Americium-241 Contamination in the Town of Tonawanda Landfill
Review of 1989 State Task Force Decision and Recommendations for Future Management

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July 2005

1.0 Introduction

1.1 Purpose of this Report

In 1984, it was discovered that the Town of Tonawanda Landfill, in Erie County, New York, contained incinerator ash that was contaminated with a radioactive material, americium-241 (Am-241). In 1989, a State Agency Task Force decided that the ash could remain in the landfill. For a number of reasons not related to the americium contamination, a final cover has not yet been installed on the landfill. In 2001, the New York State Department of Environmental Conservation ("DEC" or "the Department"), in consultation with the New York State Department of Health ("DOH"), undertook a review of the history and current information regarding the americium contamination, to assess whether the 1989 decision would be considered consistent with current regulations and guidance for sites contaminated with radioactive materials. The Department tested the solubility of the americium, sampled and analyzed groundwater at the landfill, and performed radiation dose pathway analyses. This report describes those studies and the results.

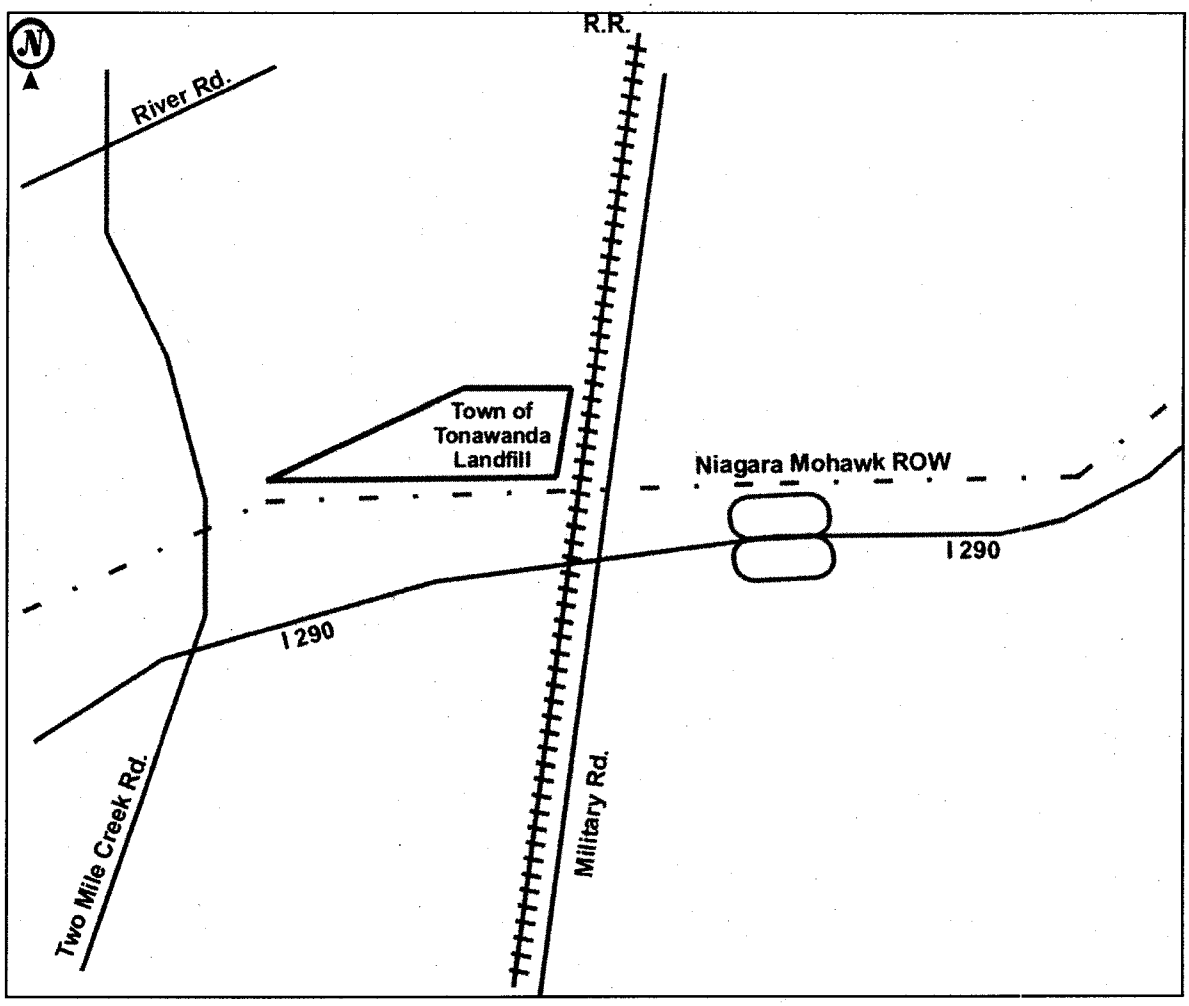
1.2 History

The Town of Tonawanda owns an inactive municipal landfill in the Town of Tonawanda, Erie County. It is located about a quarter mile east of Two Mile Creek Road and a quarter mile north of Interstate Highway 290 (see Figure 1, page 2). Landfill operations began in the mid-1930s and continued through October 1989. In the later years, the landfill was used for the disposal of various solid wastes, including ash from the Town's incinerator, which was located adjacent to the landfill. The wastes treated in the incinerator included sludge from the Town's sewage treatment plant.

Between 1977 and 1983, EAD Metallurgical, Inc. (EAD) operated at 71 Pearce Avenue in the Town of Tonawanda. EAD manufactured radioactive foils containing americium-241 for use in smoke detectors. The company discharged wastewater containing americium-241 into the Town's sewer system. The wastewater was treated in the Town's sewage treatment plant, where the americium-241 was concentrated in the sludge. When the sludge was incinerated, the americium-241 was further concentrated in the incinerator ash, which was then placed in the Town landfill. As a result of EAD's discharges, the sewer, the sewage treatment plant, the incinerator, and the landfill were all contaminated with americium-241.

The americium contamination was detected in 1984, during an initial effort to decontaminate the building EAD had occupied. This was brought to the attention of the two New York State agencies that regulated EAD, the Department of Environmental Conservation and the Department of Labor. Because the contamination extended into buildings and facilities beyond EAD, and therefore posed a radiation risk to the general public, the State Department of Health also became involved. In 1984, representatives of those three agencies served on a State Agency Task Force to address the contamination. The Task Force was headed by the Department of Health.

Figure 1. Location of Town of Tonawanda Landfill



The Town received an appropriation from the State legislature, which was used to remediate the sewage treatment plant, the sewer lines, and the incinerator. No State funds were appropriated to remove the americium contaminated ash from the landfill.

In an April 10, 1989 letter (Attachment 1), DOH informed the Town that the Town's proposal to cover the americium-241 in the landfill with three feet of hard fill and a clay cap was "acceptable to the Task Force." There is no documentation from that time describing the basis for the decision. However, in 1984, DOH staff had prepared a draft report on the americium-241 contamination in Tonawanda, which may have been considered by the Task Force. The draft was distributed to the Task Force for review, but apparently, was not issued as a final report.

The 1984 DOH draft report included a section entitled "Estimates of Public Health Impact," in which DOH evaluated the potential radiation dose to landfill workers and to an individual riding a bicycle on the landfill (these were considered the most likely exposure pathways). DOH concluded that the site did not pose an immediate health threat, but that the site warranted remedial action. Two options were evaluated: (1) removal to a low-level radioactive waste site and (2) on-site stabilization (by covering the material, not by in-situ chemical or thermal treatment). The draft report did not recommend a remedial action, but it did conclude that on-site stabilization could meet federal guidance, if land use restrictions were in place and routine monitoring would be conducted to assure that the material does not migrate off the site.

On March 13, 1991, the DOH wrote to the Town again regarding closure of the landfill. In this letter (Attachment 2), DOH stated that the three feet of additional cover material proposed in 1989 would not be necessary. The letter stated that the additional fill was considered necessary in 1989 because at the time, the Town had requested approval to place other americium-contaminated wastes in the landfill. However, the Department of Environmental Conservation did not approve that proposal, and the additional wastes were disposed of at a licensed low-level radioactive waste disposal facility. Therefore, DOH concluded in the 1991 letter, the additional fill would not be necessary.

In the spring of 2001, the US Army Corps of Engineers asked the State about the basis for the Task Force's 1989 decision regarding the disposition of the ash in the landfill. In a letter dated April 12, 2001 (Attachment 3), DOH described a number of technical factors on which the decision was based:

- Closure was not considered an acceptable remediation for unrestricted release, but required continued control of the use of the site; thus, there was a requirement for stabilization of the material on site; cover with clean soil to a minimum of three feet and a clay cap; and in addition to any deed restriction imposed by the landfill closure, a notation indicating the estimated ash volume and Am-241 activity in the deed.

- Criteria for residual contamination used were those provided by NRC's Branch Technical Position on "Disposal or On-Site Storage of Thorium and Uranium Wastes from Past Operations"; This was prior to the development of the RESRAD computer program (and others) that allows calculation of residual contamination of other isotopes under various scenarios;

- Americium in the landfill came from the ash that was produced by incinerating the sludge at the Sewage Treatment Plant (STP). Americium oxide is highly insoluble.

- Samples taken at the site showed no evidence of mobility of the contaminant to the surrounding environment;

- The Americium at the landfill did not pose an immediate health threat.

This paper reviews those factors, in light of additional sampling, analyses, and dose assessments performed by DEC between 2002 and 2004. Those results are compared to current regulatory requirements that are considered relevant to the Tonawanda Landfill.

2. Historical Data on Extent of Contamination

2.1 New York State Department of Health Investigation, 1984

In 1984, DOH prepared a draft report on the americium contamination in the Town of Tonawanda. The DOH had performed radiological surveys and collected a limited number of samples, including ash from the incinerator and contaminated soil and ash from the landfill. Five soil samples and one ash sample were taken from the landfill. Results ranged from <0.2 to 300±100 picocuries per gram (pCi/g).

