Health Consultation

GOODRICH LANDING GEAR

AIR SAMPLING RESULTS EVALUATION

TULLAHOMA, COFFEE COUNTY, TENNESSEE

SEPTEMBER 4, 2012

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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 the Environmental Epidemiology Program in dealing with hazardous waste sites is to be an advisor. Often, our recommendations will be action 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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Introduction

The Tennessee Department of Health's (TDH) Environmental Epidemiology Program (EEP) reviewed the August 20, 2012 *Indoor Air Quality Evaluation Report* prepared by URS Inc. (URS) for the responsible party. The report was prepared for the Goodrich Landing Gear (GLG) Site located at 201 Mitchell Boulevard in Tullahoma, Coffee County, Tennessee. The Tennessee Department of Environment and Conservation (TDEC), Division of Remediation (DoR), State Remediation Program (SRP), asked EEP to (1) review the results and (2) to evaluate if the levels of chemicals found in the indoor air in the GLG manufacturing building could be a concern for the health of the employees working in the building.

This review specifically evaluated the indoor air testing results from inside the site building, as asked for by TDEC SRP. The preparation of this health consultation was done to document the evaluation of the air sampling results and provide information to TDEC and GLG.

Background

Since 1993, URS Corporation (URS) has been the environmental consultant investigating potential environmental concerns at GLG. URS has investigated several areas to determine if various chemicals had been released to the environment. Site investigations found chemicals were released to soil and groundwater. Petroleum-related constituents and several chlorinated solvent chemicals, including benzene, tetrachloroethylene (PCE), trichloroethylene (TCE), cis-1,2-dichloroethylene (cis-1,2-DCE), vinyl chloride, and 1,1-dichloroethylene (1,1-DCE), were found in on-site groundwater. Some of these same chemicals including benzene, PCE, TCE, cis-1,2-DCE, vinyl chloride, and 1,1-DCE were also found in groundwater off-site. Six privately-owned water wells were identified within a 1-mile radius of the site. All private wells were located upgradient or cross-gradient from the site. TDEC SRP required that URS perform an Exposure Assessment (EA) to evaluate the potential risk of chlorinated solvent chemicals found to be migrating in groundwater at three potential source areas (Areas 2, 8, and 9). In addition, TDEC SRP requested that URS perform a Risk Evaluation (RE) for the migration of benzene, PCE, TCE, cis-1,2-DCE, vinyl chloride, and 1,1-DCE in groundwater (URS 2010).

GLG discontinued the use of solvents in their operations, based on communications with TDEC (Roy Crowder March 23 and 30, 2010, and April 12, 2011). Based on 2011 vapor intrusion report prepared by URS, the site area impacted by the solvent releases appeared to be relatively small and confined to the northeastern portion of the on-site building.

URS performed an earlier vapor intrusion evaluation (URS 2010) which suggested that PCE and TCE vapors from groundwater in Areas 8 and 9 could potentially migrate into indoor air. The migration could create an inhalation exposure to workers breathing the indoor air inside the GLG building. Based on the 2010 evaluation of the indoor air pathway, an indoor vapor intrusion investigation of the site was recommended by TDEC and TDH EEP.

As part of the recommended vapor intrusion investigation, URS performed a sub-slab soil-gas study on September 28, 2010. Sub-slab soil-gas samples were collected in the northern portion of the GLG building, near a paint booth (Titanium Etch Area), near a wash room above a former

PCE tank (location is between Areas 8 and 9), in the northern corner of the building (Nital Etch Area), and in the building's shipping and receiving area. Sub-slab samples were collected using mini canisters for 20 to 26 minutes. Samples were analyzed using modified EPA Method TO-15 gas chromatography/mass spectroscopy. Results are presented in Table 1. Reporting limits were suitably low.

Additionally, indoor air was sampled by the GLG Environmental, Health and Safety Manager. The indoor air sampling was done using a Sensidyne air sampling pump equipped with colorimetric tubes specific for PCE and TCE. The sampling was performed sometime after the sub-slab sampling so no correlation of indoor air results and sub-slab soil gas results could be done. The detection limit for the colorimetric tube indoor air sampling were 200 parts per billion (ppb). PCE and TCE were not measured in the indoor air of the building at the time of the testing.

