Health Consultation

EVALUATION OF THE VAPOR INTRUSION INVESTIGATION FOR THE

TOKHEIM SITE

JASPER, MARION COUNTY, TENNESSEE

MAY 27, 2011

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Cooperative Agreement with the Agency for Toxic Substances and Disease Registry,
U.S. Department of Health and Human Services.

Foreword

This document summarizes an environmental public health investigation performed by the Environmental Epidemiology Program of the State of Tennessee Department of Health. Our work is conducted under a Cooperative Agreement with the federal Agency for Toxic Substances and Disease Registry. In order for the Health Department to answer an environmental public health question, several actions are performed:

Evaluate Exposure: Tennessee health assessors begin by reviewing available information about environmental conditions at a site. We interpret environmental data, review site reports, and talk with environmental officials. Usually, we do not collect our own environmental sampling data. We rely on information provided by the Tennessee Department of Environment and Conservation, U.S. Environmental Protection Agency, and other government agencies, businesses, or the general public. We work to understand how much contamination may be present, where it is located on a site, and how people might be exposed to it. We look for evidence that people may have been exposed to, are being exposed to, or in the future could be exposed to harmful substances.

Evaluate Health Effects: If people have the potential to be exposed to contamination, then health assessors take steps to determine if it could be harmful to human health. We base our health conclusions on exposure pathways, risk assessment, toxicology, cleanup actions, and the scientific literature.

Make Recommendations: Based on our conclusions, we will recommend that any potential health hazard posed by a site be reduced or eliminated. These actions will prevent possible harmful health effects. The role of Environmental Epidemiology in dealing with hazardous waste sites is to be an advisor. Often, our recommendations will be actions items for other agencies. However, if there is an urgent public health hazard, the Tennessee Department of Health can issue a public health advisory warning people of the danger, and will work with other agencies to resolve the problem.

If you have questions or comments about this report, we encourage you to contact us.

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Glossary of Terms and Acronyms

Additive effect: A biologic response to exposure to multiple substances that equals the sum of responses of all the individual substances added together.

Adverse health effect: A change in body function or cell structure that might lead to disease or health problems

Ambient: Surrounding (for example, *ambient* air).

ATSDR: Agency for Toxic Substances and Disease Registry.

Background level: An average or expected amount of a substance in a specific environment, or typical amounts of substances that occur naturally in an environment.

Cancer: Any one of a group of diseases that occur when cells in the body become abnormal and grow or multiply out of control.

Cancer risk: The theoretical excess risk for getting cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower. The excess cancer risk is often expressed as $1x10^{-6}$ for one excess cancer in 1 million people.

Carcinogen: A substance that may cause cancer.

Chronic exposure: Contact with a substance that occurs over a long time (more than 1 year).

Comparison value (CV): Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.

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

Contaminant: A substance that is either present in an environment where it does not belong.

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

EPA: United States Environmental Protection Agency.

Epidemiology: The study of the distribution and determinants of disease or health status in a population; the study of the occurrence and causes of health effects in humans.

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

Exposure pathway: The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: 1. a source of contamination (such as an abandoned business), 2. an environmental media and transport mechanism (such as movement through ground water), 3. a point of exposure (such as a private well), 4. a route of exposure (eating, drinking, breathing, or touching), and 5. a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.

Groundwater: Water beneath the Earth's surface in the spaces between soil particles and between rock surfaces.

Health Consultation: A review of available information or collection of new data to respond to a specific health question or request for information about a potential environmental hazard. Health consultations are focused on a specific exposure issue. Health consultations are therefore more limited than a public health assessment, which reviews the exposure potential of each pathway and chemical.

Inhalation: The act of breathing. A hazardous substance can enter the body this way.

Intermediate duration exposure: Contact with a substance that occurs for more than 14 days and less than a year.

Migration: Chemical movement from one location to another.

Minimal risk level (MRL): An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects.

Plume: A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction they move. For example, a plume can be a column of smoke from a chimney or a substance moving with ground water.

ppb: Parts per billion.

Remediation: 1. Cleanup or other methods used to remove or contain a toxic spill or hazardous materials from a site; 2. for the Asbestos Hazard Emergency Response program, abatement methods including evaluation, repair, enclosure, encapsulation, or removal of greater than 3 linear feet or square feet of asbestos-containing materials from a building.

Remedial Investigation (RI): The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process of determining the type and extent of hazardous material contamination at a site.

Risk: The probability that something will cause injury or harm.

Route of exposure: The way people come into contact with a hazardous substance. Three routes of exposure are breathing (inhalation), eating or drinking (ingestion), or contact with the skin (dermal contact).

Sample: A portion or piece of a whole. A selected subset of a population or subset of whatever is being studied. For example, in a study of people the sample is a number of people chosen from a larger population. An environmental sample, such as a small amount of soil or water, might be collected to measure contamination in the environment at a specific location.

Soil-Gas: Gaseous elements and compounds in the small spaces between particles of earth and soil. Such gases can be moved or driven out under pressure.

Solvent: A liquid capable of dissolving or dispersing another substance (for example, acetone or mineral spirits).

Source Area: The location of or the zone of highest soil or ground water concentrations, or both, of the chemical of concern. The source of contamination is the first part of an exposure pathway.

Toxicological Profile: An ATSDR document that examines, summarizes, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.

Toxicology: The study of the harmful effects of substances on humans or animals.

Volatile organic compounds (VOCs): Organic compounds that evaporate readily into the air. VOCs include substances such as benzene, dichloroethylene, toluene, trichloroethylene, methylene chloride, methyl chloroform, and vinyl chloride.

SUMMARY

INTRODUCTION

The Tennessee Department of Health's (TDH) Environmental Epidemiology Program (EEP) wrote this health consultation at the request of the Tennessee Department of Environment and Conservation (TDEC), Division of Solid and Hazardous Waste Management's (DSWM) State Remediation Program (SRP). This health consultation was prepared to evaluate the results of indoor air and soil-gas sampling. Two of the sampling points were located inside the former Tokheim Building located at 150 Hickman Road in Jasper, Marion County, Tennessee. Six other air samples were collected inside 6 homes downgradient from the Tokheim Site. One soil-gas sample was collected near another home downgradient from the site.

Site investigations have been ongoing for many years. The Tokheim site had releases of degreasing solvents over time. Several chemicals, documented to have been used at the site, were found in groundwater during site investigations. The chemicals migrated through soil and into groundwater. The most abundant chemical found was tetrachloroethylene (PCE). Also found were the PCE breakdown chemicals trichloroethylene (TCE), cis-1,2-dichloroethylene (cis-1,2-DCE), and vinyl chloride (VC). PCE has been indentified in groundwater beneath the site and beneath residential properties east and northeast of the site. PCE, TCE, cis-1,2-DCE, and VC vapors can potentially migrate from groundwater into the indoor air of overlying buildings. People working or living in these buildings could breathe air containing these chemicals. Because of this, the vapor intrusion investigation was performed.

Data supplied for this health consultation were compared to residential and industrial health comparison values, provided by the Agency for Toxic Substances and Disease Registry (ATSDR) and the U.S. Environmental Protection Agency (EPA). Comparison values are chemical concentrations based on toxicology below which no harmful health effects are predicted to occur.

CONCLUSIONS

The EEP reached four conclusions in this health consultation:

Conclusion 1

EEP concludes that the chemical tetrachloroethylene (PCE) is present in the indoor air of all 6 homes above the ground-water contamination found downgradient from the former Tokheim Site. Levels of PCE in the indoor air of 3 of the 6 homes were slightly elevated above background levels. One of the homes was the closest home to the Tokheim site. The other two were located along a drainage downgradient from the site. However, the calculated theoretical excess cancer risk based on the sampling results

is in the range considered acceptable by EPA (EPA 1991) and will not likely create unhealthy indoor air.

Basis for Conclusion

The indoor air of 3 homes contains low but slightly elevated levels of PCE, ranging from 0.31 to 0.98 parts per billion. PCE breakdown chemicals were also present in the indoor air samples. Based on the location of these homes, the results, and the building inventories conducted at the time of sampling, there could be vapors migrating through the subsurface from the underlying contaminated ground water. The low levels of PCE measured in the homes would not result in adverse health effects.

Next Steps

Additional indoor air sampling of the 3 homes is recommended. Because minor amounts of PCE were detected in the home closest to the site and two downgradient, TDEC should have the responsible party perform the additional sampling. Additional sampling would allow a better understanding and establish a trend over time.

Conclusion 2

EEP concludes that the minor amounts of PCE or PCE breakdown chemicals found in the remaining 3 homes tested will not harm the health of residents of those homes.

Basis for Conclusion

Even though site-related chemicals were measured in the indoor air of these 3 homes, the levels were very low. Breathing indoor air with these very low PCE levels would not result in adverse health effects.

Next Steps

It would be prudent to sample these 3 homes downgradient from the site again to confirm the results of testing evaluated in this report.

Conclusion 3

EEP concludes that the chemicals detected in the indoor air of the former Tokheim site building are not expected to harm the health of the workers.

Basis for Conclusion

Indoor air of the former Tokheim site building contained measurable amounts of the site-related chemicals PCE and cis-1,2-DCE. The amounts of both chemicals were very low and would not lead to unacceptable non-cancer or cancer health effects for those breathing the indoor air. The amounts of these chemicals in the air were below their respective comparison values.

Next Steps

Indoor air in the former Tokheim site building should also be sampled when indoor air in homes downgradient from the former Tokheim site is sampled in the future. This future sampling would confirm the results of the testing evaluated by this report.

Conclusion 4

Based on the soil-gas sample, EEP has concludes that PCE and TCE are present in soil-gas near the Home 7at levels below EPA target levels for shallow soil-gas.

Basis for Conclusion

Even though site-related chemicals were measured in the soil-gas sample collected, their levels were very low. The levels were below EPA shallow soil-gas target levels for indoor air.

Next Steps

No additional steps are recommended.

FOR MORE INFORMATION

If you have any questions or concerns about your health, you should contact your healthcare provider. For more information on this site, call the Tennessee Department of Environment and Conservation's Division of Solid and Hazardous Waste Management at 615-532-0780. For health information, call the Tennessee Department of Health's Environmental Epidemiology Program at 615-741-7247 or toll-free at 1-800-404-3006 during normal business hours. You may also e-mail the Tennessee Department of Health's Environmental Epidemiology Program at eep.health@tn.gov.

