

**APPENDIX F**

**Human Health Risk Assessment**

## 1.0 Introduction

This section summarizes the methodology and results of the risk assessment (RA) conducted to support the need for a Non-Time Critical Removal Action (NTCRA) based on potential exposure of human receptors to chemicals in soil gas that migrate indoors in the area of Building 965 within Parcel 1A at DoDHF Novato (i.e., study site). The RA is conducted according to U.S. EPA's Risk Assessment Guidance for Superfund (RAGS) Volume I, *Human Health Evaluation Manual* (Part A) (U.S. EPA, 1989) and supplemental U.S. EPA guidance. In addition, guidance provided by Cal-EPA's Department of Toxic Substances Control (DTSC) at <http://www.dtsc.ca.gov>, has been incorporated where applicable.

The RA was conducted using existing soil gas data collected by the Navy during the volatile organic compound (VOC) investigation of August 2007 (Battelle, 2007a) and the Preliminary Sampling Activities starting on May 8, 2008 (Battelle, 2008). Baseline risks/hazards were calculated for a residential receptor for the vapor intrusion pathway based on the soil gas concentrations measured during the August 2007 and May 2008 investigations. The groundwater and soil data collected during the Preliminary Sampling Activities in May 2008 also were assessed collectively to help estimate risks/hazards and to help with determining the extent of the NTCRA.

## 2.0 Summary of Baseline Risk/Hazard for Soil Gas

All of the soil gas data collected during August 2007 (Battelle, 2007a) and during the Preliminary Sampling Activities starting on May 8, 2008, are provided in [Appendix D](#). Concentrations detected in soil gas were compared to chemical-specific risk-based screening levels (RBSLs) for vapor intrusion as shown in [Appendix D](#). RBSLs for soil gas were derived by DTSC using the DTSC-modified J&E spreadsheets for soil gas with site-specific soil parameters and DTSC default parameters to back-calculate a value in soil gas equal to  $1 \times 10^{-6}$  risk level or 1.0 hazard quotient. The Abbreviated Work Plan (Battelle, 2007b) contains the site-specific parameters and DTSC model default input parameters used to calculate the RBSLs, as well as the RBSLs DTSC derived for soil gas for the VOC investigation. For chemicals detected for which an RBSL had not been derived by DTSC, the same DTSC-modified J&E spreadsheets used by DTSC to derive the risk-based values were used to determine an RBSL for those chemicals. Concentrations exceeding the RBSLs have been shaded on these tables. The majority of the chemicals detected in soil gas were much lower than their respective RBSLs as shown on these tables. Therefore, only those compounds exceeding their RBSL (i.e., termed primary risk drivers) were used to complete the baseline risk/hazard evaluation. Table F-1 summarizes the data for the primary risk drivers in soil gas data (this data comprises the baseline dataset).

The concentrations of chemicals in the exposure medium at the exposure point are termed "exposure point concentrations" (EPC). The EPC term represents the average exposure contracted over the exposure period; therefore the EPC is estimated by using an average value and not the maximum observed concentration (U.S. EPA, 1989, 1992, and 2007). The average concentration is regarded as a reasonable estimate of the concentration likely to be contacted over time (U.S. EPA, 1989). The EPCs for this evaluation were calculated using the ProUCL (version 4.00.02) software package developed by U.S. EPA (2007) and represent an upper confidence limit (UCL) of the population mean (i.e., measure of the central tendency of a data distribution). ProUCL 4.0 contains statistical methods to address various environmental issues for both full data sets without nondetects and for data sets with nondetects (also known as left-censored data sets). Table F-2 provides the summary statistics produced by ProUCL for all of the 2007 soil gas data prior to excavation.

