

# Public Health Assessment

**Public Comment Release**

**JJ SEIFERT MACHINE COMPANY**

**SUN CITY, HILLSBOROUGH COUNTY, FLORIDA**

**EPA FACILITY ID: FLN000410232**

**Prepared by  
Florida Department of Health**

**SEPTEMBER 20, 2011**

**COMMENT PERIOD ENDS: NOVEMBER 21, 2011**

Prepared under a Cooperative Agreement with the  
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES  
Agency for Toxic Substances and Disease Registry  
Division of Health Assessment and Consultation  
Atlanta, Georgia 30333

## THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment-Public Comment Release was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6)), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR's Cooperative Agreement Partner has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate. This document represents the agency's best efforts, based on currently available information, to fulfill the statutory criteria set out in CERCLA section 104 (i)(6) within a limited time frame. To the extent possible, it presents an assessment of potential risks to human health. Actions authorized by CERCLA section 104 (i)(11), or otherwise authorized by CERCLA, may be undertaken to prevent or mitigate human exposure or risks to human health. In addition, ATSDR's Cooperative Agreement Partner will utilize this document to determine if follow-up health actions are appropriate at this time.

This document has previously been provided to EPA and the affected state in an initial release, as required by CERCLA section 104 (i) (6) (H) for their information and review. Where necessary, it has been revised in response to comments or additional relevant information provided by them to ATSDR's Cooperative Agreement Partner. This revised document has now been released for a 30-day public comment period. Subsequent to the public comment period, ATSDR's Cooperative Agreement Partner will address all public comments and revise or append the document as appropriate. The public health assessment will then be reissued. This will conclude the public health assessment process for this site, unless additional information is obtained by ATSDR's Cooperative Agreement Partner which, in the agency's opinion, indicates a need to revise or append the conclusions previously issued.

Use of trade names is for identification only and does not constitute endorsement by the U.S. Department of Health and Human Services.

Please address comments regarding this report to:

Agency for Toxic Substances and Disease Registry  
Attn: Records Center  
1600 Clifton Road, N.E., MS F-09  
Atlanta, Georgia 30333

You May Contact ATSDR Toll Free at  
1-800-CDC-INFO or  
Visit our Home Page at: <http://www.atsdr.cdc.gov>

PUBLIC HEALTH ASSESSMENT

JJ SEIFERT MACHINE COMPANY  
SUN CITY, HILLSBOROUGH COUNTY, FLORIDA  
EPA FACILITY ID: FLN000410232

Prepared by:

Florida Department of Health  
Under Cooperative Agreement with the  
US Department of Health and Human Services  
Agency for Toxic Substances and Disease Registry

*This information is distributed solely for the purpose of pre-dissemination public comment under applicable information quality guidelines. It has not been formally disseminated by the Agency for Toxic Substances and Disease Registry. It does not represent and should not be construed to represent any agency determination or policy.*

## Contents

Tables and Appendixes.....	iii
Foreword.....	iv
1.0 Summary.....	1
1.1 Statement of Issues.....	3
2.0 Background.....	4
2.1 Site History.....	4
2.2 Site Description.....	6
2.3 Site Geology and Hydrogeology.....	7
2.4 Site Visit.....	7
3.0 Discussion.....	7
3.1 Environmental Contamination.....	8
3.2 Pathways Analyses.....	11
3.3 Public Health Implications.....	12
3.4 Risk of Illness, Dose Response/Threshold and Uncertainty.....	22
3.5 Health Outcome Data.....	22
4.0 Child Health Considerations.....	22
5.0 Community Health Concerns.....	23
6.0 Conclusions.....	23
7.0 Recommendations.....	24
8.0 Public Health Action Plan.....	25
Report Preparation.....	26
References.....	27

**Tables and Appendices**

**Table 1. Exposure pathways.....31**

**Table 2. Maximum concentrations in drinking water wells.....32**

**Table 3. Well ID and sampling dates for maximum CV exceedances  
in drinking water wells.....33**

**Table 4. History of CV exceedances in off-site drinking water wells.....34**

**Table 5. Calculations table.....35**

**Table 6. Oral Hazard Quotient and Hazard Index Values.....36**

**Table 7. Inhalation Hazard Quotient and Hazard Index Values.....37**

**Table 8. Margin of Safety, Ingestion.....38**

**Table 9. Margin of Safety, Inhalation.....39**

**Table 10. Total oral dose and inhalation concentration calculations.....40**

**Table 11. Hepatic Target Toxicity Dose Calculations for  
Endpoint Specific Mixtures Evaluation.....41**

**Table 12. Renal Target Toxicity Dose Calculations for  
Endpoint Specific Mixtures Evaluation.....42**

**Appendix A. Risk of Illness, Dose Response/Threshold and Uncertainty.....43**

**Appendix B. Figures.....46**

**Appendix C. Calculations.....49**

**Appendix D. Evaluation of Single Chemicals and Mixtures.....52**

**Appendix E. Glossary of Environmental Health Terms.....57**

## Foreword

This document summarizes the Florida Department of Health's health assessment from exposure to the contaminants in the environment around the JJ Seifert Machine Company site. The Florida Department of Health (DOH) evaluates site-related public health issues through the following processes:

- **Evaluating exposure:** Florida DOH scientists begin by reviewing available information about environmental conditions at the site. The first task is to find out how much contamination is present, where it is on the site, and how human exposures might occur. Usually the Florida DOH does not collect its own environmental sampling data. A combination of government agencies and private consulting firms provided the information for this public health assessment. These entities include: the Florida Department of Environmental Protection (DEP), the United States Environmental Protection Agency (EPA) and private consultant firms; QORE Property Sciences (QORE), MACTEC Engineering and Consulting, Inc. (MACTEC), and Tetra Tech, Inc. (Tetra Tech).
- **Evaluating health effects:** If we find evidence that exposures to hazardous substances are occurring or might occur, Florida DOH scientists will determine whether that exposure could be harmful to human health. We focus this report on public health: that is, the health impact on the community as a whole, and base it on existing scientific information.
- **Developing recommendations:** In this evaluation report, the Florida DOH outlines its conclusions regarding any potential threat posed by the JJ Seifert site, and offers recommendations for reducing or eliminating human exposure to contaminants. The role of the Florida DOH in dealing with hazardous waste sites is primarily advisory. For that reason, the evaluation report will typically recommend actions for other agencies, including the EPA and the DEP. If, however, an immediate health threat exists or is imminent, the Florida DOH will issue a public health advisory warning people of the danger, and will work to resolve the problem.
- **Soliciting community input:** The evaluation process is interactive. The Florida DOH starts by soliciting and evaluating information from various government agencies, individuals or organizations responsible for cleaning up the site, and those living in communities near the site. We share any conclusions about the site with the groups and organizations providing the information. Once we prepare an evaluation report, the Florida DOH seeks feedback from the public.

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

*Please write to:* Program Manager/Health Assessment Team  
Bureau of Environmental Public Health Medicine/Florida Department of Health  
4052 Bald Cypress Way, Bin # A-08  
Tallahassee, FL 32399-1712

*Or call us at:* (850) 245-4299, or toll-free during business hours: 1-877-798-2772

## 1.0 Summary

### INTRODUCTION

---

In the Sun City community, the Florida Department of Health (DOH) and the US Agency for Toxic Substances and Disease Registry (ATSDR) work jointly to serve the public. We take quick public health actions, when needed. We tell people who live near hazardous waste sites what they need to know to avoid health risks from contact with toxic chemicals found at such sites.

JJ Seifert Machine Company, which has operated at the site since approximately 1962, manufactures products such as electronic components, tools, dies, jigs and fixtures. A paint shed, a drum storage area, and a plating operation formerly existed at the site. The primary source of contamination in the ground water is a former tetrachloroethylene (PCE) vapor degreaser, which was used to clean parts. Trichloroethylene (TCE) and cis-1,2-dichloroethylene are also solvents that occur as natural breakdown products of PCE.

This public health assessment estimates the health risk for individuals exposed to the highest measured levels of contamination. The highest measured levels of contamination are used for assessment because these levels are the most conservative and protective in estimating risks to human health. This assessment, however, does not apply equally to all Sun City residents. Most Sun City residents with private drinking water wells were exposed to less than the highest contaminant levels. The health risk for these individuals would be less than the health risk estimated in this report. For those Sun City residents whose wells were not contaminated, the health risk from groundwater is essentially zero at this time. Groundwater contamination is dynamic and wells that are unaffected now may become contaminated over time as pollutants migrate through the water.

### CONCLUSIONS

---

#### Groundwater

The DOH concludes that using unfiltered, contaminated groundwater under the JJ Seifert Machine Company, Inc. site and nearby area could increase people's risk of illnesses unrelated to cancer (non-cancer illness), and also cancer related illness. This is a public health hazard.

Because water from wells tested and found to be polluted is now filtered, the current public health risk is reduced. Also, other wells are checked regularly. If filters are not maintained or other wells are not tested routinely in the future, that could pose a health threat to those continuing to drink or use the water.

People who drank well water polluted with PCE at the highest past level found every day for 35 years (1975-2010) are at a “moderate” (1 in 1,000) theoretical increased cancer risk. This means that if 1,000 persons drank this PCE-contaminated water for 35 years, the number of extra cases of cancer is predicted to be (or estimated to be) 0 to 1. The number of extra cases means that it is estimated 1 person in 1,000 people may contract cancer if exposed to this contamination for this length of time (35 years). People who inhaled showering vapors polluted with PCE at the highest past level found every day for 35 years (1975-2010) are at a “moderate” (5 in 1,000) theoretical increased cancer risk. This means that if 1,000 persons inhaled this PCE-contaminated water vapor for 35 years, the number of extra cases of cancer is predicted to be 0 to 5.

People who drank well water polluted with TCE at the highest past level found every day for 35 years (1975-2010) are at a “very low” (1 in 100,000) increased theoretical risk of cancer. This means that if 100,000 persons drank this TCE-contaminated water for 35 years, the number of extra cancer cases is predicted to be 0 to 1. People who inhaled showering vapors polluted with TCE at the highest past level found every day for 35 years (1975-2010) are at a “moderate” (2 in 1,000) theoretical increased cancer risk. This means that if 1,000 persons inhaled this TCE-contaminated water vapor for 35 years, the number of extra cases of cancer is predicted to be 0 to 2.

Florida DOH concludes that ingestion and/or inhalation of a mixture of *cis*-1,2-DCE, 1,2-DCP, PCE, and TCE could harm people’s health.

### Soil

Florida DOH has not found any sampling data that demonstrates soil contamination from the site in the Sun City community, nor does it expect to find any. Because solvents used at the site tend to either evaporate into the air or sink down to the groundwater, it is unlikely that nearby surface soil is contaminated. The property is inaccessible to the public. There is a 6-8 feet high, chain link fence surrounding the property.

### Groundwater to Indoor Air Vapor Intrusion (also called Soil Vapor Intrusion)

Contaminated groundwater vapors could move beneath Sun City homes near the site and migrate up into the indoor air. Florida DOH is not able to assess the risks from this pathway at this time because there are no air sampling data available.

BASIS FOR  
DECISION

---

Five private wells had contamination exceeding health based standards. The highest levels of contamination found off-site (in two private wells)

were used to calculate risk estimates. Groundwater west and southwest of the site has levels of PCE and TCE in it that may harm health. Florida DOH expects people drinking this water or breathing contaminant vapors during showering may be at risk of adverse health effects. Mixtures of PCE and 1,2-DCP may have additive non-cancer effects, however complete interaction profiles for all contaminants are not available. Drinking water contaminated with TCE at the levels found in private wells is estimated to cause a “very low” increase in one’s theoretical cancer risk (1 in 100,000 people). Off-site groundwater also has some PCE breakdown products in it. PCE was associated with a “moderate” (1 in 1,000) theoretical increased cancer risk. This level of carcinogenic risk due to ingestion constitutes a potential health hazard from using water with a mixture of contaminants.

#### NEXT STEPS

- 
- Residents with contaminated wells should not use them without a filter that removes solvents such as TCE and PCE.
  - Residents should maintain their private well filter systems with help from the Florida Department of Environmental Protection (DEP). If people put in a new well, they should use a filter system to take out chemicals.
  - The Hillsborough County Health Department (HCHD) should periodically test Sun City private wells.
  - EPA should assess the possibility of vapor intrusion into homes located above VOC contaminated groundwater.

#### FOR MORE INFORMATION

---

If you have concerns about your health or the health of your children, you should call your doctor. You may also call the Florida DOH at 1-877-798-2772. You can ask for more details about the JJ Seifert site.

### 1.1 Statement of Issues

In this public health assessment, the Florida DOH evaluates past, current and potential future exposures to chemicals from the JJ Seifert site. Specifically, this report evaluates drinking water from private wells, groundwater and soil data collected by the Florida DOH, the Florida DEP, Hillsborough County Health Department, contractors for Florida DEP and JJ Seifert Machine Co., Inc. Florida DOH then discusses the risk of illness and actions needed to protect public health.

Because of the inherent uncertainties, this public health assessment does not represent an absolute estimate of risk to persons exposed to chemicals at or near the JJ Seifert site. The assumptions, interpretations, and recommendations made throughout this public health

assessment, however, intentionally err on the side of protecting public health and may overestimate risk.

This public health assessment estimates the health risk for individuals exposed to the highest measured levels of contamination. The highest measured levels of contamination are used for assessment because these levels are the most conservative and protective in estimating risks to human health. This assessment does not apply equally to all Sun City residents. Most Sun City residents with private drinking water wells were exposed to less than the highest contaminant levels. The health risk for these individuals would be less than the health risk estimated in this report. For those Sun City residents whose wells were not contaminated, the health risk from groundwater is essentially zero at this time. Groundwater is dynamic and wells that are unaffected now may become contaminated over time as the contaminated groundwater migrates.

This is the first comprehensive public health assessment (PHA) of the JJ Seifert site by either the Florida DOH or the ATSDR. Florida DOH evaluates the public health significance of hazardous waste sites through a cooperative agreement with ATSDR.

## **2.0 Background**

### **2.1 Site History**

The JJ Seifert Machine Company, Inc. began in 1960-61 with the construction of the original on-site machine shop building [EPA 2008a]. The machine company is currently operating.

In 1969, Mr. Seifert built a second building to accommodate Upcavage and Bauer's plating operations (UB Corporation). This business, run from approximately 1969 to 1972, was independent of the machine company, although it was housed on the JJ Seifert site. Upcavage and Bauer's operations did not result in any known site specific contamination.

The machine company performed chromating until late 1990. Chromating is a process of putting a chemical film on aluminum using a mill etch, followed by dipping the part in a chromate solution, then air drying. This process ceased in late 1990. The machine company then changed to small part passivation (making the surface non-reactive, sometimes using chromium) and iridizing (to point or tip with iridium).

From approximately 1975 until 1998, a heated, immersion type vapor degreaser was used or present for cleaning residual soils from machine parts [EPA 2008a]. In 1998, the vapor degreaser was removed. The chlorinated solvent used in the vapor degreaser was PCE. Fresh PCE and used or spent PCE were stored at three locations on the property. There were drums of fresh PCE located near the degreaser outside and southwest of the original machine shop. Some drums were stored within the southern portion of the original machine shop. Also, drums of spent solvent were stored on a partially covered concrete pad at the northeast corner of the property. The concrete pad had a small, one inch diameter drain.

The property and business were put up for sale soon after a 1998 property cleanup. Used PCE was removed during the property cleanup. In 2000, an interested buyer hired QORE, Inc. Property Sciences (QORE) to perform a Phase I environmental assessment as part of due

diligence. Potential sources of contamination were identified and summarized in the Phase I report [QORE 2000a].

The JJ Seifert Machine Company then hired QORE to conduct a Phase II environmental assessment [QORE 2000b]. Three temporary on-site monitoring wells were sampled and groundwater contamination was discovered. Groundwater contaminants included the solvent PCE and its natural breakdown products, TCE and *cis*-1,2-dichloroethylene (*cis*-1,2-DCE). TCE and *cis*-1,2-DCE are also solvents. Soil samples were also sampled and analyzed; no soil contamination was found exceeding Florida DEP's Soil Cleanup Target Levels [FDEP 1999].

