Final Report

Grand Prairie Vapor Intrusion Investigation
Grand Prairie, Dallas County, Texas

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Summary

Introduction
Trichloroethylene (TCE) groundwater plumes were identified in Grand Prairie at Delfasco Forge, Northeast 15th Street area, and Southeast 14th Street area. The Texas Department of State Health Services (DSHS) through the Texas Environmental Health Institute (TEHI), a legislatively mandated entity jointly established by DSHS and the Texas Commission on Environmental Quality (TCEQ), worked with the Agency for Toxic Substances and Disease Registry (ATSDR), the University of Texas (UT), and the Division of Laboratory Sciences at the Centers for Disease Control and Prevention (CDC) to determine whether people living in homes above the plumes were being exposed to the TCE through vapor intrusion.

For this investigation, DSHS/TEHI, UT, ATSDR, and CDC collected and analyzed samples to determine whether residents living above a TCE groundwater plume have higher levels of TCE in their bodies than residents who do not live above a TCE groundwater plume. This investigation provided appropriate follow-up recommendations as well as information about the relationship between human exposures and the vapor intrusion pathway.

Results

Delfasco Forge Site
Significantly higher blood and indoor air TCE levels were measured in the Delfasco area compared to the three other sampling locations in Grand Prairie and to a previous sampling of residents and homes in the United States. Blood levels measured in people living in homes with detectable levels of TCE in indoor air were highly correlated with the indoor air levels. Although a few homes had TCE levels in indoor air above long-term residential health-based screening levels, these screening levels are very conservative with respect to protecting people’s health; thus, the levels detected (up to 112.01 micrograms per cubic meter or μg/m$^3$) would not be expected to cause health effects in people.

Southeast 14th Street Groundwater Plume Site
Low levels of TCE were measured in the blood, soil gas, indoor air, and outdoor air samples collected in the Southeast 14th Street area. The TCE levels found in the indoor air (maximum of 3.39 μg/m$^3$) are similar to levels previously found in a sampling of homes across the United States, while blood levels (maximum of 0.028 micrograms per liter or µg/L) were significantly higher than those previously found in a sample of residents throughout the United States. TCE is found in many common household products so the sources of TCE found in the residents at this site are not known. The air levels found are lower than those known to cause harmful effects.

Northeast 15th Street Groundwater Plume Site
Low levels of TCE were measured in the blood, soil gas, indoor air, and outdoor air samples collected in the Northeast 15th Street area. Levels of TCE in the blood (maximum of 0.312 µg/L) and indoor air (maximum of 0.795 μg/m$^3$) are similar to the levels of TCE previously found in residents and homes across the United States. The source(s) of the TCE is not known and could be coming from common household products. The air levels found are lower than those known to cause harmful effects.
Comparison Area
Samples were collected from several homes not located over a contaminated groundwater plume. Levels of TCE measured in the blood (maximum of 0.016 µg/L) and indoor air (less than 0.17 µg/m³) are similar to those previously found in a sampling of residents and homes across the United States. These air levels may be coming from common household products and are below the levels known to cause harmful effects.

Uncertainties
There are many potential sources of TCE in indoor air, including solvents used to remove grease from automotive and metal parts and household and consumer products (such as a residue in plastics, typewriter correction fluid, paint removers, adhesives, and spot removers). Under the right conditions, vapor intrusion from contaminated groundwater is also a potential source of TCE in indoor air.

Some of the indoor air TCE levels found in the Delfasco Forge site were above long-term residential health-based screening levels for TCE. The screening levels used are considered to be conservative with respect to protecting people’s health; thus, we would not expect these levels to result in adverse health effects. Additionally, the measured levels only represent the levels in the homes at the time the samples were collected and indoor air levels can vary with changes in the weather or ventilation inside and around the home. Based on the current sampling and available toxicological information we would not expect to see adverse health effects resulting from these exposures; however, there is a paucity of toxicological information about potential health effects in people exposed to low levels of TCE over a long period of time (years).

Conclusions
Based upon the data collected, the participants in the Northeast 15th Street area, Southeast 14th Street area, and the comparison area had a greater percentage of people with detectable levels of TCE in their blood and people with higher levels of TCE in their blood than what would be expected based on a previous sampling of other United States residents. TCE levels in the indoor air of homes in these areas were close to or less than the levels previously measured in a sample of homes across the United States. In the Delfasco area, TCE levels in the blood and indoor air were higher than those found in the United States sample. Based on a comparison of these levels to those known to cause adverse health effects we would not expect the levels found in these homes to affect the health of the people who live in these homes.
Purpose and Health Issues

The purpose of this investigation was to determine whether residents living above a trichloroethylene (TCE) groundwater plume have higher levels of TCE in their bodies than residents who do not live above a TCE groundwater plume. A secondary purpose was to provide information on the relationship between human exposure and the vapor intrusion pathway.

Contaminants, such as TCE, present in shallow groundwater have the potential to volatilize (change to a vapor or gas) and move up through the soil into overlying buildings. The process of vapors moving into buildings from the subsurface via pathways such as openings in the floor for utility lines and/or piping is called vapor intrusion. The pathway through which people can be exposed to contaminants in this way is called the vapor intrusion pathway.

In order to obtain more information about the vapor intrusion pathway, the Environmental Protection Agency Region 6 (EPA-6) conducted a vapor intrusion study at four sites located in Texas, Louisiana, and Arkansas. The Texas Department of State Health Services (DSHS)\(^1\) built on the information collected by the EPA-6 at one of those sites (Delfasco Forge in Grand Prairie, Texas) by conducting an exposure investigation. The findings of the exposure investigation are presented in this report. A full list of the acronyms and abbreviations used in this report are included in Appendix A. Figures and Tables are presented in Appendices B and C, respectively. Information about TCE is presented in Appendix D.

Background

In 2008, the EPA-6 initiated a vapor intrusion study at four sites including Kelly Air Force Base in San Antonio, Texas; Parker Solvents in Little Rock, Arkansas; England Air Force Base in Alexandria, Louisiana; and Delfasco Forge in Grand Prairie, Texas. The purpose of the EPA-6 study was to look at the vapor intrusion pathway to determine if vapors from contaminated groundwater can move through the soil and enter indoor areas of residential and commercial structures. Sub-slab soil gas, crawl space, and indoor air samples were collected and analyzed for the contaminants of concern at each site [1].

In addition to the Delfasco Forge site in Grand Prairie, EPA-6 investigated the potential for vapor intrusion at two other sites in Grand Prairie – the Northeast 15\(^{th}\) Street Groundwater Plume area and the Southeast 14\(^{th}\) Street Groundwater Plume area. At these two sites, EPA-6 collected groundwater and passive\(^2\) soil gas samples. In follow-up to the vapor intrusion study, EPA-6

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\(^1\) This project was partially funded by the Texas Environmental Health Institute (TEHI), a legislatively mandated joint entity between the DSHS and the Texas Commission on Environmental Quality (TCEQ). TEHI funds projects designed to examine ways to identify, treat, manage, prevent, and reduce health problems associated with environmental contamination.

\(^2\) Passive soil gas samplers do not require electricity or pumps. Rather, they are placed in the ground for a period of time and rely on diffusion and adsorption for sample collection. Vapors move from an area of higher concentration (the soil) to an area of lower concentration (the sample device). Because they are inexpensive and compact, passive soil gas samplers are used for screening large areas. Results for passive soil gas samples are reported as total mass.
collected and analyzed passive soil gas, groundwater, active soil gas, and ambient outdoor air samples from the Delfasco Forge area [2].

In order to obtain more information about the vapor intrusion pathway, DSHS/TEHI conducted an exposure investigation in Grand Prairie. Residential locations above the TCE groundwater plumes at Delfasco Forge, Northeast 15th Street, and Southeast 14th Street as well as residences from a comparison neighborhood located outside the plume areas were included in the investigation. Blood, urine, tap water, indoor air, outdoor air, and soil gas samples were collected and an exposure survey was administered to participants of this investigation.

**Site Description**

The EPA-6 has identified three TCE groundwater plume areas in Grand Prairie; these are Delfasco Forge, Northeast 15th Street, and Southeast 14th Street. A comparison neighborhood outside the plume areas also was identified (Figure 1).

Groundwater in these areas is approximately 15 to 25 feet below ground surface. Homes are generally pier-and-beam construction with a crawlspace under the home. Maintenance of ventilation under the homes varied throughout the neighborhoods with some homes having well maintained crawlspace vents and others having blocked or partially blocked vents.

Delfasco Forge was a metal fabrication and forging facility operating in Grand Prairie from 1981 to 1997. In July 2008, owners of Delfasco Forge filed for bankruptcy. The property is currently being leased by an automotive repair business [1]. The Delfasco Forge groundwater plume is located under a residential neighborhood directly northeast of the former forge site. In May 2008, EPA-6 used a Trace Atmospheric Gas Analyzer (TAGA) and found indoor air levels of TCE from 0.59 to 64 micrograms per cubic meter (µg/m³) and tetrachloroethylene (PCE, also known as perchloroethylene) from 0.05 to 0.95 µg/m³ in homes near the Delfasco Forge site [3]. Passive soil gas samples were collected in August and November 2008; the samplers were installed approximately 2 feet deep and were retrieved a week later. The maximum amount of TCE detected in the soil gas samples was 21,702 nanograms (ng) and was located in the residential area [4]. Monitoring wells sampled in November 2008 showed groundwater concentrations of TCE up to 1,500 micrograms per liter (µg/L) [4].