Table F-1. Summary of Analytical Soil Gas Data for Primary Risk Drivers

Chemical			Vinyl Chloride	1,3 Butadiene	cis-1,2-Dichloroethene	Benzene	Trichloroethene	Ethylbenzene	1,2-Dichloroethane	1,2-Dichloropropane
DTSC RBSL (µg/m3)			20.7	7.3	28100	60.6	910	780	80	190
U.S. EPA RBSL (µg/m3)			190	42	28100	225	910	813,000	80	190
Sample Location	Depth (ft bgs)	Date								
SG-1A-1	5	8/27/2007	910	27 U	800	170	35 U	47 J	34 U	21 U
SG-1A-2	4	8/27/2007	350	63	4100	130	75 U	10 U	34 U	21 U
SG-1A-3	3	8/27/2007	29	120	260	130	30 U	42 J	34 U	21 U
SG-1A-3-DUP	3	8/27/2007	34	100	250	160	30 U	34 J	34 U	21 U
SG-1A-4	3.5	8/27/2007	14,000	80 J	89000	1000	1100 J	80 J	34 U	21 U
SG-1A-5	5	8/27/2007	36	78 J	43 U	280	39 U	32 J	34 U	21 U
SG-1A-6	5	8/27/2007	43	260	43 U	110	30 U	30 J	34 U	21 U
SG-1A-7	5	8/28/2007	2.4 J	7 J	43 U	35 U	36 U	21 J	34 U	21 U
SG-1A-8	4.5	8/28/2007	89	27 U	85 J	130	34 U	52 J	34 U	21 U
SG-1A-9	4.5	8/28/2007	370	27 U	430	880	64 U	77 J	34 U	21 U
SG-1A-10	3.5	8/28/2007	230	27 U	2100	150	30 U	150	34 U	21 U
SG-1A-11	5	8/28/2007	70	27 U	83 J	84	380 J	130	34 U	21 U
SG-1A-12	5	8/28/2007	650	27 U	6200	240	53 U	54 J	34 U	21 U
SG-1A-13	3	8/28/2007	2.6 J	27 U	43 U	67	54 U	800	34 U	21 U
SG-1A-13-DUP	3	8/28/2007	1.7 J	27 U	43 U	84	30 U	1,100	34 U	21 U
SG-1A-14	5	8/29/2007	1.2 U	27 U	43 U	15 U	30 U	100 U	34 U	21 U
SG-1A-15	5	8/29/2007	2.7 J	27 U	43 U	35	30 U	100 U	34 U	21 U
SG-1A-16	3	8/29/2007	4 J	27 U	66 J	77	30 U	11,000	34 U	21 U
SG-1A-17	4	8/29/2007	350	27 U	7200	340	100 J	100 U	34 U	21 U
SG-1A-17-DUP	4	8/29/2007	330	27 U	6500	460	95 J	100 U	34 U	21 U
SG-1A-18	3.5	8/29/2007	35	27 U	290	170	30 U	100 U	34 U	21 U
SG-1A-19	5	8/29/2007	2.2 J	27 U	43 U	24 U	100 J	100 U	34 U	21 U
SG-1A-20	3	8/29/2007	9.8 J	27 U	130	140	62 J	1,700	34 U	21 U
PS-1A-1	3	5/11/2008	7800	2 U	19000	1300	13000	1500	150	47 U
	6	5/12/2008	15000	2 U	39000	890	4300	270	84	79
PS-1A-2	3.5	5/13/2008	120	2 U	91	51	81 U	66 U	61 U	190
	9	5/14/2008	8.1 J	2 U	83 U	52 J	110 U	91 U	84 U	96 U
PS-1A-3	3.5	5/15/2008	300	2 U	240	69	59 U	48 U	44 U	51 U
	6	5/16/2008	130	2 U	160	52 J	130 U	100 U	98 U	110 U
PS-1A-5	3.5	5/17/2008	380	2 U	5500	200	450	52 U	48 U	55 U
	7	5/18/2008	140	2 U	2300	130	84 U	68 U	63 U	72 U
PS-1A-6	3.5	5/19/2008	3.7 J	2 U	55	54	58 U	51	44 U	50 U
	6	5/20/2008	36	2 U	280	36	58 U	47 U	44 U	50 U
PS-1A-7	3.5	5/21/2008	1.6 U	2 U	41 U	24 J	57	45 U	42 U	48 U
	7	5/22/2008	22 J	2 U	60 U	29 J	81 U	66 U	61 U	70 U
	9.5	5/23/2008	160	2 U	72	65	270	100	71	100
PS-1A-8	4	5/24/2008	1.6 U	2 U	44 U	47	60 U	49 U	45 U	250
PS-1A-9	4	5/25/2008	1.6 U	2 U	41 U	21 J	56 U	45 U	42 U	48 U

Notes:

All data shown on this table were used to calculate the baseline risk/hazard estimates.

J – estimated value

U – indicates the chemical was not detected above the method detection limit (MDL). The value reported is the MDL.

**Table F-2. Summary Statistics for the Baseline Soil Gas Data (ProUCL, ver 4.0)**

Chemical	Number Detects	Number Nondetects	% Nondetects	Raw Statistics using Detected Observations								Exposure Point Concentration (µg/m3)		
				Minimum	Maximum	Mean	Median	Standard Deviation	MAD/0.675	Skewness	Coefficient of Variation	Value	Statistic	Rationale
Vinyl Chloride	31	4	11.43%	2.15	15000	1332	89	3781	126.5	3.17	2.84	7208	99% KM (Chebyshev) UCL	Nonparametric
1,3-Butadiene	6	29	82.86%	63	260	110.3	79	75.04	17.79	2.218	0.68	82	95% KM (t) UCL	Nonparametric
cis-1,2-Dichloroethene	23	12	34.29%	55	89000	7699	290	19752	332.1	3.639	2.565	32721	99% KM (Chebyshev) UCL	Nonparametric
Benzene	32	3	8.57%	21	1300	226.1	120	320.5	100.8	2.288	1.417	538	97.5% KM (Chebyshev) UCL	Nonparametric
Trichloroethene	10	25	71.43%	57	13000	1982	325	4081	363.6	2.676	2.059	1283	95% KM (t) UCL	Nonparametric
Ethylbenzene	18	17	48.57%	21	11000	904.6	78.5	2572	70.42	3.973	2.843	3674	99% KM (Chebyshev) UCL	Nonparametric
1,2-Dichloroethane	3	32	91.43%	71	150	101.7	84	42.36	19.27	1.55	0.417	78	95% KM (t) UCL	Nonparametric
1,2-Dichloropropane	4	31	88.57%	79	250	154.8	145	79.69	82.28	0.407	0.515	99	95% KM (t) UCL	Nonparametric

Notes:

N/A – not applicable

Duplicate samples were averaged prior to conducting statistics. One-half the detection limit was used as the value for a duplicate sample that was nondetect.

