APPENDIX 3
Equations for the Development of Inhalation Remediation Standards
Residential and Non-residential Use

Equation 1
Carcinogenic Inhalation Human Health-based Criteria

Source: USEPA, Regional Screening Table, User's Guide (November 2014), Section 4.1.3

$$Inh_c = \frac{TR * AT * LT}{IUR * 1000\,{}^{\mu g}\!/_{mg} * EF * \left(\frac{1}{VF} + \frac{1}{PEF}\right) * ED * ET * \frac{1day}{24hours}}$$

| Parameter | Definition | Units | Default |
|---|---|---|---|
| $Inh_c$ | Carcinogenic inhalation human health-based criterion | mg/kg | Chemical-specific |
| *TR* | Target cancer risk | unitless | $1x10^{-6}$ |
| *AT* | Averaging time | days/year | 365 |
| *LT* | Lifetime | years | 70 |
| *IUR* | Inhalation unit risk factor | $(\mu g/m^3)^{-1}$ | Chemical-specific |
| *EF* | Exposure frequency | days/year | 350 (Residential)<br>225<br>(Non-residential) |
| *VF* | Soil-to-air volatilization factor | $m^3/kg$ | Chemical-specific |
| *PEF* | Particulate emission factor | $m^3/kg$ | $1.67x10^9$<br>(Residential)<br>$1.64x10^9$<br>(Non-residential) |
| *ED* | Exposure duration | years | 26 (Residential)<br>25<br>(Non-residential) |
| *ET* | Exposure time | hours/day | 24 (Residential)<br>8 (Non-residential) |

Equation 2
Non-Carcinogenic Inhalation Human Health-based Criteria

Source: USEPA, Regional Screening Table, User's Guide (November 2014), Section 4.1.2

$$Inh_{nc} = \frac{THQ * AT * ED}{EF * ED * ET * \frac{1day}{24hours} * \frac{1}{RfC} * \left(\frac{1}{VF} + \frac{1}{PEF}\right)}$$

| Parameter | Definition | Units | Default |
|---|---|---|---|
| $InhSRS_{nc}$ | Non-carcinogenic inhalation human health-based criterion | mg/kg | Chemical-specific |
| *THQ* | Target hazard quotient | unitless | 1 |
| *AT* | Averaging time | days/year | 365 |
| *EF* | Exposure frequency | days/year | 350 (Residential)<br>225 (Non-residential) |
| *ED* | Exposure duration | years | 26 (Residential)<br>25(Non-residential) |
| *ET* | Exposure time | hours/day | 24 (Residential)<br>8(Non-residential) |
| *RfC* | Reference concentration | $mg/m^3$ | Chemical-specific |
| *VF* | Soil-to-air volatilization factor | $m^3/kg$ | Chemical-specific |
| *PEF* | Particulate emission factor | $m^3/kg$ | $1.67x10^9$ (Residential)<br>$1.64x10^9$ (Non-residential) |

Equation 3
Volatilization Factor (VF)

Source: Soil Screening Guidance: Technical Background Document EPA/540/R-95/128 (May 1996) (Equation 6)

$$VF = Q/C * \frac{(3.14 * D_A * T)^{1/2}}{(2 * \rho_b * D_A)} * 10^{-4} \, m^2/cm^2$$

| Parameter | Definition | Units | Default |
|---|---|---|---|
| *VF* | Soil-to-air volatilization factor | $m^3/kg$ | Chemical-specific |
| *Q/C* | Inverse concentration at center of source | $(g/m^2\text{-}s)/(kg/m^3)$ | 86.6 (Residential)<br>85<br>(Non-residential) |
| $D_A$ | Apparent diffusivity | $cm^2/s$ | Chemical-specific |
| *T* | Exposure interval | seconds | $8.20 \times 10^8$ |
| $\rho_b$ | Dry soil bulk density | $g/cm^3$ | 1.5 |

Equation 4
Apparent Diffusivity ($D_A$)