The Northeast 15th Street Groundwater Plume was discovered in February 2001 by the Texas Natural Resource Conservation Commission (TNRCC), predecessor agency to the Texas Commission on Environmental Quality (TCEQ), during their Site Inspection of the Southeast 14th Street Groundwater Plume site. TCE was found in background samples collected from two residential water wells in the Northeast 15th Street area. TCEQ conducted additional groundwater sampling in July and August 2001, and found TCE concentrations ranging from 6 to 899 µg/L. Groundwater samples collected by EPA-6 in November and December 2008 from residential water

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3 In this investigation, active soil gas samples were collected. Active soil gas samples are collected using a pump, similar to how the indoor and outdoor air samples are collected. Results for active soil gas samples are reported as a concentration.
wells and temporary monitoring wells in the area contained concentrations of TCE up to 230 µg/L. Passive soil gas samples were collected in November 2008 and February 2009 by the EPA-6. Samplers, installed approximately 1.5 feet deep and retrieved a week later, found a maximum amount of TCE in soil gas of 322 ng. The Northeast 15th Street area is a residential neighborhood and the source of the TCE in the groundwater has not yet been identified [5].

The Southeast 14th Street Groundwater Plume is located just west of the United States (U.S.) Naval Weapons Industrial Reserve Plant and was discovered in 1993-1995 when the U.S. Navy conducted groundwater sampling during remediation efforts for closure of the Dallas Naval Air Station. Groundwater samples collected in April 1995 from monitoring wells expected to be upgradient of known sources of contamination at the U.S. Naval Weapons Industrial Reserve Plant contained TCE up to 32,000 µg/L. In 1996, the U.S. Navy concluded that the U.S. Naval Weapons Industrial Reserve Plant was not the source of the Southeast 14th Street Groundwater Plume, and in March 1997 the TNRCC concurred. In 1997, TNRCC sampled five residential water wells in the area and found TCE up to 3,014 µg/L. Additional groundwater samples were collected by the TNRCC in 2001 from monitoring wells and residential water wells. TCE was detected up to 7,900 µg/L. Passive soil gas samples were collected in November 2008 by the EPA-6. Samplers were installed approximately 1.5 feet deep and were retrieved a week later. The maximum amount of TCE detected in the soil gas samples was 243 ng. Groundwater samples collected by EPA-6 in December 2008 from temporary monitoring wells in the area contained concentrations of TCE up to 2,920 µg/L. The Southeast 14th Street area is a residential neighborhood and the source of the TCE in the groundwater has not yet been identified [6].

Site Visits

On September 30, 2008, DSHS staff conducted a site visit of the Delfasco Forge area and attended an EPA-6 community meeting regarding the Delfasco Forge site. During the meeting, EPA-6 provided information about completed and planned activities for the site. DSHS staff responded to questions about adverse health effects related to TCE exposure.

On December 9 through 12, 2008, staff from DSHS and the Agency for Toxic Substances and Disease Registry (ATSDR) conducted a site visit of the four neighborhoods to be included in the vapor intrusion investigation. In all four areas, staff went door-to-door, distributed flyers, talked to residents about the investigation, conducted a survey of home information, and mapped each neighborhood.

Residents from each of the neighborhoods were randomly selected and letters were mailed asking for their participation. Due to the low response rate, DSHS staff conducted a second door-to-door site visit on March 4 through 6, 2009, and tried to contact all residents who had been sent letters. Staff provided more information about the investigation and obtained contact information for those residents who agreed to participate. Flyers with information about the investigation were left with the randomly selected residents.

Environmental and biological samples were collected from participants on April 3 through 6, April 17 through 20, and May 29 through June 1, 2009. Staff from DSHS and the University of Texas...
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(UT) collected blood, urine, tap water, indoor air, outdoor air, and soil gas samples and had each participant complete an exposure survey.

On September 29, 2009, DSHS, ATSDR, and EPA-6 hosted an Open House in Grand Prairie to provide community members with information about the results of the vapor intrusion investigation and to allow participants the opportunity to discuss their results individually with DSHS staff.

**Exposure Investigation**

Three Grand Prairie neighborhoods located above different TCE groundwater plumes and a comparison neighborhood not over a plume were included in this investigation. The comparison area was similar to the Delfasco Forge, Northeast 15th Street, and Southeast 14th Street areas, but without the groundwater contamination.

Prior to conducting the investigation, the protocol was reviewed and approved by the DSHS Institutional Review Board (IRB) to ensure that participants’ safety, rights, and welfare were adequately protected and individual risks were minimal.

Staff sent letters to 150 randomly selected homes in the 4 areas asking for 2 volunteers (at least 6 years old) from each home. They were told that the volunteers would be asked to complete a brief exposure survey, provide blood and urine samples, and allow DSHS and UT staff to collect tap water, indoor air, outdoor air, and soil gas samples at their property. Environmental and blood samples were collected simultaneously, during appointments set up with the participants. Each participant was provided materials and instructions and collected the urine sample on the day of the appointment. A copy of the exposure survey is available in Appendix E.

Each participant signed an informed consent which outlined: the purpose of the investigation; the procedures involved; the expected time commitment; any reasonably foreseeable risks or discomforts; potential benefits to the participant or to others; how their information will be kept confidential; and who they could contact with any questions or concerns regarding the consent form or the specimen collection procedures.

Participants were provided with their test results and an explanation of their results via mail. Fact sheets summarizing the results of the investigation and information about exposure to TCE were mailed to all residents living in the four neighborhoods in this investigation. These fact sheets, as well as a fact sheet with specific information for physicians, were mailed to local physician offices.

**Biological Sampling**

Biological samples were collected using validated procedures and materials so that the reported results were not biased by contamination or loss. Individual appointments were made and the blood samples were collected from participants in their homes by a DSHS registered nurse who collected the blood into a 10 milliliter (mL) hermetically-sealed volatile organic compound
(VOC)-free blood collection tube. The samples were packed on ice and shipped cold to the Division of Laboratory Science in the Centers for Disease Control and Prevention/National Center for Environmental Health (CDC/NCEH) for TCE analysis. Urine cups and specimen collection instructions were distributed to participants at least one day prior to their appointment. Participants were asked to collect the first morning void on the day of their appointment and place the sample in the refrigerator until DSHS staff’s arrival. Urine samples were packed on ice and shipped cold to NMS Labs for trichloroacetic acid (TCAA, a metabolite of TCE) analysis. A brief description of the analytic procedures is available in Appendix F.

Levels of TCE in participants’ blood were compared to sample results collected in the 2003-2004 National Health and Nutrition Examination Survey (NHANES). Based on NHANES data, less than 5% of the general United States population has detectable levels of TCE in their blood[^7]. In addition to looking at the percentage of people with detectable levels of TCE in their blood, the individual blood TCE levels were compared to blood TCE levels seen in the NHANES data set using non-parametric data analyses (Appendix G).

**Tap Water Sampling**

In most cases, the tap water sample was collected from the participant’s kitchen sink (non-filtered). Cold water was allowed to flow at high volume for approximately 1 minute. Water flow was then reduced to minimum flow before the sample was collected. The water samples were collected in pre-treated 5 mL vials with no headspace to prevent the volatilization of VOCs out of the sample. Samples were packed on ice and shipped cold to the CDC/NCEH laboratory for TCE analysis. A brief description of the analytic procedures is available in Appendix F.

Levels of TCE in tap water were compared to the EPA’s maximum contaminant level (MCL) for TCE in drinking water (5 µg/L). MCLs are contaminant specific regulatory standards representing the maximum concentration of a chemical that is allowed in a public drinking water system under the Federal Safe Drinking Water Act. All participants obtained their drinking water from the City of Grand Prairie.

**Indoor Air, Outdoor Air, and Soil Gas Sampling**

Two indoor air samples were collected simultaneously for 80 minutes in each home. Indoor air samples were collected in a common living area, such as in the living room, dining room, or kitchen. Two outdoor air samples also were collected simultaneously for 80 minutes in the yard of each home at approximately the same time that the indoor samples were collected. In addition to the indoor and outdoor air samples, a single soil vapor sample was collected on the property within 10 feet of the home when possible. All air samples were collected on adsorbent tubes and analyzed for TCE by UT staff. A brief description of the analytic procedures is available in Appendix F.

[^4]: As the same laboratory analyzed the blood samples for both the NHANES data set and for this investigation, the detection limit was the same.
The ATSDR, a federal agency within the Department of Health and Human Services, has developed minimal risk levels (MRLs) for a variety of compounds. An MRL is an estimate of the daily human exposure to a hazardous substance that is not likely to cause adverse noncancer health effects over a specified duration of exposure (acute – less than 2 weeks, intermediate – 2 weeks to 1 year, and chronic – greater than one year). MRLs are substance-specific screening values and while exceeding an MRL does not mean that adverse health effects will occur, it does indicate that further evaluation is necessary.