## 2.1 Potential Receptors and Exposure Pathways

Currently, the area surrounding Building 965 is scheduled to be transferred along with the other portions of Parcel 1A to the Novato Unified School District (NUSD) for potential future uses ranging from vehicle storage to a school site. However, as a conservative measure, the exposure assessment evaluates cancer risks and noncancer health hazards to a residential receptor for a reasonable maximum exposure (RME). U.S. EPA (1989) defines the RME as the highest exposure that is reasonably expected to occur at a site. Risk decisions are based on the RME consistent with the NCP (U.S. EPA, 1985). Exposure assumptions used for the residential receptor incorporate a longer exposure duration (i.e., 30 years) and a more frequent period of exposure (i.e., 350 days) than would be assumed for a student or teacher who utilizes the school in the future. Inhalation of indoor air (i.e., vapor intrusion) is the only exposure pathway evaluated because vapor intrusion is the most significant exposure pathway driving risk for volatile organic chemicals (VOCs) (Cal-EPA, 2005), and other exposure pathways were determined to be insignificant or not complete as described below.

An estimation of the risk/hazard associated with incidental ingestion, dermal contact and inhalation of ambient air was determined by comparing maximum concentrations detected in soil to U.S. EPA Regional Screening Levels (RSL) for Chemical Contaminants at Superfund Sites (U.S. EPA, 2008). For each chemical detected, risk ratios were derived by dividing the maximum concentration detected by the corresponding RSL. For carcinogenic compounds, risk ratios were multiplied by  $10^{-6}$  to estimate the cancer risk and then summed to provide an estimate of total risk. Similarly, risk ratios for noncarcinogenic chemicals were used as an estimate of the hazard quotient (HQ) and subsequently summed to estimate the hazard index (HI). Estimated cancer risks and noncancer health hazards were well below  $1 \times 10^{-6}$  and 1.0, respectively. As explained in the Final Revised Risk Assessment for Former UST Site 957/970 (Battelle, 2001), direct contact with groundwater for the PBC Parcel 1A study area is very unlikely because groundwater is not currently used for any purpose (e.g., drinking, showering, cooking, irrigation), nor is it likely to be used in the future due to high total dissolved solids and low yield, and potable water is already supplied to Parcel 1A and the surrounding area by the municipality. Therefore, aside from risk associated with vapor intrusion, all other risks from potential groundwater pathways will not be evaluated. Table F-3 contains the risk ratio comparisons.

Based upon the methodology used to calculate inhalation risks/hazards, child cancer risks are less than the risks calculated for the adult and child health hazards are equal to those of the adult; therefore, a separate child receptor was not included in the RA.

## 3.0 Indoor Air Risks/Hazards for Baseline Conditions

Indoor air risks/hazards associated with soil gas were calculated using the DTSC-modified J&E spreadsheets for soil gas with new site-specific soil parameters obtained during the May 2008 sampling event and DTSC default parameters. Consistent with the manner in which estimations of cancer risks were evaluated at Former UST Site 957/970 in previous risk assessments (Battelle, 2001; 2006), two sets of risk estimates are provided to take into account Cal-EPA derived, DTSC-recommended cancer toxicity values and U.S. EPA cancer toxicity values for benzene, 1,3-butadiene, ethylbenzene, and vinyl chloride. Table F-4 summarizes the two sets of toxicity values (e.g., inhalation unit risk factor [URF]) for these four chemicals in addition to providing the URFs and noncancer toxicity values (e.g., reference concentrations [RfC]) for the other COCs. The more recent site-specific soil parameters are summarized in Table F-5. The original soil parameters used in the Final Revised Risk Assessment for Former UST Site 957/970 (Battelle, 2001) also are provided on Table F-5 for comparison purposes.

**Table F-3. Maximum Concentrations Detected in Soil and Comparison to U.S. EPA Regional Screening Levels for Estimates of Risk/Hazard**