Introduction

The Tennessee Department of Environment and Conservation (TDEC), Division of Solid and Hazardous Waste Management's (DSWM), State Remediation Program (SRP) requested that the Tennessee Department of Health's (TDH) Environmental Epidemiology Program (EEP) review the results of soil-gas, indoor air, and ambient outdoor air samples collected at the former Tokheim Site. All samples were collected as part of a vapor intrusion investigation.

Through previous environmental investigations, soil and groundwater beneath the site were found to be contaminated by various chemicals, many of which were chlorinated volatile organic solvent compounds (VOCs). Historical ground-water sampling at, north, and northeast from the site found 1,1-dichloroethane (1,1-DCA), 1,1-dichloroethylene (1,1-DCE), cis-1,2-dichloroethylene (cis-1,2-DCE), trans-1,2-dichloroethylene (trans-1,2-DCE), tetrachloroethylene (PCE), trichloroethylene (TCE), vinyl chloride (VC), benzene, tert-butylbenzene, ethylbenzene, isopropylbenzene, n-propylbenzene, and xylenes. The VOC ground-water plume had migrated north and northeast from the former Tokheim property. PCE has been the dominant chemical found in groundwater both on-site and downgradient from the site. TDEC SRP was concerned about intrusion of vapors of PCE and its breakdown chemicals, TCE, cis-1,2-DCE, and VC, coming from the contaminated ground water beneath the main site building into the indoor air. TDEC SRP was also concerned about these vapors from the off-site ground-water contaminant plume migrating into nearby homes. All air samples collected as part of the vapor intrusion investigation were collected by St. John-Middelhauser and Associates Inc. (SM&A) of Downers Grove, Illinois, working for the responsible party.

As asked for by TDEC SRP, this review will specifically evaluate the soil-gas, indoor air, and outside air sampling results of downgradient homes and the former Tokheim site building. Because the major chemicals found in ground water were PCE, TCE, cis-1,2-DCE, and VC, this public health consultation was done to protect the health of those who live in homes downgradient from the site and those who currently work in the former Tokheim site building.

Background

The former Tokheim facility is located at 150 Hickman Road, Jasper, Tennessee 37347. According to SM&A (2010), the site is an approximate 21.3 acre parcel located in a mixed agricultural, residential, commercial, and industrial area just south of the City of Jasper, Marion County, Tennessee. The investigation area for this report was made up of two parts: the office/fabrication building on the site and the residential area located above the migrating groundwater contamination. It is unknown when the site was developed and manufacturing operations began. The site has had different uses throughout its life. The first environmental investigations were conducted in 1992. It is unknown when the releases of chlorinated solvents occurred at the site. The site is currently owned by the Marion County Industrial and Environmental Development Board (SM&A 2010). The facility was occupied until recently by Universal Form Clamp, a manufacturer of scaffolding and concrete shoring equipment. A new tenant, Jasper Materials, Inc., now occupies the site (SM&A 2011b). Jasper Materials manufactures the same items as Universal Form Clamp. The site (Figure 1) is bordered to the east by a railroad right of way. Beyond the railroad right-of way to the east are private homes

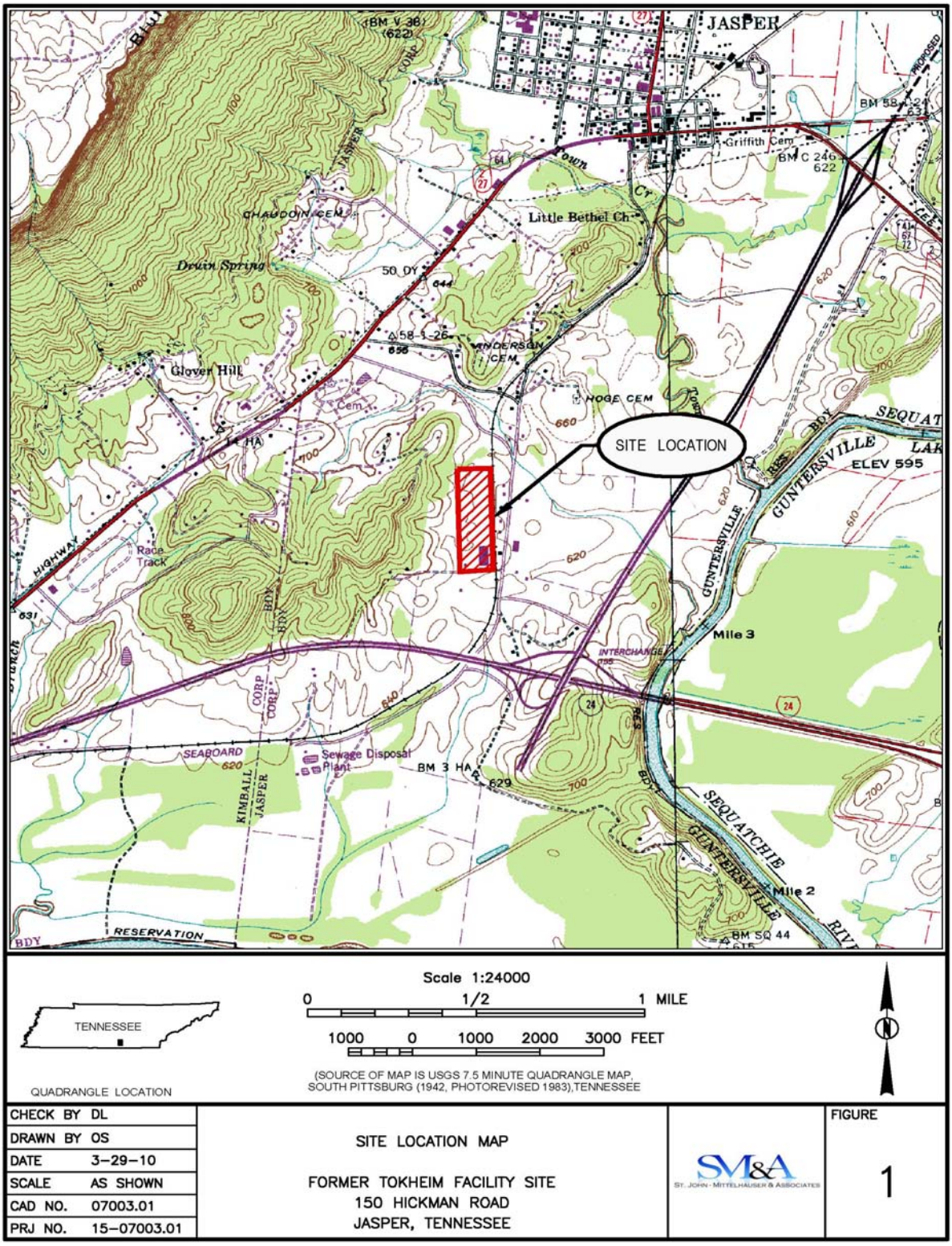


Figure 1. Former Tokheim Site location in Jasper, Marion County, Tennessee. There are homes east and northeast of the Site. (Source: SM&A 2011a).

along Industrial Boulevard. An office of Mountain Valley Mental Health and a Variform plant that manufactures vinyl siding, soffit, skirting, and accessories are located to the south, agricultural land and a wooded area and hillside are located to the west, and open and wooded areas are located to the north.

The solvents PCE and TCE are no longer used to clean manufactured parts at the site. Current workers are not covered under a workplace health and safety plan that would outline the hazards associated with solvents.

Remaining contaminated soil and groundwater beneath industrial sites can lead to vapor intrusion. Vapor intrusion is the movement of volatile chemicals from the subsurface into overlying buildings. Volatile chemicals in buried wastes and/or contaminated ground water can emit vapors that migrate through subsurface soils and into the indoor air of overlying buildings. Vapors may accumulate in buildings to levels that pose safety hazards, health risks, or odor problems. Vapor intrusion has been documented in buildings with basement, crawlspace, or slab-on-grade foundation types. Vapor intrusion can be an acute health hazard. Usually, indoor vapor levels are low. Low levels of vapors, breathed over a long period of time, may or may not be a chronic health concern.

Findings of Previous Investigations

TDEC SRP is managing the site and has designated it State Remediation Program Site SRS-0472. Many previous environmental investigations have been conducted at the site. Soil and ground water investigations have been carried out on the site property and downgradient (mainly north and northeast) from the site.

The previous environmental investigations done by SM&A have focused on the delineation of the extent of on-site soil contamination and both on-site and off-site ground water contamination. Investigations to determine the full extent of ground water impact are ongoing. Data gathered from the environmental investigations suggest that there were two potential source areas for the chlorinated solvent PCE. One is located northeast of the facility building. The other is at the former location of a pump testing pit near the center of the former Tokheim fabrication and office building. The source area in the northeast portion of the site may be related to a broken pipe from a floor drain leading from a former parts washer along the east side of the facility building. The pipe leads to an industrial septic system in the rear of the facility. The septic system was used to discharge facility industrial wastewater prior to the facility connecting to the municipal sewer system. The pump testing pit was installed as a continuous concrete pour at the same time as the building floor slab. These source areas appear to have created a groundwater contaminant plume that is migrating beneath the fabrication and office building and an established residential area east and northeast of the site. Vapors from the ground water plume could potentially migrate into the indoor air of the former fabrication and office building on-site and into homes downgradient from the site.

