor Air	02/12/14	ND
	15	Post-mitigation sample	Indoor Air	02/24/15	0.2
	15	Post-mitigation sample	Indoor Air	02/25/16	0.27
Lindon Park	16		Indoor Air	08/15/12	0.9
	16		Indoor Air	02/21/13	1.4
	16		Indoor Air	02/12/14	0.96
	16		Indoor Air-EPA	07/24/14	ND
	16		Indoor Air-EPA	07/24/14	ND
	16		Indoor Air	10/28/14	14
	16		Indoor Air	10/28/14	25
	16		Indoor Air – EPA	03/04/15	1.2
	16		Indoor Air – EPA	03/04/15	1.4
	16		Indoor Air – EPA	03/04/15	1.5
	16		Indoor Air – EPA	03/04/15	1.2
	16		Indoor Air – EPA	03/04/15	1.2
	16		Indoor Air – EPA	03/04/15	1.2
	16	Post-mitigation sample	Indoor Air	06/10/15	0.18
	16	Post-mitigation sample	Indoor Air Duplicate	06/10/15	0.18
	16	Post-mitigation sample	Indoor Air	02/25/16	0.2

The highest detected indoor air TCE concentrations in four of the homes (#38, 71, 75 and 76) exceeded the EMEG and RfC. However, the TCE concentrations in sub-slab soil gas did not

exceed the sub-slab rank indicator. A complete vapor intrusion exposure pathway is not evident from the available data. It is possible that indoor sources could be contributing TCE in indoor areas at that location. EPA reported that 50% of homes in urban areas have TCE concentrations up to 1.1 µg/m^3 in indoor air due to the common home use of commercial products containing TCE (EPA 2011). Additional indoor air samples were collected in 2013, and the TCE concentrations were below 2 µg/m^3 in those homes.

One of the residences had the detected indoor TCE concentration of 2.8 µg/m^3 in February 2012. The TCE concentrations in sub-slab (1,200, 2,400, and 2,500 µg/m^3) also exceeded the sub-slab rank indicator. TCE detected in indoor air at the residence can be related to vapor intrusion. The homeowner declined the installation of a mitigation system. Additional indoor air samples were collected in February 2014, and June 2015. Both measured TCE concentrations were below 2 µg/m^3 (0.39 µg/m^3 for the 2014 sample, and non-detect for the 2015 sample).

Cancer Health Effects

EPA classified TCE as "carcinogenic in humans by all routes of exposure" based on a causal association between TCE exposure in humans and kidney cancer, and positive cancer bioassays of mice and rats (EPA IRIS 2015). IARC has classified TCE as carcinogenic to humans (Group 1) (Guha 2012). The National Toxicological Program (NTP) determined that TCE is "reasonably anticipated" to be a human carcinogen based on limited evidence in humans and sufficient evidences in animals (NTP 2011).

EPA reviewed numerous human epidemiological data. Based on these reviews, EPA found that the evidence is convincing for TCE exposure and kidney cancer: higher exposure groups showed higher risks for kidney cancer. Significant increased risk of non-Hodgkin's lymphoma with TCE exposure was reported in three human epidemiological studies. Low incidences of liver and gallbladder cancer with TCE exposure were reported in some studies. EPA determined an inhalation unit risk of 4.1×10^{-6} based on effects on three target tissues: kidney (kidney cancer), lymphoid tissue (non-Hodgkin's lymphoma), and liver (liver cancer).

The highest measured TCE concentrations at schools, commercial buildings, Lindon Park Area, McDowell Northside, and Southside exceeded their respective comparison values (Table 2). EPA has set a site-specific Interim Action Level (IAL) of 1 µg/m^3 for addressing TCE vapor intrusion inhalation exposures. ADHS estimated a range of cancer risks from TCE exposure using EPA's Interim Action Level (IAL), and the highest TCE indoor air levels at each area.

