Appendix 6: EPA Soil Screening Guidance for Radionuclides

Derivation of the Risk-Based Soil Sceening Levels (Pu 239 in Soil)

The EPA has promulgated the use of Soil Screening Levels (SSLs; http://risk.lsd.ornl.gov/rad_start.shtml; Table 3) as "… **guidance is intended to be used to screen out areas of sites, exposure pathways, or chemicals of concern from further consideration, assuming certain conditions are present, or to determine that further study is warranted at a site."** These SSLs are risk-based concentrations that may be used to exclude areas or contaminants from further evaluation, or conversely identify areas or contaminants that require additional evaluation.

Using standard EPA default assumptions for intake and exposure conditions and an excess cancer risk of one in million, the SSL for Pu 239 in soil is 2.9 pCi/g. [15] This SSL is based on ingestion of soil that is age adjusted over a period of 30 years. More importantly, this SSL is based on an average soil concentration over an entire residential lot of ½ acre (EPA 2002). Use of the SSL (or the previously referenced PRG) as a screening value for single point, maximum value samples is inappropriate. Correct use of these risk-based SSLs requires that soil samples be composited or averaged over an entire exposure area (1/2 acre in this evaluation).

None of the available sampling data for either Pu 239 or gross alpha have been averaged over an area that is appropriate for comparison to the SSL (or PRG) concentrations. However, as all of the currently available, maximum point values are below the SSL of 2.9 pCi/g, it is very unlikely that any potential exposure areas will contain an average Pu 239 soil concentration above the SSL.

[15] SSLs for inhalation, food ingestion, and external exposure are higher than the soil ingestion SSL (4,700 pCi/g, 8.1 pCi/g, and 560 pCi/g, respectively). The SSL is the same as the previously referenced PRG of 2.5 pCi/g. The difference in the SSL value of 2.9 pCi/g is due to changes in the Pu 239 dose conversion factors.

Usage and Limitations:

- **SSLs are not national cleanup standards.**
- **Radionuclide SSLs are based on a target risk of one-in-a-million (10^{-6}), or, for the ground water migration pathway, a maximum contaminant level (MCL), where available.**
- **Although the application of SSLs during site investigations is not mandatory at sites being addressed by CERCLA or RCRA, EPA recommends the use of SSLs as a tool to facilitate prompt identification of radionuclides and exposure areas of concern.**
- **In addition, this guidance presents methodologies to address the leaching of radionuclides through soil to an underlying potable aquifer. This pathway should also be addressed in the development of PRGs.**
- **The Soil Screening Guidance is a tool for screening at National Priorities List (NPL) sites.**
- **Some NPL sites will not meet all the conditions necessary for use of this tool; consequently, EPA does not expect this tool to be applicable for all NPL sites.**
- **The guidance is intended to be used to screen out areas of sites, exposure pathways, or chemicals of concern from further consideration, assuming certain conditions are present, or to determine that further study is warranted at a site.**
- **Generally, areas of a site which fall below the screening levels may be eliminated from further assessment. Areas above the screening levels generally warrant further evaluation.**
- **The levels should not be interpreted to represent cleanup standards for a site, and concentrations in soil above screening levels do NOT automatically designate a site as dirty.**
- **SSLs do not supersede existing federal or state ARARs and use of the guidance is not legally binding.**
- **An ecological assessment should also be performed as part of the RI/FS to evaluate potential risks to ecological receptors.**
- **Although SSLs are "risk-based," they do not eliminate the need to conduct a site-specific risk assessment for those areas identified as needing further investigation.**
- **Exposure Pathways are as follows:**

  - **Direct ingestion of soil**
  - **Inhalation of fugitive dusts**
  - **External radiation exposure from photon-emitting radionuclides in soil**
  - **Ingestion of homegrown produce that has been contaminated via plant uptake**
  - **Ingestion of contaminated ground water caused by migration of radionuclides through soil to an underlying potable aquifer**

Table 3. Usage and Limitations of risk-based Soil Screening Levels (SSLs); from http://risk.lsd.ornl.gov/rad_start.shtml (EPA 2002).

http://risk.lsd.ornl.gov/rad-ssg/radssl1.shtml

SELECTION:
Your **Analytes** are:
Pu-239
Your **Pathways** are
Ingestion of Soil
Ingestion of Produce
Inhalation of Fugitive Dust
Default Parameters
Each pathway you have selected is given below along with the applicable Equations and its associated Default Parameters. For each equation, the default values will be used unless you enter a different value.