DOH estimated the total americium-241 activity in the landfill at 3.8 ± 2.5 curies. This was based on the average concentration of americium-241 found in five ash samples (380± 250 pCi/g) and the total amount of ash known to have been disposed of at the landfill (9,996 tons). The average concentration of 380 pCi/g was obtained from five samples: one 1979 clinker, one 1981 ash sample, and three 1983 ash samples.

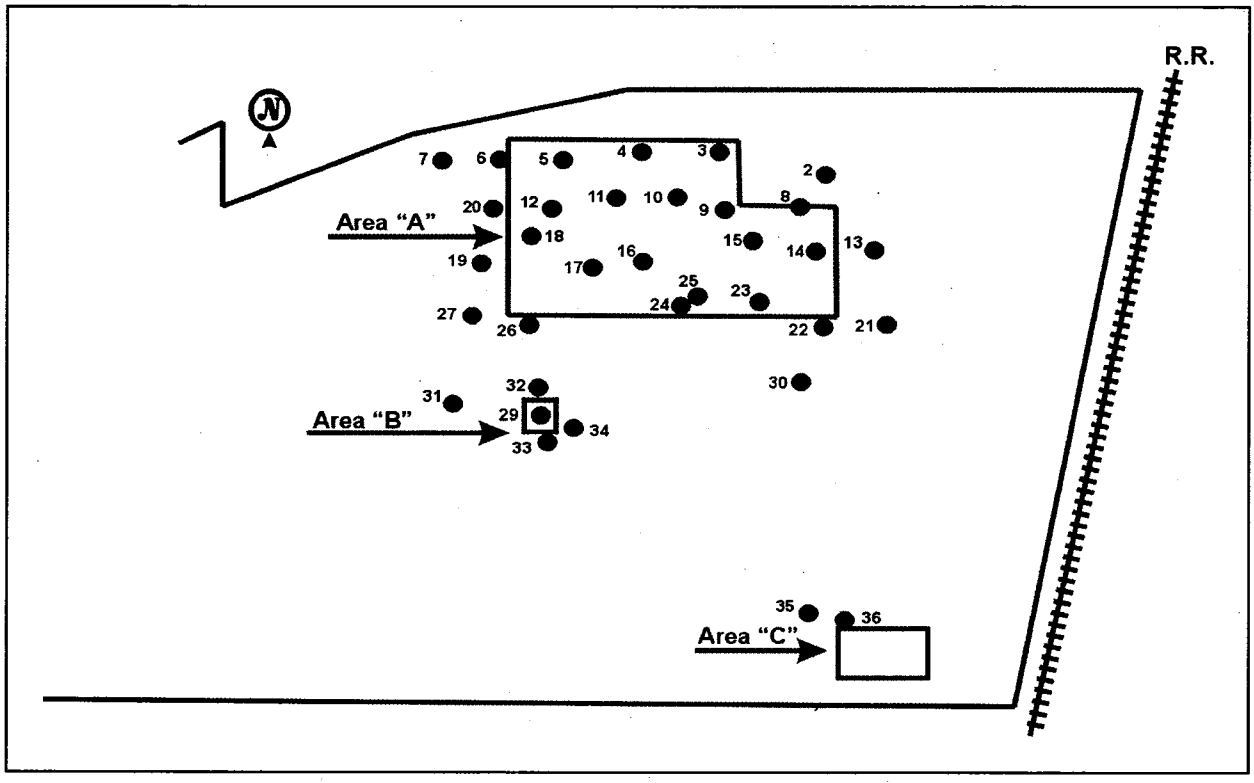
2.2 TMA/Eberline Characterization, 1988

In 1987, the Town of Tonawanda hired TMA\Eberline to perform a radiological survey of the landfill, in preparation for final closure (TMA/Eberline, 1988). The purpose was not to determine the distribution and concentration of contamination throughout the landfill, but rather to obtain information that would be needed for landfill closure operations (such as to determine where additional cover would be required). The study was designed to define the following: (1) the horizontal extent of the americium contaminated ash deposited on the landfill, (2) the concentrations of americium-241 in ash on the surface, (3) the extent of contamination in near-surface soil of the landfill, and (4) the vertical extent of americium contamination.

The survey included radiation measurements at the surface, collection and analysis of surface samples, and borings to investigate the subsurface. The total number of boreholes was limited to 40; therefore, the borings were concentrated in and around the areas where americium-241 was detected at the surface. Some boreholes were placed outside those areas, to define their limits.

Three areas of contamination were delineated and labeled Areas A, B and C (see Figure 2, below). Area A (about 7,500m^2 in area) is located on the northeast side of the landfill. Areas B (1,060 m^2) and C (230 m^2) are located south of Area A. The surface soil outside of Areas A, B and C, and inside the survey boundaries, was found to be free of americium-241 contamination. In addition, boreholes placed around the three contaminated areas and at random locations outside them found either no americium-241, or low concentrations (up to 13 pCi/g). However, there were areas between the contaminated areas where no borings were taken (see Figure 2, below).

Figure 2. Americium-241 Contaminated Areas in the Tonawanda Landfill Showing Locations of Boreholes in 1988



TMA/Eberline collected and analyzed 118 samples from a total of 34 boreholes (six were not completed, for various reasons). Of those 34 boreholes, 19 yielded results greater than the MDA in at least one depth interval (MDAs ranged from 1 to 6 pCi/g). The average of all results (treating less than values as positive numbers) from these 19 boreholes is 50.5 pCi/g, with a standard deviation of 109. The maximum depth of contamination was six feet, and the maximum concentration reported was 544 pCi/g, in the zero- to one-foot interval.

Based on the TMA/Eberline results, the americium-241 is unevenly distributed vertically. In the same borehole, the concentration varied by hundreds of picocuries per gram, between one-

foot intervals. There is little or no correlation with depth, except that the concentration of americium-241 did not exceed 100 pCi/g in samples collected from depths greater than three feet.

3.0 DEC Investigations of Solubility of the Americium-241

3.1 Leach Tests

In 1984, the Task Force had assumed that the americium was highly insoluble, based on the chemical nature of americium and the fact that it had been incinerated. To test that assumption, in July 2002, DEC collected two samples of contaminated soil and ash from the Tonawanda Landfill. They were analyzed for americium-241. The results were 183 pCi/g ± 28 pCi/g and 104 pCi/g ± 15.7 pCi/g. The sample containing the higher concentration of americium-241 was used for a set of leachability tests.

Three aliquots of sample were subjected to the standard Toxicity Characteristic Leaching Procedure (TCLP) (EPA Method 1311), using leaching solutions at three pH levels: 3.5, 4.9, and 10.0 (i.e., in all, nine aliquots were analyzed). The values of 3.5 and 10.0 were chosen to bracket the range of pH to which the ash in the landfill might be subjected:

- The 3.5 is based on the DEC Acid Deposition Reports for the years 1995 through 2000. The minium pH of rainfall reported for the Buffalo, New York, sampling station was 3.77, in 1995.

- The 10.0 is based on data presented in the *Landfill Closure Investigation Report* for the Tonawanda Landfill (Malcolm Pirnie, 1995), prepared for closure of the landfill under 6 NYCRR Part 360. The pH results from monitoring wells sampled in January 1995, February 1995, July 1998, December 1998, June 1999, December 1999, and March 2002 were reviewed. The maximum pH reported was 10.0.

- The pH of 4.9 was chosen as an intermediate pH.

In December 2003, DEC collected a third sample of ash from the contaminated area. It was used in two more leach tests, at pH 6.5 and 7.9. All results are presented in Table 1, page 7.

These results indicate that the americium-241 is soluble only at very low pH (3.5). Based on pH measurements reported in the *Landfill Closure Investigation Report* (Malcolm Pirnie, 1995) and the report on the *Characterization of Waste/Fill Material on the Niagara Mohawk Power Corporation ROW Located Adjacent to the Town of Tonawanda Landfill* (Malcolm Pirnie, 1999), the pH in landfill leachate ranges from 6.65 to 9.79. Therefore, under current conditions, the americium-241 would be insoluble. This confirms the Task Force's 1989 assumption.

Table 1. Solubility of Americium-241 in Ash Samples from the Town of Tonawanda Landfill

pH of Leach Test	Sample ID	Am-241 in Ash Before Leaching (pCi/g)	Am-241 Leachate (pCi/l)	Result or MDA*	Am-241 in Leachate (pCi/cc)	% Soluble **
3.5	NR902-PH3.5A	1.58E+02	2.43E+03	result	2.43E+00	1.53797
3.5	NR902-PH3.5B	1.58E+02	1.89E+03	result	1.89E+00	1.19620
3.5	NR902-PH3.5C	1.58E+02	1.85E+03	result	1.85E+00	1.17089
4.9	NR90S0702S071607	1.83E+02	1.13E+00	MDA	1.13E-03	0.00062
4.9	NR9020702S071607 (D)	1.33E+02	5.98E-01	MDA	5.98E-04	0.00045
4.9	NR9020702S071608	1.04E+02	3.60E-01	MDA	3.60E-04	0.00035
6.5	NR9031203S121716-6.5	3.20E+02	2.24E-02	MDA	2.24E-05	0.00001
6.5	NR9031203S121716-6.5 (D)	3.20E+02	1.63E-02	MDA	1.63E-05	0.00001
7.9	NR9031203S121716-7.9	3.20E+02	1.11E-01	result	1.11E-04	0.00003
10.0	NR902-PH10-A	1.58E+02	5.72E+00	result	5.72E-03	0.00362
10.0	NR902-PH10-B	1.58E+02	5.24E+00	result	5.24E-03	0.00332
10.0	NR902-PH10-C	1.58E+02	4.06E+00	result	4.06E-03	0.00257

* When the analytical result for the concentration of americium-241 in the leachate was less than the minimal detected activity (MDA), the MDA was used in the calculations.