Sun City residents around the JJ Seifert site have historically relied on private wells for drinking water. No Hillsborough County municipal water hook-ups have been or are currently available in the area. Residents use water from their wells for drinking, showering, and other household purposes.

As a result of the on-site groundwater contamination discovery, off-site private drinking water well sampling was initiated by Florida DEP with the assistance of Florida DOH and the HCHD. In December 2000, 10 nearby private potable wells were sampled [HCHD 2001a]. Samples were analyzed for a number of volatile organic compounds (VOCs) including PCE and its breakdown products. Two of the 10 wells showed contamination. PCE (5.2 micrograms per liter [ $\mu\text{g/L}$ ]) and TCE (10  $\mu\text{g/L}$ ) contamination was found in one well (well ID AAE9663, ~300 ft southwest of the JJ Seifert site). PCE (100  $\mu\text{g/L}$ ), TCE (100  $\mu\text{g/L}$ ) and *cis*-1,2-DCE (73  $\mu\text{g/L}$ ) were found in another residential well (well ID AAE9656, ~100 ft west of the JJ Seifert site). These concentrations are above drinking water standards [FDEP 2004b].

The well water samples were also analyzed for various metals, including chromium. The levels of all metals, including chromium were below drinking water standards.

How long these two wells were contaminated is unknown. Florida DEP installed whole-house granular activated carbon (GAC) drinking water filtration units in two homes on January 1, 2001 and April 30, 2002, respectively. The filters capture contaminants before the water is used in the households. Florida DEP, with the assistance of Florida DOH and the HCHD, began periodic and on-going testing of impacted and nearby private potable wells [HCHD 2001a, 2001b, 2002; FDEP 2004a; WSWA 2004a].

In January 2001, Florida DEP, in cooperation with Florida DOH and the HCHD sampled 11 nearby private drinking water wells. These included some of the 10 previously sampled wells and additional wells. One well (well ID AAE9673, ~500 ft southwest) showed PCE (7.2  $\mu\text{g/L}$ ) levels above drinking water standards. Florida DEP installed a GAC filter system on this well also.

In October of 2004, 16 nearby community private potable wells were tested for volatile organic chemicals (VOCs) (WSWA 2004b). All samples met Florida DEP's drinking water standards [FDEP 2004a].

In 2008, Florida DEP hired MACTEC Engineering and Consulting, Inc. (MACTEC) to complete a site investigation report including on-site and community sampling [MACTEC 2008]. Florida

DEP contacted the EPA and the site was proposed to the National Priorities List (NPL) in September of 2009 [EPA 2009a; FDEP 2007; 2008]. EPA added the JJ Seifert site to the NPL on March 2, 2010.

## **2.2 Site Description**

The 0.75-acre JJ Seifert Machine Company, Inc. site is located at 4202-4212 Old US Highway 41 on the southwest corner of Vidor Avenue and US Highway 41 in Sun City, Hillsborough County, Florida (Appendix B, Figure 2). The approximate latitude (27° 40' 43.788") and longitude (-82° 28' 41.376") coordinates of the site, in decimal degrees, are 27.67883 North and -82.47816 West, respectively. On site are a machine shop, machine shop addition, and a metal building, and an unoccupied, storage mobile home on the property. The property is cordoned by a 6-8 feet high chain link fence on all sides. A publicly accessible drive and parking area for the machine company occupies the western border along Old US Hwy 41 South.

The Sun City community surrounds the JJ Seifert site. Sun City is located in southwestern Hillsborough County, approximately two miles east of Cockroach Bay and two miles south of the mouth of the Little Manatee River. The town of Ruskin is approximately three miles to the northeast of Sun City. When viewed aerially, Sun City is shaped like a teardrop and bounded on its west by a CSX Transportation railway line running southwest/northeast. US Hwy 41 curves around Sun City to its east and serves simultaneously as its northern, eastern, and southern borders. Old US Hwy 41 bisects this small community, running parallel to both the rail line and US Hwy 41 (Appendix B, Figure 1).

The Sun City neighborhood is a blend of single-family homes and light commercial and industrial development. For the purpose of this public health assessment report, the Sun City community is defined by the people living on Old US Hwy 41, US Hwy 41, Vidor Avenue, Fox Street, Fox Place, and Uncle Brack Road. The Sun City community borders the JJ Seifert site to the north, west, and south. US Hwy 41 provides the eastern property border for the JJ Seifert site. Land to the east of US Hwy 41 is agricultural. A church is located approximately 0.1 mile southeast of the JJ Seifert site on the east side of US Hwy 41 (Appendix B, Figure 1).

Sun City is distinct from Sun City Center and Greater Sun Center. These two retirement communities are approximately 10 miles northeast of Sun City. Although the physical addresses of the community are located in Sun City, the community takes its delivery zip code as 33570, which includes Ruskin. Most residents of Sun City use a post office box zip code of 33586.

**2.2.1 Demographics** - Approximately 65 homes are within a 0.5 mile radius of the site. Estimating 2.5 persons per home, the 0.5 mile radius population of Sun City is about 163 persons. The ethnicity is mixed with Spanish- and English-speaking residents. There is not a specific concentration of neighborhood homes, but rather most are evenly dispersed radially from the site.

**2.2.2 Land Use** – The Sun City community is in an unincorporated section of Hillsborough County. Mixed residential, agriculture, light commercial and industrial developments surround the JJ Seifert site. Homes and businesses border the site to the north. Homes are to the west

across Old US Hwy 41. Businesses and homes border the property to the south. US Hwy 41 serves as the property's eastern border.

### **2.3 Site Geology and Hydrogeology**

Land surface elevation in the area is approximately 20 to 25 feet above mean sea level (msl). There are essentially three aquifer systems beneath the JJ Seifert site: the surficial aquifer, the intermediate aquifer, and the Floridan aquifer. The surficial aquifer begins within a few feet of the land surface and consists of undifferentiated sand, clay and marl ranging from a few inches thick to approximately 100 feet thick. This aquifer is connected with lakes and other surface wetland features. The water table is typically found at less than 10 feet below ground surface (bgs). Recharge to this aquifer is primarily from local rainfall. The principal use of this aquifer is for lawn irrigation and livestock watering.

Underlying the surficial aquifer system are deposits composed of sandy clay, carbonates, marl and silt. These deposits, from 0 to 100 feet thick in Hillsborough County, separate the surficial aquifer system from the underlying Floridan aquifer system. Below the JJ Seifert site an intermediate aquifer system exists within permeable deposits of white to gray, soft, sandy, porous limestone.

In Hillsborough County, the Floridan aquifer system is the major source of potable groundwater and is first encountered at a depth of 25 to 100 feet. Underground formations here consist of limestone and varying amounts of quartz sand, clay and phosphate. The formations are very permeable and can yield up to 3,000 gallons per minute (gpm) and supplies most domestic, public and commercial wells in the county [MACTEC 2008; USGS 1985].

PCE and other solvents have been found in both the surficial and intermediate aquifer systems under the site and in parts of the Sun City community. Groundwater in the surficial and intermediate aquifers appears to flow to the west-southwest. The highest levels of off-site groundwater contamination are found in private wells screened in the intermediate aquifer.

### **2.4 Site Visit**

An initial preliminary site visit was conducted in October 2009. Florida DOH employees walked around the outside of the JJ Seifert fence and performed a drive-through community evaluation. They observed low to middle income housing, a mixed ethnicities population, homes, businesses, and mobile homes. They saw several private well water pump systems. The site topography is flat. No natural pathways (trails) were noted through the property. No children's toys were noted. No physical hazards were noted. No gardens were seen near the site. Generally, the property appeared active, mowed, and well maintained. A small swale (~1-2 feet deep) ran around the perimeter of the JJ Seifert property and captures storm water runoff.

### **3.0 Discussion**

In this section, Florida DOH reviews the available site information (groundwater and soil). There have been no previous Florida DOH reports on this site. Florida DOH reviews how nearby residents can contact chemicals. Florida DOH predicts whether chemicals could affect

people's health, if they were to come into contact with those chemicals. This report does not assess the health risk to JJ Seifert workers. Worker health and safety is the responsibility of the employer and is regulated by the U.S. Occupational Safety and Health Administration (OSHA). If the land use at the JJ Seifert site changes from commercial to residential use in the future, community exposure risk would need to be re-evaluated.

The public health assessment process has inherent uncertainties because:

- The risk assessment process is inexact,
- Information on the site and on actions (and interactions) of chemicals is never complete, and
- Scientific opinions on the implications of known information differ.

All risk assessments, to varying degrees, require the use of assumptions, judgments, and incomplete data. These contribute to the uncertainty of the final risk estimate conclusions. Important sources of uncertainties include environmental sampling and analysis, exposure parameter estimates, use of modeled data, and present toxicological knowledge (Appendix A). These uncertainties can cause risk to be over- or under-estimated. The assumptions, interpretations, and recommendations made throughout this public health assessment intentionally err on the side of protecting public health and may overestimate the risk. Because of the inherent uncertainties, this public health assessment does not represent an absolute estimate of risk to persons exposed to chemicals at or near the JJ Seifert site.

This public health assessment is a deterministic style risk assessment. For each variable in the risk equation (such as exposure concentration or exposure duration) this assessment selects one value. The result is a single estimate of the risk. In contrast, probabilistic risk assessments use a range of values for each variable. The result of probabilistic risk assessments is a range of risk. Both deterministic and probabilistic style risk assessments are useful in describing the risk.

### **3.1 Environmental Contamination**

The Florida DOH used the following screening guidelines in order of priority to select contaminants of concern:

1. Cancer Risk Evaluation Guide (CREG). A CREG is the contaminant concentration estimated to result in no more than one excess cancer per one million persons exposed during a lifetime (i.e., 70 years). ATSDR calculates CREGs from EPA-established cancer slope factors [ATSDR 2005].
2. Environmental Media Evaluation Guide (EMEG). ATSDR derives an EMEG from a Minimal Risk Level (MRL), using standard exposure assumptions (e.g., ingestion of 200 milligrams (mg) of soil per day and body weight of 30 kilograms (kg) for children, ingestion of 100 mg of soil per day and body weight of 70 kg for adults). ATSDR establishes acute, intermediate, and chronic MRLs. Acute MRLs are levels of daily human exposure to a chemical for a period of 1-14 days which is likely to be without any appreciable risk of non-cancer illnesses. Intermediate MRLs are levels of daily human exposure to a chemical for a period of 14-364 days which is likely to be without any appreciable risk of non-cancer

- illnesses. Chronic MRLs are levels of daily human exposure to a chemical for a period of 1 year or longer which is likely to be without any appreciable risk of non-cancerous illnesses.
3. Maximum Contaminant Levels (MCL). The Florida DEP derives MCLs from the US EPA standards or from health data compiled from state and federal resources. MCLs are fully enforceable standards and must be equal to or more stringent (i.e., lower) than federal MCLs (such as EPA's).
  4. Florida DEP soil cleanup target levels (SCTLs) are contained in Table 2 of Chapter 62-777 Florida Administrative Code (FAC) [FDEP 1999].

The screening guidelines are conservative estimates of levels at or below where no health effects would be expected. The Florida DOH utilizes the above criteria to screen all data. Any results that exceed the guideline values are selected for further evaluation. The next step in the process for toxicological review is to compare an estimated dose or concentration that has been calculated from site related data to established No Observable Adverse Effect Levels (NOAELs) and Lowest Observable Adverse Effect Levels (LOAELs).

Using the criteria listed above, the Florida DOH selected 1,2-dichloropropane (1,2-DCP), *cis*-1,2-dichloroethylene (*cis*-1,2-DCE), tetrachloroethylene (PCE), and trichloroethylene (TCE) as contaminants of concern. We selected each chemical because it occurred in the groundwater at levels equal to or greater than the screening guideline (Table 2). The *cis*-1,2-DCE, and TCE may be breakdown products of PCE. The 1,2-DCP may have originated as a soil fumigant used to treat agricultural crops in surrounding fields.

Identifying a contaminant of concern in this section of the report does not necessarily mean that exposure to the chemical will cause illness. To be protective of health, ATSDR screening guidelines are usually set hundreds or thousands of times below levels that actually are associated with illness. Identifying contaminants of concern helps to narrow the focus of the public health assessment to those contaminants that require further evaluation for potential public health risk.

### **3.1.1 On-Site Contamination**

PCE was found in the surface and subsurface soils. The most prevalent VOCs showing widespread onsite contamination were *cis*-1,2 DCE, PCE, TCE, and vinyl chloride (VC). Upgradient ground water test results confirm that the VOC contaminant plume originates at JJ Seifert Machine Company.

On-site contamination is not evaluated in this public health assessment because the property is currently operating and is inaccessible to the public. There is 6-8 feet high, chain link fence surrounding the property. If land use were to change in the future the on-site risk would need to be evaluated.

### **3.1.2 Off-Site Contamination**

“Off-site” is defined as the area outside the JJ Seifert property boundary (Appendix B, Figure 2).

**3.1.2.1 Off-Site Soil** - Off-site soil sampling (0-2 ft below ground surface) was limited to “background” sampling and found no contaminants of concern above screening levels. Background samples were taken from across Vidor Avenue, northeast of the site. They were used to establish natural (‘background’) soil chemical levels.

### **3.1.2.2 Off-Site Surface Water**

There are no surface water bodies on or near the JJ Seifert site. No off-site surface water samples have been collected because there are no off-site surface water bodies within 500 feet of the JJ Seifert site.

### **3.1.2.3 Off-Site Groundwater**

**3.1.2.3.1 Shallow aquifer (4-69 feet below ground surface)** - Groundwater in the shallow aquifer (sampled at 10 to 15 feet below ground surface) is contaminated with PCE and its natural breakdown products. EPA found this contamination immediately west and southwest of the JJ Seifert site [EPA 2009b, MACTEC 2008].

**3.1.2.3.2 Deeper aquifer (70-225 feet below ground surface)** - In December 2000, the Florida DEP and HCHD collected samples from 10 off-site private drinking water wells in the Sun City community. The Florida DOH laboratory analyzed samples for arsenic, chromium and VOCs (which includes PCE and its breakdown products). Because contaminants were discovered in two private wells during this sampling event, Florida DEP and HCHD began quarterly, annual, and bi-annual private well sampling. Not all wells or the same wells were sampled during each sampling event. Florida DOH assumes these wells are screened in the deeper, intermediate aquifer [MACTEC 2008]. The actual depths of the wells, however, are unknown.

Between January 2001 and August 2008, the Florida DOH with the help of the HCHD, Florida DEP, and MACTEC Engineering and Consulting, Inc. sampled numerous nearby private wells and analyzed for VOCs. Periodic sampling is on-going in the Sun City community around JJ Seifert. The sampling schedule varies for each private well sampled. The approximate 25 off-site private wells within 0.25 mile from the site have been tested. This sampling has focused hydraulically downgradient of the site to the west-south-west (WSW) where contaminated private wells have been identified. Table 3 summarizes the history of maximum exceedances and Table 4 summarizes the history of all exceedances of health based screening values in off-site well testing, respectively. For the purpose of this report, off-site private well groundwater quality has been adequately characterized.

**3.1.2.4 Quality Assurance and Quality Control** - This PHA uses existing environmental data. Florida DOH assumes these data are valid because government consultants or consultants overseen by government agencies collected and analyzed the environmental samples. Florida DOH also assumes that consultants who collected and analyzed these samples followed adequate quality assurance and quality control measures concerning chain-of-custody, laboratory procedures, and data reporting.