The background concentration of PCE in the environment is usually less than 1 ppb. The significance of exposure to small amounts of PCE is unknown, but to date, they appear to be relatively harmless (ATSDR 1997). For this site, we are concerned with the inhalation of PCE from vapor intrusion into indoor air. Through releases at the former Tokheim facility, PCE

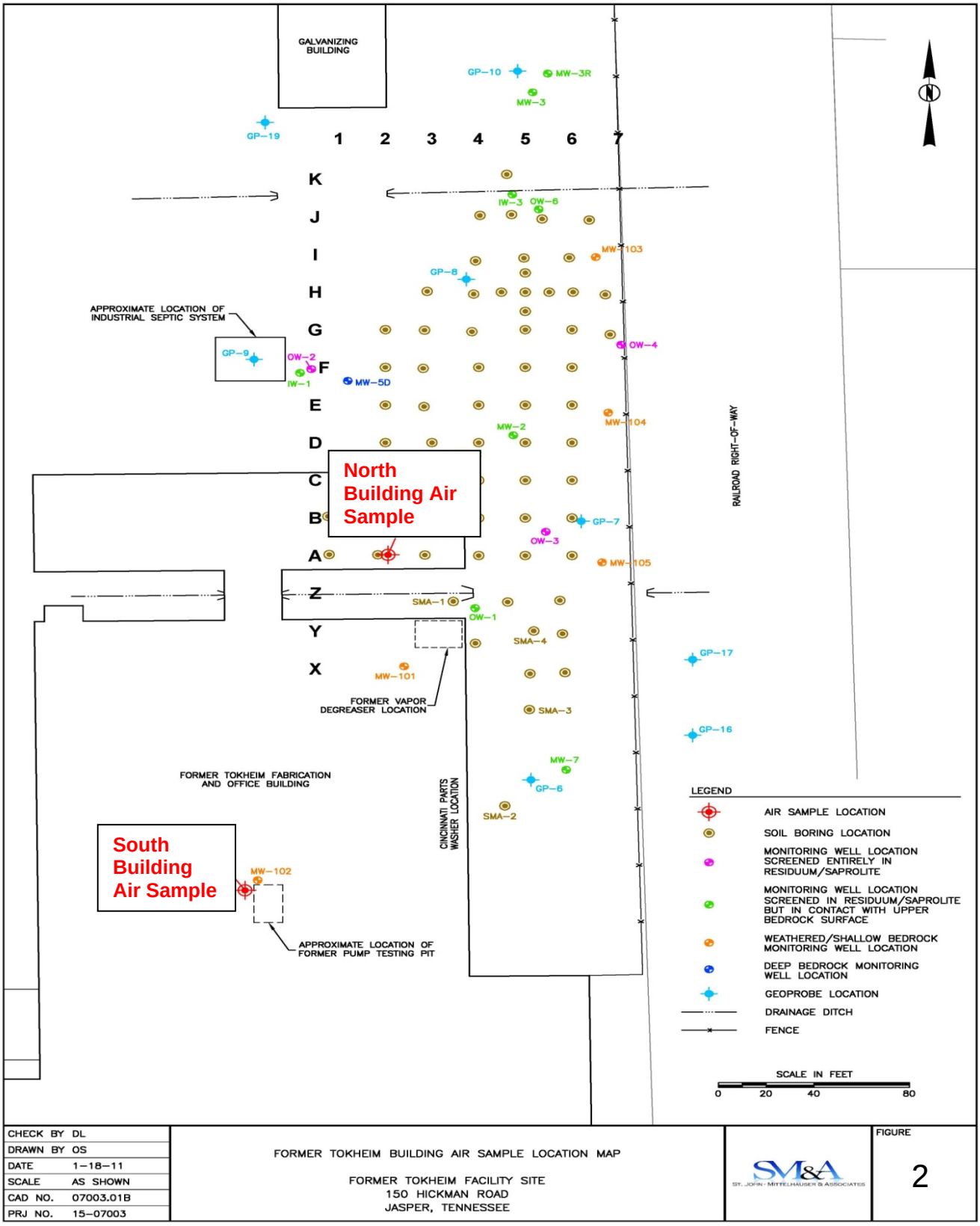


Figure 2. Air sampling locations inside the former Tokheim building. (SM&A 2011a).

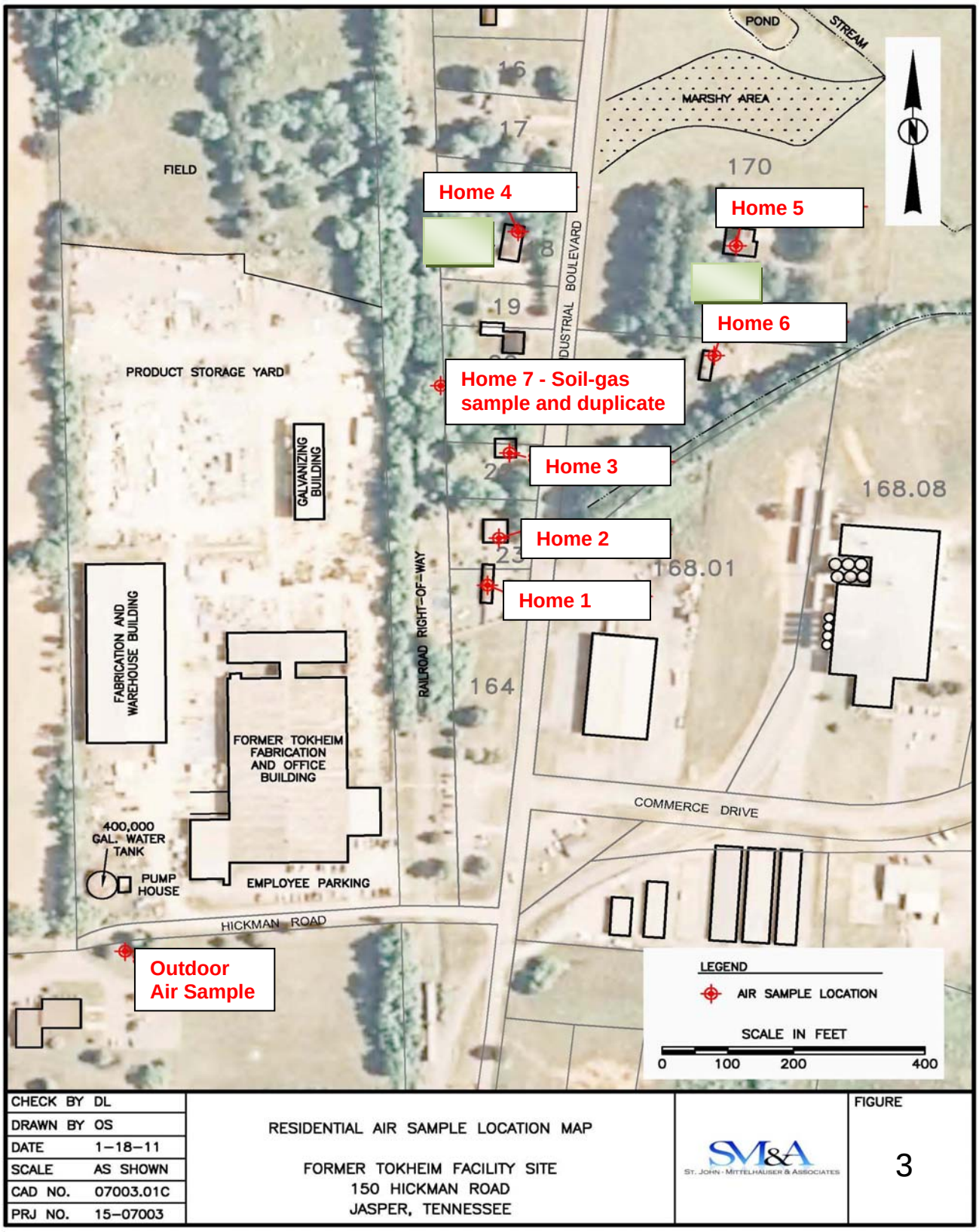


Figure 3. Locations of indoor air samples collected in homes, an outdoor air sample, and a soil-gas sample collected on October 25, 2010. (Source: SM&A 2011a)

migrated into the soil and eventually into groundwater beneath the site. In the environment, PCE is broken down by microorganisms that live in the soil to TCE, cis-1,2-DCE, and VC.

Background concentrations of TCE in the environment are also usually less than 1 ppb. TCE is used mainly as a solvent to remove grease from metal parts, but it is also an ingredient in adhesives, paint removers, and spot removers (ATSDR 1997). 1,2-Dichloroethlyene enters the environment through industrial activity. 1,2-Dichloroethylene is released to the environment from chemical factories that make or use this chemical, from landfills and hazardous waste sites containing this chemical, from chemical spills, from burning of objects made of vinyl, and from breakdown of other chlorinated chemicals. VC is a manufactured substance that does not occur naturally; however, it can be formed in the environment when other manufactured substances, such as PCE, TCE, and trichloroethane are broken down by certain microorganisms.

The north-northeasterly flow of ground water carries the dissolved PCE, TCE, cis-1,2-DCE, and VC into off-site areas. The topography of the bedrock surface beneath the site is highly variable and was encountered at depths ranging from 16 to 42 feet (ft) below ground surface (bgs). The groundwater contamination has been found to extend approximately 1,000 feet downgradient from the main site building (Figures 2 and 3). Ground water occurs near the facility at approximately 15 ft to 21 ft below ground surface (bgs), based on water level measurements collected in November 2010 (SM&A 2011a). Topography in the vicinity of the site slopes to the northeast. Therefore, the depth to groundwater becomes shallower to the northeast, and is approximately 8 ft bgs near the northeastern limits of the plume (SM&A 2011b).

Since PCE and its breakdown chemicals, TCE, cis-1,2-DCE, and VC, appear to be the dominant site-related solvents found in groundwater (SM&A 2010), remedial efforts tailored to those chemicals were completed at the Tokheim site. Emulsified edible oil was injected in November 2010 in permanent wells installed in 2 lines oriented diagonally from southwest to northeast following the centerline of the impacted groundwater plume (SM&A 2011b). Sampling to confirm that the oil is stimulating biologic breakdown of the PCE in groundwater sampling is scheduled. TDEC (2011) and SM&A (2011b) both report further investigation of the groundwater contamination off-site is proposed by the responsible party.

Both PCE and TCE are classified as "*reasonably anticipated to be carcinogens"* (IARC 1995, NTP 2001). VC is a known human carcinogen (NTP 2005). PCE concentrations in groundwater near the downgradient residential area were found to range from under 2 to over 7,500 parts per billion (ppb). No one is currently drinking the groundwater near the site. Because of the concentrations of these VOCs in groundwater, both TDEC SRP and TDH EEP were concerned about vapors coming from the groundwater plume. With the locations of the homes near the source area and over the plume, TDEC SRP and TDH EEP agreed that the next logical step in TDEC's site evaluation process should be to determine if vapor migration and intrusion were occurring in the residential area downgradient of the site.

The residences located downgradient of the site and over the groundwater contamination were single family homes. Home construction varied; most were wood framed homes sided with aluminum, vinyl, or brick. Lot sizes also vary with most lots appearing to be less than an acre while others appear to be more (Google Earth 2010). Most were typical of a rural residential setting.

