

"This page has been left blank intentionally"

Approach to Developing Risk-Based Human Health Criteria

Protection of Future Site Users from Potential Vapour Inhalation

The approach to developing site specific risk-based criteria is based on the Johnson and Ettinger (J&E) (1991) one-dimensional analytical model to determine theoretical values that would apply to soil at depth based on a potential to generate vapours at levels that would pose a risk to future site users.

Johnson and Ettinger (J&E) (1991) provides a screening-level model that incorporates both convective and diffusive mechanisms for estimating the transport of contaminant vapours emanating from either subsurface soils or groundwater into indoor spaces located directly above the source of contamination.

A users guide to the Johnson and Ettinger (J&E) (1991) model has been developed by the US EPA (2004).

Calculating Risk-Based Criteria

To calculate risk-based criteria, the model is run using a populated spreadsheet that requires variable input based on site and soil conditions.

Specific contaminant compounds of concern at the Site were selected based on whether the compounds are considered to have sufficient volatility and toxicity to pose a risk to human health. Table 1 of the users guide lists 114 chemicals that may be found at hazardous waste sites and indicates whether the chemical is sufficiently toxic and volatile to result in a potentially unacceptable indoor inhalation risk.

The contaminants selected were based on the contaminants of concern at the Site, which included those identified in the table.

Benzene	o-xylene	Benzo(b)fluoranthene
Toluene	p-xylene	Chrysene
Ethylbenzene	Naphthalene	Fluorene
m-xylene	Acenaphthene	Pyrene

The chemical properties of these compounds drive the calculations. The soil conditions are based on a set of variables for particular soil types. The soil type selected was based on the expectation that backfill material will consist of a sandy clay material. The following properties were used to populate each spreadsheet for individual compounds:

- Depth of floor base – 15cm (i.e. concrete slab on ground).
- Depth of risk based interval – 250cm, 400cm or 800cm (i.e. depth to which criteria apply).
- Soil temperature – 15°C.
- Soil type – Sandy Clay.
- Soil bulk density – 1.63g/cm³ (model default).
- Soil porosity – 0.385 unitless (model default).
- Soil water-filled porosity – 0.197cm³/cm³ (model default).

The remainder of the variable inputs are model defaults. The results tab on the calculation spreadsheet provides a final indoor exposure soil concentration (in µg/kg). This value was used as the risk-based soil criteria value. The results spreadsheet for each compound is provided at the rear of this appendix.

DATA ENTRY SHEET

SL-SCREEN
Version 3.1; 02/01

Reset to
Defaults

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

YES ☒ OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES ☐

ENTER Chemical CAS No. Initial soil conc., C_s ($\mu\text{g/kg}$) Numbers only, no dashes	ENTER Chemical Benzene
--	------------------------------

MORE
↓

ENTER Depth below grade to bottom of enclosed space floor, L_f (15 or 200 cm)	ENTER Depth below grade to top of contamination L_t (cm)	ENTER Average soil temperature, T_s (°C)	ENTER Vadose zone SCS soil type (used to estimate soil vapor permeability)	ENTER User-defined vadose zone soil vapor permeability, k_v (cm^2)
15	250	15	SC	

MORE
↓

ENTER Vadose zone SCS soil type Lookup Soil Parameters	ENTER Vadose zone soil dry bulk density, ρ_b (g/cm^3)	ENTER Vadose zone soil total porosity, n_v (unitless)	ENTER Vadose zone soil water-filled porosity, θ_w (unitless)	ENTER Vadose zone soil organic carbon fraction, f_{oc} (unitless)	ENTER Average vapor flow rate into bldg. (leave blank to calculate) Q_{soil} (L/m)
SC	1.63	0.305	0.197	0.002	5

MORE
↓

ENTER Averaging time for carcinogens, AT_c (yrs)	ENTER Averaging time for noncarcinogens, AT_{nc} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-05	1

END

Used to calculate risk-based
soil concentration.

RESULTS SHEET

RISK-BASED SOIL CONCENTRATION CALCULATIONS:

Indoor exposure soil conc., carcinogen (µg/kg)	Indoor exposure soil conc., noncarcinogen (µg/kg)	Risk-based indoor exposure soil conc., (µg/kg)	Soil saturation conc., C_{sat} (µg/kg)	Final indoor exposure soil conc., (µg/kg)	Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
1.07E+01	1.07E+02	1.07E+01	4.57E+05	1.07E+01	NA	NA

MESSAGE SUMMARY BELOW:
 MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.

