

Appendix A

Calculation of Risk-Based Media Cleanup Standards

Appendix A-1: Media Cleanup Standards Calculations for
Theoretical ILCR = 10^{-6} and HI = 1

APPENDIX A: GROUNDWATER AND SOIL MEDIA CLEANUP STANDARD CALCULATION SUMMARY
LAWRENCE BERKELEY NATIONAL LABORATORY HHRA

Input Parameters for all MCS Calculations	
Cancer Risk	1.00E-06
Hazard Quotient	1
η*	0.002
Depth to Groundwater (feet)	5
Depth to Soil Source (feet)	5

Risk Estimates

Groundwater COPCs	Groundwater				Soil COPCs	Soil	
	Indoor Workers		Intrusive Workers			Indoor Workers	
Compound	Calculated Target Cancer Risk Cw (μg/L)	Calculated Target Non-Cancer Risk Cw (μg/L)	cancer Cw (μg/L) ^{g/}	Non-cancer Cw (μg/L) ^{g/}		Calculated Target Cancer Risk Cs (mg/kg)	Calculated Target Non-Cancer Risk Cs (mg/kg)
Organic Compounds							
1,1,1-Trichloroethane	--	1,570,783	--	2,596,355	1,1,1-Trichloroethane	--	690
1,1,2-Trichloroethane	1,905	--	14,833	61,026			
1,1-Dichloroethane	3,663	1,025,767	277,640	2,260,781	1,1-Dichloroethane	1.3	364
1,1-Dichloroethene	--	28,873	--	639,607	1,1-Dichloroethene	--	7.9
1,2-Dichloroethane	1,030	3,088,688	53,714	1,081,945	1,2-Dichloroethane	0.23	8.5
1,2-Dichloroethene, cis-	--	98,405	--	199,358	1,2-Dichloroethene, cis-	--	38.1
1,2-Dichloroethene, trans-	--	94,405	--	320,269	1,2-Dichloroethene, trans-	--	49.6
1,2-Dichloropropane	1,071	15,302	27,688	--			
Benzene	175	108,838	8,092	46,238	Benzene	0.10	6.0
Carbon tetrachloride	27	1,004	3,084	4,625	Carbon tetrachloride	0.05	1.7
Chloroform	1,206	684,732	8,770	38,838	Chloroform	0.49	0.28
Methylene chloride	10,381	1,482,958	235,804	2,829,653	Methylene Chloride	1.8	1974
Tetrachloroethene	343	25,265	384	29,661	Tetrachloroethene	0.45	380
Trichloroethene	1,594	682,956	55,015	3,065	Trichloroethene	2.3	966
Vinyl chloride	12	33,798	7,236	83,736	Vinyl chloride	0.0035	9.7

*Areal fraction of cracks in foundations/walls (cm²-cracks/cm²-total area)

^{g/} Refer to the Model Unit Definition table for all associated unit definitions.

Risk-Based MCS

APPENDIX A: GROUND WATER RISK CALCULATIONS
MODELING VOLATILIZATION FROM GROUNDWATER INTO INDUSTRIAL/COMMERCIAL INDOOR AIR (ASTM MODEL)

LAWRENCE BERKELEY NATIONAL LABORATORY CMS

Equations	Input Parameter Definition ^{a/}		Commercial Input Parameters
1i) Enclosed Space (Indoor) Air Concentration Due to Volatilization from Ground Water C _{air-indoor} = C _w VF _{wesp}	C _{air-indoor}	Modeled COPC indoor air concentration (µg/m ³)	Calculated (Eq. 1i)
	C _w	Groundwater COPC concentration (µg/L)	Measured
2i) Cross-Media Groundwater-to-Enclosed (Indoor) Space Air Volatilization Factor	VF _{wesp}	Cross-media groundwater-to-enclosed (indoor) space volatilization factor(mg/m ³ -air)/(mg/L-water)	Calculated (Eq. 2i)
	H	Henry's law constant (cm ³ -water)/(cm ³ -air)	Chemical-specific
	Deff _{ws}	Effective diffusion coefficient between ground water and soil surface (cm ² /s)	Calculated (Eq. 3 on Page: C _{air-gw} outdoor)
	LGW	Depth to ground water = h _{cap} + h _v (cm)	152
	ER	Enclosed-space air exchange rate (1/sec)	0.00023
	LB	Enclosed-space volume/infiltration area ratio (cm)	300
	Deff _{crack}	Effective diffusion coefficient through foundation cracks (cm ² /s)	Calculated (Eq. 3i)
	L _{crack}	Enclosed-space foundation or wall thickness (cm)	15
	η	Areal fraction of cracks in foundations/walls (cm ² -cracks/cm ² -total area)	0.002
	D _{air}	Diffusion coefficient in air (cm ² /s)	Chemical-specific
	θ _{crack}	Volumetric air content in foundation/wall cracks (cm ³ -air/cm ³ total volume)	0.26
	θ _T	Total soil porosity (cm ³ /cm ³ -soil)	0.38
	θ _{wcrack}	Volumetric water content in foundation/wall cracks (cm ³ -water/cm ³ total volume)	0.12
	D _{wat}	Diffusion coefficient in water (cm ² /s)	Chemical-specific
		Target Cancer Risk (user defined)	1.00E-06

$$VF_{wesp} = \frac{H \left[\frac{D_{air}^{eff} / L_{crack}}{ER L_B} \right]}{1 + \left[\frac{D_{ws}^{eff} / L_{GW}}{ER L_B} \right] + \left[\frac{D_{crack}^{eff} / L_{crack}}{ER L_B} \right] \eta} \times 10^3 \frac{L}{m^3}$$

3i) Effective Diffusion Through Foundation Cracks

$$D_{crack}^{eff} = D_{air} \frac{\theta_{crack}^{3.33}}{\theta_T^2} + D_{wat} \frac{1}{H} \frac{\theta_{wcrack}^{3.33}}{\theta_T^2}$$

Compound	Calculated C _w based on Target Cancer Risk (µg/L)	Calculated C _w based on Target Non-Cancer Risk (µg/L)	H	D _{air} (cm ² /s)	D _{wat} (cm ² /s)	Deff _{crack} (cm ² /s)	Deff _{ws} (cm ² /s)	VF _{wesp}	Target Cancer Risk		Target Non-Cancer Risk	
									C _{air-indoor} (µg/m ³)			
Organic Compounds												
1,1,1-Trichloroethane	--	1,570,783	7.05E-01	7.80E-02	8.80E-06	6.09E-03	3.59E-04	6.17E-03	--	--	9.69E+03	--
1,1,2-Trichloroethane	1,905	--	3.74E-02	7.80E-02	8.80E-06	6.09E-03	1.34E-03	4.03E-04	7.67E-01	--	--	--
1,1-Dichloroethane	3,663	1,025,767	2.30E-01	7.42E-02	1.05E-05	5.79E-03	5.14E-04	2.09E-03	7.67E+00	--	2.15E+03	--
1,1-Dichloroethene	--	28,873	1.07E+00	9.00E-02	1.04E-05	7.02E-03	3.90E-04	1.06E-02	--	--	3.07E+02	--
1,2-Dichloroethane	1,030	3,088,688	4.01E-02	1.04E-01	9.90E-06	8.12E-03	1.53E-03	5.68E-04	5.85E-01	--	1.75E+03	--
1,2-Dichloroethene, cis-	--	98,405	1.67E-01	7.36E-02	1.13E-05	5.74E-03	6.19E-04	1.56E-03	--	--	1.53E+02	--
1,2-Dichloroethene, trans-	--	94,405	3.85E-01	7.07E-02	1.19E-05	5.52E-03	4.27E-04	3.25E-03	--	--	3.07E+02	--
1,2-Dichloropropane	1,071	15,302	1.15E-01	7.82E-02	8.73E-06	6.10E-03	6.76E-04	1.15E-03	1.23E+00	--	1.75E+01	--
Benzene	175	108,838	2.28E-01	8.80E-02	9.80E-06	6.87E-03	5.54E-04	2.42E-03	4.23E-01	--	2.63E+02	--
Carbon tetrachloride	27	1,004	1.25E+00	7.80E-02	8.80E-06	6.09E-03	3.30E-04	1.07E-02	2.92E-01	--	1.07E+01	--
Chloroform	1,206	684,732	1.50E-01	1.04E-01	1.00E-05	8.12E-03	7.34E-04	1.92E-03	2.32E+00	--	1.32E+03	--
Methylene chloride	10,381	1,482,958	8.98E-02	1.01E-01	1.17E-05	7.88E-03	1.02E-03	1.18E-03	1.23E+01	--	1.75E+03	--
Tetrachloroethene	343	25,265	7.54E-01	7.20E-02	8.20E-06	5.62E-03	3.28E-04	6.07E-03	2.08E+00	--	1.53E+02	--
Trichloroethene	1,594	682,956	4.22E-01	7.90E-02	9.10E-06	6.16E-03	4.11E-04	3.85E-03	6.14E+00	--	2.63E+03	--
Vinyl chloride	12	33,798	1.11E+00	1.06E-01	1.23E-05	8.27E-03	4.57E-04	1.30E-02	1.57E-01	--	4.38E+02	--

^{a/} Refer to the Model Unit Definition table for all associated unit definitions.