** Calculated as follows, assuming density of leachate is 1 g/cc:

$$\frac{\text{Am-241 in leachate (pCi/cc)}}{\text{Am-241 in ash before leaching (pCi/g)}} \times 100$$

(D) = duplicate analysis

3.2 Groundwater Monitoring

In addition to the tests performed on the ash samples, DEC collected groundwater samples to assess whether the americium-241 has entered the groundwater. Samples were collected in September 2001, July 2003, and December 2003. The results are presented in Table 2, on pages 9 and 10.

Americium-241 was positively detected (i.e., the result, minus the counting uncertainty, was greater than the minimal detected activity) in two samples, from well BM 15 in September 2001, and well DW2, in December 2003. In BM 15, the analytical result was 1.79 ± 0.88 pCi/l. BM 15 was sampled again in July 2003 and in December 2003. Those later results were less than the minimal detected activity (MDA). The December 2003 result from well DW 2 was 0.40 ± 0.24 pCi/l. DW 2 was also sampled in July 2003, and the result was less than the MDA.

Based on these results, very little, if any, americium-241 has reached the groundwater in the 20 years since the material was placed in the landfill. This supports the Task Force's assumption that the americium-241 is insoluble.

Table 2. Results of NYSDEC Groundwater Sampling at Tonawanda Landfill

Note: Results in bold indicate that result minus counting uncertainty is greater than the MDA

Date/ Sample No.	Well No.	Am-241 (pCi/l)	+/- (pCi/l)	MDA
20 SEP 01				
RN9000903W092002	BM 15	**1.79**	0.88	0.49
RN9000903W092006	BM 17	0.07	0.21	0.53
RN9000903W092005	BM 18	0.09	0.26	0.62
RN9000903W092003	BM 19	0.85	0.54	0.36
RN9000903W092007	BM 4	0.28	0.41	0.77
RN9000903W092004	BM 8	0.26	0.43	0.88
RN9000903W092001	L 3	0.64	0.55	0.73
min		0.07		0.36
max		1.79		0.88
10 JUL 03				
NR9030704W072214	BM 13 D	0.16	0.18	0.14
NR9030704W072203	BM 13 S	-0.04	0.03	0.31
NR9030704W072213	BM 14 S	0.36	0.30	0.42
NR9030704W072204	BM 15	0.14	0.17	0.28
NR9030704W072205	BM 16	0.02	0.10	0.29
NR9030704W072209	BM 17	0.28	0.27	0.40
NR9030704W072206	BM 18	0.08	0.13	0.25
NR9030704W072207	BM 19	0.02	0.09	0.26
NR9030704W072210	BM 4	0.12	0.15	0.24
NR9030704W072215	BM 7	0.26	0.25	0.37
NR9030704W072208	DW 1	-0.01	0.10	0.36
NR9030704W072212	DW 2	-0.05	0.04	0.36
NR9030704W072211	DW 4R	0.03	0.16	0.42
min		-0.05		0.14
max		0.36		0.42

Date/ Sample No.	Well No.	Am-241 (pCi/l)	+/- (pCi/l)	MDA
12 DEC 03				
NR9031203W121708	BM 13D	0.06	0.09	0.14
NR9031203W121707	BM 13S	-0.01	0.02	0.26
NR9031203W1217010	BM 14S	0.07	0.10	0.17
NR9031203W121709	BM 15	0.05	0.08	0.13
NR9031203W1217015	BM 16	0.41	0.65	1.04
NR9031203W121705	BM 17	0.02	0.05	0.14
NR9031203W121706	BM 18	0.09	0.12	0.21
NR9031203W121703	BM 19	0.09	0.11	0.19
NR9031203W1217012	BM 7	0.02	0.07	0.17
NR9031203W121704	DW 1	0.02	0.06	0.15
NR9031203W1217014	DW 2	**0.40**	0.24	0.15
NR9031203W1217013	DW 4	0.10	0.11	0.15
NR9031203W1217011	DW 4R	-0.03	0.03	0.33
min		-0.03		0.13
max		0.41		1.04

4. Historical Data on Movement of the Americium-241

According to the DOH's April 12, 2001 letter, another factor the Task Force considered in making the 1989 decision was that there was no evidence of mobility of the contaminant to the surrounding environment. The1984 draft report prepared by DOH states, "Water samples were collected from a number of rainwater collection areas on-site as well as from drainage ditches and adjacent storm sewer systems." The draft report concluded, "While not all samples have been analyzed, all indications obtained so far point to no significant public exposure to americium-241 migrating through air or water from the contaminated locations."

In 1988, TMA/Eberline found no indication that americium-241 was migrating from the site, based on observations, samples, and boreholes on the north slope of the landfill and the slope south of Area C.

In 1992, Oak Ridge National Laboratory (ORNL, 1993) conducted a radiological survey of the western portion of the landfill and a small area south of the landfill. The ORNL survey did not include the eastern part of the landfill, where the americium contaminated ash was known to be present. ORNL reported detecting concentrations of americium-241 ranging from 0.10 to 0.67 pCi/g, in seven surface samples. These were located near the road that went from the incinerator to the eastern section of the landfill. ORNL speculated that the americium-241 resulted from hauling the incinerator ash to the disposal area. The fact that ORNL found americium-241 only near the old incinerator provides some confirmation that the americium-241 did not move to other parts of the landfill.

5. Exposure Pathway and Dose Assessments Performed

In the 1980s, the Task Force relied on the NRC's Branch Technical Position, "Disposal or On-Site Storage of Thorium and Uranium Wastes from Past Operations." That approach was recommended by the NRC in a May 19, 1984 letter written in response to DEC's request for guidance on acceptable limits for americium-241 contamination in the landfill. The Branch Technical Position had been issued in 1981. The NRC advised DEC that although the Branch Technical Position addressed uranium and thorium contamination, it would be appropriate to apply the criteria in it to americium.

The NRC's Branch Technical Position recommended various site closure options, based on the average concentration of uranium or thorium in the soil. Since that time, the approach to setting criteria for residual radioactive materials has changed. Current criteria are expressed in terms of a limit on the radiation dose an individual could receive from the radioactive materials remaining on the site. To assess compliance with dose-based criteria, site-specific pathway analyses and dose assessments must be performed.

In 2004, DEC used the RESRAD code (version 6.21), developed by Argonne National Laboratory, to estimate the potential radiation dose to an individual from the americium-241 in the landfill. RESRAD is a computer-based model designed to estimate radiation doses to

humans from RESidual RADioactive materials. It is currently the standard approach to assessing the impacts of radioactive material contamination in soils.

5.1 Scenario Modeled

The half-life of americium-241 is 432 years. When estimating dose rates from long-lived radionuclides, it is reasonable to model the exposure scenario under which a person could receive the highest dose from the radioactive material, even though land use controls will be put in place with the intention of preventing such doses. Estimating doses under such a scenario presents an estimate of the upper bound to the possible hazards, and provides information on the consequences, if the land use controls fail.

In this case, the resident farmer scenario was modeled. It was assumed that a person lives on the contaminated property. In addition, a portion of the resident's food is produced on the contaminated land, and water used for drinking and crop irrigation comes from a well on the edge of the contaminated area.

5.2 Input Parameters

Site-specific parameter values were used to the extent they were available, particularly for the parameters that describe the physical characteristics of the site. Site-specific values were selected for 38 of the 61 parameters needed to run the model for this site with the selected exposure pathways. Default values were used for the remaining 23 parameters. These included erosion rates for the cover and the contaminated zone, as well as most parameters for food and water consumption. All parameters used are presented in Table 3, on pages 13-17. A few specific parameters are discussed in this section.

Table 3. RESRAD Input Parameters - Default Values and Values Used for Tonawanda Landfill

Parameter	Value Used	Units*	Default Value	Notes (see key to references at end of table)
Soil bulk density				
Cover material	1.3	g/cm^3	1.5	Grading material placed on americium-241 areas will be soil (EnSol, 2002). 1.3 selected based on nature of soils in western New York.
Contaminated zone	1.3	g/cm^3	1.5	
Saturated zone	1.3	g/cm^3	1.5	
Total porosity				
Cover material	.48	-	0.4	Value used in HELP model simulations for Landfill Closure Investigation Report, Appendix E
Contaminated zone	0.44	-	0.4	Contaminated zone assumed to be ash, therefore, similar to fine sands or silt; In Table 3.2 of RRDCH, mean value for fine sand is 0.43, for silt is 0.45.
Saturated zone	.5	-	0.4	Based on on-site soil conditions
Effective porosity				
Contaminated zone	0.27	-	0.2	Contaminated zone assumed to be ash; therefore, similar to fine sands or silt; In Table 3.2 of RRDCH, mean value for fine sand is 0.33, for silt is 0.20; 0.27 is average.
Saturated zone	0.12	-	0.2	Based on on-site soil conditions
Hydraulic conductivity				
Contaminated zone	3.15 E3	m/yr	10	Based on on-site conditions
Saturated zone	0.315	m/yr	100	Based on on-site soil conditions
Precipitation rate	.96	m/yr	1	Local average rate - value used in HELP model simulations in Landfill Closure Investigation Report, Appendix E
Runoff coefficient	.24	-	0.2	Value used in HELP model simulations for Landfill Closure Investigation Report, Appendix E
Irrigation rate	0.48	m/yr	0.2	Calculated, based on RRDCH, Formula 11.2
Evapotranspiration coefficient	.63	-	0.5	Calculated: evapotranspiration rate/precipitation rate

Parameter	Value Used	Units*	Default Value	Notes (see key to references at end of table)
Soil-specific b parameter				
Contaminated zone	10.4	-	5.3	Value for silty clay soils, from Table 13.1, RRDCH
Saturated zone	10.4	-	5.3	Value for silty clay soils, from Table 13.1, RRDCH
Erosion rate				
Cover material	.001	m/yr	0.001	Default - conservative, because cover will be maintained for some time
Contaminated zone	.001	m/yr	0.001	Default
Hydraulic gradient	0.04	-	0.02	Considered conservative value, representative of average conditions for the site as a whole
Length of contaminated zone parallel to the aquifer flow	152.4	m	100	RRDCH defines as the maximum horizontal distance measured in the contaminated zone, from its upgradient edge to the down gradient edge, along the direction of the groundwater flow in the underlying aquifer. The predominant groundwater flow is to the west. Area A is about 500 feet wide in the east-west direction.
Watershed area for nearby stream or pond	1.55 E7	m^2	1 × 10 6	Area of Two Mile Creek watershed, reported in DOE RI 1993, p. 3-7
Water table drop rate	1.5	m/yr	0.001	Variation in water table is about 5 feet per year, on average.
Well-pump intake depth	6.1	m	10	Midpoint elevation of screens in many of the shallow wells at the landfill is about 20 feet.
Average annual wind speed	5.8	m/s	2	Average annual wind speed in western New York
Thickness of uncontaminated unsaturated zone	0	m	4	Waste in the landfill is in direct contact with the saturated zone.