The intermediate-duration MRL for TCE of 500 µg/m³ is based on a study in which neurological effects (decreased wakefulness during exposure and decreased post-exposure sleeping heart rate) were noted in rats exposed to TCE for 6 weeks. The acute-duration MRL for TCE of 10,000 µg/m³ is based upon a study in which headaches, fatigue, and drowsiness were noted in humans voluntarily exposed to TCE for 5 days [8]. Other levels of significant exposure to TCE in air and related health effects are presented in Figure 2.

The TCEQ does not typically evaluate indoor air data and for remediation sites being addressed under the Texas Risk Reduction Program (TRRP) rule, the TCEQ typically does not evaluate soil gas data as part of routine site sampling unless the agency determines that there is a vapor intrusion concern. While TRRP was not written to specifically address these exposure scenarios, the TCEQ will evaluate these data as needed. For such an evaluation, detected constituents in indoor residential air would be compared to the TRRP residential Risk-Based Exposure Limits (RBELs) for inhalation (\text{Air RBEL}_{\text{in}}). The inhalation RBELs apply to sites under TRRP and are conservative health-based values and that are protective against long-term (i.e., chronic) inhalation for 30 years of exposure, 350 days per year, based on adult and child exposure scenarios. Use of these values is considered very conservative when compared to short-term sample results. The current TRRP residential RBEL for TCE is 12 µg/m³ [9].

During their investigations, EPA considered both cancer risk as well as non-cancer health effects in their evaluation of indoor air data collected in Grand Prairie. For the Delfasco Forge site, EPA used 14 µg/m³ as a screening value to be protective against both cancer and non-cancer effects for short-term exposures (less than 7 years). For longer term exposures (30 years), residential indoor air concentrations above 10 µg/m³ which are due to vapor intrusion would need remediation [10].

Following the completion of this project, the EPA released a reference concentration for chronic inhalation exposures (RfC). The RfC is an estimate of continuous inhalation exposure to a hazardous substance that is not likely to result in adverse health effects over a lifetime. The RfC for TCE is 2 µg/m³. This RfC is protective against non-cancer effects for long-term exposures. The EPA also determined that TCE is a human carcinogen. The inhalation unit risk (IUR) for estimating cancer risk is $4.1 \times 10^{-6}$ per µg/m³ [11].

Dawson and McAlary [12] completed a detailed review of published data related to chemical concentrations in North American residences unaffected by subsurface vapor intrusion. Their assessment included TCE, and was focused on 13 studies spanning the years 1990 to 2005. Percentile statistics were provided based on over 2,400 reported indoor air samples for TCE in rural, suburban, and urban homes. The analytical reporting limit range for the studies evaluated by
Dawson and McAlary was 0.02 to 2.7 µg/m³ and using the Kaplan-Meier method for censored data, they reported a median (50th percentile) and 95th percentile TCE concentrations of 0.3 µg/m³ and 1.6 µg/m³, respectively. The maximum concentration was reported to be 84 µg/m³ [12].

**Exposure Survey**

As part of this investigation, participants completed an exposure survey (Appendix E). Information collected in the exposure survey included basic demographic and household information, occupation, home structure, indoor air quality, use of fuels inside the home, water sources, hobbies, general health questions, and means of communication. While this data was not used quantitatively in the data analysis, it did provide useful information in analyzing the data.

**Data Analysis Procedures**

The purposes of this investigation were to determine whether residents living above a TCE plume have higher levels of TCE in their bodies as compared to residents who do not live above a TCE plume and to provide additional information on the relationship between human exposures and the vapor intrusion pathway. Data collected in this investigation were analyzed using non-parametric data analysis and multiple linear regression analysis. A brief description of the statistical analyses is included in Appendix G.

**Results**

The overall results of this investigation are presented below. In addition, to improve individuals’ accessibility to personally relevant results, the results for each neighborhood are presented separately.

**Overall Results**

In total, 74 people living in 40 homes across the 4 neighborhoods participated in the investigation (Table 1). Due to a low response rate, samples were collected from non-random participants (NRPs) who were not in the original randomly selected sample but expressed an interest in participating. While results from NRPs are included in this report, only results for randomly selected participants were used in the statistical analyses.

Blood samples were collected from 70 of the 74 participants; 4 of the participants (2 adults and 2 children) did not provide blood. Results for TCE in blood ranged from not detected (less than 0.0124 µg/L) to 0.728 µg/L with 14 of the participants (20%) having detectable levels of TCE in their blood (Table 2).

Urine samples were collected from 74 participants and results for TCAA in urine are presented in Table 3. TCAA was not detected in any urine samples.
Tap water samples were collected from all 40 homes with the TCE levels ranging from not detected (less than 0.0124 µg/L) to 0.04 µg/L. Only two samples had detectable levels of TCE (Table 4).

Two indoor air samples were collected from each of the 40 homes; one using a low flow rate and one using a high flow rate. Similarly, two outdoor air samples were collected at each of the 40 homes, one using a low flow rate and one using a high flow rate. Both indoor and outdoor air samples were reported as either not detected, detected (TCE was present in the sample, but the amount present was too small to quantify), or detected with a quantifiable value. For each home the low and high flow rate sample results were averaged. Indoor air levels of TCE ranged from not detected (less than 0.12 µg/m³) to 112.01 µg/m³ (Table 5). Outdoor air levels of TCE ranged from not detected (less than 0.12 µg/m³) to 0.605 µg/m³ (Table 6).

Soil gas samples were collected at 38 of the homes; samples could not properly be collected at 2 of the homes (one in the Southeast 14th Street area and one in the comparison neighborhood) due to significant rainfall prior to the sampling trip. Results for TCE in soil gas ranged from not detected (less than 1.6 µg/m³) to 54,300 µg/m³ (Table 7).

**Results by Neighborhood**

**Delfasco Forge Groundwater Plume Area**

In the Delfasco Forge Groundwater Plume area, 21 people living in 11 homes participated in the investigation (Table 1). This included samples collected from two people living in one home in which EPA-6 had installed a crawlspace fan to reduce indoor air concentrations of TCE.

Blood samples were collected from 20 of the participants living in this area. Results for TCE in blood ranged from not detected (less than 0.0124 µg/L) to 0.728 µg/L with nine of the participants (45%) in this area having detectable levels of TCE in their blood (Table 2).

Tap water samples were collected from all 11 homes in this area with the TCE levels ranging from not detected (less than 0.0124 µg/L) to 0.04 µg/L. Only two samples had detectable levels of TCE (Table 4).

Indoor and outdoor air samples were collected from all 11 homes in this area. Indoor air levels of TCE ranged from not detected (less than 0.12 µg/m³) to 112.01 µg/m³ with seven homes having quantifiable levels of TCE in the indoor air (Table 5). Outdoor air levels of TCE ranged from not detected (less than 0.12 µg/m³) to 0.5 µg/m³ (Table 6).

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5 At one home in the comparison area, the high-volume pumped failed, thus only the low-volume sample was collected.

6 At one home in the Delfasco Forge area, the high-volume pumped failed, thus only the low-volume sample was collected.

7 If both sample results were quantifiable, the two numbers were averaged. If both results were either non-detect or detect, the result was called non-detect or detect, respectively. In all other cases, the result for the high volume sampler was used as the “average” because the high volume sampler is more sensitive (i.e. can detect lower levels of TCE).
Soil gas samples were collected at all 11 homes in this area. TCE was detected in all but one of the soil gas samples collected in this area, and results for TCE in soil gas ranged from not detected (less than 1.6 µg/m³) to 54,300 µg/m³ (Table 7).

**Northeast 15th Street Groundwater Plume Area**

In the Northeast 15th Street Groundwater Plume area, 18 people living in 9 homes participated in the investigation (Table 1). This included samples collected from three NRPs living in two homes.

Blood samples were collected from 16 of the participants living in this area. Only one of the participants (6.3%) in this area had a detectable level (0.312 µg/L) of TCE in their blood (Table 2).

Tap water samples were collected from all nine homes in this area. TCE was not detected in any of the tap water samples (Table 4).

Indoor and outdoor air samples were collected at all nine homes in this area. Indoor air levels of TCE ranged from not detected (less than 0.12 µg/m³) to 0.795 µg/m³, with two homes having quantifiable levels of TCE in the indoor air (Table 5). Although TCE was detected in the outdoor air in this area, no outdoor air samples had quantifiable levels of TCE (Table 6).

Soil gas samples were collected at all nine homes in this area. TCE was detected in all of the soil gas samples collected in this area, with results ranging up to 26.1 µg/m³ (Table 7).

**Southeast 14th Street Groundwater Plume Area**

In the Southeast 14th Street Groundwater Plume area, 18 people living in 10 homes participated in the investigation (Table 1).

Blood samples were collected from 17 of the participants living in this area. Results for TCE in blood ranged from not detected (less than 0.0124 µg/L) to 0.028 µg/L, with three of the participants (17.6%) in this area having detectable levels of TCE in their blood (Table 2).

Tap water samples were collected from all 10 homes in this area. TCE was not detected in any of the tap water samples (Table 4).

Indoor and outdoor air samples were collected at all 10 homes in this area. Indoor air levels of TCE ranged from not detected (less than 0.12 µg/m³) to 3.39 µg/m³, with four homes having quantifiable levels of TCE in the indoor air (Table 5). Outdoor air levels of TCE ranged from not detected (less than 0.12 µg/m³) to 0.27 µg/m³ (Table 6).