TDEC requested a vapor intrusion work plan from SM&A to determine if site-related chemicals in the ground water were off-gassing and causing a potential vapor intrusion problem at the former Tokheim site and in the downgradient homes. Current or future workers may not know that there were potential exposure issues at the site from previous TCE solvent use. The residents who live downgradient from the site would likely be unaware of a potential PCE, TCE, cis-1,2-DCE, or VC exposure issue. TDEC DSWM SRP asked TDH EEP to assess the work plan to better understand the sampling approach and to ensure that the proposed plan would provide enough data for TDH EEP to make public health conclusions. The details of the plan and subsequent sampling activities are discussed in the following paragraphs.

Indoor Air Investigation Work Plan

SM&A submitted a vapor intrusion investigation work plan to both the TDEC SRP and TDH EEP for review. The work plan was very complete and proposed collecting 10 separate samples, including samples of indoor air at two locations inside the former Tokheim building, indoor air inside 7 homes above the ground-water contamination, and outside air near the site.

TDEC SRP and TDH EEP worked together to evaluate the proposed investigation activities. TDH EEP submitted a Technical Assist to ATSDR on March 9, 2010 for the assistance provided to TDEC. Based on comments and feedback from TDEC SRP and TDH EEP, SM&A incorporated the suggestions into their work plan. The plan as proposed by SM&A was valid as it allowed samples to be collected from several different locations above the ground-water contamination. After the work plan was accepted, SM&A obtained access agreements from the former Tokheim facility and downgradient homeowners to collect samples.

The intent of the vapor intrusion investigation conducted by SM&A was to provide a screening evaluation as to whether or not the inhalation exposure pathway was complete at the site and in the residential area downgradient from the site. If the inhalation exposure pathway was found to be complete, further evaluation would be done to determine whether there was a risk to human health. SM&A collected one soil-gas, 8 indoor air, and one ambient (outdoor) air samples on October 25, 2010.

After the indoor air samples were collected, and as part of an inventory of each building sampled, a direct measurement of volatile organic vapors was made. The vapors inside each sample location were measured using a portable photoionization detector (PID) capable of reading in very low ppb levels.

Discussion

Introduction to Chemical Exposure

To determine whether persons have been or are likely to be exposed to chemicals, TDH EEP evaluates mechanisms that could lead to human exposure. Chemicals released into the environment have the potential to cause harmful health effects. Nevertheless, a release does not always result in exposure. People can only be exposed to a contaminant if they come into contact with it. If no one comes into contact with a contaminant, then no exposure occurs, and thus, no health effects could occur. An exposure pathway contains five parts:

- a source of contamination,
- contaminant transport through an environmental medium,
- a point of exposure,
- a route of human exposure, and
- a receptor population.

An exposure pathway is considered complete if there is evidence that all five of these elements have been, are, or will be present at the site. An exposure pathway is considered incomplete if one of the five elements is missing.

The source is the place where the chemical was released. For this site, the source is spills from past activities performed at the site. The environmental media (such as, groundwater, soil, surface water, or air) transport the contaminants. For this site, the chemicals are transported through the ground water and indoor air. The point of exposure is the place where persons come into contact with the contaminated media. Indoor air is the point of exposure for this site. The route of exposure (for example, ingestion, inhalation, or dermal contact) is the way the contaminant enters the body. For this site, the route of exposure is inhalation of indoor air.

Physical contact alone with a potentially harmful chemical in the environment by itself does not necessarily mean that a person will develop adverse health effects. A chemical's ability to affect health is controlled by a number of other factors, including:

- The amount of the chemical that a person is exposed to (dose),
- the length of time that a person is exposed to the chemical (duration),
- the number of times a person is exposed to the chemical (frequency),
- the person's age and health status, and
- the person's diet and nutritional habits.

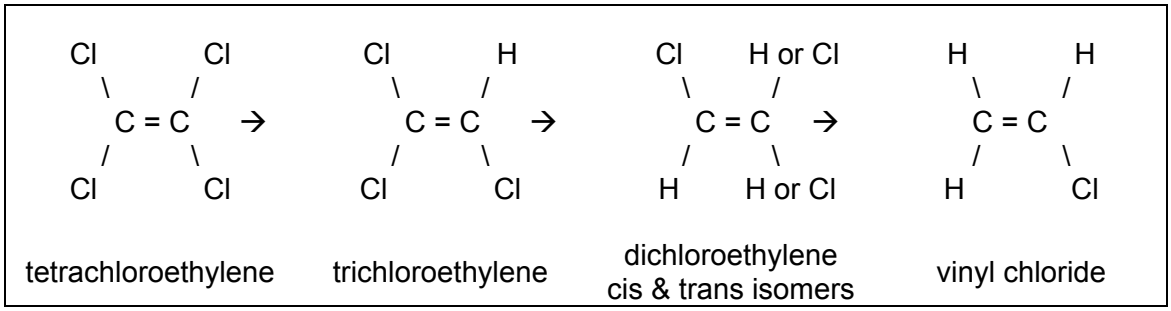
For this project, people who live in homes nearby and above the ground-water contamination are one receptor population. A second receptor population for this project is the workers in the former Tokheim site building.

Solvent Explanation

Past activities included the use of PCE for degreasing in the former Tokheim building. Instead of water, PCE was used as the main solvent to remove grease and other contaminants from the

metal parts manufactured at the site. Therefore, for this evaluation we will focus on PCE and its chemical breakdown products.

PCE is a volatile organic compound. It can quickly evaporate into a gas at room temperature. As its name implies, tetrachloroethylene has four chlorine anions on a two-carbon molecule. The molecule breaks down into other chlorinated volatile organics. Each of these breakdown chemicals has slightly different chemical properties and toxicities. The following diagram is an example of how one chemical can break down to form another.



In this example, PCE can break down to TCE, and then to DCE, and then to VC. The only way to truly know the ratio of these breakdown chemicals is to collect environmental samples. The degradation products cis-1,2-DCE, trans-1,2-dichloroethylene (trans-1,2-DCE), 1,1-dichlororethylene (1,1-DCE), and VC have been noted in ground water samples collected at the site. PCE appears to be the dominant chemical present in the groundwater. The solvents, PCE, TCE, cis-1,2-DCE, and VC, were carefully considered in developing this report.

Comparison Values

To evaluate exposure to a hazardous substance, health assessors often use health comparison values. If the chemical concentrations are below the comparison value, then health assessors can be reasonably certain that no adverse health effects will occur in people who are exposed. If concentrations are above the comparison values (ATSDR 2011) for a particular chemical, then further evaluation is needed.

The Agency for Toxic Substances and Disease Registry's (ATSDR) develops Minimal Risk Levels (MRLs) using conservative assumptions. ATSDR uses the term 'conservative' to refer to values that are protective of public health in essentially all situations. Environmental Media Evaluation Guidelines (EMEGs) are calculated by ATSDR from their MRLs. EMEGs consider non-cancer adverse health effects. Exposure durations are defined as acute (14 days or less), intermediate (15–365 days), and chronic (365 days or more) exposures. ATSDR does not use serious health effects, such as irreparable damage to the liver or kidneys, or birth defects, as a basis for establishing EMEGs. Chronic EMEGs assume exposure for 24 hours per day, 7 days per week, 52 weeks, 365 days per year, over a 70-year lifetime exposure. Exposure to a level above the EMEG does not necessarily mean that adverse health effects will occur (ATSDR 2007).

To understand if concentrations of the solvents PCE, or PCE's breakdown chemicals TCE, cis-1,2-DCE, and VC could lead to excess cancers, measured concentrations of these chemicals were

also compared to ATSDR cancer risk evaluation guides (CREGs). Thus, environmental media concentrations are compared to CREGs to understand the potential cancer health effects of exposure to the chemical. Lifetime exposure to a chemical at a concentration equal to its CREG comparison value could theoretically result in a one in a million risk of developing cancer in addition to the background risk of developing cancer. Both ATSDR and EPA prefer to have a residential risk value less than 1 excess cancer in 1,000,000 people or $1x10^{-6}$. EPA considers an excess cancer risk between 1 in 10,000 and 1 in 1,000,000 as acceptable (EPA 1991).

EPA's Regional Screening Levels (RSLs) for residential air inhalation were also used in evaluating the results of the indoor air testing. Exposure to workers and residents would be involuntary. Since Tokheim no longer occupies the site and it is being reused, current site workers may not know that there are potential exposure issues in the site building. Solvents are no longer used to clean manufactured parts at the site. Federal Occupational Safety and Health Administration (OSHA) work place standards were not used because employees of Jasper Materials Inc., which is using the former Tokheim site building, no longer use PCE and TCE solvents and are not covered under a workplace safety plan outlining the hazards associated with these chemicals. Industrial health comparison values were not used for comparison of the indoor air values measured in the Tokheim building because of the involuntary exposure that would be experienced by those workers. Residential comparison values were used for evaluation of exposure for those living in homes above the ground-water contamination that has migrated downgradient from the site.

PCE and its breakdown chemical TCE were of interest at the site and were evaluated because they are thought to be *"reasonably anticipated to be human carcinogens"* (IARC 1995, NTP 2001). PCE is readily absorbed following inhalation and oral exposure as well as from direct exposure to the skin. For this site, we are concerned with the inhalation of PCE and TCE from vapor intrusion into indoor air. Compared to pulmonary exposure, uptake of PCE vapor by the skin is minimal (ATSDR 1997a).

Breathing small amounts of TCE may cause a variety of short-term health effects including headaches, lung irritation, dizziness, poor coordination, and difficulty concentrating. Breathing it for long periods may cause nerve, kidney, and liver damage (ATSDR 1997b).

The toxicity class of both PCE and TCE has been under review. ATSDR recently adapted California EPA's oral cancer slope factors to generate interim CREGs for both PCE and TCE (ATSDR 2011). The interim PCE CREG is 0.03 ppb while the interim TCE CREG is 0.09 ppb. EPA has residential setting PCE inhalation regional screening levels (RSL) for one excess cancer in 1,000,000 people of 0.06 ppb. EPA also has a residential setting TCE inhalation RSL for one excess cancer in 1,000,000 people of 0.22 ppb, respectively.

Cis-1,2-DCE is not classified with regards to carcinogenicity. VC has been determined to be a *"known human carcinogen"* (NTP 2005). ATSDR has a published CREG of 0.04 ppb. ATSDR does not have a chronic EMEG for VC, but has an intermediate EMEG of 30 ppb. EPA has both a non-cancer and cancer RSL for VC. EPA's non-cancer RSL is 39 ppb. EPA's RSL for one excess cancer in 1,000,000 people for VC is 0.06 ppb.