## 3.2 Pathways Analyses

Chemical contaminants in the environment can harm people's health, but only if people have contact with those contaminants often enough at a high enough concentration (dose) to cause a health effect. Knowing or estimating the frequency with which people could have contact with hazardous substances is essential to assessing the public health importance of these contaminants. To decide if people can contact contaminants at or near a site, Florida DOH looks at the human exposure pathways. An exposure pathway has five parts. These parts are:

1. a source of contaminants, like a hazardous waste site,
2. an environmental medium like air, water or soil that can hold or move the contamination,
3. a point where people come in contact with a contaminated medium, like drinking water or soil in a garden,
4. an exposure route like drinking contaminated water from a well or eating contaminated soil on homegrown vegetables, and
5. a population who could be exposed to the contaminants.

Florida DOH eliminates an exposure pathway if at least one of the five parts referenced above is missing and is very unlikely to be present in the future. Exposure pathways not eliminated are either completed or potential pathways. For completed pathways, all five pathway parts exist and exposure to a contaminant has occurred, is occurring, or will occur. For potential pathways, at least one of the five parts is missing but could exist. Also for potential pathways, exposure to a contaminant could have occurred, could be occurring, or could occur in the future. Contaminant exposure pathways are displayed in Table 1.

### 3.2.1 Eliminated Exposure Pathways

**3.2.1.1 On-site Groundwater** – This exposure pathway is eliminated from consideration because there is no public access to the property. Signs have been posted that prohibit workers and visitors from drinking from the on-site well.

**3.2.1.2 On-site Soil** – This exposure pathway is eliminated from consideration because there is no public access to the property. The property is currently operating and there is 6-8 feet high, chain link fence surrounding the property. The on-site mobile home is unoccupied and is intermittently used for storage. If land use were to change in the future the on-site risk would need to be evaluated. This report does not assess the health risk if homes are later built on the site. Also, this report does not assess the health risk to on-site workers. The U.S. OSHA is responsible for worker health and safety. Because workers are not drinking on-site well water we don't expect exposures to the water would cause harm.

**3.2.2 Potential Exposure Pathways – Vapor Intrusion (also called Soil Vapor Intrusion)** – Off-site VOC contaminated groundwater under nearby Sun City residents' homes may vaporize and intrude up into homes. Assessment of the possibility of a health threat, if any, from soil vapor intrusion is recommended for EPA. There are currently no air sampling data available.

**3.2.3 Completed Exposure Pathways – Off-site Groundwater** – Prior to filter installation on their private wells, Sun City residents in at least five homes who used private wells were exposed to groundwater contamination in exceedance of ATSDR Comparison Values [ATSDR 2009]. How long they were exposed is unknown. For this assessment, however, we assume they could have been exposed beginning as early as 1975 when the site owners began using PCE in the vapor degreaser.

### **3.3 Public Health Implications**

In the following sections, we discuss exposure levels and possible health effects that might occur in people exposed to the contaminants of concern at the site.

**3.3.1 Toxicological Evaluation** – The Florida DOH evaluates exposures by estimating daily doses for children and adults. Kamrin [1988] explains the concept of dose in the following manner:

...all chemicals, no matter what their characteristics, are toxic in large enough quantities. Thus, the amount of a chemical a person is exposed to is crucial in deciding the extent of toxicity that will occur. In attempting to place an exact number on the amount of a particular compound that is harmful, scientists recognize they must consider the size of an organism. It is unlikely, for example, that the same amount of a particular chemical that will cause toxic effects in a one pound rat will also cause toxicity in a one ton elephant.

Thus, instead of using the amount that is administered or to which an organism is exposed, it is more realistic to use the amount per weight of the organism. Thus, one ounce administered to a one pound rat is equivalent to 2,000 ounces to a 2,000 pound (one ton) elephant. In each case, the amount per weight is the same; i.e., one ounce for each pound of animal.

This amount per weight is called the *dose*. Toxicology uses dose to compare the toxicity of different chemicals in different animals. We use the units of milligrams (mg) of contaminant per kilogram (kg) of body weight per day (mg/kg/day) to express doses in this public health assessment. A milligram is 1/1,000 of a gram; a kilogram is approximately two pounds.

To calculate the daily dose of each contaminant, the Florida DOH uses standard assumptions about body weight, ingestion and inhalation rates, duration of exposure (period of time), and other factors needed for dose calculation [ATSDR 2005, EPA 1997]. The Florida DOH uses Risk Assistant, a software model that uses EPA risk assessment guidelines, to calculate estimated doses based upon measured contaminant levels in the environment. The Florida DOH estimated exposure for Sun City residents using the highest concentrations found in a private drinking water well for each contaminant. The highest measured levels of contamination are used for assessment because these levels are the most conservative and protective in estimating risks to human health. These contaminants, their maximum concentrations, and health-based comparison values are listed in Table 2.

ATSDR's toxicological profiles on contaminants found at this site address toxicity from two relevant exposure routes – ingestion, and inhalation of vapors from showering. For each of these exposure routes, ATSDR also groups health effects by duration (length) of exposure. Acute exposures are those with duration of 14 days or less; intermediate exposures are those with duration of 15-364 days; and chronic exposures are those that occur for 365 days or more (or an equivalent period for animal exposures). ATSDR Toxicological Profiles also provide information on the environmental transport and regulatory status of contaminants.

To estimate exposure from ingestion of contaminated water, Florida DOH used the following assumptions:

1. Children ingest about 1 liter of water per day and adults ingest about 2 liters of water per day from all sources including tapwater, drinks prepared with tapwater, purchased drinks, and water intrinsic to purchased foods,
2. children weigh an average of 16 kg,
3. adults weigh an average of 70 kg.

To estimate exposure from inhalation of vapors during/following showering, Florida DOH used the Risk Assistant software with the following assumptions for both children and adults:

1. bathroom volume equal to nine cubic meters
2. shower flow rate of 600 liters per hour
3. fraction of contaminant volatilized equal to 75 percent
4. shower duration of 0.20 hours or 12 minutes

### **3.3.1.1 Off-Site Groundwater**

Florida DOH bases these theoretical calculations on the assumption that exposure to any concentration of a chemical that causes cancer, increases the risk of cancer by some degree. The calculations assume exposure to maximum contaminant levels. The calculated risk is theoretical and may not reflect the actual risk number of cancer cases that occur in Sun City residents. These calculations tend to overestimate the risk associated with exposures that may have occurred. Table 5 gives a complete list of non-cancer and cancer calculations.

Exposure to contaminated groundwater may have been through ingestion (drinking, food preparation, ice) or inhalation (breathing) of vapors during showering/other household use.

How long some residents were drinking contaminated groundwater is unknown. Some may have been drinking contaminated groundwater since as far back as 1975 when the vapor degreaser at the JJ Seifert site is reported to have been installed. This results in 35 years (1975-2010) of potential exposure in those off-site wells that remain contaminated and unfiltered. Approximately 25 off-site unfiltered and/or filtered wells are estimated to exist within one quarter mile of the machine shop [FDEP 2004a].

Residents still use groundwater for drinking and showering. GAC filter systems have been installed on most of those private wells where groundwater contamination was found. As

contamination still exists under the JJ Seifert site and there has been no cleanup of the contamination, there is also a current and future public health hazard from groundwater.

The following section considers the health risk from exposure to individual chemicals. For each chemical Florida DOH estimates the health risk separately for each route of exposure (drinking and breathing). Appendix D explains the health scientist's approach to individual chemical evaluation and provides definitions for hazard quotient (HQ).

#### *1,2-Dichloropropane (1,2-DCP)*

Ingestion non-cancer risk - Drinking well water with the highest measured concentration of 1,2-DCP (7 µg/L) is unlikely to result in any non-cancer illness. The highest estimated ingestion dose of 1,2-DCP for a child (0.0004 mg/kg/d) is 225 times below the ATSDR chronic MRL (0.09 mg/kg/d). This means that the estimated dose is well below health guidelines. The calculated oral HQ for 1,2-DCP is 0.004 (Table 6). Since the HQ is less than 1.0, non-cancerous harmful effects are not likely from drinking private well water.

Inhalation non-cancer risk - Breathing 1,2-DCP vapors during showering with this contaminated well water is unlikely to result in any non-cancer illness. The inhalation HQ for 1,2-DCP is 2.1 (Table 7). Because this value exceeds unity (>1.0), additional evaluation is necessary. An intermediate exposure duration is selected because there are no chronic exposure values available for inhalation of 1,2-DCP.

It is helpful here to briefly explain/revisit some toxicological terms previously mentioned in section 3.1. This further detailed evaluation includes comparing the individual chemical dose or inhaled air concentration against values established from human and animal research studies. There are two main values of toxicological interest: the No Observed Adverse Effect Level (NOAEL) and the Lowest Observed Adverse Effect Level (LOAEL). The NOAEL is the highest dose or inhaled air concentration where no health change (no adverse health effect) was noted. The LOAEL is the lowest dose or inhaled air concentration that resulted in an adverse health change in the human or animal studies.

Additionally, Florida DOH calculates a Margin of Safety (MOS) by dividing the NOAEL or LOAEL by the estimated ingestion dose or inhaled air concentration. This gives a perspective on how many times below the NOAEL or LOAEL the estimated dose or concentration is. The ingestion and inhalation MOS tables are available in Tables 8 and 9.

The estimated inhalation exposure concentration for 1,2-DCP is 0.015 parts per million (ppm). The LOAEL for 1,2-DCP inhalation is 15 ppm where upper respiratory lesions were first noted in rat studies. Because the estimated exposure concentration is 1000 times below the LOAEL, it is unlikely this estimated exposure concentration (0.015 ppm) would contribute to non-cancer illness.

Ingestion and inhalation cancer risk - Not enough is known about the cancer causing potential of this chemical to estimate the cancer risk from drinking or showering with 1,2-DCP contaminated water [ATSDR 1989; IRIS 2010].

### *cis*-1,2-dichloroethylene (*cis*-1,2-DCE)

Ingestion non-cancer risk - Drinking well water with the highest measured concentration of *cis*-1,2-DCE (100 µg/L) is unlikely to result in any non-cancer illness.

The highest estimated ingestion dose of *cis*-1,2-DCE for a child (0.006 mg/kg/d) exceeds the EPA chronic oral reference dose (0.002 mg/kg/d) by three times (HQ = 3.0). This requires additional health evaluation, which is briefly explained below.

When establishing a chronic oral reference dose (RfD), EPA also provides a health based value, using the laboratory research that helped EPA establish a chronic oral RfD. In the case of *cis*-1,2-DCE, EPA used a value called a benchmark dose (BMD) which involves fitting mathematical models to the available dose-response data (from single or multiple studies) and using the results to select a dose associated with a specific low level of risk (e.g., 5% or 10% increase) in the incidence of an adverse health effect [ATSDR 2005]. The adverse health effect that was found for *cis*-1,2-DCE was kidney weight gain in male laboratory rats. In order to be statistically rigorous, the BMD is mathematically surrounded by a range of values, defined as the 95% confidence limits of a particular value (here, the BMD). If EPA takes the most conservative of this limit (the lower value) it can provide a number which is called the BMDL<sub>10</sub>. The BMDL<sub>10</sub> is the 95% lower confidence limit on the benchmark dose (BMD<sub>10</sub>) corresponding to a 10% increase in relative kidney weight when compared with study controls.

The BMDL<sub>10</sub> for *cis*-1,2-DCE is 5.1 mg/kg/d. Again, this value sets a benchmark for where 10% of the exposed population would be expected to have the adverse effect. The estimated child dose of 0.006 mg/kg/d is 850 times lower than 5.1 mg/kg/d and therefore *cis*-1,2-DCE is not likely to cause non-cancer illness in children at this conservative exposure dose estimate.

The estimated adult ingested dose of *cis*-1,2-DCE (0.002 mg/kg/d) is equal to the chronic oral RfD, which is established to be protective of human health, and is therefore not likely to cause non-cancer illness for adults.

Inhalation non-cancer risk – Human and animal studies are inadequate to determine the non-cancer health risk from breathing *cis*-1,2-DCE vapors during showering with contaminated groundwater near the JJ Seifert site [ATSDR 1996].

Ingestion and inhalation cancer risk - Too little is known about *cis*-1,2-DCE to determine the theoretical risk of cancer for people using contaminated groundwater near the JJ Seifert site.

### *Tetrachloroethylene* (*Perchloroethylene*, *PCE*)

Ingestion non-cancer risk - Drinking Sun City groundwater with the highest levels of PCE (160 µg/L) is unlikely to cause non-cancer illness. The highest estimated ingestion dose of PCE for a child (0.01 mg/kg/day) is equal to the EPA chronic oral RfD (0.01 mg/kg/day, HQ = 1.0) and therefore is not likely to cause illness [IRIS 2010].

Inhalation non-cancer risk - Breathing PCE vapors during showering with this well water is unlikely to result in non-cancer illness. An estimated inhalation concentration from exposure to

the highest level of PCE in groundwater was calculated using Risk Assistant, a software model that uses EPA risk assessment guidelines. The highest estimated inhalation air concentration of PCE for Sun City residents (0.2 ppm) is 6 times greater than the chronic inhalation MRL (0.04 ppm). Dividing the concentration by the chronic MRL gives an HQ = 6.0 and therefore PCE inhalation requires additional evaluation (see Table 7).

The estimated inhalation exposure concentration for PCE is 0.24 ppm. The LOAEL for PCE inhalation is 15 ppm where increased reaction times were first noted in human studies. Because the estimated exposure concentration is approximately 63 times below the chronic LOAEL, it is unlikely this estimated exposure concentration (0.24 ppm) would contribute to non-cancer illness.

The US Department of Health and Human Services (DHHS) has concluded PCE may reasonably be anticipated to be a carcinogen [NTP 2005]. Studies of dry cleaning workers suggest a possible association between chronic PCE exposure and increased risk of esophageal cancer, cervical cancer, and non-Hodgkin's lymphoma. These studies are inconclusive, however, because of exposure to other solvents, exposure to tobacco smoke, limited control populations, and incomplete follow-up.

Ingestion cancer risk - Those Sun City residents who every day between 1975 and 2010 (35 years) drank contaminated groundwater with the highest measured PCE concentration (160 µg/L) are at a "moderate" (1 in 1,000) theoretical increased risk of cancer including kidney and leukemia (Table 5) [ATSDR 2011]. This means that if 1,000 persons drank this PCE-contaminated water for 35 years, the number of extra cases of cancer is 0 to 1.

Inhalation cancer risk - Inhaling PCE vapors during showering is estimated to increase the cancer risk by 5 in 1,000 people and is considered a "moderate" increased risk (Table 5) [ATSDR 2011]. This means that if 1,000 persons inhaled this PCE-contaminated water vapor for 35 years, the number of extra cases of cancer is 0 to 5.

#### *Trichloroethylene (TCE)*

Ingestion non-cancer risk - Drinking groundwater with the highest TCE levels (150 µg/L) is unlikely to contribute to non-cancer illnesses in children.

Because the hypothetical maximum TCE dose for children drinking contaminated groundwater near the JJ Seifert site (0.009 mg/kg/day) is 30 times greater (HQ = 30) than the EPA chronic oral RfD of 0.0003 mg/kg/day, Florida DOH evaluated this exposure in more detail (Table 6).

The LOAEL for TCE intermediate ingestion is 1.0 mg/kg/d [EPA 2001]. This is a dose where the first adverse health effects were noted in animal studies (liver weight changes in mice). The estimated hypothetical ingestion dose of 0.009 mg/kg/day for children drinking contaminated groundwater near the JJ Seifert site is approximately 111 times lower than the LOAEL. The estimated ingested dose of TCE (0.004 mg/kg/d) for adults drinking contaminated groundwater near the JJ Seifert site is approximately 250 times lower than the LOAEL of 1.0 mg/kg/d. Long-term animal studies showing adverse kidney effects, dermal effects, or decreased body weight all had effect levels thousands of times higher than the doses estimated to have occurred for children

(0.009 mg/kg/d) and adults (0.004 mg/kg/d) at this site [ATSDR 1997b]. Multiple studies have shown that these effects occurred at doses well above 100 mg/kg/day.