Using the highest TCE concentrations as a potential worst-case situation, the estimated cancer risks are listed below (Appendix D):

Location	Highest Measurements (µg/m^3)	Estimated Cancer Risk for potential worst-case scenarios	
Schools	0.58	1.7×10^{-7}	It represents about 2 possible extra cancer cases in a population of 10,000,000 over a

			lifetime.
Commercial buildings	8.6	2.6×10^{-6}	It represents about 3 possible extra cancer cases in a population of 1,000,000 over a lifetime.
Lindon Park residences	25	1×10^{-4}	It represents about 1 possible extra cancer cases in a population of 10,000 over a lifetime.
Lindon Park residences	16.6	6.6×10^{-5}	It represents about 7 possible extra cancer cases in a population of 100,000 over a lifetime.
McDowell Southside residences	3.8	1.5×10^{-5}	It represents about 2 possible extra cancer cases in a population of 100,000 over a lifetime.
McDowell Northside residences	24	9.5×10^{-5}	It represents about 10 possible extra cancer cases in a population of 100,000 over a lifetime.
EPA's IAL	1	2×10^{-6}	It represents about 2 possible extra cancer cases in a population of 1,000,000 over a lifetime.

Based on the data collected from 2011 to 2016, the estimated cancer risks for school staff, commercial building workers, and residents at McDowell Southside did not exceed the NCP's target risk range of 1 in 1,000,000 to 1 in 10,000 (10^{-6} to 10^{-4}) for hazardous waste sites.

For the Lindon Park residence area, the highest measured TCE concentration was 25 µg/m^3, detected in October 2014. The TCE measurements in this residence ranged from non-detected to 25 µg/m^3 from August 2012 to February 2016. ADHS used the highest 95% UCL (upper confidence level of the arithmetic mean) of 16.6 µg/m^3 as a reasonable maximum exposure concentration to calculate the cancer risk. The estimated cancer risk did not exceed the NCP's target risk range. After a mitigation system was installed in 2015, the post-mitigation samples were below EPA's IAL, representing a 2×10^{-6} cancer risk.

For the McDowell Northside residence area, the highest measured TCE concentration was 24 µg/m^3, detected in February 2012. There was only one measurement available for this house. Using this value as the exposure concentration, the estimated cancer risk was about to exceed the EPA target cancer risk range, which indicates that exposure to the highest indoor TCE concentration over a lifetime might be associated with an elevated cancer risk. A mitigation system was installed right after the investigation, and the post-mitigation samples were below EPA's IAL.

ADHS could not determine whether a significant cancer risk exists from the past exposure (i.e. before installation of mitigation systems) for this house because the estimated cancer risk might be lower due to intermittent exposure (not 24 hours a day, 7 days a week, and 52 weeks a year). Also, the vapor intrusion-related indoor air VOC levels probably vary greatly (higher and

lower) over time, and only one measurement was available for this house. A mitigation system was installed right after the initial investigation, and all post-mitigation sampling results were below the EPA's IAL. All other houses had an averaged TCE concentration below the EPA's IAL. Therefore, elevated cancer risk is not expected based on the available data.

Chloroform and Bromodichloromethane (BDCM)

Chloroform and BDCM are by-products from chlorinating potable water and are commonly found in indoor air. At high enough concentrations for long enough periods of time, chloroform and BDCM could cause non-cancer or cancer health effects.

In 2002, EPA set a health based limit for total trihalomethanes of 80 µg/L. This limit was a running annual average of all the sampling sites in the distribution system. This allowed some sites to have trihalomethanes concentrations over 80 µg/L as long as other sites offset this by being well under the limit. Drinking water supplied by the city of Phoenix met the EPA health based limits for trihalomethanes established in 2002. In 2012, EPA tightened the health based limit for total trihalomethanes by making 80 µg/L a locational running annual average, meaning that every site within the distribution system must meet the 80 µg/L limit. To meet the tightened 2012 limits for trihalomethanes, the city conducted extensive research and invested approximately $300 million in new treatment processes and operational practices. These improvements were under construction during 2011. After completion of the improvements, the city saw a substantial drop in trihalomethanes levels in the drinking water in 2012 with results well below the new EPA health based limits. This substantial drop in trihalomethanes levels is also reflected in the EPA indoor air sampling results for the few homes with results for chloroform and BDCM measured in both 2011 and 2012 (Table 4).

