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**RADIONUCLIDE DETECTION LIMITS REQUIRED TO
ESTIMATE HEALTH EFFECTS IN CERCLA RISK
ASSESSMENT (U)**

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RADIONUCLIDE DETECTION LIMITS REQUIRED TO ESTIMATE HEALTH EFFECTS IN CERCLA RISK ASSESSMENTS

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INTRODUCTION

Lower limits of detection (LLDs) have been calculated for radionuclides of environmental and ecological interest. The detection limits are risk-based and were derived using a methodology similar to that described by the Environmental Protection Agency for determining Preliminary Remediation Goals (PRGs) [EPA 1991]. PRGs, and the LLDs calculated in this report, are calculated assuming a risk level of 10^{-6} , the risk deemed acceptable by the EPA.

LLDs have been calculated for radionuclides in water and soil. Water concentrations are based on risks resulting from the consumption of drinking water while soil concentrations are based on risks from incidental soil ingestion and external radiation exposure from ground surface contamination.

Water/soil concentrations are given in Table 1 for the requested radionuclides. Four radionuclides (Pb-210, Ac-228, Th-228, and Th-230) have been added to the list since they are daughter products in either the natural thorium decay series (Th-232) or the natural uranium decay series (U-238). Concentrations in the table are those that would result in a 10^{-6} risk to individuals exposed to radionuclides via the pathways described above.

Detection limits for "gross alpha" and "gross beta" are meaningless unless the assumption is made that the contamination is always made up of the same constituents. Furthermore, these measurements are generally for screening purposes and would not be of acceptable quality for most CERCLA activities.

RADIONUCLIDES IN WATER

Water Consumption. The detection limits for radionuclides in water samples are calculated using,

$$LLD_i^w \text{ [pCi/mL]} = \frac{\text{Risk}}{CR \text{ [L/d]} \cdot 1000 \text{ [mL/L]} \cdot SF_i^{ing} \text{ [risk/pCi]} \cdot EF \text{ [d/yr]} \cdot ED \text{ [yr]}}$$

where CR is the water consumption rate, SF_i^{ing} is the ingestion slope factor for nuclide i, EF is the exposure frequency, and ED is the exposure duration. "Slope factors" are nuclide-specific risk/dose factors and are provided by EPA [1992]. A standard consumption rate of 2 L/d has been used to calculate LLDs. It is further assumed that the individual is exposed for a period of 30 years (ED) with a frequency of 350 days per year (EF). These assumptions are consistent with the future resident scenario which generally dominates a given risk assessment. For consistency with EPA guidance [EPA 1989], radioactive decay over the 30 year exposure period is not considered.

RADIONUCLIDES IN SOIL

Soil Ingestion. Detection limits, based on ingestion, for radionuclides in soil are given by,

$$LLD_i^s \text{ [pCi/g]} = \frac{\text{Risk}}{IR \text{ [g/d]} \cdot SF_i^{ing} \text{ [risk/pCi]} \cdot EF \text{ [d/yr]} \cdot ED \text{ [yr]}}$$

where IR is the incidental soil ingestion rate; the other variables were described above. The EPA [EPA 1989] has determined that the soil ingestion rate for children (ages 0 to 6) is 0.2 g/d and 0.1 g/d for adults. It is assumed that soil ingestion occurs for a period of 30 years. A weighted average ingestion rate (0.12 g/d) has been used here to account for 6 years of intake at a rate of 0.2 g/d and 24 years at a rate of 0.1 g/d.