Parameter	Value Used	Units*	Default Value	Notes (see key to references at end of table)
Fraction of time spent indoors on-site	.5	-	0.5	Default
Fraction of time spent outdoors on-site	.25	-	0.25	Default
Area of contaminated zone	8,800	m^2	10,000	TMA Eberline,1988, reported area of Area A as 81,000 square feet. Based on figure 3 of that report, the area of Area B is about 2,500 ft^2, and Area C, 11,440 ft^2 (9.29E-2 m^2/ft^2).
Cover depth	various	m	0	Three scenarios modeled: no cover; 2 m cover approved in 1989; 6.4 m, max thickness of cover now proposed (EnSol 2002)
Distribution coefficient	Am-241: 76,000 Np-237: 50	cm^3/g	**	Americium-241 value based on leach tests at pH 10 Np-237 value taken from RRDCH, Table 32.1 (value for clay).
Leach rate	0	1/yr	0	Value of 0 causes model to calculate this, based on the distribution coefficient (RRDCH Section 34.2).
Livestock fodder intake				
Meat	68	kg/d	68	Default
Milk	55	kg/d	55	Default
Mass loading for inhalation	2E-4	g/m^3	2×10^{-4}	Default
Milk consumption rate	92	L/yr	92	Model calculates portion from site based on ratio between contaminated zone area and minium area needed to obtain 92 L/y, 20,000 m^2 (RRDCH Section 47.1).
Shielding factor for inhalation	0.4	-	0.4	Default
Depth of roots	.9	m	0.9	Default
Soil ingestion rate	36.5	g/yr	36.5	Default

Parameter	Value Used	Units*	Default Value	Notes (see key to references at end of table)
Thickness of contaminated zone	1.8	m	2	TMA/Eberline 1988; maximum depth of positive Am-241 detection
Radiation dose limit	25	mrem/yr	30	NRC License Termination Rule (10 CFR 20)
Dilution length for airborne dust	3	m	3	Default
Seafood consumption rate				
Fish	5.4	kg/yr	5.4	Default
Other seafood	0.9	kg/yr	0.9	Default
Fruit, vegetable, and grain consumption rates	160	kg/yr	160	Default consumption rate; model assumes 50% is grown on contaminated area (RRDCH Section 42).
Inhalation rate	8400	m^3 /yr	8400	Default
Leafy vegetable consumption rate	7	kg/yr	14	Reduced default consumption rate due to difficulty in storing leafy vegetables; model assumes 50% is grown on contaminated area (RRDCH Section 44.).
Livestock water intake rate				
Meat	50	L/d	50	Default
Milk	160	L/d	160	Default
Meat and poultry consumption rate	63	kg/yr	63	Default
Shielding factor for external gamma	.7	-	0.7	Default
Elapsed time of waste placement	20	yr	0	EAD closed in April 1984.
Shape factor, external gamma	1	-	1	Default, i.e., contaminated area is assumed to be circular. For areas greater than 1,000 m^2, circle is acceptable approximation for purposes of calculating external gamma dose.

Parameter	Value Used	Units*	Default Value	Notes (see key to references at end of table)
Initial concentrations of principal radionuclide	100	pCi/g	**	Average of positive borehole sample results from TMA/Eberline 1988
Drinking water intake rate	510	L/yr	510	Default
Fraction of drinking water from site	1	-	1	Assumed 1, to be conservative; no pump tests have been done for potential yield.
Fraction of aquatic food from site	.01	-	0.5	Most would come from Lake Erie and Niagara River.
Mass loading for foliar deposition	1 x 10-4	g/m^3	1×10^{-4}	Default
Depth of soil mixing layer	.15	m	0.15	Default
Fraction from groundwater				
Drinking water	1	-	1	Assumed 1, to be conservative; no pump tests have been done for potential yield.
Livestock water	1	-	1	Assumed 1, to be conservative; no pump tests have been done for potential yield.
Irrigation water	1	-	1	Assumed 1, to be conservative; no pump tests have been done for potential yield.

* A hyphen indicates that the parameter is dimensionless.

** The default value is radionuclide dependent.

Sources Referenced in Notes

EnSol, 2002. - 11/15/02 letter from J. Battaglia, EnSol,. to B. Youngberg, DEC (Attachment 4)

TMA/Eberline, 1988 - TMA\Eberline, 1988. *Radiological Characterization of the Municipal Landfill, Town of Tonawanda, NY*, Albuquerque, NM. February 1988

RRDCH - RESRAD Data Collection Handbook - *Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil,* ANL/EAIS-8, Argonne National Laboratory, Argonne, Ill. April 1993

DOE RI - *Remedial Investigation Report for the Tonawanda FUSRAP site*, US Department of Energy, 1993

Landfill Closure Investigation Report - Malcolm Pirnie, 1995. *Landfill Closure Investigation Report*, Malcolm Pirnie, Inc., Buffalo, NY. 1995, Revised March 2002.

Distribution Coefficient for Americium-241

One parameter that has a major influence on the radiation doses predicted by RESRAD is the distribution coefficient, designated as K_d. The K_d represents the ratio between the concentration of the radionuclide in the soil and that in the groundwater. To obtain an estimate of the K_d for the americium-241 in the Tonawanda Landfill, an additional analysis was performed on the first set of leach tests described in section 3.1. For the samples leached at pH 3.5, 4.9, and 10, the post-leach ash was also analyzed for americium-241. (This was not done for the samples leached at 6.9 and 7.9; those samples were only analyzed to assess the solubility of americium-241 in that pH range.) The K_ds were then calculated as the americium-241 concentration in the post-leach ash divided by the americium-241 concentration in the leachate. The results are presented in Table 4, page 19.

To select the pH most representative of conditions in the landfill, historical data on the pH of landfill leachate was reviewed. The pH of leachate in the landfill was measured during studies conducted for the Town in preparation for landfill closure. The results are reported in the 1995 *Landfill Closure Investigation Report* (Malcolm Pirnie, 1995). Later, studies were performed adjacent to the landfill and reported in *Characterization of Waste/Fill Material on the Niagara Mohawk Power Corporation ROW Located Adjacent to the Town of Tonawanda Landfill* (Malcolm Pirnie, 1999). In each document, the pH measurements from five leachate samples were reported. The range of pH in those ten samples ranged from 6.65 to 9.79. Therefore, the K_d calculated at pH 3.5 is not representative of actual conditions, and it is not considered further in this report.

The K_ds derived from the leach tests performed at pH 4.9 and 10.0 are 450,000 and 76,000, respectively (see Table 4, page 19). Sensitivity studies were performed with RESRAD over that range of K_d values. The results of the sensitivity studies demonstrated that within that range, changing the K_d does not have a significant effect on the dose predictions. Therefore the K_d for americium-241 used in the model runs reported here was set at 76,000, which was derived from the leach test at pH 10.

Table 4. Estimates of Distribution Coefficient (K_d) for Americium-241 in Tonawanda Landfill

K_d Calculated as Ratio Between Concentration of Americium-241 in Post- Leach Ash (pCi/g) and Concentration of Americium-241 in Leachate (pCi/cc)

pH	Sample ID	Am-241 in Post- Leach Ash (pCi/g)	Am-241 in Leachate (pCi/l)	Result* or MDA	Leachate (pCi/cc)	K_d (cc/g) **	Mean K_d, Rounded (cc/g)
3.5	NR902-PH3.5A	5.10E+01	2.43E+03	MDA	2.43E+00	65	78
3.5	NR902-PH3.5B	5.4E+01	1.89E+03	MDA	1.89E+00	84	
3.5	NR902-PH3.5C	3.2E+01	1.85E+03	MDA	1.85E+00	85	
4.9	NR9020702S071607	3.42E+02	5.98E-01	MDA	5.98E-04	571,906	450,000
4.9	NR90S0702S071607	2.82E+02	1.13E+00	MDA	1.13E-03	249,558	
4.9	NR9020702S071608	1.86E+02	3.60E-01	MDA	3.60E-04	516,667	
10.0	NR902-PH10-A	3.80E+02	5.72E+00	result	5.72E-03	66,434	76,000
10.0	NR902-PH10-B	3.51E+02	5.24E+00	result	5.24E-03	66,985	
10.0	NR902-PH10-C	3.79E+02	4.06E+00	result	4.06E-03	93,350	