The concentrations of chloroform and BDCM would be expected to fluctuate as water use fluctuates throughout the day and day-by-day. For example, chloroform and BDCM can be released with water vapor while running hot water and can linger in the air for a short period of time. The sampling protocol followed in the vapor intrusion study was designed to understand the vapor intrusion exposure pathway, and inadvertently measured varying levels of chloroform and BDCM. There is no evidence that these chemicals are present in indoor air due to vapor intrusion. Because the measured levels in the homes vary significantly and only one measurement is taken in most homes, ADHS is unable to estimate potential risk (Table 4).

Table 4. Some measured concentrations of chloroform and BCDM.

Residence Location	Chemical	Sample Type	Concentration (µg/m^3); (Sampling Date)	Concentration (µg/m^3); (Sampling Date)
Lindon Park Area	Chloroform	Indoor air	8.4 (7/25/11)	0.21 (2/23/12)
		Sub-slab soil gas	Not detected (7/25/11)	—
McDowell Northside		Indoor air	14 (10/5/11)	5.3 (2/24/12)
		Sub-slab soil gas	Not detected (10/6/11)	Not detected (2/23/12)

Residence Location	Chemical	Sample Type	Concentration (µg/m^3); (Sampling Date)	Concentration (µg/m^3); (Sampling Date)
McDowell Southside		Indoor air	51 (10/5/11)	
		Sub-slab soil gas	76 (10/6/11)	
McDowell Southside		Indoor air	11 (10/5/11)	
		Sub-slab soil gas	74, 79 (10/6/11)	
Lindon Park Area	BDCM	Indoor air	3.2 (7/25/11)	0.41 (2/23/12)
		Sub-slab soil gas	37 (7/26/11)	—
Lindon Park Area		Indoor air	1.2 (7/26/11)	ND (7/27/11)
		Sub-slab soil gas	0.38 (2/23/12)	—
McDowell Northside		Indoor air	6.6 (10/5/11)	2.7 (2/24/12)
		Sub-slab soil gas	ND (10/6/11)	ND (2/23/12)
McDowell Southside		Indoor air	12 (7/25/11)	—
		Sub-slab soil gas	ND (7/26/11)	—
McDowell Southside		Indoor air	9.6 (7/25/11)	—
		Sub-slab soil gas	ND (7/26/11)	—

Child Health Concern

ADHS recognizes that the unique vulnerabilities of infants and children demand special emphasis in communities faced with contaminants in environmental media. A child's developing body systems can sustain permanent damage if toxic exposures occur during critical growth stages. Children may absorb chemicals in greater amounts by inhalation due to increased respiration rate per kg body weight, and the fact that the alveolar surface is 2-fold larger in infants compared to adults (EPA 2008). Furthermore, children often engage in vigorous outdoor activities, making them more sensitive to pollution than healthy adults. All health analyses in this report take into consideration the unique vulnerability of children.

Conclusions

This health consultation evaluated the health risks associated with exposure to indoor air samples. Based on the available information, ADHS concludes the following:

PCE

- The measured PCE indoor levels were below the ATSDR's MRL of 41 µg/m^3. Therefore, harmful noncancerous health effects are not expected to occur among school staff, commercial building workers, and residents at Lindon Park, McDowell Northside and Southside areas.

- Based on the available data, the cancer risks did not exceed NCP's target risk range of 1 excess cancer case in 1,000,000 to 1 excess cancer case in 10,000 (10^{-6} to 10^{-4}) for hazardous waste site. The measured PCE indoor levels do not present a long-term cancerous health concern for school staff, commercial building workers, and residents at Lindon Park, McDowell Northside and Southside areas.
- The actual risks are likely to be less because exposure is likely to be intermittent. For example: the residential exposure is not likely to be 24 hours a day, 7 days a week, and 52 weeks a year.