URS estimated the indoor air concentration using the sub-slab soil-gas data. Target indoor air concentrations were calculated from the soil-gas results using media-specific attenuation factors. The U.S. Environmental Protection Agency (EPA) OSWER guidance for shallow soil-gas uses screening levels for indoor vapor intrusion that were conservatively developed using an attenuation factor (AF) of 0.1. Rather than compare soil-gas concentrations to applicable screening levels, URS chose to multiply the sub-slab soil-gas levels by an alternate AF to estimate the concentrations of PCE and TCE that would be present in the indoor air of the GLG building. The AF chosen was 0.002 and was based on a proposed EPA AF for larger industrial/commercial buildings (Dawson 2006). This less conservative AF was chosen on the premise that industrial/commercial buildings typically enclose a large area and the air flow in a commercial building is increased when compared to a normal single family home.

URS's evaluation of the sub-slab soil-gas results included comparing the calculated indoor air concentration values to the EPA's industrial/commercial Regional Screening Values (RSL's) for indoor air (EPA 2010). The comparison showed 3 of the 4 calculated indoor air results would exceed the industrial air RSL for PCE. For TCE, URS's evaluation showed that none of the calculated indoor air concentration values would exceed EPA's industrial RSL for cancer risk.

TDEC, in a December 12, 2011, letter to Goodrich Landing Gear, requested additional indoor air samples to be collected to further evaluate potential vapor intrusion concerns in the GLG building. TDEC recommended additional indoor air samples. The request was made because of the relatively high sub-slab soil-gas PCE levels and the high detection limits of the initial indoor air sampling. These latest additional indoor air samples collected on July 5, 2012, using the appropriate methodology, were thought to be able to provide adequate data to evaluate the vapor intrusion concerns.

TABLE 1. Sub-slab soil-gas data for the Goodrich Landing Gear manufacturing building, Tullahoma, Coffee County, TN. Samples were collected on September 28, 2010, using Summa canisters for a period of 20 to 26 minutes. Values reported in parts per billion (ppb) and micrograms per cubic meter (µg/m^3). Health screening guidelines based on EPA Risk-Based Concentrations (EPA 2010). Data provided by URS Corporation, February 28, 2011. Sub-slab soil-gas results for sample GLG-SS-R-002 were below EPA shallow soil screening levels. Sub-slab soil-gas results for GLG-SS-R-001, 003, and 004 were above EPA shallow soil screening levels. Because most levels were well above soil-gas screening levels, further investigation of the vapor intrusion pathway was needed at the site.

Chemical	Acronym	September 28, 2010								EPA OSWER Shallow soil screening level (10^{-5} cancer risk level)	
		GLG-SS-R-001 (Titanium Etch Area)		GLG-SS-R-002 (PCE UST Area)		GLG-SS-R-003 (Nital Etch Area)		GLG-SS-R-004 (Shipping and Receiving Area)			
		ppb	µg/m^3	ppb	µg/m^3	ppb	µg/m^3	ppb	µg/m^3	ppb	µg/m^3
tetrachloroethylene	PCE	**177**	**1,200**	7.1	48	**236**	**1,600**	**1,769**	**12,000**	12	81
trichloroethylene	TCE	**5.4**	**29**	<0.16	<0.85	**2.4**	**13**	**67**	**360**	0.41	2.2

Notes:

<0.16 = Not detected in the sub-slab sample (analytical reporting limit concentration for the compound listed is shown).

160 = Concentration measured exceeds one or more regulatory guidance values.

EPA = Regulatory comparison values are EPA shallow soil-gas target values with an attenuation factor of 0.1 (EPA 2002).

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 exposure-related 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, soil, surface water, groundwater, or air) transport the contaminants. For this site, the chemicals are transported through the soil and indoor air. The point of exposure is the place where persons come into contact with the contaminated media. Indoor air is the potential 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, if the indoor air has measureable levels of VOCs, the route of exposure would be breathing of indoor air.

Physical contact alone with a potentially harmful chemical in the environment by itself does not necessarily mean that a person will be harmed. 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, the people who would be exposed if vapor intrusion was occurring, the exposed population, are the workers in and visitors to the GLG building. It is not known how many people work in the GLG building, how many hours per day or week they work, or if there are worker stations near the locations where the indoor air samples were collected.