APPENDIX A: GROUNDWATER RISK CALCULATIONS

INDOOR WORKER -- RME SCENARIO

CARCINOGENIC AND NONCARCINOGENIC RISK ESTIMATES - INHALATION OF VOLATILE COPCS IN INDOOR AIR FROM GROUNDWATER

LAWRENCE BERKELEY NATIONAL LABORATORY CMS

Exposure Assumptions			Risk and Hazard Equations
Receptor	Indoor Office Worker: RME Scenario		Carcinogenic:
COPC Ambient Air Concentration (C _{air-indoor})	chemical-specific	µg/m ³	$Risk = \frac{(C_{air-indoor})(EF)(ED)(ET)(URF)}{(AT_c)(365days/year)}$
Exposure Frequency (EF)	250	days/yr	
Exposure Duration (ED)	25	yrs	Noncarcinogenic:
Fraction of EF breathing air at the site (ET)	0.333	unitless	
Averaging Time, Carcinogens (ATC)	70	yrs	$HQ = \frac{(C_{air-indoor})(EF)(ED)(ET)}{(RfC)(AT_{nc})(365days/year)}$
Averaging Time, Noncarcinogens (ATNC)	25	yrs	
Inhalation Unit Risk Factor (URF)	chemical-specific	(µg/m ³)-1	
Inhalation Reference Concentration (RfC)	chemical-specific	µg/m ³	

COPC ^w	CAS Number ^w	Indoor Air Concentration for Target Cancer Risk (µg/m ³) ^w	Indoor Air Concentration for Target Non-Cancer Risk (µg/m ³) ^w	URF (µg/m ³) ⁻¹	HHRA URF (if different)	RfC (µg/m ³)	Cancer Risk	Hazard Quotient
Organic Compounds								
1,1,1-Trichloroethane	71-55-6	--	9.69E+03	--		2.21E+03	1.00E-06	1.0
1,1,2-Trichloroethane	79-00-5	7.67E-01	--	1.60E-05		--	1.00E-06	1.0
1,1-Dichloroethane	75-34-3	7.67E+00	2.15E+03	1.60E-06		4.90E+02	1.00E-06	1.0
1,1-Dichloroethene	75-35-4	--	3.07E+02	--	5.00E-05	7.00E+01	1.00E-06	1.0
1,2-Dichloroethane	107-06-2	5.85E-01	1.75E+03	2.10E-05		4.00E+02	1.00E-06	1.0
1,2-Dichloroethene, cis-	156-59-2	--	1.53E+02	--		3.50E+01	1.00E-06	1.0
1,2-Dichloroethene, trans-	156-60-5	--	3.07E+02	--		7.00E+01	1.00E-06	1.0
1,2-Dichloropropane	78-87-5	1.23E+00	1.75E+01	1.00E-05		4.00E+00	1.00E-06	1.0
Benzene	71-43-2	4.23E-01	2.63E+02	2.90E-05		6.00E+01	1.00E-06	1.0
Carbon tetrachloride	56-23-5	2.92E-01	1.07E+01	4.20E-05		2.45E+00	1.00E-06	1.0
Chloroform	67-66-3	2.32E+00	1.32E+03	5.30E-06		3.00E+02	1.00E-06	1.0
Methylene chloride	75-09-2	1.23E+01	1.75E+03	1.00E-06		4.00E+02	1.00E-06	1.0
Tetrachloroethene	127-18-4	2.08E+00	1.53E+02	5.90E-06	5.80E-07	3.50E+01	1.00E-06	1.0
Trichloroethene	79-01-6	6.14E+00	2.63E+03	2.00E-06	1.70E-06	6.00E+02	1.00E-06	1.0
Vinyl chloride	75-1-4	1.57E-01	4.38E+02	7.80E-05		1.00E+02	1.00E-06	1.0

^w COPC = chemical of potential concern.

^w CAS = Chemical Abstracts Service number.

^w Modeled indoor air concentrations are based on the COPC-specific cancer risk and hazard quotient

^w µg/m³ = micrograms per cubic meter.

-- = data not available.

APPENDIX A: GROUNDWATER RISK CALCULATIONS
MODELING VOLATILIZATION FROM GROUNDWATER TO SOIL SURFACE (ASTM MODEL)
LAWRENCE BERKELEY NATIONAL LABORATORY CMS

	Input Parameter Definition ^{d/}	Input Parameters
3) Effective Diffusion Coefficient Between Ground Water and Soil Surface	H Deffws hcap hv Deffcap Deffs Dair θ acap θ T θ wcap Dwat θ as θ ws	Henry's law constant (cm3-water)/(cm3-air) Effective diffusion coefficient between ground water and soil surface (cm2/s) Thickness of capillary fringe (cm) Thickness of vadose zone (cm) Effective diffusion coefficient through capillary fringe (cm2/s) Effective diffusion coefficient in soil based on vapor-phase concentration (cm2/s) Diffusion coefficient in air (cm2/s) Volumetric air content in capillary fringe soils (cm3-air/cm3 total volume) Total soil porosity (cm3/cm3-soil) Volumetric water content in capillary fringe soils (cm3-water/cm3-soil) Diffusion coefficient in water (cm2/s) Volumetric air content in vadose zone soils (cm3-air/cm3-soil) Volumetric water content in vadose zone soils (cm3-water/cm3-soil)
		Chemical-specific Calculated (Eq. 3) 5 147 Calculated (Eq. 4) Calculated (Eq. 5) Chemical-specific 0.038 0.38 0.342 Chemical-specific 0.26 0.12

3) Effective Diffusion Coefficient Between Ground Water and Soil Surface

$$D_{ws}^{eff} = (h_{cap} + h_v) \left[\frac{h_{cap}}{D_{cap}^{eff}} + \frac{h_v}{D_s^{eff}} \right]^{-1}$$

$$D_{cap}^{eff} = D_{air} \frac{\theta_{acap}^{3.33}}{\theta_T^2} + D_{wat} \frac{1 - \theta_{wcap}^{3.33}}{H \theta_T^2}$$

5) Effective Diffusion Coefficient in Soil Based on Vapor-Phase Concentration

$$D_s^{eff} = D_{air} \frac{\theta_{as}^{3.33}}{\theta_T^2} + D_{wat} \frac{1 - \theta_{ws}^{3.33}}{H \theta_T^2}$$

Compound	H	Dair (cm ² /s)	Dwat (cm ² /s)	Deffs (cm ² /s)	Deffcap (cm ² /s)	Deffws (cm ² /s)	VFWamb
1,1,1-Trichloroethane	7.05E-01	7.80E-02	8.80E-06	6.09E-03	1.25E-05	3.59E-04	4.32E-05
1,1,2-Trichloroethane	3.74E-02	7.80E-02	8.80E-06	6.09E-03	5.58E-05	1.34E-03	5.34E-06
1,1-Dichloroethane	2.30E-01	7.42E-02	1.05E-05	5.79E-03	1.85E-05	5.14E-04	1.82E-05
1,1-Dichloroethene	1.07E+00	9.00E-02	1.04E-05	7.02E-03	1.35E-05	3.90E-04	7.21E-05
1,2-Dichloroethane	4.01E-02	1.04E-01	9.90E-06	8.12E-03	6.14E-05	1.53E-03	7.06E-06
1,2-Dichloroethene, cis-	1.67E-01	7.36E-02	1.13E-05	5.74E-03	2.27E-05	6.19E-04	1.49E-05
1,2-Dichloroethene, trans-	3.85E-01	7.07E-02	1.19E-05	5.52E-03	1.51E-05	4.27E-04	2.62E-05
1,2-Dichloropropane	1.15E-01	7.82E-02	8.73E-06	6.10E-03	2.49E-05	6.76E-04	
Benzene	2.28E-01	8.80E-02	9.80E-06	6.87E-03	1.97E-05	5.54E-04	1.99E-05
Carbon tetrachloride	1.25E+00	7.80E-02	8.80E-06	6.09E-03	1.14E-05	3.30E-04	7.17E-05
Chloroform	1.50E-01	1.04E-01	1.00E-05	8.12E-03	2.64E-05	7.34E-04	1.68E-05
Methylene chloride	8.98E-02	1.01E-01	1.17E-05	7.88E-03	3.84E-05	1.02E-03	1.24E-05
Tetrachloroethene	7.54E-01	7.20E-02	8.20E-06	5.62E-03	1.14E-05	3.28E-04	4.23E-05
Trichloroethene	4.22E-01	7.90E-02	9.10E-06	6.16E-03	1.44E-05	4.11E-04	2.87E-05
Vinyl chloride	1.11E+00	1.06E-01	1.23E-05	8.27E-03	1.58E-05	4.57E-04	8.78E-05

^{d/} Refer to the Model Unit Definition table for all associated unit definitions.

APPENDIX A: GROUNDWATER RISK CALCULATIONS
CALCULATION OF DOSE ABSORBED PER UNIT AREA PER EVENT (DAevent)
INTRUSIVE WORKER -- RME SCENARIO

LAWRENCE BERKELEY NATIONAL LABORATORY HHRA

Equations	Input Parameter Definition	Input Parameters
<p><i>Organics:</i></p> <p>If $t_{event} < t^*$, then:</p> $DA_{event} = 2K_p C_w \sqrt{\frac{6\tau_{event} t_{event}}{\pi}}$ <p>If $t_{event} > t^*$, then:</p> $DA_{event} = K_p C_w \left[\frac{t_{event}}{1+B} + 2\tau_{event} \left(\frac{1+3B+3B^2}{(1+B)^2} \right) \right]$	<p>t_{event} Duration of event (hr/event) ^w</p> <p>t^* Time it takes to reach steady state (hr/event)</p> <p>DA_{event} Dose absorbed per unit area per event (mg/cm²-event) ^{lv}</p> <p>K_p Permeability coefficient from water (cm/hr) ^{lv}</p> <p>C_w Concentration of chemical in water (mg/cm³) ^{lv}</p> <p>τ_{event} Lag time per event (hr/event)</p> <p>B Relative contribution of permeability coefficients in stratum corneum and viable epidermis (unitless)</p> <p>pi Target Cancer Risk (user defined)</p>	<p>0.25</p> <p>Chemical-specific</p> <p>Calculated</p> <p>Chemical-specific</p> <p>Measured</p> <p>Chemical-specific</p> <p>Chemical-specific</p> <p>3.141592654</p> <p>1.00E-06</p>