Soil gas samples were collected at nine of the homes in this area. Results for TCE in soil gas ranged from not detected (less than 1.6 µg/m³) to 21.2 µg/m³ (Table 7).
Comparison Area

In the comparison area, 17 people living in 10 homes participated in the investigation (Table 1). This included samples collected from two volunteers living in one home.

Blood samples were collected from all 17 participants living in this area. Results for TCE in blood ranged from not detected (less than 0.0124 µg/L) to 0.016 µg/L, with only one of the participants (5.9%) in this area having detectable levels of TCE in their blood (Table 2).

Tap water samples were collected from all 10 homes in this area. TCE was not detected in any of the tap water samples (Table 4).

Indoor and outdoor air samples were collected at all 10 homes in this area. Although TCE was detected in the indoor air of homes in this area, no indoor air samples had quantifiable levels of TCE (Table 5). Outdoor air levels of TCE ranged from not detected (less than 0.12 µg/m³) to 0.605 µg/m³ (Table 6).

Soil gas samples were collected at nine of the homes in this area. TCE was detected in all of the soil gas samples collected in this area, and results for TCE in soil gas ranged from detected (between 1.6 µg/m³ and 2.3 µg/m³) to 900 µg/m³ (Table 7).

Results of Statistical Analyses

In this investigation, a higher percentage of people had detectable levels of TCE in their blood compared to the general population. Residents in the Delfasco Forge area and the Southeast 14th Street area had significantly higher (p < 0.0001) blood TCE levels than a sampling of residents across the United States. Residents in the Northeast 15th Street and the comparison areas had levels of TCE in blood that were similar (p = 0.6528 and p = 0.1254, respectively) to those found in the NHANES data.

Non-parametric data analyses showed that blood TCE levels for people living in the Delfasco Forge area were significantly higher than both the comparison population (p=0.0238) and the Northeast 15th Street area (p=0.0129). Blood TCE levels for people living in the Northeast 15th Street area and the Southeast 14th Street area were not significantly different than blood TCE levels for people living in the comparison neighborhood.

Multiple linear regression analysis of the cumulative data showed indoor air TCE levels were positively associated with blood TCE levels. The indoor air TCE level was the only predictor (independent) variable that remained in the final regression model, indicating that the level of TCE in the blood is primarily determined by the level of TCE in the indoor air of the home. The geometric mean blood TCE level of residents living in homes with indoor air TCE levels of 14 µg/m³ or greater was approximately 600 times higher than the geometric mean blood TCE level in residents living in homes with no detectable levels of TCE in the indoor air. In addition, the geometric mean blood TCE level of residents living in homes with a quantifiable level of TCE in indoor air (but less than 14 µg/m³) was approximately 20 times higher than the geometric mean blood TCE level in residents living in homes with no detectable levels of TCE in the indoor air.
While these differences are noteworthy it is not possible to predict differences in potential risks for adverse health effects based on these results.

**Discussion**

TCE was present in the tap water, indoor air, outdoor air, and soil gas at various residential locations in Grand Prairie. TCE also was detected in the blood of people living in these homes. These data indicate that exposure to TCE is occurring and suggest that vapor intrusion is likely occurring in some homes above the groundwater plume in the Delfasco Forge area. Vapor intrusion did not appear to be occurring to a significant extent in the majority of the homes in the Northeast 15th Street, Southeast 14th Street, and comparison areas.

TCE was detected in two tap water samples collected in the Delfasco Forge area. Both samples had levels of TCE just slightly above the detection limit of 0.0124 µg/L and well below the EPA’s MCL for TCE in drinking water (5 µg/L); levels not likely to cause adverse health effects. Both of these homes also had the highest levels of TCE in the indoor air.

Of the 40 homes sampled 23 had detectable levels of TCE in the indoor air, 13 of which had levels that could be quantified (Table 5). In this investigation, 9 homes had TCE levels above 1.6 µg/m³, the 95th percentile TCE concentration in North American residences unaffected by subsurface vapor intrusion [12]. While the TCE indoor air level was less than 5 µg/m³ in five of these homes, four homes, above the groundwater plume in the Delfasco Forge area, had levels above 10 µg/m³. These four homes also were located, where TCE concentrations in soil gas were highest based both on data collected by the EPA-6 [4] and in this investigation (Table 7).

In this investigation, the highest concentration of TCE measured in indoor air (112.01 µg/m³) was approximately 5 times lower than the intermediate-duration MRL for TCE (500 µg/m³). This MRL is based on a study in which neurological effects (decreased wakefulness during exposure and decreased post-exposure sleeping heart rate) were noted in rats exposed to TCE for 6 weeks. The lowest observable adverse effect level (LOAEL) associated with the study was 269,000 µg/m³ 8].

The level of TCE measured in the indoor air of 4 homes exceeded TCEQ’s TRRP residential RBEL for TCE of 12 µg/m³. Use of a long-term comparison value to evaluate short-term sampling results is considered conservative. Although the indoor air level of TCE in 4 homes exceeded TCEQ’s residential RBEL, the maximum level of TCE in these homes (112.01 µg/m³) was almost 2,500 times lower than the level at which adverse health effects have been observed (LOAEL of 269,000 µg/m³). Therefore, based upon available toxicologic information, adverse health effects from the levels of TCE found in the indoor air in Grand Prairie would be unlikely (Figure 2).

At the time this project was conducted, there was no RfC for TCE; therefore, EPA-6 developed a screening value of 14 µg/m³ for use at the Delfasco site [10]. Although we only found two homes

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8 Although a number of homes exceeded EPA’s new RfC for TCE, the RfC is similar to background levels of TCE in indoor air in homes with no evidence of vapor intrusion [12].
with levels of TCE above this site-specific screening value, EPA-6 is taking a health-protective approach by offering mitigation systems to homeowners in the Delfasco Forge area with evidence of significant vapor intrusion.

Using the maximum concentration of TCE detected in indoor air for this project (112.01 µg/m³) and the IUR for TCE (4.1 × 10⁻⁶ per µg/m³), the theoretical excess lifetime cancer risk associated with exposure to TCE in indoor air would be 4.6 × 10⁻⁴. We would interpret this risk as posing a low increased lifetime risk for cancer. However, this maximum concentration was nearly five times greater than all the other indoor air levels of TCE measured in the homes. Using the next highest indoor air concentration of TCE (22.8 µg/m³), the theoretical excess lifetime cancer risk associated with exposure to TCE in indoor air would be 9.4 × 10⁻⁵. Therefore, in all other homes, there was a no apparent increased lifetime risk for cancer.

TCE was detected in some outdoor air samples; however, the highest concentration was less than 1 µg/m³. Based upon available toxicologic information, the levels of TCE found in the outdoor air are not normally known to cause health effects.

TCE was detected in soil gas in all four areas of this investigation. All but one of the highest levels of TCE found in soil gas samples were from the Delfasco Forge area, consistent with findings from the EPA-6’s soil gas investigations. At one property in the comparison area, the concentration of TCE in soil gas was 900 µg/m³. The reason for this finding is not known as there are no known groundwater plumes in this area and may be due to some characteristic unique to that property. The levels of TCE in soil gas in the Northeast 15th Street and Southeast 14th Street areas were much lower than those in the Delfasco Forge area.

There was an apparent relationship between people living in homes with detectable levels of TCE in the indoor air and detectable levels of TCE in the blood (Figure 3). While the relationship between blood levels and adverse health effects is not known, based on what is known about levels in air we would not expect these exposures to cause adverse health effects. The levels of TCE found in the indoor air during this investigation were much lower than air levels shown by others to cause adverse health effects.

The purposes of this investigation were to determine whether residents living above a TCE groundwater plume have higher levels of TCE in their bodies than residents not living above a TCE groundwater plume and to provide additional information on the relationship between human exposures and the vapor intrusion pathway.

The results of this investigation are consistent with the conclusion that vapor intrusion is likely occurring in the Delfasco Forge area which had the highest indoor air TCE levels, the highest soil gas levels, and people with significantly higher levels of TCE in their blood than residents living in the comparison area. In addition, a larger percentage of people living over the Delfasco Forge Groundwater Plume had detectable levels of TCE in blood (45%) than either people not living over a plume (5.9%) or the general population (<5%) [7].
Based on the data collected, the majority of homes in the Northeast 15th Street area, Southeast 14th Street area, and the comparison area had indoor air TCE levels similar to those found in homes across the United States [12]. Compared to the general population, a higher percentage of people tested from these three areas had detectable levels of TCE in their blood. The blood levels in this combined area were significantly higher than a sample of individuals taken across the United States (p = 0.0003). Although TCE was detected in the indoor air, the levels were low. Living in a home subject to TCE vapor intrusion is not the only way that people may be exposed to TCE, other sources include the use of solvents to remove grease from automotive and metal parts or the use of various household and consumer products (such as a residue in plastics, typewriter correction fluid, paint removers, adhesives, and spot removers). Based upon the low levels of TCE in indoor air and the geographic distribution of the sampling results, the intrusion of TCE vapors in the Northeast 15th Street area, Southeast 14th Street area, and the comparison area does not appear to be a significant pathway for exposure.

Statistical analyses of the cumulative data show that indoor air TCE levels were positively associated with blood TCE levels. In multiple linear regression analysis, only indoor air TCE levels remained as a significant predictor variable in the model, indicating that a primary determinant of the level of TCE in the blood is the level of TCE in the indoor air of the home.