Ingestion

Ingestion of Radionuclides in Soil - Age Adjusted

$$SSL_{DC} = \frac{TR * t * \lambda}{SF_s * IR_s * 10^{-3} * EF * ED * (1 - e^{-\lambda t})}$$

$$IR_S = \frac{IR_{soilAge\,1\text{-}6} * ED_{age1-6} + IR_{soilAge\,7\text{-}31} * ED_{age7-31}}{ED}$$

1.0E-6 TR (target risk) unitless
350 EF (exposure frequency) d/yr
100 IR_a (adult ingestion rate) mg/d
200 IR_c (child ingestion rate) mg/d
24 ED_a (adult exposure duration) yr
6 ED_c (child exposure duration) yr
30 ED (exposure duration) yr
30 t (time of exposure) yr
120 IR_s (soil ingestion rate) mg/d

NOTES:

1. Screening level equations have been modified to account for radioactive decay.
2. SF_s=Oral Slope Factor for Soil Ingestion. Radionuclide-specific.*
3. λ= Decay constant (0.693/halflife) yr^{-1}. Radionuclide-specific.

4. 10^{-3} = conversion factor (g/mg)

Ingestion of Radionuclides in Soil - Adult Only

$$SSL_{DC} = \frac{TR * t * \lambda}{SF_s * IR_s * 10^{-3} * EF * ED * (1 - e^{-\lambda t})}$$

1.0E-6 TR (target risk) unitless

250 EF (exposure frequency) d/yr

25 ED (exposure duration) yr

50 IR_s (soil ingestion rate) mg/d

25 t (time of exposure) yr

NOTES:

1. Screening level equations have been modified to account for radioactive decay.
2. SF_s=Oral Slope Factor for Soil Ingestion. Radionuclide-specific.*
3. **Use this pathway for adult-only situations (i.e. worker, etc.)**
4. λ = Decay constant (0.693/halflife) yr^{-1}. Radionuclide-specific.
5. 10^{-3} = conversion factor (g/mg)

Inhalation of Fugitive Dusts

Inhalation of Fugitive Dusts - Particulate Emission Factor

$$PEF = Q/C * \frac{3{,}600}{0.036 * (1 - V) * (U_m / U_t)^3 * F(x)}$$

San Francisco (II) City (Climatic Zone)

0.5 Surface (acres)

89.51 Q/C (inverse of the mean conc. at the center of a 0.5-acre-square source) g/m^2-s per kg/m^3

0.5 V (fraction of vegetative cover) unitless

3.89 U_m (mean annual windspeed) m/s

11.32 U_t (equivalent threshold value of windspeed at 7m) m/s

0.0391 F(x) (function dependent on U_m/U_t) unitless

NOTES:

1. PEF (particulate emission factor) m^3/kg. Default is $1.32x10^9$
2. The Surface Area and City/Climate Zone are used to look up a Q/C. Q/C is the inverse of mean concentration at center of a 0.5 acre-square source (g/m^2-s per kg/m^3). Pick the city with the most similar climatic conditions (map).
3. The F(x) function is derived using Cowherd et al. (1985)

Inhalation of Radionuclides in Fugitive Dusts

$$SSL_{DC} = \frac{TR * t * \lambda}{SF_i * IR_i * (\frac{1}{PEF}) * 10^3 * EF * ED * [ET_o + (ET_i * DF_i)] * (1 - e^{-\lambda t})}$$

1.0E-6	TR (target risk) unitless
20	IR_i (inhalation rate) m^3/d
0.073	ET_o (outdoor exposure time fraction) unitless
0.683	ET_i (indoor exposure time fraction) unitless
350	EF (exposure frequency) d/yr
30	ED (exposure duration) yr
0.4	DF_i (indoor dilution factor) unitless
30	t (time of exposure) yr

NOTES:

1. Screening level equations have been modified to account for radioactive decay.
2. SF_i (inhalation slope factor) (pCi^{-1}) - chemical specific.*
3. PEF (particulate emission factor) m^3/kg. Default is $1.32x10^9$.
4. λ = Decay constant (0.693/halflife) yr^{-1}. Radionuclide-specific.
5. 10^3 = conversion factor (g/kg)

Ingestion of Produce

Ingestion of Homegrown Produce in Soil

$$SSL_{DC} = \frac{TR * t * \lambda}{SF_p * (IR_{vf} + IR_{lv}) * 10^3 * TF_p * CPF * ED * (1 - e^{-\lambda t})}$$

1.0E-6	TR (target risk) unitless
42.7	IR_{vf} (vegetable and fruit ingestion rate) kg/year
4.66	IR_{lv} (leafy vegetables ingestion rate) kg/year
0.5	CPF (contaminated plant fraction from the site) unitless
30	ED (exposure duration) yr
30	t (time of exposure) yr