Several epidemiologic studies describe non-cancer effects caused by exposure to drinking water contaminated with TCE and other solvents. A study of a community in Arizona exposed to elevated levels (up to 239 micrograms per liter,  $\mu\text{g/L}$ ) of TCE in drinking water showed an association between maternal exposure to TCE in water while pregnant and congenital heart defects in their newborns [Goldberg et al 1990]. A study of communities in northern New Jersey with drinking water containing TCE greater than 5 micrograms per liter ( $\mu\text{g/L}$ ) (and other solvents) reported an association between TCE level and oral cleft defects, central nervous system defects, and neural tube defects [Bove et al 1995]. A study of people in Woburn, Massachusetts exposed to up to 267  $\mu\text{g/L}$  TCE in drinking water suggested an association between maternal exposure and a combination of eye and ear anomalies and a combination of central nervous system, chromosomal, and oral cleft anomalies in newborns [Lagakos et al 1986]. However, other researchers have questioned the unusual groupings of these anomalies, and all the studies are limited by (1) the presence of other contaminants in the water which may have caused the observed health effects, (2) small sample sizes, and (3) poorly defined TCE exposure levels.

Animal studies have confirmed some of the suggested non-cancer effects from epidemiologic studies. Rat studies have identified heart defects in newborn rats whose mothers were exposed during fetal development to doses as low as 0.05 mg/kg/day [Johnson 2003].

Because of this particular study, FDOH calculated a dose for pregnant women drinking water at 150  $\mu\text{g/L}$ . The estimated dose (0.0018 mg/kg/d) is approximately 28 times below the pregnant rat study LOAEL of 0.05 mg/kg/d, where newborn rat pups first displayed cardiac malformations [Johnson 2003]. However, exposure to volatile organic chemicals (including TCE) while showering in contaminated water increases the total exposure amount, usually more than doubling the exposure dose from just ingestion [RA 1995, ATSDR 2005]. Drinking and showering in TCE-contaminated water at the maximum levels found at this site would bring the total TCE dose close to the rat study LOAEL (0.05 mg/kg/day) and may be a health concern for pregnant women.

Inhalation non-cancer risk - Inhaling (breathing) shower vapors with the highest TCE levels (0.27 ppm) is unlikely to result in non-cancer illnesses.

Using the highest TCE concentration found in any off-site well (150  $\mu\text{g/L}$ ), Florida DOH used Risk Assistant software to estimate an inhalation air TCE concentration of 0.27 ppm from showering and other indoor water use (Table 7). This estimated exposure level is 2.7 times above the TCE intermediate inhalation MRL (0.1 ppm) [ATSDR 1997b]. Intermediate inhalation is used because chronic inhalation data is unavailable. Because this value (0.27 ppm) is above the MRL (HQ = 2.7), Florida DOH evaluated this exposure in more detail.

This further evaluation includes comparing the individual inhaled air concentration against values established from human and animal research studies. The LOAEL is the lowest inhaled air concentration where adverse health effects were first noted.

The intermediate inhalation LOAEL for TCE is 50 ppm, where decreased wakefulness was noted in animal (rat) studies [ATSDR 1997b]. Again, this value sets a concentration where the first adverse health effects were noted. The estimated inhalation concentration of 0.27 ppm from showering with contaminated groundwater near the JJ Seifert site is approximately 185 times lower than the LOAEL. Therefore, inhalation of TCE vapors during showering is unlikely to result in non-cancer illness at this estimated exposure concentration.

Research based intermediate non-cancer health effects near the 0.27 ppm exposure concentration include: increased brain cell size (astroglial hypertrophy) at 60 ppm in gerbils and liver changes (increased enzyme activity and liver weight) at 75 ppm in mice [ATSDR 1997b]. Studies show that neurological effects occur in rats exposed for 6 weeks to TCE at 50 ppm and in gerbils exposed to 60 ppm for 3 months. Harmful effects observed were decreased wakefulness, decreased sleeping heart rate, and damage to brain cells [ATSDR 1997b]. The estimated bathroom air concentration of 0.27 is about 200 times below these levels. Harmful effects to people are not expected.

Cancer illness such as childhood leukemia has been observed after maternal exposure to TCE-contaminated drinking water during the prenatal period [EPA 2001, NJDHSS 2003]. Evidence from animal and epidemiological studies also suggest that exposure to TCE might be associated with congenital heart defects and poor intrauterine growth. Studies in rats and mice suggest that TCE may affect fertility, but the relevance to humans is not clear [NRC 2006]. Human epidemiological studies have been limited by difficulties in estimating exposure levels and by the presence of other solvents with similar toxic effects.

The National Toxicology Program (NTP) reviewed the carcinogenicity of TCE and concluded:

“(TCE) is reasonably anticipated to be a human carcinogen based on limited evidence of carcinogenicity from studies in human, sufficient evidence of carcinogenicity from studies in experimental animals, which indicate there is an increased incidence of malignant and/or a combination of malignant and benign tumors at multiple tissue sites in multiple species of experimental animals and information suggesting TCE acts through mechanisms that indicate it would likely cause cancer in humans” [NTP 2005].

In a 2001 draft assessment, EPA also reviewed the risk of cancer from exposure to TCE and concluded:

“Epidemiological studies, considered as a whole, have associated TCE exposures with excess risk of kidney cancer, liver cancer, lympho-hematopoietic cancer, cervical cancer, and prostate cancer. TCE has been extensively tested in animals, with mice developing liver tumors, lung tumors, and lymphomas, and rats developing kidney tumors and testicular tumors. The epidemiologic evidence is strongest at sites where the animals develop cancer, with site concordance for kidney cancer (in rats and humans), liver cancer (in mice and humans), and lympho-hematopoietic cancer (in mice and humans). TCE is also associated with cervical cancer and prostate cancer in humans, sites for which there are no corresponding animal models.” [EPA 2001]

In this 2001 draft risk assessment, EPA also established a range of slope factors to estimate the theoretical cancer risk from exposure to TCE. In 2006, the National Research Council (NRC) found that the evidence on carcinogenic risk and other health hazards from exposure to TCE has strengthened since 2001 [NRC 2006].

Ingestion cancer risk - Sun City residents who every day for 35 years drank contaminated groundwater with the highest measured TCE concentration in any off-site well (150 µg/L) are at a “very low” (1 in 100,000) increased risk of cancer including kidney, liver, leukemia, and lymphoma (Table 5) [ATSDR 2011]. This means that if 100,000 persons were to drink this TCE-contaminated drinking water for 35 years, the number of extra cases of cancer is between 0 and 1. This risk estimate is based on ATSDR’s 2011 interim guidance memorandum recommending California’s cancer slope factor (CSF = 0.0059 per mg/kg-day). Diabetes or chronic alcohol consumption may further increase the cancer risk [EPA 2001].

Inhalation cancer risk - People who inhaled showering vapors polluted with TCE at the highest past level found every day for 35 years (1975-2010) are at a “moderate” (2 in 1,000) theoretical increased cancer risk. This means that if 1,000 persons were to breathe in this TCE-contaminated showering water vapor for 35 years, the number of extra cases of cancer is between 0 and 2. This risk estimate is based on ATSDR’s 2011 interim guidance memorandum recommending California’s CSF (0.000002 per ug/m<sup>3</sup>) (Table 5) [ATSDR 2011].

This public health assessment uses the health-protective assumption that Sun City residents were exposed to the highest concentration of TCE found in any off-site private drinking water well (150 µg/L). The TCE concentrations that Sun City residents were actually exposed to likely varied over time and likely varied from well to well. The concentration of TCE that Sun City residents were actually exposed to may have been lower or higher than 150 µg/L. In addition, Sun City residents may have been exposed for less than 35 years because it is unknown when groundwater contamination began.

The following section considers the health risk from exposure to a mixture of chemicals. For mixtures, Florida DOH estimates the health risk separately for each route of exposure (drinking and breathing). Appendix D explains the health scientist’s approach to mixtures evaluation for both non-cancer and cancer health effects.

*Evaluating oral exposure to the mixture of chemicals in contaminated groundwater (non-cancer effects)*

As seen in Table 6, the HQ for three of the four chemicals (*cis*-1,2-DCE, PCE and TCE) have HQs exceeding 0.1. This means that the estimated doses are within 10 of the health guidelines or they exceed the health guideline (e.g., MRL or RfD). The HQ for 1,2-DCP is below 0.1. The general oral HI for this mixture of chemicals is 34. Therefore, a TTD refinement of the HI method is employed for specific endpoints. Table 11 gives the calculations for the hepatic endpoint (adverse liver effects). Table 12 gives the endpoint calculations for renal (adverse kidney) effects. Neurological effects were not selected as an endpoint because the ATSDR toxicological profiles and/or EPA IRIS information for *cis*-1,2-DCE, PCE and TCE list liver and kidney effects as specific endpoints [ATSDR 1997a, 1997b, EPA 2011]. However, more serious

effects (death in laboratory animals) occurred at 386 mg/kg/d (PCE, mice) and 500 mg/kg/d (TCE, rats) in chronic studies [ATSDR 1997a, 1997b].

TTD analysis is route and duration specific. The route is oral ingestion and the duration is chronic (> 1 yr). The  $HI_{\text{HEPATIC}}$  is equal to approximately 59. This means that the combined dose from the mixture of chemicals exceeds the guideline established for the liver by a factor of 59. Thus, harmful effects to the liver might be possible. The  $HI_{\text{RENAL}}$  is approximately 65. Thus, harmful effects to the kidney might be possible.

In order to understand interactive effects, a Binary Weight of Evidence (BINWOE) analysis is employed, when available from ATSDR. BINWOE analyses qualitatively measure interactive effects (additive, synergistic, or antagonistic) for each chemical in the mixture with every other chemical in the mixture. BINWOE analyses are available from ATSDR regarding interactions between PCE and TCE [ATSDR 2004b]. For the pairing of PCE with TCE, evidence suggests that PCE inhibits the metabolism of TCE in humans. It is plausible that the interaction may act less than additively for liver and kidney effects from TCE metabolites. No BINWOEs have been prepared for *cis*-1,2-DCE or 1,2-DCP and how they might interact with each other and/or PCE, and TCE. However, it has been determined that 1,2-DCP has an additive toxic effect when given orally with ethylene dichloride and PCE [ATSDR 1989]. The total oral dose is estimated (most conservatively, for a child) as 0.03 mg/kg/d (Table 10). This total oral dose is approximately 33 times less than the lowest LOAEL (1.0 mg/kg/d, TCE) of all the chemicals in the mixture [EPA 2001]. The total oral dose conservatively assumes that a Sun City resident would ingest (drink) the highest measured amount for each chemical in the mixture all at the same time. This may overestimate or underestimate the risk to residents as more or less of the chemicals may be present in the drinking water and may be consumed at any given time. Also, one or more chemicals may or may not be present in the mixture at any given time.

*Conclusions for the mixture of chemicals and drinking contaminated groundwater (non-cancer effects)*

Due to lack of complete interactive effects of all chemicals in the mixture and the fact that some components of the mixture have been shown to have additive effects, Florida DOH concludes that ingestion of a mixture of *cis*-1,2-DCE, 1,2-DCP, PCE, and TCE could harm people's health.

*Conclusions for the mixture of chemicals and drinking contaminated groundwater (carcinogenic effects)*

Because the sum of calculated ingestion cancer risks exceeds 0.0001 (PCE is 1 in 1,000 or 0.001) ingestion (drinking) of a mixture of these chemicals could harm people's health [ATSDR 2004a]. Although BINWOE analyses suggest a less than additive effect for the interaction of PCE on TCE, FDOH conservatively concludes this level of PCE may interact with other mixture components (*cis*-1,2-DCE and 1,2-DCP) resulting in a potential carcinogenic health hazard from oral ingestion of this mixture [ATSDR 2004a].

*Evaluating inhalation exposure to the mixture of chemicals in contaminated groundwater (non-cancer effects)*

As seen in Table 7, the HQs for 1,2-DCP, PCE, and TCE exceed unity (>1.0). Information regarding chronic inhalation for *cis*-1,2-DCE is unavailable in order to make an HQ calculation. The route of inhalation was not subjected to TTD analysis because most, but not all chemicals have the same critical effects (neurological). The general inhalation HI is equal to approximately 11. This requires further evaluation.

BINWOE analyses are available from ATSDR regarding interactions between PCE and TCE [ATSDR 2004b]. For the pairing of PCE with TCE, evidence suggests that PCE inhibits the metabolism of TCE in humans. It is plausible that the interaction may act less than additively for liver and kidney effects from TCE metabolites. No BINWOEs have been prepared for *cis*-1,2-DCE or 1,2-DCP and how they might interact with each other and/or PCE, and TCE. It has been determined that 1,2-DCP has an additive toxic effect when given by inhalation with ethylene dichloride and PCE [ATSDR 1989]. Therefore, there are potential interactive (additive) effects and this mixture of chemicals requires additional analysis. The total inhalation concentration is estimated as 0.775 ppm (Table 10). This total inhalation concentration is approximately 19 times less than the lowest LOAELs (15 ppm, 1,2-DCP and PCE) of all the chemicals in the mixture. The total inhalation concentration conservatively assumes that a Sun City resident would inhale (from showering) the highest measured concentration for each chemical in the mixture all at the same time. This may overestimate or underestimate the risk to residents as more or less of the chemicals may be present in the shower water at any given time. Also, one or more chemicals may or may not be present in the mixture at any given time.

*Conclusions for the mixture of chemicals and showering with contaminated groundwater (non-cancer effects)*

Due to lack of complete interactive effects of all chemicals in the mixture and the fact that some components of the mixture have been shown to have additive effects, Florida DOH concludes that inhalation (during showering and other household uses) of a mixture of *cis*-1,2-DCE, 1,2-DCP, PCE, and TCE could harm people's health.

*Conclusions for the mixture of chemicals and showering with contaminated groundwater (carcinogenic effects)*

Because the sum of calculated inhalation cancer risks exceeds 0.0001 (PCE is 5 in 1,000 and TCE is 2 in 1,000 for a total of 7 in 1,000 or 0.007) inhalation (during showering) of a mixture of these chemicals could harm people's health [ATSDR 2004a]. Although BINWOE analyses suggest a less than additive effect for the interaction of PCE on TCE, FDOH conservatively concludes this level of PCE and TCE may interact with other mixture components (*cis*-1,2-DCE and 1,2-DCP) resulting in a potential carcinogenic health hazard from inhalation (breathing in showering vapors) of this mixture [ATSDR 2004a].

### **3.3.1.2 Off-site soil**

One soil boring was collected at a residence north of the JJ Seifert site. This soil boring served as a background sample to compare with on-site soil borings. No exceedances above DEP Soil Cleanup Target Levels (SCTLs) were found when testing for VOCs and metals [FDEP 1999].

No soil contamination has been detected or is expected in the Sun City community related to the JJ Seifert site. The JJ Seifert property is cordoned by a 6-8 foot perimeter fence that discourages access and natural foot pathways through the site. The site soil sources of contamination are inaccessible to the surrounding community and general public.

Solvents like PCE, TCE, and *cis*-1,2-DCE do not typically adsorb (stick) to soil particles. Rather, they either evaporate into the air or move down through the soil and dissolve upon reaching the groundwater.

### **3.4 Risk of Illness, Dose Response/Threshold and Uncertainty**

Appendix A discusses limitations on estimating the risk of illness, the theory of dose response and the concept of thresholds. It also discusses the sources of uncertainty inherent in public health assessments.

### **3.5 Health Outcome Data**

Because the theoretical increased risk of cancer from exposure to solvents from the JJ Seifert site is moderate and the probability of demonstrating an increased incidence of solvent associated cancer in a population of less than 1,000 people is even lower, Florida DOH did not evaluate health outcome data in the Florida Cancer Data System. The exposed Sun City population, estimated to be 163 people, is very small. It is unlikely any statistically significant increases would be found due to the small population size.