<b>COPC</b>	<b>Maximum Concentration Detected (µg/kg)</b>	<b>U.S. EPA Regional Screening Levels<sup>(a)</sup> (car) (µg/kg)</b>	<b>U.S. EPA Regional Screening Levels<sup>(a)</sup> (noncar) (µg/kg)</b>	<b>Cancer Risk</b>	<b>Non-Cancer Hazard</b>
1,2,4-Trimethylbenzene 23	0	NA	67000	ND	0.003
1,3,5-Trimethylbenzene 87		NA	47000	ND	0.002
2-Butanone (MEK)	11	NA	28,000,000	ND	0.0000004
4-Isopropyltoluene 23	0	NA	NA	ND	ND
Acetone 6	9	NA	61,000,000	ND	0.000001
Benzene 0.	99	1100	90,000	9.0E-10	0.00001
Carbon Disulfide	0.28	NA	670,000	ND	0.0000004
cis-1,2-Dichloroethene 62		NA	780,000	ND	0.00008
Cyclohexane 11		NA	7,200,000	ND	0.000002
Dichloromethane (Methylene Chloride)	5.1	11000	1,700,000	4.6E-10	0.000003
Ethylbenzene 9.	1	5700	3,600,000	1.6E-09	0.000003
Isopropylbenzene 32			2,200,000	ND	0.00001
m,p-Xylenes 41		NA	600,000	ND	0.00007
Methyl tert-Butyl Ether	0.28	39000	15,000,000	7.2E-12	0.00000002
Naphthalene 88		3900	150,000	2.3E-08	0.0006
n-Butylbenzene 18	0	NA	NA	ND	ND
n-Heptane 44		NA	NA	ND	ND
n-Hexane 1.	4	NA	570,000	ND	0.000002
n-Propylbenzene 11	0	NA	NA	ND	ND
o-Xylene 59		NA	5,300,000	ND	0.00001
sec-Butylbenzene 13	0	NA	NA	ND	ND
tert-Butylbenzene 7.	8	NA	NA	ND	ND
Tetrachloroethene (PCE)	3.9	570	380,000	6.8E-09	0.00001
Tetrahydrofuran	480	NA	NA	ND	ND
Toluene 24		NA	5,000,000	ND	0.000005
trans-1,2-Dichloroethene 3	4	NA	110,000	ND	0.00003
Trichloroethene (TCE)	10	2800	NA	3.6E-09	ND
Vinyl Chloride	1.4	60	74,000	2.3E-08	0.00002
<b>TOTAL</b>				<b>6.0E-08</b>	<b>0.006</b>

<sup>(a)</sup> U.S. EPA, 2008

**Table F-4. Summary of Inhalation Toxicity Values**

Chemical	Cal-EPA URF <sup>(a)</sup> ( $\mu\text{g}/\text{m}^3$ ) <sup>-1</sup>	U.S. EPA URF <sup>(b)</sup> ( $\mu\text{g}/\text{m}^3$ ) <sup>-1</sup>	Cal-EPA RfC <sup>(a)</sup> ( $\text{mg}/\text{m}^3$ )
1,1-Dichloroethylene NA		NA	0.07
1,2,4-Trimethylbenzene NA		NA	0.00595
1,3,5-Trimethylbenzene NA		NA	0.00595
1,3-Butadiene 0.	00017	0.00003	0.002
Acetone NA		NA	0.35
Benzene 0.	00003	0.0000078	0.03
cis-1,2-Dichloroethene NA		NA	0.035
Ethylbenzene 0.	0000025	NA	1
Isopropylbenzene NA		NA	NA
m,p-Xylenes NA		NA	0.1
MTBE 0	.0000003	NA	3
n-Propylbenzene NA		NA	0.14
o-Xylene NA		NA	0.1
p-Isopropyltoluene NA		NA	NA
sec-Butylbenzene NA		NA	0.14
Tetrachloroethene 0.	000006	NA	0.035
Toluene NA		NA	0.3
trans-1,2-Dichloroethene NA		NA	0.07
Trichloroethene 0.	000002	NA	0.6
Vinyl chloride	0.000078	0.0000088	0.1

NA – not applicable.

- (a) Values provided in DTSC Vapor Intrusion Spreadsheet (SG-SCREEN) EPA Version 2.0; 04/03. DTSC Vapor Intrusion Guidance Interim Final 12/05 (last modified 1/21/05).
- (b) Values for benzene, 1,3-butadiene, and vinyl chloride obtained from U.S. EPA's Integrated Risk Information System, accessed March 27, 2008 (<http://www.epa.gov/iris/subst/index.html#v>).

**Table F-5. Summary of Soil Physical Properties Used in the J&E Model to Estimate Baseline Conditions Associated with Soil Gas**

Soil Parameter	Units	Original Value <sup>(a)</sup>	New Value <sup>(b)</sup>
Soil bulk density	$\text{g}/\text{cm}^3$	4	1.65
Fraction organic carbon in vadose zone soil	---	0.0017	0.0032
Average soil temperature	C	15	20 <sup>(c)</sup>
Vadose zone soil total porosity	---	0.48	0.377
Vadose zone soil water-filled porosity	---	0.1	0.1 <sup>(a)</sup>
Soil vapor permeability		3.03E-08	3.03E-08 <sup>(a)</sup>
Soil gas sampling Depth	cm	91.4	152.4 <sup>(d)</sup>

- (a) Original values obtained from the Final Revised Risk Assessment for Former UST Site 957/970 (Battelle, 2001).
- (b) New values are averages of the results obtained during the May 2008 sampling event unless indicated otherwise.
- (c) Average temp in MW-2D for the month of May for the years 2002 through 2007.
- (d) Soil gas sampling depth based on the average depth for the Baseline scenario.

Cancer risks and noncancer health hazards are summarized in Table F-6 for the baseline exposure scenario. The NCP risk management range of  $10^{-4}$  and  $10^{-6}$  for carcinogenic risk (U.S. EPA, 1990) and 1.0 for the non-cancer risk are used to evaluate the relative magnitude of risk calculated for the area of Building 965 within Parcel 1A. Chemical-specific hazard quotients (HQs) are summed to calculate the hazard index (HI). The HI is the value compared to the U.S. EPA noncancer criterion of 1.