NOTES:

1. Screening level equations have been modified to account for radioactive decay.
2. SF_p (produce ingestion slope factor) $(pCi)^{-1}$ - radionuclide-specific.*
3. TF_p (soil-to-plant transfer factor) (pCi/g plant per pCi/g soil).
4. λ = Decay constant (0.693/halflife) yr^{-1}. Radionuclide-specific.
5. 10^3 = conversion factor (g/kg)

*Slope factors are taken from the updated Health Effects Assessment Summary Tables (HEAST): (Radionuclide Carcinogenicity Slope Factors), in units of picocuries. The curie (Ci), the customary unit of activity, is equal to 3.7 x 1010 nuclear transformations per second. 1 picocurie (pCi) = 10-12 Ci. The International System (SI) unit of activity is the becquerel (1 Bq =1 nuclear transformation per second). If required, screening levels can be converted into SI units.

Please select desired units option:

- (•) pCi/g
- ( ) Bq/g

You must select one of the following output options

- (•) View on Screen

Tab delimited file

Comma delimited file

RETRIEVE clear selection

URL: http://risk.lsd.ornl.gov/radssl1.cgi
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Equation Values for Ingestion of Soil

Age-adjusted Parameter	Value	Adult-only Parameter	Value
Target Risk (unitless)	1.0E-6	Target Risk (unitless)	1.0E-6
Adult Exposure Duration (yr)	24	Exposure Duration (yr)	25
Child Exposure Duration (yr)	6		
Exposure Frequency (day/yr)	350	Exposure Frequency (day/yr)	250
Adult Intake Rate (mg/day)	100		
Child Intake Rate (mg/day)	200		
Age-adjusted Intake Rate (mg/day)	120	Intake Rate (mg/day)	50
Time of Exposure (yr)	30	Time of Exposure (yr)	25

Decay-Corrected Screening Levels for Ingestion of Soil

Analyte	Soil Ingestion Slope Factor (risk/pCi)	Decay Constant λ (yr^{-1})	Halflife (yr)	SSL (Age-adjusted) (pCi/g)	SSL (Adult) (pCi/g)	SSL (Age-adjusted) (mg/kg)	SSL (Adult) (mg/kg)
Pu-239 decaychain	2.8E-10	2.9E-05	2.4E+04	2.9E+00	1.2E+01	4.6E-05	1.9E-04

Equation Values for Ingestion of Produce

Parameter	Value
Target Risk (unitless)	1.0E-6
Exposure Duration (yr)	30
Contaminated Plant Fraction from the site (unitless)	0.5
Vegetable and Fruit Ingestion Rate (kg/yr)	42.7
Leafy Vegetable Ingestion Rate (kg/yr)	4.66
Time of Exposure (yr)	30

Decay-Corrected Screening Levels for Ingestion of Produce

Analyte	Food Ingestion Slope Factor (risk/pCi)	Decay Constant λ (yr^{-1})	Halflife (yr)	Soil-to-plant Transfer Factor (pCi/g plant/pCi/g soil)	SSL (pCi/g)	SSL (mg/kg)
Pu-239 decaychain	1.7E-10	2.9E-05	2.4E+04	1.0E-03	8.1E+00	1.3E-04

Equation Values for Inhalation of Fugitive Dust

Particulate Emission Factor Parameter	Value	Equation Parameter	Value
Surface Area (acres)	0.5	Target Risk (unitless)	1.0E-6
City (climate zone)	SanFrancisco(II)	Exposure Duration (yr)	30
Q/C (g/m^2-s per kg/m^3)	89.51	Exposure Frequency (day/yr)	350
Fraction of vegetative cover (unitless)	0.5	Inhalation Rate (m^3/day)	20
Mean annual windspeed (m/s)	3.89	Outdoor Exposure Time Fraction (unitless)	0.073
Equivalent threshold value of windspeed at 7m (m/s)	11.32	Indoor Exposure Time Fraction (unitless)	0.683
Function dependent on U_m/U_t (unitless)	0.0391	Indoor Dilution Factor (unitless)	0.4
		Time of Exposure (yr)	30

Decay-Corrected Screening Levels for Inhalation of Fugitive Dust

Analyte	Inhalation Slope Factor (risk/pCi)	Decay Constant λ (yr^{-1})	Halflife (yr)	Particulate Emission Factor (m^3/kg)	SSL (pCi/g)	SSL (mg/kg)
Pu-239 decaychain	3.3E-08	2.9E-05	2.4E+04	1.1E+10	4.7E+03	7.5E-02