TCE

- The indoor TCE level does not present a health concern to school staff because the highest measurement did not exceed the ATDSR's chronic EMEG and EPA RfC, and the corresponding cancer risk was within NCP's target risk range. The actual risks are likely to be less because exposure is likely to be intermittent.
- The indoor TCE level does not present a health concern to commercial building workers. One commercial building was found to have elevated TCE concentration that could pose potential health concern. Yet, this building is not occupied and is going through a deed restriction. Freescale has committed to install appropriate mitigation when the new property use is identified. From time to time, EPA communicates with Arizona Department of Transportation (the owner of the property and building) to keep track of the status of the building.
- Past Condition (before the installation of mitigation systems):

  Non-cancerous health effects:

  - Based on the available data, residents at several homes at Lindon Park, McDowell Northside and Southside might have been exposed before mitigation systems were installed to indoor air concentrations contaminated with TCE at levels that could harm their health.
  - The noncancerous health effect of greatest concern is the potential for heart defects in children whose mother were exposed to elevated levels of TCE during the first trimester of their pregnancy. A mitigation system was installed in 16 houses and all the post-mitigation samples were below the EPA's IAL of 2 $\mu g/m^3$.

  Cancerous health effects:

  - Exposure to elevated levels of TCE can increase the risk of developing kidney cancer. Based on the available data, the estimated cancer risks for worst-case scenarios at Lindon Park and McDowell Southside residential areas did not exceed NCP's target risk range.
  - For the McDowell residential area, all houses, except one, had an averaged TCE concentration below the EPA's IAL representing a cancer risk of 7.9×10^{-6}. Therefore, elevated cancer risk is not expected based on the available data.

- ADHS cannot determine whether a significant cancer risk existed in the house having the highest measurement at the McDowell Northside residential area because the cancer risk might be lower due to intermittent exposure. Also, the vapor intrusion-related indoor air VOC levels probably vary greatly (higher and lower) over time and only one discrete 24-hour sample was available. A mitigation system was installed in this house, and all post-mitigation air sampling results were within the EPA's IAL.

- Current Condition (after the installation of mitigation systems):
  - EPA's IAL is 1 $\mu g/m^3$. The post-mitigation indoor air samples showed that the installed mitigation systems have effectively reduced TCE indoor air concentrations to levels that do not pose a public health concern.
  - Residents should identify potential indoor air sources to reduce TCE exposure if their homes are still having elevated TCE indoor levels, which are not due to vapor intrusion.
  - Residents are encouraged to use an engineering control, such as a mitigation system to quickly reduce TCE exposure, if their homes have elevated TCE indoor levels which cannot be attributed to indoor air sources.

Recommendations

To protect the current and future health of individuals living near the M52 Superfund site, ADHS recommends the following:

- Continue taking prompt actions to eliminate soil vapor intrusion and reduce indoor air levels, so that M52 neighborhood residences are not exposed to VOCs at levels that might pose a health concern.
- Continue reducing residential exposure by using engineering controls, such as vapor intrusion mitigation systems, at residences where vapor intrusion is found to pose a potential health concern.
- Continue monitoring the levels of VOCs in sub-slab soil gas and indoor air at homes that have been mitigated to ensure the efficiency of the mitigation systems.
- Conduct as-needed periodic soil gas and indoor air VOC monitoring in homes that currently do not warrant mitigation systems to ensure that future site conditions do not pose new hazards.
- Help residents identify potential indoor air sources for VOCs such as TCE, chloroform, and BDCM.

Public Health Action Plan

- Upon request, ADHS will continue to work with EPA and ADEQ to evaluate the potential health effects associated with vapor intrusion exposure pathway.