Calculated cancer risks for the residential receptor (Table F-6) indicate that the total cancer risk is  $3 \times 10^{-4}$  based on Cal-EPA toxicity values and  $4 \times 10^{-5}$  based on U.S. EPA toxicity values, which are only slightly above and within the NCP risk management range, respectively. Benzene, 1,3-butadiene, and vinyl chloride are the primary contributors to a combined risk above  $1 \times 10^{-6}$ . Noncancer HQs are below 1.0 for all chemicals and the HI is equal to 1.0 (Table F-6).

**Table F-6. Summary of Cancer Risks/Noncancer Health Hazards for the Baseline Scenario**

Chemical	EPC (ug/m3)	Cal-EPA Toxicity		U.S. EPA Toxicity	
		Risk	Hazard	Risk	Hazard
Vinyl Chloride	7208 3.E	-04	0.1	3.E-05	0.08
1,3-Butadiene	81.6 1.E	-05	0.1	2.E-06	0.07
cis-1,2-DCE	32721 ND		0.9	ND	0.85
Benzene	538 7.E	-06	0.02	2.E-06	0.02
TCE	1283 1.E	-06	0.002	1.E-06	0.002
Ethylbenzene	3674 4.E	-06	0.003	ND	0.003
1,2-DCA	78 8.E	-07	0.0002	8.E-07	0.0002
1,2-DCP	99 4.E	-07	0.02	4.E-07	0.02
<b>Total</b>			3.E-04 1	4.E-05	1

EPC – exposure point concentration; determined using U.S. EPA’s ProUCL, ver 4.0. Soil gas sampling depth below grade was about 5 ft bgs, which is the average depth of the samples used to calculate the EPC.

ND – not detected/not determined.

#### 4.0 Risk/Hazard Associated with Vapor Intrusion from Groundwater Detections

Chemicals detected in groundwater were evaluated for the vapor intrusion to indoor air pathway given that groundwater is shallow. The risks estimated using groundwater data can be used for bounding purposes to aid in risk management decisions.

Tables F-7 and F-8 summarize the maximum concentrations detected in groundwater and provide estimates of cancer risk and non-cancer health hazards via risk ratio comparisons to RBSLs. RBSLs were derived by DTSC HERD using the DTSC-modified J&E spreadsheet with site-specific soil parameters obtained from the Final Revised Risk Assessment for Former UST Site 957/970 (Battelle, 2001) and DTSC default parameters in conjunction with Cal-EPA toxicity values to back-calculate a value in groundwater equal to  $1 \times 10^{-6}$  risk level or 1.0 hazard quotient (Table F-7). An additional set of RBSLs were derived for benzene, ethylbenzene, 1,3-butadiene, and vinyl chloride using U.S. EPA toxicity values (Table F-8).

For RBSLs derived using Cal-EPA toxicity values (Table F-7), the total cancer risk was estimated to be  $6 \times 10^{-6}$ . As indicated by shading on Table F-7, 1,3-butadiene and vinyl chloride were the primary contributors to the total risk. The non-cancer health hazard index was less than 1.0. For RBSLs derived using U.S. EPA toxicity values (Table F-8), the total cancer risk was estimated to be  $1 \times 10^{-6}$ . None of the chemicals individually exceeded  $1 \times 10^{-6}$ . The non-cancer health hazard index was less than 1.0.

**Table F-7. Comparison of Maximum Detected Concentrations in Groundwater and Estimates of Risk/Hazard for Vapor Intrusion – Cal-EPA Toxicity**

COPC	Maximum Concentration Detected (ug/L)	RBSL - Cal-EPA Toxicity (car)	RBSL (nc)	Cancer Risk	Non-Cancer Hazard
1,1-Dichloroethene (1,1-DCE)	0.5	NA	1,150	ND	0.0004
1,2,4-Trimethylbenzene 7.	7	NA	726	ND	0.01
1,2-Dichlorobenzene 0.	33	NA	55,800	ND	0.000006
1,2-Dichloroethane (EDC)	0.13	30.7	NA	4.2E-09	ND
1,2-Dichloropropane 0.	07	37.9	NA	1.8E-09	ND
1,3,5-Trimethylbenzene 0.	9	NA	749	ND	0.001
1,3-Butadiene 0.	069	0.029	4.22	2.4E-06 0.	02
1,4-Dichlorobenzene 0.	11	49	185,000	2.2E-09	0.000001
2-Butanone (MEK)	7.9	NA	6,335,608	1.2E-12	0.000001
4-Chlorotoluene 0.	09	NA	NA	ND	ND
4-Isopropyltoluene 2.	7	NA	NA	ND	ND
Acetone 42		NA	438,712	9.6E-11	0.00010
Benzene 0.	49	6.4	2,380	7.7E-08	0.0002
Carbon Disulfide	0.34	NA	8,785	ND	0.00004
Chloromethane 0.	11	73.8	2,850	1.5E-09	0.00004
cis-1,2-Dichloroethene 42		NA	4,011	ND	0.01
Cyclohexane 2.	6	NA	34,957	ND	0.00007
Ethylbenzene 0.	66	70.4	75,500	9.4E-09	0.000009
Isopropylbenzene 5.	6	NA	298	ND	0.02
m,p-Xylenes 1		NA	7,559	ND	0.0001
Methyl tert-Butyl Ether	1.8	3065	1,000,000	5.9E-10	0.0000018
Naphthalene 0.	57	46.8	2000	1.2E-08	0.0003
n-Butylbenzene 3.	3	NA	2000	ND	0.0017
n-Heptane 11	.1	NA	NA	ND	ND
n-Hexane 0.	88	NA	26.6	ND	0.03
n-Propylbenzene 9.	3	NA	10379	ND	0.0009
o-Xylene 1.	3	NA	9508	ND	0.0001
sec-Butylbenzene 6.	5	NA	3940	ND	0.00165
tert-Butylbenzene 1		NA	8980	ND	0.0001
Toluene 1.	2	NA	21833	ND	0.00005
trans-1,2-Dichloroethene 2.	6	NA	3,892	ND	0.0007
Trichloroethene (TCE)	16	59.5	30,000	2.7E-07	0.0005
Vinyl Chloride	1.3	0.373	1,200	3.5E-06 0.	001
<b>TOTAL</b>				<b>6.E-06</b>	<b>0.1</b>