Inorganics:

$$DA_{event} = K_p C_w t_{event}$$

Preliminary COPC ^{lv}	Type ^{lv}	t*	Kp	cancer Cw (µg/L) ^{lv}	cancer Cw (mg/cm ³) ^{lv}	non-cancer Cw (µg/L) ^{lv}	non-cancer Cw (mg/cm ³) ^{lv}	τ_{event}	B	cancer DAevent (organics)	non-cancer DAevent (organics)	DAevent (inorganics)	DAevent (all)
1,1,1-Trichloroethane	o	1.43E+00	1.30E-02	--	--	2,596,355.04	2.60E+00	6.00E-01	1.00E-01	--	3.61E-02		
1,1,2-Trichloroethane	o	1.43E+00	6.40E-03	14,833	1.48E-02	61,025.93	6.10E-02	6.00E-01	1.12E-02	1.02E-04	4.18E-04		
1,1-Dichloroethane	o	9.20E-01	6.70E-03	277,640	2.78E-01	2,260,780.63	2.26E+00	3.80E-01	6.17E-03	1.58E-03	1.29E-02		
1,1-Dichloroethene	o	8.90E-01	1.20E-02	--	--	639,606.58	6.40E-01	3.70E-01	1.35E-02	--	6.45E-03		
1,2-Dichloroethane	o	9.20E-01	4.20E-03	53,714	5.37E-02	1,081,945.02	1.08E+00	3.80E-01	3.02E-03	1.92E-04	3.87E-03		
1,2-Dichloroethene, cis-	o	8.90E-01	7.70E-03	--	--	199,357.89	1.99E-01	3.70E-01	7.24E-03	--	1.29E-03		5.93E-07
1,2-Dichloroethene, trans-	o	8.20E-01	1.00E-02	--	--	320,269.49	3.20E-01	3.40E-01	7.20E-03	--	2.58E-03		
1,2-Dichloropropane	o	1.00E+00	1.00E-02	27,688	2.77E-02	--	--	4.30E-01	1.00E-02	2.51E-04	--		
Benzene	o	7.00E-01	1.50E-02	8,092	8.09E-03	46,237.54	4.62E-02	2.90E-01	1.00E-01	9.03E-05	5.16E-04		1.34E-08
Carbon tetrachloride	o	1.86E+00	1.60E-02	3,084	3.08E-03	4,625.47	4.63E-03	7.80E-01	1.00E-01	6.02E-05	9.03E-05		
Chloroform	o	1.19E+00	6.80E-03	8,770	8.77E-03	38,838.38	3.88E-02	5.00E-01	9.33E-03	5.83E-05	2.58E-04		
Methylene chloride	o	7.60E-01	3.50E-03	235,804	2.36E-01	2,829,653.40	2.83E+00	3.20E-01	1.78E-03	6.45E-04	7.74E-03		
Tetrachloroethene	o	2.18E+00	3.30E-02	384	3.84E-04	29,661.31	2.97E-02	9.10E-01	2.00E-01	1.67E-05	1.29E-03		
Trichloroethene	o	1.39E+00	1.20E-02	55,015	5.50E-02	3,065.15	3.07E-03	5.80E-01	1.00E-01	6.95E-04	3.87E-05		
Vinyl chloride	o	5.10E-01	7.30E-03	7,236	7.24E-03	83,736.30	8.37E-02	2.10E-01	2.30E-03	3.35E-05	3.87E-04		1.38E-07

^w hr/event = hours per event

^{lv} mg/cm²-event = milligrams per centimeter-event

^{lv} cm/hr = centimeters per hour

^{lv} mg/cm³ = milligrams per cubic centimeter

^{lv} Preliminary COPC = preliminary chemical of potential concern.

^{lv} "o" indicates an organic compound, "i" indicates an inorganic compound

^{lv} Cw is the maximum detected contaminant concentration; mg/L = micrograms per liter

^{lv} mg/cm³ = milligrams per cubic centimeter

APPENDIX A: GROUNDWATER RISK CALCULATIONS
INTRUSIVE WORKER -- RME SCENARIO
CARCINOGENIC AND NONCARCINOGENIC RISK ESTIMATES -- DERMAL CONTACT WITH GROUNDWATER

LAWRENCE BERKELEY NATIONAL LABORATORY HHRA

Exposure Assumptions	Intrusive Worker: RME Scenario	Risk and Hazard Equations
Receptor	Intrusive Worker: RME Scenario	Carcinogenic:
COPC Absorbed Dose per Event (DAevent)	chemical-specific mg/cm ² -event	$Risk = \frac{(DA_{event})(EV)(EF)(EC)(ED)(SA)(SF_d)}{(BW)(AT_c)(365days/year)}$
Event Frequency (EV)	1 events/day	
Exposure Frequency (EF)	60 days/yr	
Fraction of EF in Contact with Ground Water (EC)	1.0 unitless	
Exposure Duration (ED)	1 yrs	
Exposed Body Surface Area (SA)	3300 cm ²	
Averaging Time, Carcinogens (ATC)	70 yrs	Noncarcinogenic:
Averaging Time, Noncarcinogens (ATN)	1 yrs	$HQ = \frac{(DA_{event})(EV)(EF)(EC)(ED)(SA)}{(RfD_d)(BW)(AT_{nc})(365days/year)}$
Oral Slope Factor Adjusted for GI Absorption (SFd)	chemical-specific (mg/kg-day) ⁻¹	
Body Weight (BW)	70 kg	
Oral Reference Dose Adjusted for GI Absorption (RfDd) where: RfDd = RfDoral*OAF	chemical-specific µg/m ³	
Gastrointestinal (oral) Absorption Fraction (OAF)	chemical-specific unitless	

Preliminary COPC ^w	CAS Number ^{bx}	Cancer DAevent (mg/cm ² -event) ^w	Non-cancer DAevent (mg/cm ² -event) ^w	SFd (mg/kg-day) ⁻¹ ^w	RfDd (mg/kg-day)	Cancer Risk	Hazard Quotient
1,1,1-Trichloroethane	71-55-6	--	3.61E-02	--	2.80E-01	1.00E-06	1.00E+00
1,1,2-Trichloroethane	79-00-5	1.02E-04	4.18E-04	8.89E-02	3.24E-03	1.00E-06	1.00E+00
1,1-Dichloroethane	75-34-3	1.58E-03	1.29E-02	5.70E-03	1.00E-01	1.00E-06	1.00E+00
1,1-Dichloroethene	75-35-4	--	6.45E-03	--	5.00E-02	1.00E-06	1.00E+00
1,2-Dichloroethane	107-06-2	1.92E-04	3.87E-03	4.70E-02	3.00E-02	1.00E-06	1.00E+00
1,2-Dichloroethene, cis-	156-59-2	--	1.29E-03	--	1.00E-02	1.00E-06	1.00E+00
1,2-Dichloroethene, trans-	156-60-5	--	2.58E-03	--	2.00E-02	1.00E-06	1.00E+00
1,2-Dichloropropane	78-87-5	2.51E-04	--	3.60E-02	--	1.00E-06	1.00E+00
Benzene	71-43-2	9.03E-05	5.16E-04	1.00E-01	4.00E-03	1.00E-06	1.00E+00
Carbon tetrachloride	56-23-5	6.02E-05	9.03E-05	1.50E-01	7.00E-04	1.00E-06	1.00E+00
Chloroform	67-66-3	5.83E-05	2.58E-04	1.55E-01	2.00E-03	1.00E-06	1.00E+00
Chloromethane	74-87-3	5.56E-04	--	1.63E-02	--	1.00E-06	1.00E+00
Methylene chloride	75-09-2	6.45E-04	7.74E-03	1.40E-02	6.00E-02	1.00E-06	1.00E+00
Tetrachloroethene	127-18-4	1.67E-05	1.29E-03	5.40E-01	1.00E-02	1.00E-06	1.00E+00
Trichloroethene	79-01-6	6.95E-04	3.87E-05	1.30E-02	3.00E-04	1.00E-06	1.00E+00
Vinyl chloride	75-1-4	3.35E-05	3.87E-04	2.70E-01	3.00E-03	1.00E-06	1.00E+00

^w Preliminary COPC = preliminary chemical of potential concern.

^{bx} CAS = Chemical Abstracts Service number.

^w mg/cm²-event = milligram per square centimeter per event.

^w mg/kg-day = milligram per kilogram per day.

"--" = Data unavailable.