Vapor Intrusion

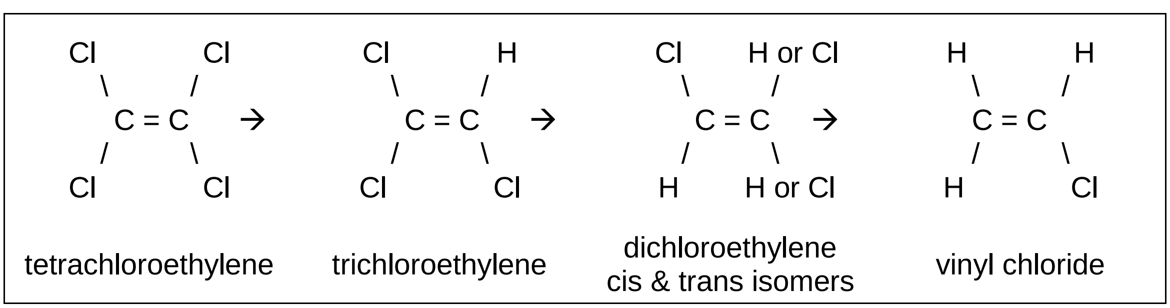
Volatile and semi-volatile chemicals can evaporate from impacted subsurface soil and/or groundwater beneath a building and move toward areas of lower chemical levels such as in the atmosphere, utility conduits, or basements. This process is called vapor intrusion. Subsurface vapors can enter a building due to two main factors: environmental effects and building effects. Some examples of these factors are barometric pressure changes, wind load, temperature currents, or depressurization from building exhaust fans. Chemicals can migrate up and enter indoor air through foundation slabs, crawl spaces, or basements. The chemical migration depends on the construction of the building, unsealed joints or cracks in the foundation, the building's heating and ventilation characteristics, and other factors. The amount of movement of the vapors into the building is difficult to measure and depends on soil type, chemical properties, building design and condition, and pressure differences between the outside and inside air (ITRC 2007). Upon entry into a structure, chemical vapors mix with the existing air through the natural or mechanical ventilation of the building.

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.

Solvent Explanation

Past activities at GLG included the use of PCE. It is inferred that the PCE was historically used as a parts cleaner as a step in GLG's manufacturing process. PCE is a colorless liquid and has sweet smell (ATSDR 1997). PCE is a volatile organic compound. It will quickly evaporate into a gas at room temperature. PCE has a high odor threshold meaning that a large amount of PCE must be present in the air before a person can smell it. Therefore, odor is not a reliable warning sign of PCE exposure. For this evaluation we will focus on PCE and its chemical breakdown products.

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 TCE and cis-1,2-DCE, have been noted in groundwater samples collected at the site. PCE appears to be the dominant chemical present in site soil. The solvents PCE and TCE 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 2012) for a particular chemical, then further evaluation is needed.

Comparison values levels established by the Agency for Toxic Substances and Disease Registry's (ATSDR) and U.S. Environmental Protection Agency (EPA) for residential air inhalation were used in evaluating the results of the indoor air testing. The reason for using these comparison values was that there would be an involuntary exposure to workers and any visitors to the building to PCE and TCE since both of these chemicals are no longer used in the manufacturing process. Federal Occupational Safety and Health Administration (OSHA) work place standards were not used for this same reason. Additionally, EPA industrial health comparison values were also not used for comparison of the indoor air values measured in the GLG building because of this involuntary exposure.

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 (ATSDR 2012a) and are used for comparison to the indoor air data that was collected. 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. It should be noted that chemicals found at levels that are above their respective comparison values do not necessarily represent a health threat. Instead, the results of the comparison value screening identify those chemicals that warrant a more detailed, site-specific evaluation to find out if health effects are expected to occur (ATSDR 2012b).

EPA's Regional Screening Levels (RSLs) for residential air inhalation were also used in evaluating the results of the indoor air testing (EPA 2012).

ATSDR has a chronic EMEG for PCE in indoor air of 40 parts per billion (ppb). The EPA non-cancer RSL for a residential exposure for PCE is 42 ppb.

PCE and its breakdown chemical TCE were of special interest at the site and were evaluated because they are thought to be *"reasonably anticipated to be human carcinogens"* (IARC 1995, NTP 2011). Both PCE and TCE were found in sub-slab soil-gas samples. PCE was found in the indoor air. TCE was found in indoor air at only 1 location. For this site, we are concerned with the inhalation of both PCE and TCE from vapor intrusion into indoor air. PCE is readily absorbed following inhalation and oral exposure as well as from direct exposure to the skin. Compared to pulmonary and ingestion exposure, uptake of PCE vapors by the skin is minimal (ATSDR 1997a, 1997b).