Environmental Sampling

One soil-gas, 8 indoor, and one outdoor air samples were collected on October 25, 2010. Indoor air samples were taken at two locations inside the former Tokheim site building. Indoor air was also tested in 6 homes downgradient from the site. A soil-gas sample was collected near a seventh home as a substitute for an indoor air sample. The property owner did not provide access to SM&A to conduct indoor air sampling. Therefore, a soil-gas sample was collected as close as possible to the home where access was obtained. Figures 2 and 3 shown previously in this report show the sampling locations.

A PID was used to identify volatile organic compound (VOC) vapors at each indoor air sampling location, both in the off-site homes and in the former Tokheim site building. The PID was used to take general VOC vapor measurements during a building survey to find out if there are sources such as drycleaned clothing, household products, or other items that have the chemicals of interest in the homes or building. The PID was placed near items that were known have VOCs as ingredients or will off-gas VOCs. These items could contribute to the amounts of VOCs found in the indoor air. The building survey was done before the indoor air was sampled.

The indoor air testing inside the former Tokheim site building was carried out over an 8-hour period during work hours, from approximately 7 am to 3 pm (Mr. Darren Lamsma, SM&A, personal communication May 11, 2011). One sample location in the building was centered in the fabrication area. The second sample location was in the northern portion of the building. The sample locations (Figure 2) were chosen because soil and groundwater samples collected from these two locations displayed the highest or the nearly highest measurements of VOCs collected within the building footprint (SM&A 2011a).

The air samples collected from inside the residences, the soil-gas sample, and the outdoor ambient air sample were collected over a 24-hour period. The one soil-gas sample was collected on the Sequatchie Valley Railroad property between the home and the former Tokheim Site as a surrogate indoor air sample. The outdoor ambient air sample was collected south of the main building in an upwind location. All other air samples were collected from inside homes downgradient and above the groundwater contamination migrating from the site (Figure 3).

All investigation samples were shipped in their appropriate containers under chain-of-custody procedures to Environmental Sciences Corporation in Mount Juliet, Tennessee (SM&A 2011a). The samples collected were tested for the entire TO-15 list of chemicals using the selective ion mode (SIM) methodology. The SIM method allows lower detection levels to be met.

Results

The outdoor air testing results showed that PCE was measured in very low amounts. Neither TCE, cis-1,2-DCE, nor VC were found in the outdoor air sample. PCE and TCE were measured in low amounts in the indoor air samples from most of the homes tested. VC was not measured in indoor air of any of the homes. No other site-related chemicals were measured in the homes. Inside the former Tokheim site building, PCE was measured in low amounts. TCE and VC were not measured. Small amounts of PCE and TCE were also measured in the soil-gas sample collected.

Outdoor Air

See Table 1 for results of the outdoor air sampling. Six VOCs were detected: these are: benzene, carbon tetrachloride, chloromethane, 1,4-dichlorobenzene, ethylbenzene, and PCE. Four VOCs, carbon tetrachloride, chloromethane, 1,4-dichlorobenzene, ethylbenzene were not identified in the groundwater contamination coming from the site and thus not pertinent to this project. The small amount of benzene measured is one-third of EPA's measured background benzene concentration for the southeast (EPA Region 4) of 0.32 ppb (EPA 2008). Therefore, the benzene found in the outdoor air at the site is likely a normal background amount. The results from the outdoor air samples were not compared to any regulatory concentrations or comparison values. They were used as reference information for ambient conditions and for comparison of indoor air results.

Soil-Gas

See Table 2 for results of the soil-gas sampling. The surrogate soil-gas sample had small measured amounts of PCE, TCE, and VC (Table 2). PCE was detected at 0.43 ppb. TCE was detected at 0.02 ppb. Cis-1,2-DCE was not detected. VC was detected at 0.07 ppb. A duplicate soil-gas sample was also collected at this location. PCE and VC were detected in the duplicate sample but TCE was not. The PCE amount in the duplicate at 0.12 ppb was approximately 4 times less than the PCE amount measured in the original sample. The VC amount in the duplicate was the same as the original sample at 0.07 ppb.

A total of 7 other VOCs were detected above laboratory detection limits in the soil-gas sample. These include benzene, carbon tetrachloride chloroethane, chloroform, chloromethane, 1,4-dichlorobenzene, and ethylbenzene. Some of these compounds were the same as those found in outdoor air.

Indoor Air — Tokheim Building

See Table 3 for results of the indoor air sampling in the Tokheim building. PCE was identified in the indoor air samples collected (Table 3). One sample was collected from the south building and one from the north building. The 2 indoor air samples had measurements of PCE at 0.27 and 0.22 ppb. TCE and VC were not detected in these two air samples. Cis-1,2-DCE was detected in the indoor air sample from the south building at 0.08 ppb. Along with PCE and cis-1,2-DCE, amounts of 9 other VOCs were measured. These 9 VOCs included acetone, benzene, carbon tetrachloride, chloroform, chloromethane, ethanol, dichlorodifluoromethane, n-hexane, and ethylbenzene. Benzene, carbon tetrachloride, chloroform, and ethylbenzene were measured in concentrations above the outdoor air sample concentrations and above their respective ATSDR or U.S. EPA health comparison values for indoor air concentrations. These chemicals are not considered related to the site groundwater contamination and their origin is unknown.

Indoor Air — Residences

See Table 4 for results of the indoor air sampling of the homes downgradient from the Tokheim site building. Indoor air PCE measurements in 6 homes downgradient from the Tokheim

building ranged from 0.03 ppb to 0.98 ppb. TCE measurements in indoor air in these homes ranged from non-detect (<0.02 ppb to 0.32 ppb). VC was not measured in any of the homes.

The highest PCE measurement of 0.98 ppb (Home 1 on Figure 3) was collected from the home along Industrial Boulevard that was closest to the former Tokheim Site. This home also displayed the lowest volatile organic compound (VOC) vapor reading at 0 ppb. Total VOCs were measured inside the homes using a PID capable of reading in ppb. Therefore, there were likely no contributions of VOC vapors to indoor air from inside Home 1. A neighboring home directly north of this home (Home 2) had one of the lowest PCE concentrations at 0.14 ppb but had the highest VOC PID reading at 2,389 ppb. A home diagonally across Industrial Boulevard and along a small intermittent drainage (Home 6) had the next highest PCE indoor air measurement at 0.83 ppb. This home had the third highest indoor air VOC vapor reading (114 ppb). The third highest PCE measurement was in Home 3 at 0.31 ppb. The remaining homes tested had indoor air PCE measurements of 0.035 ppb (Home 4) and 0.03 ppb (Home 5).

TCE measurements were typically low, ranging from non-detect (<0.02 ppb) to 0.32 ppb. The highest TCE measurement was in the northern-most home tested along Industrial Boulevard (Home 4). This home had one of the lowest PCE indoor air measurements.

Along with site chemicals of concern, 10 other VOCs were detected above laboratory reporting limits in the indoor air of homes sampled. The 10 VOCs included: benzene, carbon tetrachloride, chloroethane, chloroform, chloromethane, 1,4-dichlorobenzene., cis-1,2-DCE, ethylbenzene, 1,1,1-trichloroethane, and vinyl acetate. Of these 10 chemicals, 5 including benzene, carbon tetrachloride, chloroform, 1,4-dichlorobenzene, and ethylbenzene, were measured in concentrations above the outdoor air sample concentrations and above their respective ATSDR or U.S. EPA non-cancer and/or cancer health comparison values for indoor air concentrations. However, none of these 5 VOCs were associated with the PCE groundwater contamination being investigated. Instead, these VOCs are attributed to sources other than the ground-water contamination (SM&A 2011a).

Several possible sources for the indoor air contaminants were identified and documented on the pre-sampling indoor air building survey forms prepared by SM&A. The following possible sources were identified at one or more of the residences:

- kerosene or fuel oil
- car exhaust emissions
- paints/thinners/strippers
- cleaning solvents
- moth balls
- other house cleaning products
- polishes/waxes
- air freshener(s)
- nail polish/remover
- candles

Health Risk Evaluation

The evaluation of the health risk at the site and in homes downgradient from the site will only consider the main chemicals of concern that have been confirmed to be present in ground water. These chemicals include PCE, and the PCE breakdown chemicals TCE, cis-1,2-DCE, and VC. The evaluation is organized by locations of samples; soil-gas and indoor air samples collected at the former Tokheim Site, and those samples collected in and near homes downgradient from the site.

Outdoor Air

Outdoor air near the site was tested to better understand the levels of site-related and other chemicals in the ambient outdoor air in the area. Results are shown in Table 1. One site-related chemical, PCE, was found in the outdoor air sample collected upwind and immediately south of the Tokheim Site. All other site-related chemicals were below their analytical reporting limits. The source of the PCE in the outdoor air is unknown. A major interstate highway is located approximately one-quarter mile south and generally upwind from the outdoor air sample location. Chemicals found in the outdoor air were compared to background measurements collected by EPA and ATSDR as a reference (Table 1).

TABLE 1. Outdoor air sampling results for the former Tokheim Site, Jasper, Marion County, TN. Site-related chemicals are shown. Sample was collected on October 25, 2010, over 24 hours with Summa canisters (SM&A 2011a). Location of outdoor air sample is shown on Figure 3. Values reported in parts per billion (ppb). Background chemical measurements are from various sources and are in ppb.

Chemical / Sampling Data and Location Name	Acronym	Tokheim site Outdoor Air Measurements	Measured United States Background Levels
tetrachloroethylene	PCE	*0.024*	0.12[3]
trichloroethylene	TCE	<0.02	0.17[4]
1,1-dichloroethylene	1,1-DCE	<0.079	131[4]
cis-1,2-dichloroethylene	cis-1,2-DCE	<0.079	0.67[4]
trans-1,2-dichloroethylene	trans-1,2-DCE	<0.079	0.93[4]
vinyl chloride	VC	<0.051*	<0.008[5]

Notes:

<0.079 = Not detected in the air sample. Concentration represents the analytical reporting limit.

<0.051* = Detection limit was greater than measured United States background.

0.33 = Detection of chemical in outdoor air.

[1] = EPA Background Level for the Southeastern U.S.

[2] = Median level of ethylbenzene in city and suburban air (ATSDR 1999).

[3] = EPA Region 9 Ambient Air background values (EPA 2004).

