US EPA RECORDS CENTER REGION 5
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APPENDIX D

FINAL RISK ASSESSMENT

LANE STREET GROUNDWATER CONTAMINATION SITE

ELKHART, ELKHART COUNTY, INDIANA

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CONTENTS

Section **Page**

ACRONYMS AND ABBREVIATIONS v

1.0 INTRODUCTION 1

1.1 OVERVIEW 1
1.2 SITE DESCRIPTION AND HISTORY 2
1.2.1 Site Description 2
1.2.2 Site History 3
1.3 HISTORICAL INVESTIGATIONS 4
1.4 RI ACTIVITIES 7
1.4.1 Summary of Phase I Vertical Aquifer Sampling and Soil Sampling Events 7
1.4.2 Monitoring Well Installation 9
1.4.3 Quarterly Groundwater Monitoring Sampling 10
1.4.4 Soil Vapor Sampling 10
1.5 NATURE AND EXTENT OF CONTAMINATION 11
1.5.1 Groundwater 11
1.5.2 Distribution of COIs in Groundwater 12
1.5.3 Soil 13
1.5.4 Soil Vapor VOC Results 14
1.6 POTENTIAL FATE AND TRANSPORT PROCESSES 14
1.7 RISK ASSESSMENT EXPOSURE AREAS 16
1.8 DOCUMENT ORGANIZATION 16

2.0 HUMAN HEALTH RISK ASSESSMENT 17

2.1 HHRA CONCEPTUAL SITE MODEL 18
2.1.1 Potential Receptors and Exposure Points 19
2.1.2 Potential Exposure Routes 22
2.2 DATA EVALUATION AND COPC SELECTION 22
2.2.1 HHRA Data Sets 23
2.2.2 Data Evaluation 24
2.2.3 HHRA Screening Process 25
2.2.4 COPC Identification 27
2.3 EXPOSURE ASSESSMENT 27
2.3.1 Exposure Point Concentrations 28
2.3.2 Receptor Exposure Assumptions 38
2.4 TOXICITY ASSESSMENT 45
2.4.1 Non-Carcinogenic Chemicals 46
2.4.2 Carcinogenic Chemicals 47
2.5 RISK CHARACTERIZATION 48
2.5.1 Risk Calculation Methodology 48
2.5.2 Risk Characterization Results 50
2.6 HHRA UNCERTAINTY ASSESSMENT 62
2.6.1 Uncertainty in Conceptual Site Model 63
2.6.2 Uncertainty in Analytical Data 64
2.6.3 Uncertainty in Exposure Estimates 65

2.6.4 Uncertainty in Toxicity Estimates *67*
2.7 HHRA SUMMARY AND CONCLUSIONS 67
2.7.1 EA 1 ..... *68*
2.7.2 EA 2 ..... *72*
3.0 SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT **76**
4.0 RISK ASSESSMENT SUMMARY AND CONCLUSIONS **78**
4.1. HUMAN HEALTH RISK ASSESSMENT 78
4.1.1 Objectives *78*
4.1.2 Exposure Areas *78*
4.1.3 HHRA Approach *78*
4.1.4 HHRA Summary and Conclusions *81*
4.2 SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT 82
5.0 REFERENCES **83**

FIGURES

Figure D-1-1 Site Location
Figure D-1-2 Site Layout
Figure D-1-3 Groundwater Sampling Locations (VAS, Roberts, and SulTRAC wells)
Figure D-1-4 Soil Sampling Locations
Figure D-1-5 Soil Vapor Sampling Locations
Figure D-1-6 Hadley Sub-slab Sampling Locations
Figure D-1-7 Human Health Exposure Areas
Figure D-2-1 Human Health Conceptual Site Model

TABLES

Table D-1-1 Address Information for Property 6 in Residential Area
Table D-1-2a Groundwater Monitoring Well Network
Table D-1-2b Groundwater Zone Designation
Table D-2-1 Groundwater Screening Level Selection
Table D-2-2 Soil Screening Level Selection
Table D-2-3 Soil Gas Screening Level Selection
Table D-2-4 Risk and Hazard Summary -- EA 1
Table D-2-5 Risk and Hazard Summary – EA 2

ATTACHMENTS

Attachment D-1	HHRA RAGS Part D Tables
Attachment D-2	Exposure Point Concentration Documentation
Attachment D-3	Groundwater-to-Outdoor Air Model for Construction and Utility Worker Trench Exposure
Attachment D-4	Qualitative Vapor Intrusion Risk Estimates

ACRONYMS AND ABBREVIATIONS

µg/L	Micrograms per liter
µg/m^3	Micrograms per cubic meter
µg/mg	*Micrograms per milligram*
ADAF	Age-dependent adjustment factor
amsl	Above mean sea level
AT	Averaging time
AT_c	Averaging time for carcinogens
AT_{nc}	Averaging time for non-carcinogens
ATSDR	Agency for Toxic Substances and Disease Registry
B	Ratio of permeability coefficient of a compound through the corneum relative to its *permeability coefficient across the viable epidermis*
bgs	Below ground surface
BW	Body weight
BW_{child}	Body weight – child
CAF	Calculated toxicity value adjustment factor for cancer
Cal/EPA	California Environmental Protection Agency
CDE	Chronic daily exposure
CDI	Chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CF	*Conversion factor*
CLP	Contract Laboratory Program
cm^2	Square centimeter
cm/hour	Centimeters per hour
cm^2/day	Square centimeters per day
cm^2/s	Square centimeters per second
cm^2-event/kg	Square centimeter-event per kilogram
COC	Chemical of concern
COI	Chemical of interest
COPC	Chemical of potential concern
CSM	Conceptual site model
CTE	Central tendency exposure
DA_{event}	Absorbed dose per event
DCA	Dichloroethane
DCE	Dichloroethene
DFW_{adj}	Age-adjusted dermal contact factor for water (inorganics)
$DFWM_{adj}$	Age-adjusted dermal contact factor for water for mutagens (inorganics)
DHC	*Dehalococcoides ethenogenes*
EA	Exposure area
ED	Exposure duration

ED_{adj}	Age-adjusted exposure duration for carcinogens
ED_{child}	Exposure duration – child
EDM_{adj}	Age-adjusted exposure duration for mutagens
EF	Exposure frequency
ELCR	Excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
EPC	Exposure point concentration
ET	Exposure time
ET_b	Exposure time bathing
ET_{child}	Exposure time – child
ET_d	Exposure time -- dermal
ET_{od}	Exposure time outdoors
EV	Event frequency
FA	Fraction absorbed water
FI	Fractional intake
FS	Feasibility study
g/cm^3	Grams per cubic centimeter
g/day	Grams per day
GI_{abs}	Gastrointestinal absorption factor
HEAST	Health Effects Assessment Summary Table
HHRA	Human health risk assessment
HI	Hazard index
HQ	Hazard quotient
hr/day	Hour per day
HRS	Hazard Ranking System
IDEM	Indiana Department of Environmental Management
IRGW	Ingestion rate of groundwater
IRIS	Integrated Risk Information System
IRW	Ingestion rate of water
IRW_{adj}	Age-adjusted ingestion rate of water
IRW_{child}	Ingestion rate of water – child
$IRWM_{adj}$	Age-adjusted ingestion rate of water for mutagens
K	Andelman Volatilization Factor
K_d	Dissociation constant
kg	Kilogram
kg/day	Kilograms per day
kg-year/kg-day	Kilogram-year per kilogram-day
kg/mg	Kilogram per milligram
KM	Kaplan-Meier
K_{OC}	Organic carbon partitioning coefficient
K_{ow}	*n*-Octanol/water partitioning coefficient

L/cm^3	Liters per cubic centimeter
L/day	Liters per day
L-year/kg-day	Liter-year per kilogram-day
LOAEL	Lowest observed adverse effect level
m^3/kg	Cubic meters per kilogram
MAF	Calculated toxicity value adjustment factor for mutagens
MCL	Maximum contaminant level
MEE	Methane, ethane, ethylene
mg/µg	Milligram per microgram
mg/cm^2	Milligrams per square centimeter
mg/cm^2-event	Milligrams per square centimeter per event
mg/day	Milligrams per day
mg/kg	Milligrams per kilogram
mg/kg-day	Milligrams per kilogram per day
mg/m^3	Milligrams per cubic meter
mg-year/kg-day	Milligram-year per kilogram-day
MNA	Monitored natural attenuation
MRL	Minimal risk level
NHL	non-Hodgkins lymphoma
NOAEL	No observed adverse effect level
NPL	National Priorities List
OEHHA	Office of Environmental Health Hazard Assessment
OERR	Office of Emergency and Remedial Response
OSWER	Office of Solid Waste and Emergency Response
PAL	Project action limit
PCB	Polychlorinated biphenyl
PCE	Tetrachloroethene
PID	Photoionization detector
PPRTV	Provisional Peer Reviewed Toxicity Values
QA/QC	Quality assurance/quality control
RA	Risk assessment
RAC	Remedial action contract
RAGS	*Risk Assessment Guidance for Superfund*
RAO	Remedial action objective
RfC	Reference concentration
RfD	Reference dose
RI	Remedial investigation
RL	Reporting limit
RME	Reasonable maximum exposure

ROD	Record of Decision
ROW	Right-of-way
RPD	Relative percent difference
RSL	Regional screening level
RV	Recreational vehicle
SA	Skin surface area
SF	Slope factor
SLERA	Screening level ecological risk assessment
START	Superfund Technical Assessment and Response Team
SVOC	Semi-volatile organic compounds
t*	Time to reach steady state
t_{event}	Receptor exposure time (dermal contact with water)
TAL	Target analyte list
tao_{event}	Lag time per event
TCA	Trichloroethane
TCE	Trichloroethene
TCL	Target compound list
THQ	Target hazard quotient
TOC	Total organic carbon
TR	Target risk
UCL	Upper confidence limit
95UCL	One-sided 95 percent upper confidence limit of the mean
URF	Unit risk factor
USGS	U.S. Geological Survey
VAS	Vertical aquifer sample
VDEQ	Virginia Department of Environmental Quality
VF	Volatilization factor
VI	Vapor intrusion
VISL	Vapor Intrusion Screening Level
VRP	Voluntary Remediation Program
VOC	Volatile organic compound

1.0 INTRODUCTION

1.1 OVERVIEW

Under U.S. Environmental Protection Agency (EPA) Remedial Action Contract (RAC) 2 for Region 5, Contract No. EP-S5-06-02, Work Assignment No. 159-RICO-B5LH (EPA 2011), SulTRAC has prepared this draft risk assessment (RA) report for EPA as part of the remedial investigation (RI) report for the Lane Street Groundwater Contamination Site in Elkhart, Indiana (see Figure D-1-1). The Lane Street Site RI (and hence the RA) was initiated during the base period of the RAC II contract under Work Assignment No. 059-RICO-B5LH. EPA tasked SulTRAC to complete an RI (including an RA) at the Lane Street Site. Specifically, SulTRAC reviewed historical information, collected samples, and prepared this RA report in accordance with applicable EPA guidance.

The RI (and hence the RA) consisted of multiple multi-media sampling events from May 2011 to October 2014. These investigations included collection of numerous groundwater, soil, and soil gas samples. The SulTRAC sampling events are as follows:

- Vertical Aquifer Sampling (VAS) Events, Phase I (April 2011 through September 2014)
- Four Quarterly Groundwater Sampling Events, Phase I (October 2013 to July 2014)
- Soil Vapor Sampling Event, Phase I (October 2013)
- 1,4-Dioxane Sampling Event, Phase I (September 2014)

This RA document is an appendix to the RI report and encompasses the human health risk assessment (HHRA) component of the RA that evaluates current and potential future human health risks and hazards associated with exposure to site-related constituents. A screening level ecological risk assessment (SLERA) that evaluates potential current ecological risks associated with ecological exposure to site-related constituents was not completed because the RI concluded that there were no complete exposure pathways for ecological receptors.

In March 2014, before the HHRA described above was conducted, SulTRAC prepared and submitted human health conceptual site models (CSM), exposure factors and assumptions, and a summary of the technical approach to EPA. (EPA forwarded these materials to the Indiana Department of Environmental Management [IDEM].) On April 3, 2014, SulTRAC received concurrence for EPA's Region 5 senior risk assessor with the draft methodology (EPA 2014c). On April 11, 2014, SulTRAC received comments on

the methodology from EPA and IDEM (EPA 2014d). SulTRAC responded to EPA's and IDEM's comments and incorporated necessary changes into this HHRA. Specifics of the methodology, in addition to selection of exposure areas and groundwater data points to use in exposure point concentration (EPC) calculations, were discussed further with EPA's senior risk assessor in multiple telecommunication and e-mail exchanges during November 2014 through January 2015.

The remainder of this section presents site background and history (Section 1.2), a summary of RI activities (Section 1.4), and a summary of the nature and extent of contamination (Section 1.5).

1.2 SITE DESCRIPTION AND HISTORY

Sections 1.2.1 and 1.2.2 present the site description and history (including a summary of historical investigations).

1.2.1 Site Description

The Lane Street Site, in Elkhart, Elkhart County, Indiana, occupies about 65 acres (Figure D-1-1). The site consists of both active and inactive industrial, commercial, and residential properties, located above a groundwater plume. The depth to groundwater at the site has been recorded at approximately 6 to 12 feet below ground surface (bgs), and the aquifer consists of unconsolidated sand and gravel materials. Most of the residents and industrial facilities within the approximate site boundary do not use private wells, except for five industrial locations (Properties 1 through 5) and one residential location (Property 6). During the RI, Properties 2, 3, and 5 were vacant. The northern boundary extends approximately 750 feet to include some additional industrial properties in the northeast corner (see Figure D-1-2 and Table D-1-1). As presently defined, the site is bounded by the eastern property boundary of the Property 6 on the east, Barley Street on the south, and an undeveloped property (Parcel ID 02-26-301-024-026) on the west. North of County Road 106, the eastern boundary widens to include the industrial/commercial area bounded by Cooper Drive on the north, Marina Drive on the east, County Road 106 on the south, and Ada Drive on the west. During the RI field activities, SulTRAC conducted investigations both within and outside these site boundaries to investigate the groundwater plume at the Lane Street Site.

Within the currently defined site boundaries, there are 29 residences along Lane Street and County Road 106 and 17 parcels in the industrial park area north of Lane Street, including both operating and vacant industrial and commercial buildings (see Figure D-1-2). There are no schools within the boundaries of the Lane Street Site. Within a 1-mile radius from the intersection of Lane Street and County Road 106, however, there are four schools and one child care center. Of these four schools, the Michiana Christian

Montessori School is the closest to the site, located at 23830 County Road 106, 500 feet west of the site. SulTRAC verified with an engineer from the City of Elkhart that the school is using City of Elkhart municipal water (City of Elkhart 2015).

To the east of Lane Street is a separate contaminated groundwater plume along Kershner Lane that is associated with the Geocel Corporation (Geocel) facility at 2502 Marina Drive in the industrial park. The Geocel plume originated from a tetrachloroethene (PCE) release and appears to be separate from the Lane Street Site plume. Geocel is addressing its plume under IDEM's Voluntary Remediation Program (VRP) (EPA 2011a).

In the City of Elkhart, five Superfund sites are or have been on the National Priorities List (NPL): the Himco Dump (a/k/a Himco Landfill), the Main Street Well Field, the Conrail Rail Yard, the Lane Street Groundwater Contamination Site, and the Lusher Street Groundwater Contamination Site (ATSDR 2013b) (Figure D-1-3). The Himco Dump, the Main Street Well Field, and the Lane Street Groundwater Contamination Site all are located on the north side of the St. Joseph River. The Conrail Rail Yard and the Lusher Site both are located on the south side of the St. Joseph River.

1.2.2 Site History

On August 22, 2007, IDEM was notified by the Elkhart County Health Department that a Lane Street resident had tested drinking water from a private water-supply well because of known groundwater contamination in the residential area one street east of Lane Street (Kershner Lane). The resident's drinking water sample was submitted to Water Quality Laboratory at Heidelberg College in Tiffin, Ohio. The analysis revealed elevated levels of trichloroethene (TCE), at 1,560 micrograms per liter (µg/L), as well as other breakdown products of volatile organic compounds (VOCs) (IDEM 2007).

In late August 2007, IDEM conducted a preliminary assessment of the Lane Street Site, which consisted of a site reconnaissance of the surrounding properties and sampling drinking water from 39 private water supply wells for analysis of VOCs. Results indicated that 11 residential wells and two business wells (north of County Road 106) contained elevated levels of VOCs, mainly TCE (IDEM 2007).

IDEM provided bottled water to the residences that contained elevated levels of VOCs in their private well water and alerted EPA to the concentrations above EPA maximum contaminant levels (MCLs) in the drinking water at the Lane Street Site (EPA and IDEM 2009). EPA conducted confirmatory groundwater sampling at the Lane Street Site in September 2007. EPA results confirmed that some VOC

concentrations were above MCLs in the residential groundwater. Additionally, in December 2007, Weston conducted 24-hour indoor air sampling in two residences where elevated TCE concentrations in groundwater had been documented. TCE, PCE, and vinyl chloride were not detected in either air sample collected at the two residences (Weston 2008).

EPA authorized installation of carbon filtration water treatment systems for the affected residences as well as 1 year of maintenance on the systems until a more permanent solution could be implemented. The treatment systems were installed in the fall and winter of 2007 and 2008 for 13 residences located on Lane Street (Weston 2008).

In November 2008, EPA connected 26 residences (23 on Lane Street, two on Barley Street, and one on County Road 106) to the City of Elkhart municipal water supply system and abandoned the residential wells at those residences (EPA 2011a). Several additional unaffected downgradient residences were connected to the City of Elkhart municipal water supply system because the groundwater plume appears to be flowing in a south-southwesterly direction. Residences farther south of Barley Street were already connected to municipal water. One resident on County Road 106, within the current Lane Street Site boundary declined to be connected to municipal water.

IDEM conducted site visits at facilities in the industrial park to the north of Lane Street in April and September 2008 and found at least three facilities that have stored or used hazardous substances. However, at that time, there was insufficient information to evaluate whether releases from these facilities contribute to the groundwater plume or plumes associated with the Lane Street Site (EPA and IDEM 2009). As many as eight other facilities are within the Lane Street Site study area were investigated to assess their potential impacts.

1.3 HISTORICAL INVESTIGATIONS

As part of the Hazard Ranking System (HRS) process for including a site on the NPL, IDEM conducted a site inspection from April 14 through April 17, 2008. IDEM collected 132 groundwater samples from private residential wells and from discrete locations from the industrial park north of County Road 106 through direct-push methods. Groundwater samples were generally collected from depths of 8 feet (corresponding to the position of the water table), 18 feet, and 30 feet bgs, except when groundwater was not encountered at 8 feet or topographic concerns required modification of the sampling plan (IDEM 2008). Additionally, nine soil samples were collected from depths ranging from 4 to 9 feet in the industrial park in an attempt to identify a source area. It was concluded during this investigation that the

groundwater is likely flowing south to southwest toward the St. Joseph River, which is located approximately 1.4 miles south of the site. Twelve residential private well samples contained concentrations of TCE and other VOCs during this sampling event. In addition, many of the direct-push discrete groundwater samples contained elevated concentrations of VOCs, with a maximum TCE concentration of 770 µg/L collected from direct-push discrete sampling in the industrial park north of Lane Street. No VOCs were detected in the soil samples collected during IDEM's 2008 site inspection (IDEM 2008).

During IDEM's investigations, several chemicals of interest (COI) were identified in groundwater as potentially hazardous to human health and the environment at the Lane Street Site. These constituents include TCE, 1,1-dichloroethene (1,1-DCE), 1,1-dichloroethane (1,1-DCA), cis-1,2-dichloroethene (cis-1,2-DCE), trans-1,2-dichloroethene (trans-1,2-DCE), 1,1,1-trichloroethane (1,1,1-TCA), and PCE.

On September 14, 2009, the Lane Street Site was listed on the NPL and the process of investigation under the EPA Superfund program began (EPA 2014f).

Before and during SulTRAC's investigation at the site, Roberts Environmental Services, LLC (Roberts) was hired by Flexsteel Industries, Inc. (Flexsteel) to conduct an environmental investigation at 2503 Marina Drive and 3507 Cooper Drive, independent of EPA's RI at the Lane Street Site. In March 1997, Flexsteel purchased the former Dygert Seating facility that previously conducted business at the aforementioned locations. Between March 2011 and November 2013, Roberts collected grab groundwater and soil samples and installed numerous groundwater monitoring wells on and surrounding the Flexsteel property. In March 2011, Roberts advanced 19 borings along the northern right-of-way (ROW) of Cooper Drive and collected three to four VAS groundwater samples from each boring. In October 2011, Roberts conducted additional VAS at 23 locations south of Cooper Drive near the former Flexsteel property. In November and December 2011, Roberts installed nested monitoring wells, consisting of three to five wells of varying depths per nest, at 13 locations surrounding the two facilities. After the wells had been developed, these wells were sampled for a limited list of VOCs including but not limited to TCE, PCE, and 1,1,1-TCA.

Roberts advanced 94 shallow borings in a grid pattern in the southwest corner in July 2012 to address the concerns about possible dumping that was allegedly conducted on the southwestern portion of the former Flexsteel property. Three subsurface soil samples were collected from 2.5 feet bgs to 12 feet bgs from each boring for limited analysis of VOCs. Roberts also collected soil samples from the loading dock

areas of the former Flexsteel property. There were no detectable concentrations of the selected VOCs in the soil samples.

In July, September, and October 2012, Roberts collected additional VAS on the southern portion of 2503 Marina Drive, installed additional monitoring wells to better characterize the contamination detected near the water table at monitoring wells R-MW-10 and R-MW-11. Roberts also installed additional nested well sets (R-MW-14 and R-MW-15) at similar locations where IDEM had collected VAS in 2007. By this time, a total of 54 monitoring wells had been installed at 15 locations ranging from just north of Cooper Drive (R-MW-13) to approximately 300 feet north of County Road 106 (Henke Street) on the western property boundary of 3506 Henke Street (R-MW-12) (Roberts 2012). The highest concentration of TCE detected in the Roberts monitoring wells was 410 µg/L at R-MW-12i (screened from 21 to 26 feet bgs), which corresponded to VAS sample location GW-N (or sample ID E2Q90) collected at 30 feet bgs, where IDEM had detected a high TCE concentration of 690 µg/L in groundwater (Roberts 2012). Well R-MW-12i is located on the Riverside Tool property at 3504 Henke Street.

TCE and PCE were also detected in Roberts well R-MW-13, the northernmost monitoring well. Roberts conducted additional VAS farther north on the 2601 Marina Drive property in May 2013. Roberts advanced an additional 16 VAS locations (identified as PB-1 through PB-16), which included collecting four groundwater samples from each location. The maximum TCE and PCE concentrations were 120 µg/L TCE and 380 µg/L PCE, both detected at VAS location PB-9 at 2601 Marina Drive. Roberts continued further investigation on 2503 Marina Drive in September 2013 by conducting VAS just north of the building on the property. Five additional VAS locations (identified as GW-26 through GW-30) were advanced, which included collecting six groundwater samples from each location. TCE was detected in the shallowest samples collected at 2 to 12 feet bgs at two locations (GW-28 and GW-29) at 2503 Marina Drive. The other three laterally (east to west) adjacent VAS sample results did not exhibit detectable TCE concentrations from the same shallow sampling interval.

In addition to these five VAS locations, Roberts installed 17 monitoring wells at already established nested well locations (identified as R-MW-1, R-MW-2, R-MW-3, R-MW-5, R-MW-7, R-MW-8, and R-MW-13). For example, four existing monitoring wells were in place at the nested monitoring wells at R-MW-1, and Roberts installed a fifth well at that nested well location. The additional wells were installed in various depths that had not been previously sampled.

In October 2013, Roberts re-sampled two of its monitoring wells and installed an additional shallow screening well (designated as "-ss") at the R-MW-7 nested well location. Subsequently, in November 2013, Roberts installed four additional monitoring wells on the property north of Cooper Drive at 2601 Marina Drive, near the area where previous investigation had detected high PCE and TCE concentrations, and installed another shallow screening well at the R-MW-8 nested well location. The sample results from monitoring wells installed on the 2601 Marina Drive property (R-MW-16 nested well location) confirmed elevated TCE and PCE concentrations discovered during the VAS sampling in May 2013. The groundwater samples collected from the shallow screening ("-ss") monitoring wells installed at R-MW-7 (R-MW-7ss) and R-MW-8 (R-MW-08ss) on the 2503 Marina Drive property had TCE at concentrations of 5.3 µg/L and 1.7 µg/L.

The Roberts groundwater sampling data were also incorporated into SulTRAC's Lane Street Site database to generate tables and figures for site-wide interpretation. Table A-2 in the RI presents the groundwater sample data collected by Roberts that are compared with the screening values used in the RI.

1.4 RI ACTIVITIES

The scope of the RI activities at the Lane Street Site was developed with EPA by combining information from previous site investigation reports. SulTRAC conducted the RI to better characterize site-related contamination. This information ultimately will be used to develop a Record of Decision (ROD) for the Lane Street Site. The scope of work for the project included delineating the groundwater contamination plume and determining if vapor intrusion is occurring in the residential area. The RI field activities were conducted over multiple events consisting of multi-media sampling, including VAS, monitoring well installation, quarterly monitoring well sampling, soil vapor sampling, and sampling for analysis of 1,4-dioxane, as discussed below. However, the reader should refer to Section 3.0 of the RI report for a more comprehensive discussion of the RI. The HHRA is based on the analytical results from the RI to evaluate and characterize risks to human receptors from potential exposure to site-related contaminants. Both analytes and spatial coverage were represented reasonably and comprehensively in this investigation and represent the most up-to-date analytical data set. (In other words, the appropriate analyte groups associated with historical contamination were used and samples were collected across, adjacent to, and up- and down-gradient of the Lane Street Site.)

1.4.1 Summary of Phase I Vertical Aquifer Sampling and Soil Sampling Events

SulTRAC collected VAS grab groundwater samples to (1) investigate the horizontal and vertical extent of contamination, and (2) select the locations and depths where the permanent monitoring wells should be

installed and screened. These sampling events also included soil sampling and sampling of private wells within the site boundary and of select monitoring wells. VAS was performed in three events: from April through May 2011, in June 2013, and in September 2014. Twenty-five VAS locations were sampled in April and May, 2011; 12 VAS locations were sampled in June 2013; and 10 VAS locations were sampled in September 2014. VAS sampling locations are presented in Figure D-1-3.

2011 Vertical Aquifer Sampling Event

During the April to May 2011 VAS event, up to 10 groundwater samples at 10-foot intervals were collected and analyzed for VOCs at 25 locations identified as VAS-01 through VAS-25. Thirteen soil samples were collected by SulTRAC in adjacent boreholes at select VAS locations. However, soil from all boreholes adjacent to the 25 VAS locations was logged and screened for possible contamination. Field screening (photoionization detector [PID] and visual observations) did not identify an affected interval; therefore, SulTRAC collected soil samples for analysis from the 2-foot interval immediately above the water table. The 13 soil samples were analyzed for VOCs. Eleven of the 13 soil samples were also analyzed for semi-volatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), and target analyte list (TAL) metals. The soil sampling locations are presented on Figure D-1-4.

In addition to the VAS, in May 2011 SulTRAC collected two samples at private groundwater wells from a residential and commercial property (Property 2 and Property 6) along County Road 106, otherwise known as Henke Street. The groundwater samples from the private wells were analyzed for VOCs. The private well sampling locations are presented on Figure D-1-3.

The groundwater and soil samples collected during the 2011 sampling event were submitted to Contract Laboratory Program (CLP) laboratories A4 Scientific, Inc. (for organic sample analysis) and Sentinel, Inc. (for inorganic sample analysis). Due to data anomalies associated with some analytical laboratory data discovered in 2014, it was determined that organic data collected during the 2011 sampling event were of unknown quality and could not be used for making investigative decisions.

2013 Vertical Aquifer Sampling Event

Based on the field data and analytical results from the April and May 2011 sampling event as well as data obtained from the Roberts investigations, SulTRAC returned to the site to further investigate the lateral and vertical extent of the groundwater plume. SulTRAC mobilized to the site in June 2013 to advance a total of 12 additional VAS locations (identified as VAS-26 through VAS-37). Groundwater samples were collected from the water table and from 10-foot intervals until the desired depth was reached, which

varied from 30 to 60 feet bgs and resulted in three to six groundwater samples per location. All groundwater samples were submitted for analysis of VOCs.

During the 2013 VAS event, one soil sample was collected for analysis of VOCs at VAS-37 from a 0- to 2-foot interval (VAS-SO37), and multiple subsurface soil samples were collected for grain size analysis. Additionally, SulTRAC collected groundwater samples from 22 of the Roberts monitoring wells that were submitted for analysis of VOCs.

2014 Vertical Aquifer Sampling Event

In May 2014, EPA concluded that due to data anomalies associated with organic sample data collected during the 2011 VAS event were of unknown quality and could not be used for making investigative decisions. The affected data included results for groundwater and soil samples analyzed for VOCs, SVOCs, and PCBs from VAS locations VAS-01 through VAS-25 and two private wells. SulTRAC evaluated the available remaining data, including VAS data from the 2013 VAS event (Section 1.4.1.2), available quarterly monitoring well data (Section 1.4.3) and historical sample data. This evaluation was intended to determine what additional data would be required to support selection of monitoring well locations and fill in any remaining data gaps resulting from the affected analytical laboratory data.

Based on this evaluation, SulTRAC mobilized to the site in August 2014 to advance a total of 10 additional VAS locations (identified as VAS-GW38 through VAS-GW47). Nine of the 10 locations were selected to attempt to recreate the analytical data from the 2011 VAS sampling event, and one location (VAS-GW44) was selected to investigate the potential western boundary of contamination. Groundwater samples were collected from the water table and from 10-foot intervals thereafter until the desired depth was reached, which varied from 74 to 80 feet bgs, and resulted in seven groundwater samples per location.