External Exposure to Ground Surface Radionuclides. Detection limits for radionuclides in soil resulting in a risk of 10^{-6} from external exposure are given by,

$$LLD_i^e \text{ [pCi/g]} = \frac{\text{Risk} \cdot 8760 \text{ [hr/yr]}}{ET \text{ [hr/d]} \cdot SF_i^{ext} \text{ [risk/yr per pCi/g]} \cdot EF \text{ [d/yr]} \cdot ED \text{ [yr]}}$$

where ET is the exposure time (1 hr/d) and SF_i^{ext} is the external exposure slope factor; the other variables are defined above. The external exposure slope factor is given in units of risk/yr per pCi/g. Therefore, a calculation is made of the equivalent number of years that the individual is assumed to be exposed to ground surface contamination in units of activity per mass of soil. The LLD for radionuclides in soil is the lower of the two concentrations calculated for soil ingestion and external exposure.

Table 1. CERCLA Risk-Based Radionuclide Detection LimitsRisk Level = $1 \text{E-}6$

Nuclide	Detection Limits		
	Water (pCi/mL)	Soil (ingestion) (pCi/g)	Soil (external) (pCi/g)
H-3	8.8E-01	1.5E+04	
C-14	5.3E-02	8.8E+02	
K-40	4.3E-03	7.2E+01	1.5E+00
Co-60	3.2E-03	5.3E+01	9.7E-02
Sr-89	1.6E-02	2.6E+02	1.8E+03
Sr-90	1.4E-03	2.4E+01	
Y-90	1.5E-02	2.5E+02	
Tc-99	3.7E-02	6.1E+02	1.4E+06
Ru-106	5.0E-03	8.4E+01	
Sb-125	5.7E-02	9.4E+02	7.0E-01
I-129	2.5E-04	4.2E+00	2.0E+02
Cs-134	1.2E-03	1.9E+01	1.6E-01
Cs-137*	1.7E-03	2.8E+01	4.2E-01
Eu-152	2.3E-02	3.8E+02	2.3E-01
Eu-154	1.6E-02	2.6E+02	2.0E-01
Eu-155	1.1E-01	1.8E+03	1.4E+01
Pb-210†	9.3E-05	1.6E+00	6.4E+03
Ra-226	4.0E-04	6.6E+00	7.0E+01
Ra-228	4.8E-04	7.9E+00	
Ac-228†	9.5E-02	1.6E+03	2.9E-01
Th-228†	4.3E-03	7.2E+01	1.5E+03
Th-230†	3.7E-03	6.1E+01	1.5E+04
Th-232†	4.0E-03	6.6E+01	3.2E+04
U-233	3.0E-03	5.0E+01	2.0E+04
U-234	3.0E-03	5.0E+01	2.8E+04
U-235	3.0E-03	5.0E+01	3.5E+00
U-238†	3.0E-03	5.0E+01	4.0E+04
Np-237	2.2E-04	3.6E+00	1.1E+02
Pu-238	2.2E-04	3.6E+00	3.0E+04
Pu-239	2.1E-04	3.5E+00	4.9E+04
Pu-240	2.1E-04	3.5E+00	3.1E+04
Pu-242	2.2E-04	3.6E+00	3.6E+04
Am-241	2.0E-04	3.3E+00	1.7E+02
Am-243	2.0E-04	3.3E+00	3.5E+01
Cm-243	2.5E-04	4.2E+00	5.2E+00
Cm-244	3.0E-04	5.0E+00	2.8E+04
Cm-245	2.0E-04	3.3E+00	1.6E+01
Cm-246	2.0E-04	3.3E+00	3.1E+04
Cm-247	2.2E-04	3.6E+00	9.1E-01
Cm-248	5.2E-05	8.7E-01	3.8E+04

*includes gamma emissions from Ba-137m.

†in natural uranium (U-238) or thorium (Th-232) decay series.

REFERENCES

- [EPA 1989] Environmental Protection Agency, "Risk Assessment Guidance for Superfund: Volume 1 - Human Health Evaluation Manual (Part A)", EPA/540/1-89/002, Washington, DC, December 1989.
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- [EPA 1992] Environmental Protection Agency, "Health Effects Assessment Summary Tables", OERR 9200.6-303(92-1), Washington, DC, March 1992.

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