**Community Health Concerns**

As part of the exposure investigation, we asked participants and other residents about their health concerns. Residents voiced concerns about headaches, dizziness, respiratory problems, and other allergy-type symptoms, all of which are relatively non-specific with multiple possible causes including infectious agents, allergens, and other environmental pollutants. Based on toxicological information and the data collected in this investigation, the levels of TCE found in the indoor air are not normally known to cause adverse health effects. Nevertheless, EPA-6 has agreed to take a health-protective approach by offering mitigation systems to homeowners in the Delfasco Forge area with evidence of significant vapor intrusion. DSHS staff also recommends that individuals with specific health problems consult their family physician.

**Limitations**

This investigation was designed to determine whether residents living above a TCE groundwater plume have higher levels of TCE in their bodies compared to residents who do not live above a TCE groundwater plume. Although the investigation was not designed to determine the specific source of exposure, we were able to use the various sample types (blood, urine, tap water, indoor air, outdoor air, and soil gas) to look at potential relationships. As with any investigation, there were limitations; the limitations that we identified for this investigation included the following:

- This investigation only captured information about recent exposures. VOCs such as TCE have a short half-life in the body (hours); therefore, unless exposures are known to be ongoing, the levels found in the body only represent recent exposures.
- The measured indoor air levels represented the levels in the homes at the time the samples were collected. Indoor air levels can vary with changes in the weather or ventilation inside
and around the home, and the impact of vapor intrusion can vary significantly between adjacent homes. Sampling over at least two 24-hour periods is recommended to evaluate long-term vapor intrusion exposures. Because vapor intrusion contaminant levels typically build up overnight and are highest in the morning, when the air sampling occurred during the day could influence the reading relative to a 2-day average concentration. In addition, potential sources of TCE inside the home (household products) were not removed prior to and during the indoor air sampling. However, the exposure survey captured information about household products in the home.

- In outdoor air, the mixing height is defined as the height to which outdoor air is uniformly mixed. As the outdoor air temperature increases, the mixing height also increases reducing the concentration of pollutants measured at ground level. Approximately half of the outdoor air samples were collected in the afternoon; thus, mixing height could have impacted outdoor air sample results.
- Based on the current sampling and available toxicological information we would not expect to see adverse health effects resulting from these exposures; however, there is a paucity of toxicological information about potential health effects in people exposed to low levels of TCE over a long period of time (years).
- Instrument result values for blood samples, which are reported down to 0 µg/L, were used in statistical analyses. The analytical method is less accurate below the limit of detection (0.0124 µg/L) so there is less confidence in instrument results below the limit of detection.
- TCE instrument results for blood samples were log-transformed for statistical analyses, in order to meet linear regression assumptions. As it is not possible to log-transform instrument results of 0 µg/L, all instrument results of 0 µg/L were assigned a value of 0.0001 µg/L (a value well below the detection limit).
- While there were statistically significant findings in this investigation, these results should be taken with caution because of the small sample sizes and reduced power with non-parametric tests. In addition, the NHANES data used for the non-parametric analyses are not weighted and therefore are not considered to be representative of the United States population.

**Children’s Health Considerations**

In communities faced with air, water, or soil contamination, children could be at greater risk than are adults from certain kinds of exposure to hazardous substances. A child’s lower body weight and higher intake rate result in a greater dose of hazardous substance per unit of body weight. Sufficient exposure levels during critical growth stages can result in permanent damage to the developing body systems of children. Children are dependent on adults for access to housing, for access to medical care, and for risk identification. Consequently, adults need as much information as possible to make informed decisions regarding their children’s health.

As vapor intrusion is a relatively new area of focus and more information regarding human exposures in vapor intrusion situations is needed, children (at least 6 years old) were included in this investigation. Blood samples were collected from nine children and analyzed for TCE. In all cases, the level of TCE in the child’s blood sample was similar (less than 0.01 µg/L difference) to the level of TCE measured in an adult living in the same home. Although we do not have good
information about potential health effects related to low levels of exposure to TCE in adults or children, the highest level of TCE measured in indoor air (112.01 µg/m³) was well below the ATSDR intermediate-duration inhalation MRL for TCE (500 µg/m³) as well as levels known to cause adverse health effects [8].

**Conclusions**

DSHS reached four conclusions in this health consultation:

1. Evidence indicates that exposure to TCE is occurring and suggests that vapor intrusion likely is occurring in homes above the groundwater plume in the Delfasco Forge area. There was a relationship between soil gas levels, indoor air levels, and blood levels of TCE. This relationship was most apparent in the Delfasco Forge area where the soil gas concentrations and indoor air levels were highest, and where the residents had higher levels of TCE in their blood when compared to the other areas. In addition, compared to the other areas more of the people tested in the Delfasco Forge area had detectable levels of TCE in their blood.

2. Vapor intrusion did not appear to be occurring to a significant extent in the majority of the homes in the Northeast 15th Street, Southeast 14th Street, and comparison areas. Most of the homes in these areas had indoor air levels of TCE similar to those found in homes from the comparison area and a sampling of homes from across the United States.

3. Statistical analyses of the cumulative data indicate that the indoor air level of TCE was the best predictor of the blood TCE level. A multiple linear regression analysis using indoor air, outdoor air, soil gas, and blood TCE levels was used to determine associations with measured blood levels and the indoor air level was the only variable that remained in the final model.

4. Although TCE was detected in the indoor air of some residences the levels found are well below those previously associated with adverse health effects.
Recommendations

Based upon the results of this investigation, the following recommendations are appropriate and protective of public health:

1. Any home with evidence of significant vapor intrusion should be equipped with environmental controls to remove vapors beneath the homes. Examples include active crawl space fans (for pier and beam construction homes) or fresh air intake ventilation (for slab construction homes). It is recommended that confirmatory sampling be conducted after the installation of such systems to ensure indoor air levels are sufficiently reduced.

2. Based on the results of this investigation, special precautions regarding TCE are not required for the majority of homes sampled in the Northeast 15th Street, Southeast 14th Street, and comparison areas.

3. People concerned about possible exposure to TCE should:
   • Make sure that crawl space vents are open and not blocked
   • Make sure that louvers on crawl space vents are in good working condition (not bent)
   • Allow fresh air indoors to help prevent any potential buildup of chemicals in the air
   • Store unused chemicals in tightly sealed containers
   • Use products containing TCE in well ventilated areas

4. People with specific health concerns should consult their family physician. Physicians concerned about possible environmental causes for the patient’s condition can send their concerns to epitox@dshs.state.tx.us with Grand Prairie in the subject line or they can contact the Health Assessment and Toxicology Program at (800) 588-1248.
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References


Appendix A: Acronyms and Abbreviations

ATSDR  Agency for Toxic Substances and Disease Registry
CDC  Centers for Disease Control and Prevention
DSHS  Texas Department of State Health Services
EPA-6  Environmental Protection Agency, Region 6
GC-MS  gas chromatography and mass spectrometry
IRB  Institutional Review Board
IUR  inhalation unit risk
L  liters
LOAEL  lowest observable adverse effect level
MCL  maximum contaminant level
µg/m³  micrograms per cubic meter
µg/L  micrograms per liter
mg/L  milligrams per liter
mL  milliliters
mL/min  milliliters per minute
MRL  minimal risk level
NCEH  National Center for Environmental Health
NHANES  National Health and Nutrition Examination Survey
ND  not detected
ng  nanograms
NRP  non-random participants
OSHA  Occupational Safety and Health Administration
PCE  tetrachloroethylene or perchloroethylene
RBEL  risk-based exposure limit
RfC  reference concentration for chronic inhalation exposure
SPME  solid phase microextraction
TAGA  Trace Atmospheric Gas Analyzer
TCAA  trichloroacetic acid
TCE  trichloroethylene
TCEQ  Texas Commission on Environmental Quality
TEHI  Texas Environmental Health Institute
TNRCC  Texas Natural Resource Conservation Commission
TRRP  Texas Risk Reduction Program
U.S.  United States
UT  University of Texas
VOC  volatile organic compound
Appendix B: Figures

Figure 1. Map of Grand Prairie area with the four neighborhoods\(^a\) included in the investigation.

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\(^a\) Shaded areas indicate the general areas of investigation and do not represent the site boundaries.
Figure 2. Comparison of TCE levels in air. The 95th percentile TCE concentration in North American residences unaffected by subsurface vapor intrusion is 1.6 µg/m³ [12]. The maximum indoor air level measured in Grand Prairie was 112.01 µg/m³. Screening values and levels at which adverse health effects have been observed are presented [8].
Figure 3. Levels of TCE in indoor air compared to levels of TCE in blood samples.
Appendix C: Tables

Table 1. Participants in the Grand Prairie Vapor Intrusion Investigation.

