Department of Energy

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Mr. Joseph J. Holonich
Acting Chief, Uranium Recovery Branch
Division of Low-Level Waste Management and Decommissioning
Office of Nuclear Material Safety and Safeguards
U. S. Nuclear Regulatory Commission
Mail Stop 5E-4 OWFN
Washington, DC 20555

Dear Mr. Holonich:

Per the request of Elaine Brummett of your staff, the Uranium Mill Tailings Remedial Action (UMTRA) Project has prepared a Residual Radioactive Material Program (RESRAD) computer code analysis of the radiation doses to a future intruder that could result from buried thorium-230 (Th-230) at UMTRA Project sites. The analysis indicates that, when a reasonable particle size is assumed, between 59 and 64 pCi/g of Th-230 left in the ground today would produce an effective dose equivalent of 100 mrem/year in 1000 years. The analysis is conservative, since anyone digging down to the Th-230 would probably be exposed to dust which was diluted by the overlying material.

This RESRAD analysis demonstrates the adequacy of the safety margins afforded by the UMTRA Project Thorium-230 Protocol, which is awaiting your concurrence.

The RESRAD analysis is enclosed. Please call Bob Cornish of my staff at 505-845-5654 if you have any questions.

Sincerely,

Clinton C. Smythe

Albert R. Chernoff
Project Manager
Uranium Mill Tailings Remedial Action
Project Office

Enclosure

cc w/o enclosure:
E. Brummett, NRC
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M. Miller, TAC
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EVALUATION OF GENERIC PROTOCOL FOR Th-230 CLEANUP/VERIFICATION AT UMTRA PROJECT SITES USING THE RESRAD COMPUTER CODE

1.0 PURPOSE:

The purpose of this position paper is to use the RESRAD computer code to evaluate the cleanup criteria of Th-230 described in the Generic Protocol for Thorium-230 Cleanup/Verification at UMTRA Project Sites.[1]

2.0 SCENARIO/ASSUMPTIONS:

An intruder has disrupted the former processing site by excavating through approximately 3 feet of clean fill, thereby exposing contaminated soil containing Th-230. The intruder is receiving dose from exposure to Th-230 immediately, and subsequently may receive additional dose from exposure following the ingrowth of Th-230 daughter products. The total pathway dose contribution is modeled to include external dose from the ground, and internal dose from the inhalation (excluding radon) of aerosol distributions of either 1-μm or 20-μm Activity Median Aerodynamic Diameter (AMAD) soil particulates, radon and radon progeny. The intruder is also receiving internal dose from the ingestion of contaminated plants, meat, milk, aquatic foods, soil, and drinking water. It is conservatively assumed that the intruder spends 100% of the time on site in the contaminated area without taking credit for shielding external and internal pathways. Tables 1 through 4 summarize the individual and total annual pathway dose contribution from 1 pCi/g of Th-230 distributed in a 100 m^2 contaminated area at varying wind speeds, and different sizes (e.g., 1-μm and 20-μm AMAD) of soil particulates for time periods ranging from 0 to 1000 years. Tables 1 through 4 also provide the allowable concentration in pCi/g for Th-230 in soil that will lead to a total annual pathway dose of 100 mrem/yr effective dose equivalent (EDE). Except for user-defined input values, RESRAD default values were used for all calculations.[2,3]

3.0 RESULTS:

Table 1 lists the dose contributions in mrem/yr and percent (%) contribution from all pathways. The pathways listed included external dose from exposure to contaminated ground, and internal dose from particulate inhalation (excluding radon), radon and radon progeny. Internal dose also results from the ingestion of plants (e.g., vegetables, etc.). At t=0, approximately 98% of the dose contribution from Th-230 is from inhalation (excluding radon), with less than 1% contributing from external dose from gamma radiation. For purposes of comparison, the values generated by RESRAD were compared to the total effective dose equivalent (TEDE) reported by NUREG/CR-5512.[4] The ONSITE/MAXI1, and GENII codes were used to generate values in NUREG/CR-5512. The annual TEDE in NUREG/CR-5512 is 0.22 mrem/yr, and is comparable to the total pathway EDE contribution from RESRAD, reported as 0.34 mrem/yr. Essentially, the inhalation pathway contributes approximately 100% of the dose to the intruder for both NUREG/CR-5512 and RESRAD. The observed differences in results are attributable to the minor variations in default values used in each of the codes.