- ADHS will continue to attend additional public meetings, make presentations, develop handout literature, and engage in other actions to notify the property owners and residents in the area of the findings of this health consultation.
- ADHS will notify EPA and ADEQ regarding the findings of this report and work with both agencies to evaluate the protectiveness of remedial action plans if requested.
- ADHS will remain available to review and evaluate data provided for this site upon request.

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REPORT PREPARATION

"This report was supported in part by funds provided through a cooperative agreement with the Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services. The findings and conclusions in these reports are those of the author(s) and do not necessarily represent the views of the Agency for Toxic Substances and Disease Registry or the U.S. Department of Health and Human Services. This document has not been revised or edited to conform to agency standards."

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Appendix A: Environmental Guideline Hierarchy

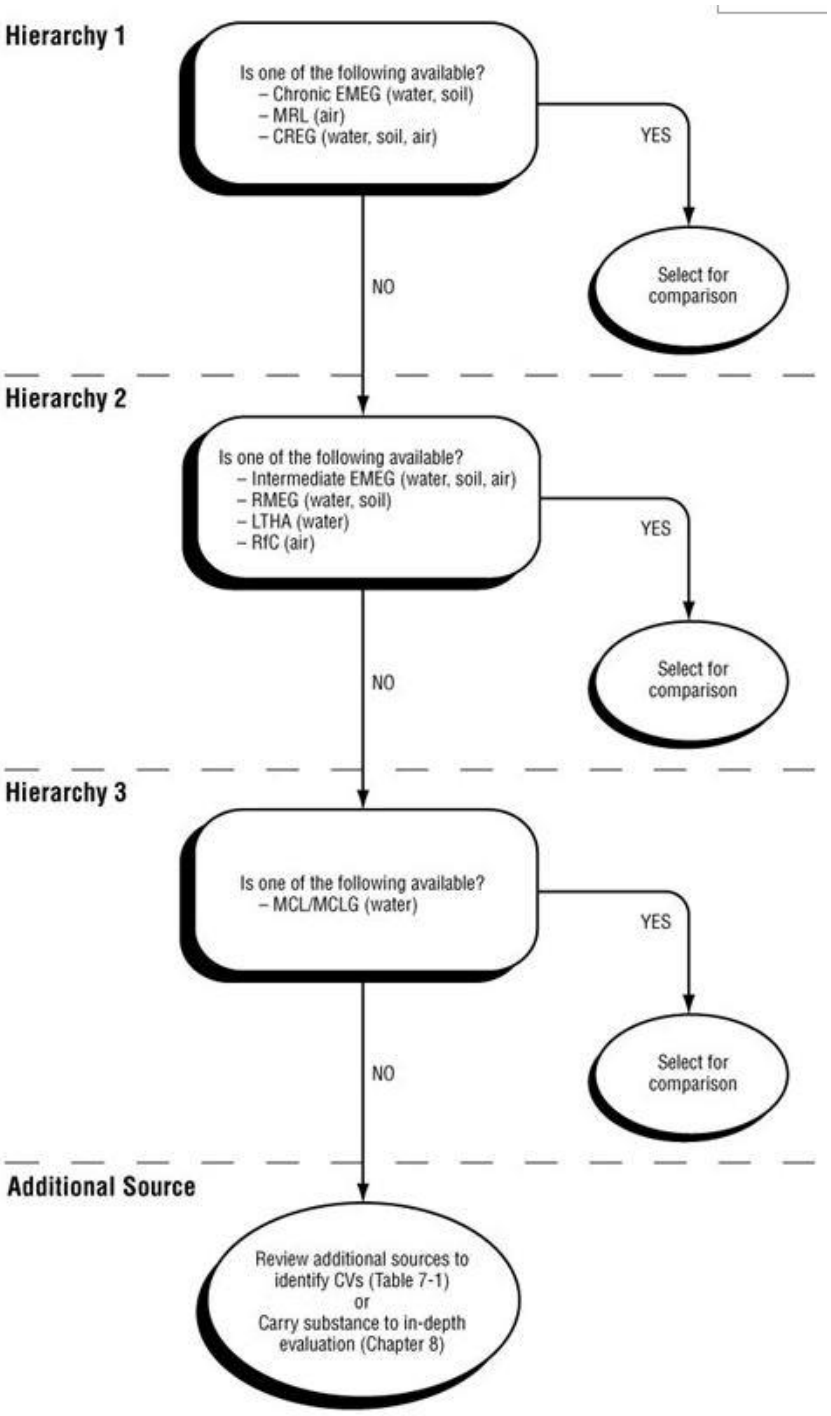

Figure 7-2. Environmental Guideline Hierarchy

Adapted from: Public Health Assessment Guidance Manual, ATSDR, January 2005.

Appendix B: Description of Comparison Values

ATSDR Comparison Values:

MRL: Minimal Risk Level is an estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to cause measurable noncancerous adverse health effects.

EMEG: Environmental Media Evaluation Guide represents concentrations of substances in water, soil, and air to which humans might be exposed during a specific period of time (acute, intermediate or chronic) without experiencing adverse health effects.

CREG: Cancer Risk Evaluation Guide is a media-specific comparison value that is used to identify concentrations of cancer causing substances that are unlikely to result in an increase of cancer rates in an exposed population after a lifetime of exposure.

EPA Comparison Values:

RfC: Reference Concentration, developed by US EPA, is an estimate, considering uncertainty or safety factors, of the daily lifetime air concentration of a substance that is unlikely to cause harm in humans.

