

Appendix 4C

Exposure equations

A generalised equation for estimating exposure associated with contaminated soil is presented in Section 4. Specific forms of the general equation are presented in this appendix for the following exposure routes:

- ingestion of soil
- inhalation of volatiles
- dermal absorption
- consumption of home grown produce.

Ingestion of Contaminated Soil

The Chronic Daily Intake (CDI) may be determined by the following expression:

$$CDI = \frac{C \times CF \times IR_{adj} \times EF \times MF}{AT} \quad (C1)$$

where:

- CDI = chronic daily intake (mg/kg/d)
- C = concentration of contaminant in the soil (mg/kg)
- CF = conversion factor = 10^{-6} kg/mg
- EF = exposure frequency (d/yr)
- AT = averaging time (d)
- = (ED x 365) days for non-carcinogens by convention or (70 years x 365) days for carcinogens, representing lifetime exposure, by convention (USEPA, 1989a)
- MF = matrix factor, accounts for reduced bioavailability of contaminant due to binding to the soil matrix. In the absence of necessary information, MF usually taken as 1.0. (USEPA, 1989a)
- IR_{adj} = age adjusted ingestion rate

$$= S \frac{ED_i \times IR_i}{BW_i} \quad (C2)$$

where:

- ED_i = exposure duration (yr) for age group i
- IR_i = ingestion rate (mg/d) for age group i
- BW_i = body weight (kg) for age group i

The CDI determined using equation C1 is a weighted average, taking account of variation in body weight and ingestion rate with age.

Inhalation of Volatile Contaminants

The Chronic Daily Intake (CDI) by inhalation of volatile may be determined by the following expression:

$$\text{CDI} = \frac{\text{IR} \times \text{C} \times \text{VF} \times \text{EF} \times \text{ED}}{\text{AT} \times \text{BW}} \quad (\text{C3})$$

CDI = chronic daily intake (mg/kg/d)

where:

C = concentration of contaminant in soil (mg/kg)

VF = volatilisation factor (kg/m³)

EF = exposure frequency (d/yr)

AT = averaging time (d)

= (ED x 365) days for non-carcinogens by convention or (70 years x 365) days for carcinogens, a lifetime by convention

ED = exposure duration (yr)

IR = inhalation rate (m³/d)

BW = body weight (kg)

Refer to Appendix 4D for the results of modelling of the emission of volatile components.

Note: for the inhalation pathway an age adjusted inhalation rate is not required because weight standardised inhalation rates for adults and children are similar

(child: 3.8 m³/d/15 kg=0.257, adult: 20 m³/d / 70 kg = 0.286, body weight ratio:

15 kg/70 kg = 0.214). For other pathways an age adjustment factor is necessary due to larger differences between these values.

Dermal Absorption from Contaminated Soil

The Chronic Daily Intake (CDI) for dermal absorption from contaminated soil may be determined using the following expression:

$$\text{CDI} = \frac{\text{C} \times \text{AH}_{\text{adj}} \times \text{AR} \times \text{AF} \times \text{EF} \times \text{CF}}{\text{AT}} \quad (\text{C4})$$

where:

CDI = chronic daily intake (mg/kg/d)

C = concentration of contaminant in the soil (mg/kg)

AR = area of exposed skin (face, neck, forearms, hands) (cm²/d)

AF = absorption factor (unitless)

EF = exposure frequency (d/yr)

CF = conversion factor (10⁻⁶ kg/mg)

AT = averaging time (d)

= (ED x 365) days for non-carcinogens by convention or (70 years x 365) days for carcinogens, a lifetime by convention

AH_{adj} = age adjusted soil adherence

$$= S \frac{AH_i \times ED_i}{BW_i} \quad (C 5)$$

where:

AH_i = soil adherence (mg/cm²) for age group i'

ED_i = exposure duration (yr) for age group i

BW_i = body weight (kg) for age group i

The CDI determined in equation C4 is a weighted average, taking into account variation in body weight, skin area and exposure patterns with age.

Ingestion of Produce

The Chronic Daily Intake (CDI) for ingestion of produce may be estimated using the following expression:

$$CDI = \frac{C \times PUF \times IP_{adj} \times EF \times Pg}{AT} \quad (C6)$$

where

CDI = chronic daily intake (mg/kg/d)

C = concentration of contaminant in soil (mg/kg)

PUF = product uptake factor (unitless)

EF = exposure frequency (d/yr)

AT = averaging time (d)

= (ED x 365) days for non-carcinogens by convention or (70 yrs x 365) days for carcinogens by convention

Pg = proportion of produce grown on-site

IP_{adj} = age adjusted ingestion rate for produce

$$= S \frac{IP_i \times ED_i}{BW_i} \quad (C 7)$$

where:

IP_i = ingestion rate for produce (kg/d) for age group i

ED_i = exposure duration (yrs) for age group i

BW_i = body weight (kg) for age group i

The CDI estimated in equation C6 is a weighted average taking into account variation in body weight and produce consumption with age.