ATSDR has generated cancer risk evaluation guides (CREGs) for both PCE and TCE (ATSDR 2012). The PCE CREG is 0.57 parts per billion (ppb), while the TCE CREG is 0.045 ppb. EPA has a residential setting PCE cancer health effects inhalation regional screening level (RSL) of 0.6 ppb for one excess cancer in 1 million people (IRIS 2012).

Environmental Sampling

At TDEC's request, the environmental consultant for GLG collected indoor and outdoor air samples on July 5, 2012. To be conservative, indoor air samples were collected from the same approximate locations of the September 2011 sub-slab soil gas samples. A total of seven air locations were sampled during the investigation (URS 2012). The sample locations were identified as the following**:**

- one sample from Shipping and Receiving (GLG-IA-004);
- two samples from the Nital Etch Area (GLG-IA-002 and 003);
- one sample from the Titanium Etch Area (GLG-IA-001);
- one sample from the primary manufacturing area adjacent to the Nital Etch Area (GLG-IA-005);
- one sample from the administrative office area (GLG-IA-007), and;
- one ambient air sample from a location outside of the manufacturing facility (GLG-IA-006).

According to their methodology (URS 2012), indoor air samples were collected in general accordance with US EPA *Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils* dated November 2002 and the *Interstate Technology and Regulatory Council procedures (ITRC) Vapor Intrusion Pathway: A Practical Guide* dated January 2007.

Indoor air samples were collected over an eight (8) hour period using laboratory prepared six (6) liter evacuated stainless steel Summa canisters equipped with the appropriate flow controllers and teflon-lined tubing. Indoor air samples were collected at breathing zone height, approximately 3 to 5 feet above floor. Any obstructions that would prevent free airflow were cleared from the sampling locations prior to collecting the samples. Building operations remained unchanged during the sample collection period. The outdoor ambient air sample was collected simultaneously with the indoor air samples. The outdoor ambient air sample was collected west of the GLG building. Indoor air samples were shipped to Air Toxics, Ltd., (ATL) analytical laboratory located in Folsom, California, under standard URS chain-of-custody protocol for analysis. Each air sample was analyzed for low level analysis via EPA Method TO-

15 for PCE and TCE only. No other breakdown products of PCE, other than TCE, were included in the testing.

Results

Indoor air testing results showed measurements of PCE at all 6 indoor air sampling locations. The levels of PCE are consistent among all indoor air sampling locations. PCE was not found in the 1 outdoor air sample collected. TCE was only found in 1 of 6 indoor sampling locations. TCE was also not found in the 1 outside air sample. Table 2 shows the results of the indoor air sampling. Sample detection limits were appropriately low.

Health Risk Evaluation

For this health consultation, the evaluation of the health risk at the site will consider the PCE and TCE that have been confirmed to be present in the sub-slab soil-gas beneath the GLG building and have potential health risks. Based on both the soil-gas and indoor air testing results, the process of vapor intrusion appears to be occurring at the site.

As shown in Table 2, all 6 PCE indoor air results were below its ATSDR and EPA non-cancer health effects comparison values. The 1 measured level of TCE in indoor air sample GLG-IA-001 was above both ATSDR's and EPA's non-cancer comparison values. All 6 measured levels of PCE in indoor air were above its ATSDR and EPA cancer health effects comparison values. The 1 measured level of TCE was also above both its ATSDR and EPA cancer health effects comparison values.

As stated in the Solvent Explanation section above, PCE has a high odor threshold meaning that a large amount of PCE must be present in the air before a person can smell it. Therefore, odor is not a reliable warning sign of PCE exposure as the workers in the GLG building would not detect any odor. The remaining PCE and TCE in the sub-slab soil-gas is migrating into the indoor air of the GLG building, as noted by the low levels detected in the indoor air. PCE is a contaminant of concern with regards to vapor intrusion at the GLG Site.

To gain a better understanding of the cancer risk produced by the PCE concentrations in indoor air, an estimated risk was calculated using the highest measured PCE concentration and EPA's inhalation unit risk (IUR). Using the highest measured PCE level in indoor air of 28 $\mu g/m^3$ (4.1 parts per billion – ppb) and multiplying it by the inhalation unit risk (IUR) for PCE of $2.6x10^{-7}$ $(\mu g/m^3)^{-1}$, results in an estimated excess lifetime cancer risk (ELCR) of $7.3x10^{-6}$. Therefore, the possible ELCR would be about 7 extra cancers in addition to the background cancer risk in 1 million people. This is a worst-case evaluation as the highest PCE level measured was used and the IUR value was established for a continuous daily exposure for a lifetime. Therefore, the actual excess cancer risk would be less. The background lifetime cancer risk is 1 in 2 for men and 1 in 3 for women (NTP 2011). The estimated ELCR of $7.3x10^{-6}$ is negligible and is considered acceptable by EPA (1991).