APPENDIX A: SOIL RISK CALCULATIONS
MODELING VOLATILIZATION FROM SOILS (0 - 20 FT BGS) INTO INDOOR AIR (ASTM MODEL)

Equations	Input Parameter Definition ^{4/}	Residential Input Parameters
<p>1i) Enclosed Space (Indoor) Air Concentration Due to Volatilization from Subsurface Soil</p> $C_{air-indoor} = C_s VF_{seep} 10^3$	<p>P_s Soil bulk density (g-soil/cm³-soil)</p> <p>$C_{air-indoor}$ Modeled COPC indoor air concentration (µg/m³)</p> <p>C_s Soil COPC concentration (mg/kg)</p> <p>VF_{seep} Cross-media subsurface soil-to-enclosed (indoor) space volatilization factor (mg/m³-air)/(mg/kg-soil)</p>	<p>1.7</p> <p>Calculated (Eq. 1i)</p> <p>Measured</p> <p>Calculated (Eq. 2i)</p>
<p>2i) Cross-Media Subsurface Soil-to-Enclosed (Indoor) Space Air Volatilization Factor</p> $VF_{seep} = \frac{\left[\frac{HP_s}{\theta_{ws} + k_s P_s + H\theta_{as}} \right] \left[\frac{D_s^{eff}/L_s}{ER L_B} \right]}{1 + \left[\frac{D_s^{eff}/L_s}{ER L_B} \right] + \left[\frac{D_s^{eff}/L_s}{(D_{crack}^{eff}/L_{crack})\eta} \right]} \times 10^3 \frac{cm^3 - kg}{m^3 - g}$	<p>H Henry's law constant (cm³-water)/(cm³-air)</p> <p>θ_{ws} Volumetric</p> <p>θ_{as} Volumetric air content in vadose zone soils (cm³-air/cm³-soil)</p> <p>L_s Depth to subsurface soil source (cm)</p> <p>ER Enclosed-space air exchange rate (1/sec)</p> <p>L_B Enclosed-space volume/infiltration area ratio (cm)</p> <p>D_{crack}^{eff} Effective diffusion coefficient through foundation cracks (cm²/s)</p>	<p>Chemical-specific</p> <p>0.12</p> <p>0.26</p> <p>152.4</p> <p>0.00023</p> <p>300</p> <p>Calculated (Eq. 3i)</p>
<p>3i) Effective Diffusion Through Foundation Cracks</p> $D_{crack}^{eff} = D^{air} \frac{\theta_{crack}^{3.33}}{\theta_T^2} + D^{wat} \frac{1}{H} \frac{\theta_{wcrack}^{3.33}}{\theta_T^2}$	<p>L_{crack} Enclosed-space foundation or wall thickness (cm)</p> <p>η Areal fraction of cracks in foundations/walls (cm²-cracks/cm²-total area)</p> <p>D^{air} Diffusion coefficient in air (cm²/s)</p> <p>θ_{crack} Volumetric air content in foundation/wall cracks (cm³-air/cm³ total volume)</p> <p>θ_T Total soil porosity (cm³/cm³-soil)</p> <p>θ_{wcrack} Volumetric water content in foundation/wall cracks (cm³-water/cm³ total volume)</p> <p>D^{wat} Diffusion coefficient in water (cm²/s)</p> <p>K_{oc} Soil-water partition coefficient</p> <p>F_{oc} fraction of organic carbon</p>	<p>15</p> <p>0.002</p> <p>Chemical-specific</p> <p>0.26</p> <p>0.38</p> <p>0.12</p> <p>Chemical-specific</p> <p>$K_s = K_{oc} X f_{oc}$</p> <p>Chemical-specific</p> <p>0.01</p>
	<p>Target Cancer Risk</p>	<p>1.00E-06</p>

Compound	Koc (cm ³ water-g-carbon)	Ks (cm ³ -water/cm ³ -soil)	Calculated Target Cancer Risk Cs (mg/kg)	Calculated Target Non-Cancer Risk Cs (mg/kg)	H	D ^{air} (cm ² /s)	D ^{wat} (cm ² /s)	D ^{crack} (cm ² /s)	D ^{air} (cm ² /s)	VF _{seep}	Cair-indoor (µg/m ³) Target Cancer Risk	Cair-indoor (µg/m ³) for Target Non-Cancer Risk
1,1,1-Trichloroethane	1.10E+02	1.10E+00	--	690.17	7.05E-01	7.80E-02	8.80E-06	6.09E-03	6.09E-03	6.35E-03	--	4.38E+03
1,1-Dichloroethane	3.13E+01	3.13E-01	1.27	364.20	2.30E-01	7.42E-02	1.05E-05	5.79E-03	5.79E-03	6.03E-03	7.67E+00	2.19E+03
1,1-Dichloroethene	5.82E+01	5.82E-01	--	7.92	1.07E+00	9.00E-02	1.04E-05	7.02E-03	7.02E-03	1.74E-02	--	1.38E+02
1,2-Dichloroethane	1.68E+01	1.68E-01	0.23	8.54	4.01E-02	1.04E-01	9.90E-06	8.12E-03	8.12E-03	2.52E-03	5.85E-01	2.15E+01
1,2-Dichloroethene, cis-	3.55E+01	3.55E-01	--	38.15	1.67E-01	7.36E-02	1.13E-05	5.74E-03	5.74E-03	4.02E-03	--	1.53E+02
1,2-Dichloroethene, trans-	5.21E+01	5.21E-01	--	49.65	3.85E-01	7.07E-02	1.19E-05	5.52E-03	5.52E-03	6.18E-03	--	3.07E+02
Benzene	5.82E+01	5.82E-01	0.10	6.04	2.28E-01	8.80E-02	9.80E-06	6.87E-03	6.87E-03	4.32E-03	4.23E-01	2.61E+01
Carbon tetrachloride	2.08E+02	2.08E+00	0.05	1.75	1.25E+00	7.80E-02	8.80E-06	6.09E-03	6.09E-03	6.14E-03	2.92E-01	1.07E+01
Chloroform	3.97E+01	3.97E-01	0.49	0.28	1.50E-01	1.04E-01	1.00E-05	8.12E-03	8.12E-03	4.70E-03	2.32E+00	1.32E+00
Methylene Chloride	1.17E+01	1.17E-01	1.84	1,974.09	8.98E-02	1.01E-01	1.17E-05	7.88E-03	7.88E-03	6.66E-03	1.23E+01	1.32E+04
Tetrachloroethene	1.56E+02	1.56E+00	0.45	379.96	7.54E-01	7.20E-02	8.20E-06	5.62E-03	5.62E-03	4.60E-03	2.08E+00	1.75E+03
Trichloroethene	1.67E+02	1.67E+00	2.25	966.19	4.22E-01	7.90E-02	9.10E-06	6.16E-03	6.16E-03	2.72E-03	6.14E+00	2.63E+03
Vinyl chloride	1.43E+01	1.43E-01	0.00	9.66	1.11E+00	1.06E-01	1.23E-06	8.27E-03	8.27E-03	4.54E-02	1.57E-01	4.38E+02

^{4/} Refer to the Model Unit Definition table for all associated unit definitions.

APPENDIX A: SOIL RISK CALCULATIONS

INDOOR WORKER -- RME SCENARIO

CARCINOGENIC AND NONCARCINOGENIC RISK ESTIMATES - INHALATION OF VOLATILE COPCS IN INDOOR AIR FROM SOILS (0-20 FT BGS)

LAWRENCE BERKELEY NATIONAL LABORATORY, CALIFORNIA

Exposure Assumptions		Risk and Hazard Equations
Receptor	Indoor Office Worker: RME Scenario	Carcinogenic:
COPC Ambient Air Concentration ($C_{air-indoor}$)	chemical-specific $\mu\text{g}/\text{m}^3$	$Risk = \frac{(C_{air-indoor})(EF)(ED)(ET)(URF)}{(AT_c)(365days/year)}$
Exposure Frequency (EF)	250 days/yr	
Exposure Duration (ED)	25 yrs	Noncarcinogenic:
Fraction of EF breathing air at the site (ET)	0.333 unitless	
Averging Time, Carcinogens (AT_c)	70 yrs	$HQ = \frac{(C_{air-indoor})(EF)(ED)(ET)}{(RfC)(AT_{nc})(365days/year)}$
Averging Time, Noncarcinogens (AT_{nc})	25 yrs	
Inhalation Unit Risk Factor (URF)	chemical-specific $(\mu\text{g}/\text{m}^3)^{-1}$	
Inhalation Reference Concentration (RfC)	chemical-specific $\mu\text{g}/\text{m}^3$	

Preliminary COPC ^{a/}	CAS Number ^{b/}	Indoor Air Concentration for Target Cancer Risk ($\mu\text{g}/\text{m}^3$) ^{d/}	Indoor Air Concentration for Target Non-Cancer Risk ($\mu\text{g}/\text{m}^3$) ^{d/}	URF ($\mu\text{g}/\text{m}^3$) ⁻¹	RfC ($\mu\text{g}/\text{m}^3$)	Cancer Risk	Hazard Quotient
1,1,1-Trichloroethane	71-55-6	--	4.38E+03	--	1.00E+03	1.00E-06	1.00
1,1-Dichloroethane	75-34-3	7.67E+00	2.19E+03	1.60E-06	5.01E+02	1.00E-06	1.00
1,1-Dichloroethene	75-35-4	--	1.38E+02	--	3.15E+01	1.00E-06	1.00
1,2-Dichloroethane	107-06-2	5.85E-01	2.15E+01	2.10E-05	4.90E+00	1.00E-06	1.00
1,2-Dichloroethene, cis-	156-59-2	--	1.53E+02	--	3.50E+01	1.00E-06	1.00
1,2-Dichloroethene, trans-	156-60-5	--	3.07E+02	--	7.00E+01	1.00E-06	1.00
Benzene	71-43-2	4.23E-01	2.61E+01	2.90E-05	5.95E+00	1.00E-06	1.00
Carbon tetrachloride	56-23-5	2.92E-01	1.07E+01	4.20E-05	2.45E+00	1.00E-06	1.00
Chloroform	67-66-3	2.32E+00	1.32E+00	5.30E-06	3.01E-01	1.00E-06	1.00
Methylene Chloride	75-09-2	1.23E+01	1.32E+04	1.00E-06	3.00E+03	1.00E-06	1.00
Tetrachloroethene	127-18-4	2.08E+00	1.75E+03	5.90E-06	3.99E+02	1.00E-06	1.00
Trichloroethene	79-01-6	6.14E+00	2.63E+03	2.00E-06	6.00E+02	1.00E-06	1.00
Vinyl chloride	75-1-4	1.57E-01	4.38E+02	7.80E-05	1.00E+02	1.00E-06	1.00

^{a/} Preliminary COPC = preliminary chemical of potential concern.

^{b/} CAS = Chemical Abstracts Service number.

^{c/} Modeled indoor air concentrations (ASTM vapor intrusion model) were based on the exposure-point concentration of each COPC detected at the evaluated area.

^{d/} $\mu\text{g}/\text{m}^3$ = micrograms per cubic meter.