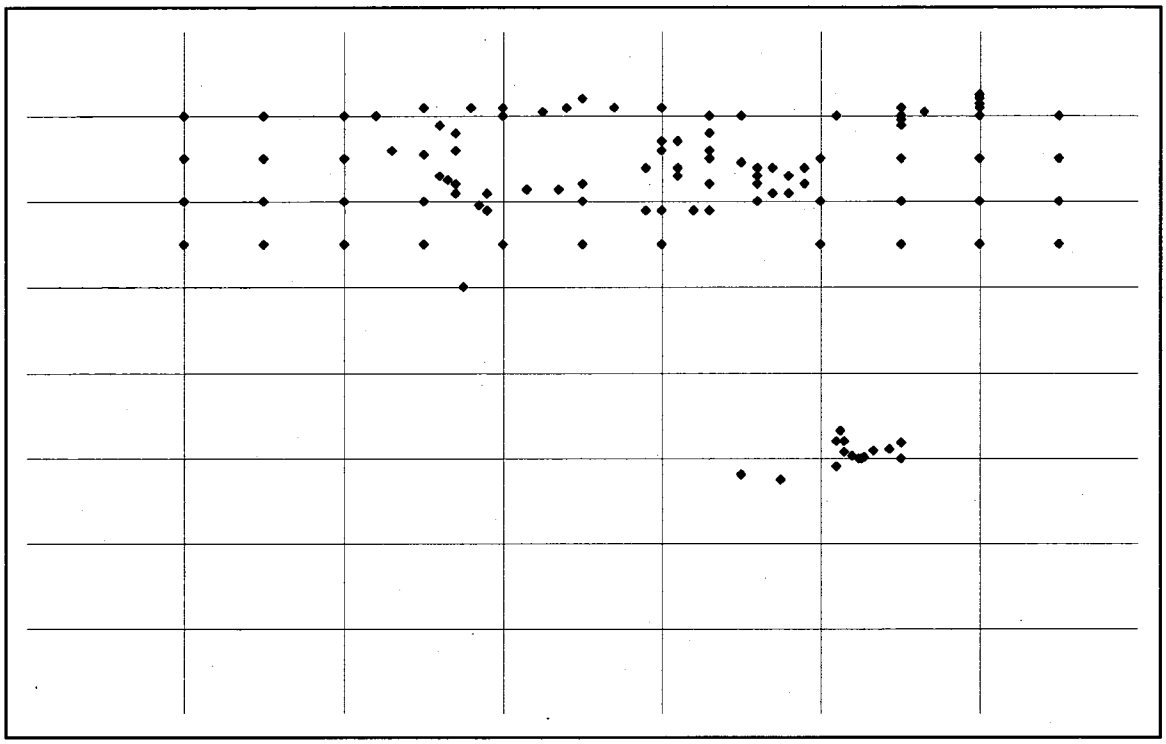
Source Term

To estimate the average concentration of americium-241 in the landfill, the data from the 1987 study by TMA\Eberline was reviewed (TMA/Eberline, 1988). TMA\Eberline collected a total of 34 cores from within and around the three areas that were found to be contaminated, based on surface scans and samples. An aliquot was taken from each one-foot interval, and some of those aliquots were analyzed using a FIDLER (Field Instruments for Detection of Low Energy Radiation) detector coupled to a Canberra 10 Multi-Channel Analyzer. TMA/Eberline also took gamma measurements down each borehole and concluded, "Review of the gamma measurement indicated that all of the samples taken would not require analysis." The specific criterion for selecting samples for analysis was not explained further in the report.

In all, 118 subsurface samples were analyzed for Am-241. Of those, the results for 38 samples were greater than the reported detection limit for the analysis (the detection limits ranged from 1 to 6 pCi/g). The 38 positive results ranged from 1 pCi/g to 544 pCi/g, with a mean of 97 pCi/g and a standard deviation of 137. Based on these results, the initial concentration of americium-241 in the landfill was assumed to be 100 pCi/g for the dose assessments. This is considered a reasonably conservative estimate, given that the mean of all 118 results (including MDAs as positive values) is 33 pCi/g.

Surface samples (0 to 2 inch depth) were also collected to define the boundaries of the surface contamination; 114 samples were collected. TMA/Eberline reported that in selecting the surface sample locations, "Attention was given to the definition of the surface boundaries of the americium-241 contamination rather than to sampling in the areas where FIDLER measurements indicated the highest concentrations of americium-241." Figure 3 (page 21) is a plot of the spatial distribution of the surface samples. It appears that some samples were collected on a grid, but others were concentrated in certain areas. The mean concentration of all surface samples (including MDAs as positive results) is 16 pCi/g; the range is < 1 to 157 pCi/g. These are significantly lower than the mean and range of the subsurface sample results.

Figure 3 Plot of Surface Sample Locations in 1988 Characterization Study, Showing Spatial Distribution



Cover Depth

In RESRAD, the parameter "cover depth" represents the thickness of the cover over the contaminated layer. Cover depth was varied to represent three options: no cover, two meters, and 6.4 meters. The no-cover option was modeled to assess the importance of the cover and to estimate the radiation dose impacts if the cover were removed. The two-meter cover approved by the Task Force in 1989 was modeled because one purpose of this paper is to review the assumptions the Task Force relied upon. The 6.4-meter cover option represents the maximum depth in the cover now proposed by the Town of Tonawanda (see Attachment 4). The additional cover material in the current design is needed to meet grading requirements for closure of the landfill under 6 NYCRR Part 360.

Decay Products of Americium-241

Neptunium 237 (Np-237) is the decay product of americium-241. The half-life of Np-237 is 2.14 million years; therefore, on a by-weight basis, Np-237 is far less radioactive than americium-241. After 5,000 years, virtually all of the americium-241 in the landfill will have decayed into Np-237 (and some of the Np-237 will have decayed into protactinium-233). However, the concentration of Np-237 in terms of radioactivity will be only about 0.02 pCi/g.

The initial concentration of Np-237 was set at zero. The K_d for Np-237 was kept constant, at 50, based on the value for Np-237 in clay reported in Table 32.1 in the data collection handbook for RESRAD (Yu, et al., 1993).

Time Frames

The model was initially run to predict doses for 5,000 years. This is sufficient for americium-241, which has a half-life of 432 years. Five thousand years is 11.6 half-lives, and at the end of that time period, the average concentration of americium-241 will be reduced by radioactive decay to 0.032 pCi/g. This is an insignificant concentration. However, under the 6.4-meter cover scenario, the maximum dose was predicted to occur at 5,000 years. In order to determine the year and magnitude of the maximum dose, that scenario was run for an additional 5,000 years.

5.2 Dose Assessment Results

The summary reports from the RESRAD runs and graphs showing the results are presented in Attachments 5 -13. The maximum dose rates are presented in Table 5:

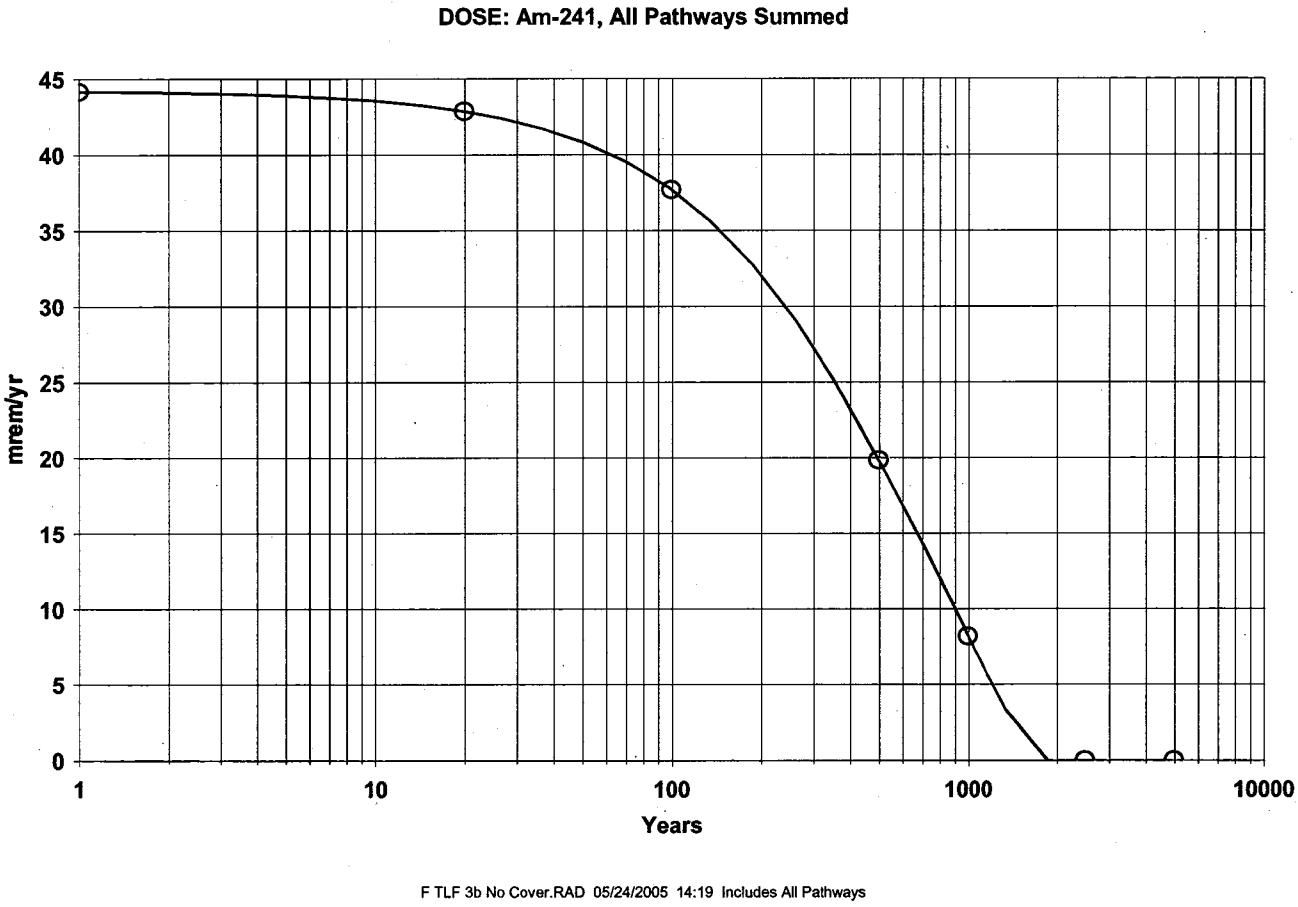
Table 5. Summary of RESRAD Model Results for Tonawanda Landfill

Cover Depth	Maximum Dose Rate (millirems./yr)	Year in Which Maximum Dose Rate Occurs
no cover	44	0*
2 m	1.8	2000 ± 4
6.4 m	0.0015	6398

* RESRAD reports the year of occurrence in terms of the number of years that have passed. Thus, doses that are predicted to occur in Year 0 are those that occur in the first year, i.e., before one year has elapsed.