TABLE 2. Indoor air data for the Goodrich Landing Gear manufacturing building, Tullahoma, Coffee County, TN. Samples were collected on July 5, 2012 using Summa canisters over an 8-hour time period. Values are reported first in parts per billion (ppb) and then in micrograms per cubic meter (µg/m^3). Health screening guidelines based on ATSDR comparison values (2012) and EPA Regional Screening Levels (2012). Data provided by URS Corporation, August 20, 2012.

Chemical	July 5, 2012							ATSDR Chronic EMEG (non-cancer) ppb (µg/m^3)	ATSDR CREG (10^{-6} excess cancer risk) ppb (µg/m^3)	EPA RSL non-cancer health effects ppb (µg/m^3)	EPA RSL (10^{-6} excess cancer risk) ppb (µg/m^3)
	GLG-IA-001 (Titanium Etch Area)	GLG-IA-002 (PCE UST Area)	GLG-IA-003 (Nital Etch Area)	GLG-IA-004 (Shipping & Receiving)	GLG-IA-005 (Manufact-uring Area)	GLG-IA-006 (Outside Air)	GLG-IA-007 (Admin/ Office Area)				
PCE	3.4 (23)	3.3 (22)	3.4 (23)	1.5 (10)	4.1 (28)	<0.2 (<1.4)	3.1 (21)	40 (270)	0.57 (3.8)	6.2 (42)	0.6* (4.1)
TCE	0.63 (3.4)	<0.19 (<1.0)	<0.19 (<1.0)	<0.18 (<0.98)	<0.19 (<1.0)	<0.2 (<1.1)	<0.19 (<1.0)	0.37 (2)	0.045 (0.24)	0.39 (2.1)	0.06 (0.43)

Notes:

ATSDR EMEG = Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide (ATSDR 2012). 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 2012). Cancer risk comparison values for cancer risk of 1 excess cancer in 1,000,000 people (10^{-6} risk).

EPA RSL = Environmental Protection Agency Regional Screening Level (EPA 2012). The 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.

0.6* = PCE Integrated Risk Information System (IRIS) air concentration RSL at a 1×10^{-6} (1 in 1,000,000) excess risk, March 13, 2012.

Modifiers:

23
(3.4) = Results are reported in micrograms per cubic meter on top and in parts per billion below.

<0.16 = Not detected in the indoor air sample (analytical reporting limit concentration for the compound listed is shown).

EPA = Regulatory comparison values are EPA shallow soil-gas target values with an attenuation factor of 0.1 (EPA 2002).

The Minnesota Department of Health (MDH) has developed a level for PCE in indoor air where health effects are not expected to occur. The level MDH established was 20 $\mu g/m^3$ (MDH 2011). This level suggests that an exposure to an annual average PCE air concentration of 20 $\mu g/m^3$ for a lifetime will result in no more than 1 additional cancer in one hundred thousand people. The measured levels of PCE in the indoor air of the GLG building are about the same as this level. Further, the average of the 6 measured PCE levels is nearly identical to the MDH level. Because the workers and anyone visiting the GLG building will not be exposed every year for a lifetime to the measured PCE levels, there should not be any additional risk higher than 1 additional cancer in one hundred thousand people from breathing the indoor air inside the site building.

To gain a better understanding of the cancer risk from TCE in the indoor air, the estimated risk was calculated using the single TCE detection of 3.4 $\mu g/m^3$. As a worst case evaluation, the measured TCE level was assumed to be consistent throughout the indoor air of the site building. Using the 3.4 $\mu g/m^3$ (0.63 ppm) TCE concentration and multiplying it by the IUR for TCE of $4.1x10^{-6}$ $(\mu g/m^3)^{-1}$, an estimated risk of $1.4x10^{-5}$ was calculated. Therefore, the possible ELCR from this single detection would be about 1 extra cancer in addition to the background cancer risk in one hundred thousand people. The background lifetime cancer risk is 1 in 2 for men and 1 in 3 for women (NTP 2011). This theoretical ELCR is also negligible and is considered acceptable by EPA (1991). Similar to the estimation for PCE, the actual excess risk from breathing air with the measured TCE level would be less as the workers are not exposed every day for a lifetime.