[4] = Some emission and exposure data for trichloroethylene and related chemicals EPA National Center for Environmental Assessment, Office of Research and Development, Washington, D.C. March 2001.

[5] = Background concentrations of 18 air toxics for North America, J. of Air and Waste Mgmt. Assoc. 2006. 56: 3-11

Soil-Gas

Table 2 shows the result of the soil-gas sample and it's duplicate. Site-related chemicals detected in the soil-gas sample collected include PCE, TCE, and VC (Table 2).

PCE was measured at 0.43 ppb in the original sample and 0.09 ppb in the duplicate. TCE was measured at 0.02 ppb in the original sample and not measured in the duplicate. VC was measured at 0.07 ppb in both the original sample and in the duplicate. It appears that the duplicate had much lower readings of two of the main chemicals of interest. Health comparison values have not been developed for soil-gas measurements. However, target levels for indoor air based soil-gas results have been developed, are shown in Table 2, and are discussed below.

A total of 7 other VOCs were detected above laboratory detection limits in the soil-gas sample. These include benzene, carbon tetrachloride chloroethane, chloroform, chloromethane, 1,4-dichlorobenzene, and ethylbenzene. Some of these compounds were the same as those found in outdoor air. None of these compounds were detected above the EPA OSWER generic screening levels for a cancer risk of 1 excess cancer above background in 1 million people, or a 10^{-6} cancer risk.

TABLE 2. Off-site soil-gas sampling results for the former Tokheim Site, Jasper, Marion County, Tennessee. The sample was collected on October 25, 2010, over 8 hours with a Summa canister (SM&A 2011a). Location of the sample is shown on Figure 3. Values reported in parts per billion (ppb). Regulatory comparison values are EPA shallow soil-gas target values with an attenuation factor of 0.1 and both the 10^{-6} and 10^{-4} risk health comparison values are shown.

Chemical / Sampling Data and Location Name	Acronym	Soil-gas sample	duplicate soil-gas sample	EPA OSWER Shallow Soil-Gas Target Levels Attenuation Factor = 0.1	
				10^{-6} excess cancer risk (ppb)	10^{-4} excess cancer risk (ppb)
tetrachloroethylene	PCE	0.43	0.09	1.2	120
trichloroethylene	TCE	0.024	<0.02	0.041	4.1
1,1-dichloroethylene	1,1-DCE	<0.02	<0.02	500	500
cis-1,2-dichloroethylene	cis-1,2-DCE	<0.02	<0.02	88	88
trans-1,2-dichloroethylene	trans-1,2-DCE	<0.04	<0.04	180	180
vinyl chloride	VC	<0.07	<0.07	1.1	110

Notes:
EPA OSWER = Environmental Protection Agency Office of Solid Waste and Emergency Response Shallow Soil-Gas Target Levels (EPA 2002).
Modifiers:
<0.02 = Not detected in the air sample. Concentration represents the analytical reporting limit.

EPA's *OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance)* (2002) suggests all PCE, TCE and VC measurements in the soil gas sample were below their respective generic target shallow soil-gas concentration corresponding to target indoor air concentration where the soil-gas to indoor air attenuation factor equals 0.1, for one excess cancer in 1,000,000 people (10^{-6}) risk, the most conservative health comparison value for this setting.

Building Indoor Air — Non-Cancer Evaluation

To better evaluate the adverse health effects site-related chemicals may have on Jasper Materials workers within the former Tokheim site building, indoor air was evaluated. Indoor air results showed detections of 2 site-related chemicals – PCE and cis-1,2-DCE (Table 3). Other site-related chemicals were not detected. The PCE and cis-1,2-DCE measurements were compared to their respective non-cancer indoor air health comparison values published by the ATSDR (2011) and EPA (2010). The concentrations measured for PCE were well below its respective non-cancer chronic (greater than 365 days) exposure health comparison value of 40 ppb. For cis-1,2-DCE, there is not a non-cancer health comparison value established and thus no comparison could be made.

Even though there were no detections of TCE, trans-1,2-DCE, 1,1-DCE, and VC, their detection limit concentrations were compared to their respective non-cancer indoor air health comparison values published by the ATSDR (2011) and EPA (2010). These comparisons were made as a worst case scenario evaluation. All concentrations were below their respective non-cancer health comparison values. The workers should not experience non-cancer health effects from breathing the indoor air of the Tokheim site building.

Building Indoor Air — Cancer Evaluation

As discussed above, both PCE and cis-1,2-DCE were site-related contaminants measured in the indoor air of the Tokheim site building. Other site-related chemicals were not detected. The PCE and cis-1,2-DCE measurements were compared to their respective cancer indoor air health comparison values published by the ATSDR (2011) and EPA (2010). PCE concentrations measured in the north and south portions of the Tokheim site building were similar: 0.27 ppb in the north and 0.22 ppb in the south. The PCE measurements were compared to the PCE ATSDR Interim CREG of 0.3 ppb and an EPA RSL risk comparison value of 0.6 ppb for one excess cancer in 100,000 people (10^{-5} risk). A 10^{-5} theoretical risk value is typically used as a health comparison value in a commercial or business setting (EPA 1991). The PCE concentrations were not compared to OSHA work place occupational comparison values because PCE is no longer used at the site and workers of Jasper Materials Inc. may not know about the previous use of chemicals at the site. The PCE measurements were approximately equal to the ATSDR 10^{-5} cancer risk comparison value and about one-half of the 10^{-5} EPA RSL cancer risk comparison value. This theoretical risk is an acceptable excess cancer risk to workers, according to EPA (1991). For cis-1,2-DCE, it is not classified as to its carcinogenicity. There is not a cancer health comparison value established and thus no comparison could be made.

There were no detections of TCE, trans-1,2-DCE, 1,1-DCE, and VC in indoor air (Table 3). As a worst case scenario, their detection limit values were compared to their respective health comparison values published by the ATSDR (ATSDR 2011) or EPA (2010). The test detection limits were low, ranging from 0.02 ppb to 0.20 ppb. However, a comparison was done for TCE as a worst case scenario evaluation. The TCE detection limit was compared to the TCE EPA RSL risk comparison value of 2.2 ppb for one excess cancer in 100,000 people (10^{-5} risk). The highest detection limit value of 0.20 ppb for TCE was much less than the 10^{-5} cancer risk comparison values of 0.9 ppb (ATSDR) and 2.2 ppb (EPA). Therefore, there should not be any

TABLE 3. Former Tokheim building, Jasper, Marion County, TN indoor air sampling results. Two samples were collected on October 25, 2010, over 8 hours with Summa canisters (S&ME 2011a). Locations of samples are shown on Figure 3. Values reported in parts per billion (ppb). Where the chemical was not detected, the result is reported as being less than (<) the reporting limit. Health comparison values used are non-cancer chronic environmental media evaluation guides (ATSDR 2011), ATSDR cancer risk evaluation guides (ATSDR 2011b and 2011c), and EPA residential indoor air Regional Screening Levels (EPA 2010).

Chemical / Sampling Data and Location Name	Acronym	North Building	South Building	ATSDR EMEG (non-cancer) (ppb)	ATSDR CREG (10^{-6} excess cancer risk) (ppb)	EPA RSL	
						(10^{-6} excess cancer risk) (ppb)	(10^{-4} excess cancer risk) (ppb)
tetrachloroethylene	PCE	*0.27**	*0.22**	40	0.03[1]	0.06	6
trichloroethylene	TCE	<0.20	<0.02	7.4[EPA]	0.09[1]	0.22	22
1,1-dichloroethylene	1,1-DCE	<0.20	<0.02	20i	nc	ngv	ngv
cis-1,2-dichloroethylene	cis-1,2-DCE	<0.20	*0.32*	ngv	nc	nc	nc
trans-1,2-dichloroethylene	trans-1,2-DCE	<0.20	<0.02	200i	nc	nc	nc
vinyl chloride	VC	<0.20*	<0.02	30i	0.04[2]	0.06	6

Notes:

Reporting Limit = Limits that can be greater than or equal to the method detection limit for the analysis.

ATSDR EMEG = Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide (ATSDR 2011). Chronic non-cancer exposure comparison values (exposure greater than 365 days) used to determine if chemical concentrations warrant further health-based screening.

ATSDR CREG [1] = Agency for Toxic Substances and Disease Registry Cancer Risk Evaluation Guide (ATSDR 2011b). April 26, 2011, Interim cancer risk comparison values for cancer risk of 1 excess cancer in 1,000,000 people.

ATSDR CREG [2] = Agency for Toxic Substances and Disease Registry Cancer Risk Evaluation Guide (ATSDR 2011c). Cancer risk comparison values for cancer risk of 1 excess cancer in 1,000,000 people.

EPA RSL = Environmental Protection Agency Regional Screening Level (EPA 2010). The screening levels were developed using risk assessment guidance from the EPA Superfund Program. They are risk-based concentrations derived from standardized equations combining exposure information assumptions with EPA toxicity data. RSLs are considered by EPA to be protective for humans (including sensitive groups) over a lifetime.

Modifiers:

<0.20 = Not detected in the air sample. Numerical values represent the analytical reporting limit.

* = Reporting limit was greater than one or more comparison values.

0.27 = Measurement in air that is above one or more comparison values.

EPA = There is not a published EMEG for TCE. The results were compared to the EPA's most current evaluation of the potential health risks from exposure to TCE at 7.4 ppb (EPA 2001).

I = ATSDR comparison value for intermediate exposures (15-365 days); typically higher than a chronic value.

nc = Not classified as to carcinogenicity and no guidance value is available.

ngv = No guidance value available.

health concerns from breathing indoor air containing small amounts of TCE in the building. Both the ATSDR CREGs and EPA RSLs were developed for a 24 hours per day, 7 days a week, 365 days per year, 70-year lifetime exposure. A typical work place exposure would be much less than the timeframes for which these health comparison values were developed.

None of the other TCE breakdown chemicals including 1,1-DCE, cis-1,2-DCE, trans-1,2-DCE, and vinyl chloride, were present above their reporting limits of 0.02 ppb or 0.20 ppb. These reporting limits were very low. 1,1-DCE, cis-1,2-DCE, and trans-1,2-DCE do not have cancer risk comparison values because they are not considered to be known or potential human carcinogens. The highest reporting limit of 0.20 ppb was considered as the theoretical measured concentration for vinyl chloride. A concentration of 0.20 ppb would be half of 0.4 ppb ATSDR CREG adjusted for a 10^{-5} risk (ATSDR 2011).