<table>
<thead>
<tr>
<th>Groundwater Plume Area</th>
<th>Number of Homes</th>
<th>Number of Participants</th>
<th>Number of Adults</th>
<th>Number of Children</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delfasco Forge</td>
<td>11&lt;sup&gt;a&lt;/sup&gt;</td>
<td>21&lt;sup&gt;a&lt;/sup&gt;</td>
<td>19&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Northeast 15&lt;sup&gt;th&lt;/sup&gt; Street</td>
<td>9&lt;sup&gt;b&lt;/sup&gt;</td>
<td>18&lt;sup&gt;b&lt;/sup&gt;</td>
<td>14&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Southeast 14&lt;sup&gt;th&lt;/sup&gt; Street</td>
<td>10</td>
<td>18</td>
<td>16</td>
<td>2</td>
</tr>
<tr>
<td>Comparison</td>
<td>10&lt;sup&gt;c&lt;/sup&gt;</td>
<td>17&lt;sup&gt;c&lt;/sup&gt;</td>
<td>14&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>40</strong></td>
<td><strong>74</strong></td>
<td><strong>63</strong></td>
<td><strong>11</strong></td>
</tr>
</tbody>
</table>

<sup>a</sup> One home (with one adult and one child participating in the investigation) had a crawlspace fan installed
<br><sup>b</sup> Includes three volunteers (two adults and one child) living in two homes
<br><sup>c</sup> Includes two volunteers (adults) living in one home

Table 2. Blood sample results for the Grand Prairie Vapor Intrusion Investigation. The detection limit for TCE in blood samples was 0.0124 µg/L.

<table>
<thead>
<tr>
<th>Groundwater Plume Area</th>
<th>Number of Adults</th>
<th>Number of Children</th>
<th>Range (µg/L)</th>
<th>Number Detected in Adults</th>
<th>Number Detected in Children</th>
</tr>
</thead>
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<tr>
<td>Delfasco Forge</td>
<td>18&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>ND&lt;sup&gt;b&lt;/sup&gt;-0.728</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Northeast 15&lt;sup&gt;th&lt;/sup&gt; Street</td>
<td>14</td>
<td>2</td>
<td>ND-0.312</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Southeast 14&lt;sup&gt;th&lt;/sup&gt; Street</td>
<td>15</td>
<td>2</td>
<td>ND-0.028</td>
<td>2</td>
<td>1</td>
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<td>3</td>
<td>ND-0.016</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>61</strong></td>
<td><strong>9</strong></td>
<td><strong>ND-0.728</strong></td>
<td><strong>11</strong></td>
<td><strong>3</strong></td>
</tr>
</tbody>
</table>

<sup>a</sup> Includes 2 people (1 adult and 1 child) living in a home with a crawlspace fan installed
<br><sup>b</sup> ND indicates “not detected”
Table 3. Urine sample results for the Grand Prairie Vapor Intrusion Investigation. The detection limit for TCAA in urine samples was 3.0 milligrams per liter (mg/L).

<table>
<thead>
<tr>
<th>Groundwater Plume Area</th>
<th>Number of Adults</th>
<th>Number of Children</th>
<th>Range (mg/L)</th>
<th>Number Detected in Adults</th>
<th>Number Detected in Children</th>
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<tr>
<td>Delfasco Forge</td>
<td>19(^a)</td>
<td>2(^a)</td>
<td>ND</td>
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<td>0</td>
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<tr>
<td>Northeast 15(^{th}) Street</td>
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<td>ND</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Southeast 14(^{th}) Street</td>
<td>16</td>
<td>2</td>
<td>ND</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Comparison</td>
<td>14</td>
<td>3</td>
<td>ND</td>
<td>0</td>
<td>0</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>63</strong></td>
<td><strong>11</strong></td>
<td>ND</td>
<td><strong>0</strong></td>
<td><strong>0</strong></td>
</tr>
</tbody>
</table>

\(^a\) Includes 2 people (1 adult and 1 child) living in a home with a crawlspace fan installed

Table 4. Tap water sample results for the Grand Prairie Vapor Intrusion Investigation. The detection limit for TCE in tap water samples was 0.0124 µg/L.

<table>
<thead>
<tr>
<th>Groundwater Plume Area</th>
<th>Number of Samples</th>
<th>Range (µg/L)</th>
<th>Number Detected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delfasco Forge</td>
<td>11(^a)</td>
<td>ND-0.04</td>
<td>2(^a)</td>
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<tr>
<td>Northeast 15(^{th}) Street</td>
<td>9</td>
<td>ND</td>
<td>0</td>
</tr>
<tr>
<td>Southeast 14(^{th}) Street</td>
<td>10</td>
<td>ND</td>
<td>0</td>
</tr>
<tr>
<td>Comparison</td>
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<td>ND</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>40</strong></td>
<td>ND-0.04</td>
<td><strong>2</strong></td>
</tr>
</tbody>
</table>

\(^a\) Includes one home with a crawlspace fan installed
Table 5. Indoor air sample results for the Grand Prairie Vapor Intrusion Investigation. Based upon the high volume samples, the limit of detection for TCE in indoor air was 0.12 µg/m$^3$ and the limit of quantification for TCE in indoor air was 0.17 µg/m$^3$.

<table>
<thead>
<tr>
<th>Groundwater Plume Area</th>
<th>Number of Samples</th>
<th>Range (µg/m$^3$)</th>
<th>Number Detected$^a$</th>
<th>Number Quantifiable$^b$</th>
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<tr>
<td>Delfasco Forge</td>
<td>11$^c$</td>
<td>ND-112.01</td>
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<td>Northeast 15$^{th}$ Street</td>
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<td>Southeast 14$^{th}$ Street</td>
<td>10</td>
<td>ND-3.39</td>
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<td>Comparison</td>
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<tr>
<td><strong>Total</strong></td>
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<td><strong>ND-112.01</strong></td>
<td><strong>23</strong></td>
<td><strong>13</strong></td>
</tr>
</tbody>
</table>

$^a$ Number of samples with detectable levels of TCE includes homes in which TCE was detected, but could not be accurately quantified.

$^b$ Number of samples with quantifiable levels of TCE only includes those homes in which the level of TCE could be accurately determined.

$^c$ Includes one home with a crawlspace fan installed

Table 6. Outdoor air sample results for the Grand Prairie Vapor Intrusion Investigation. Based upon the high volume samples, the limit of detection for TCE in outdoor air was 0.12 µg/m$^3$ and the limit of quantification for TCE in outdoor air was 0.17 µg/m$^3$.

<table>
<thead>
<tr>
<th>Groundwater Plume Area</th>
<th>Number of Samples</th>
<th>Range (µg/m$^3$)</th>
<th>Number Detected$^a$</th>
<th>Number Quantifiable$^b$</th>
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<tbody>
<tr>
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<td>4</td>
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<tr>
<td>Northeast 15$^{th}$ Street</td>
<td>9</td>
<td>ND-Detect</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Southeast 14$^{th}$ Street</td>
<td>10</td>
<td>ND-0.27</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Comparison</td>
<td>10</td>
<td>ND-0.605</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>40</strong></td>
<td><strong>ND-0.605</strong></td>
<td><strong>17</strong></td>
<td><strong>7</strong></td>
</tr>
</tbody>
</table>

$^a$ Number of samples with detectable levels of TCE includes homes in which TCE was detected, but could not be accurately quantified.

$^b$ Number of samples with quantifiable levels of TCE only includes those homes in which the level of TCE could be accurately determined.
Table 7. Soil gas sample results for the Grand Prairie Vapor Intrusion Investigation. For the first nine houses, the limit of detection for TCE in soil gas was 0.12 µg/m³ and the limit of quantification for TCE in soil gas was 0.17 µg/m³. For the remaining homes, the limit of detection for TCE in soil gas was 1.6 µg/m³ and the limit of quantification for TCE in soil gas was 2.3 µg/m³ (See Appendix F).

<table>
<thead>
<tr>
<th>Groundwater Plume Area</th>
<th>Number of Samples</th>
<th>Range (µg/m³)</th>
<th>Number Detectedᵇ</th>
<th>Number Quantifiableᶜ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delfasco Forge</td>
<td>11</td>
<td>ND-54,300</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Northeast 15ᵗʰ Street</td>
<td>9</td>
<td>Detect-26.1</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>Southeast 14ᵗʰ Street</td>
<td>9</td>
<td>ND-21.2</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Comparison</td>
<td>9</td>
<td>Detect-900</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>38</td>
<td>ND-54,300</td>
<td>34</td>
<td>30</td>
</tr>
</tbody>
</table>

ᵃ After the first sampling trip, the sample flow rate and sample time were reduced. See Results, Soil Gas for more information. All “not detected” results were from properties sampled after the first sampling trip, thus “not detected” indicates a result of less than 1.6 µg/m³. One home in the Southeast 14ᵗʰ Street area had a “detect” result during the first sampling trip, indicating a result between 0.12 µg/m³ and 0.17 µg/m³. All other “detect” results were from properties sampled in subsequent trips.

ᵇ Number of samples with detectable levels of TCE includes homes in which TCE was detected, but could not be accurately quantified.

ᶜ Number of samples with quantifiable levels of TCE only includes those homes in which the level of TCE could be accurately determined.
Appendix D: Trichloroethylene (TCE)

TCE, a liquid at room temperature, is a solvent that is primarily used to remove grease from metal parts. It is found in some household products such as typewriter correction fluid, paint removers, adhesives, and spot removers. Because it is a highly used chemical, it is one of the more common man-made compounds found in the environment. It also is a breakdown product of tetrachloroethylene (PCE) [8].