1.4.2 Monitoring Well Installation

In June 2013, SulTRAC installed 22 single or nested permanent monitoring wells at 11 locations throughout the Lane Street Site to further evaluate the groundwater contaminate plume boundaries. These newly installed monitoring wells were installed to monitor seasonal variation and movement of groundwater contamination at the Lane Street Site through quarterly sampling events. Locations of the monitoring wells were selected in consultation with EPA and IDEM and were based on the 2011 VAS event data (at the time, there was no reason to question analytical laboratory data and the data were used for decision making purposes). Additionally, monitoring well locations were supported by the analytical

results for samples collected from Roberts wells through 2013, as well as VAS sample results in 2014. The location of these monitoring wells is presented on Figure D-1-3.

1.4.3 Quarterly Groundwater Monitoring Sampling

SulTRAC conducted quarterly groundwater sampling to monitor seasonal variation and movement of groundwater contamination at the site. SulTRAC combined the 22 newly installed monitoring wells with 22 wells installed by Roberts to create the Lane Street Site monitoring well network for the quarterly sampling events. Table D-1-2a and Figure D-1-3 present the Lane Street Site monitoring well network.

A total of four rounds of groundwater sampling events were conducted in October 2013, January 2014, April 2014, and July 2014. A total of 176 groundwater samples were collected over the four rounds of groundwater sampling. In addition, four groundwater samples were collected from three private wells located at Property 1, Property 2, and Property 6.

The groundwater samples collected from monitoring well network were submitted to off-site CLP laboratories for VOC analysis. Of the 176 samples collected, five were analyzed for SVOCs, four for PCBs, and 13 for TAL metals (total and dissolved) by the CLP laboratory. Private well groundwater was analyzed for VOCs only.

In addition to the chemical parameters specified above, SulTRAC submitted 10 representative groundwater samples from the October 2013 groundwater sampling event for analysis of monitored natural attenuation (MNA) parameters. The MNA parameters included: dissolved gases (methane, ethane, ethylene [MEE]), sulfate, total sulfides, ferrous iron, total organic carbon (TOC), alkalinity, nitrates, nitrites, and the presence of *Dehalococcoides ethenogenes* (DHC), the microbe that degrades chlorinated VOCs.

1.4.4 Soil Vapor Sampling

SulTRAC conducted field activities to assess whether groundwater contamination at the Lane Street site is contributing to vapor intrusion (VI) in overlying residences and businesses. Eleven soil vapor probes were installed in August 2013 (identified as SV-01 through SV-06 and SV-08 through SV-12). The locations are presented on Figure D-1-5. SulTRAC returned to the site on October 16 and 18, 2013, to collect soil vapor samples from the 11 soil vapor sampling ports.

Additionally, three sub-slab soil vapor samples, and one outdoor air ambient sample were collected in August 2014 at the Hadley Facility (2503 Marina Drive) located in the industrial area above the highest concentrations of the TCE plume. These sub-slab soil vapor samples were collected by Rose & Westra, Inc. (Rose & Westra), as a contractor for Hadley Products Corporation. (It should be noted that a fourth sub-slab soil vapor sample [SV-04] was also to have been collected [see Figure D-1-6]. However, a soil vapor sample was unable to be collected at location SV-04) (Rose & Westra 2014).

Soil vapor sampling results are further discussed in Section 1.5.

1.5 NATURE AND EXTENT OF CONTAMINATION

This section summarizes the nature and extent of contamination at the Lane Street Site in media with potentially complete exposure pathways to human receptors. However, the reader should refer to Section 5.0 of the RI report for a more comprehensive presentation and analysis of nature and extent of contamination at the site. The nature and extent of contamination is summarized below for soil, soil vapor, and groundwater. Contaminant results were compared in the RI with medium-specific project action levels (PAL) to describe the nature and extent of contamination at the Lane Street Site.

1.5.1 Groundwater

Groundwater samples were collected from VAS locations, private water wells, and permanent monitoring wells. Many monitoring wells had nested wells screened in different geologic intervals, with up to four wells per location. Generally, both Roberts and SulTRAC wells groundwater monitoring wells had the following sampling intervals: super shallow (ss) (0 to 10 feet bgs), shallow (s) (10 to 20 feet bgs), intermediate (i) (20-30 feet bgs), and deep (d) (more than 35 feet bgs). Additional sampling intervals applicable to only a few wells include: intermediate upper (iu) (Note: upper is above the shallow interval) and intermediate shallow (is).

- The primary COIs for the Lane Street Site are VOCs. All groundwater samples were analyzed for VOCs.
- Four monitoring wells (R-MW-14i, MW-10ss, MW-06i, and MW-02i) (selected where VOC contamination was prominent) from the Lane Street Site monitoring well network were sampled and analyzed for SVOCs, PCBs, and total and dissolved metals. Monitoring well R-MW-11d was also sampled for SVOCs. Additionally, four other monitoring wells (MW-01i, MW-11s, R-MW-07i, and R-MW-07s) were also sampled for total metals.
- No SVOCs exceeded the PAL in the four monitoring wells sampled except for bis(2-ethylhexyl)phthalate in October 2013. Bis(2-ethylhexyl)phthalate exceeded the PAL of 5.6 µg/L, at a concentration of 11 µg/L, in the sample collected from well MW-02i at 30 feet bgs in

October 2013. Bis(2-ethylhexyl)phthalate was not detected above PAL in the subsequent April 2014 sampling event. Also, bis(2-ethylhexyl)phthalate is considered a common laboratory contaminant (EPA 1989). Based on these results, SVOCs have been considered as not present in groundwater.

- No PCBs exceeded the PAL in the four monitoring wells sampled. Based on these results, PCBs have been considered as not present in groundwater.

- No total or dissolved metal concentrations exceeded their PALs in the monitoring wells sampled, except for arsenic and manganese in October 2013. The maximum dissolved arsenic concentration was 8.4 µg/L detected at well R-MW-14i (26 feet bgs) located in the intermediate groundwater zone. The maximum total arsenic concentration was 8.6 µg/L detected at well MW-10ss (11 feet bgs) located in the shallow groundwater zone. The maximum dissolved manganese concentration was 1,830 µg/L and the maximum total manganese concentration was 1,810 µg/L, detected at well MW-10ss (11 feet bgs) in the shallow groundwater zone. The PALs for arsenic and manganese are 0.052 µg/L and 320 µg/L, respectively. Based on site history, it was concluded that metals are not site related.

- Nine monitoring wells were sampled for analysis of 1,4-dioxane. Monitoring wells were selected for sampling at locations in the core of the plume in addition to residential monitoring well locations (downgradient), and a single upgradient monitoring well location. The sample locations include MW-01d, MW-01i, MW-02d, MW-02i, MW-03i, R-MW-7i, R-MW-10-iu, R-MW-12i, and R-MW-13s. No concentrations in any of the groundwater monitoring wells were above the PAL. Based on these results, 1,4-dioxane has been considered as not present in groundwater above the PAL.

- Three groundwater samples were collected from private wells at Property 1, Property 2, and Property 6. No concentrations in any of the groundwater samples were above PALs. However, Vacant Property 2 exhibited a cis-1,2-DCE concentration of 31 µg/L above the tapwater regional screening level (RSL) (target hazard quotient [THQ]=0.1) of 3.6 µg/L. This detection was carried through the risk screening process, as described in Section 2.2.

1.5.2 Distribution of COIs in Groundwater

This section discusses the distribution of VOCs in the super shallow, shallow, intermediate, and deep ground water zones. Table D-1-2b displays the groundwater sampling location specific to each zone. Analytical results for VOCs are presented in Table 5.3.1 of the RI.

- Super shallow groundwater generally based on data from monitoring wells or VAS screened between 0 and less than10 feet bgs. Three wells and one VAS location were screened in the super shallow zone. Concentrations of 1,1-DCA, cis-1,2-DCE, PCE and TCE did not exceed the screening levels in the super shallow groundwater zone.

- Shallow groundwater generally based on data from monitoring wells or VAS screened between above 10 and below 20 feet bgs. Twenty wells and 19 VAS were screened in the shallow zone. 1,1-DCA did not exceed screening levels in shallow groundwater, but cis-1,2-DCE exceeded the screening level at only one location, R-MW-14iu, in the center of the industrial area. PCE was detected at concentrations exceeding the screening level in the northeast portion of the site (MW-10ss, MW-10s and R-MW-13s) at approximately 11 to 13 feet bgs. TCE was detected at

concentrations that exceeded the screening level in shallow groundwater in the center of the industrial area (R-MW-7s, R-MW-11is, R-MW-11iu, R-MW-12s, R-MW-14is, and R-MW-14iu). TCE was also detected at concentrations that exceeded the screening level in the residential area (MW-02s and VAS-GW41) and the northeast portion of the site (MW-10ss, MW-10s, R-MW-13s, VAS-GW31, VAS-GW34, and VAS-GW36).

- Intermediate groundwater generally based on data from monitoring wells or VAS screened between above 20 and 35 feet bgs. Thirteen wells and 29 VAS were screened in the intermediate zone. 1,1-DCA was detected at concentrations exceeding the screening level in the intermediate groundwater zone in the residential area (VAS-GW27, VAS-GW38, VAS-GW41, and MW-01i). Cis-1,2-DCE exceeded the screening level, primarily in the center of the industrial area, but extends southwest into the residential area, with the highest concentration at MW-02i (370 µg/L). PCE was not detected at concentrations exceeding the screening level in the intermediate groundwater zone. TCE was detected at concentrations that exceeded the screening level in intermediate groundwater that extends from the northeast portion of the site (VAS-GW34, MW-10ss, MW-10s, and R-MW-13s) to the residential area of the site (VAS-GW38 and VAS-GW41). The highest concentrations were detected in the center of the industrial area (R-MW-11i, R-MW-12i, R-MW-14i, MW-06i, VAS-GW29, and VAS-GW45).

- Deep groundwater based on data from monitoring wells or VAS screened below 35 feet bgs. Eight wells and 90 VAS were screened in the deep zone. 1,1-DCA did not exceed the screening level in deep groundwater, but cis-1,2-DCE exceeded the screening level, primarily in the center of the industrial area (R-MW-12d, VAS-GW43, and VAS-GW45), with a detected concentration of 40 µg/L at VAS-GW38. PCE was not detected at concentrations that exceeded the screening level in deep groundwater. TCE was detected at concentrations that exceeded the screen level in deep groundwater at VAS locations that extended from the center of the industrial area of the site (VAS-GW43 and VAS-GW45) to the residential area of the Lane Street Site (VAS-GW38 and VAS-GW41). No TCE concentrations exceeded the screening level in groundwater deeper than 40 feet bgs.

1.5.3 Soil

Eleven soil samples were collected by SulTRAC during the 2011 VAS event and one sample was collected during the 2013 VAS event. The Lane Street Site is predominantly a site where groundwater is contaminated by VOCs. However, soil samples were also collected for analysis of VOCs, SVOCs PCBs, and total metals. Due to data anomalies associated with some analytical laboratory data discovered in 2014, it was determined that organic data collected during the 2011 sampling event were of unknown quality and could not be used for making investigative decisions.

- The single surface soil sample (0 to 2 feet bgs) collected by SulTRAC in June 2013 (see Figure D-1-4) did not have concentrations of VOCs that exceeded screening levels or laboratory detection limits.

- At the 11 VAS locations (see Figure D-1-4) sampled for analysis of metals, arsenic was the only metal above the screening level and was detected in all sample locations. Based on site history, it was concluded that metals are not site related.

- As discussed in Section 1.3, IDEM collected soil samples at nine locations during the initial site investigation in 2008 in an attempt to locate a source area. Additionally, Roberts also collected 94 soil samples in the southwestern portion of the former Flexsteel property. No VOCs in either of these historical sampling events were detected above screening levels.

1.5.4 Soil Vapor VOC Results

Soil vapor samples were collected from 11 soil vapor sampling ports installed in August 2013 (see Figure D-1-5). All samples were analyzed by a subcontracted laboratory for VOCs. The primary reason soil vapor was sampled and analyzed was to investigate whether VOCs are emanating from the VOC plume and are volatizing into unsaturated subsurface soils and potentially into buildings. Based on the results, the main COI, TCE, was not detected at levels exceeding the screening values. Chloroform, dichlorodifluoromethane, and PCE were detected above screening values from sampling points located in the current commercial/industrial area. The results where specific analytes exceeded screening values (EPA 2014e) are discussed below.

- Chloroform. The concentration at one soil vapor sampling location (SV-03) was 19 micrograms per cubic meter ($\mu g/m^3$) for chloroform, above the residential screening level of 1.2 $\mu g/m^3$.
- Dichlorodifluoromethane. The concentration at one soil vapor sampling location (SV-04) was 2,080 $\mu g/m^3$ for dichlorodifluoromethane, above the residential screening level of 1,000 $\mu g/m^3$. SV-04 is located in the current industrial/commercial area. The vapor intrusion screening level (VISL) for commercial exposure is 4,400 $\mu g/m^3$. Dichlorodifluoromethane is also known as Freon-12, a common refrigerant, and may be an anomalous detection.
- PCE. The concentration at one soil vapor sampling location (SV-01) was 344 $\mu g/m^3$ for PCE, above the residential screening level of 110 $\mu g/m^3$. SV-01 is located in the current industrial/commercial area. The VISL for commercial exposure is 470 $\mu g/m^3$.

Three sub-slab soil vapor samples and one outdoor air ambient sample were collected in August 2014 at the Hadley Facility (2503 Marina Drive) located in the industrial area right above the core of the TCE plume (ref report) (see Section 1.4.4). No VOC concentrations exceeded screening levels.

1.6 POTENTIAL FATE AND TRANSPORT PROCESSES

This section summarizes potential fate and transport processes at the Lane Street Site that are relevant to human receptor exposure. The reader should refer to Section 6 of the RI report for a more comprehensive presentation and analysis of the potential fate and transport processes at the Site.

Understanding the contaminants present and their fate and transport processes is fundamental to development of a CSM. Constituent fate and transport are influenced by physiochemical properties of constituents, as well as site physical features. This section summarizes the expected fate and transport

processes and migration routes at the Lane Street Site that are relevant to potentially complete exposure pathways identified in the human health CSMs (see Figure D-2-1).

As discussed in Section 1.0, the source of the Lane Street Site groundwater plume or plumes is unknown, although it is expected to be within the industrial area based on chemical usage and measured concentrations in groundwater.

The primary contamination associated with the Lane Street Site is VOCs in groundwater. The most frequently found COI identified in the RI is TCE. Additional primary COIs include 1,1-DCA, cis-1,2-DCE, and PCE. PCE was generally detected only in the upper northeastern industrial area, while the remaining COIs were detected in both the industrial and residential plumes. PCE in soil vapor was also detected above screening level in the northeastern portion of the industrial area, as identified in Section 1.5.

Based on the physiochemical properties of the primary contaminant groups and the physical conditions at the site (including the primary affected medium, groundwater), the secondary contaminant release and transport mechanisms at the Lane Street Site include:

- Volatilization from groundwater to soil gas (in some cases through preferential pathways)
- Volatilization from groundwater through soil gas to indoor air (expected to be limited [see Section 2.1.1])
- Sorption and diffusion within groundwater in low-permeability subsurface soil zones
- Irrigation (and possibly related activities such as filling a "kiddie pool" or washing a car) using contaminated groundwater from private hand-driven wells.

Key factors influencing fate and transport of each VOC are its water solubility, volatility (vapor pressure and Henry's law constant), affinity for organic carbon as indicated by its K_{OC} or octanol-water partitioning coefficient (K_{OW}), and potential for adsorption (partition coefficient [K_d]).

Mobility of contaminants from soil to groundwater depends on chemistry conditions in the soil (soil pH and the presence of dissolved organic matter or metal oxides) and physiochemical properties of the environment (such as soil permeability, porosity, bulk density, particle size distribution, and extent and connectivity of fractures). Generally, soluble forms of contaminants tend to be more mobile, whereas other forms may adsorb to sediments or soils. The higher a chemical's water solubility, the more likely it is to dissolve in and be mobile in the groundwater.

VOCs present in groundwater may volatilize and move (sometimes through an intermediate migration through soil gas) into ambient or indoor air (including air within confined spaces such as a utility or construction trench). Typically, potential exposure to volatile constituents in ambient air is very small compared with potential exposure to the same volatile constituents in indoor air. Therefore, potential exposure to ambient air contaminated by underlying groundwater was not quantitatively evaluated in the HHRA.

The fate and transport of the four VOCs identified as COIs in the RI (PCE, TCE, cis-1,2-DCE, and 1,1-DCA) can be summarized as (1) denser than water and will sink to the bottom of the aquifer and (2) subject to reductive dechlorination by microorganisms.

1.7 RISK ASSESSMENT EXPOSURE AREAS

The Lane Street Site was subdivided into two primary exposure areas (EAs) to conduct the HHRA, primarily according to current and potential future land use within the site boundary (see Figure D-1-7):

- Industrial Area (central and northeastern portion of the site), consisting of a central TCE plume and northeastern PCE plume –EA 1
- Residential Area (southwest portion of the site), consisting of a single groundwater plume -- EA 2

1.8 DOCUMENT ORGANIZATION

The content and organization of the remainder of this comprehensive risk assessment document are as follows:

- ***Section 2.0:*** HHRA
- ***Section 3.0:*** SLERA
- ***Section 4.0:*** Risk Assessment Summary and Conclusions
- ***Section 5.0:*** References

Portions of the RI report relevant to the evaluation of risks are summarized in this appendix; however, potential risks should be viewed in the full context of the RI report. Therefore, the reader should refer to the RI report for a more comprehensive presentation and analysis of the site-specific information and data

2.0 HUMAN HEALTH RISK ASSESSMENT

The HHRA conservatively characterizes risks to hypothetical human receptors potentially exposed to constituents detected in environmental media at two exposure areas at the Lane Street Site. As described in Section 1.7, the exposure areas are designated as follows: (1) industrial area, and (2) residential area. The exposure areas are shown on Figure D-1-7.

The objectives of the HHRA were as follows:

- To evaluate whether site-related constituents detected in environmental media pose potentially unacceptable risks to potential current and future human receptors under conditions at the time of the RI (unremediated conditions)
- To provide information to support decisions regarding need for further evaluation or action based on current and reasonably anticipated (or hypothetical) future land use.

Consistent with standard risk assessment practice and EPA guidance, this HHRA includes the following components:

- ***Data Evaluation and Selection of chemicals of potential concern (COPCs):*** The analytical data used in the HHRA are summarized from the RI report. Summary statistics for each human health exposure area are presented. COPCs in environmental media are identified through comparisons of maximum detected concentrations with conservative, risk-based screening levels.
- ***Exposure Assessment:*** Current and reasonably anticipated future land use scenarios under which exposure to site-related constituents could occur are qualitatively discussed for each exposure area. (Note: in some instances, future land use scenarios not reasonably anticipated were assumed and quantitatively evaluated in this HHRA to support the evaluation of risk management measures during the feasibility study [FS]). A set of exposure assumptions is developed to quantitatively evaluate each land use scenario by calculating current and future risks. Medium-specific EPCs are developed for each COPC in each human health exposure area, and conservative estimates of the intake of each COPC by each receptor through the selected pathways are calculated.
- ***Toxicity Assessment:*** The dose-response characteristics of carcinogens (including mutagens) and noncarcinogens are described and toxicity values for each COPC are presented.
- ***Risk Characterization:*** The information provided by the exposure and toxicity assessments is combined for each receptor and exposure scenario to yield quantitative risk estimates that characterize the relationship between hypothetical exposures and potential toxicity. Estimates of potential theoretical excess cancer risks and non-cancer hazards are provided and discussed, both qualitatively and quantitatively. Uncertainties associated with the risk assessment are also discussed.

Risk management is a separate step, when the magnitude of potential risks and the necessity of corrective actions to mitigate those risks are evaluated. Risk management measures, including remedial action objectives (RAO), will be addressed as part of the FS.

The remainder of Section 2.0, Human Health Risk Assessment, is organized as follows:

- ***Section 2.1:*** HHRA Conceptual Site Model
- ***Section 2.2:*** Data Evaluation and COPC Selection
- ***Section 2.3:*** Human Health Exposure Assessment
- ***Section 2.4:*** Human Health Toxicity Assessment
- ***Section 2.5:*** Human Health Risk Characterization
- ***Section 2.6:*** HHRA Uncertainty Assessment
- ***Section 2.7:*** HHRA Summary and Conclusions.

The exposure pathways and receptors, exposure variables, and toxicity values are presented in tabular form in accordance with the standard tables of *Risk Assessment Guidance for Superfund* (RAGS) Part D (EPA 2001). All RAGS Part D Tables are presented in Attachment D-1. A list of HHRA attachments is provided in the Table of Contents.

2.1 HHRA CONCEPTUAL SITE MODEL

The Lane Street Site was subdivided into two exposure areas to conduct the HHRA, primarily according to current and potential future land use. The EAs are identified in Section 1.7 and shown in Figure D-1-7.

This section presents the CSMs for human receptors at the Lane Street Site. The CSM identifies potentially complete exposure pathways by which receptors could come in contact with site-related constituents in groundwater. The CSM is used throughout the site investigation and remediation processes to (1) provide a framework for addressing potential risks, (2) evaluate the need for additional data acquisition, and (3) quantify health risks and evaluate the need for corrective measures.

As defined in RAGS Part A (EPA 1989), the following four elements are necessary to form a complete exposure pathway:

- A source or release from a source
- A mechanism of release and transport
- A point of contact for potential receptors
- An exposure route.

If any one of the four elements is missing, the exposure pathway is incomplete. In general, only potentially complete exposure pathways were evaluated in the HHRA. However, in some instances, exposure pathways not reasonably anticipated to be complete were assumed and quantitatively evaluated to provide support for evaluation of risk management measures during the FS.

The first two elements (a source, or a release from a source and a mechanism of release and transport) were discussed in Section 1.0. Briefly, IDEM conducted site visits at facilities in the industrial park north of Lane Street in April and September 2008 and found at least three facilities that have stored or used hazardous substances. However, insufficient information was available to evaluate whether releases from these facilities contribute to the groundwater plumes associated with the Lane Street Site (EPA and IDEM 2009). As many as eight other facilities are within the Lane Street Site study area that was investigated to evaluate their potential impacts.

The remaining two elements of the CSM — potential receptors' exposure points and exposure routes — are described in the following subsections. The Lane Street Site human health CSM is diagrammatically presented on Figure D-2-1 and is summarized in the RAGS Part D Table 1 in Attachment D-1.

2.1.1 Potential Receptors and Exposure Points

Current and future receptors reasonably anticipated or assumed exposed to site-related constituents in environmental media were identified based on the information presented in Section 1.2 and are described below for the Lane Street Site.

These receptors are described are described below and summarized in Table 1 of Attachment D-1:

- ***Current/Future Resident:*** A single residence (Property 6) currently uses a private groundwater well as a source of potable drinking water. However, no COPCs were identified. Therefore, there is no exposure to contaminated groundwater to a current residential receptor. On the other hand, future residents are assumed to use contaminated site groundwater as a source of potable water (ingestion, bathing, and other household uses). Future residents may also be exposed to volatile contaminants in groundwater released from use of potable groundwater.

  Current and future residents may also be exposed via inhalation of VOCs which have migrated into indoor air via the VI migration pathway. However, the potential for VI is expected to be limited to the northern part of EA 1, in the area of the PCE Plume based on an evaluation of historical, RI, and private sampling investigations as summarized below. The discussion is organized by (1) comparison of groundwater concentrations to EPA VISLs, (2) characterization of limited VOCs in the super shallow groundwater zone, and (3) evaluation of soil vapor and indoor air sample results.

1. Comparison of Groundwater Concentrations to EPA VISLs

The maximum detected concentrations in groundwater (any depth) in EA 1 (both PCE and TCE Plumes) and EA 2 were compared to EPA groundwater-based VISLs (based on an average groundwater temperature of 15°C [average groundwater temperature for the Lane Street Site]) (EPA 2014e).

- EA 1 (PCE Plume) – the maximum detected concentration of PCE (120 µg/L) exceeded both the residential (26 µg/L) and the commercial (110 µg/L) VISLs. Similarly, the maximum detected concentration of TCE (40 µg/L) exceeded both the residential (2.0 µg/L) and commercial (12 µg/L) VISLs.

- EA 1 (TCE Plume) – the maximum detected concentration of chloroform (8.5 µg/L) exceeded both the residential (1.3 µg/L) and commercial (5.5 µg/L) VISLs. However, the summed concentration of all trihalomethanes (including primarily chloroform, bromodichloromethane, and dibromochloromethane) is well below the EPA maximum contaminant level (MCL) of 80 µg/L) (EPA 2014f). Chloroform may not be associated with site groundwater contamination and may be related to a release of chlorinated drinking water. Also, the maximum detected concentration of TCE (320 µg/L) exceeded both the residential (2.0 µg/L) and commercial (12 µg/L) VISLs.

- EA 2 – the maximum detected concentrations of bromodichloromethane (1.9 µg/L) exceeded the residential (1.5 µg/L) VISL. Similarly, the maximum detected concentration of chloroform (4.3 µg/L) exceeded the residential (1.3 µg/L) VISL. As noted above for EA 1 (PCE Plume), the total trihalomethanes concentration at EA 2 is well below the EPA MCL for total trihalomethanes and these compounds may be related to a release of chlorinated drinking water. Finally, the maximum detected concentration of TCE (89 µg/L) exceeded both the residential (2.0 µg/L) and commercial (12 µg/L) VISLs.

These results suggest that PCE and TCE may be present in EA 1 at the PCE Plume (both PCE and TCE) and at the TCE Plume (TCE only) and TCE may be present in EA 2 at groundwater concentrations that could result in potentially unacceptable indoor air concentrations.

2. Characterization of Limited VOCs in the Supershallow Groundwater Zone in EA 1

Three wells (MW-10SS, R-MW-12SS, and R-MW-14SS) and one VAS location (VAS-34) were screened and sampled during the RI in the supershallow (-SS) groundwater zone. Concentrations of VOCs, including 1,1-DCA; cis-1,2-DCE; PCE; and TCE, did not exceed groundwater-based residential and commercial EPA VISLs, based on a groundwater temperature of 15 °C (EPA 2014e).

Well R-MW-7SS, was sampled by Roberts in 2013, with a TCE concentration of 5.3 µg/L, which exceeded the residential (2.0 µg/L) VISL (EPA 2014e).

These results suggest a layer of "clean" or less contaminated layer of supershallow groundwater is present over at least some portions of EA 1. Such a layer is expected to limit or eliminate the potential for VI from more highly contaminated deeper groundwater.

3. Evaluation of soil vapor and indoor air sample results

VOCs in soil vapor and indoor air samples have been found at concentrations above screening levels only at limited locations based on historical, RI, and private sampling results

- In December 2007, 24-hour indoor air samples were collected in two residences in EA 2 where elevated TCE concentrations had been detected in groundwater. TCE, PCE, and vinyl chloride were not detected at either residence (Weston 2008)

- As part of the RI, soil vapor samples were collected at 11 locations in EA 1 (SV-01 through SV-05) and EA 2 (SV-06 and SV-08 through SV-12) (see Figure D-1-5). No VOCs were detected above VISL-based screening levels (residential and commercial) in EA 2.

  PCE was measured at 344 $\mu g/m^3$ at SV-01 (at the PCE Plume in EA 1). This concentration exceeded the residential VISL of 110 $\mu g/m^3$, but is less than the commercial VISL of 470 $\mu g/m^3$ (EPA 2014e).

  Chloroform was detected at 19 $\mu g/m^3$ at SV-03 (at the TCE Plume in EA 1). This concentration exceeded the residential VISL of 1.2 $\mu g/m3$, but is less than the commercial VISL of 5.3 $\mu g/m^3$. However, as noted above under item 1, chloroform may not be associated with site groundwater contamination and may be associated with a release of chlorinated drinking water.

  Finally, dichlorodifluoromethane (Freon 12) was detected at 2,080 $\mu g/m^3$ at SV-04 (at the TCE Plume in EA 1). This concentration exceeded the residential VISL of 1,000 $\mu g/m^3$, but is less than the commercial VISL of 4,400 $\mu g/m^3$. However, as discussed in Section 1.5, Freon 12 is a common refrigerant, is not associated with site groundwater contamination, and may be an anomalous detection.

- Three sub-slab soil vapor and one outdoor ambient air sample were collected in 2014 at the Hadley Facility (2503 Marina Drive) above the TCE Plume in EA 1. No VOC concentrations exceeded residential or commercial VISLs.

These results, along with consideration of the preceding groundwater results, indicate that the potential for exposure to indoor air impacted by VI at potentially unacceptable concentrations appears to be limited to residents in EA 1 at the PCE Plume area. No residents are currently present in EA 1, which is used entirely for commercial and industrial purposes under current conditions. Therefore, potential unacceptable exposure via the VI migration pathway is expected to be limited to future residents in EA 1 at or near the PCE Plume.

- ***Current/Future Industrial/Commercial Worker:*** Currently, five industrial/commercial properties (Property 1 through Property 5) are not connected to municipal water and rely on private groundwater wells as a source of potable drinking water (see Figure D-1-2). However, three of the facilities (Properties 2, 3, and 4) are currently vacant. Additionally, Property 1 does not currently use private well water as a source of potable water or have identified COPCs, and Property 5 (not sampled because access could not be obtained) is located along the western boundary of the Site where monitoring well data also do not identify any COPCs in groundwater. Therefore, the current exposure to groundwater pathway for current industrial/commercial workers is considered incomplete and will be evaluated qualitatively. On the other hand, future industrial/commercial workers are assumed to be exposed to

contaminated site groundwater through use of potable water (ingestion, washing hands, and other domestic uses), and process water (washing RVs and parts).

As noted above under current/future resident, potential exposure via VI is expected to be limited for both current and future industrial/commercial workers.