## **4.0 Child Health Considerations**

ATSDR and the Florida DOH recognize the unique vulnerabilities of infants and children demand special attention. Children are at a greater risk than adults if exposed to certain kinds of exposure to hazardous substances. Because they play outdoors and because they often carry food into contaminated areas, children are more likely to be exposed to contaminants in the environment. Children are also shorter than adults, which means they breathe dust, soil, and heavy vapors closer to the ground. They are also smaller, resulting in higher doses of chemical exposure per body weight. If toxic exposures occur during critical growth stages, the developing body systems of children can experience permanent damage. However, most important is that children depend on adults for risk identification and risk management, housing, and access to medical care. Thus, adults should be aware of public health risks in their community, so they can guide their children accordingly.

Other susceptible populations may have different or enhanced susceptibilities to chemicals than will most persons exposed to the same levels of that chemical in the environment. Reasons may include genetic makeup, age, health, nutritional status, and exposure to other toxic substances

(like cigarette smoke and alcohol). These factors may limit that person's ability to detoxify or excrete harmful chemicals or may increase the effects of damage to their organs or systems.

The developing fetus, children, and especially the developing nervous system may be particularly susceptible to the toxic effects of PCE. Studies in mice suggest that PCE can cross the placenta and that its breakdown metabolite trichloroacetic acid (TCA) concentrates in the fetus. Unmetabolized PCE has been excreted in breast milk and was detected in an exposed infant with liver damage. In addition, possible chemical effects were detected in children in Woburn, Massachusetts. Children in that community may have been exposed to solvent-contaminated drinking water as infants or in the womb, possibly contributing to elevated incidences of acute lymphocytic leukemia or impaired immunity [ATSDR 1997a].

The youngest of the population with immature and developing organs (i.e., premature and newborn infants) will be more vulnerable to toxic substances in general than healthy adults. If the metabolic products are more toxic than the parent compound, an individual with higher metabolic rates (such as children and adolescents) would be expected to have greater toxicity [ATSDR 1997b].

## **5.0 Community Health Concerns**

Based on two comments received following the May 2010 open house there are community health concerns of severe illnesses, though unspecified. Florida DOH will release this PHA for public comment and then solicit additional health concerns from the community.

## **6.0 Conclusions**

### Groundwater

The DOH and ATSDR find that use of contaminated groundwater under the JJ Seifert site and nearby area could increase people's non-cancer illness and cancer risk. This poses a public health hazard.

Because wells tested and found to be contaminated are now using filters, the current public health risk is reduced. Also, other wells are checked regularly. If filters are not maintained or other wells are not tested routinely in the future, that could pose a health threat to those exposed.

People who drank well water polluted with PCE at the highest past level found every day for 35 years (1975-2010) are at a "moderate" (1 in 1,000) theoretical increased cancer risk. This means that if 1,000 persons drank this PCE-contaminated water for 35 years, the number of extra cases of cancer is estimated to be 0 to 1. The number of extra cases means that it is estimated 1 person in 1,000 people may contract cancer if exposed to this contamination for this length of time (35 years). People who inhaled showering vapors polluted with PCE at the highest past level found every day for 35 years (1975-2010) are at a "moderate" (5 in 1,000) theoretical increased cancer risk. This means that if 1,000 persons inhaled this PCE-contaminated water vapor for 35 years, the number of extra cases of cancer is predicted to be 0 to 5.

People who drank well water polluted with TCE at the highest past level found every day for 35 years (1975-2010) are at a “very low” (1 in 100,000) increased theoretical risk of cancer. This means that if 100,000 persons drank this TCE-contaminated water for 35 years, the number of extra cancer cases is estimated to be 0 to 1. The number of extra cases means that it is estimated 1 person in 100,000 people may contract cancer if exposed to this contamination for this length of time (35 years). People who inhaled showering vapors polluted with TCE at the highest past level found every day for 35 years (1975-2010) are at a “moderate” (2 in 1,000) theoretical increased cancer risk. This means that if 1,000 persons inhaled this TCE-contaminated water vapor for 35 years, the number of extra cases of cancer is predicted to be 0 to 2.

Again, the highest measured levels of contamination are used for assessment because these levels are the most conservative and protective in estimating risks to human health. Florida DOH concludes that ingestion and/or inhalation of a mixture of *cis*-1,2-DCE, 1,2-DCP, PCE, and TCE could harm people’s health.

### Soil

Florida DOH has not found any sampling data that demonstrates soil pollution from the site in the Sun City community, nor does it expect to find any. Because solvents used at the site tend to either evaporate into the air or sink down to the groundwater, it is unlikely that nearby surface soil is polluted.

### Groundwater to Indoor Air Vapor Intrusion (also called Soil Vapor Intrusion)

Polluted groundwater vapors could move beneath Sun City homes near the site and up into the indoor air.

This report does not assess the health risk if homes are later built on the site.

This report does not assess the health risk to on-site workers. The US Occupational and Health Administration (OSHA) is responsible for worker health and safety. Because workers are not drinking on-site well water we don’t expect exposures to the water would cause harm.

## **7.0 Recommendations**

- Residents should not use unfiltered polluted Sun City groundwater for drinking, showering, or other household purposes.
- Residents should not install drinking water wells into the surficial aquifer.
- Residents should properly maintain any water filter systems used on polluted private drinking water wells.
- US EPA and/or Hillsborough County Health Department, should continue to test private drinking water wells for VOCs until pollution is remediated.
- US EPA should install a GAC water filter system (with help from the Florida DEP) on any well that has levels of VOCs above drinking water standards, including any wells installed in the future that are found to be contaminated.

- US EPA should assess if there is any risk of vapors entering homes located above the polluted groundwater.
- If future land use at the site changes from business use to where people live, the responsible party should assess the health risk.
- If you are concerned about your health related to this contamination, contact your local health professional.

## **8.0 Public Health Action Plan**

- Florida DOH will inform the Sun City community of the findings of this public health assessment report and post this report on-line ([www.myfloridaeh.com/medicine/SUPERFUND/pha.htm](http://www.myfloridaeh.com/medicine/SUPERFUND/pha.htm)).
- Florida DOH will release this PHA for public comment and then solicit additional health concerns from the community. A final PHA will be released that addresses any public comments and community health concerns.
- Florida DOH will consider assessing additional environmental data, such as soil vapor intrusion data, as they become available.

## **REPORT PREPARATION**

This Public Health Assessment for the JJ Seifert Site was prepared by the Florida Department of Health under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with the approved agency methods, policies, procedures existing at the date of publication. Editorial review was completed by the cooperative agreement partner. ATSDR has reviewed this document and concurs with its findings based on the information presented. ATSDR's approval of this document has been captured in an electronic database, and the approving agency reviewers are listed below.

### **Author**

Joseph Mark Higginbotham  
Bureau of Environmental Public Health Medicine  
Division of Environmental Health  
Florida Department of Health  
(850) 245-4299

### **State Reviewer**

Randy Merchant  
Bureau of Environmental Public Health Medicine  
Division of Environmental Health  
Florida Department of Health  
(850) 245-4299

### **ATSDR Reviewers**

Jennifer Freed  
Technical Project Officer  
ATSDR/DHAC/CAPEB

Alan Yarbrough  
Cooperative Agreement Team Lead  
ATSDR/DHAC/CAPEB

Rick Gillig  
Cooperative Agreement and Program Evaluation Branch Chief  
ATSDR/DHAC/CAPEB

Lynn Wilder, ATSDR/DHAC  
Assistant Director for Science

William Cibulas, ATSDR/DHAC  
Division Director, DHAC

Yulia Iossifova, ATSDR/NCEH  
Office of Science

## References

- [ATSDR 2011] Agency for Toxic Substances and Disease Registry. 2011. Memorandum: Guidance on the Interim Use of California EPA's (Cal EPA) Cancer Potency Information for PCE and TCE Assessment. U.S. Department of Health and Human Services. April 26, 2011.
- [ATSDR 2009] Agency for Toxic Substances and Disease Registry. 2009. Drinking Water Comparison Values. Atlanta: U.S. Department of Health and Human Services.
- [ATSDR 2005] Agency for Toxic Substances and Disease Registry. Public Health Assessment Guidance Manual (Update). U.S. Department of Health and Human Services, Atlanta, GA. January 2005.
- [ATSDR 2004a] Agency for Toxic Substances and Disease Registry. 2004. Guidance Manual for the Assessment of Joint Toxic Action of Chemical Mixtures. Atlanta: U.S. Department of Health and Human Services.
- [ATSDR 2004b] Agency for Toxic Substances and Disease Registry. 2004. Interaction Profile for: 1,1,1-Trichloroethane, 1,1-Dichloroethane, Trichloroethylene, and Tetrachloroethylene. Atlanta: U.S. Department of Health and Human Services.
- [ATSDR 1997a] Agency for Toxic Substances and Disease Registry. 1997. Toxicological profile for tetrachloroethylene. Atlanta: U.S. Department of Health and Human Services.
- [ATSDR 1997b] Agency for Toxic Substances and Disease Registry. 1997. Toxicological profile for trichloroethylene. Atlanta: U.S. Department of Health and Human Services.
- [ATSDR 1996] Agency for Toxic Substances and Disease Registry. 1996. Toxicological profile for cis-1,2-dichloroethene. Atlanta: U.S. Department of Health and Human Services.
- [ATSDR 1989] Agency for Toxic Substances and Disease Registry. 1989. Toxicological profile for 1,2-dichloropropane. Atlanta: U.S. Department of Health and Human Services.
- [Bove et al 1995] Bove FJ, Fulcomer MC, Klotz JB, Esmart J, Dufficy EM, Savrin JE. 1995. Public drinking water contamination and birth outcomes. *Am J of Epi* 141:850-862.
- [EPA 2011] US Environmental Protection Agency, Integrated Risk Information System; Available from: <http://www.epa.gov/iris/index.html>
- [EPA 2009a] HRS Documentation Record, JJ Seifert Machine, EPA ID Number: FLN000410232. September 2009. Also in US EPA electronic CD: HRS Documentation Record – JJ Seifert Machine, FL, pdf file 10539322. JJ Seifert was included in the Code of Federal Regulations (CFR) 40 CFR Part 300, Vol 74, No. 183, p. 48504 in the Proposed Rules on Wednesday, September 23, 2009, Docket ID No. EPA-HQ-SFUND-2009-0581. (<http://www.epa.gov/superfund/sites/npl/newprop.htm>)

[EPA 2009b] US Environmental Protection Agency, Final Report for JJ Seifert Machine Shop Site Groundwater Study, Sun City – Ruskin, Hillsborough County, Florida, SESD Project # 09-0471, July 21, 2009. Study date June 16-18, 2009. Also in US EPA electronic CD: HRS Documentation Record – JJ Seifert Machine, FL, reference number 84 (pdf file 10676192).

[EPA 2008a] US Environmental Protection Agency, Letter to Shanna Davis from Suzanne K. Armor concerning transmittal of JJ Seifert Machine Co., Inc., JJ Seifert Land Co., and Ms. Pamela Ahlen. May 27, 2008. Also in US EPA electronic CD: HRS Documentation Record – JJ Seifert Machine, FL, reference number 78 (pdf file 10676186).

[EPA 2008b] Toxicological review of tetrachloroethylene, external review draft EPA/635/R-08/011A.

[EPA 2001] US Environmental Protection Agency, Office of Research and Development. Trichloroethylene Health Risk Assessment: Synthesis and Characterization. External Review Draft. EPA/600/P-01/002A. August 2001.

[EPA 1997] US Environmental Protection Agency, Office of Research and Development. Exposure Factors Handbook. Volumes I, II, and III. EPA/600/P-95/002F(a, b, and c).

[FDEP 2008] Pre-CERCLIS Screening Assessment Checklist/Decision Form for J.J. Seifert Machine Shop, Sun City, Hillsborough County, Florida. J. Koch of FDEP. May 13, 2008.

[FDEP 2007] FDEP interoffice e-mail Re: Southwest District Potential Sites for CERCLA PA/SI Screening. Tyner, N. to J. McCarthy. October 4, 2007.

[ATSDR 2005] Agency for Toxic Substance and Disease Registry. Public Health Assessment Guidance Manual (Update). U.S. Department of Health and Human Services, Atlanta, GA. January 2005.

[FDEP 2004a] Florida Department of Environmental Protection, Environmental Protection Well Survey, JJ Seifert Machine Shop, with Environmental Health Services. Environmental Chemistry Analysis Report for Job ID: DEP Water-041014-08, Project ID: TOX-REQ. October 27, 2004. Also in US EPA electronic CD: HRS Documentation Record – JJ Seifert Machine, FL, reference number 11 (pdf file 10676119).

[FDEP 2004b] Florida Department of Environmental Protection. 2004. Development of Primary Drinking Water Standards, for Chapter 62-550.310, F.A.C.

[FDEP 1999] Florida Department of Environmental Protection. 1999. Development of Soil Target Cleanup Levels, Table 4 in Chapter 62-777, F.A.C. Prepared for the Division of Waste Management, Florida DEP.

[Goldberg et al 1990] Goldberg SJ, Lebowitz, MD, Graver EJ, Hicks S. 1990. An association of human congenital cardiac malformations and drinking water contaminants. J Am Coll Card 16:155-164.

[Hayes 1986] Hayes JR, Condie Jr. LW, Borzelleca JF. 1986. The subchronic toxicity of tetrachloroethylene (perchloroethylene) administered in the drinking water of rats. *Tox Sci* 7: 119-125.

[HCHD 2002] Hillsborough County Health Department, Environmental Health Services. Environmental Chemistry Analysis Report for Job ID: DEP Water-020412-19, Project ID: Request-01. April 30, 2002. Also in US EPA electronic CD: HRS Documentation Record – JJ Seifert Machine, FL, reference number 37 (pdf file 10676145).

[HCHD 2001a] Hillsborough County Health Department, Environmental Health Services. Environmental Chemistry Analysis Report for Job ID: Hillsborou-001220-10, Project ID: Request-00. January 19, 2001. Also in US EPA electronic CD: HRS Documentation Record – JJ Seifert Machine, FL, reference number 10 (pdf file 10676118).

[HCHD 2001b] Hillsborough County Health Department, Environmental Health Services. Environmental Chemistry Analysis Report for Job ID: Hillsborou-010105-09, Project ID: Hill-00. January 11, 2001. Also in US EPA electronic CD: HRS Documentation Record – JJ Seifert Machine, FL, reference number 35 (pdf file 10676143).

[IRIS 2010] US Environmental Protection Agency. Intergraded Risk Information System. 2010.

[Johnson et al 2003] Johnson PD, Goldberg SJ, Mays MZ, Dawson BV. 2003. Threshold of trichloroethylene contamination in maternal drinking waters affecting fetal heart development in the rat. *Env Health Persp* 111: 289-292.

[Kamrin 1988] Toxicology – A Primer on Toxicology Principles and Applications. Lewis Publishers. Chelsea MI.

[Lagakos et al 1986] Lagakos SW, Wessen BJ, Zelen M. 1986. An analysis of contaminated well water and health effects in Woburn, Massachusetts. *J Am Stat Assoc* 81:583-596.

[MACTEC 2008] Private well previous sampling results January 2001- May 2008. Appendix C: HCPHD Potable well sample analytical results. Site Inspection Report, JJ Seifert Machine Shop, November 2008. Also in US EPA electronic CD: HRS Documentation Record – JJ Seifert Machine, FL, reference number 9 (pdf file 10676117).

[NJDHSS 2003] New Jersey Department of Health and Senior Services. 2003. Case-control study of childhood cancers in Dover Township (Ocean Country), New Jersey. Trenton, New Jersey: New Jersey Department of Health and Senior Services.

[NRC 2006] National Research Council, National Academy of Sciences. Assessing the Human Health Risk of Trichloroethylene: Key Scientific Issues. National Academies Press. July 2006.

[NTP 2005] National Toxicology Program, US Department of Health and Human Services. Report on Carcinogens, 11<sup>th</sup> Edition. January 2005.