Table 2 lists results similar to Table 1 regarding external dose from the ground and internal dose from inhalation. However, a faster wind speed (e.g., 2.0 m/s vs. 0.02 m/s) is shown to affect dose contribution from radon and its daughter products only. As wind speed increases two orders of magnitude from 0.02 m/s to 2.0 m/s, the dose contribution from radon becomes negligible.

Additional calculations were performed by increasing the AMAD of particle sizes from 1 μm to 20 μm. The larger particle size reflects a very conservative lower bound on small, potentially respirable particles expected under actual site conditions. This is substantiated by the sample gradation studies performed at the Gunnison UMTRA Project site which indicated that over 96% of soil particle size distribution was greater than 75 μm.[5] For modeling purposes, we estimated the AMAD to be 20 μm. To accommodate a new AMAD, the developer of the code recommended that we recalculate a new inhalation dose conversion factor.[6] The method used to calculate particle size corrections to committed dose equivalent per intake of unit activity (Sv/Bq) of Th-230 for an AMAD other than 1 μm is given in ICRP-30.[7] The results of these calculations for an AMAD of 20 μm suggest that there would be a decrease in inhalation dose by a factor of approximately 3.5. A soil particle size of 20-μm AMAD is considered to be the most representative of actual expected site conditions.[5] As the particle size increases with negligible wind speed as shown in Table 3, the dose contribution from inhalation using the new dose conversion factor decreases from 0.34 mrem/yr per pCi/g to 0.09 mrem/yr per pCi/g. The allowable concentration of Th-230 remaining in soil which results in 100 mrem/yr EDE in 1000 years increases from 51 to 59 pCi/g as particle size increases from 1 μm to 20 μm. When the concentration of Th-230 in soil is below 59 pCi/g, further remedial action will not be required. In addition, the dose to the intruder will be below the proposed guidelines.[8,9]

The results in Table 4 confirm Table 2 results which show that the change in wind speed affects dose contribution from radon and its daughter products only.

4.0 SUMMARY:

The results demonstrate that the Generic Protocol for Th-230 Cleanup/Verification at UMTRA Project Sites[1] will be effective in maintaining dose contribution to the general public via various pathways, that are below proposed guidelines.[8,9] Also, the larger AMAD of 20 μm encountered at the various UMTRA Project sites will result in a lower internal dose contribution than the standard 1 μm default value, specifically for inhalation.

5.0 REFERENCES:

1. Generic Protocol for Thorium-230 Cleanup/Verification at UMTRA Project Sites, DOE-UMTRA, Albuquerque, NM. December 13, 1993.

2. Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD, Version 5.0, ANL/EAD/LD-2, Argonne National Laboratory, Argonne, IL. September 1993.

3. Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil, ANL/EAIS-8, Argonne National Laboratory, Argonne, IL. April 1993.

4. Residual Radioactive Contamination from Decommissioning Technical Basis for Translating Contamination Levels to Annual Dose, NUREG/CR-5512, Battelle Pacific Northwest Laboratory, Richland, WA. January 1990.

5. D.E. Gonzales, K.K. Nielson, and V.C. Rogers, "Measurements of Radon Gas Diffusion in Cobbly Soils," RAE-8944/3-1, Rogers & Associates Engineering Corporation, Salt Lake City, UT. September 1991.

6. C. Yu, Argonne National Laboratory, Argonne, IL. Private Communication. February 18, 1994. Additional Information provided in memo to file included with the attachments.

7. "Section 5.5., Particle Size Correction," in Limits for Intakes of Radionuclides by Workers, ICRP-30, Part 1, Including Addendum, Volume 2, No. 3/4. 1979. p. 29.

8. Issues Paper on Radiation Site Cleanup Regulations, EPA 402-R-93-084, United States Environmental Protection Agency, Washington, DC. September 1993.