- ***Current/Future Construction and Utility Workers*:** Current and future construction workers and utility workers could be exposed to site-related constituents in groundwater while performing short-duration construction related to possible redevelopment or utility maintenance. Construction and utility workers are expected to be exposed to contaminants in shallow groundwater via dermal contact as well as via inhalation of volatile constituents in groundwater that migrate from groundwater into trench air.

2.1.2 Potential Exposure Routes

The exposure routes quantitatively evaluated for the various exposure scenarios described in Section 2.1.1 are described below.

The exposure routes that were considered either quantitatively or qualitatively in the HHRA for the various exposure scenarios described in Section 2.1.1 include the following:

- ***Current/Future Resident:*** There is no current residential exposure to site contaminated groundwater. Future residents in EA 1 and EA 2 may be exposed to site-related contaminants in groundwater via ingestion of, dermal contact with, and inhalation of VOCs released from potable groundwater use. As presented in detail in Section 2.1.1, future residents in the northeastern portion of EA 1, as indicated by soil vapor results at SV-01, may also be exposed via inhalation of volatile contaminants that have migrated from groundwater through soil gas to indoor air via vapor intrusion. This VI exposure will be evaluated qualitatively.
- ***Current/Future Commercial/Industrial Worker:*** There is no current commercial/industrial worker exposure to site contaminated groundwater. Future commercial/industrial workers in EA 1 and EA 2 may be exposed to site-related contaminants in groundwater via ingestion of, dermal contact with, and inhalation of VOCs released from potable groundwater use. Additionally, if current operations were to continue in the future at Property 1, commercial/industrial workers may also be exposed to groundwater via dermal contact with process water (RV and parts washing). Finally, as noted above in Section 2.1.1, potential exposure via VI is expected to be limited. Any VI exposure will be evaluated qualitatively.
- ***Current/Future Construction and Utility Worker:*** Current and future construction workers may be exposed to site-related contaminants through groundwater seeping into trenches and inhalation of volatile chemicals inside construction/utility trenches.

2.2 DATA EVALUATION AND COPC SELECTION

The section presents the HHRA data sets (summarized from the RI report), describes the approaches for data evaluation and screening, and presents the COPCs for each exposure area at the Lane Street Site. Only analytical data obtained during the RI were evaluated in the HHRA. These data are considered the most up-to-date available and provide reasonable geographic coverage. It was conservatively assumed

that conditions at the time of the RI (unremediated conditions) are representative of current and future conditions.

2.2.1 HHRA Data Sets

As discussed in Section 1.4, the HHRA data set is based on available medium-specific analytical results collected during multiple sampling events associated with the Phase I RI at the Lane Street Site. These sampling events have resulted in the collection and analysis of numerous groundwater, in addition to soil and soil vapor samples as summarized in Section 1.4. Medium-specific analytical results for the Lane Street Site are presented in a series of summary tables (Tables 5-1 through 5-12) in the RI report. Additional details regarding each medium-specific data set are discussed below.

Soil

As summarized in Sections 1.3 (historical investigations) and 1.4 (RI), no VOCs were detected above laboratory detection limits. Also, as discussed in Section 1.5, metals detected in site soils are not considered to be site-related. Therefore, soil data were not considered further in the HHRA.

Groundwater

Groundwater samples were collected during numerous sampling events during the RI. These groundwater samples were collected as VAS and groundwater samples from permanent Roberts and SulTRAC monitoring wells. All RI groundwater samples were considered in the HHRA, with the exception of the affected data, as discussed in Section 1.4.1.1.

On- and off-site monitoring well locations are shown on Figure D-1-3.

Soil Vapor

All RI soil vapor results were considered in the HHRA.

Additionally, three sub-slab soil vapor samples, and one outdoor air ambient sample were collected at the Hadley Facility in August 2014 (see Section 1.4.4). After review and validation of the data, it was determined by SulTRAC, in consultation with EPA, that the data were usable and thus considered in this HHRA.

Soil vapor sampling locations are shown on Figures D-1-5 and D-1-6.

2.2.2 Data Evaluation

This section summarizes the procedures used to validate the analytical data, the constituents excluded from quantitative evaluation, and the procedures used to address duplicate samples.

Data Validation

Data were evaluated based on completeness, holding times, initial and continuing calibrations, surrogate recoveries, internal standards, compound identification, laboratory and field quality assurance/quality control (QA/QC) procedures and results, reporting limits (RL), documentation practices, and application of validation qualifiers (EPA 1992). Rejected (R-qualified) data were not included in screening or risk estimation. Censored values (U- or UJ-qualified values) were assigned the reported RL. Uncertainties associated with the inclusion or exclusion of data based on the assigned data qualifiers are discussed in the uncertainty section.

Constituents Excluded from Quantitative Evaluation

Analytical data results from the MNA evaluation (MEE, sulfate, total sulfides, ferrous iron, TOC, alkalinity, nitrates, nitrites, and DHC) were excluded from this HHRA. In addition, non-VOC constituents were not evaluated quantitatively in this HHRA. Although metals (such as arsenic), were present in soils and groundwater, they are not considered site-related contaminants. In accordance with EPA Superfund guidance, calcium, magnesium, potassium, and sodium were also eliminated from further quantitative evaluation because they are classified as essential nutrients (EPA 1989).

Duplicate Sample Data

During the RI, field duplicate samples were collected at several of the sampling locations to be evaluated in the HHRA. Before data were analyzed (before screening and EPC calculation), duplicate sample results were processed as follows:

- If a constituent was detected in both samples and the relative percent difference (RPD) between the results was less than 25 percent, the average concentration was used.
- If a constituent was detected in both samples and the RPD between the results was more than 25 percent, the maximum concentration was used.
- If a constituent was detected in one sample but not the other, the detected concentration was used.
- If a constituent was not detected in either sample, the average RL (from the duplicate pair) was recorded and used in EPC calculations. EPA's ProUCL Program replaces censored (nondetected) results as appropriate depending on distribution, detection frequency, and other factors for a given data set (see Section 2.3.1).

2.2.3 HHRA Screening Process

This section describes the screening process, including screening levels, background screening, evaluation of infrequently detected constituents, and evaluation of non-detected constituents. Consistent with EPA's approach to selecting chemical constituents for quantitative evaluation, maximum detected concentrations of constituents were compared with conservative screening levels, to identify COPCs.

Screening Levels

If the maximum detected constituent concentration was less than its conservative screening criterion, the constituent was eliminated as a COPC because the constituent will not contribute significantly to overall risk (EPA 1993a). Results that exceed screening levels do not in themselves indicate a potentially unacceptable risk. Rather, these results indicate need for further evaluation in the risk assessment. Screening levels for environmental media at the Lane Street Site are summarized as follows:

- **Groundwater:** Groundwater screening values (for total and dissolved data) for the protection of human health were selected as the minimum of:
    - Federal MCLs (EPA 2015a);
    - EPA tapwater RSLs (EPA 2015a) (based on a target cancer risk of 1E-06 or a hazard quotient [HQ] of 0.1 for non-cancer effects);
    - Residential Groundwater Screening Levels for Selected Chlorinated Compounds (IDEM 2010) (based on 30-year exposure and a depth to groundwater of 5 feet);
    - EPA's Vapor Intrusion Screening Levels (VISL) Calculator (EPA 2014e) (based on a target risk of 1E-06 and a target HQ of 0.1 [GW Temp=15°C]) and site-specific inputs);
    - 2014 IDEM Remediation Closure Guide Screening Levels for Residential Tap groundwater (Table A-6, Appendix A, based on target risk of 1E-05 and a target HQ of 1.0) (IDEM 2014).
- **Soil:** Soil screening values for the protection of human health were selected as the minimum of:
    - EPA residential soil RSLs (EPA 2015a) (based on a target cancer risk of 1E-06 or an HQ of 0.1 for non-cancer effects);
    - 2014 IDEM Remediation Closure Guide Screening Levels for Residential Soil, Direct Contact. Table A-6, Appendix A, based on target risk of 1E-05 and a target HQ of 1.0) (IDEM 2014).
- **Soil Vapor:** Soil vapor screening values for the protection of human health were selected as the minimum of:

- EPA's VISL Calculator (EPA 2014e) (based on a target risk of 1E-06 and a target HQ of 0.1 [groundwater temperature=15°C]) and site-specific inputs);
- IDEM 2010 Residential Sub-Slab, Crawl Space, and Soil Gas Screening Levels for Selected Chlorinated Compounds. Draft Vapor Intrusion Pilot Program Guidance Supplement. (based on a 30-year exposure and an excess cancer risk of 1E-05 or an HQ of 1.0 for non-cancer health effects) (IDEM 2010).

Primary screening criteria were not available for a limited number of constituents detected at the Lane Street Site. Surrogate screening values were therefore selected for these chemicals and documented based on structural similarities, potential toxicity, and health endpoints. Uses of surrogates are documented in the appropriate screening tables. Medium-specific screening levels are listed in Tables D-2-1 through D-2-3.

Background Screening

As described in EPA's RAGS, background screening was a secondary step in the COPC selection process (EPA 1989). However, based on more recent EPA guidance, background screening was not considered in the selection of COPCs (EPA 2002a)..

Evaluation of Infrequently Detected Constituents

The detection frequency, toxicity, and history of detected constituent concentrations were also considered in the identification of COPCs. A chemical was eliminated as a COPC if the following conditions were met: (1) a constituent was detected in less than 5 percent of the samples, (2) the sample size was sufficiently large (greater than 30), and (3) the maximum concentration was (a) less than a screening value based on the construction worker scenario, or (b) less than 10 times the screening value based on the residential scenario. Regardless of detection frequency, constituents classified as "known human carcinogens" (EPA Class A carcinogens) were retained as COPCs.

Evaluation of Non-Detected Constituents

One-half of the maximum RL of a constituent not detected in a given medium was compared with the appropriate screening level to ensure that elevated RLs did not result in inappropriate exclusion of chemicals from further evaluation. These comparisons for the Lane Street Site are discussed as part of the uncertainty discussion (Section 2.6). Results above screening levels were reviewed on a case-by-case basis; no additional COPCs were identified based on the comparisons.

2.2.4 COPC Identification

Summary statistics for detected constituents, their screening levels, and the basis for their selection or exclusion as COPCs are presented in the following Attachment D-1 tables:

- EA 1 – 2.1.1, 2.1.1.P01, 2.1.2, and 2.1.2.P02
- EA 2 -- 2.2.1, and 2.2.1.P06

2.3 EXPOSURE ASSESSMENT

Exposure assessment is the process of measuring or estimating the intensity, frequency, and duration of human exposure to a chemical in the environment. This section describes current and future land use assumptions, characterizes exposure factors for potential receptors, discusses the mechanisms by which these receptors might come in contact with COPCs in environmental media, and estimates the degree of contact between potential human receptors and COPCs. This information is integrated with EPC estimates and intake assumptions to quantitatively estimate exposure (dose). In accordance with EPA guidance, an exposure assessment consists of three basic steps (EPA 1989):

1. Characterization of the exposure setting (physical environment and potential receptors).
2. Identification of exposure pathways (constituent sources, exposure points, and exposure routes).
3. Quantification of pathway-specific exposures (exposure point concentrations [EPC], calculation of receptor intakes, and exposure assumptions).

The first two components are described in detail in Sections 1.2 and 2.1 and diagrammatically presented in the site-specific human health CSM (Figure D-2-1). The third component, *Quantification of Exposures*, is described in the following subsections. Risks were estimated under both a reasonable maximum exposure (RME) scenario and an average or central tendency exposure (CTE) scenario to provide a range of risk estimates for use by risk managers. The RME is estimated by selecting values for exposure variables such that the combination of all variables results in the maximum exposure reasonably expected. The CTE is estimated by selecting values such that the combination of all variables results in the typical (average) exposure that could occur at a site (EPA 1993). The following sections present the methods used to estimate EPCs, the equations used to calculate risk, and the RME and CTE assumptions and their basis.

2.3.1 Exposure Point Concentrations

EPCs were developed for both non-modeling (direct) and modeling scenarios. The approaches used to calculate EPCs under these two scenarios are presented in Sections 2.3.1.1 and 2.3.1.2. Section 2.3.1.3 identifies the locations where medium-specific EPCs are presented.

Non-Modeling (Direct)

Initial selection of the approach for calculating descriptive statistics and EPCs is based on relative sample size, detection frequency, and determination of the best-fit model for describing the underlying distribution of analytical results for each chemical. Results are provided only for chemicals with at least one detected result. The EPC defaults to the maximum detected concentration for chemicals detected fewer than four times in fewer than 10 samples and for chemicals for which the calculated one-sided 95 percent upper confidence limit of the mean (95UCL) exceeds the maximum detected concentration. Nondetected (censored) results that exceed the maximum detected concentration for each chemical are excluded from all analyses but are reported in the summary tables. As discussed in Helsel (2012), these high censored results provide no useful information for calculating the 95UCL, so their exclusion has no effect on estimates provided using the censored methods currently recommended in EPA guidance (EPA 2013b, 2013c, 2013d).

The approach used for calculating EPCs for chemicals with and without censored results followed EPA (2002b) and recommendations offered in EPA's ProUCL 5.0.00 Technical Guide (EPA 2013d). The revised algorithms in ProUCL 5.0 were developed through extensive research into optimal methods for calculating the 95UCL for data with censored results (EPA 2013d).

The 95UCL recommended by ProUCL 5.0 was selected as the EPC if the 95UCL is less than the maximum detected concentration for COPCs with four or more detected values in a data set of at least 10 samples. The 95UCLs calculated by ProUCL 5.0 are based on distribution testing of detected data only. The 95UCL from the appropriate distribution (normal, gamma, lognormal, or nonparametric) was selected for data sets for which ProUCL 5.0 recommended more than one 95UCL. If more than one distribution is identified as appropriate for the data set, ProUCL 5.0 identifies the distribution as most appropriate in the order normal, gamma, lognormal, and nonparametric from most preferred to least preferred (EPA 2013d).

The Kaplan-Meier (KM) product limit estimator was used to estimate the mean for data sets with nondetected values. All recommended 95UCL methods for censored data in EPA (2006, 2013d) are based on the nonparametric KM product limit estimator. The KM approach employs a well-studied method that

has been used in the field of causal analysis for more than 50 years (Kaplan and Meier 1958). The KM estimator is an empirical, nonparametric, maximum likelihood procedure that can be applied to data with multiple reporting or detection limits. Details of the underlying mathematics of the KM model are available from a number of sources (Kaplan and Meier 1958, Meeker and Escobar 1998, Klein and Moeschberger 2003, Lee and Wang 2003, Helsel 2012, EPA 2013d).

Recommendations in EPA (2006, 2013d) were followed for calculating 95UCLs for all chemicals with one or more censored results. The decision rules followed for selecting methods based on the underlying distribution, sample size, degree of skewness, and detection frequency. The ProUCL 5.0 Technical Guidance (EPA 2013d) does not provide a specific decision matrix for selecting an EPC from the possible 95UCLs for censored data similar to that provided for data with all detected results. For this reason, the highest recommended 95UCL appropriate to the data distribution was selected as the EPC for all receptors, with two exceptions. The maximum detected concentration was selected as the EPC for all medium except groundwater for construction and utility workers.

Groundwater involves unique circumstances that complicate calculation of EPCs. Receptors are not expected to be exposed to groundwater from multiple locations across an exposure area. Rather, receptors may ingest groundwater from a single well installed at a particular location or may have direct contact with groundwater in a construction trench at a particular location. As a result, EPCs for groundwater were calculated in accordance with EPA guidance including "Determining Groundwater Exposure Point Concentrations" (EPA 2014b). Three or more wells considered representative of the center of each groundwater "plume" or area of consistent elevated concentrations at each exposure area were identified based on review of the site-specific groundwater analytical results for the evaluation of potential exposure to groundwater at the Lane Street Site. Temporary wells, installed primarily to ascertain the potential for interaction between groundwater and surface water drainage ways at the Lane Street Site, are not generally considered appropriate for use in calculating groundwater EPCs and were not considered in this HHRA (EPA 2014b).

As discussed in Section 1.5, two distinct plumes or areas of consistent elevated concentrations were identified in EA 1 (the Industrial Exposure Area): the PCE plume was identified in the northeast portion of EA 1 and the TCE plume was identified in the south-central portion of EA 1. In contrast, a single area of consistent elevated concentrations was identified for EA 2 (the Residential Exposure Area). The approximate locations of these three plumes or areas of consistent elevated concentrations are shown in Figure D-1-7.

The plume-specific wells representative of the center of each plume or an area of consistent elevated concentrations in EA 2 were identified in two primary steps:

- First, wells associated with each plume or area of consistent elevated concentrations was identified. Table D-2-4 presents the last four rounds of data from the SulTRAC monitoring network, including SulTRAC monitoring wells, SulTRAC VAS wells, and Roberts wells incorporated into the SulTRAC monitoring network. The wells associated with each plume or area of consistent elevated concentrations are as follows (see Figure D-1-7). (Note: the following definitions apply regarding well depths – iu – intermediate upper; ss – super shallow; is – intermediate shallow; s – shallow; I – intermediate; and d – deep):

    - EA 1 – PCE Plume: MW-09s, MW-10 (s,ss), MW-11s, VAS-GW31, VAS-GW32, VAS-GW-33, VAS-GW34, VAS-GW35, VAS-GS-36, VAS-GW-37, and R-MW-13s.

    - EA 1 – TCE Plume: MW-04d, MW-06 (s,i,d), MW-07s, MW-08 (s,i), VAS-GW-29, VAS-GW30, VAS-GW42, VAS-GW43, VAS-GW44, VAS-GW45, VAS-GW46, VAS-GW47, R-MW-3i, R-MW-7 (s,i,d), R-MW-10 (i, iu, is, d), R-MW-11 (i, iu, is, d), R-MW-12 (ss, s, i, d), and R-MW-14 (ss, iu, is, i).

    - EA 2: MW-01i, MW-02 (s, i, d), MW-03i, VAS-GW26, VAS-GW27, VAS-GW38, VAS-GW39, VAS-GW40, and VAS-GW41.

- Second, available analytical results, focusing on the most recent four rounds of data for each analyte detected at least once at a concentration greater than its EPA tapwater RSL, were reviewed for these wells. Four rounds of analytical data were reviewed to assess whether any apparent seasonal variation in concentrations were observed. Table D-2-5 presents the range of analytical results for each well (based on consideration only of the lowest and highest detected concentrations for a series of collocated wells [for example, MW-06s, MW-06i, and MW-06d]).

Based on these two primary steps, the following wells were identified for use in calculating groundwater EPCs for each plume or area of consistent elevated concentrations for each EA at the Lane Street site:

- **EA 1 – PCE Plume**: MW-10 (s, ss), R-MW-13s, and VAS-GW34. The basis for the selection of each of these wells is as follows:

    - MW-10 (s, ss) – highest PCE concentration (exceeding the EPA tapwater RSL [target risk [TR] = 1E-06 and THQ = 0.1] and MCL) and TCE exceeding the EPA tapwater RSL (TR = 1E-06 and THQ = 0.1) and MCL.

    - R-MW-13s – only detection of chloroform (exceeding the EPA tapwater RSL [TR = 1E-06 and THQ = 0.1], but less than the MCL for total halomethanes); second highest PCE concentration (exceeding EPA tapwater RSL [TR = 1E-06 and THQ = 0.1] and MCL); and highest TCE concentration (exceeding EPA tapwater RSL [TR = 1E-06 and THQ = 0.1] and MCL).

    - VAS-GW34 – concentration of PCE exceeding EPA tapwater RSL and MCL and concentration of TCE exceeding EPA tapwater RSL and MCL.

- **EA 1 – TCE Plume**: MW-06 (s, i, d), R-MW-11 (is, iu, i, d), R-MW-12 (ss, s, i, d), R-MW-14 (ss, iu, is, i), and VAS-GW45. The basis for the selection of each of these wells is as follows:

    - MW-06 (s, I, d) – detections of chloroform exceeding the EPA tapwater RSL, but less than the MCL (total halomethanes); second highest cis-1,2-DCE concentration (exceeding EPA tapwater RSL and MCL); and fifth-highest TCE concentration (exceeding the EPA tapwater RSL and MCL).

    - R-MW-11 (is, iu, i, d) – concentrations of cis-1,2-DCE exceeding the EPA tapwater RSL and MCL; third highest TCE concentration (exceeding the EPA tapwater RSL and MCL); detections of 1,1-DCA, methylene chloride, and PCE.

    - R-MW-12 (ss, s, i, d) – concentrations of cis-1,2-DCE exceeding the EPA tapwater RSL and equal to MCL; highest TCE concentration (exceeding the EPA tapwater RSL and MCL); detection of 1,1-DCA.

    - R-MW-14 (ss, iu, is, i) – second highest TCE concentration (exceeding the EPA tapwater RSL and MCL); detections of 1,1-DCA, methylene chloride, and PCE.

    - VAS-GW45 – concentrations of bromodichloromethane exceeding the EPA tapwater RSL, but less than the MCL (total halomethanes); second-highest concentration of chloroform (exceeding EPA tapwater RSL, but less than MCL [total halomethanes]); second-highest concentration of dibromochloromethane (exceeding the EPA tapwater RSL, but less than the MCL [total halomethane]); cis-1,2-DCE concentration exceeding the EPA tapwater RSL and MCL; and detections of 1,1-DCA and PCE.

- **EA 2**: MW-02 (s, i, d), VAS-GW38, and VAS-GW41. The basis for the selection of each of these wells is as follows:

    - MW-02 (s, i, d) -- highest concentration of cis-1,2-DCE (exceeding the EPA tapwater RSL and MCL); second-highest TCE concentration (exceeding the EPA tapwater RSL and MCL).

    - VAS-GW38 – detections of bromodichloromethane (exceeding the EPA tapwater RSL, but less than the MCL [total halomethanes]); detections of chloroform (exceeding the EPA tapwater RSL, but less than the MCL [total halomethanes]); concentrations of cis-1,2-DCE (exceeding the EPA tapwater RSL, but less than the MCL); highest concentration of 1,1-DCA (exceeding the EPA tapwater RSL; no MCL); concentration of TCE exceeding the EPA tapwater RSL, but less than the MCL.

    - VAS-GW41 -- highest concentration of chloroform (exceeding the EPA tapwater RSL, but less than the MCL [total halomethanes]); only detections of dibromochloromethane (exceeding the EPA tapwater RSL, but less than the MCL [total halomethanes]); second-highest concentration of cis-1,2-DCE (exceeding the EPA tapwater RSL and MCL); concentrations of 1,1-DCA (exceeding the EPA tapwater RSL; no MCL); and highest concentration of TCE (exceeding the EPA tapwater RSL and MCL).

No seasonal variations in groundwater contaminant concentrations were observed (see Table D-2-4).

Therefore, consistent with EPA's recent groundwater guidance, exposure area-specific groundwater EPCs

were calculated based on the two most recent rounds of sampling results from each well. A single set of groundwater EPCs was compiled for EA 1 based on the highest COPC-specific EPCs from the PCE and TCE plumes.

As noted above, statistical treatment was not conducted for constituents with fewer than 10 samples and four detected results. In this circumstance, the maximum detected concentration was used as the groundwater EPC. This approach used to calculate groundwater EPCs at the Lane Street Site is conservative. Current and future receptors may not always be exposed in the area of the wells used to calculate exposure area- and depth-specific EPCs. The uncertainty associated with this approach is discussed in the Uncertainty Assessment (Section 2.6).

Documentation for the calculation of direct (non-modeling) EPCs in presented in Attachment D-3.

Modeling

Modeling was used to generate medium-specific EPCs for media not sampled directly. Specifically, modeling was used to estimate EPCs for trench air and indoor air, as discussed below.

Trench Air

Concentrations of VOCs in outdoor air within a construction or utility trench and that have migrated from groundwater were estimated using a methodology developed by the Virginia Department of Environmental Quality (VDEQ) as part of its "Voluntary Remediation Program Risk Assessment Guidance" (VDEQ 2014). This methodology assumes a default trench 3 feet wide, 8 feet long, and 15 feet deep. The methodology's algorithms can be modified depending on the depth to groundwater (greater than or less than 15 feet bgs). Maximum VOC concentrations measured in groundwater at each Lane Street Site exposure area were used as the EPCs because of the limited size of the assumed construction and utility trench; however, this assumption is conservative, as concentrations of VOCs in groundwater were variable. Modeled trench air concentrations for the Lane Street Site are presented in Attachment D-3.

Indoor Air

As discussed in Section 2.1.1, the potential for the migration of groundwater VOCs into indoor air via vapor intrusion is expected to be limited to the PCE plume area in the northern part of EA 1. Soil gas sampling location SV-01 is located within the PCE plume. PCE was measured at this location at a concentration of 344 $\mu g/m^3$. This concentration is less than the EPA VISL soil gas level for industrial/commercial workers of 470 $\mu g/m^3$, but above the VISL soil gas level for residents of

110 µg/m^3. Indoor air concentrations were not modeled based on the limited VI potential at the Lane Street Site. It was judged that such modeling would be associated with a large amount of uncertainty. Instead, potential current and future receptor-specific risks and hazards related to potential VI were estimated using EPA's VISL Calculator (EPA 2014e).

On the other hand, indoor air concentrations resulting from household use of groundwater were estimated using the Andelman Volatilization Factor (K) as illustrated in RAGS D Table 4s for residents and industrial/commercial workers (see Attachment D-1).

Medium Specific EPCs

RAGS D tables presenting medium-specific EPCs for the Lane Street Site are presented in Attachment D-1 (with the exception of construction trench and indoor air EPCs – see Section 2.3.1.2) and are summarized below by medium and exposure area:

Groundwater:

- EA 1 – Table 3.1.1 (PCE Plume), 3.1.1.P01 (Property 1), 3.1.2 (TCE Plume), 3.1.2.P02 (Propety 2), and 3.1.3 (EA-wide, merger of Tables 3.1.1 and 3.1.2)
- EA 2 – Table 3.2.3 (EA-wide) and 3.2.3.P06 (Property 6)

Dose is the quantification of exposure to constituents in environmental media for quantitative risk assessment. The type of dose or exposure estimate used in a risk assessment depends on the route of exposure. Ingested and dermally absorbed doses both are presented in daily dose rates per unit of body weight (milligrams per kilogram per day [mg/kg-day]); "chronic daily intake" (CDI) is the general parameter used to quantify exposure dose for ingestion and dermal contact pathways. Inhalation concentrations are calculated as the amount of constituent per cubic meter of air (milligrams per cubic meter [mg/m^3] or µg/m^3); "chronic daily exposure" (CDE) is the general parameter used to quantify exposure for inhalation pathways. In the risk characterization stage, dose estimates are combined with toxicity criteria to estimate potential risk associated with exposure to COPCs. (Note: Receptor-specific exposure concentrations are used in conjunction with concentration-dependent toxicity factors for the inhalation pathway risk evaluation.)

Age-adjusted ingestion rates and age-adjusted dermal contact rates were used to estimate exposure for scenarios involving receptors 0 to 16 years old. These adjustments account for differences in body weights, exposure durations (ED), ingestion rates, and skin surface areas between various age groups. These rates for mutagenic compounds also take into account age-specific susceptibility to mutagens

through use of an age-dependent adjustment factor (ADAF) (EPA 2005a, 2014g). EDs for the inhalation pathway were adjusted to account for mutagenic potential.

The following subsections present the equations for calculating the intake for each exposure pathway evaluated in the HHRA.

Groundwater

This section presents the equations for calculating intake of COPCs from groundwater via ingestion, dermal contact, and inhalation (groundwater only).

Ingestion of COPCs in Groundwater

The CDI received through ingestion of constituents in groundwater was calculated as follows:

$$CDI_{ing-w_0-16} = \frac{EPC_W \times IRW[M]_{adj} \times FI \times EF \times CF_W}{AT}$$

$$CDI_{ing-w_16+} = \frac{EPC_W \times IRW \times FI \times EF \times ED \times CF_W}{BW \times AT}$$

where:

CDI_{ing-w_0-16}	=	Chronic daily intake of COPCs via ingestion of water for children ages 0 to 16 (mg/kg-day)
CDI_{ing-w_16+}	=	Chronic daily intake of COPCs via ingestion of water for adults ages 16 and older (mg/kg-day)
EPC_W	=	Exposure point concentration in water (µg/L)
IRW	=	Ingestion rate of water (µg/L; incorporated into $IRW[M]_{adj}$)
IRW_{adj}	=	Age-adjusted ingestion rate of water (liter-year per kilogram-day [L-year/kg-day])
$IRWM_{adj}$	=	Age-adjusted ingestion rate of water for mutagens (L-year/kg-day)
IRW_{child}	=	Ingestion rate of water – child (liters per day [L/day])
FI	=	Fraction ingested from contaminated source
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years; incorporated into $IRW[M]_{adj}$)
ED_{child}	=	Exposure duration – child (years)
CF_W	=	Conversion factor for water (1×10^{-3} milligram per microgram [mg/µg])
BW	=	Body weight (kg; incorporated into $IRW[M]_{adj}$)
BW_{child}	=	Body weight – child (kg)

AT = Averaging time (days)

AT_c (carcinogens) = 70-year life-time × 365 days/year

AT_{nc} (non-carcinogens) = ED (years) × 365 days/year

Dermal Contact with COPCs in Groundwater

CDIs received through dermal contact with COPCs in groundwater are calculated differently for inorganic and organic constituents. The equations used to calculate CDIs for inorganic COPCs are presented first, followed by the equations used to calculate CDIs for organic constituents.