In surface water, TCE easily evaporates and is broken down within days to weeks. In groundwater, this process occurs more slowly because of a slower evaporation rate and the absence of photocatalysis. Very little TCE in soil gets broken down, and TCE in the soil can move into groundwater. Although TCE can be found in some foods, this contamination is thought to originate from the use of contaminated water during food preparation [8]. TCE taken up into plants does not accumulate as most of it volatilizes out of the plant [13, 14].

People are exposed to TCE by breathing air, by drinking or using TCE-contaminated water, or by direct contact with TCE. These exposures generally occur in areas near factories that use TCE, near hazardous waste sites with TCE contamination, or due to use of household products. Workers at facilities that use TCE may be routinely exposed to the chemical. Approximately half of the TCE vapors that are inhaled are absorbed into the bloodstream, while the remaining portion leaves the body in the exhaled air. TCE that is ingested also will make its way into the blood. Once in the blood, TCE may either be eliminated from the body or stored into body tissues such as fat. TCE may be eliminated in the breath or in the urine (in about a day) either as the intact compound or after it has been broken down into other compounds by the liver. Breakdown products of TCE also may be stored in body fat [8].

TCE was once used as an anesthetic for surgery because inhalation of large amounts makes people dizzy or sleepy and could result in a loss of consciousness. Dermal exposure to concentrated solutions of TCE can cause skin rashes. Inhalation of moderate levels of TCE may result in headaches or dizziness. Exposure to high concentrations can damage facial nerves, damage the liver and/or the kidneys, cause changes in heart rate, or even result in death [8]. These types of effects typically occur at doses significantly higher than environmental levels (Figure 2).

Some studies have suggested that drinking high levels of TCE in water over a long time may result in increased cancer risk or adverse birth outcomes, including childhood leukemia, heart defects, a rare defect in the respiratory system, eye defects, neural tube defects, oral cleft palates, and hearing and speech impairments; however, the results of these studies are not conclusive [8].

Based only on limited evidence of carcinogenicity in humans, the National Toxicology Program has classified TCE as reasonably anticipated to be a human carcinogen. Experimental studies in animals have shown an increased incidence of malignant and/or a combination of malignant and benign tumors at multiple tissue sites in multiple animal species after inhaling TCE (Figure 2). In mice, TCE induced tumors of the liver, lung, and blood. In rats, exposure to TCE resulted in kidney cancer, interstitial-cell tumors of the testis, and possible leukemia [15].
Tests to determine if people have been exposed to TCE are available; however, they are not routinely performed in doctors’ offices. TCE can be measured in the breath for up to a day after an exposure. These breath tests can indicate if a person has been exposed to a large or small amount of TCE. Breakdown products of TCE can be measured in the urine up to a week after exposure; however, other chemicals also produce the same breakdown products making it difficult to determine whether the person was exposed to TCE [8].
Appendix E: Exposure Survey

Control No. ____________________________

Texas Department of State Health Services
Grand Prairie Vapor Intrusion Investigation Survey

Interviewers Name: ____________________________ Date: ____________________________

Participant Information:

First Name: ____________________________ Last Name: ____________________________ MI: ______

(if child) Parents First Name: ____________________________ Last Name: ____________________________

Street Address: ____________________________ Zip: __________

Mailing Address (if different): ____________________________ Zip: __________

Phone #: (Home) __________ (Work) __________ (Cell) __________

Email Address: ____________________________

What is the primary language spoken in your home? ____________________________

Gender: M F Date of Birth: __/__/______

What is your ethnicity? ____________________________ What is your race? ____________________________

What is your current height? ____________________________ Current weight? ____________________________

(if female) Are you pregnant? If yes, what trimester? ____________________________

General Information:

How many people currently live in your home fulltime? ____________________________

If there are children in the home what are their ages? ____________________________

Are there children that regularly visit the household? If yes, what are their ages and how often do they visit? ____________________________

How long have you lived at this address? ____________________________ (If <1 year ask next question)

Was your previous address in Grand Prairie? If so, what was it? ____________________________
Control No. ____________________

**Occupation:** *(Surveyor: If these questions pertain to more than the person being interviewed ask for each person not participating)*

Which best describes your current employment status?
- Work outside of home
- Work at home
- Unemployed
- Retired

What is your occupation? ____________________________________________

Describe the type of work you do at your present job.
- What are your main job tasks? ______________________________________
- When did you start to work for your current employer? ________________

Do you have contact with harmful chemicals at your current job? Yes / No

If yes, please describe the chemicals and their use. ______________________

Have you had or could you have contact with TCE at your job? Yes / No

Do you wear protective equipment such as gloves, dust mask or respirator, hood, etc at work? Yes / No

What type of equipment is worn? ______________________________________

Do you wear your work clothes home? Yes / No / Sometimes

Do you wear your work shoes home? Yes / No / Sometimes

Do you shower and/or change clothes before coming home from work? Yes / No / Sometimes

Have you ever been off work from your current job for more than a day because of an illness or injury related to your work? Yes / No

If yes, explain ______________________________________________________

Have you worked at any other jobs in the past year? Yes / No

If yes, please describe other jobs ________________________________________
Control No. __________________________

**Home Structure Information:**

Is the home on a slab or pier & beam? ________________________________

Does it have a crawlspace, and/or basement? __________________________

Wall construction: concrete / cinder blocks / stone / wood / other (specify): ______________________

If there’s a basement, depth below grade surface ______ ft

Basement floor construction: concrete / dirt / floating / stone / other (specify): ______________________

What is the overall condition of your home? ________________________________

About when was it built? __________________________

Type of heating system (circle all that apply):

- Hot air circulation
- Hot air radiation
- Wood
- Steam radiation
- Heat pump
- Hot water radiation
- Kerosene heater
- Electric baseboard
- Other (specify): __________________________

Type of ventilation system (circle all that apply):

- Central air conditioning
- Mechanical fans
- Bathroom ventilation fans
- Individual air conditioning units
- Kitchen range hood fan
- Outside air intake
- Other (specify): __________________________

Is there a whole house (attic) fan? Yes / No

Sub-slab vapor/moisture barrier in place? Yes / No

In the last 6 months have you or anyone else renovated your home in any way? Yes / No

- Indoor painting
- Refinishing floors
- Adding rooms to the house
- Laying new carpet
- Stripping cabinets
- Other (Specify): __________________________

How often do you leave your windows open? __________________________

Do you use any air purification devices? Yes / No

If yes, what type of device is used? Is it a device using activated carbon? __________________________
Control No. _____________________

**Indoor Air:**

How many hours per day do you usually spend inside your home on a **weekday or on the days you are working outside the home**? _____________________________

How many hours per day do you usually spend inside your home on a **weekend or on the days you are home from work**? _____________________________

What days of the week do you work? _____________________________

How many fewer hours do you spend indoors during the warmer months? (How much additional time are you outside)? _____________________________

Do you smoke in the household? ___________ How much per day? _____________

Are there any *(other)* smokers in the household? ___________ How many? ___________

If there are smokers:

- Do they smoke inside the home? ________ How many cigarettes per day? ________
- How many cigars a day? _______________ How many pipes per day? ___________

Have you or others in your household noticed odors or fumes in your home or in common areas where you spend most of your time (bedroom, living room, kitchen)? If yes, please describe the odors, their location, when they occur, and for how long. _____________________________

Have you recently used any pesticides including animal repellant, fungicide, herbicide, insecticide, etc to get rid of insects, rodents or other pests?  Yes / No

- If yes, was it done inside outside both
- What was used? _____________________________
- How often was it used? _____________________________

In the past month, were any chemicals used to treat this home to control fleas, roaches, ants, termites, or other insects?  Yes / No

Are there any dry cleaned materials in the home other than clothing? *(curtains, table clothes, etc)*?  Yes / No

If yes, please explain. _____________________________

Do the occupants of the home have their clothes dry cleaned?  Yes / No

- If yes, how often? Weekly / Monthly / 3-4 times a year
Air Sampling:

Was any cleaning done in the rooms where the air samplers were placed? Yes / No

Have you recently used any cleaning products inside the home? (Example: air fresheners, bleach, toilet bowl cleaner, etc)? Yes / No

If so, what types did you use?

Over the past two days, did any activities in the home or elsewhere involve working with or being near stain or spot removers? Yes / No

If so, what type?

Over the past two days have you used any auto products such as brake fluid, de-icer, lubricant, sealant, etc? Yes / No

If so what type?

Fuels Used Indoors:

Do you use any of the following in your home?

<table>
<thead>
<tr>
<th>Natural Gas</th>
<th>Propane Gas</th>
<th>Kerosene</th>
<th>Coal</th>
<th>Wood Burning Stove</th>
<th>Gasoline</th>
<th>Artificial Logs</th>
</tr>
</thead>
</table>

During which month do you usually start using heating devices?

During which month do you usually stop using heating devices?