END

DATA ENTRY SHEET

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

SI-SCREEN
Version 3.1; 02/01

YES ☒ OR

Reset to Defaults

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES ☐

ENTER	ENTER	ENTER	ENTER
Initial soil conc., C_0 (ug/kg)	Chemical		
71432	Benzene		

ENTER	ENTER	ENTER	ENTER
Depth below grade to bottom of enclosed space floor, L_F (15 or 200 cm)	Depth below grade to top of contamination, L_t (cm)	Average soil temperature, T_s ($^{\circ}$ C)	User-defined vadose zone soil vapor permeability, k_v (cm^2)
15	400	15	
		SC	

MORE $\downarrow$

ENTER	ENTER	ENTER	ENTER	ENTER	ENTER
Vadose zone SCS soil type	Vadose zone soil dry bulk density, ρ_d^A (g/cm^3)	Vadose zone soil total porosity, n^V (unitless)	Vadose zone soil water-filled porosity, θ_w^V (cm^3/cm^3)	Vadose zone soil organic carbon fraction, f_{oc}^V (unitless)	Average vapor flow rate into bldg. (Leave blank to calculate)
SC	1.63	0.305	0.197	0.002	5

MORE $\downarrow$

ENTER	ENTER	ENTER	ENTER	ENTER	ENTER
Averaging time for carcinogens, ATC (Yrs)	Averaging time for noncarcinogens, ATNC (Yrs)	Exposure duration, ED (Yrs)	Exposure frequency, EF (days/yr)	Target risk for carcinogens, TR (unitless)	Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-05	1
					Used to calculate risk-based soil concentration.

MORE $\downarrow$

END

RESULTS SHEET

RISK-BASED SOIL CONCENTRATION CALCULATIONS:

Indoor exposure soil conc., carcinogen ($\mu\text{g}/\text{kg}$)	Indoor exposure soil conc., noncarcinogen ($\mu\text{g}/\text{kg}$)	Risk-based indoor exposure soil conc., ($\mu\text{g}/\text{kg}$)	Soil saturation conc., C_{sat} ($\mu\text{g}/\text{kg}$)	Final indoor exposure soil conc., ($\mu\text{g}/\text{kg}$)
1.68E+01	1.68E+02	1.68E+01	4.57E+05	1.68E+01

MESSAGE SUMMARY BELOW:

MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	NA

END

DATA ENTRY SHEET

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "x" in "YES" box)

SL-SCREEN
Version 3.1; 02/01

Reset to
Defaults

YES ☒ OR ☐

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "x" in "YES" box and initial soil conc. below)

YES ☐

ENTER	ENTER	ENTER	ENTER
Initial	Initial	Initial	Initial
Chemical	Chemical	Chemical	Chemical
CAS No.	CAS No.	CAS No.	CAS No.
Conc.,	Conc.,	Conc.,	Conc.,
C _s	C _s	C _s	C _s
Numbers only,	Numbers only,	Numbers only,	Numbers only,
no dashes	no dashes	no dashes	no dashes
(μg/kg)	(μg/kg)	(μg/kg)	(μg/kg)
71432			Benzene

ENTER	ENTER	ENTER	ENTER	ENTER
Depth	Depth	Depth	Depth	Depth
below grade	below grade	below grade	below grade	below grade
to bottom	to bottom	to bottom	to bottom	to bottom
of enclosed	of enclosed	of enclosed	of enclosed	of enclosed
space floor,	space floor,	space floor,	space floor,	space floor,
if contamination	if contamination	if contamination	if contamination	if contamination
temperature,	temperature,	temperature,	temperature,	temperature,
T _s	T _s	T _s	T _s	T _s
(°C)	(°C)	(°C)	(°C)	(°C)
15				
800				
15				
SC				
15				
SC				
15				
SC				

MORE
↓

ENTER	ENTER	ENTER	ENTER	ENTER	ENTER	ENTER	ENTER
Vadose zone	Vadose zone	Vadose zone	Vadose zone	Vadose zone	Vadose zone	Vadose zone	Vadose zone
SCS	SCS	SCS	SCS	SCS	SCS	SCS	SCS
soil type	soil type	soil type	soil type	soil type	soil type	soil type	soil type
Look-up Soil	Look-up Soil	Look-up Soil	Look-up Soil	Look-up Soil	Look-up Soil	Look-up Soil	Look-up Soil
Parameters	Parameters	Parameters	Parameters	Parameters	Parameters	Parameters	Parameters
1.63							
0.395							
0.197							
0.002							

MORE
↓

ENTER
Average vapor
flow rate into bldg.
(leave blank to calculate)
Q_{avg}
(l/m)
5

ENTER	ENTER	ENTER	ENTER	ENTER	ENTER	ENTER	ENTER
Averaging	Averaging	Averaging	Averaging	Averaging	Averaging	Averaging	Averaging
time for	time for	time for	time for	time for	time for	time for	time for
carcinogens,	carcinogens,	carcinogens,	carcinogens,	carcinogens,	carcinogens,	carcinogens,	carcinogens,
ATc	ATc	ATc	ATc	ATc	ATc	ATc	ATc
(YTS)	(YTS)	(YTS)	(YTS)	(YTS)	(YTS)	(YTS)	(YTS)
70							
30							
30							
350							
1.0E-05							
1							

MORE
↓

END