Inorganics

$$CDI_{derm-w(i)_0\text{-}16} = \frac{EPC_W \times K_P \times DFWM_{adj} \times EF \times EV \times CF_W \times CF_V}{AT}$$

$$CDI_{derm-w(i)_16+} = \frac{EPC_W \times K_P \times SA \times EF \times EV \times ED \times ET \times CF_W \times CF_V}{BW \times AT}$$

where

$CDI_{derm\text{-}w(i)_0\text{-}16}$=Chronic daily intake of inorganic COPCs via dermal contact with water for children ages 0 to 16 (mg/kg-day)

$CDI_{derm\text{-}w(i)_16+}$= Chronic daily intake of inorganic COPCs via dermal contact with water for adults ages 16 and older (mg/kg-day)

EPC_W = Exposure point concentration of constituent in water (µg/L)

K_p = Dermal permeability constant (centimeter per hour [cm/hour])

SA = Skin surface area exposed to water (square centimeter [cm^2]; incorporated into $DFWM_{adj}$)

DFW_{adj} = Age-adjusted dermal contact factor for water (square centimeter-year per kilogram [cm^2-year/kg])

$DFWM_{adj}$ = Age-adjusted dermal contact factor for water for mutagens (cm^2-year/kg)

EF = Exposure frequency (days/year)

EV = Event frequency (event/day)

ED = Exposure duration (years; incorporated into $DFWM_{adj}$)

ET = Exposure time (hours/event)

CF_W = Conversion factor for water (1×10^{-3} mg/µg)

CF_V = Conversion factor for surface water volume (1×10^{-3} liter per cubic centimeter [L/cm^3])

BW = Body weight (kg; incorporated into $DFWM_{adj}$)

AT = Averaging time (days)

AT_c (carcinogens) = 70-year life-time × 365 days/year

AT_{nc} (non-carcinogens) = ED (years) × 365 days/year

Organics

$$CDI_{derm-w(o)_0-16} = \frac{DA_{event} \times DFWM_{adj} \times EV \times EF}{AT}$$

$$CDI_{derm-w(o)_16+} = \frac{DA_{event} \times SA \times EV \times EF \times ED}{BW \times AT}$$

where

$CDI_{derm-w(o)_0-16}$ = Chronic daily intake of organic COPCs via dermal contact with water for children ages 0 to 16 (mg/kg-day)

$CDI_{derm-w(o)_16}$ += Chronic daily intake of organic COPCs via dermal contact with water for adults ages 16 and older (mg/kg-day)

SA_w = Skin surface area exposed to water (cm^2; incorporated into $DFWM_{adj}$)

SA_{child} = Skin surface area for a child exposed to water (cm^2)

DFW_{adjo} = Age-adjusted dermal contact factor for water for organics (cm^2-year/kg)

$DFWM_{adjo}$ = Age-adjusted dermal contact factor for mutagens for organics (cm^2-year/kg)

EV = Event frequency (event/day)

EF = Exposure frequency (days/year)

ED = Exposure duration (years; incorporated into $DFSM_{adj}$)

BW = Body weight (kg; incorporated into $DFSM_{adj}$)

BW_{child} = Body weight for a child (kg)

AT = Averaging time (days)

ATc (carcinogens) = 70-year life-time × 365 days/year

ATnc (non-carcinogens) = ED (years) × 365 days/year

DAevent = Absorbed dose per event (milligrams per square centimeter per event [mg/cm2-event]) (see equations below for calculating DA_{event})

where:

If $t_{event} \leq t^*$, then:

$$DA_{event} = 2 \times FA \times Kp \times EPC_W \times CF_V \times CF_W \times \left(\frac{6 \times tao_{event} \times t_{event}}{\Pi} \right)^{1/2}$$

If $t_{event} > t^*$, then:

$$DA_{event} = FA \times Kp \times EPC_W \times CF_V \times CF_W \times \left(\left(\frac{t_{event}}{1+B} \right) + \left(2 \times tao_{event} \times \frac{\left(1+3B+3B^2\right)}{(1+B)^2} \right) \right)$$

where:

FA	=	Fraction absorbed water (dimensionless)
K_p	=	Dermal permeability constant (cm/hour)
EPC_W	=	Exposure point concentration of constituent in water (µg/L)
CF_W	=	Conversion factor for water (1×10^{-3} mg/µg)
CF_V	=	Conversion factor for water volume (1×10^{-3} L/cm^3)
t_{event}	=	Receptor ET (hours/event; for aggregate residents, maximum of child and adult ET)
t*	=	Time to reach steady state (hours)
tao_{event}	=	Lag time per event
B	=	Ratio of permeability coefficient of a compound through the corneum relative to its permeability coefficient across the viable epidermis

Note: for receptor-exposure scenarios that spanned multiple age groups (residential scenarios) and, thus, were considered multiple age-specific ET (t_{event}) values, t_{event} was factored out of the DA_{event} equation and incorporated into the age-adjusted dermal contact equation. However, in selecting the appropriate DA_{event} equation, the maximum ET for the receptors considered was compared with t*. These modified equations are provided in the residential Table 4 series included in Attachment D-1.

Dermal permeability constant (K_p) values expressed in units of cm/hour were taken directly from the EPA RSL tables (EPA 2015a), which cite EPA's Estimation Program Interface Suite (EPA 2013a) and RAGS Part E (EPA 2004).

Inhalation of Volatile COPCs in Groundwater

Concentrations of volatile groundwater and soil gas COPCs in indoor air resulting from household use of groundwater were estimated using K. Using the calculated air concentrations in $\mu g/m^3$, the CDE received from inhalation of vapors in air was calculated using the following equations based on consideration of EPA's RAGS Part F guidance (EPA 2009):

$$CDE_{inh_NC} = \frac{EPC_a \times EF \times ED \times ET \times CF_{nc} \times CF_t}{AT_{nc}}; \text{ or}$$

$$CDE_{inh_CA} = \frac{EPC_a \times EF \times ED[M]_{adj} \times ET \times CF_t}{AT_c}$$

where:

CDE_{inh_NC}	=	Chronic daily exposure to non-carcinogenic COPCs via inhalation for adults (ages 16 and older – mg/m^3)
CDE_{inh_CA}	=	Chronic daily exposure to carcinogenic/mutagenic COPCs via inhalation for adults (ages 16 and older – $\mu g/m^3$)
EPC_a	=	Exposure point concentration in air (mg/m^3)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
ED_{adj}	=	Age-adjusted exposure duration for carcinogens
EDM_{adj}	=	Age-adjusted exposure duration for mutagens
ED_{child}	=	Exposure duration – child (years)
ET	=	Exposure time (hours)
ET_{child}	=	Exposure time – child (hours)
CF_t	=	Conversion factor (1/24 day/hours)
CF_{nc}	=	Conversion factor (1×10^{-3} mg/µg)
AT	=	Averaging time (days)
		AT_c (carcinogens) = 70-year life-time × 365 days/year
		AT_{nc} (non-carcinogens) = ED (years) × 365 days/year

2.3.2 Receptor Exposure Assumptions

The RAGS Part D 4 Series tables (included as part of Attachment D-1) list the exposure factors that were used to estimate risks under both RME and CTE scenarios to provide a range of risk estimates for use by risk managers. As described previously, the RME was estimated by selecting values for exposure

variables so that the combination of all variables results in the maximum exposure reasonably expected at a site. However, the CTE was estimated by selecting values so that the combination results in the typical (average) exposure that could occur at a site (EPA 1993). The tables also list references used to select the exposure assumptions. Exposure assumptions are based on a combination of standard default values from EPA guidance documents and best professional judgment considering site-specific information. The following sections present the rationales for selection of exposure assumptions. More specifically, the large majority of exposure parameter values were obtained from EPA's RSL User's Guide (EPA 2014g). Residential and industrial/commercial worker exposure parameter values presented in this document were originally presented in recent EPA technical memorandum "Recommended Default Exposure Factors" (Office of Solid Waste and Emergency Response [OSWER] Directive 9200.1-120) (EPA 2014a). CTE values are largely based on earlier EPA recommendations (EPA 2004), adjusted as necessary for consistency with the more recently updated RME factors.

Current and Future Residential Exposure Factors

Residential receptors are currently present at EA 2. However, EA 1 could be developed for residential use in the future. Under this scenario, residents were assumed exposed to site-related constituents in groundwater.

As discussed below, two groups — child and aggregate residents — were considered in the exposure assessment. The method for calculating risk for aggregate residents used age-adjusted ingestion, dermal, and inhalation factors to take into account the difference in daily ingestion and surface area, body weights, and exposure durations for children and older residents.

Child Resident Exposure Factors

The child resident scenario was deemed more conservative and appropriate for the evaluation of potential noncarcinogenic risk because noncarcinogenic risk is an event-driven phenomenon and not a result of exposure over a lifetime. Exposure pathways for groundwater at the site include exposure of future residents to groundwater through ingestion, dermal contact, and inhalation during household use. The child resident exposure factors for potential groundwater exposures are presented in Tables 4.1.1.RME and 4.1.1.CTE of Attachment D-1 and are discussed below.

- The RME and CTE ingestion rate of groundwater (IRW) of 0.78 L/day is the recommended default ingestion rate for residential children (EPA 2014g).
- The RME and CTE fractional intake (FI) of 1 was identified based on best professional judgment. This value means that receptors obtain all of their potable groundwater from the site.

- The RME and CTE SA of 6,378 cm^2 is the EPA (2014g) recommended default SA for residential children exposed during bathing.
- The RME and CTE volatilization factor (VF) of 0.5 is the recommended default value for volatilization resulting from domestic use of groundwater (EPA 2014g).
- The RME and CTE event frequency (EV) of 1 event per day is the default value (EPA 2004).
- The RME ET of 24 hours/day is the default ET for residents (EPA 2014g). The CTE ET of 17 hours/day is the amount of time spent indoors at a residence by a child 0 to 6 years (EPA 2011).
- The RME exposure time bathing (ET_b) value of 0.54 hour/day is the EPA (2014g) recommended time spent bathing for residential children. The CTE ET_b value of 0.33 hour/day is the EPA (2004) recommended mean duration of bathing for residential children.
- The EF of 350 days per year is the EPA (2014g) default value for residents.
- By default, the ED for the child resident is 6 years (0 to 6 years old) (EPA 2014g).
- The RME exposure time outdoors (ET_{od}) of 24 hours/day is the default ET for residents (EPA 2014g). The CTE ET_{od} of 3 hours/day is the amount of time spent outdoors at a residence by a child 0 to 6 years old based on the EPA (2011b) recommendation of 2 hours/day for residents of all ages.
- The BW of 15 kg is the EPA (1989, 2014g) default child body weight.
- Consistent with EPA (1989, 2014g) guidance, the AT_{nc} is equal to the ED and corresponds to a value of 2,190 days for RME and CTE. Carcinogenic effects for residents are evaluated in the aggregate resident scenario only.

Aggregate Resident Exposure Factors

As described in the previous section, groundwater will be evaluated as a source of potable water at EAs 1 and 2 at the Lane Street Site. Exposure pathways for groundwater include exposure of future residents to groundwater through ingestion, dermal contact, and inhalation during household use. The ET parameters are the same as those used to estimate potential child groundwater exposure. The aggregate resident scenario was used to evaluate potential carcinogenic (and mutagenic) risk to a future resident because potential carcinogenic risk is estimated over the lifetime of an individual. Age-adjusted groundwater ingestion and dermal contact rates are used to estimate exposure for scenarios involving receptors 0 to 16 years old. Parameter values for EF, FI, and EV are as described above for the child resident. The age-adjusted aggregate resident (0 to 26 years old) exposure factors for potential groundwater exposures are presented in Tables 4.1.2.RME and 4.1.2.CTE of Attachment D-1 and are discussed below.

- The total RME ED of 26 years is based on the 90th percentile for time at one residence (EPA 2014g) and is divided as ED_{child} of 6 years and ED_{adult} of 20 years. The CTE ED of 11.7 years is the mean residential occupancy period (EPA 2011b) and is divided as ED_{child} of 6 years and $ED_{adolescent}$ of 5.7 years. The youngest receptors were assumed for the EDs because the early years generally are the most sensitive to exposure (0 to 26 years old for RME and 0 to 11.7

years old for CTE). These terms are not included in the ingestion and dermal intake equations for the future aggregate resident because age-adjusted rates account for body weight and exposure duration.

- EPA default body weight values of 15 kg for child receptors and 80 kg for adult receptors were used for the aggregate resident (EPA 2014g).
- Consistent with EPA (1989) guidance, the AT_c for both RME and CTE represents an average 70-year lifetime and corresponds to 25,550 days. Noncarcinogenic effects for residents are evaluated in the child resident scenario only.
- The RME and CTE age-adjusted ingestion rate of groundwater ($IRGW_{adj}$) for the aggregate residents is based on EPA (2014g) exposure inputs and the equation presented below. The resulting RME and CTE $IRGW_{adj}$ values are 0.94 and 0.49 mg-year/kg-day.

$$IRGW_{adj} = \frac{ED_{0-2} \times IRGW_{child}}{BW_{child}} + \frac{ED_{2-6} \times IRGW_{child}}{BW_{child}} + \frac{ED_{6-16} \times IRGW_{adult}}{BW_{adult}} + \frac{ED_{16-26} \times IRGW_{adult}}{BW_{adult}}$$

  - The RME and CTE IRGW values for adults (2.5 L/day) and children (0.78 L/day) correspond to the EPA (2014g) recommended tap water ingestion rates for adult and child residents.

- To account for potential mutagenic effects during early life exposure (before 16 years old), EPA applies an ADAF to each of the four residential age groups identified above. Thus, the $IRGW_{adj}$ equation for mutagenic compounds is modified as presented below. The resulting RME and CTE age-adjusted ingestion rates of groundwater for mutagens ($IRGWM_{adj}$) are 2.9 mg-year/kg-day RME and 2.2 mg-year/kg-day CTE.

$$IRGWM_{adj} = \frac{ED_{0-2} \times IRGW_{child} \times ADAF_{0-2}}{BW_{child}} + \frac{ED_{2-6} \times IRGW_{child} \times ADAF_{2-6}}{BW_{child}} + \frac{ED_{6-16} \times IRGW_{adult} \times ADAF_{6-16}}{BW_{adult}} + \frac{ED_{16-26} \times IRGW_{adult} \times ADAF_{16-26}}{BW_{adult}}$$

  - For the ages 0 to 2 years old (ED of 2 years for RME and CTE), the ADAF is 10.
  - For the ages 2 to 6 years old (ED of 4 years for RME and CTE), the ADAF is 3.
  - For the ages 6 to 16 years old (EDs of 10 years for RME and 3 years for CTE), the ADAF is 3.
  - For the ages 16 to 26 years old (EDs of 10 years for RME and 0 years for CTE), the ADAF is 1.

- The age-adjusted dermal contact factor for groundwater (DFW_{adj}) for the aggregate residents is based on EPA (2014g) exposure inputs and the equation presented below. This parameter is used to estimate dermal exposures to groundwater for inorganic constituents and organic constituents for which ET_b is less than a COPC's time to reach steady state (t*). The resulting RME and CTE $DFGW_{adj}$ are 7,776 cm^2-event/kg RME and 4,040 cm^2-event/kg CTE.

$$DFW_{adj} = \frac{ED_{0-2} \times SA_{child}}{BW_{child}} + \frac{ED_{2-6} \times SA_{child}}{BW_{child}} + \frac{ED_{6-16} \times SA_{adult}}{BW_{adult}} + \frac{ED_{16-26} \times SA_{adult}}{BW_{adult}}$$

  - Child and adult SAs are the EPA (2014g) default values for bathing of 6,738 and 20,900 cm^2.

- The age-adjusted exposure time for bathing (ET_b) for the aggregate residents is based on EPA (2014g) exposure inputs and the equation presented below. The resulting RME and CTE ET_b values are 0.67 and 0.29 hr/day.

$$ET_b = \frac{ET_{child} \times ED_{child}}{ED_{res}} + \frac{ET_{adult} \times ED_{adult}}{ED_{res}}$$

  - The RME adult and child ETs are the EPA (2014g) recommended upper-bound bathing times of 0.71 and 0.54 hour/day. The CTE adult and child ETs are the EPA (2004) mean bathing times of 0.25 and 0.33 hour/day.

- The RME ET of 24 hours/day is the default ET for residents (EPA 2014g). The CTE ET of 16 hours/day is the time-weighted average of the mean time spent indoors at a residence by a child 0 to 11.7 years (EPA 2011b, Table 16-1).

- EPA assumes that children 0 to 2 years old are 10 times more susceptible to mutagenic effects, children 2 to 6 years old are 3 times more susceptible, and adolescents 6 to 16 years old also are 3 times more susceptible (EPA 2014g). The RME $DFWM_{adj}$ for the aggregate resident is based on EPA (2014g) exposure inputs as described above and calculated as follows. (This parameter is used to estimate dermal exposures to groundwater for inorganic constituents and organic constituents for which ET is less than t*.)

$$DFWM_{adj} = \frac{ED_{0-2} \times SA_{child} \times 10}{BW_{child}} + \frac{ED_{2-6} \times SA_{child} \times 3}{BW_{child}} + \frac{ED_{6-16} \times SA_{adult} \times 3}{BW_{adult}} + \frac{ED_{16-26} \times SA_{adult} \times 1}{BW_{adult}}$$

  The resulting RME and CTE $DFWM_{adj}$ are 24,056 and 18,074 cm^2-event/kg.

- The RME mutagenic ED (EDMadj) is 72 years. To account for potential mutagenic effects via inhalation, age-dependent factors of 10, 3, 3, and 1 were applied to the EDs for ages 0-2, 2-6, 6-16, and 16-26 years, respectively. Similarly, the CTE EDMadj is 49.1 years; age-dependent factors of 10 were applied to the ED for ages 0 to 2, of 3 for ages 2 to 6, of 3 for ages 6 to 16, and 1 for ages 16 to 26.

Current and Future Commercial/Industrial Worker Exposure Factors

Commercial/industrial workers are currently present at EA 1. However, EA 2 could be developed for commercial/industrial use in the future. Under this scenario, commercial/industrial workers were assumed exposed to site-related constituents in groundwater. Commercial/industrial worker exposure to groundwater via ingestion was evaluated under the assumption that groundwater may be used as a source of potable water under future land use conditions. Potential exposure via dermal contact as the result of work-related activities or hand washing was evaluated. Finally, volatile chemicals present in groundwater may be released to indoor air from household groundwater uses (for example, running sinks, flushing toilets, or running dishwashers). Therefore, potential exposure through inhalation of volatile constituents in indoor air was evaluated for current and future industrial/commercial workers. Commercial/industrial

exposure parameters used to estimate potential exposures are presented in Tables 4.2.1.RME and 4.2.1.CTE of Attachment D-1 and are summarized below, except for FI and EV, which are as described above for the child resident.

- The RME and CTE IRGW of 1.25 liter is the EPA (2014g) default rate for an industrial/commercial worker. This value assumes that the worker ingests half of his or her daily intake (1.25 out of 2.5 liters) at work.
- Two values for EF were evaluated. The RME and CTE EF of 250 days per year is the default value for indoor workers (EPA 2014g) and was applied in all cases except for commercial/industrial workers washing RVs at Property 1. The RVs are washed outdoors and, therefore, exposure is assumed limited to warm weather months. Warm weather months are assumed to be April through October, approximately 31 weeks. Therefore, the RME and CTE EF of 155 days/year (assuming exposure 5 days/week) was applied to workers washing RVs at Property 1.
- Two values for surface area (SA) were evaluated. The first is based on potential dermal exposure while washing parts in a sink and washing RVs outdoors at Property 1 in EA 1. As a simplification, it was assumed that workers would be exposed on their hands, forearms, and face under either of these activities. Therefore, the RME and CTE SA at Property 1 is 2,696 cm^2 (EPA 2011b, Tables 7-12 and 7-13). It was assumed at all other commercial/industrial properties that workers are exposed via dermal contact only while washing their hands. Therefore, the RME and CTE SA at all other properties is 980 cm^2 (EPA 2011b, Tables 7-12 and 7-13).
- The RME ED of 25 years is the EPA default RME (EPA 2014g) and the CTE ED of 6.6 years is the median occupational tenure (EPA 2011b) for industrial/commercial workers.
- The ET for the RME and CTE scenarios was assumed to be 8 hours per day, or 40 hours per week over a period of 5 days (EPA 2014g).
- Three values of ET for potential dermal exposure (ET_d) were evaluated. The first is based on based on potential dermal exposure at Property 1, as described above. It was assumed that a worker washes parts in a sink for approximately one-half of the daily 8-hour daily shift, or 4 hours per day. Workers washing RVs at Property 1 were assumed to be exposed throughout their 8-hour daily shift, or 8 hours per day. It was assumed at all other commercial/industrial properties that workers washed their hands for 5 minutes per day (0.083 hour per day).
- The industrial/commercial worker BW of 80 kg is the EPA (2014g) default value for adults.
- Consistent with EPA (1989, 2014g) guidance, the averaging time for non-carcinogens (AT_{nc}) is equal to the ED and corresponds to a value of 9,125 days for RME and 2,409 days for CTE. The averaging time for carcinogens (AT_c) for both the RME and CTE scenarios represents an average 70-year lifetime and corresponds to 25,550 days.

Current and Future Construction Worker Exposure Factors

The current and future construction worker exposure scenarios include potential exposure to groundwater at the Lane Street Site. As discussed in Section 2.1, it was conservatively assumed that groundwater may enter trenches and workers may experience dermal contact. In addition, volatile constituents may volatize

from groundwater and enter the air within a construction trench. Vapor concentrations in air inside a trench or excavation area were estimated using the trench model developed by VDEQ (2014). The parameters used to estimate potential exposure to chemicals in soil are presented in Tables 4.3.1.RME and 4.3.1.CTE of Attachment D-1 and are summarized below.

- Construction workers are assumed to be involved in short-duration redevelopment projects. Construction workers were assumed to be present on site for 5 days a week during the course of a 13-week redevelopment project for RME, which corresponds to an RME EF of 65 days per year. The CTE EF of 30 days per year assumes similar exposure over a 6-week construction project.
- The RME and CTE ED of 1 year is the EPA (2014g) default value for construction workers.
- The ET for the RME and CTE soil exposure scenarios was assumed to be 8 hours per day, 40 hours per week over a period of 5 days.
- The construction worker BW of 80 kg is the EPA (2014g) default value for adults.
- Consistent with the EPA (1989), the AT_{nc} is equal to the length of the construction project and corresponds to a value of 91 days (13 weeks) for the RME scenario and 42 days for the CTE scenario. The AT_c for both the RME and CTE scenarios represents an average 70-year lifetime and corresponds to 25,550 days.
- The SA of 2,275 cm^2 assumes construction workers are exposed to their hands and feet (EPA 2011b).
- The RME and CTE groundwater ET of 4 hours per day is based on the VDEQ model for trench work (VDEQ 2014).

Current and Future Utility Worker Exposure Factors

The current and future utility worker exposure scenarios include potential exposure to groundwater at the Lane Street Site. Potential exposures to COPCs in or from groundwater in a utility trench are as described for construction workers. The parameters used to estimate potential exposure to soil are presented Tables 4.4.1.RME and 4.4.1.CTE of Attachment D-1. Parameter values for ET, BW, and AT are as described above for the construction worker in Section 2.3.2.3. The EF values used for RME and CTE conditions are as listed below.

- For a utility worker, the RME ED of 25 years is the EPA default RME (EPA 2014g) and the CTE ED of 6.6 years is the median occupation tenure (EPA 2011b) for industrial/commercial workers.
- Exposure for a utility worker is expected to occur infrequently (less than once a month). RME and CTE EFs of 20 and 10 days were conservatively assumed based on best professional judgment.

2.4 TOXICITY ASSESSMENT

The toxicity assessment describes the relationship between a dose of a chemical and the potential likelihood of an adverse health effect. The purpose of the toxicity assessment is to quantitatively estimate the inherent toxicity of COPCs for use in risk characterization. In the context of the regulatory risk assessment process, potential effects of chemicals are separated into two categories: carcinogenic (cancer) and noncarcinogenic (noncancer) effects. This division relates to current EPA policy that the mechanisms of action for these endpoints are different. The EPA generally makes the conservative assumption that carcinogenic chemicals do not exhibit a response threshold[1] (EPA 1986, 2005b), while noncarcinogenic effects are universally recognized as threshold phenomena. However, chemicals believed to be carcinogenic may also be capable of producing noncancer health effects. Potential health risks for COPCs are evaluated for both carcinogenic and noncarcinogenic risks.

The risk assessment used the default toxicity values presented in the EPA RSL tables (EPA 2015a). The default values were obtained from the following sources in the order they are presented below:

- Integrated Risk Information System (IRIS) on-line database (EPA 2015b)
- Provisional Peer Reviewed Toxicity Values (PPRTV) derived by EPA's Superfund Health Risk Technical Support Center for the EPA Superfund Program
- The Agency for Toxic Substances and Disease Registry (ATSDR) minimal risk levels (MRL) (ATSDR 2013a)
- The California Environmental Protection Agency (Cal/EPA)/Office of Environmental Health Hazard Assessment's toxicity values (Cal/EPA 2015)
- Screening toxicity values in appendices to certain PPRTV assessments
- The EPA Superfund Program's Health Effects Assessment Summary Tables (HEAST) (EPA 2011d)

Toxicity values used in the HHRA are listed in Tables 5.1 and 5.2 (noncancer toxicity values) and Tables 6.1 and 6.2 (cancer toxicity values) of Attachment D-1. Chemical-specific parameter values are presented in Table 5.3.

[1] A threshold indicates that a minimum amount of drug or chemical agent is required to elicit an effect. For example, certain metals such as iron and selenium are toxic above a threshold dose but safe and, in fact, required dietary components at lower doses. EPA assumes that no threshold exists for carcinogens and that there is some increased risk at every dose level.

2.4.1 Non-Carcinogenic Chemicals

It is well accepted that noncarcinogenic biological effects of chemicals occur only after a threshold dose is exceeded (Klaassen 2001). This concept implies that a range of exposures up to some defined threshold can be tolerated without appreciable risk of harm. Potential effects may be precluded at concentrations below the threshold by pharmacokinetic processes such as decreased absorption, distribution to non-target organs, metabolism to less toxic chemical forms, and excretion (EPA 2005b). Once the threshold dose is reached, one or more of these processes may become compromised, resulting in toxic responses.

Potential noncarcinogenic effects resulting from human exposure to chemicals are generally estimated quantitatively using reference doses (RfD) and reference concentrations (RfC). The RfD, expressed in units of daily dose (mg/kg-day), is an estimate of the daily maximum level of exposure to human populations (including sensitive sub-populations) that is likely to be without an appreciable risk of deleterious effects (EPA 1989). EPA has derived RfCs for some chemicals for inhalation exposures. In concept, an inhalation RfC is similar to an RfD. If a human is exposed to a concentration of a chemical in air that is lower than the RfC, no appreciable risk for noncancer health effects results from that exposure.

The threshold dose (RfD and RfC) for a compound is usually estimated from the no observed adverse effect level (NOAEL) or the lowest observed adverse effect level (LOAEL), from animal studies or human data. The NOAEL is the highest dose at which no adverse effects are identified, while the LOAEL is the lowest dose at which adverse effects are detectable. Safety factors are applied to either the NOAEL or the LOAEL to estimate an RfD and RfC to account for uncertainties such as extrapolation from animals to humans, time period of exposure, and potential for sensitive individuals within the human population.

Noncarcinogenic toxicity criteria are typically only available for oral (RfD) and inhalation (RfC) exposures. In this risk assessment, dermal RfDs were extrapolated from the oral RfDs using a constituent-specific gastrointestinal absorption factor (GI_{ABS} – unitless). This factor represents the relationship between an administered dose and an absorbed dose for the oral route, essentially estimating the dose that enters a receptor's circulation and elicits a toxic effect. Constituent-specific oral absorption factors were obtained from *RAGS, Part E, Supplemental Guidance for Dermal Risk Assessment* (EPA 2004).

Tables 5.1 and 5.2 of Attachment D-1 present the oral/dermal RfDs and inhalation RfCs. These tables also include toxicity value sources and uncertainty and modifying factors, GI_{ABS} values, and target organs.

2.4.2 Carcinogenic Chemicals

For regulatory purposes, EPA generally makes the conservative assumption that carcinogenic chemicals do not exhibit a response threshold (EPA 1986). However, recent scientific evidence clearly indicates that this assumption is an oversimplification of carcinogenic responses. A growing number of chemicals have been shown to elicit carcinogenic effects in experimental animals via mechanisms that are either not relevant to human biological processes or that are not expected to occur in humans at significantly lower, environmentally relevant doses (James and Saranko 2000). The EPA has recently revised the Guidelines for Carcinogen Risk Assessment (2005b), in which EPA recognizes these issues and provides alternative approaches for addressing them within the regulatory framework for cancer risk assessment.

Potential carcinogenic effects resulting from human exposure to chemicals are estimated quantitatively using cancer slope factors (SF), which represent the theoretical increased risk per milligram of constituent intake per kilogram body weight per day $(mg/kg\text{-}day)^{-1}$, or unit risk factors (URF), which are the theoretical increased risk at a defined exposure concentration $(mg/m^3)^{-1}$. SFs or URFs are used to estimate a theoretical upper-bound lifetime probability of an individual developing cancer as a result of exposure to a potential carcinogen.

SFs and URFs are derived by EPA from the results of chronic animal bioassays, human epidemiological studies, or both. Animal bioassays are usually conducted at dose levels much higher than those likely to be achieved by human exposure to environmental media. Such high levels are used to detect possible adverse effects in the relatively small test populations used in the studies. Therefore, a large degree of conservatism exists in the form of high-dose to low-dose extrapolation. Human epidemiological studies often are based on historical occupational exposures at levels much higher than those currently experienced in environmental settings, requiring quantitative extrapolation to account for the dose differences.

EPA has developed SFs specific to the oral route of exposure and URFs specific to the inhalation route of exposure. In accordance with EPA guidance (EPA 2004), this risk assessment uses an extrapolation calculation to estimate dermal SFs from the oral SFs. The oral SF is multiplied by the GI_{ABS} dermal SF. Constituent-specific oral absorption factors were obtained from *RAGS Part E, Supplemental Guidance for Dermal Risk Assessment* (EPA 2004).

Tables 6.1 and 6.2 of Attachment D-1 present the oral and dermal SFs and inhalation URFs. These tables also include the toxicity value sources, GI_{ABS} values, and the carcinogenic class.