NA - not applicable because a toxicity value does not exist for this chemical.

ND - not determined.

Shading indicates exceedence of  $1 \times 10^{-6}$ .

**Table F-8. Comparison of Maximum Detected Concentrations in Groundwater and Estimates of Risk/Hazard for Vapor Intrusion – U.S. EPA Toxicity**

<b>COPC</b>	<b>Maximum Concentration Detected (ug/L)</b>	<b>RBSL - U.S. EPA Toxicity (car)</b>	<b>RBSL (nc)</b>	<b>Cancer Risk</b>	<b>Non-Cancer Hazard</b>
1,1-Dichloroethene (1,1-DCE)	0.5	NA	1,150	ND	0.0004
1,2,4-Trimethylbenzene 7.	7	NA	726	ND	0.01
1,2-Dichlorobenzene 0.	33	NA	55,800	ND	0.000006
1,2-Dichloroethane (EDC)	0.13	30.7	NA	4.2E-09	ND
1,2-Dichloropropane 0.	07	37.9	NA	1.8E-09	ND
1,3,5-Trimethylbenzene 0.	9	NA	749	ND	0.001
1,3-Butadiene 0.	069	0.164	4.22	4.2E-07	0.02
1,4-Dichlorobenzene 0.	11	49	185,000	2.2E-09	0.000001
2-Butanone (MEK)	7.9	NA	6,335,608	1.2E-12	0.000001
4-Chlorotoluene 0.	09	NA	NA	ND	ND
4-Isopropyltoluene 2.	7	NA	NA	ND	ND
Acetone 42		NA	438,712	9.6E-11	0.00010
Benzene 0.	49	23.7	2,380	2.1E-08	0.0002
Carbon Disulfide	0.34	NA	8,785	ND	0.00004
Chloromethane 0.	11	73.8	2,850	1.5E-09	0.00004
cis-1,2-Dichloroethene 42		NA	4,011	ND	0.01
Cyclohexane 2.	6	NA	34,957	ND	0.00007
Ethylbenzene 0.	66	NA	75,500	ND	0.000009
Isopropylbenzene 5.	6	NA	298	ND	0.02
m,p-Xylenes 1		NA	7,559	ND	0.0001
Methyl tert-Butyl Ether	1.8	3065	1,000,000	5.9E-10	0.0000018
Naphthalene 0.	57	46.8	2000	1.2E-08	0.0003
n-Butylbenzene 3.	3	NA	2000	ND	0.0017
n-Heptane 11	.1	NA	NA	ND	ND
n-Hexane 0.	88	NA	26.6	ND	0.03
n-Propylbenzene 9.	3	NA	10379	ND	0.0009
o-Xylene 1.	3	NA	9508	ND	0.0001
sec-Butylbenzene 6.	5	NA	3940	ND	0.00165
tert-Butylbenzene 1		NA	8,980	ND	0.0001
Toluene 1.	2	NA	21,833	ND	0.00005
trans-1,2-Dichloroethene 2.	6	NA	3,892	ND	0.0007
Trichloroethene (TCE)	16	59.5	30,000	2.7E-07	0.0005
Vinyl Chloride	1.3	3.3	1,200	3.9E-07	0.001
<b>TOTAL</b>				<b>1.E-06</b>	<b>0.1</b>

NA - not applicable because a toxicity value does not exist for this chemical.

ND - not determined.

Shading indicates exceedence of  $1 \times 10^{-6}$ .