-- = data not available.

Appendix A-2: Media Cleanup Standards Calculations for
Theoretical ILCR = 10^{-4} and HI = 1

APPENDIX A: GROUNDWATER AND SOIL MEDIA CLEANUP STANDARD CALCULATION SUMMARY
LAWRENCE BERKELEY NATIONAL LABORATORY HHRA

Input Parameters for all MCS Calculations	
Cancer Risk	1.00E-04
Hazard Quotient	1
η*	0.002
Depth to Groundwater (feet)	5
Depth to Soil Source (feet)	5

Risk Estimates

Groundwater COPCs	Groundwater				Soil COPCs	Soil	
	Indoor Workers		Intrusive Workers			Indoor Workers	
Compound	Calculated Target Cancer Risk Cw (μg/L)	Calculated Target Non-Cancer Risk Cw (μg/L)	cancer Cw (μg/L) ^{g/}	Non-cancer Cw (μg/L) ^{g/}		Calculated Target Cancer Risk Cs (mg/kg)	Calculated Target Non-Cancer Risk Cs (mg/kg)
Organic Compounds							
1,1,1-Trichloroethane	--	1,570,783	--	2,596,355	1,1,1-Trichloroethane	--	690
1,1,2-Trichloroethane	190,489	--	1,483,269	61,026			
1,1-Dichloroethane	366,345	1,025,767	27,763,973	2,260,781	1,1-Dichloroethane	127.3	364
1,1-Dichloroethene	--	28,873	--	639,607	1,1-Dichloroethene	--	7.9
1,2-Dichloroethane	102,956	3,088,688	5,371,358	1,081,945	1,2-Dichloroethane	23.24	8.5
1,2-Dichloroethene, cis-	--	98,405	--	199,358	1,2-Dichloroethene, cis-	--	38.1
1,2-Dichloroethene, trans-	--	94,405	--	320,269	1,2-Dichloroethene, trans-	--	49.6
1,2-Dichloropropane	107,116	15,302	2,768,767	--			
Benzene	17,514	108,838	809,157	46,238	Benzene	9.81	6.0
Carbon tetrachloride	2,732	1,004	308,365	4,625	Carbon tetrachloride	4.76	1.7
Chloroform	120,582	684,732	876,996	38,838	Chloroform	49.23	0.28
Methylene chloride	1,038,071	1,482,958	23,580,445	2,829,653	Methylene Chloride	184.2	1974
Tetrachloroethene	34,258	25,265	38,450	29,661	Tetrachloroethene	45.19	380
Trichloroethene	159,356	682,956	5,501,542	3,065	Trichloroethene	225.4	966
Vinyl chloride	1,213	33,798	723,647	83,736	Vinyl chloride	0.3468	9.7

*Areal fraction of cracks in foundations/walls (cm²-cracks/cm²-total area)

^{g/} Refer to the Model Unit Definition table for all associated unit definitions.

Risk-Based MCS

APPENDIX A: GROUND WATER RISK CALCULATIONS
MODELING VOLATILIZATION FROM GROUNDWATER INTO INDUSTRIAL/COMMERCIAL INDOOR AIR (ASTM MODEL)

LAWRENCE BERKELEY NATIONAL LABORATORY CMS

Equations	Input Parameter Definition ^{u/}		Commercial Input Parameters
1i) Enclosed Space (Indoor) Air Concentration Due to Volatilization from Ground Water Cair-indoor = CwVFwesp	Cair-indoor	Modeled COPC indoor air concentration (µg/m3)	Calculated (Eq. 1i)
	Cw	Groundwater COPC concentration (µg/L)	Measured
2i) Cross-Media Groundwater-to-Enclosed (Indoor) Space Air Volatilization Factor	VFwesp	Cross-media groundwater-to-enclosed (indoor) space volatilization factor(mg/m3-air)/(mg/L-water)	Calculated (Eq. 2i)
	H	Henry's law constant (cm3-water)/(cm3-air)	Chemical-specific
	Deffws	Effective diffusion coefficient between ground water and soil surface (cm2/s)	Calculated (Eq. 3 on Page: Cair-gw outdoor)
	LGW	Depth to ground water = hcap + hv (cm)	152
	ER	Enclosed-space air exchange rate (1/sec)	0.00023
	LB	Enclosed-space volume/infiltration area ratio (cm)	300
	Deffcrack	Effective diffusion coefficient through foundation cracks (cm2/s)	Calculated (Eq. 3i)
	Lcrack	Enclosed-space foundation or wall thickness (cm)	15
	η	Areal fraction of cracks in foundations/walls (cm2-cracks/cm2-total area)	0.002
	Dair	Diffusion coefficient in air (cm2/s)	Chemical-specific
	θ acrack	Volumetric air content in foundation/wall cracks (cm3-air/cm3 total volume)	0.26
	θ T	Total soil porosity (cm3/cm3-soil)	0.38
	θ wcrack	Volumetric water content in foundation/wall cracks (cm3-water/cm3 total volume)	0.12
	Dwat	Diffusion coefficient in water (cm2/s)	Chemical-specific
		Target Cancer Risk (user defined)	1.00E-04

$$VF_{wesp} = \frac{H \left[\frac{D_{ws}^{eff}}{ER L_B} \right]}{1 + \left[\frac{D_{ws}^{eff}}{ER L_B} \right] + \left[\frac{D_{crack}^{eff}}{L_{crack} \eta} \right]} \times 10^3 \frac{L}{m^3}$$

3i) Effective Diffusion Through Foundation Cracks

$$D_{crack}^{eff} = D^{air} \frac{\theta_{acrack}^{3.33}}{\theta_T^2} + D^{wat} \frac{1}{H} \frac{\theta_{wcrack}^{3.33}}{\theta_T^2}$$

Compound	Calculated	Calculated Cw	H	Dair	Dwat	Deffcrack	Deffws	VFwesp	Target Cancer Risk	Target Non-Cancer Risk
	Cw based on Target Cancer Risk (µg/L)	based on Target Non-Cancer Risk (µg/L)								
Organic Compounds										
1,1,1-Trichloroethane	--	1,570,783	7.05E-01	7.80E-02	8.80E-06	6.09E-03	3.59E-04	6.17E-03	--	9.69E+03
1,1,2-Trichloroethane	190,489	--	3.74E-02	7.80E-02	8.80E-06	6.09E-03	1.34E-03	4.03E-04	7.67E+01	--
1,1-Dichloroethane	366,345	1,025,767	2.30E-01	7.42E-02	1.05E-05	5.79E-03	5.14E-04	2.09E-03	7.67E+02	2.15E+03
1,1-Dichloroethene	--	28,873	1.07E+00	9.00E-02	1.04E-05	7.02E-03	3.90E-04	1.06E-02	--	3.07E+02
1,2-Dichloroethane	102,956	3,088,688	4.01E-02	1.04E-01	9.90E-06	8.12E-03	1.53E-03	5.68E-04	5.85E+01	1.75E+03
1,2-Dichloroethene, cis-	--	98,405	1.67E-01	7.36E-02	1.13E-05	5.74E-03	6.19E-04	1.56E-03	--	1.53E+02
1,2-Dichloroethene, trans-	--	94,405	3.85E-01	7.07E-02	1.19E-05	5.52E-03	4.27E-04	3.25E-03	--	3.07E+02
1,2-Dichloropropane	107,116	15,302	1.15E-01	7.82E-02	8.73E-06	6.10E-03	6.76E-04	1.15E-03	1.23E+02	1.75E+01
Benzene	17,514	108,838	2.28E-01	8.80E-02	9.80E-06	6.87E-03	5.54E-04	2.42E-03	4.23E+01	2.63E+02
Carbon tetrachloride	2,732	1,004	1.25E+00	7.80E-02	8.80E-06	6.09E-03	3.30E-04	1.07E-02	2.92E+01	1.07E+01
Chloroform	120,582	684,732	1.50E-01	1.04E-01	1.00E-05	8.12E-03	7.34E-04	1.92E-03	2.32E+02	1.32E+03
Methylene chloride	1,038,071	1,482,958	8.98E-02	1.01E-01	1.17E-05	7.88E-03	1.02E-03	1.18E-03	1.23E+03	1.75E+03
Tetrachloroethene	34,258	25,265	7.54E-01	7.20E-02	8.20E-06	5.62E-03	3.28E-04	6.07E-03	2.08E+02	1.53E+02
Trichloroethene	159,356	682,956	4.22E-01	7.90E-02	9.10E-06	6.16E-03	4.11E-04	3.85E-03	6.14E+02	2.63E+03
Vinyl chloride	1,213	33,798	1.11E+00	1.06E-01	1.23E-05	8.27E-03	4.57E-04	1.30E-02	1.57E+01	4.38E+02

^{u/} Refer to the Model Unit Definition table for all associated unit definitions.