The maximum dose rate predicted is about 44 millirems per year, under the no-cover option. This dose rate is predicted to occur during the first year, and declines gradually, over time (see Figure 4, page 23). Most of that dose is predicted to be delivered through the plant food, water independent pathway. That is, plants grown in the contaminated soil would take up americium-241 through their roots, and people who consume the plants would ingest the radioactive material. Sixty-nine percent of the maximum dose rate (30 millirems per year) is due to this pathway. The only other pathway contributing significantly to the maximum dose of 44 millirems per year is soil ingestion (10 millirems per year). The remainder of the total dose is due to direct radiation (2.5 millirems per year) and inhalation (1 millirem per year). The latter two pathways are insignificant.

Figure 4 No Cover Scenario - Graph of RESRAD Dose Estimates, All Pathways Summed



The model results with the 2-meter and the 6.4-meter covers demonstrate the value of the cover. With either cover in place, food crops would not grow in the contaminated soil, which would eliminate the dominant pathway for a radiation dose to people living on the site. If the cover is maintained, the maximum radiation dose is predicted to be less than 1 millirem per year.

The two cover scenarios assume that the cover material erodes at a constant rate of 0.001 meter per year. As a result, the model predicts that the two-meter cover is removed in 2,000 years. By that time, the americium-241 would have decayed to about 4 percent of its original concentration. The result is an insignificant dose rate, 1.8 millirems per year. With a 6.4-meter cover, the model predicts that the cover would preclude the plant pathway until the americium-241 had decayed to insignificant concentrations, and the resulting maximum dose rate is trivial, 0.0015 millirem per year.

5.3 Comparison of Dose Assessment Results to Current Regulations and Guidance

The americium contaminated ash was placed in the Town of Tonawanda Landfill unknowingly. The Department has not adopted regulations that set limits on doses resulting from inadvertent disposal of radioactive waste. However, the Department has adopted guidance that is useful for evaluating the results of the dose modeling. In addition, the US Nuclear Regulatory Commission (NRC) has adopted regulations to which the results can be compared.

DEC's Cleanup Guideline for Soils Contaminated with Radioactive Materials

In 1993, the Department of Environmental Conservation adopted a *Cleanup Guideline for Soils Contaminated with Radioactive Materials,* (DEC, 1993), which applies to sites that are remediated for radioactive contamination. The Guideline recommends that following cleanup, any residual radioactive material should not result in a radiation dose greater than 10 millirems per year to the maximally exposed member of the general public.

Although the landfill has not been remediated, it is useful to compare the RESRAD results to the 10 millirem per year guidance. The dose modeling results for the two scenarios with a cover in place predict a dose rate far less than 10 millirems per year. It is noteworthy that these scenarios take into account erosion of the cover; in the event that the cover is not actively maintained, it could still prevent uptake of the americium by plants, and therefore maintain radiation doses less than 10 millirems per year.

Under the no-cover scenario, leaving the americium in the landfill would not meet the dose guideline. The dose modeling predicts a dose of about 44 millirems per year to a resident farmer. Therefore, if the cover were actively removed from an area of sufficient size to allow residential farming on the contaminated soil, there is a potential for radiation doses to exceed the 10 millirem per year dose in the DEC guidance. Based on the half-life of americium-241 and assuming the concentration of americium is 100 pCi/g, this potential would exist for about 1,000 years.

US Nuclear Regulatory Commission Regulation

The NRC's regulation for license termination (10 CFR 20, Subpart E) establishes requirements for decommissioning of sites contaminated with licensed radioactive materials. These regulations, referred to as the License Termination Rule (LTR), are not directly applicable to the Town of Tonawanda Landfill; however, the LTR provides criteria for evaluating sites that cannot be released for unrestricted use. The LTR is therefore useful for evaluating the dose modeling results for the Tonawanda Landfill.

The LTR established a dose limit for unrestricted release of sites contaminated with radioactive materials: 25 millirems per year. With the cover in place at the Tonawanda Landfill, radiation doses would be well below that limit. If the cover is actively removed and the contaminated soil is used for residential farming, there is a potential for the dose to a resident

farmer to exceed 25 millirems per year. Based on the half-life of americium-241 and assuming the concentration of americium is 100 pCi/g, this potential would exist for about 400 years.

The LTR includes requirements that must be met if institutional controls, such as land use restrictions, are used to prevent doses greater than 25 millirems per year. Except in unusual circumstances, institutional controls can only be relied upon if it is demonstrated that in the event the controls fail, the resulting dose will be less than 100 millirems per year. The dose assessments reported in this paper predict that without the cover, the maximum radiation dose to a resident farmer would be 44 millirems per year. Therefore, relying on institutional controls at the Tonawanda Landfill is consistent with the NRC's LTR.

6. Alternative Considered by the Task Force

As noted in section 1, there is no formal documentation of the factors considered by the Task Force in deciding that the americium could remain in the landfill; however, the draft report prepared by DOH in 1984 was available to the Task Force. That draft report evaluated the option of removing the contaminated ash to a low-level radioactive waste disposal facility. The report concluded that there was an available disposal facility, in Richland, Washington. The estimated cost for disposal, assuming that the ash would be packaged in 76,200 fifty-five-gallon drums, was $22.8 million. The report pointed out that this did not include the cost of detailed characterization of the site, removal and packaging, nor restoration of the site. The report also noted that "removal of the ash also involves additional risks associated with exposure to workers, potential spread off-site and transportation of the material to a disposal site." There are no records in the Department's files indicating that removal of the ash was considered further in the years between 1984 and 1989, when the Task Force approved the Town's proposal.

There is no question that removal of the americium is feasible, but costly. Removal would eliminate the need to control use of the landfill for the next several hundred years. Removal and proper disposal is almost always the preferred option for remediating soil contaminated with long-lived radionuclides. In this particular case, the Task Force apparently relied upon the unique characteristics of the radionuclide involved (its insolubility, limited exposure pathways, and relatively low concentrations) and concluded that containment of this radioactive material within the landfill would be acceptable.

7. Conclusions

Based on the analyses and results reported here, as long as the americium remains insoluble and food crops are not grown in the contaminated soil, the americium will not present a significant radiation hazard to the public or the environment.

7.1 1989 Task Force Decision

DEC has performed leach tests, groundwater monitoring, and radiation dose assessments and compared them to the factors on which the Task Force based its 1989 decision that the

americium-241 could remain in the landfill. The results of DEC's recent investigations support a conclusion that those factors are valid under current conditions (each factor, as described in the DOH's April 12, 2001 letter, is presented in italics, followed by DEC's conclusion):

> *Closure was not considered an acceptable remediation for unrestricted release, but required continued control of the use of the site; thus, there was a requirement for stabilization of the material on site* [by covering the material, not by in-situ chemical or thermal treatment]*; cover with clean soil to a minimum of three feet and a clay cap; and in addition to any deed restriction imposed by the landfill closure, a notation indicating the estimated ash volume and Am-241 activity in the deed.*
>
> Based on the radiation dose projections performed by DEC and reported here, land use must be controlled to prevent significant radiation doses to the public from plant foods grown in the contaminated soil.
>
> *Criteria for residual contamination used were those provided by NRC's Branch Technical Position on "Disposal or On-Site Storage of Thorium and Uranium Wastes from Past Operations;" This was prior to the development of the RESRAD computer program (and others) that allows calculation of residual contamination of other isotopes under various scenarios;*
>
> DEC has now performed radiation dose projections using the RESRAD computer program, and compared the results to current, relevant guidelines and regulations. Containing the americium within the landfill will meet those criteria.
>
> *Americium in the landfill came from the ash that was produced by incinerating the sludge at the Sewage Treatment Plant (STP). Americium oxide is highly insoluble.*
>
> Leach tests and groundwater monitoring results reported here demonstrate that under current conditions, the americium is insoluble.
>
> *Samples taken at the site showed no evidence of mobility of the contaminant to the surrounding environment*
>
> Radiological surveys performed in 1988 and 1992 found no evidence that significant concentrations of americium had moved into the surrounding environment. Groundwater monitoring performed by DEC in 2002 and 2003 found no significant movement of americium to the groundwater.

The Americium at the landfill did not pose an immediate health threat.

The ameriucium is in the same location and form as it was in 1989, and the only changes to the landfill have been placement of alternate grading material on some portions. Therefore, this statement remains valid.

7.2 Current Regulatory Status of the Americium in the Landfill

At present, the authorization for the presence of the americium in the landfill is a letter, stating that a Task Force, which is no longer in existence, agrees with the Town's proposal to construct a cover over the contaminated soil. The DOH did not issue a radioactive materials license or order pursuant to its authority, nor did the DEC issue a permit, to authorize or control the permanent containment of the americium in the landfill. The americium in the landfill is currently unregulated.

8. Recommendations

The following actions are recommended:

1. During any landfill closure activities that have the potential to disturb the americium contaminated ash, measures should be taken to prevent dispersion of the americium and contamination of personnel and equipment.