[QORE 2000a] Phase I Environmental Assessment, Machine Shop Property. QORE, Inc., Property Sciences, January 20, 2000. Also in US EPA electronic CD: HRS Documentation Record – JJ Seifert Machine, FL, reference number 78 (pdf file 10676186).

[QORE 2000b] Phase II Environmental Assessment, JJ Seifert Machine Co. QORE, Inc., Property Sciences, February 24, 2000. Also in US EPA electronic CD: HRS Documentation Record – JJ Seifert Machine, FL, reference number 78 (pdf file 10676186).

[RA 1995] Risk Assistant for Windows 1.1, Hampshire Research Institute, Washington DC, Thistle Publishing Group.

[USGS 1985] Hydrology of the Floridan aquifer system in west-central Florida. Paul D. Ryder, Geological Survey Professional Paper 1403-F, US Geological Survey. 1985. Also in US EPA electronic CD: HRS Documentation Record – JJ Seifert Machine, FL, reference number 40 (pdf file 10676148).

[WSWA 2004a] Water Supply Well Analysis.pdf, SUPER Act Survey Form, Investigator Jim Phillips, request RE21332.

[WSWA 2004b] Water Supply Well Analysis 01.pdf, Environmental Chemistry Analysis Report, Job ID: DEP\_Water-041014-08, Project ID: TOX-REQ. October 27, 2004.

**Table 1. Exposure Pathways**

<b>Pathway Name</b>	<b>Exposure Pathway Elements</b>						<b>Time Frame</b>
	<b>Pathway Status</b>	<b>Source</b>	<b>Environmental Medium</b>	<b>Point of Exposure</b>	<b>Potentially Exposed Population</b>	<b>Route of Exposure</b>	
Soil Vapor Intrusion	Potential	Contaminated Groundwater	Air	Indoor Air	Local Residents	Inhalation	Past Present Future
Off-site Groundwater (Private Wells)	Complete	Contaminated Groundwater	Groundwater (Private Wells)	Residences, Tap, Shower	Local Residents	Ingestion and Inhalation	Past Present Future
On-site Groundwater	Eliminated			No Public Exposure			
On-site Soil	Eliminated			No Public Exposure			

**Table 2. Maximum concentrations in drinking water wells**

contaminant of concern	maximum concentration (µg/L)	# samples greater than comparison value / total # samples	Comparison Value*	
			(µg/L)	source
1,2-Dichloropropane (1,2-DCP)	7	1/148	5	EPA MCL 2011**
<i>cis</i> -1,2-Dichloroethylene ( <i>cis</i> -1,2-DCE)	100	3/148	70	EPA MCL 2011
Tetrachloroethylene (PCE)	160	25/148	0.06	ATSDR 2011***
Trichloroethylene (TCE)	150	8/148	5	EPA MCL 2011

µg/L = micrograms per liter

\* Comparison values used to select chemicals for further scrutiny, not for determining the possibility of illness

\*\* EPA Maximum Contaminant Level 2011

\*\*\*ATSDR 2011 Interim Guidance Memorandum

**Table 3. Well ID and sampling dates for maximum CV exceedances in drinking water wells**

	Well ID and sampling date	
	AAE9656	AAE9667
Contaminant of concern	11-Apr-02	11-Aug-08
1,2-Dichloropropane (1,2-DCP)		7 <sup>ε</sup>
cis-1,2-Dichloroethylene (cis-1,2-DCE)	100	
Tetrachloroethylene (PCE)	160	
Trichloroethylene (TCE)	150	

CV = comparison value

<sup>ε</sup> All concentrations given in micrograms per liter (µg/L)

**Table 4. History of CV exceedances in off-site drinking water wells**

Well ID	Date	Contaminant of concern			
		1,2-Dichloropropane (1,2-DCP)	<i>cis</i> -1,2-Dichloroethylene ( <i>cis</i> -1,2-DCE)	Tetrachloroethylene (PCE)	Trichloroethylene (TCE)
AAE9656	12/18/00		73 <sup>±</sup>	100	100
AAE9656	04/11/02		100	160	150
AAE9656	09/01/07			50	28
AAE9656	08/11/08			130	100
AAE9656	09/29/09		74	130	89
AAE9663	12/18/00			5.2	10
AAE9663	09/01/07			14	25
AAE9667	08/11/08	7			
AAE9673	01/03/01			7.2	
AAE9673	08/11/08			1	
AAM8763	09/29/09				5.2
AAJ0202	10/12/04			2	
AAJ0202	08/11/08			3.3	
AAJ0202	09/29/09			3.2	
AAG0779	10/12/04			2.2	
AAG0779	08/11/08			0.6	
AAG0779	04/11/02			1.4	
AAE9664	08/11/08			0.6	
AAE9671	04/03/03			0.9	
AAE9671	01/03/01			0.9	
AAE9671	04/11/02			1.1	
AAE9671	08/14/02			1.1	
AAM0160	08/11/08			0.4	
AAE9669	04/11/02			0.4	
AAE9665	08/14/02			0.3	
AAM8763	09/29/09			3.1	
AAM8764	09/29/09			1.6	

CV = comparison value

<sup>±</sup> All concentrations given in micrograms per liter (µg/L)

**Table 5. Calculations table**

contaminant of concern	maximum groundwater concentration (µg/L)	Adult drinking water (ingestion) dose (mg/kg/d)	Child drinking water (ingestion) dose (mg/kg/d)	Showering inhalation concentration (ug/m <sup>3</sup> )	Showering inhalation concentration (ppm)	EPA ingestion cancer slope factor [CSF] (mg/kg/d) <sup>-1</sup>	Estimated drinking water (ingestion) cancer risk (unitless)	EPA inhalation cancer slope factor [CSF] (ug/m <sup>3</sup> ) <sup>-1</sup>	Estimated showering inhalation cancer risk (unitless)
1,2-Dichloropropane (1,2-DCP)	7	0.0002	0.0004	70	0.015	N/A	---	N/A	---
<i>cis</i> -1,2-Dichloroethylene ( <i>cis</i> -1,2-DCE)	100	0.003	0.006	1000	0.25	N/A	---	N/A	---
Tetrachloroethylene (PCE)	160	0.005	0.01	1600	0.24	0.54*	0.001	0.0000059	0.005
Trichloroethylene (TCE)	150	0.004	0.009	1500	0.27	0.0059**	0.00001	0.000002	0.002

µg/L = micrograms per liter

mg/kg/d = milligrams per kilograms per day

ug/m<sup>3</sup> = micrograms per meters cubed

ppm = parts per million

N/A = cancer slope factor not available

\* PCE CSF source [ATSDR 2011]

\*\*TCE CSF source [ATSDR 2011]

**Table 6. Oral Hazard Quotient and Hazard Index Values\***

General Oral HI									
Chemical	Conc (µg/L)	Adult Dose (mg/kg/d)	Child Dose <sup>‡</sup> (mg/kg/d)	MRL/RfD (mg/kg/d)	MRL/RfD source and info	NOAEL/LOAEL/BMDL <sub>10</sub> (mg/kg/d)	NOAEL/LOAEL/BMDL <sub>10</sub> /Exposure/source	Uncertainty Factor	HQ
cis-1,2-DCE	100	0.003	0.006	0.002	EPA IRIS Chronic RfD-increased relative kidney weight in rats	5.1	BMDL <sub>10</sub> /Chronic /EPA IRIS	3000	3.000
1,2-DCP	7	0.0002	0.0004	0.09	ATSDR Chronic MRL-Hepatic	62	NOAEL /Chronic /ATSDR Tox Profile	1000	0.004
PCE	160	0.005	0.01	0.01	EPA IRIS Chronic RfD-Hepatic in mice, weight gain in rats	14	NOAEL /Chronic /EPA IRIS	1000	1.000
TCE	150	0.004	0.009	0.0003	EPA 2001 TCE RA draft Chronic RfD-liver (hepatic), kidney, developing fetus	1	LOAEL /Sub-chronic** / EPA 2001 TCE RA draft	3000	30.000
<b>General Oral HI =</b>									<b>34.004</b>

\*Per ATSDR 2004 Guidance Manual for the Assessment of Joint Toxic Action of Chemical Mixtures, the hazard index method is chosen on the grounds of practicality because most, but not all, of the mixture's components have the same oral critical effect (hepatic)

<sup>‡</sup> Child dose used for HQ calculation as most conservative and protective of human health

BMDL<sub>10</sub> is the 95% lower confidence limit on the benchmark dose (BMD<sub>10</sub>) corresponding to a 10% increase in relative kidney weight compared with controls.

\*\*sub-chronic exposure duration in mice was 6 weeks

**Table 7. Inhalation Hazard Quotient and Hazard Index Values\***

General Inhalation HI								
Chemical	Conc (µg/L)	Estimated Conc (ppm)	MRL (ppm)	MRL source and info	LOAEL (ppm)	LOAEL/Exposure/source	UF	HQ
cis-1,2-DCE	100	0.25	na			no data		0.000
1,2-DCP	7	0.015	0.007	ATSDR Intermediate MRL - from intermediate LOAEL -upper respiratory lesions-respiratory	15	LOAEL/ Intermediate/ ATSDR Tox Profile	1000	2.143
PCE	160	0.24	0.04	ATSDR Chronic MRL-from the chronic LOAEL-increased reaction times-neurological	15	LOAEL/ Chronic/ ATSDR Tox Profile	100	6.000
TCE	150	0.27	0.1	ATSDR Intermediate MRL-from the intermediate LOAEL-decreased wakefulness-neurological	50	LOAEL/ Intermediate/ ATSDR Tox Profile	300	2.700
<b>General Inhalation HI =</b>								<b>10.843</b>

\*Per ATSDR 2004 Guidance Manual for the Assessment of Joint Toxic Action of Chemical Mixtures, the hazard index method is chosen on the grounds of practicality because most, but not all, of the mixture's components have the same inhalation critical effect (neurological)

**Table 8. Margin of Safety, ingestion**

<b>Chemical</b>	<b>Conc (µg/L)</b>	<b>Adult Dose (mg/kg/d)</b>	<b>Child Dose (mg/kg/d)</b>	<b>NOAEL/ LOAEL /BMDL<sub>10</sub> (mg/kg/d)</b>	<b>NOAEL/ LOAEL/ BMDL<sub>10</sub> Info</b>	<b>Margin of Safety (MOS) Adult</b>	<b>Margin of Safety (MOS) Child</b>
cis-1,2- DCE	100	0.003	0.006	5.1	BMDL <sub>10</sub>	1700	850
1,2-DCP	7	0.0002	0.0004	62	NOAEL	310000	155000
PCE	160	0.005	0.01	14	NOAEL	2800	1400
TCE	150	0.004	0.009	1	LOAEL	250	111

BMDL<sub>10</sub> is the 95% lower confidence limit on the benchmark dose (BMD<sub>10</sub>) corresponding to a 10% increase in relative kidney weight compared with controls.

**Table 9. Margin of Safety, inhalation**

<b>Chemical</b>	<b>Conc (µg/L)</b>	<b>Estimated Conc (ppm)</b>	<b>LOAEL /NOAEL (ppm)</b>	<b>LOAEL /NOAEL Info</b>	<b>Margin of Safety (MOS)</b>
cis-1,2- DCE	100	0.25		no chronic data	
1,2-DCP	7	0.015	15	LOAEL	1000
PCE	160	0.24	15	LOAEL	63
TCE	150	0.27	50	LOAEL	185

**Table 10. Total oral dose and inhalation concentration calculations**

<b>Chemical</b>	<b>Conc (µg/L)</b>	<b>Adult Oral Dose (mg/kg/d)</b>	<b>Child Oral Dose (mg/kg/d)</b>	<b>Estimated Inhalation Conc (ppm)</b>
cis-1,2-DCE	100	0.003	0.006	0.25
1,2-DCP	7	0.0002	0.0004	0.015
PCE	160	0.005	0.01	0.24
TCE	150	0.004	0.009	0.27
<b>Totals =</b>		<b>0.0122</b>	<b>0.0254</b>	<b>0.775</b>

**Table 11. Hepatic Target Toxicity Dose Calculations for Endpoint Specific Mixtures Evaluation**

<b>Hepatic Oral HI</b>									
<b>Chemical</b>	<b>Conc (µg/L)</b>	<b>Dose (mg/kg/d)</b>	<b>MRL/RfD (mg/kg/d)</b>	<b>MRL/RfD source and info</b>	<b>LOAEL /NOAEL (mg/kg/d)</b>	<b>LOAEL /NOAEL Info</b>	<b>Uncertainty Factor</b>	<b>TTD*</b>	<b>Hepatic specific values**</b>
PCE	160	0.01	0.01	EPA IRIS Chronic RfD-Hepatic in mice	14	EPA NOAEL <sup>H</sup> - hepatic	1000	0.014	0.714
TCE	150	0.009	0.0003	EPA 2001 TCE RA draft Chronic RfD-liver (hepatic)	1	EPA LOAEL <sup>¥</sup> - hepatic	3000	0.0003	27.000
								Dose/RfD PCE =	1.0000
								Dose/RfD TCE =	30.0000
								<b>HI hepatic***=</b>	58.714

\* Target Toxicity Dose = (NOAEL or LOAEL or BDML<sub>10</sub> / Uncertainty Factor)

\*\*Endpoint specific values = Dose / TTD and Dose / RfD

H 2011 EPA IRIS states NOAEL study [Hayes 1986] includes hepatic and renal effects

¥ EPA 2001 TCE RA draft states NOAEL and LOAEL for both hepatic and renal effects

\*\*\*Endpoint specific Hazard Index is the sum of endpoint specific values

**Table 12. Renal Target Toxicity Dose Calculations for Endpoint Specific Mixtures Evaluation**

<b>Renal Oral HI</b>									
<b>Chemical</b>	<b>Conc (µg/L)</b>	<b>Dose (mg/kg/d)</b>	<b>MRL/RfD (mg/kg/d)</b>	<b>MRL/RfD source and info</b>	<b>LOAEL /NOAEL (mg/kg/d)</b>	<b>LOAEL /NOAEL Info</b>	<b>Uncertainty Factor</b>	<b>TTD*</b>	<b>Renal specific values**</b>
cis-1,2-DCE	100	0.006	0.002	EPA IRIS Chronic RfD-kidney weight gain in rats	5.1	BMDL <sub>10</sub>	3000	0.0017	3.529
PCE	160	0.01	0.01	EPA IRIS Chronic RfD-kidney weight gain in rats	14	EPA NOAEL - kidney <sup>H</sup>	1000	0.014	0.714
TCE	150	0.009	0.0003	EPA 2001 TCE RA draft Chronic RfD-kidney (renal)	1	EPA LOAEL <sup>Y</sup> - kidney	3000	0.0003	27.000
								Dose/RfD <sub>DCE</sub> =	3.0000
								Dose/RfD <sub>PCE</sub> =	1.0000
								Dose/RfD <sub>TCE</sub> =	30.0000
								<b>HI renal***=</b>	<b>65.244</b>

\* Target Toxicity Dose = (NOAEL or LOAEL or BDML<sub>10</sub> / Uncertainty Factor)

\*\*Endpoint specific values = Dose / TTD and Dose / RfD

<sup>H</sup> 2011 EPA IRIS states NOAEL study [Hayes 1986] includes hepatic and renal effects

<sup>Y</sup> EPA 2001 TCE RA draft states NOAEL and LOAEL for both hepatic and renal effects

\*\*\*Endpoint specific Hazard Index is the sum of endpoint specific values

## **Appendix A - Risk of Illness, Dose Response/Threshold and Uncertainty**

### **RISK OF ILLNESS, DOSE RESPONSE/THRESHOLD, AND UNCERTAINTY IN PUBLIC HEALTH ASSESSMENTS**

#### **Risk of Illness**

In this public health assessment, the risk of illness is the chance that exposure to a hazardous contaminant is associated with a harmful health effect or illness. The risk of illness is not a measure of cause and effect. Only an in-depth health study can identify a cause and effect relationship. Instead, Florida DOH uses the risk of illness to decide if the site needs a follow-up health study and to identify possible associations. The greater the exposure to a hazardous contaminant (dose), the greater the risk of illness. The amount of a substance required to harm a person's health (toxicity) also determines the risk of illness. Exposure to a hazardous contaminant above a minimum level increases everyone's risk of illness. Only in unusual circumstances, however, do many persons become ill. Information from human studies provides the strongest evidence that exposure to a hazardous contaminant is related to a particular illness. Some of this evidence comes from doctors reporting an unusual incidence of a specific illness in exposed individuals. More formal studies compare illnesses in people with different levels of exposure. Nevertheless, human information is very limited for most hazardous contaminants, and scientists must frequently depend upon data from animal studies. Hazardous contaminants associated with harmful health effects in humans are often associated with harmful health effects in other animal species. There are limits, however, to relying only on animal studies. For example, scientists have found some hazardous contaminants are associated with cancer in animals, but lack evidence of a similar association in humans. In addition, humans and animals have differing abilities to protect themselves against low levels of contaminants, and most animal studies test only the possible health effects of high exposure levels. Consequently, the possible effects on humans of low-level exposure to hazardous contaminants are uncertain when information comes solely from animal experiments.