RSL-nc: Regional Screening Levels for non-carcinogenic chemicals, developed by US EPA, are risk-based concentrations derived from standardized equations combining exposure information assumptions with EPA toxicity data. The values are considered to be protective for humans (including sensitive population) over a lifetime.

RSL-c: Regional Screening Levels for carcinogenic chemicals, developed by US EPA, are risk-based concentrations derived from standardized equations combining exposure information assumptions with EPA toxicity data. The values are considered to be protective for humans (including sensitive population) over a lifetime.

Other Comparison Values:

CAAG: Chronic Ambient Air Guideline, developed by Maine Center for Disease Control and Prevention: http://www.maine.gov/dhhs/mecdc/environmental-health/eohp/air/documents/06aags.pdf

VISL: Vapor Intrusion Screening Levels, developed by New Jersey Department of Environmental Protection: http://www.nj.gov/dep/srp/guidance/vaporintrusion/vig_update_tables.pdf

Appendix C: General Toxicological Information

Tetrachloroethene (Tetrachloroethylene, Perchloroethylene, PCE, PERC)

Tetrachloroethene (PCE) is a man-made chemical that is widely used for drying of fabrics, including clothes. It is also used for degreasing metal parts, and making other chemicals. PCE is found in a variety of consumer products such as break and wood cleaners, glues, laundry aids, paint removers, and suede protectors. PCE is a nonflammable, colorless liquid at room temperature. It evaporates easily into the air and has a sharp, sweet-smelling odor. Most people can smell PCE in air at levels in excess of 7,000 $\mu g/m^3$ (ATSDR 1997.)

PCE can affect the central nervous system (sensitive endpoint), the liver, kidney, immune system, and perhaps the reproductive system. Both animal and human studies showed that PCE exposure results in visual changes, increased reaction time, and reduction in mental abilities in learning and comprehension (ATSDR 1997.)

Trichlorothene (TCE)

Trichloroethene (TCE) is a man-made chemical that is widely used to remove grease from metal parts, which was closely associated with automotive and metal-fabricating industries from the 1950s to 1970s (ATSDR 2013.) TCE is also used to make other chemicals. It can be found in some household products such as paint removers, adhesives, spot removers, and rug cleaning fluids. TCE is a clear, colorless solvent, and has a somewhat sweet odor. Most people can smell TCE in air at levels excess 540,000 $\mu g/m^3$ (ATSDR 1997.)