2.5 RISK CHARACTERIZATION

In the risk characterization, the toxicity factors (RfD and RfCs and SFs and URFs) were integrated with COPC concentrations and intake assumptions to estimate potential carcinogenic and noncarcinogenic health risks. This section describes the risk calculation methodology and presents the numerical risk estimates for potential exposure to COPCs detected in environmental media for potentially complete exposure pathways at the Lane Street Site.

2.5.1 Risk Calculation Methodology

This section discusses the methodology for calculating estimates of potential cancer risks and noncancer hazards and describes the evaluation for lead.

Calculation of Potential Cancer Risks

Theoretical excess cancer risks for receptors are expressed as an estimated upper-bound probability of additional lifetime cancer risk posed by exposure to site-related constituents. These estimates do not reflect a receptor's background risk of cancer (one-in-three to one-in-five range), but only the highest additional incremental risk theoretically expected to result from exposure to site constituents. Theoretical excess lifetime cancer risk (ELCR) was calculated for each carcinogenic COPC, for each complete exposure pathway, using the following general equations:

$$ELCR = CDI \times SF \qquad \text{or} \qquad ELCR = CDE \times URF$$

where:

ELCR	=	Theoretical excess lifetime cancer risk (unitless)
CDI	=	Chronic daily intake (mg/kg-day) (see Section 2.3.2 for derivation)
CDE	=	Chronic daily exposure ($\mu g/m^3$) (see Section 2.3.2 for derivation)
SF	=	Cancer slope factor (1/mg/kg -day) (see Section 2.4.2)
URF	=	Inhalation unit risk factor ($\mu g/m^3$) (see Section 2.4.2)

Chemical-specific ELCRs were summed for each receptor-exposure scenario to provide medium-specific risks. Cumulative risks to each receptor were also calculated by summing ELCRs across all relevant exposure pathways for a given receptor. This form of summarization incorporates the assumption that carcinogenic risks from multiple constituent exposures are additive. These assumptions ensure that ELCRs for each COPC, pathway, and receptor are theoretical upper-bound estimates.

The EPA target cancer risk range of 1 in 1 million to 1 in 10,000 (1E-06 to 1E-04) (EPA 1990) was used as the benchmark for identifying potentially unacceptable risks. Individual constituents with a cancer risk greater than 1×10^{-6} for a given receptor-exposure scenario were identified as chemicals of concern (COC). Those COCs and the corresponding receptor-exposure scenarios will be further evaluated in subsequent steps (including the alternative array document and the FS) in the RI/FS process.

Trichloroethene

The IRIS (EPA 2011c) toxicological review for TCE suggests that risk to the kidney be assessed using the mutagenic equations and liver and non-Hodgkins lymphoma (NHL) risk be addressed using the standard cancer equations. The standard cancer and mutagen equations need to be combined to generate cancer risk estimates for multiple age receptors, such as residential. Specifically, the risk for TCE was calculated for both mutagenic mode of action (kidney) and regular cancer end-points (liver and NHL). EPA (2014g) calculated toxicity value adjustment factors for cancer (CAF) and mutagens (MAF) to combine the cancer and mutagen equations, which are then incorporated into modified cancer risk equations. The adjustments were calculated for both oral and inhalation pathways. The mutagenic calculation incorporates the ADAFs specific to the mutagenic (kidney) endpoint. The cancer toxicity values account for all potential cancer endpoints for receptors evaluated for only adults, such as workers. Therefore, the standard cancer risk calculation can be used and adjustment of the toxicity values is not necessary.

Calculation of Potential Noncancer Risks

Potential noncancer risks for individual COPCs are expressed as HQs (EPA 1989). HQs were calculated for each noncarcinogenic COPC, for each complete exposure pathway, using the following general equations:

$$HQ = \frac{CDI}{RfD} \quad \text{or} \quad HQ = \frac{CDE}{RfC}$$

where:

HQ	=	Hazard quotient (unitless)
CDI	=	Chronic daily intake (mg/kg-day) (see Section 2.3.2 for derivation)
CDE	=	Chronic daily exposure (mg/m^3) (see Section 2.3.2 for derivation)
RfD	=	Reference dose (hazard per mg/kg body weight-day) (see Section 2.4.1)
RfC	=	Inhalation reference concentration (mg/m^3) (see Section 2.4.1)

The chemical-specific HQs were summed to yield a multiple-chemical hazard index (HI). The HI serves as conservative summary of pathway and receptor noncancer risks, since summing all the individual HQs

for the COPCs incorporates the assumption that their risks are all additive, when, in fact, different COPCs are expected to act through different mechanisms and on different target organs. The overall HIs are useful to rapidly exclude pathways or receptors with negligible potential for noncancer effects (where all the COPC HQs added together do not exceed an HI of 1). EPA guidance recognizes that noncarcinogenic effects are exhibited in specific target organs and that certain chemicals can act in an additive fashion on the same organ. EPA requires summing noncarcinogenic hazards for constituents that affect the same target organs when the total HI exceeds 1 (EPA 1989). The primary target organs identified in the studies used to derive the RfDs (or RfCs) for the COPCs are presented in Tables 5.1 and 5.2 of Attachment D-1.

2.5.2 Risk Characterization Results

The following subsections discuss the risk characterization results for each exposure area at the Lane Street Site (see Figure D-1-7) and identify COCs for each receptor-exposure scenario; the name of each COC is **bolded** in the text. The exposure areas include:

- EA 1 – Industrial Exposure Area
- EA 2 – Residential Exposure Area

COCs are those COPCs with either an individual ELCR greater than or equal to 1.0×10^{-6} or an individual noncancer HQ greater than 1 or, if the previous noncancer condition does not exist, then COPCs that contribute a HQ greater than 0.1 to a target organ-specific HI greater than 1.0. COCs are retained for further evaluation in the FS. The 7 Series tables provide the EPCs, CDIs and CDEs, toxicity values, and calculated cancer risks and noncancer hazards; these risks are summarized in the subsequent 9 and 10 Series tables. The 7, 9, and 10 Series tables are presented in Attachment D-1.

EA 1 – Industrial Exposure Area

Surface and near surface soil samples, groundwater samples, and soil gas samples were collected in this area. Potential receptors evaluated in the HHRA include future industrial/commercial workers and future residents. RAGS D Tables 7.1.1.2.1.RME, 7.1.1.2.2.RME, 7.1.1.2.3.RME, and 7.1.2.2.1.RME and matching CTE tables present the EPCs, CDIs, CDEs, toxicity values, and calculated cancer risks and noncancer hazards for potential receptors at EA 1. The risks and hazards are summarized in similarly numbered RAGS D Tables 9 and 10 (as well as a set of RAGS D Table 10s with a similar numbering scheme) and in Table D-2-4.

Future Industrial/Commercial Workers -- General

Future industrial/commercial workers were assumed exposed to groundwater via ingestion, dermal contact (hand washing only) and inhalation (potable use). EPCs, intakes, toxicity values, and resultant cancer risks and noncancer hazards for future industrial/commercial workers across EA 1 are presented in Tables 7.1.1.2.1.RME and 7.1.1.2.1.CTE; calculated risks and hazards are summarized in Tables 9.1.1.2.1.RME and 9.1.1.2.1.CTE and are described below. COCs are presented in Tables 10.1.1.2.1.RME and 10.1.1.2.1.CTE.

RME Scenario:

- The cumulative RME cancer risk is 1E-04. This cumulative risk is at the upper limit of EPA's target risk range of 1E-06 to 1E-04. Individual groundwater COPCs with risks equal to or exceeding 1E-06 are **TCE** (cumulative risk of 1.1E-04 – 5.6E-05 [ingestion], 3.1E-07 [dermal contact], and 5.4E-05 [inhalation – potable use]); **chloroform** (cumulative risk of 9.0E-06 – 1.0E-06 [ingestion], 3.0E-09 [dermal contact], and 8.0E-06 [inhalation – potable use]); **PCE** (cumulative risk of 2.3E-06 – 9.6E-07 [ingestion], 1.9E-08 [dermal contact], and 1.3E-06 [inhalation – potable use]); and **bromodichloromethane** (cumulative risk of 1.7E-06 – 2.4E-07 [ingestion], 5.6D-10 [dermal contact], and 1.5E-06 [inhalation – potable use]).

  The cumulative risks listed above do not include any risks associated with vapor intrusion. No indoor air samples were collected at the Lane Street site. As discussed in Section 2.1.1, the potential for vapor intrusion (VI) is expected to be limited primarily to the PCE Plume portion of EA 1. Because of uncertainties associated with the extent of a "clean" water layer which may limit or reduce VI potential, VI-related exposures were not estimated using EPA's Johnson & Ettinger advanced models (EPA 1991). Rather, receptor-specific risks and hazards were evaluated using EPA's VISL Calculator (EPA 2014e) based on soil vapor concentrations measured at 11 locations (five [SV-01 through SV-05] in EA 1 and six [SV-06 through SV-08 and SV-10 through SV-12] in EA 2). As shown in Table 5-9 from the RI, soil vapor concentrations exceeded screening levels only in EA 1 at locations SV-01 (PCE only), SV-03 (chloroform only), and SV-04 (dichlorodifluoromethane only). Risks were calculated for all groundwater COPCs, as well as for dichlorodifluoromethane; the results of all VISL calculations are presented in Attachment D-4. The qualitative VI risks for industrial/commercial workers (Tables D-4-1 through D-4-3) are summarized below.

  - At location SV-01 (Table D-4-1) in the PCE Plume, individual and cumulative risks are less than 1E-06 and considered insignificant.
  - At location SV-03 (Table D-4-2) in the TCE Plume, the risk for **chloroform** (3.6E-06) and cumulative risk (3.6E-06) are within EPA's target risk range of 1E-06 to 1E-04. It should be noted that chloroform is present in groundwater at EA 1 at a concentration well below the MCL for total trihalomethanes (80 µg/L). Chloroform may be present in groundwater as the result of chlorinated drinking water.
  - At location SV-04 (Table D-4-3) in the TCE Plume, individual and cumulative risks are less than 1E-06 and considered insignificant.

- The cumulative RME HI is 27. The only COPC with a HI equal to or exceeding 1 is **TCE** (cumulative HI of 25 – 6.8 [ingestion], 3.8E-02 [dermal contact], and 18 [inhalation – potable use]).

Similar to the calculated groundwater risks, VI hazards were also evaluated using EPA's VISL Calculator (EPA 2014e) based on soil vapor sample results as described above. The individual and cumulative hazards are less than 1 and considered insignificant at all locations.

Based on the RME risk characterization, COCs for future industrial/commercial workers are as follows:

- Groundwater – **TCE, chloroform, PCE,** and **bromodichloromethane.**

CTE Scenario:

- The cumulative CTE cancer risk is 3E-05. This cumulative risk is within EPA's target risk range of 1E-06 to 1E-04. Individual groundwater COPCs with risks equal to or exceeding 1E-06 are **TCE** (cumulative risk of 2.9E-05 – 1.5E-05 [ingestion], 8.2E-08 [dermal contact], and 1.4E-05 [inhalation – potable use]) and **chloroform** (cumulative risk of 2.4E-06 – 2.7E-07 [ingestion], 8.0D-10 [dermal contact], and 2.1E-06 [inhalation – potable use]).
- The cumulative RME HI is 27. The only COPC with a HI equal to or exceeding 1 is **TCE** (cumulative HI of 25 – 6.8 [ingestion], 3.8E-02 [dermal contact], and 18 [inhalation – potable use]). (It should be noted that it is not uncommon for RME and CTE HI results to be identical. Often, the only exposure parameter changing between RME and CTE scenarios is exposure duration [ED]. Since ED figures in both the numerator and denominator of the exposure equations, the contribution of this parameter is cancelled out and the resulting RME and CTE exposures and HIs are identical).

Based on the CTE risk characterization, COCs for future industrial/commercial workers are as follows:

- Groundwater – **TCE** and **chloroform.**

Future Industrial/Commercial Workers – Property 1

Future industrial/commercial workers at Property 1 were assumed exposed to groundwater via ingestion, dermal contact (RV and parts washing) and inhalation (potable use). EPCs, intakes, toxicity values, and resultant cancer risks and noncancer hazards for future industrial/commercial workers at Property 1 in EA 1 are presented in Tables 7.1.1.2.2.RME and 7.1.1.2.2.CTE; calculated risks and hazards are summarized in Tables 9.1.1.2.2.RME and 9.1.1.2.2.CTE and are described below. COCs are presented in Tables 10.1.1.2.2.RME and 10.1.1.2.2.CTE.

RME Scenario:

- The cumulative RME cancer risk is 1E-04. This cumulative risk is at the upper limit of EPA's target risk range of 1E-06 to 1E-04. Individual groundwater COPCs with risks equal to or exceeding 1E-06 are **TCE** (cumulative risk of 1.2E-04 [assuming RV washing] or 1.1E-04 [assuming parts washing] – 5.6E-05 [ingestion], 1.1E-05 [dermal contact – RV] or 2.5E-06 [dermal contact – parts], and 5.4E-05 [inhalation – potable use]); **chloroform** (cumulative risk of 9.1E-06 [assuming RV washing] or 9.0E-06 [assuming parts washing] – 1.0E-06 [ingestion], 1.2E-07 [dermal contact – RV] or 2.7E-08 [dermal contact – parts], and 8.0E-06 [inhalation – potable use]); **PCE** (cumulative risk of 2.8E-06 [assuming RV washing] or 2.4E-06 [assuming

parts washing] – 9.6E-07 [ingestion], 5.4E-07 [dermal contact – RV] or 1.4E-07 [dermal contact – parts], and 1.3E-06 [inhalation – potable use]); and **bromodichloromethane** (cumulative risk of 1.8E-06 [assuming RV washing] or 1.7E-06 [assuming parts washing] – 2.4E-07 [ingestion], 1.8E-08 [dermal contact – RV] or 4.3E-09 [dermal contact – parts], and 1.5E-06 [inhalation – potable use]).

See also qualitative VI-related risks discussed above under future industrial/commercial worker – general (second and third bullets).

- The cumulative RME HI is 28 (assuming RV washing) or 27 (assuming parts washing). The only COPC with a HI equal to or exceeding 1 is **TCE** (cumulative HI of 26 [assuming RV washing] or 25 [assuming parts washing] – 6.8 [ingestion], 1.3 [dermal contact – RV] or 0.31 [dermal contact – parts], and 18 [inhalation – potable use]).

  As discussed above under future industrial/commercial workers – general, qualitative VI-related hazards are less than 1 and considered insignificant.

Based on the RME risk characterization, COCs for future industrial/commercial workers at Property 1 are as follows:

- Groundwater – **TCE, chloroform, PCE,** and **bromodichloromethane.**

CTE Scenario:

- The cumulative CTE cancer risk is 4E-05 (assuming RV washing) or 3E-05 (assuming parts washing). This cumulative risk is within EPA's target risk range of 1E-06 to 1E-04. Individual groundwater COPCs with risks equal to or exceeding 1E-06 are **TCE** (cumulative risk of 3.2E-05 [assuming RV washing] or 3.0E-05 [assuming parts washing] – 1.5E-05 [ingestion], 2.8E-06 [dermal contact – RV] or 6.6E-07 [dermal contact – parts], and 1.4E-05 [inhalation – potable use]) and **chloroform** (cumulative risk of 2.4E-06 [assuming either RV or parts washing] – 2.7E-07 [ingestion], 3.1E-08 [dermal contact – RV] or 7.1E-09 [dermal contact – parts], and 2.1E-06 [inhalation – potable use]).
- The cumulative CTE HI is 28 (assuming RV washing) or 27 (assuming parts washing). The only COPC with a HI equal to or exceeding 1 is **TCE** (cumulative HI of 26 [assuming RV washing] or 25 [assuming parts washing] – 6.8 [ingestion], 1.3 [dermal contact – RV] or 0.31 [dermal contact – parts], and 18 [inhalation – potable use]).

Based on the CTE risk characterization, COCs for future industrial/commercial workers at Property 1 are as follows:

- Groundwater – **TCE,** and **chloroform.**

Future Industrial/Commercial Workers – Property 2

Future industrial/commercial workers at Property 2 were assumed exposed to groundwater from a property-specific well via ingestion, dermal contact (hand washing only) and inhalation (potable use). EPCs, intakes, toxicity values, and resultant cancer risks and noncancer hazards for future

industrial/commercial workers at Property 1 in EA 1 are presented in Tables 7.1.1.2.3.RME and 7.1.1.2.3.CTE; calculated risks and hazards are summarized in Tables 9.1.1.2.3.RME and 9.1.1.2.3.CTE and are described below. COCs are presented in Tables 10.1.1.2.3.RME and 10.1.1.2.3.CTE.

RME Scenario:

- No carcinogenic groundwater COPCs were identified from the property-specific well.

  See also qualitative VI-related risks discussed above under future industrial/commercial worker – general (second and third bullets).

- The cumulative RME HI is 0.2, which is less than 1 and considered insignificant.

  As discussed above under future industrial/commercial workers – general, qualitative VI-related hazards are less than 1 and considered insignificant.

Based on the RME risk characterization, COCs for future industrial/commercial workers at Property 2 are as follows:

- Groundwater – none.

CTE Scenario:

- The cumulative CTE cancer risk is 0E+00; no carcinogenic groundwater COPCs were identified from the property-specific well.
- The cumulative CTE HI is 0.2, which is less than 1 and considered insignificant.

Based on the CTE risk characterization, COCs for future industrial/commercial workers at Property 2 are as follows:

- Groundwater – none.

Future Residents

Future residents were assumed exposed to groundwater via ingestion, dermal contact, and inhalation (via household use only). EPCs, intakes, toxicity values, and resultant cancer risks and noncancer hazards for future residents at EA 1 are presented in Tables 7.1.2.2.1.RME and 7.1.1.2.1.CTE; calculated risks and hazards are summarized in Tables 9.1.1.2.1.RME and 9.1.1.2.1.CTE and are described below. COCs are presented in Tables 10.1.1.2.1.RME and 10.1.1.2.1.CTE.

RME Scenario:

- The cumulative RME cancer risk is 7E-04. This cumulative risk exceeds EPA's target risk range of 1E-06 to 1E-04. Individual medium-specific individual COPCs with risks equal to and exceeding 1E-06 are **TCE** (cumulative risk of 6.6E-04 – 2.7E-04 [ingestion], 4.5E-05 [dermal contact], and 3.4E-04 [inhalation – household use]), **chloroform** (cumulative risk of 3.9E-05 – 3.4E-06 [ingestion], 3.1E-07 [dermal contact], and 3.5E-05 [inhalation – household use]), **PCE** (cumulative risk of 1.1E-05 – 3.2E-06 [ingestion], 1.9E-06 [dermal contact], and 5.6E-06 [inhalation – household use]); **bromodichloromethane** (cumulative risk of 7.5E-06 – 8.0E-07

[ingestion], 5.6E-08 [dermal contact], and 6.6E-06 [inhalation – household use]), and **dibromochloromethane** (cumulative risk of 1.4E-06 – 2.5E-07 [ingestion], 1.7E-08 [dermal contact], and 1.1E-06 [inhalation – household use]).

Similar to industrial/commercial workers – general (see above), VI risks were qualitatively evaluated for future residents using EPA's VISL Calculator (EPA 2014e) and soil vapor concentrations. Risks were calculated for all groundwater COPCs, as well as for dichlorodifluoromethane; the results of all VISL calculations are presented in Attachment D-4. The qualitative VI-related risks for future residents (Tables D-4-4 through D-4-6) are summarized below.

- At location SV-01 (Table D-4-4) in the PCE Plume, the risk for **PCE** (3.2E-06) and cumulative risk (3.7E-06) are within EPA's target risk range of 1E-06 to 1E-04. It should be noted that these risks apply only to future residents. No residences are currently present in EA 1.
- At location SV-03 (Table D-4-5) in the TCE Plume, the risk for **chloroform** (1.6E-05) and cumulative risk (1.6E-05) are within EPA's target risk range of 1E-06 to 1E-04. It should be noted that **chloroform** is present in groundwater at EA 1 at a concentration well below the MCL for total trihalomethanes (80 µg/L). Chloroform may be present in groundwater as the result of chlorinated drinking water. Also, it should be noted that these risks apply only to future residents. No residences are currently present in EA 1.
- At location SV-04 (Table D-4-6) in the TCE Plume, individual and cumulative risks are less than 1E-06 and considered insignificant.

- The cumulative RME HI is 121. The individual COPCs with HIs exceeding 1 are **TCE** (cumulative HI of 114 – 32 [ingestion], 4.7 [dermal contact], and 77 [inhalation – household use]) and **cis-1,2-DCE** (cumulative HI of 3.9 – 3.5 [ingestion], 3.9E-01 [dermal contact].

  Similar to the calculated groundwater risks, VI-related hazards were also evaluated using EPA's VISL Calculator (EPA 2014e) based on soil vapor sample results as described above. The individual and cumulative hazards for future residents (Tables D-4-4 through D-4-6) are summarized below.

  - At location SV-01 (Table D-4-4) in the PCE Plume, the individual and cumulative hazards are less than 1 and considered insignificant.
  - At location SV-03 (Table D-4-5) in the TCE Plume, the individual and cumulative hazards are less than 1 and considered insignificant.
  - At location SV-04 (Table D-4-6) in the TCE Plume, the hazard for **dichlorodifluoromethane** (2.0) and the cumulative hazard (2.0) exceed 1. It should be noted that dichlorodifluoromethane (Freon 12) is a refrigerant and may not be related to the VOC plume at the Lane Street site.

Based on the RME risk characterization, COCs for residents are as follows:

- Groundwater – **TCE, chloroform, PCE, bromodichloromethane, dibromochloromethane,** and **cis-1,2-DCE.**

CTE Scenario:

- The cumulative CTE cancer risk is 3E-04. This cumulative risk exceeds EPA's target risk range of 1E-06 to 1E-04. Individual medium-specific individual COPCs with risks equal to and exceeding 1E-06 are **TCE** (cumulative risk of 3.2E-04 – 1.7E-04 [ingestion], 1.8E-05 [dermal contact], and 1.3E-04 [inhalation – household use]), **chloroform** (cumulative risk of 1.3E-05 – 1.8E-06 [ingestion], 1.0E-07 [dermal contact], and 1.1E-05 [inhalation – household use]), **PCE** (cumulative risk of 4.2E-06 – 1.7E-06 [ingestion], 6.6E-07 [dermal contact], and 1.8E-06 [inhalation – household use]); and **bromodichloromethane** (cumulative risk of 2.5E-06 – 4.2E-07 [ingestion], 1.9E-08 [dermal contact], and 2.1E-06 [inhalation – household use]).
- The cumulative CTE HI is 97. The individual COPCs with HIs exceeding 1 are **TCE** (cumulative HI of 91 – 32 [ingestion], 3.7 [dermal contact], and 55 [inhalation – household use]) and **cis-1,2-DCE** (cumulative HI of 3.8 – 3.5 [ingestion], 3.0E-01 [dermal contact].

Based on the CTE risk characterization, COCs for residents are as follows:

- Groundwater – **TCE, chloroform, PCE, bromodichloromethane, dibromochloromethane,** and **cis-1,2-DCE.**

Current and Future Construction Workers

Current and future construction workers were assumed exposed to groundwater via dermal contact and inhalation. EPCs, intakes, toxicity values, and resultant cancer risks and noncancer hazards for future residents at EA 1 are presented in Tables 7.1.4.3.1.RME and 7.1.4.3.1.CTE; calculated risks and hazards are summarized in Tables 9.1.4.3.1.RME and 9.1.4.3.1.CTE and are described below. COCs are presented in Tables 10.1.4.3.1.RME and 10.1.4.3.1.CTE.

RME Scenario:

- The cumulative RME cancer risk is 5E-06. This cumulative risk is within EPA's target risk range of 1E-06 to 1E-04. The only medium-specific individual COPC with a risk equal to and exceeding 1E-06 is **TCE** (cumulative risk of 4.0E-06 – 3.9E-06 [inhalation] and 6.1E-08 [dermal contact]).
- The cumulative RME HI is 135. The individual COPCs with HIs exceeding 1 are **TCE** (cumulative HI of 131 – 130 [inhalation] and 2.3 [dermal contact]) and **PCE** (cumulative HI of 2.3 – 2.2 [inhalation] and 7.5E-02 [dermal contact]).

Based on the RME risk characterization, COCs for construction workers are as follows:

- Groundwater – **TCE** and **PCE.**

CTE Scenario:

- The cumulative CTE cancer risk is 2E-06. This cumulative risk is within EPA's target risk range of 1E-06 to 1E-04. The only medium-specific individual COPC with a risk equal to and exceeding 1E-06 is **TCE** (cumulative risk of 1.8E-06 – 1.8E-06 [inhalation] and 2.8E-08 [dermal contact]).
- The cumulative CTE HI is 135. The individual COPCs with HIs exceeding 1 are **TCE** (cumulative HI of 131 – 130 [inhalation] and 2.3 [dermal contact]) and **PCE** (cumulative HI of 2.3 – 2.2 [inhalation] and 7.5E-02 [dermal contact]).

Based on the CTE risk characterization, COCs for construction workers are as follows:

- Groundwater – **TCE** and **PCE**.

Current and Future Utility Workers

Current and future utility workers were assumed exposed to groundwater via dermal contact and inhalation. EPCs, intakes, toxicity values, and resultant cancer risks and noncancer hazards for future residents at EA 1 are presented in Tables 7.1.5.3.1.RME and 7.1.5.3.1.CTE; calculated risks and hazards are summarized in Tables 9.1.5.3.1.RME and 9.1.5.3.1.CTE and are described below. COCs are presented in Tables 10.1.5.3.1.RME and 10.1.5.3.1.CTE.

RME Scenario:

- The cumulative RME cancer risk is 4E-05. This cumulative risk is within EPA's target risk range of 1E-06 to 1E-04. Individual medium-specific individual COPCs with risks equal to and exceeding 1E-06 are **TCE** (cumulative risk of 3.0E-05 – 3.0E-05 [inhalation] and 4.7E-07 [dermal contact]), **chloroform** (cumulative risk of 4.6E-06 – 4.6E-06 [inhalation] and 5.0E-09 [dermal contact]), and **bromodichloromethane** (cumulative risk of 4.6E-06 – 4.6E-06 [inhalation] and 8.0E-10 [dermal contact]).
- The cumulative RME HI is 10. The only COPC with a HI exceeding 1 is **TCE** (cumulative HI of 10 – 10 [inhalation] and 5.7E-02 [dermal contact]).

Based on the RME risk characterization, COCs for utility workers are as follows:

- Groundwater – **TCE, chloroform**, and **bromodichloromethane**.

CTE Scenario:

- The cumulative CTE cancer risk is 5E-06. This cumulative risk is within EPA's target risk range of 1E-06 to 1E-04. The only medium-specific COPC with a risk equal to and exceeding 1E-06 is **TCE** (cumulative risk of 4.0E-06 – 3.9E-06 [inhalation] and 6.2E-08 [dermal contact]).

- The cumulative CTE HI is 5. The only COPC with a HI exceeding 1 is **TCE** (cumulative HI of 5.1 – 5.1 [inhalation] and 2.8E-02 [dermal contact]).

Based on the CTE risk characterization, COCs for utility workers are as follows:

- Groundwater – **TCE**.

EA 2 – Residential Exposure Area

EA 2 occupies the southern one-third of the site (see Figure D-1). EA 2 takes its name from the fact that this exposure area is currently used for residential purposes. Surface and near surface soil samples, groundwater samples, and soil gas samples were collected in this area. Potential receptors evaluated in the HHRA include future industrial/commercial workers and future residents. RAGS D Tables 7.2.1.2.1.RME and 7.2.2.2.1.RME and matching CTE tables present the EPCs, CDIs, CDEs, toxicity values, and calculated cancer risks and noncancer hazards for potential receptors at EA 2. The risks and hazards are summarized in similarly numbered RAGS D Tables 9 and 10 (as well as a set of RAGS D Table 10s with a similar numbering scheme) and in Table D-2-5.

Future Industrial/Commercial Workers

Future industrial/commercial workers were assumed exposed to groundwater via ingestion, dermal contact (hand washing only), and inhalation (household use only). EPCs, intakes, toxicity values, and resultant cancer risks and non-cancer hazards for future industrial/commercial workers at EA 2 are presented in Tables 7.2.1.2.1.RME and 7.2.1.2.1.CTE; calculated risks and hazards are summarized in Tables 9.2.1.2.1.RME and 9.2.1.2.1.CTE and are described below. COCs are presented in Tables 10.2.1.2.1.RME and 10.2.1.2.1.CTE.

RME Scenario:

- The cumulative RME cancer risk is 4E-05. This cumulative risk is within EPA's target risk range of 1E-06 to 1E-04. Individual COPCs with risks equal to or exceeding 1E-06 are **TCE** (cumulative risk of 3.1E-05 – 1.6E-05 [ingestion], 8.6E-08 [dermal contact], and 1.5E-05 [inhalation – household use]), **chloroform** (cumulative risk of 4.6E-06 – 5.1E-07 [ingestion], 1.5E-09 [dermal contact], and 4.1E-06 [inhalation – household use]), and **bromodichloromethane** (cumulative risk of 3.4E-06 – 4.5E-07 [ingestion], 1.1E-09 [dermal contact], and 2.9E-06 [inhalation – household use]).

  As discussed in Section 2.5.2.1, the cumulative risks listed above do not include any risks associated with vapor intrusion. Receptor-specific risks and hazards were evaluated using EPA's VISL Calculator (EPA 2014e) based on soil vapor concentrations measured at 11 locations (five [SV-01 through SV-05] in EA 1 and six [SV-06 through SV-08 and SV-10 through SV-12] in EA 2). As shown in Table 5-9 from the RI, soil vapor concentrations exceeded screening levels only in EA 1 at locations SV-01 (PCE only), SV-03 (chloroform only), and SV-04 (dichlorodifluoromethane only). Based on the fact that soil vapor

concentrations measured in EA 2 were all less than screening levels, all individual and cumulative VI risks are less than 1E-06 and considered insignificant.