## 5.0 Risk/Hazard Associated with Vapor Intrusion from Chemicals Detected in Soil

Estimates of cancer risk and non-cancer health hazards via risk ratio comparisons to RBSLs also were determined for chemicals detected in soil. RBSLs were derived using the DTSC-modified J&E spreadsheet with site-specific soil parameters obtained from the Final Revised Risk Assessment for Former UST Site 957/970 (Battelle, 2001) and DTSC default parameters in conjunction with Cal-EPA and U.S. EPA toxicity values to back-calculate a value in soil equal to  $1 \times 10^{-6}$  risk level or 1.0 hazard quotient. Table F-9 summarizes the maximum concentrations detected in soil and provides estimates of cancer risk and non-cancer health hazards via risk ratio comparisons to RBSLs for chemicals expected to be primary risk drivers (Appendix D provides a summary of all chemicals detected in soil and comparison to RBSLs). Estimates of cancer risk and non-cancer health hazards have been provided for baseline in order to support risk management decisions for the site.

At baseline conditions, estimates of total risk range from  $2 \times 10^{-4}$  to  $4 \times 10^{-5}$ , depending on the toxicity source. The noncancer HI is 4.

**Table F-9. Summary of Maximum Concentrations Detected in Soil and Estimates of Cancer Risk/Non-cancer Hazard**

COPC	Maximum Concentration Detected - Baseline (ug/kg)	Location	RBSL - Cal-EPA Toxicity (car)	RBSL (nc)	Cancer Risk	Non-Cancer Hazard
1,2,4-Trimethylbenzene	230	PS-1A-1 (2-3 ft)	NA	96.4	ND	2.4
Benzene	0.99	PS-1A-1 (4-5 ft)	0.121	32.2	8.E-06 0.	03
cis-1,2-Dichloroethene	62	PS-1A-1 (4-5 ft)	NA	41.4	ND	1.5
Ethylbenzene	9.1	PS-1A-1 (2-3 ft)	2.99	3200	3.E-06	0.003
Naphthalene	88	PS-1A-1 (2-3 ft)	22.3	976	4.E-06	0.090
Tetrachloroethene (PCE)	3.9	PS-1A-1 (2-3 ft)	0.329	499	1.E-05 0.	008
Trichloroethene (TCE)	10	PS-1A-7 (3-4ft)	1.46	752	7.E-06 0.	01
Vinyl Chloride	1.4	PS-1A-1 (4-5 ft)	0.008	26	2.E-04 0.	1
<b>TOTAL</b>					<b>2.E-04</b>	<b>4</b>
COPC	Maximum Concentration Detected - Baseline (ug/kg)	Location	RBSL - U.S. EPA Toxicity (car)	RBSL (nc)	Cancer Risk	Non-Cancer Hazard
1,2,4-Trimethylbenzene	230	PS-1A-1 (2-3 ft)	NA	96.4	ND	2.4
Benzene	0.99	PS-1A-1 (4-5 ft)	0.321	32.2	3.E-06 0.	03
cis-1,2-Dichloroethene	62	PS-1A-1 (4-5 ft)	NA	41.4	ND	1.5
Ethylbenzene	9.1	PS-1A-1 (2-3 ft)	NA	3200	ND	0.003
Naphthalene	88	PS-1A-1 (2-3 ft)	NA	976		0.090
Tetrachloroethene (PCE)	3.9	PS-1A-1 (2-3 ft)	0.329	499	1.E-05 0.	008
Trichloroethene (TCE)	10	PS-1A-7 (3-4ft)	1.46	752	7.E-06 0.	01
Vinyl Chloride	1.4	PS-1A-1 (4-5 ft)	0.07	26	2.E-05 0.	1
<b>TOTAL</b>					<b>4.E-05</b>	<b>4</b>

Note: RBSLs were derived by using the DTSC-modified J&E spreadsheet with site-specific soil parameters (see Table F-5) and DTSC default parameters in conjunction with Cal-EPA and U.S. EPA toxicity values to back-calculate a value in soil equal to  $1 \times 10^{-6}$  risk level or 1.0 hazard quotient. Shading indicates exceedence of  $1 \times 10^{-6}$  or 1.0.

## 6.0 Uncertainties Associated with Baseline and Future Risk Estimates

A qualitative evaluation is provided in this section to address uncertainties associated with the estimates of risk presented in this attachment. Although the risk results are best estimates based on the most current information and risk assessment techniques, the results are not 100% certain because of variability and uncertainty associated with the inputs to the risk calculations. Two primary sources of uncertainty associated with risk estimates are:

- Model uncertainty (*i.e.*, methods/models used to calculate EPCs and risk); and,
- Parameter uncertainty (*i.e.*, uncertainty in model input parameter exposure variables).

Large uncertainties can arise in risk estimates that are based on models that simulate the fate/transport of contaminants (e.g., J&E vapor intrusion model). Parameters involved in the risk assessment are categorized according to the step in which they occur (*i.e.*, hazard identification, exposure assessment, dose-response [toxicity] assessment, and risk characterization). The various uncertainties and the likely impact of these uncertainties on the calculated risks are summarized in Table F-10.