APPENDIX A: GROUNDWATER RISK CALCULATIONS

INDOOR WORKER -- RME SCENARIO

CARCINOGENIC AND NONCARCINOGENIC RISK ESTIMATES - INHALATION OF VOLATILE COPCS IN INDOOR AIR FROM GROUNDWATER

LAWRENCE BERKELEY NATIONAL LABORATORY CMS

Exposure Assumptions			Risk and Hazard Equations
Receptor	Indoor Office Worker: RME Scenario		Carcinogenic:
COPC Ambient Air Concentration (C _{air-indoor})	chemical-specific	µg/m ³	$Risk = \frac{(C_{air-indoor})(EF)(ED)(ET)(URF)}{(AT_c)(365days/year)}$
Exposure Frequency (EF)	250	days/yr	
Exposure Duration (ED)	25	yrs	Noncarcinogenic:
Fraction of EF breathing air at the site (ET)	0.333	unitless	
Averaging Time, Carcinogens (AT _c)	70	yrs	$HQ = \frac{(C_{air-indoor})(EF)(ED)(ET)}{(RfC)(AT_{nc})(365days/year)}$
Averaging Time, Noncarcinogens (AT _{nc})	25	yrs	
Inhalation Unit Risk Factor (URF)	chemical-specific	(µg/m ³) ⁻¹	
Inhalation Reference Concentration (RfC)	chemical-specific	µg/m ³	

COPC ^{a/}	CAS Number ^{b/}	Indoor Air Concentration for Target Cancer Risk (µg/m ³) ^{d/}	Indoor Air Concentration for Target Non-Cancer Risk (µg/m ³) ^{d/}	URF (µg/m ³) ⁻¹	HHRA URF (if different)	RfC (µg/m ³)	Cancer Risk	Hazard Quotient
Organic Compounds								
1,1,1-Trichloroethane	71-55-6	--	9.69E+03	--		2.21E+03	1.00E-04	1.0
1,1,2-Trichloroethane	79-00-5	7.67E+01	--	1.60E-05		--	1.00E-04	1.0
1,1-Dichloroethane	75-34-3	7.67E+02	2.15E+03	1.60E-06		4.90E+02	1.00E-04	1.0
1,1-Dichloroethene	75-35-4	--	3.07E+02	--	5.00E-05	7.00E+01	1.00E-04	1.0
1,2-Dichloroethane	107-06-2	5.85E+01	1.75E+03	2.10E-05		4.00E+02	1.00E-04	1.0
1,2-Dichloroethene, cis-	156-59-2	--	1.53E+02	--		3.50E+01	1.00E-04	1.0
1,2-Dichloroethene, trans-	156-60-5	--	3.07E+02	--		7.00E+01	1.00E-04	1.0
1,2-Dichloropropane	78-87-5	1.23E+02	1.75E+01	1.00E-05		4.00E+00	1.00E-04	1.0
Benzene	71-43-2	4.23E+01	2.63E+02	2.90E-05		6.00E+01	1.00E-04	1.0
Carbon tetrachloride	56-23-5	2.92E+01	1.07E+01	4.20E-05		2.45E+00	1.00E-04	1.0
Chloroform	67-66-3	2.32E+02	1.32E+03	5.30E-06		3.00E+02	1.00E-04	1.0
Methylene chloride	75-09-2	1.23E+03	1.75E+03	1.00E-06		4.00E+02	1.00E-04	1.0
Tetrachloroethene	127-18-4	2.08E+02	1.53E+02	5.90E-06	5.80E-07	3.50E+01	1.00E-04	1.0
Trichloroethene	79-01-6	6.14E+02	2.63E+03	2.00E-06	1.70E-06	6.00E+02	1.00E-04	1.0
Vinyl chloride	75-1-4	1.57E+01	4.38E+02	7.80E-05		1.00E+02	1.00E-04	1.0

^{a/} COPC = chemical of potential concern.

^{b/} CAS = Chemical Abstracts Service number.

^{c/} Modeled indoor air concentrations are based on the COPC-specific cancer risk and hazard quotient

^{d/} µg/m³ = micrograms per cubic meter.

-- = data not available.

APPENDIX A: GROUND WATER RISK CALCULATIONS
MODELING VOLATILIZATION FROM GROUNDWATER TO SOIL SURFACE (ASTM MODEL)
LAWRENCE BERKELEY NATIONAL LABORATORY CMS

	Input Parameter Definition ^{a/}	Input Parameters
3) <i>Effective Diffusion Coefficient Between Ground Water and Soil Surface</i>	H Deffws hcap hv Deffcap Deffs Dair θ acap θ T θ wcap Dwat θ as θ ws	Henry's law constant (cm3-water)/(cm3-air) Effective diffusion coefficient between ground water and soil surface (cm2/s) Thickness of capillary fringe (cm) Thickness of vadose zone (cm) Effective diffusion coefficient through capillary fringe (cm2/s) Effective diffusion coefficient in soil based on vapor-phase concentration (cm2/s) Diffusion coefficient in air (cm2/s) Volumetric air content in capillary fringe soils (cm3-air/cm3 total volume) Total soil porosity (cm3/cm3-soil) Volumetric water content in capillary fringe soils (cm3-water/cm3-soil) Diffusion coefficient in water (cm2/s) Volumetric air content in vadose zone soils (cm3-air/cm3-soil) Volumetric water content in vadose zone soils (cm3-water/cm3-soil)
		Chemical-specific Calculated (Eq. 3) 5 147 Calculated (Eq. 4) Calculated (Eq. 5) Chemical-specific 0.038 0.38 0.342 Chemical-specific 0.26 0.12
$D_{ws}^{eff} = (h_{cap} + h_v) \left[\frac{h_{cap}}{D_{cap}^{eff}} + \frac{h_v}{D_s^{eff}} \right]^{-1}$		
$D_{cap}^{eff} = D_{air} \frac{\theta_{acap}^{333}}{\theta_T^2} + D_{wat} \frac{1}{H} \frac{\theta_{wcap}^{333}}{\theta_T^2}$		
5) <i>Effective Diffusion Coefficient in Soil Based on Vapor-Phase Concentration</i>		
$D_s^{eff} = D_{air} \frac{\theta_{as}^{333}}{\theta_T^2} + D_{wat} \frac{1}{H} \frac{\theta_{ws}^{333}}{\theta_T^2}$		

Compound	H	Dair (cm ² /s)	Dwat (cm ² /s)	Deffs (cm ² /s)	Deffcap (cm ² /s)	Deffws (cm ² /s)	VFWamb
1,1,1-Trichloroethane	7.05E-01	7.80E-02	8.80E-06	6.09E-03	1.25E-05	3.59E-04	4.32E-05
1,1,2-Trichloroethane	3.74E-02	7.80E-02	8.80E-06	6.09E-03	5.58E-05	1.34E-03	5.34E-06
1,1-Dichloroethane	2.30E-01	7.42E-02	1.05E-05	5.79E-03	1.85E-05	5.14E-04	1.82E-05
1,1-Dichloroethene	1.07E+00	9.00E-02	1.04E-05	7.02E-03	1.35E-05	3.90E-04	7.21E-05
1,2-Dichloroethane	4.01E-02	1.04E-01	9.90E-06	8.12E-03	6.14E-05	1.53E-03	7.06E-06
1,2-Dichloroethene, cis-	1.67E-01	7.36E-02	1.13E-05	5.74E-03	2.27E-05	6.19E-04	1.49E-05
1,2-Dichloroethene, trans-	3.85E-01	7.07E-02	1.19E-05	5.52E-03	1.51E-05	4.27E-04	2.62E-05
1,2-Dichloropropane	1.15E-01	7.82E-02	8.73E-06	6.10E-03	2.49E-05	6.76E-04	
Benzene	2.28E-01	8.80E-02	9.80E-06	6.87E-03	1.97E-05	5.54E-04	1.99E-05
Carbon tetrachloride	1.25E+00	7.80E-02	8.80E-06	6.09E-03	1.14E-05	3.30E-04	7.17E-05
Chloroform	1.50E-01	1.04E-01	1.00E-05	8.12E-03	2.64E-05	7.34E-04	1.68E-05
Methylene chloride	8.98E-02	1.01E-01	1.17E-05	7.88E-03	3.84E-05	1.02E-03	1.24E-05
Tetrachloroethene	7.54E-01	7.20E-02	8.20E-06	5.62E-03	1.14E-05	3.28E-04	4.23E-05
Trichloroethene	4.22E-01	7.90E-02	9.10E-06	6.16E-03	1.44E-05	4.11E-04	2.87E-05
Vinyl chloride	1.11E+00	1.06E-01	1.23E-05	8.27E-03	1.58E-05	4.57E-04	8.78E-05

^{a/} Refer to the Model Unit Definition table for all associated unit definitions.

APPENDIX A: GROUNDWATER RISK CALCULATIONS
CALCULATION OF DOSE ABSORBED PER UNIT AREA PER EVENT (DAevent)
INTRUSIVE WORKER -- RME SCENARIO

LAWRENCE BERKELEY NATIONAL LABORATORY HHRA

Equations	Input Parameter Definition	Input Parameters
Organics:	tevent	0.25
If tevent < t*, then:	t*	Chemical-specific
$DA_{event} = 2K_p C_w \sqrt{\frac{6\tau_{event} t_{event}}{\pi}}$	DAevent	Calculated
	Kp	Chemical-specific
If tevent > t*, then:	Cw	Measured
	tevent	Chemical-specific
$DA_{event} = K_p C_w \left[\frac{t_{event}}{1+B} + 2\tau_{event} \left(\frac{1+3B+3B^2}{(1+B)^2} \right) \right]$	B	Chemical-specific
	pi	3.141592654
Inorganics:	Target Cancer Risk (user defined)	1.00E-04