- The cumulative RME HI is 9. Individual COPCs with HIs exceeding 1 are **TCE** (cumulative HI of 7 – 1.9 [ingestion], 1.1E-02 [dermal contact], and 5.1 [inhalation – household use]) and **cis-1,2-DCE** (cumulative HI of 2 – 2 [ingestion] and 8.3E-03 [dermal contact]).

  As noted above for cancer risks, because soil vapor concentrations measured in EA 2 were all less than screening levels, all individual and cumulative VI hazards are less than 1 and considered insignificant.

Based on the RME risk characterization, COCs for future industrial/commercial workers are as follows:

- Groundwater – **TCE, chloroform, bromodichloromethane**, and **cis-1,2-DCE**.

CTE Scenario:

- The cumulative CTE cancer risk is 1E-05. This cumulative risk is within EPA's target risk range of 1E-06 to 1E-04. Individual COPCs with risks equal to or exceeding 1E-06 are **TCE** (cumulative risk of 8.1E-06 – 4.1E-06 [ingestion], 2.3E-08 [dermal contact], and 4.0E-06 [inhalation – household use]) and **chloroform** (cumulative risk of 1.2E-06 – 1.3E-07 [ingestion], 4.1D-10 [dermal contact], and 1.1E-06 [inhalation – household use]).
- The cumulative CTE HI is 9. Individual COPCs with HIs exceeding 1 are **TCE** (cumulative HI of 7.0 – 1.9 [ingestion], 1.1E-02 [dermal contact], and 5.1 [inhalation – household use]) and **cis-1,2-DCE** (cumulative HI of 2.0 – 2.0 [ingestion] and 8.3E-03 [dermal contact]).

Based on the CTE risk characterization, COCs for future industrial/commercial workers are as follows:

- Groundwater – **TCE, chloroform**, and **cis-1,2-DCE**.

Future Residents

Future residents were assumed exposed to groundwater via ingestion, dermal contact, and inhalation (household use only). EPCs, intakes, toxicity values, and resultant cancer risks and noncancer hazards for future residents at EA 2 are presented in Tables 7.2.2.2.1.RME and 7.2.2.2.1.CTE; calculated risks and hazards are summarized in Tables 9.2.2.2.1.RME and 9.2.2.2.1.CTE and are described below. COCs are presented in Tables 10.2.2.2.1.RME and 10.2.2.2.1.CTE.

RME Scenario:

- The cumulative RME cancer risk is 2E-04. This cumulative risk exceeds EPA's target risk range of 1E-06 to 1E-04. Individual COPCs with risks equal to and exceeding 1E-06 are **TCE** (cumulative risk of 1.8E-04 – 7.5E-05 [ingestion], 1.2E-05 [dermal contact], and 9.4E-05 [inhalation – household use]), **chloroform** (cumulative risk of 2.0E-05 – 1.7E-06 [ingestion], 1.6E-07 [dermal contact], and 1.8E-05 [inhalation – household use]), **bromodichloromethane** (cumulative risk of 1.5E-05 – 1.5E-06 [ingestion], 1.1E-07 [dermal contact], and 1.3E-05 [inhalation – household use]), **dibromochloromethane** (cumulative risk of 4.0E-06 – 7.1E-07 [ingestion], 4.8E-08 [dermal contact], and 3.2E-06 [inhalation – household use]), and **1,1-dichloroethane (1,1-DCA)** (cumulative risk of 1.6E-06 – 3.2E-07 [ingestion], 2.5E-08 [dermal contact], and 1.3E-06 [inhalation – household use]).

As noted above for future industrial/commercial workers, because soil vapor concentrations measured in EA 2 were all less than screening levels, all individual and cumulative VI risks for residents are less than 1E-06 and considered insignificant.

- The cumulative RME HI is 42. Individual COPCs with HIs exceeding 1 are **TCE** (cumulative HI of 32.2 – 8.9 [ingestion], 1.3 [dermal contact], and 22 [inhalation – household use]) and **cis-1,2-DCE** (cumulative HI of 10.2 – 9.2 [ingestion] and 1.0 [dermal contact]).

  As noted above for cancer risks, because soil vapor concentrations measured in EA 2 were all less than screening levels, all individual and cumulative VI hazards for residents are less than 1E-06 and considered insignificant.

Based on the RME risk characterization, COCs for residents are as follows:

- Groundwater – **TCE, chloroform, bromodichloromethane, dibromochloromethane, 1,1-DCA**, and **cis-1,2-DCE**.

CTE Scenario:

- The cumulative CTE cancer risk is 1E-04. This cumulative risk exceeds EPA's target risk range of 1E-06 to 1E-04. Individual COPCs with risks equal to and exceeding 1E-06 are **TCE** (cumulative risk of 8.9E-05 – 4.7E-05 [ingestion], 5.1E-06 [dermal contact], and 3.7E-05 [inhalation – household use]), **chloroform** (cumulative risk of 6.6E-06 – 8.9E-07 [ingestion], 5.3E-08 [dermal contact], and 5.7E-06 [inhalation – household use]), **bromodichloromethane** (cumulative risk of 4.8E-06 – 7.9E-07 [ingestion], 3.7E-08 [dermal contact], and 4.0E-06 [inhalation – household use]), and **dibromochloromethane** (cumulative risk of 1.4E-06 – 3.7E-07 [ingestion], 1.7E-08 [dermal contact], and 1.0E-06 [inhalation – household use]).
- The cumulative CTE HI is 35. Individual COPCs with HIs exceeding 1 are **TCE** (cumulative HI of 24.9 – 8.9 [ingestion], 1.0 [dermal contact], and 15 [inhalation – household use]) and **cis-1,2-DCE** (cumulative HI of 10 – 9.2 [ingestion] and 0.8 [dermal contact]).

Based on the CTE risk characterization, COCs for residents are as follows:

- Groundwater – **TCE, chloroform, bromodichloromethane, dibromochloromethane**, and **cis-1,2-DCE**.

Current and Future Construction Workers

Current and future construction workers were assumed exposed to groundwater via dermal contact and inhalation. EPCs, intakes, toxicity values, and resultant cancer risks and noncancer hazards for future residents at EA 2 are presented in Tables 7.2.4.3.1.RME and 7.2.4.3.1.CTE; calculated risks and hazards are summarized in Tables 9.2.4.3.1.RME and 9.2.4.3.1.CTE and are described below. COCs are presented in Tables 10.2.4.3.1.RME and 10.2.4.3.1.CTE.

RME Scenario:

- The cumulative RME cancer risk is 2E-06. This cumulative risk is within EPA's target risk range of 1E-06 to 1E-04. The only medium-specific COPC with a risk equal to and exceeding 1E-06 is **TCE** (cumulative risk of 1.1E-06 – 1.1E-06 [inhalation] and 1.7E-08 [dermal contact]).
- The cumulative RME HI is 37. The only COPC with a HI exceeding 1 is **TCE** (cumulative HI of 37 – 37 [inhalation] and 0.21 [dermal contact]).

Based on the RME risk characterization, COCs for construction workers are as follows:

- Groundwater – **TCE**.

CTE Scenario:

- The cumulative CTE cancer risk is 8E-07. This cumulative risk is less than EPA's target risk range of 1E-06 to 1E-04 and considered insignificant.).
- The cumulative CTE HI is 37. The only COPC with a HI exceeding 1 is **TCE** (cumulative HI of 37 – 37 [inhalation] and 0.21 [dermal contact]).

Based on the CTE risk characterization, COCs for construction workers are as follows:

- Groundwater – **TCE**.

Current and Future Utility Workers

Current and future utility workers were assumed exposed to groundwater via dermal contact and inhalation. EPCs, intakes, toxicity values, and resultant cancer risks and noncancer hazards for future residents at EA 2 are presented in Tables 7.2.5.3.1.RME and 7.2.5.3.1.CTE; calculated risks and hazards are summarized in Tables 9.2.5.3.1.RME and 9.2.5.3.1.CTE and are described below. COCs are presented in Tables 10.2.5.3.1.RME and 10.2.5.3.1.CTE.

RME Scenario:

- The cumulative RME cancer risk is 1E-05. This cumulative risk is within EPA's target risk range of 1E-06 to 1E-04. Individual medium-specific individual COPCs with risks equal to and exceeding 1E-06 are **TCE** (cumulative risk of 8.4E-06 – 8.3E-06 [inhalation] and 1.3E-07 [dermal contact]), **chloroform** (cumulative risk of 2.3E-06 – 2.3E-06 [inhalation] and 2.5E-09 [dermal contact]), **bromodichloromethane** (cumulative risk of 1.4E-06 – 1.4E-06 [inhalation] and 1.5E-09 [dermal contact]) and **1,1-DCA** (cumulative risk of 1.4E-06 --- 1.4E-06 [inhalation] and 4.5E-10 [dermal contact]).
- The cumulative RME HI is 3. The only COPC with a HI exceeding 1 is **TCE** (cumulative HI of 2.8 – 2.8 [inhalation] and 1.6E-02 [dermal contact]).

Based on the RME risk characterization, COCs for utility workers are as follows:

- Groundwater – **TCE, chloroform, bromodichloromethane,** and **1,1-DCA.**

CTE Scenario:

- The cumulative CTE cancer risk is 2E-06. This cumulative risk is within EPA's target risk range of 1E-06 to 1E-04. The only medium-specific COPC with a risk equal to and exceeding 1E-06 is **TCE** (cumulative risk of 1.1E-06 – 1.1E-06 [inhalation] and 1.7E-08 [dermal contact]).
- The cumulative CTE HI is 1 and considered insignificant..

Based on the CTE risk characterization, COCs for utility workers are as follows:

- Groundwater – **TCE.**

2.6 HHRA UNCERTAINTY ASSESSMENT

Uncertainties are inherent in the process of quantitative risk assessment because of the use of environmental sampling results, assumptions regarding exposure, and the quantitative representation of chemical toxicity. Analysis of the critical areas of uncertainty in risk assessment provides a better

understanding of the quantitative results through identification of the uncertainties that most significantly affect the results.

EPA guidance stresses the importance of providing an in-depth analysis of uncertainties so that risk managers are better informed when evaluating risk assessment conclusions (EPA 1989). Potentially significant sources of uncertainty for this assessment are discussed in terms of general sources of uncertainty (Section 2.6.1), additional site-specific uncertainties (Section 2.6.2).

The following general sources of uncertainty are discussed: the CSM (Section 2.6.1), analytical data (Section 2.6.2), exposure estimates (Section 2.6.3), and toxicity estimates (Section 2.6.4).

2.6.1 Uncertainty in Conceptual Site Model

The CSM for the Lane Street Site incorporates a number of assumptions regarding the completeness and reasonableness of the presumed exposure scenarios. Some of the assumptions seem evidently valid. For example, it is realistic to assume that current land uses (industrial/commercial at EA 1 and residential at EA 2) may continue in the future. Alternatively, given the close proximity of alternative land uses, it is reasonable to assume that some parts (if not all) of EA 1 could switch to residential land use in the future and that parts (if not all) of EA 2 could switch to industrial/commercial land use in the future.

However, other assumptions regarding receptor-specific exposures are more tenuous or are less evident. Examples of some of these assumptions are provided below:

- As discussed in Section 2.1.1, the potential for VOCs in groundwater to migrate via VI into overlying buildings (homes or businesses) is assumed to be limited. Potentially unacceptable indoor air concentrations are judged to occur only for future residents in the PCE Plume area of EA 1. Receptor-specific risks and hazards in EA 1 are addressed qualitatively using EPA's VISL Calculator (see Attachment D-4).

- Residential receptors are exposed via dermal contact with groundwater via standard exposure scenarios (such as bathing). Industrial/commercial workers were assumed to be exposed primarily through routine hand washing. Industrial/commercial workers were assumed to not be exposed via full-body contact (for example, showering in a locker room scenario). However, current industrial/commercial workers at Property 1 are known to wash machine parts in a sink and to wash RVs and are assumed to continue such activities in the future.

- Finally, groundwater may be used for various non-potable uses by residents. Such uses may include car washing, irrigation of gardens, and filling of swimming pools (most often small "kiddie" pools). Potential exposures associated with such groundwater uses have been shown at other sites to be associated with low or insignificant risks and hazards. Therefore, these non-

potable groundwater uses were not evaluated in the HHRA. The absence of these exposure scenarios is expected to introduce only a small amount of uncertainty into the HHRA.

In summary, all future land use exposure assumptions are subject to uncertainty. Some receptor-exposure pathway combinations (including those discussed above) are more or less likely than others. The uncertainty associated with particular combinations increases as the likelihood of particular combinations decreases.

2.6.2 Uncertainty in Analytical Data

Laboratory analysis of environmental samples is subject to a number of technical difficulties; however, the magnitude of uncertainty is generally small compared with other sources. Still, another source of uncertainty related to analytical data is associated with the use (or non-use) of historical analytical data for the Lane Street Site. Historical data were not directly used quantitatively in the HHRA. Rather, historical data informed the choice of sampling locations, analytes, and media sampled. However, the medium-specific EPCs calculated in the HHRA are based entirely on data obtained during the RI. Therefore, use of these data in the HHRA is judged to be associated with a minimal amount of uncertainty.

Use of only RI data for quantitative exposure calculations in the HHRA is also judged to be associated with a low amount of uncertainty. The medium-specific RI samples were collected using a consistent sampling crew, were analyzed using a consistent set of analytical procedures that met the majority of chemical- and medium-specific PALs, were adequately numerous, and represented adequate spatial coverage across all media at the Lane Street Site. Review of historical data indicated that no significant new COPCs would have been identified using historical data in addition to the RI data. The RI data were judged to represent the most up-to-date analytical data set.

With regard to the use and consideration of analytical data, three points may be judged associated with additional uncertainty by some readers. These three points are summarized below.

- Arsenic was identified as the only contaminant detected in soil at concentrations exceeding screening levels (EPA residential soil RSLs). However, as discussed in Section 1.5.3, arsenic was considered not to be a site-related contaminant. Soil samples were analyzed for metals as a matter of completeness and for consistency with historical samples. Also, the maximum arsenic detection in soil was 4.7 mg/kg at sample location VAS-SO17. The U.S. Geological Survey (USGS) conducted a nationwide study of metals in surface soils and reported a national mean of 5.2 mg/kg (USGS 1984). Similarly, the mean concentration of arsenic in soil from Elkhart County, Indiana is 7.5 mg/kg (USGS 2014). All of the sample results from the Lane Street Site are below these national and background average arsenic concentrations in soil. Therefore,

arsenic concentrations were considered typical of background levels.. Arsenic in particular and the soil medium in general was not considered further in the HHRA.

- Several trihalomethanes, including chloroform, bromodichloromethane, and dibromochloromethane, were identified as COPCs in groundwater and were found to be associated with receptor-specific risks greater than or equal to 1E-06 and hazards greater than 1. However, the Lane Street Site has historically been identified with and characterized as plumes of PCE, TCE, and their breakdown products. The three trihalomethanes identified above cannot be formed as breakdown products of either PCE or TCE. It was considered more likely that these trihalomethanes are related to the release of chlorinated drinking water from pipes or septic systems. Review of recent water quality reports for the City of Elkhart shows that the concentration of total trihalomethanes in city water ranges from about 18.0 to 28.2 µg/L (City of Elkhart 2013). These concentrations, as well as the summed concentrations of chloroform, bromodichloromethane, and dibromochloromethane at the Lane Street Site, are less than the MCL for total trihalomethanes of 80 µg/L. For these reasons, chloroform, bromodichloromethane, and dibromochloromethane were ultimately not considered to be COCs in groundwater for the Lane Street site.

- Dichlorofluoromethane was detected in soil gas at a maximum concentration exceeding the resident-based screening level from EPA's VISL Calculator. Dichlorofluormethane (Freon 12) is a refrigerant and is considered to be unrelated to the VOC-based groundwater contamination at the Lane Street Site..

2.6.3 Uncertainty in Exposure Estimates

Uncertainty associated with the overall CSM (the potentially complete exposure pathways evaluated in the HHRA) was discussed in Section 2.6.1.1. This section focuses on the uncertainty associated with estimates of exposure at the point of contact between the human receptor and constituents in environmental media.

Exposure Point Concentrations

If any sampling was intentionally biased toward areas of contamination, the resulting EPC — an attempted quantification of average concentration across an area — could overestimate risks. Use of maximum detected concentrations as EPCs likely overestimated risks, whereas use of a 95UCL as the EPC could underestimate or overestimate risks. However, this parameter is designed to overestimate the risk 95 percent of the time. Assumptions about the distribution of the data affected calculation of a 95 percent UCL and, therefore, contributed to uncertainty in the calculation. Specifically, ProUCL developers have expressed some reservation regarding use of the lognormal distribution based on the observation that the lognormal methods sometimes result in overly conservative estimates of the UCL. However, the lognormal distribution has a clear theoretical basis associated with the multiplicative process assumed with contaminant transport and dilution. Given that the simulations used to develop the ProUCL algorithm (resulting in nominal 95UCL coverage) included the lognormal theory (the appearance

of lognormal theory methods in the UCL code is not a blatant error), use of the ProUCL-recommended UCL method is the most defensible and transparent approach.

Groundwater EPCs for EA 1 may be overestimated because of the process used to calculate and select these EPCs. As characterized in Section 1.7, EA 1 is associated with two different plumes – the PCE plume toward the northern end of EA 1 and the TCE plume toward the south-central part of EA 1. To generate a conservative, and health-protective set of groundwater EPCs for EA 1, the COPC-specific EPCs generated for each plume were compared. The larger of the two plume-specific EPCs was selected as the groundwater EPC for each COPC at EA 1. As a result, the PCE EPC is from the PCE plume, while the EPCs for the remaining groundwater EPCs (including TCE) are from the TCE plume.

It is unlikely that receptors will be exposed to groundwater from both plumes over the same exposure period. Therefore, a single set of groundwater EPCs may overestimate actual groundwater exposures and related risks and hazards, depending on where receptors and future drinking water wells are located.

Exposure Parameters

Values assumed for exposure parameters (such as ingestion rate and exposure frequency) used in calculations of intakes were based primarily on default parameters recommended by EPA guidance. These assumptions might result in underestimating or overestimating the intakes calculated for specific receptors, depending on the accuracy of the assumptions relative to actual site conditions and land uses.

Modeled Medium-Specific Concentrations

No indoor air samples were collected at either EA 1 or EA 2. This decision was based primarily on the fact that, as discussed in Section 2.6.1.1, the VI migration pathway was judged to be incomplete. However, VOCs may be released into indoor air from various uses of water within homes and business places, including bathing, dish and clothes washers, and restrooms (toilets and sinks). It is standard risk assessment procedure to use a VF of 0.5 L/m^3 to estimate indoor air concentrations from a groundwater concentration. The uncertainty associated with use of a default VF is considered small for a residential exposure scenario. It is not unreasonable to assume all or most homes will have bathrooms with showers, dish and clothes washers, and restrooms with toilets and sinks.

Greater uncertainty is associated with application of the single default VF for estimating indoor air concentrations at industrial/commercial properties. Industrial/commercial properties are expected to have restrooms, but may not have dishwashers (or even kitchen sinks), and are unlikely to have clothes washers or showering facilities. Therefore, the use of the default VF in these cases may overestimate the indoor

air concentrations of groundwater VOCs in industrial/commercial buildings. In addition, at Property 1, current industrial/commercial workers experience dermal contact with water through washing machine parts in a sink, as well as washing RVs. Parts washing in an indoor sink is expected to generate VOCs, which could accumulate in an indoor setting. VOCs are also expected to be released when RVs are washed. However, RVs are primarily washed outdoors, where VOCs released may rapidly dissipate in the ambient air. Therefore, even at Property 1, the use of a single default VF is judged to be associated with at least a moderate amount of uncertainty and is more likely to overestimate the concentrations of volatile COPCs in groundwater in air to which industrial/commercial workers may be exposed.

Chemical-Specific Assumptions

The primary general source of chemical uncertainty is associated with use of chemical surrogates. Surrogates are used when toxicological or chemical-specific information is not available for particular COPCs. In these instances, standard procedure is to use chemical surrogates (identified primarily by similar chemical structures and activities). For example, cyclohexane was used as a surrogate for methylcyclohexane. Use of chemical surrogates contributes a moderate amount of uncertainty because it is not certain that chemicals with similar structures would act entirely similarly.

2.6.4 Uncertainty in Toxicity Estimates

Uncertainty is inherent in the toxicity values utilized in evaluating carcinogenic and noncarcinogenic risks. This uncertainty is chemical-specific and is incorporated into the toxicity value when it is developed. For example, an uncertainty factor may be applied for interspecies and intrahuman variability, for extrapolation from subchronic to chronic exposures, or for epidemiological data limitations. Application of uncertainty factors is expected to overestimate risks.

2.7 HHRA SUMMARY AND CONCLUSIONS

This HHRA evaluated potential exposures of human receptors to constituents detected in environmental media at the Lane Street Site. Each site was subdivided into exposure areas, primarily on the basis of current and reasonably anticipated future land use and contaminant distribution. At the Lane Street Site, these areas are designated as follows:

- EA 1 – Industrial Exposure Area
- EA 2 – Residential Exposure Area

The objectives of the HHRA were to evaluate whether site-related constituents detected in environmental media pose potentially unacceptable risks to current and future human receptors and to provide

information to support decisions regarding the need for further evaluation or action based upon current and reasonably anticipated future land use. Some future land use scenarios not reasonably anticipated were assumed and quantitatively evaluated in this HHRA to support the evaluation of risk management measures during the FS. This HHRA supports the conclusions presented in the following subsections for the Lane Street Site.

Total and COPC-specific risks and hazards under RME conditions for each of the exposure areas are discussed below in Sections 2.7.1 (EA 1) and 2.7.2 (EA 2). Four different receptors were evaluated at EAs 1 and 2: future residents, construction workers, utility workers, and future industrial/commercial workers. There are no current exposures at either EA 1 or EA 2. Future residents were assumed exposed to groundwater via ingestion, dermal contact (bathing), and inhalation associated with household use of potable water. Future industrial/commercial workers were assumed to be similarly exposed with one exception. In general, with regards dermal exposure to groundwater, future industrial/commercial workers were assumed exposed only during hand washing. However, workers at Property 1 in EA 1 experience dermal contact to groundwater as a result of their unique work activities, which include washing parts in a sink and washing RVs. Therefore, under the future land use scenario, it was assumed that industrial/commercial workers at Property 1 would be exposed to EA 1-wide groundwater via these same property-specific work activities. In addition, the current private well at Property 2 was assumed to be used in the future. (Property 2 is currently unoccupied.) Current and future construction and utility workers were assumed to be exposed through dermal contact when skin comes into contact with groundwater in a trench, and through inhalation from VOCs released from groundwater into trench air. Risks for the exposure areas are summarized in Tables D-2-4 (EA 1) and D-2-5 (EA 2).

COCs represent those COPCs associated with receptor-specific risks greater than or equal to 1E-06 or hazards greater than 1. The name of each soil COC is **bolded**.

2.7.1 EA 1

EA 1 occupies the northern two-thirds of the site (see Figure D-1). This exposure area is currently used for by numerous different operations for industrial/commercial purposes. Risks and hazards for each of the receptors evaluated for this exposure area are summarized in Table D-2-4 and discussed below.

Future Industrial/Commercial Workers – General

Future industrial/commercial workers throughout EA 1 were assumed exposed to groundwater via ingestion, dermal contact (hand washing only) and inhalation (potable use). Total risks and hazards were

evaluated for potential exposure to groundwater based on EA 1-wide groundwater EPCs and are summarized below.

- The total cumulative risk is 1E-04, which is at the upper limit of EPA's target risk range of 1E-06 to 1E-04. Risk-based COCs for groundwater include **TCE** (cumulative risk of 1.1E-04), **chloroform** (cumulative risk of 9.0E-06), **PCE** (cumulative risk of 2.3E-06), and **bromodichloromethane** (cumulative risk of 1.7E-06).

  The qualitative VI risks for industrial/commercial workers (Tables D-4-1 through D-4-3) are summarized below.

  - At location SV-01 (Table D-4-1) in the PCE Plume, individual and cumulative risks are less than 1E-06 and considered insignificant.
  - At location SV-03 (Table D-4-2) in the TCE Plume, the risk for **chloroform** (3.6E-06) and cumulative risk (3.6E-06) are within EPA's target risk range of 1E-06 to 1E-04. It should be noted that chloroform is present in groundwater at EA 1 at a concentration well below the MCL for total trihalomethanes (80 µg/L). Chloroform may be present in groundwater as the result of chlorinated drinking water.
  - At location SV-04 (Table D-4-3) in the TCE Plume, individual and cumulative risks are less than 1E-06 and considered insignificant.

- The total cumulative hazard is 27. The only groundwater hazard-based COC is **TCE** (cumulative HI of 25).

  Similar to the calculated groundwater risks, VI hazards were also evaluated using EPA's VISL Calculator (EPA 2014e) based on soil vapor sample results as described above. The individual and cumulative hazards are less than 1 and considered insignificant at all locations.

Therefore, based on the RME risk characterization, COCs for future industrial/commercial workers exposed throughout EA 1 are as follows: **TCE, chloroform, PCE,** and **bromodichloromethane.**

Future Industrial/Commercial Workers – Property 1

Future industrial/commercial workers at Property 1 were assumed exposed to groundwater via ingestion, dermal contact (RV and parts washing) and inhalation (potable use). Total risks and hazards were evaluated for potential exposure to groundwater based on EA 1-wide groundwater EPCs.

- The total cumulative risk is 1E-04, which is at the upper limit of EPA's target risk range of 1E-06 to 1E-04. Risk-based COCs for groundwater include **TCE** (cumulative risk of 1.2E-04 [assuming RV washing] or 1.1E-04 [assuming parts washing]), **chloroform** (cumulative risk of 9.1E-06 [assuming RV washing] or 9.0E-06 [assuming parts washing]), **PCE** (cumulative risk of 2.8E-06

[assuming RV washing] or 2.4E-06 [assuming parts washing]), and **bromodichloromethane** (cumulative risk of 1.8E-06 [assuming RV washing] or 1.7E-06 [assuming parts washing]).

See also the qualitative VI-related risks discussed above under future industrial/commercial workers – general (second and third bullets).

- The total cumulative HI is 28 (assuming RV washing) or 27 (assuming parts washing). The only hazard-based COC for groundwater is **TCE** (cumulative HI of 26 [assuming RV washing] or 25 [assuming parts washing]).

  As discussed above under future industrial/commercial – general, qualitative VI-related hazards are less than 1 and considered insignificant.

Therefore, based on the RME risk characterization, COCs for future industrial/commercial workers exposed at Property 1 are as follows: **TCE, chloroform, PCE, and bromodichloromethane.**

Future Industrial/Commercial Workers – Property 2

Future industrial/commercial workers at Property 2 were assumed exposed to groundwater via ingestion, dermal contact (hand washing only) and inhalation (potable use). Total risks and hazards were evaluated for potential exposure to groundwater based on Property 2-specific groundwater EPCs.

- No carcinogenic COPCs were identified from the Property 1-specific well.

  See also the qualitative VI-related risks discussed above under future industrial/commercial workers – general (second and third bullets).

- The cumulative HI is 0.2, which is less than 1 and considered insignificant.

  As discussed above under future industrial/commercial – general, qualitative VI-related hazards are less than 1 and considered insignificant.

Therefore, based on the RME risk characterization, no COCs were identified for future industrial/commercial workers exposed at Property 2.

Future Residents

Future residents were assumed exposed to groundwater via ingestion, dermal contact, and inhalation (via household use only). Total risks and hazards were evaluated for potential exposure to groundwater based on EA 1-wide groundwater EPCs.

- The total cumulative risk is 7E-04, which exceeds EPA's target risk range of 1E-06 to 1E-04. Risk-based COCs for groundwater include **TCE** (cumulative risk of 6.6E-04), **chloroform** (cumulative risk of 3.9E-05), **PCE** (cumulative risk of 1.1E-05), **bromodichloromethane** (cumulative risk of 7.5E-06), and **dibromochloromethane** (cumulative risk of 1.4E-06).

  The qualitative VI-related risks for future residents (Tables D-4-4 through D-4-6) are summarized below.

  - At location SV-01 (Table D-4-4) in the PCE Plume, the risk for **PCE** (3.2E-06) and cumulative risk (3.7E-06) are within EPA's target risk range of 1E-06 to 1E-04. It should be noted that these risks apply only to future residents. No residences are currently present in EA 1.

- At location SV-03 (Table D-4-5) in the TCE Plume, the risk for **chloroform** (1.6E-05) and cumulative risk (1.6E-05) are within EPA's target risk range of 1E-06 to 1E-04. It should be noted that **chloroform** is present in groundwater at EA 1 at a concentration well below the MCL for total trihalomethanes (80 µg/L). Chloroform may be present in groundwater as the result of chlorinated drinking water. Also, it should be noted that these risks apply only to future residents. No residences are currently present in EA 1.
- At location SV-04 (Table D-4-6) in the TCE Plume, individual and cumulative risks are less than 1E-06 and considered insignificant.

- The total cumulative HI is 121. Hazard-based COCs for groundwater include **TCE** (cumulative HI of 114), **cis-1,2-DCE** (cumulative HI of 3.9), and **PCE** (cumulative HI of 3.0).

  The individual and cumulative hazards for future residents (Tables D-4-4 through D-4-6) are summarized below.

  - At location SV-01 (Table D-4-4) in the PCE Plume, the individual and cumulative hazards are less than 1 and considered insignificant.
  - At location SV-03 (Table D-4-5) in the TCE Plume, the individual and cumulative hazards are less than 1 and considered insignificant.
  - At location SV-04 (Table D-4-6) in the TCE Plume, the hazard for **dichlorodifluoromethane** (2.0) and the cumulative hazard (2.0) exceed 1. It should be noted that dichlorodifluoromethane (Freon 12) is a refrigerant and may not be related to the VOC plume at the Lane Street site.

