APPENDIX D

Combined Average Daily Dose Estimates for Soil Exposures

When the primary health concern posed by a chemical is noncancerous, including exposures to carcinogenic chemicals that are not considered lifelong (>70 years), exposure doses are usually presented as average daily doses (ADDs). Moreover, if more than one route of exposure for an exposure pathway is of public health concern, the exposure doses are sometimes combined into one aggregate dose. Thus, the combined ADD may take the form of the equation listed below (EPA 1996; EPA 2001; EPA 2004; Paustenbach 2000). Again, this equation of average daily dose is generally more applicable to exposures that are not considered lifelong and carcinogenic.

$$ADD_C = \frac{10^{-6} \cdot C \cdot EF \cdot ED \cdot B \cdot (IRS + SA \cdot AF \cdot ABS)}{BW \cdot AT} + D_{Inh}$$

where,
- ADD_C = combined average daily dose, (mg/kg/day)
- C = soil concentration, (mg/kg)
- EF = exposure frequency, (days/yr)
- ED = exposure duration, (years)
- B = bioavailability, (dimensionless)
- IRS = soil ingestion rate, (mg/day)
- SA = exposed surface area for soil/dust, (cm^2/day)
- AF = adherence factor, soils (mg/cm^2)
- ABS = skin absorption defaults, (dimensionless)
- BW = body weight, (kg)
- AT = averaging time, (days)

$$D_{Inh} = \frac{C \cdot EF \cdot ED \cdot B \cdot IRA \cdot IF \cdot (FRL + FS \cdot GIA)}{BW \cdot PEF \cdot AT}$$

where,
- D_{Inh} = average daily inhalation dose, (mg/kg/day)
- PEF = particulate ($\leq$ 10 μm) emission factor, (m^3/kg)
- IRA = inhalation rate, (m^3/day)
- IF = inspired fraction, (dimensionless)
- FRL = fraction remaining in lungs, (dimensionless)
- FS = fraction swallowed, (dimensionless)
- GIA = fraction absorbed by GI tract, (dimensionless)

$$PEF = \left(\frac{Q}{C}\right) \cdot \left[\frac{3600}{0.036 \cdot (1 - V) \cdot \left(\frac{U_m}{U_t}\right)^3 \cdot F(x)}\right]$$

where,

Q/C	=	inverse of the mean concentration at the center of an areal square source, (g/m^2-s per kg/m^3)
V	=	fraction of vegetative cover, (dimensionless)
U_m	=	mean annual windspeed, (m/s)
U_t	=	equivalent threshold value of windspeed at 7m, (m/s)
F(x)	=	derived function dependent on U_m/U_t (Cowherd 1985), (dimensionless)

In assessing exposures at and near the Reading Gray Iron site (RGI), only the potential exposure doses to chemicals screened for further public health evaluation were estimated. Default values used in estimating these potential doses are listed in Tables D-1 and D-2, along with limiting assumptions.

Applying the default values as listed in Tables D-1 and D-2, ATSDR environmental health scientists estimated the potential combined ADDs at maximum, mean, and median soil concentrations for the chemicals selected for further public health evaluation. These estimates yielded on-site potential doses due to ingestion and dermal contact for maximum, mean, and median exposures, which are shown in Table D-3, along with limiting assumptions. Because inhalation exposures can occur offsite and the potential ADDs due to inhalation are approximated with air concentrations (estimated from the soil concentration), inhalation doses for the selected chemicals were estimated as a separate dose and combined with the potential dose for ingestion and dermal contact in areas where such exposures are most likely to combine (i.e., on site). The estimated inhalation doses and its combination with potential doses due to ingestion and dermal contact are shown in Tables D-4 and D-5, respectively, along with limiting assumptions.

In regard to the limiting assumptions, volatile organic compounds and semivolatile organic compounds were assumed to be entrained in the soil matrix, with any volatilization or off-gassing of these compounds being at a minimum. Also, the vegetative cover factor, V, used in the dose estimates was assumed to be 0.5 to account for any vegetation or nonerodible elements (e.g., building debris, abandoned motor vehicles and parts, pebbles, rocks, or stones) that remain after and during site redevelopment. If the site area is totally cleared during site redevelopment, it is highly probable the value of V may approach zero, causing the estimated doses to double. Even if the estimated inhalation doses are doubled, these estimated doses will still not exceed the health guidelines listed in Table D-4 or not pose any potential impact to public health (as discussed in the Public Health Implications section).

Potential doses for maximum exposures are probably unrealistic estimates of ADDs; however, such potential doses are useful guides for assessing short-term or acute exposures. Potential doses for mean and median exposures are probably more realistic estimates of ADDs because the exposure concentrations used in these dose estimates are values of central tendency or averages of the sampled data that may constitute concentrations for average exposures. Potential doses for maximum exposure are used only for comparative purposes to illustrate that even at the most unrealistic exposures, no appreciable health effects will probably occur.

References

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