TCE is slightly soluble in water, but dissolved TCE remains in groundwater for a long time. Studies showed that TCE in water will quickly form a gas when it comes into contact with air. TCE in groundwater can vaporize into the air space between adjacent soil grains. It will then disperse by two primary routes: 1) diffusion through the soil air spaces and then be reabsorbed by groundwater or infiltrating rainwater, and 2) mitigation as a gas to the surface and being released to the atmosphere or nearby buildings (ATSDR 2013.)

Chloroform

Chloroform is a colorless liquid with a pleasant, nonirritating odor and a slightly sweet taste at room temperature. Chloroform can be used as an extraction solvent in floor polish, resins, fat, oils and rubber and in dry-cleaning to remove spots. Chloroform is present in household products like bleaches, household cleaning products and air deodorizers. Exposure to chloroform occurs mainly through chlorinated water because public water supplies contain trihalomethanes, which are the by-products of water treatment. Reported air concentrations of chloroform in urban areas in the US are between 0.1 to 10 $\mu g/m^3$, and 0.17 to 43.9 $\mu g/m^3$ in indoor air (ATSDR 1997 NTP 2011.)

Bromodichloromethane (BDCM)

Bromodichloromethane (BDCM) is a colorless heavy nonflammable liquid. It usually is formed as a byproduct when chlorine is added to water system. BDCM evaporates quite easily, so most BDCM that escapes into the environment from chemical facilities, waste sites, or drinking water

enters the atmosphere as a gas. BDCM is slowly broken down (about 90% in a year) by chemical reactions in the air (ATSDR 1989.)

Appendix D: Cancer Risk Calculation

ADHS estimated the potential cancer risks by using the following assumptions: (1) 78-year life expectancy for both school staff and residents, (2) school staff could be exposed for 8 hours/day, 5 days/week, 50 weeks/year for 25 years, and (3) residents could be exposed for 24 hours/day, 7 days/week, 52 weeks/year for 33 years.

$$\text{Exposure Adjusting Factor} = \frac{Exposure\ Frequency\ \left(\frac{days}{year}\right) \times Exposure\ Duration\ (year)}{Averaging\ Time\ (day)}$$

Cancer Risk Calculation:

Trichloroethene (TCE): EPA's age-dependent adjustment factors were used to account for increased early-life susceptibility to kidney cancer. A 10 fold adjustment for age 0 – 2, a 3 fold adjustment for age 3 – 16, and no adjustment for age 16 and above.

Cancer Risk (unitless) = ∑ Air Concentration (μg/m^3) × Inhalation Unit Risk [(μg/m^3)$^{-1}$] × Exposure Adjusting Factor × Age-adjusting Factor

Other Chemicals:

Cancer Risk (unitless) = Air Concentration (μg/m^3) × Inhalation Unit Risk [(μg/m^3)$^{-1}$] × Exposure Adjusting Factor

Tetrachloroethene (Tetrachloroethylene, Perchloroethylene, PCE, PERC)

Residents:

Cancer Risk = $37 \times 2.6 \times 10^{-7} \times 0.42 = 4 \times 10^{-6}$

Trichloroethene (TCE)

School staff:

Cancer Risk = $0.58 \times 4.1 \times 10^{-6} \times 0.07318 = 1.7 \times 10^{-7}$

Commercial building workers:

Cancer Risk = $8.6 \times 4.1 \times 10^{-6} \times 0.07318 = 2.6 \times 10^{-6}$

Residents:

Using 2 μg/m^3 as an example:

Age 0-2: $2 \times 4.1 \times 10^{-6} \times 0.026 \times 10 = 2.1 \times 10^{-6}$

Age 3-16: $2 \times 4.1 \times 10^{-6} \times 0.167 \times 3 = 4.1 \times 10^{-6}$

Age 17-33: $2 \times 4.1 \times 10^{-6} \times 0.205 \times 1 = 1.7 \times 10^{-6}$

Cancer Risk = $2.1 \times 10^{-6} + 4.1 \times 10^{-6} + 1.7 \times 10^{-6} = 7.9 \times 10^{-6}$