Therefore, based on the RME risk characterization, COCs for future residents exposed throughout EA 1 are as follows: **TCE, chloroform, PCE, bromodichloromethane, dibromochloromethane,** and **cis-1,2-DCE.**

Current and Future Construction Workers

Current and future construction workers were assumed exposed to groundwater via dermal contact and inhalation. Total risks and hazards were evaluated for potential exposure to groundwater based on EA 1-wide groundwater EPCs.

- The total cumulative risk is 7E-04, which exceeds EPA's target risk range of 1E-06 to 1E-04. Risk-based COCs for groundwater include **TCE** (cumulative risk of 6.6E-04), **chloroform** (cumulative risk of 3.9E-05), **PCE** (cumulative risk of 1.1E-05), **bromodichloromethane** (cumulative risk of 7.5E-06), and **dibromochloromethane** (cumulative risk of 1.4E-06).

- The total cumulative HI is 121. Hazard-based COCs for groundwater include **TCE** (cumulative HI of 114) and **cis-1,2-DCE** (cumulative HI of 3.9).

Therefore, based on the RME risk characterization, COCs for current and future construction workers exposed throughout EA 1 are as follows: **TCE**, **chloroform**, **PCE**, **bromodichloromethane**, **dibromochloromethane**, and **cis-1,2-DCE**.

Current and Future Utility Workers

Current and future utility workers were assumed exposed to groundwater via dermal contact and inhalation. Total risks and hazards were evaluated for potential exposure to groundwater based on EA 1-wide groundwater EPCs.

- The total cumulative risk is 7E-04, which exceeds EPA's target risk range of 1E-06 to 1E-04. Risk-based COCs for groundwater include **TCE** (cumulative risk of 6.6E-04), **chloroform** (cumulative risk of 3.9E-05), **PCE** (cumulative risk of 1.1E-05), **bromodichloromethane** (cumulative risk of 7.5E-06), and **dibromochloromethane** (cumulative risk of 1.4E-06).

- The total cumulative HI is 121. Hazard-based COCs for groundwater include **TCE** (cumulative HI of 114) and **cis-1,2-DCE** (cumulative HI of 3.9).

Therefore, based on the RME risk characterization, COCs for current and future utility workers exposed throughout EA 1 are as follows: **TCE**, **chloroform**, **PCE**, **bromodichloromethane**, **dibromochloromethane**, and **cis-1,2-DCE**.

2.7.2 EA 2

EA 2 occupies the southern one-third of the site (see Figure D-1). This exposure area is currently used for residential purposes. Risks and hazards for each of the receptors evaluated for this exposure area are summarized in Table D-2-5 and discussed below.

Future Industrial/Commercial Workers

Future industrial/commercial workers throughout EA 2 were assumed exposed to groundwater via ingestion, dermal contact (hand washing only), and inhalation (potable use). Total risks and hazards were evaluated for potential exposure to groundwater based on EA 2-wide groundwater EPCs.

- The total cumulative risk is 4E-05, which is within EPA's risk range of 1E-06 to 1E-04. Risk-based COCs for groundwater include **TCE** (cumulative risk of 3.1E-05), **chloroform** (cumulative risk of 4.6E-06), and **bromodichloromethane** (cumulative risk of 3.4E-06).

  Based on the fact that soil vapor concentrations measured in EA 2 were all less than screening levels, all individual and cumulative VI risks are less than 1E-06 and considered insignificant.

- The total cumulative HI is 9. Hazard-based COCs for groundwater include **TCE** (cumulative HI of 7) and **cis-1,2-DCE** (cumulative HI of 2).

  As noted above for cancer risks, because soil vapor concentrations measured in EA 2 were all less than screening levels, all individual and cumulative VI hazards are less than 1 and considered insignificant.

Therefore, based on the RME risk characterization, COCs for future industrial/commercial workers exposed throughout EA 2 are as follows: **TCE, chloroform, bromodichloromethane**, and **cis-1,2-DCE**.

Future Residents

Future residents were assumed exposed to groundwater via ingestion, dermal contact, and inhalation (via household use only). Total risks and hazards were evaluated for potential exposure to groundwater based on EA 2-wide groundwater EPCs.

- The total cumulative risk is 2E-04, which exceeds EPA's risk range of 1E-06 to 1E-04. Risk-based COCs for groundwater include **TCE** (cumulative risk of 1.8E-04), **chloroform** (cumulative risk of 2.0E-05), **bromodichloromethane** (cumulative risk of 1.5E-05), **dibromochloromethane** (cumulative risk of 4.0E-06), and **1,1-DCA** (cumulative risk of 1.6E-06).

  As noted above for future industrial/commercial workers, because soil vapor concentrations measured in EA 2 were all less than screening levels, all individual and cumulative VI risks for residents are less than 1E-06 and considered insignificant.

- The total cumulative HI is 42. Hazard-based COCs for groundwater include **TCE** (cumulative HI of 32.2), and **cis-1,2-DCE** (cumulative HI of 10.2).

  As noted above for cancer risks, because soil vapor concentrations measured in EA 2 were all less than screening levels, all individual and cumulative VI hazards for residents are less than 1E-06 and considered insignificant.

Therefore, based on the RME risk characterization, COCs for future residents exposed throughout EA 2 are as follows: **TCE, chloroform, bromodichloromethane, dibromochloromethane, 1,1-DCA**, and **cis-1,2-DCE**.

Current and Future Construction Workers

Current and future construction workers were assumed exposed to groundwater via dermal contact and inhalation. Total risks and hazards were evaluated for potential exposure to groundwater based on EA 2-wide groundwater EPCs.

- The total cumulative risk is 7E-04, which exceeds EPA's target risk range of 1E-06 to 1E-04. Risk-based COCs for groundwater include **TCE** (cumulative risk of 6.6E-04), **chloroform** (cumulative risk of 3.9E-05), **PCE** (cumulative risk of 1.1E-05), **bromodichloromethane** (cumulative risk of 7.5E-06), and **dibromochloromethane** (cumulative risk of 1.4E-06).

- The total cumulative HI is 121. Hazard-based COCs for groundwater include **TCE** (cumulative HI of 114) and **cis-1,2-DCE** (cumulative HI of 3.9).

Therefore, based on the RME risk characterization, COCs for current and future construction workers exposed throughout EA 2 are as follows: **TCE, chloroform, PCE, bromodichloromethane, dibromochloromethane**, and **cis-1,2-DCE**.

Current and Future Utility Workers

Current and future utility workers were assumed exposed to groundwater via dermal contact and inhalation. Total risks and hazards were evaluated for potential exposure to groundwater based on EA 2-wide groundwater EPCs.

- The total cumulative risk is 7E-04, which exceeds EPA's target risk range of 1E-06 to 1E-04. Risk-based COCs for groundwater include **TCE** (cumulative risk of 6.6E-04), **chloroform** (cumulative risk of 3.9E-05), **PCE** (cumulative risk of 1.1E-05), **bromodichloromethane** (cumulative risk of 7.5E-06), and **dibromochloromethane** (cumulative risk of 1.4E-06).

- The total cumulative HI is 121. Hazard-based COCs for groundwater include **TCE** (cumulative HI of 114) and **cis-1,2-DCE** (cumulative HI of 3.9).

Therefore, based on the RME risk characterization, COCs for current and future utility workers exposed throughout EA 2 are as follows: **TCE, chloroform, PCE, bromodichloromethane, dibromochloromethane**, and **cis-1,2-DCE**.

Overall HHRA Conclusions

Based on the information presented in Sections 2.7.1 and 2.7.2, the following conclusions were drawn:

- Total risks exceed 1E-04, the upper end of EPA's risk range, only for future residents at EA 1 (7E-04) and EA 2 (2E-04). The primary COC at both EAs is **TCE** (cumulative risk of 6.6E-04 [EA 1] and 1.8E-04 [EA 2]).
- Total risks for all other receptors (except as noted in the next bullet) are within EPA's risk range and are driven by **TCE** and other VOCs, including **chloroform** (both EAs and Property 1), **PCE** (EA 1 only), **bromodichloromethane** (both EAs and Property 1), and **1,1-DCA** (EA 2 only).
- Total risk for future industrial/commercial workers at Property 2 in EA 1 was not quantified; no carcinogenic COPCs were identified at this property.
- Total hazards exceed 1 for all receptors at both EA 1 and EA 2 (except as noted in the next bullet). The only hazard-based COCs are **TCE** (all receptors) and **cis-1,2-DCE** (industrial/commercial workers [EA 2 only] and residents [both EAs]).
- Total HI for future industrial/commercial workers at Property 2 in EA 1 is 0.2 and considered insignificant.
- The increased amount of dermal exposure to groundwater related to specific work tasks at Property 1 in EA 1 increases dermal risk and hazard, but does not change the cumulative risk or hazard for future industrial/commercial workers.
- The EA- and Property-specific EPCs for chloroform, bromodichloromethane, and dibromochloromethane are individually and as a sum less than the MCL for trihalomethanes (80 µg/L). The presence of these three COPCs is not related to any potential degradation of either PCE or TCE. The presence of chloroform, bromodichloromethane, and dibromochloromethane has been attributed to the potential release of chlorinated drinking water at other sites. While it is not known if such a release has occurred at or near the Lane Street site, the conditions (use of chlorinated public water) are present.
- The total risks and hazards calculated under CTE conditions are about 1 to 4 times lower than those calculated under RME conditions, depending on the receptor considered.
- Potentially significant VI-related risks are limited to future residents at EA 1 in the PCE Plume area. The cumulative VI-related risk of 3.7E-06 is within EPA's target risk range and is driven by potential exposure to PCE (3.2E-06). No potentially significant (greater than 1) VI-related hazards were identified for any receptors in either EA 1 or EA 2.

3.0 SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT

The primary objective of the SLERA is to address the contaminant identification, exposure assessment, toxicity assessment, and ecological risk characterization for the site.

The basic assumption that must be assessed is whether releases from the site have the potential to affect ecological receptors at the site. If ecological receptors are not exposed to releases from the site, there are no complete exposure pathways, and no potential for an ecological risk is present at the site. As noted in Section 1.0, the site involves groundwater contamination, and groundwater would have to discharge to a local surface water body for ecological receptors to be exposed. The Site is developed as an industrial and residential area with a small field to the southwest of the Site. No sensitive ecological habitats have been identified on the Site. The only known surface water body at or near the Site is a storm water drainage ditch, typically dry, located in the industrial/commercial area located just north of the 2503 Marina Drive, 3504 Henke Street, and 2503 Ada Drive properties (see Figure 1-2). Brads-ko, Roberts' surveyor, surveyed the storm drainage ditch and found the deepest portion of the drainage ditch near well R-MW-8 to have an elevation of approximately 761 feet amsl NGVD 1929 which converts to 760.57 feet amsl NAVD 1998 (or approximately 0.5 feet bgs). The groundwater elevation near the drainage ditch during the fall event (October 2013) sampling event was less than 760 feet amsl (or approximately 1 foot bgs). The groundwater during this event and the winter event (January 2014) did not appear to intersect the drainage ditch. However, it was noted that during the spring and summer sample events (April and July 2014) the groundwater elevations near the drainage ditch could potentially intersect the drainage ditch during periods with high groundwater. During the October 2013 groundwater sampling event, the TCE concentration at R-MW-7s was 8.3 µg/L. A TCE concentration of 12 µg/L was reported for well R-MW-7i, which is screened deeper at 24 to 29 feet bgs, during the October 2013 sampling event. The groundwater samples from VASGW-18 and VASGW-22 contained no detectable concentrations of contaminants in the shallowest sample depths of 15 feet bgs and 8 feet bgs, indicating no contamination in the upper aquifer at these locations. The RI report also clearly shows that the highest levels of groundwater contamination are found between the depths of 16 and 35 feet bgs. Additionally, the potential for the COPCs to migrate from the deeper portion of the aquifer to the shallow portion of the aquifer is very low because the COPCs at the Lane Street Site are chlorinated solvents that are denser than water, causing the contamination to sink into the aquifer rather than float to the surface of the aquifer.

Based on information gathered to date, groundwater may discharge to the drainage ditch during limited times of the year. Additionally, groundwater contamination is generally in the deeper portions of the aquifer with groundwater table contamination occurring in the northernmost portion of the site, at the

2601 Marina Drive property. Therefore, currently, there is no complete exposure pathway to site related contaminants for any ecological receptors at the site and a SLERA is not needed for this site. If future groundwater sampling events show increasing concentrations of COPCs at the upper water table near the drainage ditch, SulTRAC will revisit the possibility of conducting surface water sampling at the drainage ditch in consultation with EPA to verify if a SLERA is needed for the Lane Street Site.

4.0 RISK ASSESSMENT SUMMARY AND CONCLUSIONS

This section presents risk assessment summary and conclusions for the Lane Street HHRA (Section 4.1) and SLERA (Section 4.2).

4.1. HUMAN HEALTH RISK ASSESSMENT

The following sections discuss the HHRA objectives, exposure areas, approach, results, and a summary of overall conclusions for the Lane Street Site.

4.1.1 Objectives

The Lane Street HHRA evaluates current and potential future health risks and hazards associated with exposure to site-related COPCs at the Lane Street Site. The primary objectives of the HHRA are as follows:

- To evaluate if site-related constituents detected in environmental media pose potentially unacceptable risks to current and future human receptors under baseline (unremediated) conditions
- To provide information to support decisions regarding the need for further evaluation or action based on current and reasonably anticipated future land use.

4.1.2 Exposure Areas

The Lane Street Site was subdivided into two exposure areas, primarily according to the location and composition of soil and fill contamination and current and potential future land uses at and surrounding the site (see Figure D-1-7):

- EA 1 -- Industrial Exposure Area
- EA 2 – Residential Exposure Area

4.1.3 HHRA Approach

Consistent with standard risk assessment practice and EPA guidance (EPA 1989), the Lane Street HHRA includes the following components: (1) data evaluation and selection of COPCs, (2) exposure assessment, (3) toxicity assessment, and (4) risk characterization.

Medium-specific data sets used to prepare the HHRA consisted of analytical data obtained during the RI. These data are considered the most up-to-date available and provide reasonable geographic coverage. It was conservatively assumed that conditions at the time of the RI (unremediated conditions) are representative of current and future conditions. COPCs were selected following EPA guidance, primarily

EPA's RAGS (EPA 1989), based on (1) screening of maximum detected concentrations against media-specific screening levels selected as the most conservative values from EPA's RSLs, and (2) elimination of essential nutrients.

As specified in RAGS (EPA 1989), the four elements necessary to form a complete exposure pathway include:

- A source or release from a source
- A mechanism of release and transport
- A point of contact for potential receptors
- An exposure route.

If any one of the four elements is missing, the exposure pathway is incomplete. In general, only potentially complete exposure pathways were evaluated in the HHRAs. The human health CSM is diagrammatically presented in Figure D-2-1 and summarized in the RAGS D Part D Table 1-1 in Attachment D-1.

The receptors and exposure routes considered quantitatively or qualitatively in the HHRA include the following:

- ***Future Resident:*** Residents at both EA 1 and EA 2 may be exposed to site-related contaminants via ingestion of, dermal contact with, and inhalation of vapors from potable groundwater use. No current residents (EA 2 only) are exposed to groundwater because site groundwater is not currently used as a source of potable water. The VI pathway is expected to be significant only in the PCE Plume area of EA 1 (see Section 2.1.1).
- ***Future Commercial/Industrial Worker:*** Industrial/commercial workers at both EA 1 and EA 2 may be exposed to site-related contaminants ingestion of, dermal contact with, and inhalation of vapors from potable groundwater use. (Note: industrial/commercial workers are assumed to have only minimal dermal contact with groundwater [hand washing], with one exception. At Property 2 in EA 1, future industrial/commercial workers were assumed to have dermal exposure via washing machine parts and RVs.) No current industrial/commercial workers are exposed to groundwater because site groundwater is not currently used as a source of potable water. The VI pathway is not expected to be significant for future (as well as current) commercial/industrial workers.
- ***Current/Future Construction and Utility Workers*:** Current and future construction workers and utility workers could be exposed to site-related constituents in groundwater during short-duration construction related to possible redevelopment or utility maintenance. Construction and utility workers are expected to be exposed to shallow groundwater contaminants via dermal contact, as well as via inhalation of volatile constituents in groundwater that migrate from groundwater into trench air (VDEQ 2014).

Receptor-specific intakes for each exposure route were calculated under both RME and CTE conditions using equations and exposure parameter values presented in the RAGS Part D 4 Series tables (included as part of Attachment D-1).

In addition to the exposure parameter values presented in Attachment D-1, the equations also included a medium-specific concentration to which receptors were assumed exposed (the EPC). In general, EPCs were calculated as the 95UCL on the mean using EPA's ProUCL Version 5.0 statistical software package (EPA 2013a). The approach used for calculating EPCs for chemicals with and without censored results followed EPA (2002b) and recommendations offered in EPA's ProUCL 5.0.00 Technical Guide (EPA 2013b). The revised algorithms in ProUCL 5 were developed through extensive research into optimal methods for calculating the 95UCL for data with censored results (EPA 2013d).

The 95UCL recommended by ProUCL 5.0 was selected as the EPC if the 95UCL is less than the maximum detected concentration for COPCs with four or more detected values in a data set of at least 10 samples. The 95UCLs calculated by ProUCL are based on distribution testing of detected data only. The 95UCL from the appropriate distribution (normal, gamma, lognormal, or nonparametric) was selected for data sets for which ProUCL 5.0 recommended more than one 95UCL. If more than one distribution is identified as appropriate for the data set, ProUCL identifies the distribution as most appropriate in the order normal, gamma, lognormal, and nonparametric from most preferred to least preferred (EPA 2013d). The EPC was generally selected as the 95 percent UCL of the statistical method recommended by ProUCL. Construction workers and utility workers are expected to be exposed in limited portions of each exposure area. Therefore, consistent with EPA recommendations, the maximum detected concentration was used as the EPC for these receptors.

Groundwater involves unique circumstances that complicate calculation of EPCs. Receptors are not expected to be exposed to groundwater from multiple locations across an exposure area. Rather, receptors may ingest groundwater from a single well installed at a particular location or may have direct contact with groundwater in a construction trench at a particular location. As a result, EPCs for groundwater were calculated in accordance with EPA guidance, including "Determining Groundwater Exposure Point Concentrations" (EPA 2014b). Three or more wells considered representative of the center of each groundwater "plume" or area of consistent elevated concentrations at each exposure area were identified based on review of the site-specific groundwater analytical results for the evaluation of potential exposure to groundwater at the Lane Street Site. The specific wells selected for each groundwater plume or area of consistent elevated concentrations at each exposure area and the basis for selecting each well are presented in Section 2.3.1.1.

The risk assessment used the default toxicity values presented in the EPA RSL tables (EPA 2015a). The default values were obtained from the following sources in the order in which they are presented below:

- IRIS on-line database (EPA 2015b)
- PPRTV derived by EPA's Superfund Health Risk Technical Support Center for the EPA Superfund Program
- ATSDR MRLs (ATSDR 2013a)
- Cal/EPA/Office of Environmental Health Hazard Assessment's toxicity values (Cal/EPA 2015)
- Screening toxicity values in appendices to certain PPRTV assessments
- The EPA Superfund Program's HEAST (EPA 2011d).

Toxicity values used in the HHRA are listed in Tables 5.1 and 5.2 (noncancer toxicity values) and Tables 6.1 and 6.2 (cancer toxicity values) of Attachment D-1.

4.1.4 HHRA Summary and Conclusions

Cumulative and COPC-specific risks and hazards under RME conditions for each of the Lane Street exposure areas are discussed in Sections 2.7.1 and 2.7.2. Four different receptors were evaluated at the Lane Street Site: future industrial/commercial workers, construction workers, utility workers, and future residents. Risks for the Lane Street Site exposure areas are summarized in Tables D-2-4 and D-2-5.

- Total risks exceed 1E-04, the upper end of EPA's potentially acceptable risk range, only for future residents at EA 1 (7E-04) and EA 2 (2E-04). The primary COC at both EAs is **TCE** (cumulative risk of 6.6E-04 [EA 1] and 1.8E-04 [EA 2]).
- Total risks for all other receptors (except as noted in the above bullet) are within EPA's potentially acceptable risk range and are driven by **TCE** and other VOCs, including **chloroform** (both EAs and Property 1), **PCE** (EA 1 only), **bromodichloromethane** (both EAs and Property 1), and **1,1-DCA** (EA 2 only).
- Total risk from COPCs for future industrial/commercial workers at Property 2 in EA 1 is 0.0E+00; no carcinogenic COPCs were identified at this property.
- Total hazards exceed 1 for all receptors at both EA 1 and EA 2 (except as noted in the next bullet). The only hazard-based COCs are **TCE** (all receptors) and **cis-1,2-DCE** (industrial/commercial workers [EA 2 only] and residents [both EAs]).
- Total HI for future industrial/commercial workers at Property 2 in EA 1 is 0.2 and considered insignificant.
- The increased amount of dermal exposure to groundwater related to specific work tasks at Property 1 in EA 1 increases dermal risk and hazard, but does not change the cumulative risk or hazard for future industrial/commercial workers.
- The EA- and Property-specific EPCs for chloroform, bromodichloromethane, and dibromochloromethane are individually and as a sum less than the MCL for trihalomethanes

(80 µg/L). The presence of these three COPCs is not related to any potential degradation of either PCE or TCE. The presence of chloroform, bromodichloromethane, and dibromochloromethane has been attributed to the potential release of chlorinated drinking water at other sites. While it is not known if such a release has occurred at or near the Lane Street site, the conditions (use of chlorinated public water) are present.

- The total risks and hazards calculated under CTE conditions are about 1 to 4 times lower than those calculated under RME conditions, depending on the receptor considered.
- Potentially significant VI-related risks are limited to future residents at EA 1 in the PCE Plume area. The cumulative VI-related risk of 3.7E-06 is within EPA's target risk range and is driven by potential exposure to PCE (3.2E-06). No potentially significant (greater than 1) VI-related hazards were identified for any receptors in either EA 1 or EA 2.

4.2 SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT

As explained in Section 3.0, the basic assumption that must be assessed is whether releases from the site have the potential to affect ecological receptors at that the site. If ecological receptors are not exposed to releases from the site, there are no complete exposure pathways and no potential for an ecological risk is present at the site. The CSM indicates there are only limited complete exposure pathways and, therefore, no potential ecological risks at the Lane Street Site because contaminated groundwater is expected to discharge to surface water only under limited conditions and groundwater contamination is primarily in deeper groundwater and relatively absent from very shallow groundwater which could possibly discharge to surface water.

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FIGURES

Approximate site boundary

Basemaps source: Esri

document path: D:\projects\Lane Street_R1\HHRA\HHRA Figure D-1-1.mxd author: ASchubert

LANE STREET GROUNDWATER CONTAMINATION SITE

ELKHART COUNTY, INDIANA

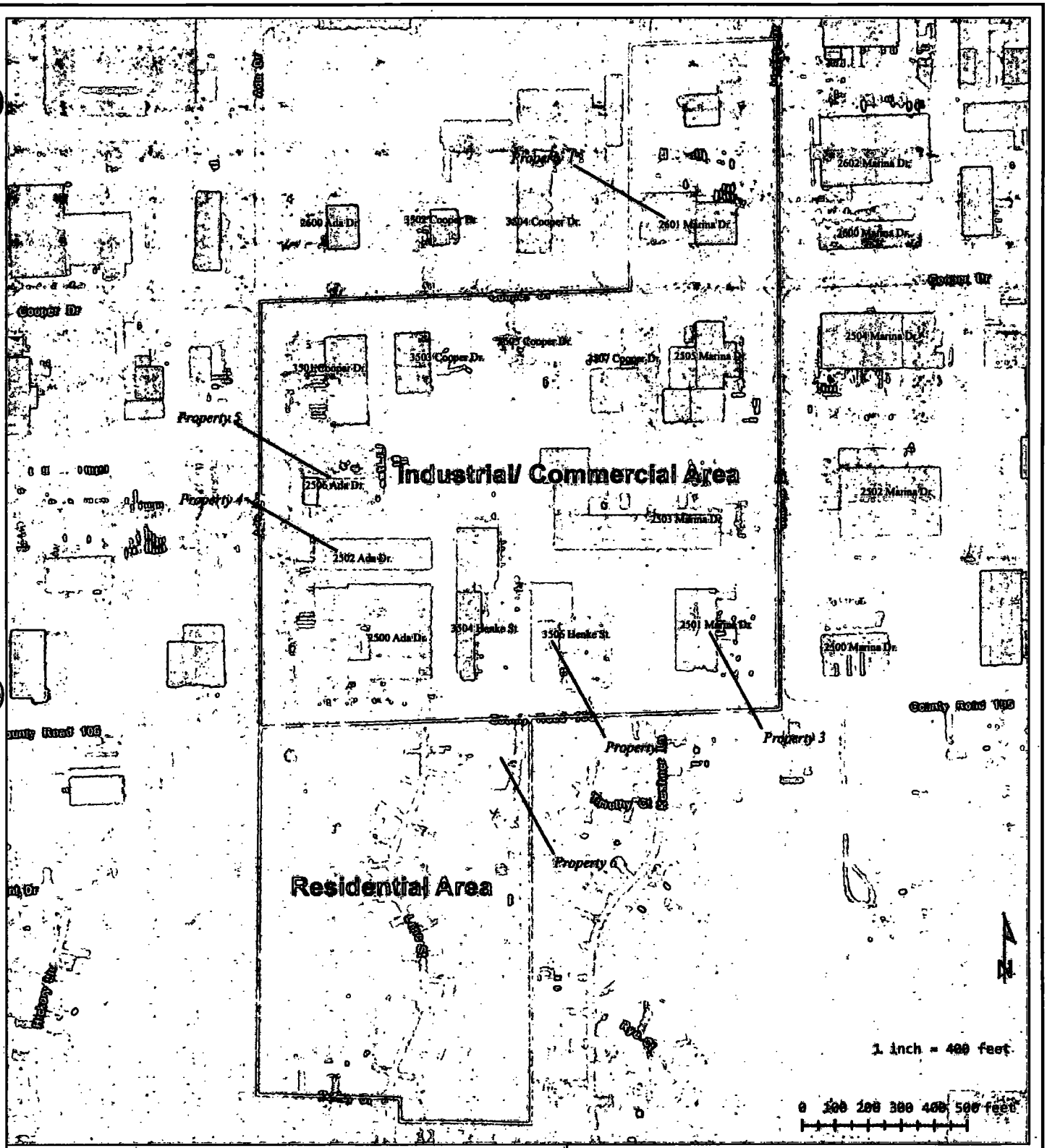
HUMAN HEALTH RISK ASSESSMENT

FIGURE D-1-1

SITE LOCATION

EPA REGION 5 RAC 2 | REVISION 1 | JUNE 2015

SulTRAC



Approximate Site Boundary

Basemap source: Esri

LANE STREET GROUNDWATER CONTAMINATION SITE
ELKHART COUNTY, INDIANA

HUMAN HEALTH RISK ASSESSMENT

FIGURE D-1-2

SITE LAYOUT

EPA REGION 5 RAC 2 | REVISION 1 | JUNE 2015

SulTRAC

Vertical aquifer sampling location

SulTRAC monitoring well

Roberts monitoring well

Approximate site boundary

Notes:
1- This map includes vertical aquifer sample (VAS) samplings and the remaining SulTRAC and Roberts wells are considered the SulTRAC groundwater monitoring well network.
2- Basemap source: Esri

LANE STREET GROUNDWATER CONTAMINATION SITE
ELKHART COUNTY, INDIANA

HUMAN HEALTH RISK ASSESSMENT

FIGURE D-1-3

GROUNDWATER SAMPLING LOCATIONS (VAS, ROBERTS, AND SULTRAC WELLS)

EPA REGION 5 RAC 2 | REVISION 1 | JUNE 2015

SulTRAC

- IDEM (2008) soil sample
- Vertical aquifer and soil sampling location
- Roberts (2012) soil grid area behind 2503 Marina (94 shallow borings from 2.5-4 ft bgs)
- Approximate site boundary