Are there any chemicals or open containers stored in or near the living spaces of your home? Yes / No

Do you use pesticides in your home? Yes / No

Have you recently used or been near fuels? Yes / No

Is any gasoline, diesel, fuel oils, or kerosene being stored in any room or basement of your home or in an attached garage or carport? Yes / No

Does the home have an attached garage directly connected to living space? Yes / No

If so, is a car usually parked in the garage? Yes / No

Are any devices with gasoline or diesel engines such as lawn mowers being stored in any room or basement of your home or in an attached garage or carport? Yes / No
Control No. ____________________________

Have you recently used any home maintenance products such as caulk, grout, insulation, paint, putty stain, etc?  Yes / No

If so, what types and how long ago did you use them? ________________________________

Are any paints or varnishes being stored in any room or basement of your home or in an attached garage?  Yes / No

**Water:**

What is your main source of drinking water? ________________________________

What is your main source of water used for cooking? ________________________________

What is your main source of water for bathing and showering? ________________________________

If a water company supplies your water what is the name of the company? ________________________________

If you have a private well, has it been tested, when was it tested, and what it was tested for? ________________________________

Do you have any water treatment devices for your home?

<table>
<thead>
<tr>
<th>None</th>
<th>Charcoal Filter/GAC</th>
<th>Ceramic Filter</th>
<th>Reverse Osmosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Softener</td>
<td>Boil Water</td>
<td>Distillation</td>
<td>Aerator</td>
</tr>
<tr>
<td>Other (Specify): ________________________________</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If you have filters, do you regularly replace and maintain them?  Yes / No

**Yard/Gardening:**

Do you work in your yard (planting, gardening)?  Yes / No

If so, how often? ________________________________

Do you use pesticides on your lawn or garden or do you use a proprietary lawn service? ________________________________

Have you recently used any landscape or yard products such as fertilizer, lawn care, swimming pool products?  Yes / No

Is yes, what did you use and how long ago did you use them? ________________________________
Control No. ____________________

**Hobbies:**

What hobbies do you or your household members engage in? _______________________________

__________________________________________

Do you burn, solder, or melt any products? Yes / No
   Describe: __________________________________

Are any woodworking solvents, paint stripping fluids, or adhesives stored in any room or basement of your home or in an attached garage? Yes / No

On average, for the past month, how many days did you paint walls, furniture, cars, or other objects?

__________________________________________

On average, for the past month, how many days did you use chemical paint strippers? _________

Have you recently used any arts and crafts products such as adhesive, glue, glaze, primer, varnish, etc? Yes / No

If so, what was used? ________________________________________________________________

**Health Questions:**

Do you have any health issues? Yes / No

Please describe: _________________________________________________________________

__________________________________________

__________________________________________

__________________________________________

Do these issues get better or worse in the winter months? Yes / No
   Explain: _________________________________________________________________

Are you under a physicians care for any conditions? Yes / No

Describe conditions: ____________________________________________________________

__________________________________________

__________________________________________

_________________________________________
Control No. __________________________

What types of treatments if any are you currently taking? ____________________________

______________________________________________________________________________

Are you currently taking any medications?  Yes  /  No
  If yes, what are they? ____________________________

______________________________________________________________________________

Please tell us any over the counter medications such as vitamins or supplements (herbal and nutritional) taken on a daily basis. ______________________________________________________________________

______________________________________________________________________________

Do you use any alternative healing or cultural practices? ____________________________

______________________________________________________________________________

Are there any adults in the household with chronic heart or lung conditions, such as coronary artery disease, asthma, or emphysema?  Yes  /  No
  If yes, please describe: ____________________________

______________________________________________________________________________

Do the adults conditions get worse at…
  Work  Home  Weekends  Vacation  School

Are there any children in the household with chronic heart or lung conditions, such as congenital heart disease, asthma or cystic fibrosis?  Yes  /  No
  If yes, what are the ages of the children? ____________________________

Please describe their condition/s: ____________________________

______________________________________________________________________________
Control No. ____________________

Do the child’s conditions get worse at…

Home   Weekends   Vacation   School

**Communication:**

Before being notified about this investigation were you aware of the groundwater plumes that were identified in the Grand Prairie area? Yes / No

If so, how did you find out about it? __________________________________________________________

How would you like to be informed of any future problems or notices? ____________________________

Is there anything you want us to know that we did not ask about?

____________________________________________________________________________________

____________________________________________________________________________________

____________________________________________________________________________________

____________________________________________________________________________________

**Surveyor Gather Following information through observation only:**

Was there significant precipitation within 12 hours prior to (or during) the sampling event? ________

Describe the general weather conditions: ______________________________________________________

Building type: Apartment  Townhouse  Single Family Home  Mobile Home  Other

Type of ground cover outside of home: grass / concrete / dirt / rocks / other (specify): __________
Appendix F: Analytical Procedures

TCE was measured in whole blood and tap water samples using headspace solid phase microextraction (SPME) coupled with gas chromatography and mass spectrometry (GC-MS) [16]. The samples were spiked with stable isotope-labeled internal standard (13C1-TCE) and analyzed within 4 weeks of collection. This method can accurately and precisely quantify TCE levels in blood and water as low as 0.0124 µg/L. All blood and tap water samples were analyzed by the Division of Laboratory Sciences in the CDC/NCEH (Atlanta, Georgia).

Trichloroacetic acid (TCAA) was measured in urine samples by utilizing a colorimetric reaction with TCAA in the presence of sodium hydroxide, pyridine, and heat. The product is measured on the spectrophotometer. This method can detect TCAA levels as low as 3 mg/L [17, 18]. All urine samples were analyzed by NMS Labs (Willow Grove, Pennsylvania).

Collection and analysis procedures for indoor air, outdoor air, and soil gas samples were developed based on the procedures and methods outlined in EPA Method TO-17, Determination of VOCs in Ambient Air using Active Sampling onto Sorbent Tubes. At each home, two indoor air samples and two outdoor air samples were collected simultaneously. For each pair of samples, one pump was calibrated for a nominal volumetric flow rate of 12.5 mL/min and the other pump was calibrated for 50.0 mL/min. Nominal sample volumes for each pair of sorbent tubes were 1 L and 4 L, respectively. Soil vapor samples were collected using a soil probe and the same sorbent tubes and sample pumps as used for air samples. During the first sampling trip (first 9 houses), the sample flow rate (50 mL/min) and the sample time (80 minutes) resulted in a total sample volume of 4 liters (L). Analysis of these samples revealed several samples with high levels of mass loadings on the sorbent tubes so for subsequent sampling trips the flow rate and sample time were reduced to 15 mL/min and 20 minutes, respectively, for a total sample volume of 300 mL. All samples were analyzed for TCE using GC-MS, operated in selective ion mode [19].
Appendix G: Statistical Analyses

Descriptive statistics pertaining to TCE levels found in blood, urine, tap water, indoor air, outdoor air, and soil gas were reported for each community. Statistical analyses were performed using data from randomly selected participants only. Levels of TCE in the blood for Grand Prairie residents were compared to data in the National Health and Nutrition Examination Survey (NHANES) using non-parametric means analysis (Wilcoxon rank-sum). Because there is no weighting scheme for this analysis, the NHANES data could not be weighted and is not considered a national estimate for this statistical test. Non-parametric tests (Kruskal-Wallis and Wilcoxon rank-sum) were also used to test differences in the number of detected samples between the three plume areas and the comparison population.

Multiple linear regression analyses were performed in order to determine associations between environmental levels of TCE (in indoor air, outdoor air, and soil gas) and levels of TCE in residents’ blood. Indoor air TCE levels, outdoor air TCE levels, and soil gas TCE levels were analyzed as independent variables. Blood TCE levels (dependent variable values) were log-transformed to meet linear regression assumptions, as were soil gas TCE levels. Indoor air and outdoor air were modeled as categorical variables. The categories for these variables are as follows:

**Indoor air:**
1. nondetect (low volume sample), nondetect (high volume sample) (reference category)
2. nondetect (low volume sample), detect (high volume sample)
3. detect (low volume sample), detect (high volume sample)
4. nondetect or detect (low volume sample), quantifiable (high volume sample)
5. both low and high volume samples quantifiable, both with levels <14 micrograms per cubic meter
6. both low and high volume samples quantifiable, at least one with a level ≥ 14 micrograms per cubic meter

**Outdoor air:**
1. nondetect (low volume sample), nondetect (high volume sample) (reference category)
2. nondetect (low volume sample), detect (high volume sample)
3. detect (low volume sample), detect (high volume sample)
4. any result (low volume sample), quantifiable level (high volume sample)

95% confidence intervals were calculated for all parameter estimates in the final linear regression model. All analyses were conducted using SAS, version 9.1 and Stata/IC, version 10.

Non-parametric data analyses showed that blood TCE levels for people living in the Delfasco Forge area were significantly higher than both the comparison population (p=0.0238) and the Northeast 15th Street area (p=0.0129). Blood TCE levels for people living in the Northeast 15th Street area and the Southeast 14th Street area were not statistically significantly different than blood TCE levels for people living in the comparison neighborhood.
Multiple linear regression analysis of the cumulative data showed indoor air TCE levels were positively associated with blood TCE levels. Indoor air TCE level was the only predictor (independent) variable that remained in the final regression model, indicating that the level of TCE in the blood is primarily determined by the level of TCE in the indoor air of the home. The geometric mean blood TCE level of residents living in homes with indoor air TCE levels of 14 µg/m$^3$ or greater was approximately 600 times higher than the geometric mean blood TCE level in residents living in homes with no detectable levels of TCE in the indoor air. In addition, the geometric mean blood TCE level of residents living in homes with a quantifiable level of TCE in indoor air (but less than 14 µg/m$^3$) was approximately 20 times higher than the geometric mean blood TCE level in residents living in homes with no detectable levels of TCE in the indoor air.