

Authorized Limits for Residual Radioactive Material

Residual soil contamination of long-lived radionuclides may be of concern for both present and future site use. Future residential use implies no institutional control of the site and necessitates identification of soil contamination limits below which the site can be released without radiological concern. Defining limits for unrestricted release of a site involves identifying soil guidelines and authorized limits.

Unrestricted release of a site is addressed in DOE Order 5400.5, Radiation Protection of the Public and the Environment. Chapter IV, Residual Radioactive Material, presents a two step procedure of 1) estimating soil guidelines, and 2) establishing authorized limits for unrestricted release of that soil. Included in this process are methods for consideration of radionuclide mixtures, ingrowth of decay products, hot spots, and external radiation.

Soil guidelines may be generic or derived. Chapter IV lists generic guidelines of 5 pCi/g (top 15 cm) for ^{226}Ra , ^{228}Ra , ^{230}Th , and ^{232}Th . Derived soil guidelines for other radionuclides and mixtures are to be derived based on limiting the public dose (not including occupational, natural background, medical, or consumer doses - DOE 5400.5, Section 10) to 100 mrem/year. The order specifies that the derivation be conducted according to DOE/CH-8901, "A Manual for Implementing Residual Radioactive Material Guidelines", commonly known as the RESRAD computer program. To derive site specific soil guidelines, the basic dose limit of 100 mrem/yr is applied to a member of the critical population group. The RESRAD program assumes that the critical population group is a family that establishes residence on a site after the site has been released for use without radiological restrictions.

All significant pathways for the critical population group must be considered in deriving soil guidelines. These pathways include:

- * Direct exposure to external radiation from the contaminated soil material;
- * Internal radiation from the inhalation of airborne radionuclides; and
- * Internal radiation from the ingestion of

- Plant foods grown in the contaminated soil,
- Meat and milk from livestock fed with contaminated fodder and water,
- Drinking water from a contaminated well,
- Contaminated soil, and
- Fish from a contaminated pond.

The RESRAD program provides default values for all input variables except radionuclide concentrations. If site-specific values are available and will result in a significant change in the calculated soil guidelines, that should be substituted for default values. Some default values, such as the assumed dust loading, are associated with the farm family scenario and should therefore be changed only with adequate justification.

Once soil guidelines have been identified, authorized limits are set equal to the guidelines unless other information suggests this is not appropriate. For example, final cleanup standards (authorized limits) may be based on a different scenario plausible-use scenario is not appropriate for the specific property or if another plausible-use scenario would result in significantly greater potential for exposure. Authorized limits shall also be consistent with other applicable State and Federal laws. The authorized limits are developed through the DOE project offices in the field and are approved by the DOE Headquarters Program Office (DOE 5400.5, Chapter IV, Section 5).

The monitoring, cleanup and control of residual radioactive material are subject to As Low As Reasonable Achievable (ALARA) policy. The objective of the ALARA process is the attainment of dose levels as low as reasonable achievable, taking technical, economic, safety, and social factors into account. Application of the ALARA process to planning activities occurs both in the development of guidelines and in the application of these guidelines to a specific site. This application should be well documented throughout the process, including prior to, during, and following field work. The resultant soil guidelines from the application of RESRAD are presented in Table 1.

Table 1
Soil Guidelines for Radionuclide Mixtures
Representative of RFP

Nuclide (i)	Radionuclide Soil Guidelines for Mixture (pCi/g)	Single Radionuclide Soil Guideline (pCi/g)
Depleted Uranium Mixture		
U-234	89	1291
U-235	12	239
U 238	816	929
Weapons Grade Enriched Uranium Mixture		
U-234	1103	1291
U-235	35	239
U-236	4.5	1399
U-238	0.3	929
Weapons Grade Plutonium Mixture		
Pu-238	6.5	362
Pu-239	234	327
Pu-240	52	327
Pu-241	1480	2137
Pu-242	0.005	347
OU1 Mixture Proportions (1992)		
Am-241	33	58
Pu-239	234	327
U-233	30	1291
U-234	30	1291
U-238	39	929

Verification and validation of the RESRAD program are ongoing tasks. Calculations were verified (checked for internal mathematical consistency and accuracy) and documented in 1989

and have been conducted on code modifications since that time. Validation (testing the model against accurately measured, independent sets of field or laboratory observations) is often not possible, and consequently, the RESRAD model has not been completely validated. However, a leaching experiment was conducted to validate that portion of the model, and RESRAD personnel have participated in international modeling meetings. An exercise less rigorous than validation - benchmarking, involves comparison of test problem results with other computer codes. Three benchmark comparisons of test problems were conducted against Environmental Protection Agency and Nuclear Regulatory Commission codes in 1990, and comparison with two additional codes began in 1992. As the RESRAD code is modified to handle the more complex situations (e.g., the presence of non-radioactive contaminants), further verification and validation efforts are planned. Current information on these ongoing efforts may be obtained by contacting the authors of the code at the Energy and Environmental Systems Division of the Argonne National Laboratory, Argonne, Illinois.