9. Draft Radiological Criteria for Decommissioning, United States Nuclear Regulatory Commission, Washington, DC. 1993.

6.0 ATTACHMENTS:

1. Tables 1 through 4.

2. Calculations.

3. RESRAD printouts.

Table 1
Effective Dose Equivalent (EDE) Contribution from 1 pCi/g of Th-230
Distributed in a 100 m^2 Contaminated Area
Wind Speed = 0.02 m/s, Particle Size = 1-μm AMAD

Year	Ground mrem/yr (%)	Inhalation (Exclude Radon) mrem/yr (%)	Radon & Progeny mrem/yr (%)	Plant mrem/yr (%)	All Pathways mrem/yr (100%)[1,2]	100 mrem/yr concentration in pCi/g[3]
0	1.1E-3 (0.3)	3.4E-1 (97.8)	0.0E0 (0.0)	4.6E-3 (1.4)	3.4E-1	291
1	4.9E-3 (1.4)	3.4E-1 (96.5)	5.0E-4 (0.1)	4.8E-3 (1.4)	3.5E-1	287
10	3.9E-2 (10.0)	3.4E-1 (86.5)	5.0E-3 (1.3)	6.6E-3 (1.7)	3.9E-1	258
100	3.3E-1 (44.5)	3.4E-1 (44.8)	4.3E-2 (5.8)	3.4E-2 (4.6)	7.5E-1	133
1000	1.3E0 (65.1)	3.4E-1 (17.3)	1.3E-1 (6.9)	1.4E-1 (7.1)	2.0E0	51

Notes:

1. Shielding Factor-inhalation = 1.0, Shielding Factor-External Gamma = 1.0, Fraction of Time Spent Outdoors on Site = 1.0.
2. Since the individual is spending 100% of their time outdoors on site, dose contributions from the ingestion pathways other than plants (e.g., meat, milk, water, fish, etc.) contribute to less than 4% of the total dose contribution from all pathways.
3. The selected annual limit of 100 mrem/yr EDE from ionizing radiation is cited in the following regulations: a) 10 CFR 20 (NRC), "Standards for Protection Against Radiation," which applies to all radioactive sources and all pathways, and b) Draft 10 CFR 834 (DOE), "Radiation Protection of the Public and the Environment," which applies to all radioactive sources and pathways.

Table 2
Effective Dose Equivalent (EDE) Contribution from 1 pCi/g of Th-230
Distributed in a 100 m^2 Contaminated Area
Wind Speed = 2.0 m/s, Particle Size = 1-μm AMAD

Year	Ground mrem/yr (%)	Inhalation (Exclude Radon) mrem/yr (%)	Radon & Progeny mrem/yr (%)	Plant mrem/yr (%)	All Pathways mrem/yr (100%)[1,2]	100 mrem/yr concentration in pC./g[3]
0	1.1E-3 (0.3)	3.4E-1 (97.8)	0.0E0 (0.0)	4.6E-3 (1.4)	3.4E-1	291
1	4.9E-3 (1.4)	3.4E-1 (96.6)	5.7E-8 (<0.0)	4.8E-3 (1.4)	3.5E-1	288
10	3.9E-2 (10.1)	3.4E-1 (87.6)	5.6E-7 (<0.0)	6.6E-3 (1.7)	3.8E-1	261
100	3.3E-1 (47.2)	3.4E-1 (47.6)	4.9E-6 (<0.0)	3.4E-2 (4.8)	7.1E-1	141
1000	1.3E0 (69.9)	3.4E-1 (18.6)	1.5E-5 (<0.0)	1.4E-1 (7.6)	1.8E0	55

Notes:

1. Shielding Factor-inhalation = 1.0, Shielding Factor-External Gamma = 1.0, Fraction of Time Spent Outdoors on Site = 1.0.
2. Since the individual is spending 100% of their time outdoors on site, dose contributions from the ingestion pathways other than plants (e.g., meat, milk, water, fish, etc.) contribute to less than 4% of the total dose contribution from all pathways.
3. The selected annual limit of 100 mrem/yr EDE from ionizing radiation is cited in the following regulations: a) 10 CFR 20 (NRC), "Standards for Protection Against Radiation," which applies to all radioactive sources and all pathways, and b) Draft 10 CFR 834 (DOE), "Radiation Protection of the Public and the Environment," which applies to all radioactive sources and pathways.