#### **Dose Response/Thresholds**

The focus of toxicological studies in humans or animals is identification of the relationship between exposure to different doses of a specific contaminant and the chance of having a health effect from each exposure level. This dose-response relationship provides a mathematical formula or graph used to estimate a person's risk of illness. The actual shape of the dose-response curve requires scientific knowledge of how a hazardous substance affects different cells in the human body. There is one important difference between the dose-response curves used to estimate the risk of non-cancer illnesses and those used to estimate the risk of cancer: the existence of a threshold dose. A threshold dose is the highest exposure dose at which there is no risk of illness. The dose-response curves for non-cancer illnesses include a threshold dose that is greater than zero. Scientists include a threshold dose in these models because the human body can adjust to varying amounts of

cell damage without illness. The threshold dose differs for different contaminants and different exposure routes. It is estimated from information gathered in human and animal studies. By contrast, the dose-response curves used to estimate the risk of cancer assume no threshold dose (or, in other words, the cancer threshold dose is zero). This assumes a single contaminant molecule could be sufficient to cause a clinical case of cancer. Such an assumption is very conservative; indeed, many scientists also believe a threshold dose greater than zero exists for the development of cancer.

## **Uncertainty**

All risk assessments, to varying degrees, require the use of assumptions, judgments, and incomplete data. These contribute to the uncertainty of the final risk estimates. Some more important sources of uncertainty in this public health assessment include environmental sampling and analysis, exposure parameter estimates, use of modeled data, and present toxicological knowledge. These uncertainties can cause risk to be overestimated or underestimated. Because of the uncertainties described below, this public health assessment does not represent an absolute estimate of risk to persons exposed to chemicals at or near the JJ Seifert site. Environmental chemistry analysis errors can arise from random errors in the sampling and analytical processes, resulting in either an over- or underestimation of risk. Increasing the number of samples collected/analyzed and sampling the same locations over several different periods can control these errors to some extent. These actions tend to minimize any uncertainty caused by random sampling errors. Two areas of uncertainty affect exposure parameter estimates. The first is the exposure point concentration estimate. The second is the estimate of the total chemical exposures. In this assessment maximum detected concentrations were used as the exposure point concentration. Using the maximum measured value is considered appropriate because one cannot be certain of the peak contaminant concentrations, and cannot statistically predict peak values. Nevertheless, this assumption introduces uncertainty into the risk assessment that could over or underestimate the actual risk of illness. When selecting parameter values to estimate exposure dose, default assumptions and values within the ranges recommended by the ATSDR or the EPA were used. These default assumptions and values are conservative (health protective) and can contribute to the overestimation of risk of illness. Similarly, the maximum exposure period was assumed to have occurred regularly for each selected pathway. Both assumptions are likely to contribute to the overestimation of risk of illness. There are also data gaps and uncertainties in the design, extrapolation, and interpretation of toxicological experimental studies. Data gaps contribute uncertainty because information is either not available or is addressed qualitatively. Moreover, the available information on the interaction among chemicals found at the site, when present, is qualitative; that is, a description instead of a number. A mathematical formula is not applied to estimate the dose. These data gaps can tend to underestimate the actual risk of illness. In addition, there are great uncertainties in extrapolating from high to low doses, and from animal to human populations. Extrapolating from animals to humans is uncertain because of the differences in the uptake, metabolism, distribution, and body organ susceptibility between different species. Human populations are also variable because of differences in genetic makeup,

diet, home and occupational environment, activity patterns, and other factors. These uncertainties can result in an over or underestimation of risk of illness. Finally, there are great uncertainties in extrapolating from high doses to low doses, and controversy in interpreting these results. Because the models used to estimate dose-response relationships in experimental studies are conservative, they tend to overestimate the risk. Techniques used to derive acceptable exposure levels account for such variables by using safety factors. Currently, there is much debate in the scientific community about the extent to which the actual risks are overestimated and what the resultant risk estimates really mean.

# Appendix B - Figures





Figure 2. JJ Seifert site property boundaries



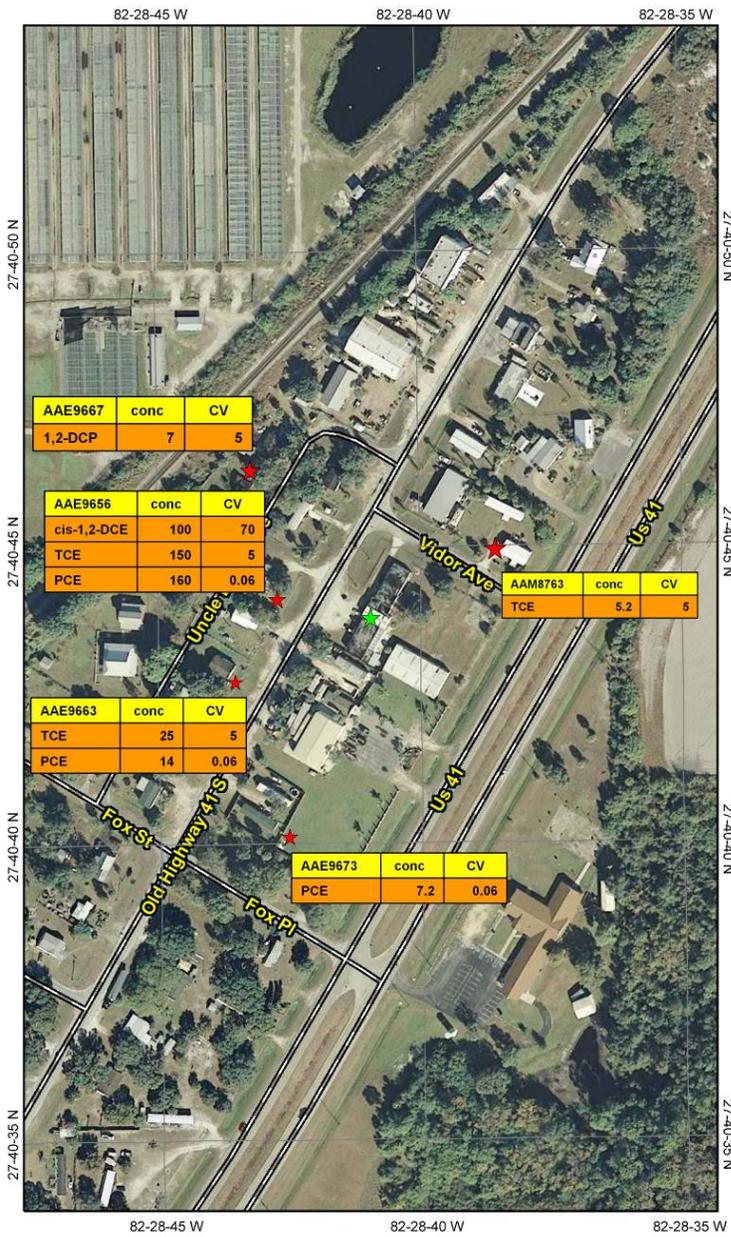
- Legend**
- Street Map
  - Cities (census places)
  - JJ Seifert Machine Company
  - property boundaries

0 70 140 ft. Map center: 549847, 409046 Scale: 1:1,186

[Florida Department of Environmental Protection] Disclaimer: This map is intended for display purposes only. It was created using data from different sources collected at different scales, with different levels of accuracy, and/or covering different periods of time.



Figure 3. Contaminated private drinking water wells



FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION  
DIVISION OF ENVIRONMENTAL HEALTH

Legend

- Street Map
  - Cities (census places)
- Conc = All concentrations in micrograms per liter  
CV = health based comparison value
- 1,2-DCP 1,2-dichloropropane
  - cis-1,2-DCE cis-1,2-dichloroethylene
  - PCE tetrachloroethylene
  - TCE trichloroethylene
  - ★ contaminated well
  - ★ JJ Seifert site

0 175 350 ft.

Map center: 549821, 409054



Scale: 1:2,965

[Florida Department of Environmental Protection] Disclaimer: This map is intended for display purposes only. It was created using data from different sources collected at different scales, with different levels of accuracy, and/or covering different periods of time.

## Appendix C – Calculations

### Calculations and examples

#### I. Adult and child exposure dose (also called the maximum daily dose)

Oral ingestion route (drinking water)

##### Non-cancer

Adult assumptions:

- Contaminant concentration is the maximum amount measured and does not change from day to day.
- Ingestion rate is 2 liters of water per day.
- Exposure factor = 1. There are no days when the adult is not exposed.
- The adult body weight is 70 kilograms.

Child assumptions:

- Contaminant concentration is the maximum amount measured and does not change from day to day.
- Ingestion rate is 1 liter of water per day.
- Exposure factor = 1. There are no days when the child is not exposed.
- The child body weight is 16 kilograms.

Abbreviations

mg = milligram

kg = kilogram

d = day

L = liter

D = exposure dose (mg/kg/d)

C = contaminant concentration (mg/L)

IR = intake rate of contaminated water (L/d)

EF = exposure factor (unitless)

BW = body weight (kg)

Exposure dose = (maximum contaminant concentration x ingestion rate x exposure factor)/body weight

$$D = (C \times IR \times EF) / BW$$

Examples:

#### **Tetrachloroethylene (PCE) measured at a maximum concentration of 0.160 mg/L**

Adult:

$$D = (0.160 \text{ mg/L} \times 2 \text{ L/d} \times 1) / 70 \text{ kg} = 0.0046 \text{ mg/kg/d}$$

Child:

$$D = (0.160 \text{ mg/L} \times 1 \text{ L/d} \times 1) / 16 \text{ kg} = 0.01 \text{ mg/kg/d}$$

#### II. Exposure dose (also called the maximum daily dose)

Inhalation route (from showering vapors)

##### Non-cancer

Assumptions:

- Bathroom volume is 9 cubic meters
- Shower flow rate is 600 liters per hour.
- Fraction of contaminant volatilized is 0.75.
- Shower duration is 0.20 hours (or 12 minutes).

#### Abbreviations

C(a) = concentration calculated in bathroom air  
 C(w) = concentration in water (also the contaminant concentration)  
 V = bathroom volume  
 F = shower flow rate  
 f = fraction of contaminant volatilized  
 t1 = shower duration

m<sup>3</sup> = cubic meters  
 h = hour  
 ug = microgram  
 mg = milligram  
 kg = kilogram  
 d = day  
 L = liter  
 ppm = parts per million

$$C(a) = (C(w) \times f \times F \times t1) / V$$

Conversion of mg/L to µg/L: There are 1000 ug in one mg

$$0.16 \text{ mg/L} \times (1000 \text{ ug} / 1 \text{ mg}) = 160 \text{ ug/L}$$

and conversion of ug/m<sup>3</sup> to mg/m<sup>3</sup>

$$1600 \text{ ug/m}^3 \times (1\text{mg} / 1000 \text{ ug}) = 1.6 \text{ mg/m}^3$$

Examples:

#### **Tetrachloroethylene (PCE) measured at a maximum concentration of 160 µg/L**

$$C(a) = (160 \text{ ug/L} \times 0.75 \times 600 \text{ L/h} \times 0.20 \text{ h}) / 9 \text{ m}^3 = 1600 \text{ ug/m}^3 \times (1\text{mg} / 1000 \text{ ug}) = 1.6 \text{ mg/m}^3$$

Conversion of mg/m<sup>3</sup> to ppm: from ATSDR Toxicological Profiles for PCE

$$1 \text{ ppm} = 6.78 \text{ mg/m}^3$$

So

$$(1.6 \text{ mg/m}^3) / 6.78 \text{ mg/m}^3 = 0.24 \text{ ppm}$$

### III. Cancer

Assumptions:

- An average lifetime is 70 years

Working from the calculated non-cancer exposure dose and with the cancer slope (from EPA):

(calculated non-cancer exposure dose x cancer slope ) x (estimated years exposed / 70 years) = cancer risk (unitless)

Examples:

**Tetrachloroethylene (PCE) cancer slope of 0.54 (mg/kg/d)<sup>-1</sup>**

$$(0.005 \text{ (mg/kg/d)} \times 0.54 \text{ (mg/kg/d)}^{-1}) \times (35 \text{ (yr)} / 70 \text{ (yr)}) = 0.001 \text{ (unitless)}$$

This would be interpreted as an increased risk of 1 person in every 1,000 people. This is considered a 'moderate' increased risk of cancer.

## Appendix D – Evaluation of single chemicals and mixtures

### How to Evaluate Exposure to a Single Chemical for Non-Cancerous Effects

This section considers the health risk from exposure to individual chemicals. For each chemical Florida DOH estimates the health risk separately for each route of exposure (drinking and breathing).

Several risk assessment methods are available for evaluating exposure to individual chemicals in the environment. To evaluate the risk of non-cancerous effects, three major steps are required: 1) estimating a person's exposure (dose) to a chemical, 2) comparing the estimated dose to a health guideline established by a health or environmental agency, and 3) if the health guideline is exceeded or if a health guideline does not exist, comparing the estimated dose to doses from human or animal studies that have or have not shown harmful effects. The goal for these steps is not only to decide if a health guideline has been exceeded, but also to decide what harmful effects might be possible.

The health guidelines commonly used for individual chemicals include A) ATSDR's oral and inhalation Minimal Risk Levels (MRLs), and B) EPA's oral Reference Dose (RfD) and inhalation Reference Concentration (RfC). Oral MRLs and RfDs are measured as milligrams (mg) of chemical per kilogram (kg) of body weight per day (mg/kg/d), while inhalation MRLs and RfCs are concentrations of a chemical measured as parts of chemical per million parts of air (ppm) or as parts per billion (ppb). Air concentrations and inhalation air guidelines are sometimes reported as milligrams or, micrograms of chemical per cubic meter of air (mg/m<sup>3</sup> or ug/m<sup>3</sup>). When necessary and for ease of discussion, we have converted these air concentrations and guidelines to ppm or ppb.

MRLs, RfDs, and RfCs have similar definitions. They are the dose (in mg/kg/d) or the concentration in air (in ppm or ppb) below which non-cancerous harmful effects are unlikely. Described another way, if the estimated dose for someone is below the oral MRL or RfD, or if the air concentration is below the inhalation MRL or RfC, then non-cancerous harmful effects are unlikely. MRLs, RfDs, and RfCs cannot be used to evaluate the cancer risk from a chemical. Other methods have been developed to evaluate cancer risk: they are described later in this report.