Due to the uncertainties associated with predicting indoor air quality for future buildings, DTSC recommends using maximum soil gas concentrations (Cal-EPA, 2005) along with other conservative default input parameters (e.g., average vapor flow into building, crack to total area ratio, building ventilation rate). The Navy does not necessarily agree with this recommendation from DTSC, and does not intend to set any precedent by calculating indoor air risks using maximum concentrations in order to determine the extent of the TCRA. However, the Navy has addressed DTSC's uncertainty with regard to indoor air quality by evaluating the indoor air risks for the primary risk drivers using maximum soil gas concentrations remaining in the subsurface for each of the TCRA Excavation Scenarios. Table F-11 provides a summary of the risks associated with the maximum soil gas concentration, as well as a comparison to the risks associated with the central tendency EPC (*i.e.*, the EPC determined by ProUCL).

Total risks based on maximum concentrations are about two to three times higher than risks based on the ProUCL EPC (e.g.,  $6 \times 10^{-4}$  using maximum versus  $3 \times 10^{-4}$  using ProUCL EPCs for Cal-EPA toxicity and  $9 \times 10^{-5}$  using maximum versus  $4 \times 10^{-5}$  using ProUCL EPCs for U.S. EPA toxicity). Based on the comparison of the total risks associated with the two types of EPCs shown in Table F-11, risks estimated based on a measure of the central tendency of the data distribution do not differ very much from the risks associated with maximum concentrations, most likely because of the conservative nature of the indoor air model and use of conservative input parameters. Therefore, the uncertainty related to the use of UCLs and maximum concentrations for determining risk is minimal and does not result in significant differences in risk estimates.

However, consistent with U.S. EPA guidance (U.S. EPA 1989, 1992, 2007) and Navy policy (DON, 2001), the RME approach for assessing risks, including an EPC estimated as an average value and not the maximum observed concentration, will be followed to assess the risk/hazard from vapor intrusion, which will be used to assist with making risk management decisions for the TCRA.

**Table F-10. Sources of Uncertainty in the Risk Assessment and Impact on Calculated Risks/Hazards**

Source of Uncertainty	Relative Level of Uncertainty	Impact on Calculated Risks
<b>Model Uncertainty</b>		
Site physical parameters	Moderate to high. Indoor air estimates from the J&E model are based on some site-specific parameters (soil vapor permeability, bulk density, and porosity) determined from historical samples collected at Former UST Site 957/970 but not in the immediate vicinity of Building 965 within Parcel 1A.	Use of site-specific data is likely to increase the accuracy of site-specific risk/hazard estimates.  Risks/hazards are more likely to be overestimated because of conservative assumptions in determining indoor air concentrations, which include no biodegradation or other loss mechanism.
J&E DTSC-modified indoor air model	Moderate to high. Indoor air estimates from the J&E model are based DTSC default input parameters for soil properties and building characteristics (average vapor flow into building, crack to total area ratio, building ventilation rate)	Risks/hazards are more likely to be overestimated because of conservative assumptions in determining indoor air concentrations.
<b>Parameter Uncertainty</b>		
Exposure point concentrations for vapor intrusion	Low to moderate. EPCs are based on measured soil gas data.	Upper confidence limits or maximum concentrations were used to calculate risks; therefore, risks are likely to be overestimated. Datasets for the majority of the chemicals contained a fair number of non-detects, or “censored” data. Statistical manipulation of censored data is somewhat problematic, and could lead to an overestimate of the EPC, and thus, an overestimate of risk/hazard.
Exposure parameters for receptors	Low to Moderate. Most values are based on standard default residential exposure values recommended by U.S. EPA and Cal-EPA and derived from scientific studies.	Risks/hazards more likely to be overestimated because conservative residential default values were used as opposed to more site-specific exposure parameters for receptors at a school.
Toxicity data	Moderate to high. Toxicity values are based on result of tests performed on animals and extrapolated to humans.  U.S. EPA and Cal-EPA toxicity values used to provide the range of risk estimates.	Because toxicity values are typically most conservative values available, risks/hazards are more likely to be overestimated than underestimated.  Cal-EPA toxicity values are associated with the upper end of risk, while U.S. EPA values provide the lower end of risk estimates; however, these risk estimates are more likely overestimated than underestimated.

**Table F-11. Comparison of Risks – ProUCL EPC and Maximum Concentrations**

Chemical	Soil Gas Maximum Concentration <sup>(a)</sup> (ug/m3)	Cal-EPA Toxicity		U.S. EPA Toxicity	
		Risk	Hazard	Risk	Hazard
Vinyl Chloride	15,000	5.E-04	0.2	6.E-05	0.2
1,3-Butadiene 26	0	3.E-05	0.2	5.E-06	0.2
cis-1,2-DCE	8,9000	ND	3	ND	3
Benzene 1,	300	2.E-05	0.03	6.E-06	0.03
TCE 13	,000	1.E-05	0.03	1.E-05	0.03
Ethylbenzene 11	,000	2.E-05	0.01	ND	0.01
1,2-DCA 15	0	2.E-06	0.0005	2.E-06	0.0005
1,2-DCP 25	0	1.E-06	0.06	1.E-06	0.06
<b>Total</b>		6.E-04 3		9.E-05	3

<sup>(a)</sup> Soil gas sampling depth below grade used in the J&E model was based on the depth of the sample containing the maximum concentration.  
 ND – not detected/not determined.

## 7.0 References

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