Downgradient Residences Indoor Air — Non-Cancer Evaluation

Indoor air was evaluated to better understand potential health effects site-related chemicals may have on residents living in homes located downgradient, and over the groundwater contamination migrating from the Tokheim building. Indoor air samples were collected from 6 downgradient homes.

Indoor air results showed detections of 3 site-related chemicals (Table 4). PCE, TCE, and cis-1,2-DCE, were measured in indoor air in 5 of the 6 homes. In 1 of the 6 homes only PCE and cis-1,2-DCE were detected. The measured concentrations were compared to their respective non-cancer indoor air health comparison values published by the ATSDR (2011) or EPA (2001, 2010).

The PCE measured in indoor air of the homes downgradient of the site ranged from 0.03 ppb to 0.98 ppb. These measured amounts were well below ATSDR's non-cancer effects EMEG comparison value of 40 ppb for chronic (greater than 365 days) exposure for PCE. TCE measured in the indoor air of the homes ranged from non-detect (<0.02 ppb) to 0.32 ppb. These amounts were well below the EPA provisional comparison value of 7.4 ppb for non-cancer health effects (EPA 2001). TCE was not measured in the ambient outdoor air sample collected.

Cis-1,2-DCE measured in the indoor air of the homes ranged from non-detect (<0.02 ppb) to 0.63 ppb.

Trans-1,2-DCE, 1,1-DCE, and VC were not measured in the indoor air of any home tested. To represent a worse-case scenario, reporting limit concentrations were compared to their respective non-cancer indoor air health comparison values published by the ATSDR (2011) or EPA (2001, 2010). The reporting limit concentrations of these chemicals were all below their respective non-cancer health comparison values.

Downgradient Residences Indoor Air — Cancer Evaluation

As mentioned above PCE, TCE, and cis-1,2-DCE were measured in the indoor air of the 5 of 6 homes tested. In sixth home only PCE and cis-1,2-DCE were measured. The measured indoor air

TABLE 4. Indoor air sampling results of samples collected in 6 downgradient homes. Samples were collected on October 25, 2010, over 24 hours with Summa canisters (S&ME 2011a). Locations of samples are shown on Figure 3. Values reported in parts per billion (ppb). Health comparison values used are non-cancer chronic exposure duration greater than 365 days (ATSDR 2011), ATSDR cancer risk evaluation guides (ATSDR 2011b and 2011c), and EPA residential indoor air Regional Screening Levels (EPA 2010). PID results measured after sampling was completed. PID results are reported in parts per billion (ppb) Four homes had low values (Homes 1, 3, 5 and 6) while 2 homes had high values (Homes 2 and 4).

Chemical / Sampling Data and Location Name	Acronym	Home 1	Home 2	Home 3	Home 4	Home 5	Home 6	Ambient Outdoor Sample	ATSDR EMEG (non-cancer) (ppb)	ATSDR CREG (10^{-6} excess cancer risk) (ppb)	EPA RSL (10^{-6} excess cancer risk) (ppb)	EPA RSL (10^{-4} excess cancer risk) (ppb)
tetra-chloroethylene	PCE	*0.98*	*0.14*	*0.31*	*0.035*	*0.03*	*0.83*	*0.024*	40	0.03[1]	0.06	6
tri-chloroethylene	TCE	<0.02	*0.026*	*0.04*	*0.32*	<0.02	*0.044*	<0.02	7.4[EPA]	0.09[1]	0.22	22
1,1-dichloroethylene	1,1-DCE	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	20i	nc	ngv	ngv
cis-1,2-dichloroethylene	cis-1,2-DCE	*0.63*	*0.80*	<0.02	*0.20*	*0.08*	*0.09*	<0.02	ngv	nc	nc	nc
trans-1,2-dichloroethylene	trans-1,2-DCE	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	200i	nc	nc	nc
vinyl chloride	VC	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	30i	0.04[2]	0.06	6
In-home PID reading (in ppb)	NA	0	2,389	15	462	103	114	NA	NA	NA	NA	NA

Notes:

ATSDR EMEG = Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide (ATSDR 2011). Chronic non-cancer exposure comparison values (exposure greater than 365 days) used to determine if chemical concentrations warrant further health-based screening.

ATSDR CREG = Agency for Toxic Substances and Disease Registry Cancer Risk Evaluation Guide (ATSDR 2011). April 26, 2011, Interim cancer risk comparison values for cancer risk of 1 excess cancer in 1,000,000 people.

ATSDR CREG = Agency for Toxic Substances and Disease Registry Cancer Risk Evaluation Guide (ATSDR 2011). Cancer risk comparison values for cancer risk of 1 excess cancer in 1,000,000 people.

EPA RSL = Environmental Protection Agency Regional Screening Level (EPA 2010). Screening levels were developed using risk assessment guidance from the EPA Superfund Program. RSLs are considered by EPA to be protective for humans (including sensitive groups) over a lifetime.

Modifiers:

0.14 = Measured amount of the chemical in the indoor air sample tested.

<0.45 = Not detected in the air sample. Value represents the detection limit of the test.

* = Reporting limit was greater than one or more comparison values.

EPA = There is not a published EMEG for TCE. The results were compared to the EPA's most current evaluation of the potential health risks from exposure to TCE at 7.4 ppb (EPA 2008).

I = ATSDR comparison value for intermediate exposures (15-365 days); typically higher than a chronic value

nc = Not classified as to carcinogenicity and no guidance value is available

ngv = No guidance value available

NA = Not Applicable

concentrations were compared to their respective cancer indoor air health comparison values published by the ATSDR (ATSDR 2011) and EPA (2010).

Three homes had PCE concentrations measured in a range between 0.1 ppb and 1 ppb. Home 1, is the home closest to the former Tokheim Site. PCE was measured in indoor air of Home 1 at 0.98 ppb. Home 6 located across Industrial Boulevard and along a small drainage had the next highest PCE indoor air measurement at 0.83 ppb. PCE was measured at 0.31 ppb in Home 3, north of Home 1. The remaining 2 homes had indoor air PCE measurements of 0.035 ppb (Home 4) and 0.03 (Home 5).

The PCE indoor air concentrations were compared to the PCE one excess cancer in one million people (10^{-6}) health risk comparison value of 0.03 (ATSDR 2011b) and 0.06 ppb (EPA 2010). The 3 highest indoor air PCE measurements of 0.98 ppb, 0.83 ppb, and 0.31 ppb exceeded the 10^{-6} PCE health comparison values. For comparison, PCE was not detected in outdoor air above 0.024 ppb.

Two of the three PCE measurements were greater than the one excess cancer in 100,000 people or 10^{-5} cancer risk comparison values of 0.3 (ATSDR) and 0.6 ppb (EPA) for PCE. Although the 10^{-5} cancer risk value is not typically used as a comparison value for residential settings, it is within the risk range that EPA considers acceptable for residential exposure (EPA 1991). All ATSDR and EPA cancer risk health comparison values are calculated for a theoretical exposure to a chemical of 24 hours per day, 7 days a week, 365 days each year, for a 70-year lifetime. Overall, because of the PCE detections, there is a potential health concern, although very slight, to residents of these three homes from breathing air containing PCE.

To gain a better understanding of the risk produced by these PCE concentrations in indoor air, a theoretical risk was calculated using the measured PCE concentrations and EPA's inhalation unit risk. Using the PCE concentrations detected in the three homes (0.98, 0.83, and 0.31 ppb) and multiplying them by the inhalation unit risk for PCE of 5.9×10^{-6}, theoretical risks of 1.2×10^{-5}, 3.3×10^{-5}, and 4×10^{-5} respectively, were calculated. Therefore, the theoretical risk would range from about 1 extra cancer above background in 100,000 people to about 4 extra cancers in 100,000 people. This range is within the range of risk considered acceptable by EPA (EPA 1991).

Studies of PCE toxicity suggest effects to liver and kidneys with effects showing up with human lowest observed adverse-effects levels (LOAELs) at approximately 20 parts per million (ppm) (ATSDR 1997). This is approximately 20,000 times higher than levels measured in the indoor air of the 2 homes. As shown, the PCE level measured was much less than the LOAEL. Additionally, there has only been one sampling event performed. This is a "snapshot in time" of the indoor air concentrations. It would be prudent to sample all homes again.

At least two studies have been conducted to collect background indoor air levels for PCE. These studies detail background levels of PCE in everyday indoor air in certain geographic areas. In addition, EPA has published a draft collection of background indoor air measurements. These background indoor air measurements are shown in Table 5. When the PCE measurements in the Homes 1, 3, and 6, are compared to the background levels in Table 5, the measured amounts in the 2 of the 3 homes are higher than the published background values.

Table 5. Tetrachloroethylene (PCE) Comparison to Indoor Air Background Concentrations	90th Percentile Value	Origin of Value
Measured Concentrations in Homes 1 and 6 0.83 ppb and 0.98 ppb (SM&A 2011a)	0.66 ppb	Proceedings from Indoor Air 2002 Conference Denver, Colorado site (282 samples) [1]
	0.43 ppb	2007 NYSDOH Indoor Air Background Study Endicott, New York site (406 samples) [2]
	0.56 ppb	2008 Draft EPA Database of Background Indoor Air Concentrations Measured in North American Residences and Indoor Air Concentrations in Residences Included in EPA's Vapor Intrusion Database (2,369 samples) [3]
Modifiers Ppb = parts per billion $\mu g/m^3$ = micrograms per cubic meter		
Notes 1 Kurtz, J.P. and D.J. Folkes. 2002. Background concentrations of selected chlorinated hydrocarbons in residential air. 9th International Conference on Indoor Air Quality and Climate. Proceedings. Volume 2. June 30-July 5, 2002**,** Monterey, CA, 2 McDonald, G.J. and W.E. Wurtz. 2007. PCE, TCE, and TCA vapors in sub-slab soil gas and indoor air: a case study in upstate New York. Ground Water Monitoring and Remediation 27, no. 4. Fall 2007. Pages 86-92. 3 DRAFT U.S. EPA's Vapor Intrusion Database: Preliminary Evaluation of Attenuation Factors Office of Solid Waste, U.S. Environmental Protection Agency, Washington, DC 2008. (*The findings and conclusions in this report have not been formally disseminated by EPA and should not be construed to represent any Agency determination or policy.)*		

Further, the residents in Home 1 do not have their clothes drycleaned. However, residents in Home 6 do have their clothes drycleaned, which may add PCE vapors to the indoor air of that home. Both homes contained various household cleaners, and Home 6 stored kerosene and paint. PID measurements in the 2 homes also varied. Home 1 had an indoor air PID reading of 0 ppb. Home 6 had an indoor air PID reading of 114 ppb. Again, because one of these sample locations was immediately downgradient from the Tokheim site, and the other sample location is near an intermittent drainage and above the distant ground-water contamination, it is possible that PCE vapor migration is occurring.