Table 3
Effective Dose Equivalent (EDE) Contribution from 1 pCi/g of Th-230
Distributed in a 100 m^2 Contaminated Area
Wind Speed = 0.02 m/s, Particle Size = 20-μm AMAD

Year	Ground mrem/yr (%)	Inhalation (Exclude Radon) mrem/yr (%)	Radon & Progeny mrem/yr (%)	Plant mrem/yr (%)	All Pathways mrem/yr (100%)[1,2]	100 mrem/yr concentration in pCi/g[3]
0	1.1E-3 (1.1)	9.0E-2 (92.2)	0.0E0 (0.0)	4.6E-3 (4.7)	9.8E-2	1019
1	4.9E-3 (4.8)	9.0E-2 (88.1)	5.0E-4 (0.5)	4.8E-3 (4.7)	1.0E-1	974
10	3.9E-2 (27.2)	9.1E-2 (63.3)	5.0E-3 (3.5)	6.6E-3 (4.6)	1.4E-1	700
100	3.3E-1 (66.1)	9.1E-2 (18.1)	4.3E-2 (8.6)	3.4E-2 (6.8)	5.1E-1	198
1000	1.3E0 (74.4)	9.5E-2 (5.5)	1.3E-1 (7.8)	1.4E-1 (8.1)	1.7E0	59

Notes:
1. Shielding Factor-inhalation = 1.0, Shielding Factor-External Gamma = 1.0, Fraction of Time Spent Outdoors on Site = 1.0.
2. Since the individual is spending 100% of their time outdoors on site, dose contributions from the ingestion pathways other than plants (e.g., meat, milk, water, fish, etc.) contribute to less than 4% of the total dose contribution from all pathways.
3. The selected annual limit of 100 mrem/yr EDE from ionizing radiation is cited in the following regulations: a) 10 CFR 20 (NRC), "Standards for Protection Against Radiation," which applies to all radioactive sources and all pathways, and b) Draft 10 CFR 834 (DOE), "Radiation Protection of the Public and the Environment," which applies to all radioactive sources and pathways.

Table 4
Effective Dose Equivalent (EDE) Contribution from 1 pCi/g of Th-230
Distributed in a 100 m^2 Contaminated Area
Wind Speed = 2.0 m/s, Particle Size = 20-μm AMAD

Year	Ground mrem/yr (%)	Inhalation (Exclude Radon) mrem/yr (%)	Radon & Progeny mrem/yr (%)	Plant mrem/yr (%)	All Pathways mrem/yr (100%)[1,2]	100 mrem/yr concentration in pCi/g[3]
0	1.1E-3 (1.1)	9.0E-2 (92.2)	0.0E0 (0.0)	4.6E-3 (4.7)	9.8E-2	1019
1	4.9E-3 (4.8)	9.1E-2 (88.6)	5.7E-8 (<0.0)	4.8E-3 (4.7)	1.0E-1	979
10	3.9E-2 (28.1)	9.1E-2 (65.6)	5.6E-7 (<0.0)	6.6E-3 (4.8)	1.4E-1	725
100	3.3E-1 (72.2)	9.1E-2 (19.8)	4.9E-6 (<0.0)	3.4E-2 (7.4)	4.6E-1	216
1000	1.3E0 (80.7)	9.5E-2 (6.0)	1.5E-5 (<0.0)	1.4E-1 (8.8)	1.6E0	64

Notes:

1. Shielding Factor-inhalation = 1.0, Shielding Factor-External Gamma = 1.0, Fraction of Time Spent Outdoors on Site = 1.0.
2. Since the individual is spending 100% of their time outdoors on site, dose contributions from the ingestion pathways other than plants (e.g., meat, milk, water, fish, etc.) contribute to less than 4% of the total dose contribution from all pathways.
3. The selected annual limit of 100 mrem/yr EDE from ionizing radiation is cited in the following regulations: a) 10 CFR 20 (NRC), "Standards for Protection Against Radiation," which applies to all radioactive sources and all pathways, and b) Draft 10 CFR 834 (DOE), "Radiation Protection of the Public and the Environment," which applies to all radioactive sources and pathways.