2. The deed notations and land use restrictions called for in the 1989 Task Force letter should be put in place.

3. The monitoring program recommended in the 1984 draft report from DOH should be implemented. The landfill leachate and groundwater near the landfill should be periodically sampled and analyzed for americium-241, to assess whether or not the americium continues to be insoluble.

4. The americium in the landfill should be brought under regulatory control, either through an order signed by the Town and the Department, or by a permit issued under the applicable provisions in 6 NYCRR Part 380, 382, and 383. The order or permit should (1) require environmental monitoring for americium-241 and annual reporting to the Department on the status of the landfill, (2) prohibit disturbance of the cover of the landfill, unless the permit is modified to authorize such action, and (3) include other appropriate conditions, consistent with the applicable sections of Parts 380, 382, and 383.

9. References Cited

DEC, 1993. *Cleanup Guideline for Soils Contaminated with Radioactive Materials*, Division of Solid & Hazardous Materials, issued as Technical Administrative Guidance Memorandum-4003 (TAGM-4003) in 1993; reformatted as DEC Program Policy DSH-RAD-05-01 in 2005

Malcolm Pirnie, 1995. *Landfill Closure Investigation Report*, Malcolm Pirnie, Inc., Buffalo, NY. 1995, Revised March 2002.

Malcolm Pirnie, 1999. *Characterization of Waste/Fill Material on the Niagara Mohawk Power Corporation ROW Located Adjacent to the Town of Tonawanda Landfill.* Malcolm Pirnie, Inc., Buffalo, NY October 1999, Revised April 2000.

ORNL, 1992. *Results of the Radiological Survey at the Town of Tonawanda Landfill, Tonawanda, New York (TNY001)* (ORNL/RASA-92/12). R. E. Rodriguez, M. E. Murray, and M. S. Uziel, Oak Ridge National Laboratory, Oak Ridge, TN, October 1992

TMA\Eberline, 1988. *Radiological Characterization of the Municipal Landfill, Town of Tonawanda, NY*, Albuquerque, NM. February 1988

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

Attachments

1. April 10, 1989 letter to the Town of Tonawanda from DOH
2. March 13, 1991 letter to the Town of Tonawanda from DOH
3. April 12, 2001 letter to the US Army Corps of Engineers from DOH
4. November 15, 2002 letter to DEC from EnSol, on behalf of the Town of Tonawanda
5. No Cover Scenario - Graph of RESRAD Dose Estimates, All Pathways Summed
6. No Cover Scenario - Graph of RESRAD Dose Estimates, Component Pathways
7. No-Cover Scenario - RESRAD Summary Report
8. Two-Meter Cover Scenario - Graph of RESRAD Dose Estimates, All Pathways Summed
9. Two-Meter Cover Scenario - Graph of RESRAD Dose Estimates, Component Pathways
10. Two-Meter Cover Scenario - RESRAD Summary Report
11. 6.4- Meter Cover Scenario - Graph of RESRAD Dose Estimates, All Pathways Summed
12. 6.4- Meter Cover Scenario - Graph of RESRAD Dose Estimates, Component Pathways
13. 6.4- Meter Cover Scenario - RESRAD Summary Report

Attachment 1

STATE OF NEW YORK
DEPARTMENT OF HEALTH

Corning Tower The Governor Nelson A. Rockefeller Empire State Plaza Albany, New York 12237

[redacted]d Axelrod, M.D.
[redacted]mmissioner

OFFICE OF PUBLIC HEALTH

[redacted], M.D., M.P.H.
Director

[redacted]
Executive Deputy Director

April 10, 1989

[redacted]
Town of Tonawanda
Municipal Building
2919 Delaware Avenue
Kenmore, NY 14217

RE: Landfill Capping

Dear [redacted]:

The New York State Task Force has reviewed your request to close the Town of Tonawanda landfill containing the Americium 241 ash materials. The proposal to cover the Am-241 areas with three feet of hard fill followed by a clay cap as indicated on the drawings you provided is acceptable to the Task Force.

The Department of Environmental Conservation is reviewing the question of disposing of the drums from the decontamination activities at the landfill, as previously suggested by the Task Force. Since complete closure of the landfill will not be completed for some time, it may be feasible to do this, saving considerable money in disposal costs, and speeding up the entire decontamination project. In addition to whatever deed restriction is imposed by the landfill closure, there should be a notation about the presence of the Americium-241 contamination, particularly about the drums if they are finally buried in the landfill.

I am also enclosing the laboratory results for the samples recently collected from the North side of the landfill. One sample showed elevated levels of Uranium, for which we have no explanation. We will probably ask for another sample from this location. The other two samples did not show the elevated Uranium levels. All three samples showed typical concentrations of naturally occuring radionuclides and less than 0.5 pCi/gm of Am-241.

Please contact me or Dr. Rimawi if you have any questions.

Sincerely,

[redacted]

[redacted], P.E., Ph.D.
Director
Center for Environmental Health

cc: [redacted], Buffalo
[redacted]e, Tonawanda
[redacted], DEC
[redacted], DOL

Attachment 2

STATE OF NEW YORK
DEPARTMENT OF HEALTH

Corning Tower The Governor Nelson A. Rockefeller Empire State Plaza Albany, New York 12237

[redacted]
Commissioner

OFFICE OF PUBLIC HEALTH
[redacted] MD MPH
Director

[redacted]
Executive Deputy Director

March 13, 1991

[redacted]
Assistant Civil Engineer
Town of Tonawanda
Municipal Building
Kenmore, NY 14217

Dear [redacted]:

The EAD Task Force has examined the question of the landfill closure and concluded that the normal closure will provide sufficient protection for the contaminated ash.

The use of additional covering materials had been considered in the earliest phases of the decontamination activities when it was planned to place other decontamination materials in a small area of the landfill. Since this has not been done, the additional cover is not needed.

Please contact me or William Condon if you have any questions.

Sincerely,

[redacted]

[redacted], P.E., Ph.D.
Director
Center for Environmental Health

cc: [redacted]
Tonawanda Town Board

Attachment 3

STATE OF NEW YORK
DEPARTMENT OF HEALTH

Flanigan Square, 547 River Street, Troy, New York 12180-2216

[redacted], M.D., M.P.H., Dr.P.H.
Commissioner

[redacted]
Executive Deputy Commissioner

April 12, 2001

[redacted]
Project Manager
Department of the Army
Buffalo District, Corps of Engineers
1776 Niagara Street
Buffalo, New York 14207-3199

Re: Town of Tonawanda Landfill

Dear Ms. [redacted]:

This is in response to your letter dated February 27, 2001 concerning the Americium-241 currently at the Town of Tonawanda Landfill. This letter will briefly address your questions. The enclosed draft report provides additional details that I hope you find useful.

The decision made by the Task Force in 1989 to cap the landfill without removing the Americium was based on a number of factors. These include:

- Closure was not considered an acceptable remediation for unrestricted release, but required continued control of the use of the site; thus, there was a requirement for stabilization of the material on site; cover with clean soil to a minimum of three feet and a clay cap; and, in addition to any deed restriction imposed by the landfill closure, a notation indicating the estimated ash volume and Am-241 activity in the deed;
- Criteria for residual contamination used were those provided by NRC's Branch Technical Position on "Disposal or on-site Storage of Thorium and Uranium Wastes from Past Operations"; This was prior to the development of the RESRAD computer program (and others) that allows calculation of residual contamination of other isotopes under various scenarios;
- Americium in the landfill came from the ash that was produced by incinerating the sludge at the Sewage Treatment Plant (STP). Americium oxide is highly insoluble.
- Samples taken at the site showed no evidence of mobility of the contaminant to the surrounding environment:
- The Americium at the landfill did not pose an immediate health threat.
- At the time the decision was made, New York State low-level radioactive waste (LLRW) generator access to out-of-state commercial LLRW disposal facilities was very tenuous, and about to be terminated. In addition, no instate commercial LLRW disposal facility was operating.

We believe it is not appropriate to use the 1989 Task Force position on Americium in the Town Landfill as a model for evaluating the alternatives for addressing the FUSRAP material currently disposed of at the landfill. This is based on the differences in the material characteristics, such as solubility and mobility in the environment; different program objectives; variation of applicable criteria over time; and availability of more advanced modeling techniques.

If you have any questions please contact Drs. Rimawi or Salame-Alfie of my staff at (518) 402-7550.

Sincerely,

[redacted]

Director
Center for Environmental Health

Enclosure

cc: [redacted]

G:ron/tonawan.doc

Attachment 4

EnSol, Inc.
Environmental Solutions

452 Third Street
Niagara Falls, NY 14301

Professional Engineering • Business Consulting

Ph (716) 285-3920 • Fx (716) 285-3928
E-Mai jbattaglial@ensolinc.com

November 15, 2002

[redacted]
New York State DEC – Albany
Div. of Solid & Hazardous Materials
Bureau of Radiation/Haz. Site Management
50 Wolf Road Room 402
Albany, NY 12233

Re: Am-241 Area Cover
Town of Tonawanda Landfill, Tonawanda, NY
EnSol, Inc. Project Number: 00-0035

Dear [redacted]:

Attached per our conference call is the method that will be used to adequately cover the three Am-241 areas located at the Town of Tonawanda Landfill, Tonawanda, NY.

As proposed in the ***Operations and Maintenance Manual Alternate Grading Material (AGM) Delivery and Placement Town of Tonawanda Landfill*** a minimum of 3-ft of AGM fill will be placed over the Am-241 areas (A, B, and C) prior to bringing the remainder of the landfill to grade. In order to meet the minimum 3-ft AGM fill and slope requirements over the Am-241 material, the proposed final contour grades had to be adjusted to provide the appropriate fill. In addition, a final cap will be placed at a minimum of 3-ft over the entire landfill area. The following table shows the average AGM fill and final cap material that will be located above the Am-241 Areas:

Am-241 Area	Average AGM fill over Am-241 Areas	Average Final Cap Over Landfill Area	Total Average Material Over Am-241 Areas
A	18 ft	3 ft	21 ft
B	14 ft	3 ft	17 ft
C	6 ft	3 ft	9 ft

Sectional views are also provided to show the amount of AGM fill material to be placed over the three Am-241 areas. In addition, two plan views are included: one that shows the entire Town of Tonawanda Landfill Site and the other that shows a blow-up of the three Am-241 areas.