Basemap source: Esri

LANE STREET GROUNDWATER CONTAMINATION SITE
ELKHART COUNTY, INDIANA

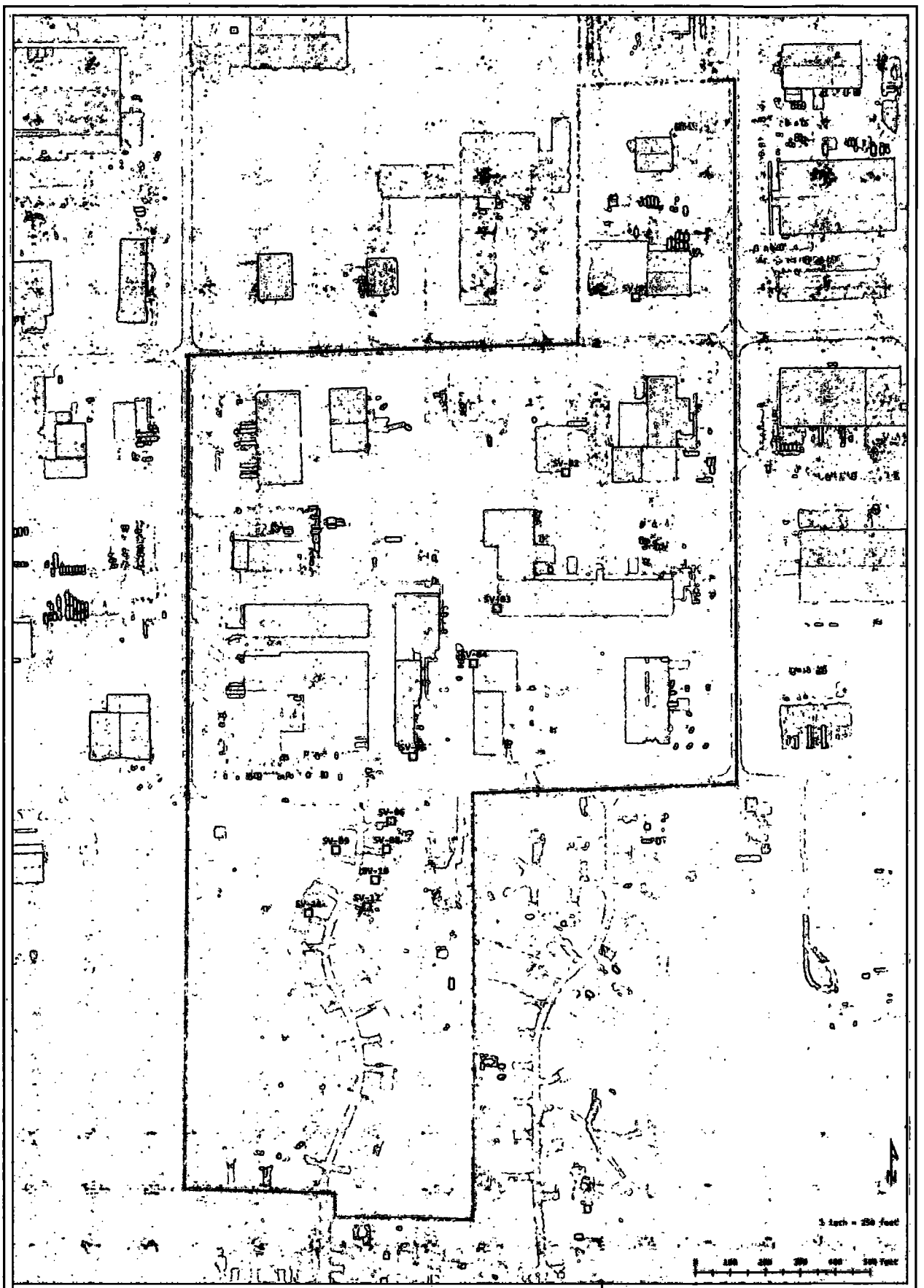
HUMAN HEALTH RISK ASSESSMENT

FIGURE D-1-4

SOIL SAMPLING LOCATIONS

EPA REGION 5 RAC 2 | REVISION 1 | JUNE 2015

SulTRAC



SulTRAC Soil Vapor Sampling Location

Approximate site boundary

LANE STREET GROUNDWATER CONTAMINATION SITE
ELKHART COUNTY, INDIANA

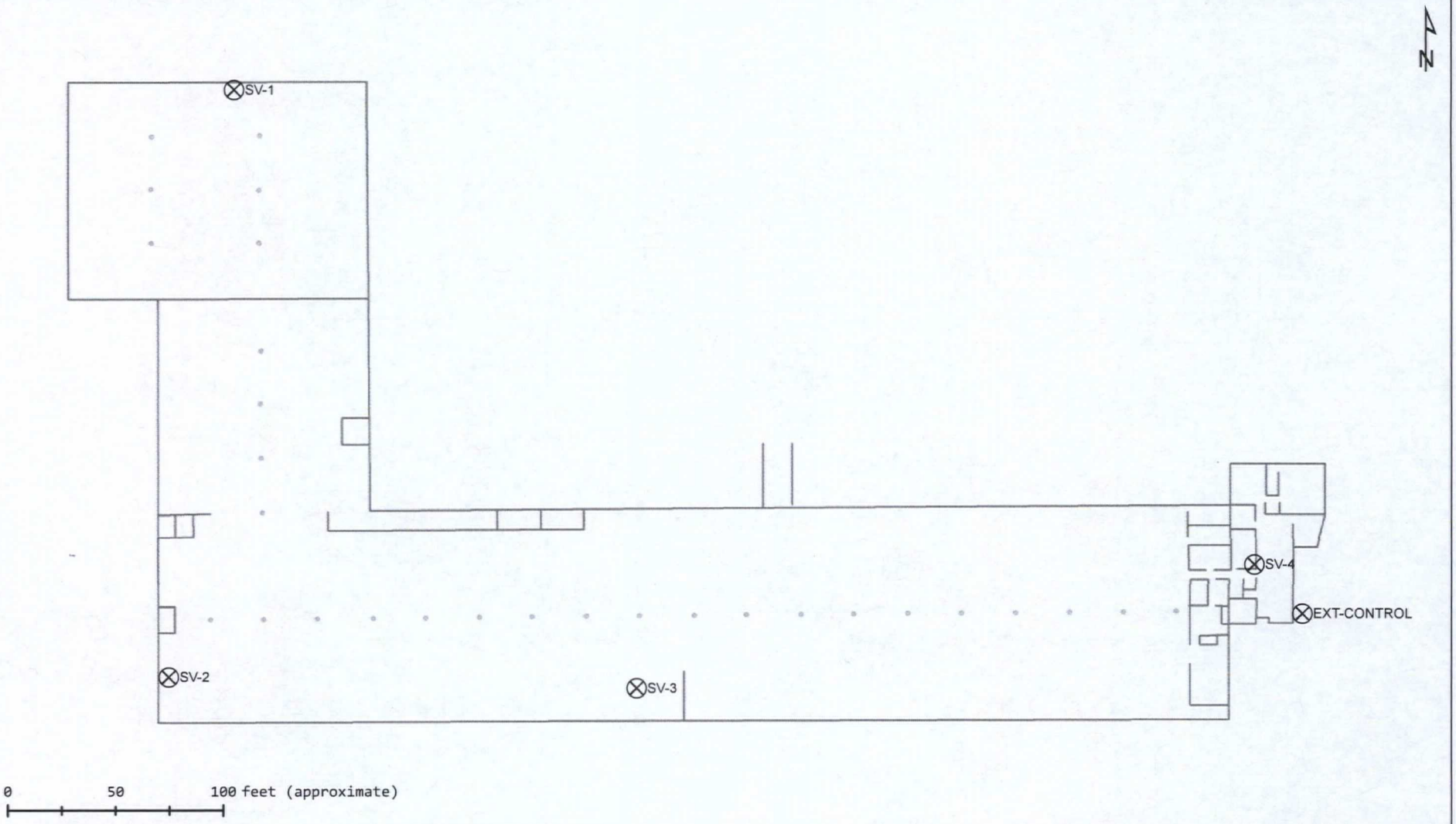
HUMAN HEALTH RISK ASSESSMENT

FIGURE D-1-5

SOIL VAPOR SAMPLING LOCATIONS

EPA REGION 5 RAC 3 | REVISION 1 | JUNE 2015

SulTRAC



⊗ Soil vent sample location (approximate)

Source:
Rose & Westra, Inc., 2014.

LANE STREET GROUNDWATER CONTAMINATION SITE
ELKHART COUNTY, INDIANA

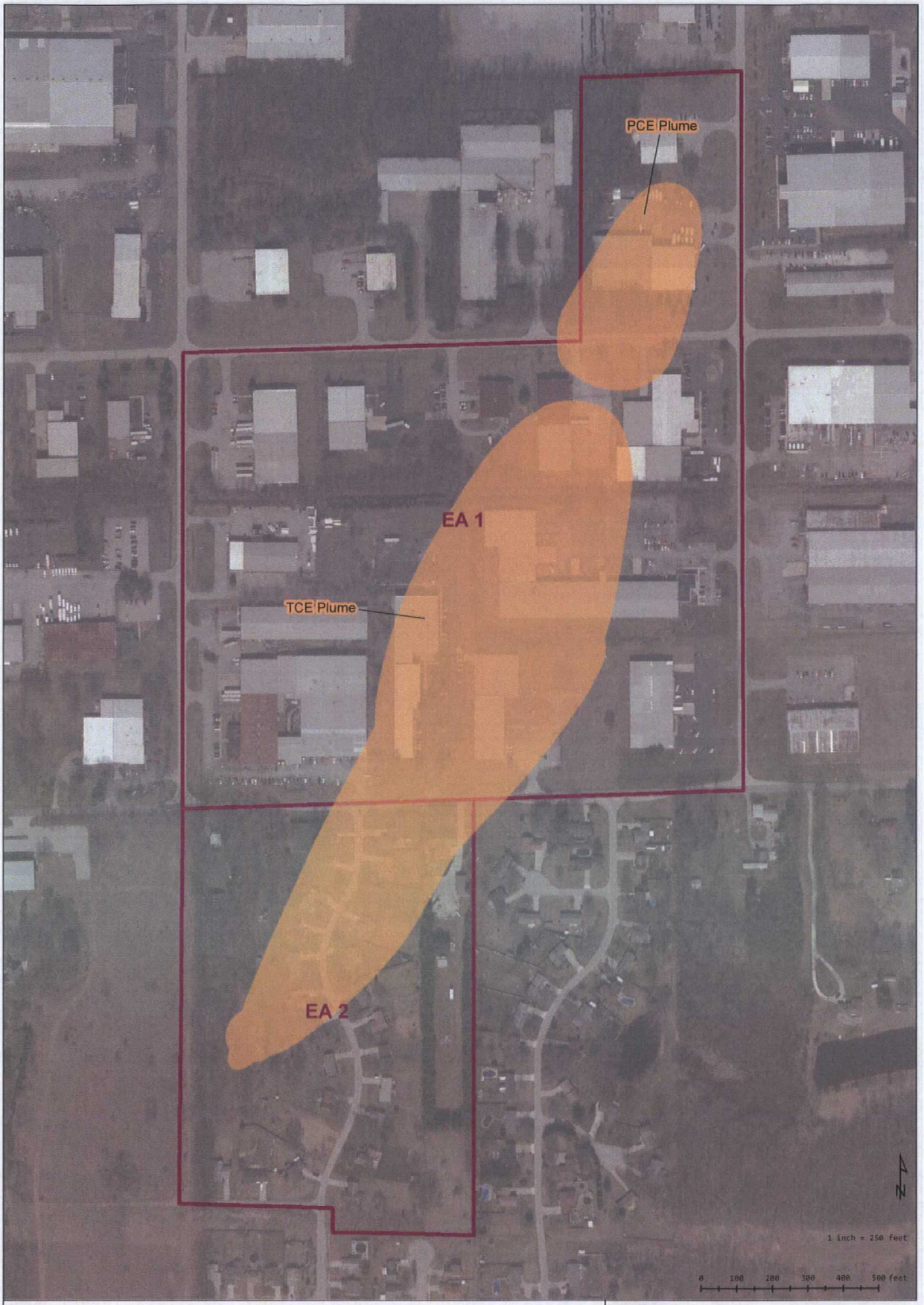
HUMAN HEALTH RISK ASSESSMENT

FIGURE D-1-6

HADLEY PRODUCTS CORP. (2503 MARINA DR.)
SUB-SLAB SOIL GAS INVESTIGATION

EPA REGION 5 RAC 2 | REVISION 1 | JUNE 2015

SulTRAC



SulTRAC composite PCE & TCE plume

Human health exposure area

EA1 - Exposure Area 1 (Industrial Area)
EA2 - Exposure Area 2 (Residential Area)

LANE STREET GROUNDWATER CONTAMINATION SITE
ELKHART COUNTY, INDIANA

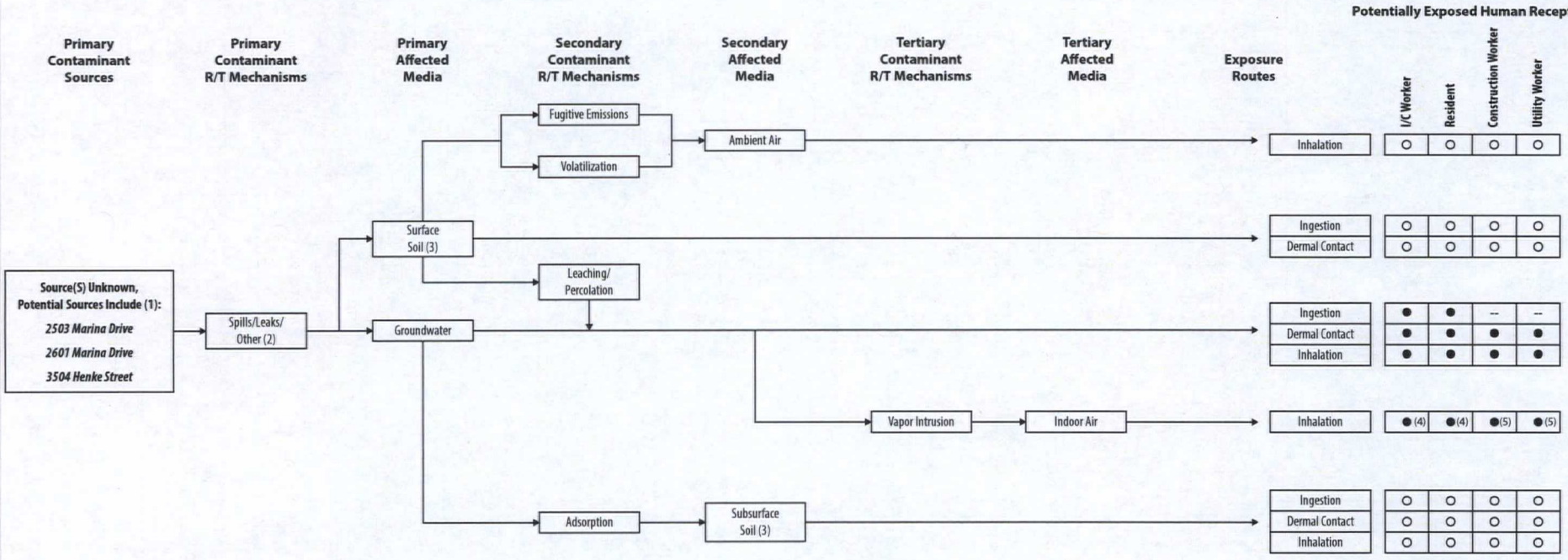
HUMAN HEALTH RISK ASSESSMENT

FIGURE D-1-7

HUMAN HEALTH EXPOSURE AREAS

EPA REGION 5 RAC 2 | REVISION 1 | JUNE 2015

SulTRAC



Notes:

EPA = U.S. Environmental Protection Agency
I/C = Industrial/Commercial
RI = Remedial investigation
R/T = Release/transport
VISL = Vapor intrusion screening level
VOC = Volatile organic compound

● = Potentially complete exposure pathway – retained for quantitative analysis
○ = Potentially complete, but insignificant exposure pathway; was not retained
-- = Incomplete exposure pathway; was not retained

1. Potential sources all handle or handled hazardous substances.
2. "Other" includes releases to floor drains, dry wells, or septic systems.
3. Only arsenic has been detected at a concentration greater than its EPA residential regional screening level (RSL). However, as discussed in Section 1.5.1 and 1.5.3, based on site history and comparison to county-specific and national background levels, arsenic was judged to not be site-related. Therefore, no soil chemicals of potential concern were identified and receptor-specific soil exposures were not evaluated in the risk assessment.
4. Exposures, risks, and hazards associated with vapor intrusion of VOCs from groundwater and soil gas are assessed qualitatively using EPA's VISL Calculator (EPA 2014).
5. EPCs for air in a construction or utility trench will be calculated using the methodology presented in Virginia Department of Environmental Quality's Voluntary Remediation Program Risk Assessment Guidance dated August 2014.

LANE STREET GROUNDWATER CONTAMINATION SITE
ELKHART, INDIANA

HUMAN HEALTH RISK ASSESSMENT

FIGURE 2-1

HUMAN HEALTH CONCEPTUAL SITE MODEL

EPA Region 5 RAC 2	Revision 1	June 2015

SulTRAC

TABLES

TABLE D-1-1

ADDRESS INFORMATION FOR PROPERTY 6 IN RESIDENTIAL AREA
LANE STREET GROUNDWATER CONTAMINATION SITE
ELKHART, ELKHART COUNTY, INDIANA

Property Number	Street Address
6	23624 County Road 106, Elkhart, IN

Note:

The information presented in this table is confidential. This table is not releasable and not available for distribution.

Table D-1-2a

LANE STREET MONITORING WELL NETWORK
LANE STREET GROUNDWATER CONTAMINATION SITE
ELKHART, ELKHART COUNTY, INDIANA

Monitoring Well ID	Screen Depth (ft bgs)	Screen Length (ft)
MW-01s	5-15	10
MW-01i	25-30	5
MW-01d	55-65	10
MW-02s	5-15	10
MW-02i	25-30	5
MW-02d	65-70	5
MW-03s	3-13	10
MW-03i	25-30	5
MW-04d	50-55	5
MW-05s	3-13	10
MW-06ss	5-10	5
MW-06s	11-13	2
MW-06i	25-30	5
MW-06d	55-60	5
MW-07s	2-12	10
MW-07i	20-25	5
MW-08s	2-12	10
MW-08i	20-25	5
MW-09s	2-12	10
MW-10ss	6-11	5
MW-10s	11-13	2
MW-11s	5-15	10
R-MW-3s	3-13	10
R-MW-3i	22-27	5
R-MW-7s	3-13	10
R-MW-7i	24-29	5
R-MW-7d	36-41	5
R-MW-10is	13-15.5	2.5
R-MW-10iu	15.2-20.2	5
R-MW-10i	25-30	5
R-MW-10d	34-39	5

Table D-1-2a

LANE STREET MONITORING WELL NETWORK
LANE STREET GROUNDWATER CONTAMINATION SITE
ELKHART, ELKHART COUNTY, INDIANA

Monitoring Well ID	Screen Depth (ft bgs)	Screen Length (ft)
R-MW-11is	7.9-10.4	2.5
R-MW-11iu	11.4-13.9	2.5
R-MW-11i	24-29	5
R-MW-11d	39-44	5
R-MW-12ss	2-7	5
R-MW-12s	3-13	10
R-MW-12i	21-26	5
R-MW-12d	35-40	5
R-MW-13s	3.5-13.5	10
R-MW-14ss	4-9	5
R-MW-14is	12.8-15.3	2.5
R-MW-14iu	15-20	5
R-MW-14i	21-26	5

Notes:
See Figure D-1-3 for the location of the monitoring well network.

bgs	Below ground surface
d	Deep
ft	Feet
i	Intermediate
ID	Identification
is	Intermediate shallow
iu	Intermediate upper
R	Roberts Environmental monitoring well network
s	Shallow
ss	Super shallow

Table D-1-2b
GROUNDWATER ZONE DESIGNATION
LANE STREET GROUNDWATER CONTAMINATION SITE
ELKHART, ELKHART COUNTY, INDIANA

Super Shallow (ss) (0 < X < 10 ft bgs)		Shallow (s) (10 < X < 20 ft bgs)		Intermediate (i) (20 < X < 35 ft bgs)		Deep (d) (35 < X ft bgs)	
MW Network	VAS	MW Network	VAS	MW Network	VAS	MW Network	VAS
R-MW-12ss (7')	VAS-GW34 (10')	R-MW-3s (13')	VAS-GW26 (18')	R-MW-3i (27')	VAS-GW26 (28')	R-MW-7d (41')	VAS-GW26 (38', 48', 56', 68', 78', 88', 98')
R-MW-14ss (9')		R-MW-7s (13')	VAS-GW27 (18')	R-MW-7i (29')	VAS-GW27 (28')	R-MW-10d (39')	
MW-06ss (10')		R-MW-10is (15.5')	VAS-GW31 (12')	R-MW-10iu (20.2')	VAS-GW29 (30')	R-MW-11d (44')	VAS-GW27 (38', 48', 58', 68', 78', 88', 98')
		R-MW-11is (10.4')	VAS-GW32 (12')	R-MW-10i (30')	VAS-GW31 (22', 32')	R-MW-12d (40')	
		R-MW-11iu (13.9')	VAS-GW33 (11')	R-MW-11i (29')	VAS-GW32 (21', 31')	MW-01d (65')	VAS-GW28 (70', 80', 90', 100', 109', 120', 130', 140')
		R-MW-12s (13')	VAS-GW34 (20')	R-MW-12i (26')	VAS-GW33 (21', 31')	MW-02d (70')	
		R-MW-13s (13.5')	VAS-GW35 (12')	R-MW-14i (26')	VAS-GW34 (30')	MW-04d (55')	VAS-GW29 (50', 60', 70', 80', 90', 100', 105', 116.5', 130', 140')
		R-MW-14is (15.3')	VAS-GW36 (13')	MW-01i (30')	VAS-GW35 (22', 31')	MW-06d (60')	
		R-MW-14iu (20')	VAS-GW37 (11')	MW-02i (30')	VAS-GW36 (22', 32')		VAS-GW30 (58', 70', 80', 90', 100')
		MW-01s (15')	VAS-GW38 (20')	MW-03i (30')	VAS-GW37 (22', 32')		
		MW-02s (15')	VAS-GW39 (20')	MW-06i (30')	VAS-GW38 (30')		VAS-GW31 (42', 50', 60')
		MW-03s (13')	VAS-GW40 (20')	MW-07i (25')	VAS-GW39 (30')		VAS-GW35 (39', 49', 60')
		MW-05s (13')	VAS-GW41 (17')	MW-08i (25')	VAS-GW40 (30')		VAS-GW38 (40', 50', 60', 70', 80')
		MW-06s (13')	VAS-GW42 (15')		VAS-GW41 (27')		
		MW-07s (12')	VAS-GW43 (20')		VAS-GW42 (25', 35')		VAS-GW39 (40', 50', 60', 70', 80')
		MW-08s (12')	VAS-GW44 (19')		VAS-GW43 (30')		
		MW-09s (12')	VAS-GW45 (20')		VAS-GW44 (29')		VAS-GW40 (40', 50', 60', 70', 80')
		MW-10ss (11')	VAS-GW46 (15')		VAS-GW45 (30')		
		MW-10s (11')	VAS-GW47 (14')		VAS-GW46 (25', 35')		VAS-GW41 (37', 47', 57', 67', 77')
		MW-11s (15')			VAS-GW47 (24', 34')		VAS-GW42 (45', 55', 65', 75')
							VAS-GW43 (40', 50', 60', 70', 80')
							VAS-GW44 (39', 49', 59', 69', 79')
							VAS-GW45 (40', 50', 60', 70', 80')
							VAS-GW46 (45', 55', 65', 75')
							VAS-GW47 (44', 54', 64', 74')

Notes:

See Figure D-1-3 for the location of the VAS and monitoring well network sample locations.

'	Feet
bgs	Below ground surface
d	Deep screen
ft	Feet
i	Intermediate screen
MW	Monitoring well
VAS	Vertical aquifer sample
s	Shallow screen
ss	Super Shallow screen

TABLE D-2-4

RISK AND HAZARD SUMMARY
LANE STREET GROUNDWATER CONTAMINATION SITE - EXPOSURE AREA 1
REASONABLE MAXIMUM EXPOSURE
ELKHART, ELKHART COUNTY, ILLINOIS

Receptor	RAGS D Tables	Total Risk	Risk Drivers	Total HI	HI Drivers
Future Industrial/ Commercial Worker	7.1.1.2.1 RME	1E-04 (GW)[1]	Trichloroethene (1.1E-04) Bromodichloromethane (1.7E-06) Chloroform (9.0E-06) Tetrachloroethene (2.3E-06)	27 (GW)[2]	Trichloroethene (25)
Future Industrial/ Commercial Worker (Property 1 : RV Washer/Parts Washer)	7.1.1.2.2 RME	1E-04 (GW)/1E-04 (GW)[1]	Trichloroethene (1.2E-04)/(1.1E-04) Bromodichloromethane (1.8E-06)/(1.7E-06) Chloroform (9.1E-06)/(9.0E-06) Tetrachloroethene (2.8E-06)/(2.4E-06)	28 (GW)/27 (GW)[2]	Trichloroethene (28)/(27)
Future Industrial/ Commercial Worker (Property 2)	7.1.1.2.3 RME	0.0E+00[1]	NA	0.2 (GW)[2]	NA
Future Residents	7.1.2.2.1 RME	7E-04 (GW)[3]	Trichloroethene (6.6E-04) Bromodichloromethane (7.5E-06) Chloroform (3.9E-05) Dibromochloromethane (1.4E-06) Tetrachloroethene (1.1E-05)	121 (GW)[4]	Trichloroethene (114) cis-1,2-Dichloromethane (3.9) Tetrachloroethene (3.0)
Future Construction Workers	7.1.4.3.1 RME	5E-06 (GW)	Trichloroethene (4.0E-06)	135 (GW)	Trichloroethene (131) Tetrachloroethene (2.3)
Future Utility Workers	7.1.5.3.1 RME	4E-05 (GW)	Trichloroethene (3.0E-05) Bromodichloromethane (4.6E-06) Chloroform (4.6E-06)	10 (GW)	Trichloroethene (10)

Notes:

	Risk ≥ 1E-06 or HI > 1
EPA	U.S. Environmental Protection Agency
GW	Groundwater
MCL	Maximum contaminant level
NA	Not applicable
RME	Reasonable maximum exposure
VI	Vapor intrusion
VISL	Vapor intrusion screening level

1 Potential VI-related risks were evaluated qualitatively using EPA's VISL Calculator based on site-specific soil vapor concentrations (see Section 2.1.1 and Attachment D-4). The qualitative risks are summarized below:
SV-01 (PCE Plume) -- risks are less than 1E-06 and considered insignificant.
SV-03 (TCE Plume) -- cumulative risk (3.6E-06), driven by chloroform (3.6E-06); chloroform concentration well below EPA's MCL for total trihalomethanes of 80 µg/L.
SV-04 (TCE Plume) -- risks are less than 1E-06 and considered insignificant.

2 Potential VI-related hazards were evaluated using EPA's VISL Calculator (see Section 2.1.1 and Attachment D-4). All hazards are less than 1 and considered insignificant.

3 Potential VI-related risks were evaluated qualitatively using EPA's VISL Calculator based on site-specific soil vapor concentrations (see Section 2.1.1 and Attachment D-4). The qualitative risks are summarized below:
SV-01 (PCE Plume) -- cumulative risk (3.7E-06), driven by PCE (3.2E-06).
SV-03 (TCE Plume) -- cumulative risk (1.6E-05), driven by chloroform (1.6E-05); chloroform concentration well below EPA's MCL for total trihalomethanes of 80 µg/L.
SV-04 (TCE Plume) -- risks are less than 1E-06 and considered insignificant.

4 Potential VI-related hazards were evaluated using EPA's VISL Calculator based on site-specific soil vapor concentrations (see Section 2.1.1 and Attachment D-4). The qualitative hazards are summarized below:
SV-01 (PCE Plume) -- hazards are less than 1 and considered insignificant.
SV-03 (TCE Plume) -- hazards are less than 1 and considered insignificant.
SV-04 (TCE Plume) -- cumulative hazard (2.), driven by dichlorodifluoromethane (2.0). Dichlorodifluoromethane (Freon 12) is a common refrigerant; detection is considered anomalous and not related to Lane Street plumes.

TABLE D-2-5

RISK AND HAZARD SUMMARY
LANE STREET GROUNDWATER CONTAMINATION SITE - EXPOSURE AREA 2
REASONABLE MAXIMUM EXPOSURE
ELKHART, ELKHART COUNTY, INDIANA

Receptor	RAGS D Tables	Total Risk	Risk Drivers	Total HI	HI Drivers
Future Industrial/ Commercial Worker	7.2.1.2.1 RME	4E-05 (GW)[1]	Bromodichloromethane (3.4E-06) Chloroform (4.6E-06) Trichloroethene (3.1E-05)	9.0 (GW)[1]	cis-1,2-Dichloroethene (2.0) Trichloroethene (7.0)
Future Residents	7.2.2.2 RME	2E-04 (GW)[1]	1,1-Dichloroethane (1.6E-06) Bromodichloromethane (1.5E-05) Chloroform (2.0E-05) Dibromochloromethane (4.0E-06) Trichloroethene (1.8E-04)	42 (GW)[1]	cis-1,2-Dichloroethene (10) Trichloroethene (32)
Future Construction Workers	7.2.4.3.1 RME	2E-06 (GW)	Trichloroethene (1.1E-06)	37 (GW)	Trichloroethene (37)
Future Utility Workers	7.2.5.3.1 RME	1E-05 (GW)	1,1-Dichloroethane (1.4E-06) Bromodichloromethane (1.4E-06) Chloroform (2.3E-06) Trichloroethene (8.4E-06)	3.0 (GW)	Trichloroethene (2.8)

Notes:

	Risk ≥ 1E-06 or HI > 1
EPA	U.S. Environmental Protection Agency
GW	Groundwater
MCL	Maximum contaminant level
NA	Not applicable
RME	Reasonable maximum exposure
VI	Vapor intrusion
VISL	Vapor intrusion screening level

1 Potential VI-related risks and hazards were evaluated qualitatively using EPA's VISL Calculator based on site-specific soil vapor concentrations (see Section 2.1.1 and Attachment D-4). Risks are less than 1E-06 and considered insignificant; similarly, hazards are less than 1 and considered insignificant.

Attachment D-1

HHRA RAGS Part D Tables

Lane Street Groundwater Contamination Site
Elkhart, Indiana

Attachment D-2

Exposure Point Concentration Documentation

Lane Street Groundwater Contamination Site
Elkhart, Indiana

Attachments D-1, D-2, D-3 and D-4 are provided on the CD located following the cover page for Attachment D-1.

Attachment D-2

Exposure Point Concentration Documentation

Lane Street Groundwater Contamination Site
Elkhart, Indiana

Attachments D-1, D-2, D-3 and D-4 are provided on the CD located following the cover page for Attachment D-1.

Attachment D-3

Groundwater-to-Outdoor Air Model for Construction and Utility Worker Trench Exposure

Lane Street Groundwater Contamination Site
Elkhart, Indiana

Attachments D-1, D-2, D-3 and D-4 are provided on the CD located following the cover page for Attachment D-1.

Attachment D-4

Qualitative Vapor Intrusion Risk Estimates

Lane Street Groundwater Contamination Site
Elkhart, Indiana

Attachments D-1, D-2, D-3 and D-4 are provided on the CD located following the cover page for Attachment D-1.