Source: Soil Screening Guidance: Technical Background Document EPA/540/R-95/128 (May 1996) (Equation 57)

$$D_A = \frac{\left[\left(\theta_a^{10/3} * D_i * H'\right) + \left(\theta_w^{10/3} * D_w\right)\right] / n^2}{\left(\rho_b * K_d\right) + \theta_w + \left(\theta_a * H'\right)}$$

| Parameter | Definition | Units | Default |
|---|---|---|---|
| $D_A$ | Apparent diffusivity | $cm^2/s$ | Chemical-specific |
| $\Theta_a$ | Air-filled soil porosity | $L_{air}/L_{soil}$ | 0.18 |
| $D_i$ | Diffusivity in air | $cm^2/s$ | Chemical-specific |
| $H'$ | Henry's law constant | unitless | Chemical-specific |
| $\Theta_w$ | Water-filled soil porosity | $L_{water}/L_{soil}$ | 0.23 |
| $D_w$ | Diffusivity in water | $cm^2/s$ | Chemical-specific |
| $n$ | Total soil porosity | $L_{pore}/L_{soil}$ | 0.41 |
| $\rho_b$ | Dry soil bulk density | $g/cm^3$ | 1.5 |
| $K_d$ | Soil-water partition coefficient | $cm^3/g$ | Chemical-specific |

Equation 5
Soil-Water Partition Coefficient ($K_d$)

Source: Soil Screening Guidance: Technical Background Document EPA/540/R-95/128 (May 1996) (Equation 23)

$$K_d = K_{oc} * f_{oc}$$

| Parameter | Definition | Units | Default |
|---|---|---|---|
| $K_d$ | Soil-water partition coefficient | $cm^3/g$ | Chemical-specific |
| $K_{oc}$ | Soil organic carbon-water partition coefficient | $cm^3/g$ | Chemical-specific |
| $f_{oc}$ | Organic carbon content of soil | g/g | 0.002 |

Equation 6
Particulate Emission Factor (PEF)

Source: Soil Screening Guidance: Technical Background Document EPA/540/R-95/128 (May 1996) (Equation 10)

$$PEF = Q/C * \left[ \frac{3{,}600\ sec/hr}{0.036 * (1 - v) * \left(\frac{U_m}{U_t}\right)^3 * F(x)} \right]$$

| Parameter | Definition | Units | Default |
|---|---|---|---|
| *PEF* | Particulate emission factor | $m^3/kg$ | $1.67x10^9$ (Residential) $1.64x10^9$ (Non-residential) |
| *Q/C* | Inverse concentration at center of source | $(g/m^2\text{-}s)/(kg/m^3)$ | 86.6 (Residential) 85 (Non-residential) |
| *v* | Percent vegetative cover | percent | 50% |

| | | | |
|---|---|---|---|
| *Um* | Mean annual wind speed | m/s | 4.56 |
| *Ut* | Equivalent threshold value of wind speed at 7 m | m/s | 11.32 |
| *F(x)* | Function dependent on Um/Ut derived using Cowherd et al. (1985) | unitless | 0.159 |

Equation 7
Soil Saturation Limit ($C_{sat}$)

Source: Soil Screening Guidance: Technical Background Document EPA/540/R-95/128 (May 1996) (Equation 9)

$$C_{sat} = \frac{S}{\rho_b} * \left[ \left( K_d * \rho_b \right) + \theta_w + \left( H' * \theta_a \right) \right]$$

| Parameter | Definition | Units | Default |
|---|---|---|---|
| $C_{sat}$ | Soil saturation limit | mg/kg | Chemical-specific |
| *S* | Water solubility | $mg/L_{water}$ | Chemical-specific |
| $\rho_b$ | Dry soil bulk density | $g/cm^3$ | 1.5 |
| $K_d$ | Soil-water partition coefficient | $cm^3/g$ | Chemical-specific |
| $\Theta_w$ | Water-filled soil porosity | $L_{water}/L_{soil}$ | 0.23 |
| *H'* | Henry's law constant | unitless | Chemical-specific |
| $\Theta_a$ | Air-filled soil porosity | $L_{air}/L_{soil}$ | 0.18 |

---

If a calculated inhalation exposure pathway human health-based criterion for a contaminant is greater than its soil saturation limit for the volatile portion of the equation, an inhalation exposure pathway human health-based criterion is not applicable to the volatile portion of the

equation for that contaminant.

If a calculated inhalation exposure pathway human health-based criterion for a contaminant is greater than one million parts per million, the inhalation exposure pathway remediation standard is not regulated for that contaminant.

If a calculated inhalation exposure pathway human health-based criterion for a contaminant is less than the soil reporting limit, the inhalation exposure pathway remediation standard defaults to the soil reporting limit.