$$DA_{event} = K_p C_w t_{event}$$

Preliminary COPC ^d	Type ^e	t*	Kp	cancer Cw		non-cancer Cw		tevent	B	cancer DAevent (organics)	non-cancer DAevent (organics)	DAevent (inorganics)	DAevent (all)
				(µg/L) ^f	(mg/cm ³) ^h	(µg/L) ^f	(mg/cm ³) ^h						
1,1,1-Trichloroethane	o	1.43E+00	1.30E-02	--	--	2,596,355.04	2.60E+00	6.00E-01	1.00E-01	--	3.61E-02		
1,1,2-Trichloroethane	o	1.43E+00	6.40E-03	1,483,269	1.48E+00	61,025.93	6.10E-02	6.00E-01	1.12E-02	1.02E-02	4.18E-04		
1,1-Dichloroethane	o	9.20E-01	6.70E-03	27,763,973	2.78E+01	2,260,780.63	2.26E+00	3.80E-01	6.17E-03	1.58E-01	1.29E-02		
1,1-Dichloroethene	o	8.90E-01	1.20E-02	--	--	639,606.58	6.40E-01	3.70E-01	1.35E-02	--	6.45E-03		
1,2-Dichloroethane	o	9.20E-01	4.20E-03	5,371,358	5.37E+00	1,081,945.02	1.08E+00	3.80E-01	3.02E-03	1.92E-02	3.87E-03		
1,2-Dichloroethene, cis-	o	8.90E-01	7.70E-03	--	--	199,357.89	1.99E-01	3.70E-01	7.24E-03	--	1.29E-03		5.93E-07
1,2-Dichloroethene, trans-	o	8.20E-01	1.00E-02	--	--	320,269.49	3.20E-01	3.40E-01	7.20E-03	--	2.58E-03		
1,2-Dichloropropane	o	1.00E+00	1.00E-02	2,768,767	2.77E+00	--	--	4.30E-01	1.00E-02	2.51E-02	--		
Benzene	o	7.00E-01	1.50E-02	809,157	8.09E-01	46,237.54	4.62E-02	2.90E-01	1.00E-01	9.03E-03	5.16E-04		1.34E-08
Carbon tetrachloride	o	1.86E+00	1.60E-02	308,365	3.08E-01	4,625.47	4.63E-03	7.80E-01	1.00E-01	6.02E-03	9.03E-05		
Chloroform	o	1.19E+00	6.80E-03	876,996	8.77E-01	38,838.38	3.88E-02	5.00E-01	9.33E-03	5.83E-03	2.58E-04		
Methylene chloride	o	7.60E-01	3.50E-03	23,580,445	2.36E+01	2,829,653.40	2.83E+00	3.20E-01	1.78E-03	6.45E-02	7.74E-03		
Tetrachloroethene	o	2.18E+00	3.30E-02	38,450	3.84E-02	29,661.31	2.97E-02	9.10E-01	2.00E-01	1.67E-03	1.29E-03		
Trichloroethene	o	1.39E+00	1.20E-02	5,501,542	5.50E+00	3,065.15	3.07E-03	5.80E-01	1.00E-01	6.95E-02	3.87E-05		
Vinyl chloride	o	5.10E-01	7.30E-03	723,647	7.24E-01	83,736.30	8.37E-02	2.10E-01	2.30E-03	3.35E-03	3.87E-04		1.38E-07

^w hr/event = hours per event

^h mg/cm³-event = milligrams per centimeter-event

^d cm/hr = centimeters per hour

^f mg/cm³ = milligrams per cubic centimeter

^d Preliminary COPC = preliminary chemical of potential concern.

^e "o" indicates an organic compound, "i" indicates an inorganic compound

^f Cw is the maximum detected contaminant concentration; mg/L = micrograms per liter

^h mg/cm³ = milligrams per cubic centimeter

**APPENDIX A: GROUNDWATER RISK CALCULATIONS
INTRUSIVE WORKER -- RME SCENARIO
CARCINOGENIC AND NONCARCINOGENIC RISK ESTIMATES -- DERMAL CONTACT WITH GROUNDWATER**

LAWRENCE BERKELEY NATIONAL LABORATORY HHRA

Exposure Assumptions	Intrusive Worker: RME Scenario	Risk and Hazard Equations
Receptor	Intrusive Worker: RME Scenario	Carcinogenic:
COPC Absorbed Dose per Event (DAevent)	chemical-specific mg/cm ² -event	$Risk = \frac{(DA_{event})(EV)(EF)(EC)(ED)(SA)(SF_d)}{(BW)(AT_c)(365days/year)}$
Event Frequency (EV)	1 events/day	
Exposure Frequency (EF)	60 days/yr	
Fraction of EF in Contact with Ground Water (EC)	1.0 unitless	
Exposure Duration (ED)	1 yrs	
Exposed Body Surface Area (SA)	3300 cm ²	
Averaging Time, Carcinogens (ATC)	70 yrs	Noncarcinogenic:
Averaging Time, Noncarcinogens (ATN)	1 yrs	$HQ = \frac{(DA_{event})(EV)(EF)(EC)(ED)(SA)}{(RfD_d)(BW)(AT_{nc})(365days/year)}$
Oral Slope Factor Adjusted for GI Absorption (SFd)	chemical-specific (mg/kg-day) ⁻¹	
Body Weight (BW)	70 kg	
Oral Reference Dose Adjusted for GI Absorption (RfDd) where: RfDd = RfDoral*OAF	chemical-specific µg/m ³	
Gastrointestinal (oral) Absorption Fraction (OAF)	chemical-specific unitless	

Preliminary COPC ^a	CAS Number ^b	Cancer DAevent (mg/cm ² -event) ^c	Non-cancer DAevent (mg/cm ² -event) ^c	SFd (mg/kg-day) ⁻¹ ^d	RfDd (mg/kg-day)	Cancer Risk	Hazard Quotient
1,1,1-Trichloroethane	71-55-6	--	3.61E-02	--	2.80E-01	1.00E-04	1.00E+00
1,1,2-Trichloroethane	79-00-5	1.02E-02	4.18E-04	8.89E-02	3.24E-03	1.00E-04	1.00E+00
1,1-Dichloroethane	75-34-3	1.58E-01	1.29E-02	5.70E-03	1.00E-01	1.00E-04	1.00E+00
1,1-Dichloroethene	75-35-4	--	6.45E-03	--	5.00E-02	1.00E-04	1.00E+00
1,2-Dichloroethane	107-06-2	1.92E-02	3.87E-03	4.70E-02	3.00E-02	1.00E-04	1.00E+00
1,2-Dichloroethene, cis-	156-59-2	--	1.29E-03	--	1.00E-02	1.00E-04	1.00E+00
1,2-Dichloroethene, trans-	156-60-5	--	2.58E-03	--	2.00E-02	1.00E-04	1.00E+00
1,2-Dichloropropane	78-87-5	2.51E-02	--	3.60E-02	--	1.00E-04	1.00E+00
Benzene	71-43-2	9.03E-03	5.16E-04	1.00E-01	4.00E-03	1.00E-04	1.00E+00
Carbon tetrachloride	56-23-5	6.02E-03	9.03E-05	1.50E-01	7.00E-04	1.00E-04	1.00E+00
Chloroform	67-66-3	5.83E-03	2.58E-04	1.55E-01	2.00E-03	1.00E-04	1.00E+00
Chloromethane	74-87-3	5.56E-02	--	1.63E-02	--	1.00E-04	1.00E+00
Methylene chloride	75-09-2	6.45E-02	7.74E-03	1.40E-02	6.00E-02	1.00E-04	1.00E+00
Tetrachloroethene	127-18-4	1.67E-03	1.29E-03	5.40E-01	1.00E-02	1.00E-04	1.00E+00
Trichloroethene	79-01-6	6.95E-02	3.87E-05	1.30E-02	3.00E-04	1.00E-04	1.00E+00
Vinyl chloride	75-1-4	3.35E-03	3.87E-04	2.70E-01	3.00E-03	1.00E-04	1.00E+00

^a Preliminary COPC = preliminary chemical of potential concern.

^b CAS = Chemical Abstracts Service number.

^c mg/cm²-event = milligram per square centimeter per event.

^d mg/kg-day = milligram per kilogram per day.

"--" = Data unavailable.

APPENDIX A: SOIL RISK CALCULATIONS
MODELING VOLATILIZATION FROM SOILS (0 - 20 FT BGS) INTO INDOOR AIR (ASTM MODEL)

Equations	Input Parameter Definition ^{u/}	Residential Input Parameters
1i) Enclosed Space (Indoor) Air Concentration Due to Volatilization from Subsurface Soil $C_{air-indoor} = C_s VF_{seesp} \times 10^3$	P_s Soil bulk density (g-soil/cm ³ -soil) $C_{air-indoor}$ Modeled COPC indoor air concentration (µg/m ³) C_s Soil COPC concentration (mg/kg) VF_{seesp} Cross-media subsurface soil-to-enclosed (indoor) space volatilization factor (mg/m ³ -air)/(mg/kg-soil)	1.7 Calculated (Eq. 1i) Measured Calculated (Eq. 2i)
2i) Cross-Media Subsurface Soil-to-Enclosed (Indoor) Space Air Volatilization Factor	H Henry's law constant (cm ³ -water)/(cm ³ -air) θ_{ws} Volumetric θ_{as} Volumetric air content in vadose zone soils (cm ³ -air/cm ³ -soil) LS Depth to subsurface soil source (cm) ER Enclosed-space air exchange rate (1/sec) L_b Enclosed-space volume/infiltration area ratio (cm) D_{crack}^{eff} Effective diffusion coefficient through foundation cracks (cm ² /s)	Chemical-specific 0.12 0.26 152.4 0.00023 300 Calculated (Eq. 3i)
3i) Effective Diffusion Through Foundation Cracks	L_{crack} Enclosed-space foundation or wall thickness (cm) η Areal fraction of cracks in foundations/walls (cm ² -cracks/cm ² -total area) D^{air} Diffusion coefficient in air (cm ² /s) θ_{crack} Volumetric air content in foundation/wall cracks (cm ³ -air/cm ³ total volume) θ_T Total soil porosity (cm ³ /cm ³ -soil) θ_{wcrack} Volumetric water content in foundation/wall cracks (cm ³ -water/cm ³ total volume) D^{wat} Diffusion K_s coefficient in K_{oc} water (cm ² /s) F_{oc} $\frac{K_{soil,water}}{K_{oc}}$ fraction of organic carbon	15 0.002 Chemical-specific 0.26 0.38 0.12 Chemical-specific Chemical-specific 0.01
	Target Cancer Risk	1.00E-04