The comparison value for 1 additional cancer in 1 million people for TCE is 0.09 ppb (ATSDR 2011b) and 0.22 ppb (EPA 2010). The highest reported measurement was in Home 4 at 0.32 ppb. This measurement was higher than the $1x10^{-6}$ risk comparison values of 0.09 and 0.22 ppb, but lower than its 10^{-5} risk comparison values of 0.9 and 2.2 ppb. No TCE was detected in outdoor air, for comparison. TCE was measured in the remaining 5 homes at less than 0.044 ppb. Again, there is some very minor additional risk of breathing the air in Home 4 but the overall added risk should be very small.

To gain a better understanding of the risk produced by the highest TCE concentration in indoor air, a theoretical risk was calculated using this measured TCE concentration and EPA's inhalation unit risk. Using the 0.32 ppb TCE concentration and multiplying it by the inhalation unit risk for TCE of $2.0x10^{-6}$, a theoretical risk of $3.4x10^{-6}$ was calculated. Therefore, the

theoretical risk would be about 3 extra cancers above background in 1,000,000 people. This range is within the range of risk considered acceptable by EPA (EPA 1991).

Cis-1,2-DCE is not classified with regard to carcinogenicity by EPA. Therefore, there are no cancer comparison values published by EPA for the chemical. Homes closest to the former Tokheim Site had the highest measurements of cis-1,2-DCE in indoor air. Since cis-1,2-DCE is a breakdown chemical of PCE and TCE, these detections may be an indicator of potential vapor migration from the site.

None of the other breakdown chemicals including 1,1-DCE, trans-1,2-DCE, and vinyl chloride, were present. The range of reporting limits was from 0.051 to 0.079 ppb. These reporting limits were very low. The presence of these chemicals in amounts below the detection limits will not create an unhealthy indoor air environment and will not likely lead to any excess cancer health effects from breathing indoor air possibly containing trace amounts of these chemicals

Chemical Mixture

When you have more than one chemical found at a sampling location, there are potential additive health effects from a mixture of chemicals to an exposed population (ATSDR 2004). There is no evidence to indicate that greater-than-additive interactions among PCE or TCE health effects happen. PCE and TCE were measured in indoor air samples collected from the former Tokheim site building and in most samples from residences downgradient from the site along Industrial Boulevard.

Adding together the approximate site-specific theoretical risks of PCE of $4.0x10^{-5}$ and approximately $3.4x10^{-6}$ for TCE, the total excess cancer risk above background was still about 4 in 100,000. The actual risk would be within EPA's acceptable range of risk (EPA 1991). Therefore, there is no increased risk because there is a mixture of both PCE and TCE in very small amounts in the indoor air in Homes 1, 3, and 6.

Other Considerations

SM&A performed a remedial injection of emulsified edible oil at the site in November 2010. This will hopefully bring down PCE levels in groundwater and reduce the potential for vapor intrusion of PCE and TCE. Continued monitoring of the downgradient groundwater plume would be prudent. TDEC (2011) and SM&A (2011b) recently stated that there may be additional groundwater investigation activities at the former Tokheim Site (TDEC 2011).

If further ground water assessment activities are conducted, it would be prudent to resample the indoor air of the former Tokheim building, ambient outdoor air, and the 6 residences. Since there has been only one sampling event and minor concentrations of PCE were detected in amounts that equate to more than a 1 in a million additional cancer risk above background, a second sampling event could confirm the PCE concentrations. This additional sampling would allow the trend over time to be assessed. It also would help in the evaluation of exposure. Additionally, if the extent of the groundwater contamination was discovered to have migrated

further from the site to other areas with residential homes, sampling indoor air or soil-gas in those areas would also be prudent.

If the site-specific depth-to-ground water trend continues, groundwater would likely be shallower farther downgradient from the site. Therefore, if impacted groundwater is found further from the site, groundwater plume contaminant vapors could be even closer to the ground surface. Shallow groundwater can provide a greater potential for vapor intrusion into residences. It is not known if the shallow groundwater comes to the surface in a downgradient stream.

Child Health Considerations

The health of children was considered as part of this health consultation. The many physical differences between children and adults demand special emphasis. Children could be at greater risk than adults from certain kinds of exposure to hazardous substances (ATSDR 1997, 1998). Children have lower body weights than adults. Although children's lungs are usually smaller than adults, children breathe a greater relative volume of air compared to adults. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. However, there is no indication that tetrachloroethylene (PCE) or its breakdown chemicals affect children's bodies differently than adults (ATSDR 1997).

PCE was measured in the indoor air of the home closest to the site and in a home along the path of the downgradient ground-water contamination. It was reported that at least 2 children under the age of 13 were living in home closest to the site (SM&A 2011a). The PCE levels were greater than an ambient outdoor air sample, meaning they likely are not from emissions from nearby manufacturing facilities or an interstate highway. The sampling plan was strong overall as indoor air samples were collected from numerous homes. As part of a very cautious approach, an evaluation was done of PCE and PCE breakdown chemicals using the indoor air test results. Results from the three homes having PCE indoor air measurements greater than 0.1 ppb have PCE levels slightly above a risk level of 10^{-5} or one excess cancer in 100,000 people.

Children are a highly susceptible portion of the population. The theoretical calculated risk was greater than what is typically used for a residential setting. However, the overall risk in all homes sampled is within the range of risk considered acceptable by EPA (1991).

The Jasper Materials workers at the former Tokheim site building are adults. Children should not have any exposure to the indoor air at the former Tokheim site building.

Conclusions

Conclusion 1: *EEP concludes that the chemical tetrachloroethylene (PCE) is present in the indoor air of all 6 homes above the ground-water contamination found downgradient from the former Tokheim Site. Levels of PCE in the indoor air of 3 of the 6 homes were slightly elevated above background levels. One of the homes was the closest home to the Tokheim site. The other two were located along a drainage downgradient from the site. However, the calculated theoretical excess cancer risk based on the sampling results is in the range considered acceptable by EPA (EPA 1991) and will not likely create unhealthy indoor air.*

The indoor air of 3 homes contains low but slightly elevated levels of PCE, ranging from 0.31 to 0.98 parts per billion. PCE breakdown chemicals were also present in the indoor air samples. Based on the location of these homes, the results, and the building inventories conducted at the time of sampling, there could be vapors migrating through the subsurface from the underlying contaminated ground water. The low levels of PCE measured in the homes would not result in adverse health effects. Additional indoor air sampling of the 3 homes is recommended. Because minor amounts of PCE were detected in the home closest to the site and two downgradient, TDEC should have the responsible party perform the additional sampling. Additional sampling would allow a better understanding and establish a trend over time.

Conclusion 2: *EEP concludes that the minor amounts of PCE or PCE breakdown chemicals found in the remaining 3 homes tested will not harm the health of residents of those homes.*

Even though site-related chemicals were measured in the indoor air of these 3 homes, the levels were very low. Breathing indoor air with these very low PCE levels would not result in adverse health effects. It would be prudent to sample these 3 homes downgradient from the site again to confirm the results of testing evaluated in this report.

Conclusion 3: *EEP concludes that the chemicals detected in the indoor air of the former Tokheim building are not expected to harm the health of the workers.*

Indoor air of the former Tokheim building contained measurable amounts of the site-related chemicals PCE and cis-1,2-DCE. The amounts of both chemicals were low and would not cause unacceptable non-cancer or cancer health effects for indoor air as they were below their respective comparison values. Indoor air in the former Tokheim site building should also be sampled when indoor air in homes downgradient from the former Tokheim site is sampled in the future. This future sampling would confirm the results of the testing evaluated by this report.

Conclusion 4: *Based on the soil-gas sample, EEP has concludes that PCE and TCE are present in soil-gas near the Home 7 at levels below EPA target levels.*

Even though site-related chemicals were measured in the soil-gas sample collected, their levels were very low. The levels were below EPA shallow soil-gas target levels for indoor air.

Recommendations

The focus of this health consultation was to make sure the indoor air breathed by residents downgradient from the site and site workers will not lead to harmful health effects. TDEC SRP was concerned about indoor air breathed by residents who live above the site-related ground-water contamination east and northeast of the site and who breathe the indoor air in the former Tokheim site building. With that in mind, the following recommendation is believed to be appropriate based on EEP's review of the air sampling data.

- EEP recommends additional air samples at the locations previously sampled, once the expanded ground water investigation is conducted and sampling of monitoring wells is finished. If groundwater contamination is found further from the site, TDH EEP recommends sampling indoor air in homes, if any, above the plume of contamination.

Public Health Action Plan

The public health action plan for the former Tokheim Site contains a list of actions that have been or will be taken by TDH EEP and other agencies. The purpose of the public health action plan is to ensure that this health consultation identifies public health concerns and offers a plan of action designed to mitigate and prevent harmful health effects that result from breathing, eating, drinking, or touching hazardous substances in the environment. Included is a commitment on the part of EEP to follow up on this plan to ensure that it is implemented.

Public health actions that have been taken by TDH's EEP include:

- Reviewing the indoor air data from the former Tokheim building and the soil-gas and indoor air data from the various residential properties east and northeast of the Tokheim building.

- Preparing this health consultation.

Public health actions that will be taken include:

- TDH EEP will provide copies of this health consultation to state and federal government agencies interested in the former Tokheim Site.

- TDH EEP will maintain dialogue with ATSDR, TDEC, EPA, and other interested stakeholders to safeguard public health.

- TDH EEP staff are available to answer questions regarding the interpretation of the indoor air and soil-gas results should homeowners be interested in speaking with us.

- TDH EEP will be available to review newly collected and additional environmental data, and provide interpretation of the data, as requested by TDEC.

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Certification

This Public Health Consultation: *Evaluation of the Vapor Intrusion Investigation for the Tokheim Site, Jasper, Marion County, Tennessee*, was prepared by the Tennessee Department of Health's Environmental Epidemiology Program. It was prepared in accordance with the approved methodology and procedures that existed at the time the health consultation was begun.

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