The URS indoor air quality investigation report (2012) reported that active ventilation systems in the Nital and Titanium Etch Areas also serve to mitigate PCE or TCE vapors that may be present. URS also reports that no changes are projected for the GLG Site that would compromise either the concrete slab integrity or effectiveness of the current ventilation system. The active ventilation systems at both etch areas should be maintained and operated to provide the added benefit of decreasing the levels of PCE and/or TCE vapors that enter the GLG building.

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. There is limited data for interaction effects for these chemicals.

Adding together the total estimated ELCRs for PCE and TCE results in a total estimated ECLR of about 2 in one hundred thousand. This level is based on a 24-hour a day, 7 days per week, 365 day per year exposure. This exposure time frame is a worst-case scenario. People working in and visitors to the building would have a much shorter exposure as work days are much shorter and there likely would not be employees working on the weekends. It is unlikely that the presence of PCE and TCE in indoor air would create any increased health effects to those who breathe the indoor air by working in the building.

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.

There is no indication that tetrachloroethylene (PCE) or its breakdown chemicals, or benzene, affects children's bodies differently than adults (ATSDR 1997). Children may be more sensitive to the carcinogenic effects of PCE than adults (IRIS 2011). ATSDR considered this increased sensitivity when they developed their CREG value.

Site workers are all adults. Children should not have any exposure to the indoor air in the building since they are not part of the population that works inside the building nor would children spend any significant time in the building.

Limitations and Uncertainties in Vapor Intrusion

Having and following an accepted protocol for conducting indoor air investigations is important. The overall protocol for this investigation was considered good. Still, even a good protocol cannot remove all limitations and uncertainties related to vapor intrusion investigations.

Several characteristics of buildings may influence the indoor air testing. Some examples of limitations and uncertainties include the number of breaks in floor slabs or utility perforations entering the buildings. It is unknown if there were background amounts of the chemicals in the indoor air. No building inventory or measurement of background sources was done. The use of cleaning products that sometimes contain many of the same chemicals that are tested for could influence the results of the testing. This can be the case especially if cleaning products were recently used inside the building. The HVAC system was operating during the testing.

Exactly what has happened in the past at the site is another uncertainty. The amounts and locations of any or all spills from the former use of PCE in the building may not have all been documented. Basic handling practices of chemicals were also different during the time period that the PCE was used.

Conclusion

Based on the results of the July 5, 2012, indoor air sampling and the September 28, 2010, sub-slab soil-gas sampling migration of vapors into the indoor air of the site building appears to be taking place. Levels of PCE and TCE in the indoor air do not suggest there would be adverse health effects from breathing the indoor air in the building. Calculated worst-case risk estimates were within EPA's acceptable excess lifetime cancer risk range.

Recommendations

The focus of this health consultation was to make sure the indoor air breathed by site workers and visitors to the building will not lead to harmful health effects. TDEC SRP was concerned about indoor air breathed by workers at the site. The sub-slab soil-gas and indoor air testing confirmed that vapor intrusion is likely occurring inside the GLG building. Based on the results of this indoor air sampling investigation, it would be a prudent public health measure to perform another indoor air test at some time in the future. This confirmation indoor air test should ideally be done in the late fall or winter season. The test should also include the analysis of other chemicals related to the breakdown of PCE. The confirmation test could confirm that levels of chemicals in the indoor air would not harm the health of those working in the site building during a season when vapor migration beneath the building would be expected to be greater.

Ventilation systems in the Nital Etch and Titanium Etch Areas should continue to be operated and maintained to provide the added benefit of decreasing the amount of PCE and/or TCE vapors from entering the GLG building.

If there would be any future excavations or drilling into the GLG building floor slab in the area of the soil vapor and groundwater plumes, extra ventilation should be provided to prevent PCE and TCE vapor concentrations from increasing in the indoor air. A program of crack repair and floor slab inspection and maintenance should be instituted, if not already being done, in the GLG building.

Public Health Action Plan

The public health action plan for the GLG 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 indoor air data from the GLG manufacturing 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 site.
- TDH EEP will provide copies of this health consultation to the environmental contractor for the 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 results.
- TDH EEP will be available to review additional environmental data, and provide interpretation of the data, as requested.

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Certification

This Public Health Consultation: *Evaluation of Air Sampling Results for the Goodrich Landing Gear Site, Tullahoma, Coffee 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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