Compound	Koc (cm ³ -water-g-carbon)	Ks (cm ³ -water/cm ³ -soil)	Calculated Target Cancer Risk		H	D ^{air} (cm ² /s)	D ^{wat} (cm ² /s)	D ^{crack} (cm ² /s)	D ^{crack} (cm ² /s)	VF _{seesp}	Cair-indoor (µg/m ³) for	
			Risk Cs (mg/kg)	Calculated Target Non-Cancer Risk Cs (mg/kg)							Target Cancer Risk	for Target Non-Cancer Risk
1,1,1-Trichloroethane	1.10E+02	1.10E+00	--	690.17	7.05E-01	7.80E-02	8.80E-06	6.09E-03	6.09E-03	6.35E-03	--	4.38E+03
1,1-Dichloroethane	3.13E+01	3.13E-01	127.34	364.20	2.30E-01	7.42E-02	1.05E-05	5.79E-03	5.79E-03	6.03E-03	7.67E+02	2.19E+03
1,1-Dichloroethene	5.82E+01	5.82E-01	--	7.92	1.07E+00	9.00E-02	1.04E-05	7.02E-03	7.02E-03	1.74E-02	--	1.38E+02
1,2-Dichloroethane	1.68E+01	1.68E-01	23.24	8.54	4.01E-02	1.04E-01	9.90E-06	8.12E-03	8.12E-03	2.52E-03	5.85E+01	2.15E+01
1,2-Dichloroethene, cis-	3.55E+01	3.55E-01	--	38.15	1.67E-01	7.36E-02	1.13E-05	5.74E-03	5.74E-03	4.02E-03	--	1.53E+02
1,2-Dichloroethene, trans-	5.21E+01	5.21E-01	--	49.65	3.85E-01	7.07E-02	1.19E-05	5.52E-03	5.52E-03	6.18E-03	--	3.07E+02
Benzene	5.82E+01	5.82E-01	9.81	6.04	2.28E-01	8.80E-02	9.80E-06	6.87E-03	6.87E-03	4.32E-03	4.23E+01	2.61E+01
Carbon tetrachloride	2.08E+02	2.08E+00	4.76	1.75	1.25E+00	7.80E-02	8.80E-06	6.09E-03	6.09E-03	6.14E-03	2.92E+01	1.07E+01
Chloroform	3.97E+01	3.97E-01	49.23	0.28	1.50E-01	1.04E-01	1.00E-05	8.12E-03	8.12E-03	4.70E-03	2.32E+02	1.32E+00
Methylene Chloride	1.17E+01	1.17E-01	184.25	1,974.09	8.98E-02	1.01E-01	1.17E-05	7.88E-03	7.88E-03	6.66E-03	1.23E+03	1.32E+04
Tetrachloroethene	1.56E+02	1.56E+00	45.19	379.96	7.54E-01	7.20E-02	8.20E-06	5.62E-03	5.62E-03	4.60E-03	2.08E+02	1.75E+03
Trichloroethene	1.67E+02	1.67E+00	225.44	966.19	4.22E-01	7.90E-02	9.10E-06	6.16E-03	6.16E-03	2.72E-03	6.14E+02	2.63E+03
Vinyl chloride	1.43E+01	1.43E-01	0.35	9.66	1.11E+00	1.06E-01	1.23E-06	8.27E-03	8.27E-03	4.54E-02	1.57E+01	4.38E+02

^{u/} Refer to the Model Unit Definition table for all associated unit definitions.

**APPENDIX A: SOIL RISK CALCULATIONS
INDOOR WORKER -- RME SCENARIO**

CARCINOGENIC AND NONCARCINOGENIC RISK ESTIMATES - INHALATION OF VOLATILE COPCS IN INDOOR AIR FROM SOILS (0-20 FT BGS)

LAWRENCE BERKELEY NATIONAL LABORATORY, CALIFORNIA

Exposure Assumptions		Risk and Hazard Equations
Receptor	Indoor Office Worker: RME Scenario	Carcinogenic:
COPC Ambient Air Concentration ($C_{air-indoor}$)	chemical-specific $\mu\text{g}/\text{m}^3$	$Risk = \frac{(C_{air-indoor})(EF)(ED)(ET)(URF)}{(AT_c)(365days/year)}$
Exposure Frequency (EF)	250 days/yr	
Exposure Duration (ED)	25 yrs	Noncarcinogenic: $HQ = \frac{(C_{air-indoor})(EF)(ED)(ET)}{(RfC)(AT_{nc})(365days/year)}$
Fraction of EF breathing air at the site (ET)	0.333 unitless	
Averging Time, Carcinogens (AT_c)	70 yrs	
Averging Time, Noncarcinogens (AT_{nc})	25 yrs	
Inhalation Unit Risk Factor (URF)	chemical-specific $(\mu\text{g}/\text{m}^3)^{-1}$	
Inhalation Reference Concentration (RfC)	chemical-specific $\mu\text{g}/\text{m}^3$	

Preliminary COPC ^w	CAS Number ^{lv}	Indoor Air Concentration for Target Cancer Risk ($\mu\text{g}/\text{m}^3$) ^{lv}	Indoor Air Concentration for Target Non-Cancer Risk ($\mu\text{g}/\text{m}^3$) ^{lv}	URF ($\mu\text{g}/\text{m}^3$) ⁻¹	RfC ($\mu\text{g}/\text{m}^3$)	Cancer Risk	Hazard Quotient
1,1,1-Trichloroethane	71-55-6	--	4.38E+03	--	1.00E+03	1.00E-04	1.00
1,1-Dichloroethane	75-34-3	7.67E+02	2.19E+03	1.60E-06	5.01E+02	1.00E-04	1.00
1,1-Dichloroethene	75-35-4	--	1.38E+02	--	3.15E+01	1.00E-04	1.00
1,2-Dichloroethane	107-06-2	5.85E+01	2.15E+01	2.10E-05	4.90E+00	1.00E-04	1.00
1,2-Dichloroethene, cis-	156-59-2	--	1.53E+02	--	3.50E+01	1.00E-04	1.00
1,2-Dichloroethene, trans-	156-60-5	--	3.07E+02	--	7.00E+01	1.00E-04	1.00
Benzene	71-43-2	4.23E+01	2.61E+01	2.90E-05	5.95E+00	1.00E-04	1.00
Carbon tetrachloride	56-23-5	2.92E+01	1.07E+01	4.20E-05	2.45E+00	1.00E-04	1.00
Chloroform	67-66-3	2.32E+02	1.32E+00	5.30E-06	3.01E-01	1.00E-04	1.00
Methylene Chloride	75-09-2	1.23E+03	1.32E+04	1.00E-06	3.00E+03	1.00E-04	1.00
Tetrachloroethene	127-18-4	2.08E+02	1.75E+03	5.90E-06	3.99E+02	1.00E-04	1.00
Trichloroethene	79-01-6	6.14E+02	2.63E+03	2.00E-06	6.00E+02	1.00E-04	1.00
Vinyl chloride	75-1-4	1.57E+01	4.38E+02	7.80E-05	1.00E+02	1.00E-04	1.00

^w Preliminary COPC = preliminary chemical of potential concern.

^{lv} CAS = Chemical Abstracts Service number.

^{lv} Modeled indoor air concentrations (ASTM vapor intrusion model) were based on the exposure-point concentration of each COPC detected at the evaluated area.

^{lv} $\mu\text{g}/\text{m}^3$ = micrograms per cubic meter.

-- = data not available.

Appendix A-3: Update on Carcinogenic Potency of Trichloroethene
for Theoretical ILCR = 10^{-4} and HI = 1

Update on the Carcinogenic Potency of Trichloroethene

The trichloroethene (TCE) carcinogenic toxicity factor recommended by the California Environmental Protection Agency (CalEPA) (www.oehha.ca.gov/risk/ChemicalDB/index.asp) was used in the Human Health Risk Assessment (Berkeley Lab, 2003) and was also used to develop proposed Media Cleanup Standards (MCSs) in the Corrective Measures Study (CMS) Report. However, recent peer-reviewed articles by experts in the toxicity of TCE (Clewell and Andersen, 2004; Kester and Clewell, 2004) suggest that the carcinogenic potency of TCE may not be as great as suggested by either CalEPA, or the United States Environmental Protection Agency (USEPA) [2002] which proposed a cancer potency value approximately 60-times more conservative than the CalEPA value in their TCE Health Risk Assessment.

As discussed in Clewell and Andersen (2004), "a physiologically based pharmacokinetic (PBPK) model was applied to estimate target tissue doses for the three principal animal tumors associated with TCE exposure: liver, lung, and kidney" by USEPA (2002) in deriving cancer potency values. Clewell and Anderson (2004) state, "However, these risk estimates ignore the evidence that the human is likely to be much less responsive than the mouse to the carcinogenic effects of TCA [trichloroacetic acid] in the liver and that the carcinogenic effects of TCE are unlikely to occur at low environmental exposures ... environmental exposures below 66 µg TCE per cubic meter in air and 265 µg TCE per liter in drinking water are considered unlikely to present a carcinogenic hazard to human health." For comparison, the 10^{-6} theoretical Incremental Lifetime Cancer Risk (ILCR) used to develop the MCSs corresponds to a concentration of 6.1 µg TCE per cubic meter in air, and the Maximum Contaminant Level (MCL) for drinking water for TCE is 5 µg/L.

Kester and Clewell (2004) provide a detailed discussion of the scientific deficiencies of the USEPA (2002) draft TCE health risk assessment and state that, "As a result, its major conclusions regarding the potential health risks associated with TCE exposure are scientifically indefensible." Therefore, based on this recent scientific evidence the risks associated with potential exposure to TCE detected in soil or groundwater and the potential risks from migration of TCE into indoor air would be significantly less than estimated in the Human Health Risk

Assessment (Berkeley Lab, 2003) and the MCS proposed for TCE in the CMS Report would be overly conservative by a factor of 10 or more.

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