To evaluate the potential for non-cancerous effects from exposure to individual chemicals, the concentration in air or the estimated dose is determined and compared to the appropriate health guideline, such as an MRL, RfD, or RfC (steps 1 and 2 mentioned previously). One approach for making this comparison is to determine either the oral Hazard Quotient (oral HQ) or the inhalation Hazard Quotient (inhalation HQ) for each chemical. An oral or inhalation HQ is a number that allows the health scientist to determine whether the estimated oral dose or concentration in air is above or below a health guideline. The formulas for determining the oral and inhalation HQ for a chemical follows:

---

Oral HQ<sub>individual chemical</sub> = The Estimated Dose in People ÷ Oral health Guideline

Inhalation HQ<sub>individual chemical</sub> = The Concentration in Air ÷ Inhalation Health Guideline

Therefore, both the oral and inhalation HQ is a number that lets the health scientist know if the estimated dose or concentration in air is above or below a health guideline. When the HQ is below one, the amount of chemical to which people are exposed to (i.e., the dose or the air concentration) is below the health guideline, and non-cancerous harmful effects are not likely from exposure to that individual chemical.

When the HQ is greater than one, the estimated dose in people or the concentration in air is above the health guideline. To evaluate whether specific harmful effects might occur when the estimated dose in people or the concentration in air exceeds the health guideline, further toxicological evaluation is necessary. For oral exposure, this additional toxicological evaluation (step 3 mentioned previously) compares the estimated doses in people to doses from human and animal studies that are known not to cause harmful effects. A similar comparison is done for air exposures. In addition, the health scientist will review the toxicological, medical, and epidemiologic literature for information that will help determine possible harmful effects. Again, the goal of this evaluation is to provide an opinion about those harmful effects that might be expected in the exposed population.

#### How To Evaluate Exposure to Multiple Chemicals for Non-Cancerous Effects

Because people are often exposed to several chemicals at the same time, health scientists are often asked to evaluate exposure to a mixture of chemicals. ATSDR developed guidance for evaluating chemical mixtures: the “Guidance Manual for the Assessment of Joint Toxic Action of Chemical Mixtures” [ATSDR 2004a]. ATSDR’s mixtures guidance manual describes ATSDR’s method to screen chemical mixtures initially for non-cancerous and for cancerous effects.

For non-cancerous effects, the guidance manual requires the health scientist to estimate an oral or an inhalation HQ for each chemical. The oral HQ for each chemical is then used to determine the oral Hazard Index (HI) for the mixture of chemicals. In the same manner, the inhalation HQ for each chemical is used to determine the inhalation Hazard Index (HI) for the mixture of chemicals. This step is used as a screening technique to indicate whether further evaluation is needed. Additional work would be needed to understand completely the interaction of the chemicals. Like the individual HQs, the oral and inhalation HI for the mixture is a number that provides insight into the potential toxicity of the mixture. Specifically, the oral HI for a mixture is the sum of the oral HQ for each chemical in the mixture. Similarly, the inhalation HI for a mixture is the sum of the inhalation HQ for each chemical in the mixture. The formula for determining the HI for a mixture containing three chemicals follows:

$$\text{Oral HI}_{\text{mixture}} = \text{oral HQ}_{\text{chemical one}} + \text{oral HQ}_{\text{chemical two}} + \text{oral HQ}_{\text{chemical three}}, \text{ or}$$

$$\text{Inhalation HI}_{\text{mixture}} = \text{inhalation HQ}_{\text{chemical one}} + \text{inhalation HQ}_{\text{chemical two}} + \text{inhalation HQ}_{\text{chemical three}}$$

Once the Hazard Quotient for each chemical is determined, the next step is to evaluate the mixture of chemicals. This portion of the mixtures evaluation evaluates the interaction of chemicals.

The health scientist first reviews the individual Hazard Quotient for each chemical to decide if an Hazard Index (HI) is needed for the mixture of chemicals. ATSDR's mixture guidance states that if all the HQs for each chemical are less than 0.1, then interactions between the chemicals in the mixture are unlikely. Stated another way, the chemical mixture will not have any significant interactions (neither additive, synergistic, or antagonistic) if each of the individual HQs are less than 0.1. ATSDR's mixtures guidance also states that if only one HQ exceeds 0.1, then interactions between that chemical and other chemicals in the mixture are also unlikely.

Whenever an HI for a mixture of chemicals exceeds 1.0, further evaluation is needed to determine if a concern for possible harmful effects might exist. Thus the health scientist needs to use methods beyond the initial screening method to make that decision. Because the HQs are based on different health endpoints (e.g. a liver endpoint for chemical one, a neurological endpoint for chemical two, etc.), the health scientist can also conduct additional evaluations by looking at organ specific endpoints when the HI exceeds 1.0, using scientific and medical judgment to determine the potential for harmful effects.

#### Target-organ Toxicity Dose Modification to Hazard Index Method

The target-organ toxicity dose (TTD) method, which is a refinement of the hazard index method, was devised in order to accommodate the assessment of mixtures whose components do not all have the same critical effect. A TTD for each endpoint of concern is calculated and then used in estimating the endpoint-specific hazard indexes. When any of the endpoint specific hazard indexes exceeds unity (>1.0), concern for the potential hazard of the mixture increases [ATSDR 2004].

The derivation of a TTD is not recommended for an endpoint that is affected only at the relatively high levels of exposure associated with severe effects. TTD derivations are performed for endpoints that are common to more than one component of a given mixture.

TTDs are specific for route and duration of exposure (i.e., chronic ingestion). Once a common endpoint (i.e., liver, kidney) is established by reviewing chemical specific toxicological literature, TTDs can be calculated based on the highest NOAEL that does not exceed a LOAEL for the particular endpoint. If such a NOAEL is not available, the TTD would be based on the lowest LOAEL for that endpoint. TTDs can also be derived using benchmark dose (BMD) modeling [ATSDR 2004].

A TTD is calculated by dividing the endpoint specific NOAEL (or appropriate value) by the uncertainty factor (UF) established in human or animal studies of a specific contaminant.

$$TTD_{\text{endpoint}} = \text{NOAEL} / \text{UF}$$

Following derivation of the TTDs, endpoint specific hazard indexes are calculated as follows:

$$HI_{\text{endpoint}} = (\text{Dose}_1 / TTD_{1 \text{ endpoint}}) + (\text{Dose}_2 / TTD_{2 \text{ endpoint}}) + (\text{Dose}_3 / \text{MRL}_3 \text{ or RfD}_3) + \dots$$

where 1, 2 and 3 are different chemicals in the mixture. The MRL (or a suitable RfD) is used if the critical effect is known for that chemical, endpoint, route and duration [ATSDR 2004]. If the  $HI_{\text{endpoint}}$  exceeds unity ( $>1.0$ ) this represents a potential health hazard due to mixture additivity.

To provide insight into a mixture's ability to cause interaction effects, the health scientist also will refer to what ATSDR calls a BINWOE analysis, which stands for Binary Weight of Evidence. A BINWOE uses three-part analysis to determine:

- how two chemicals in a mixture might interact together to increase or decrease toxicity by reviewing mechanistic information available for the chemicals,
- the toxicological significance of two chemicals interaction, and
- if any information is available that might be used to modify their actions.

The results of the BINWOE analysis provide qualitative information that helps the health scientist understand if chemicals in a mixture will interact to increase or decrease toxicity. This understanding helps the health scientist interpret the HI score more accurately.

An important part of a BINWOE analysis is to predict whether any combination of two chemicals in the mixture might act in an additive, greater than additive, or less than additive manner. For instance, if two chemicals in the mixture act in an additive manner, the health scientist would expect that the dose of each chemical has an equal weight in its ability to cause harmful effects. Mathematically, the additive nature of chemical interactions is often presented as  $2 + 3 = 5$ . If two chemicals act in an additive manner, their individual HQs can be added when evaluating the two chemicals as a mixture.

Sometimes a mixture of chemicals might act in a greater than additive manner, which is referred to as a synergistic effect or synergism. When two chemicals are acting synergistically, one chemical is enhancing the effect of the other chemical. Mathematically, a chemical mixture with a synergistic effect is often presented as  $2 + 3 = 8$  (or 6 or 12, depending upon how strong the synergistic effect between the two chemicals might be). If a mixture contains two chemicals that interact synergistically, the health scientist knows that the HI for those two chemicals is greater than simply adding the individual HQs for each chemical.

A chemical mixture that acts in a less-than-additive manner is referred to as an antagonistic effect. In this case, one of the chemicals is reducing the effect of the other chemical. Stated another way, one chemical is protecting against the effect of another chemical. An antagonistic effect might be presented mathematically as  $2 + 3 = 4$ . If a mixture contains two chemicals that interact in an antagonistic manner, the health scientist knows that the HI for those two chemicals is less than simply adding the individual HQs for each chemical. Other types of chemical reactions in a mixture are possible, and these are described in more detail in ATSDR's guidance manual for chemical mixtures. However, the three types of reactions described here (additivity, synergism, and antagonism) are the primary types.

#### How To Evaluate Exposure to Multiple Chemicals for Cancerous (Carcinogenic) Effects

In general, a summation of estimated cancer risks is used to derive conclusions regarding mixture carcinogenic effects. Initially, individual cancer risks are calculated for each chemical

of concern separately. These unitless estimated cancer risks are then compared to a nominal cancer risk of 0.000001 (1 in 1,000,000, “extremely low” risk). If the cancer risk does not exceed one in a million, it is considered unlikely exposure to these chemicals will result in adverse carcinogenic health effects and the chemical(s) is eliminated from further consideration. If only one chemical exceeds this risk level, then mixture effects (additive) are not considered further. If the cancer risks for two or more chemicals exceed one in a million (0.000001) then further evaluation is necessary [ATSDR 2004a]. The estimated cancer risks for each chemical exceeding one in a million is then compared to a selected risk of 0.0001 (1 in 10,000). If two or more chemicals exceed the one in a million estimated risk and one or more exceed 0.0001, the sum of those estimated risks is calculated. When exceedances of 0.0001 are found, there is a potential for carcinogenic health effects due to additivity [ATSDR 2004a]. If available, interactive effects (BINWOE analyses) are then evaluated for those chemicals.

## Appendix E - Glossary of Environmental Health Terms

**ATSDR:** The Agency for Toxic Substances and Disease Registry. ATSDR is a federal health agency in Atlanta, Georgia, that deals with hazardous substance and waste site issues. ATSDR gives people information about harmful chemicals in their environment and tells people how to protect themselves from coming into contact with chemicals.

**Background Level:** An average or expected amount of a chemical in a specific environment. Or, amounts of chemicals that occur naturally in a specific environment.

**Cancer:** A group of diseases that occur when cells in the body become abnormal and grow, or multiply, out of control.

**Carcinogen:** Any substance shown to cause tumors or cancer in experimental studies.

**CERCLA:** See Comprehensive Environmental Response, Compensation, and Liability Act.

**Completed Exposure Pathway:** See Exposure Pathway.

**Comparison Value: (CVs)** Concentrations or the amount of substances in air, water, food, and soil that are unlikely, upon exposure, to cause adverse health effects. Comparison values are used by health assessors to select which substances and environmental media (air, water, food and soil) need additional evaluation while health concerns or effects are investigated.

**Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA):** CERCLA was put into place in 1980. It is also known as **Superfund**. This act concerns releases of hazardous substances into the environment, and the cleanup of these substances and hazardous waste sites. ATSDR was created by this act and is responsible for looking into the health issues related to hazardous waste sites.

**Concern:** A belief or worry that chemicals in the environment might cause harm to people.

**Concentration:** How much or the amount of a substance present in a certain amount of soil, water, air, or food.

**Contaminant:** See Environmental Contaminant.

**Dose:** The amount of a substance to which a person may be exposed, usually on a daily basis. Dose is often explained as “amount of substance(s) per body weight per day”.

**Dose / Response:** The relationship between the amount of exposure (dose) and the change in body function or health that result.

**Duration:** The amount of time (days, months, years) that a person is exposed to a chemical.

**Environmental Contaminant:** A substance (chemical) that gets into a system (person, animal, or the environment) in amounts higher than that found in **Background Level**, or what would be expected.

**Environmental Media:** Usually refers to the air, water, and soil in which chemicals of interest are found. Sometimes refers to the plants and animals that are eaten by humans. **Environmental Media** is the second part of an **Exposure Pathway**.

**U.S. Environmental Protection Agency (EPA):** The federal agency that develops and enforces environmental laws to protect the environment and the public's health.

**Epidemiology:** The study of the different factors that determine how often, in how many people, and in which people will disease occur.

**Exposure:** Coming into contact with a chemical substance. (For the three ways people can come in contact with substances, see **Route of Exposure**.)

**Exposure Assessment:** The process of finding the ways people come in contact with chemicals, how often and how long they come in contact with chemicals, and the amounts of chemicals with which they come in contact.

**Exposure Pathway:** A description of the way that a chemical moves from its source (where it began) to where and how people can come into contact with (or get exposed to) the chemical. ATSDR defines an exposure pathway as having 5 parts:

- Source of Contamination,
- Environmental Media and Transport Mechanism,
- Point of Exposure,
- Route of Exposure, and
- Receptor Population.

When all 5 parts of an exposure pathway are present, it is called a **Completed Exposure Pathway**. Each of these 5 terms is defined in this Glossary.

**Frequency:** How often a person is exposed to a chemical over time; for example, every day, once a week, twice a month.

**Hazardous Waste:** Substances that have been released or thrown away into the environment and, under certain conditions, could be harmful to people who come into contact with them.

**Health Effect:** ATSDR deals only with **Adverse Health Effects** (see definition in this Glossary).

**Ingestion:** Swallowing something, as in eating or drinking. It is a way a chemical can enter your body (See **Route of Exposure**).

**Inhalation:** Breathing. It is a way a chemical can enter your body (See **Route of Exposure**).

**LOAEL: Lowest Observed Adverse Effect Level.** The lowest dose of a chemical in a study, or group of studies, that has caused harmful health effects in people or animals.

**NPL: The National Priorities List.** (Which is part of **Superfund**.) A list kept by the U.S. Environmental Protection Agency (EPA) of the most serious, uncontrolled or abandoned hazardous waste sites in the country. An NPL site needs to be cleaned up or is being looked at to see if people can be exposed to chemicals from the site.

**NOAEL: No Observed Adverse Effect Level.** The highest dose of a chemical in a study, or group of studies, that did not cause harmful health effects in people or animals.

**No Public Health Hazard:** The category is used in ATSDR's Public Health Assessment documents for sites where there is evidence of an absence of exposure to site-related chemicals.

**PHA: Public Health Assessment.** A report or document that looks at chemicals at a hazardous waste site and tells if people could be harmed from coming into contact with those chemicals. The PHA also tells if possible further public health actions are needed.

**Population:** A group of people living in a certain area; or the number of people in a certain area.

**Public Health Assessment(s):** See **PHA**.

**Public Health Hazard:** The category is used in PHAs for sites that have certain physical features or evidence of chronic, site-related chemical exposure that could result in adverse health effects.

**Public Health Hazard Criteria:** PHA categories given to a site which tell whether people could be harmed by conditions present at the site. Each is defined in the Glossary. The categories are:

- Urgent Public Health Hazard
- Public Health Hazard
- Indeterminate Public Health Hazard
- No Apparent Public Health Hazard
- No Public Health Hazard

**Route of Exposure:** The way a chemical can get into a person's body. There are three exposure routes:

- breathing (also called inhalation),
- eating or drinking (also called ingestion), and
- or getting something on the skin (also called dermal contact).

**Safety Factor:** Also called **Uncertainty Factor**. When scientists don't have enough information to decide if an exposure will cause harm to people, they use "safety factors" and formulas in place of the information that is not known. These factors and formulas can help determine the amount of a chemical that is not likely to cause harm to people.

**Source (of Contamination):** The place where a chemical comes from, such as a landfill, pond, creek, incinerator, tank, or drum. Contaminant source is the first part of an **Exposure Pathway**.

**Special Populations:** People who may be more sensitive to chemical exposures because of certain factors such as age, a disease they already have, occupation, sex, or certain behaviors (like cigarette smoking). Children, pregnant women, and older people are often considered special populations.

**Superfund Site:** See **NPL**.

**Toxic:** Harmful. Any substance or chemical can be toxic at a certain dose (amount). The dose is what determines the potential harm of a chemical and whether it would cause someone to get sick.

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