If you have any questions or comments regarding this information, please contact me at 285-3920 for assistance.

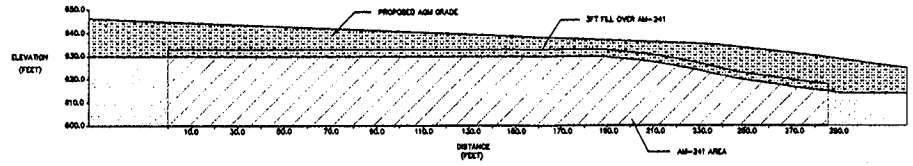
Sincerely,

[redacted]

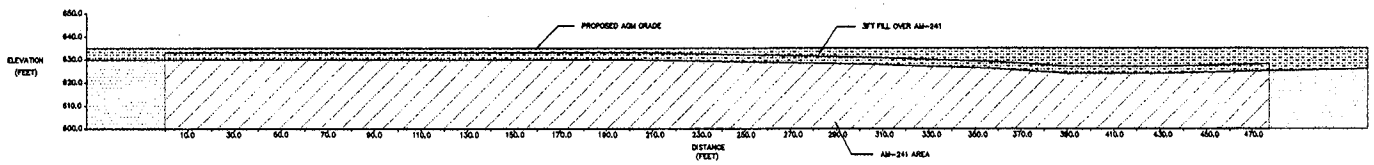
President
EnSol, Inc.

Enclosures

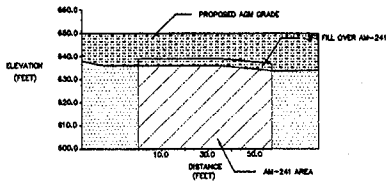
cc: [redacted] - Town of Tonawanda
[redacted], P.E. - NYSDEC Region 9
[redacted] - US Army Corps of Engineers
[redacted] - US Army Corps of Engineers



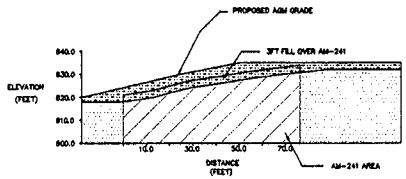
SECTION A-A
AREA "A"



SECTION B-B
AREA "A"

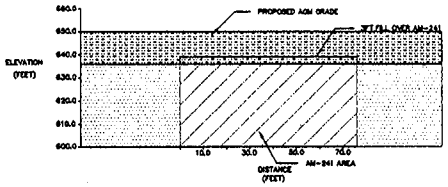


SECTION C-C
AREA "B"

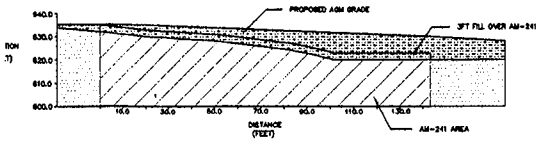


SECTION E-E

AREA "C"



SECTION D-D
AREA "B"



SECTION F-F
AREA "C"

EnSol, Inc.
Environmental Solutions

453 THIRD STREET
NIAGARA FALLS, NY 14301
PHONE (716) 295-3020
FAX (716) 295-3021

TITLE: AM-241-GRADING PLAN

PROJECT: TOWN OF TONAWANDA LANDFILL CLOSURE

PREPARED FOR: TOWN OF TONAWANDA

TOWN OF TONAWANDA | COUNTY OF ERIE

STATE OF NY

REVISION	BY	DATE

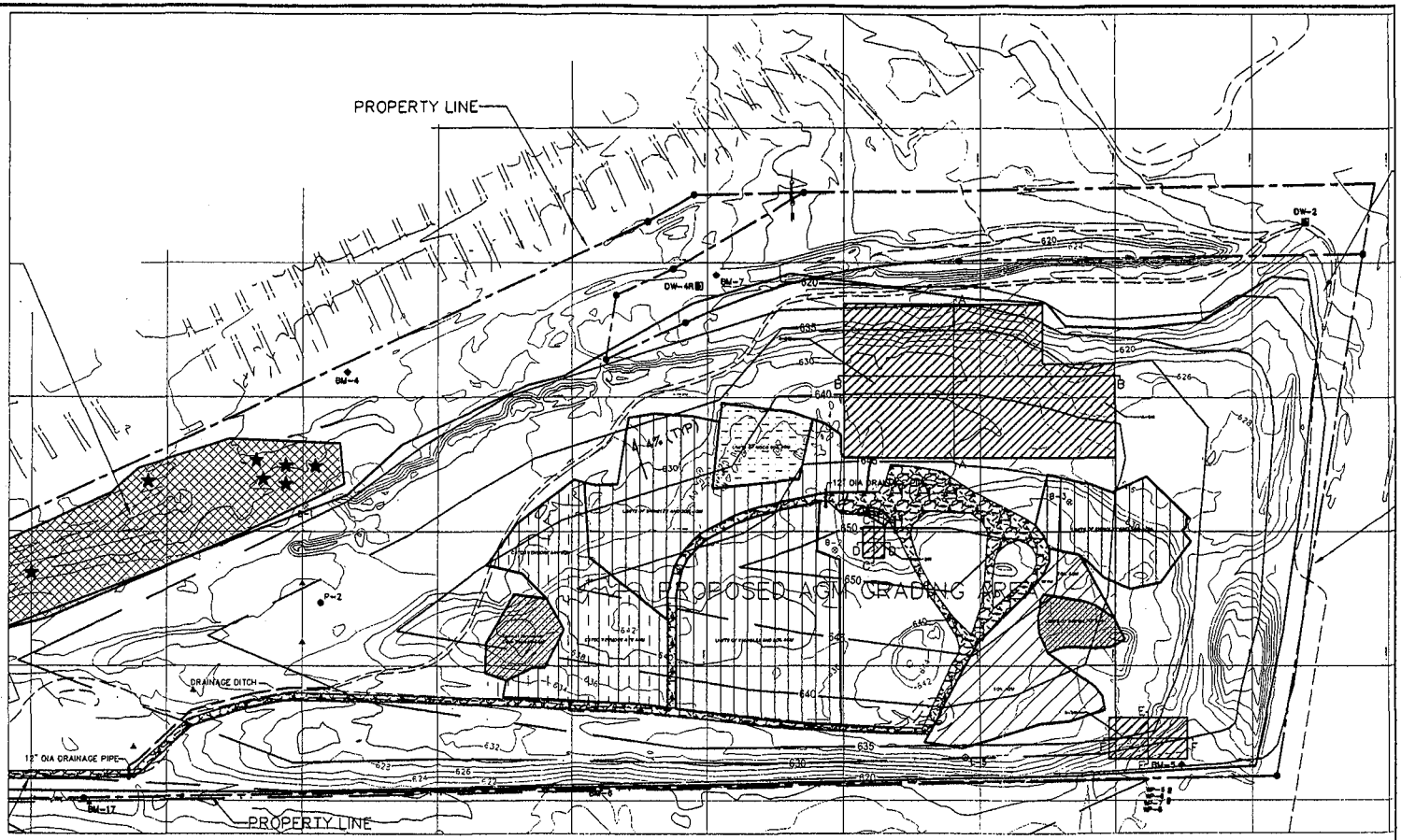
SHEET 1 OF 3

JOHN E. SATAGAJN, P.E.
NY LICENSE NO. 071338

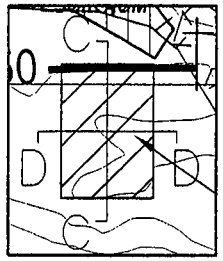
DATE	SCALE	DWG	CHECKED BY	PROJ. NO
10/31/02	1:30	AM241.DWG		99-0425

LEGEND

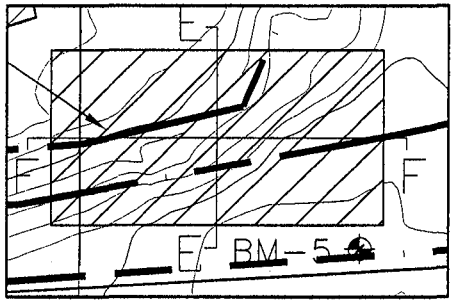
- B-1 — PREVIOUS BORING BY OTHERS
- BM-7 — EXISTING DEEP OVERBURDEN WELL BY OTHERS
- BM-19 — DEEP OVERBURDEN WELL BY MALCOLM PIRNIE
- DW-1 — EXISTING SHALLOW OVERBURDEN WELL BY OTHERS
- DW-4 — SHALLOW OVERBURDEN WELL BY MALCOLM PIRNIE
- P-1 — PIEZOMETER
- WP-1 — WELLPOINT
- AREAS OF AMERICIUM-241 DISPOSAL
- AGM GRADE
- ACCESS ROAD
- PROPERTY BOUNDARY
- TOWN OF TONAWANDA STOCKPILED CLEAN SOIL
- SOIL AGM
- LIMITS OF EMPIRE STATE AGM
- LIMITS OF EMPIRE TOPSOIL
- LIMITS OF NOCO SOIL AGM
- LIMITS OF SHINGLES AND SOIL AGM
- CATCO/KENMORE AVE
- USDOE (FUSRAP) AREA
- USDOE WASTE DETECTED (FROM ORNL, 1992)
- AM-241 WASTE DETECTED (FROM ORNL, 1992)
- 12" DIA DRAINAGE PIPE



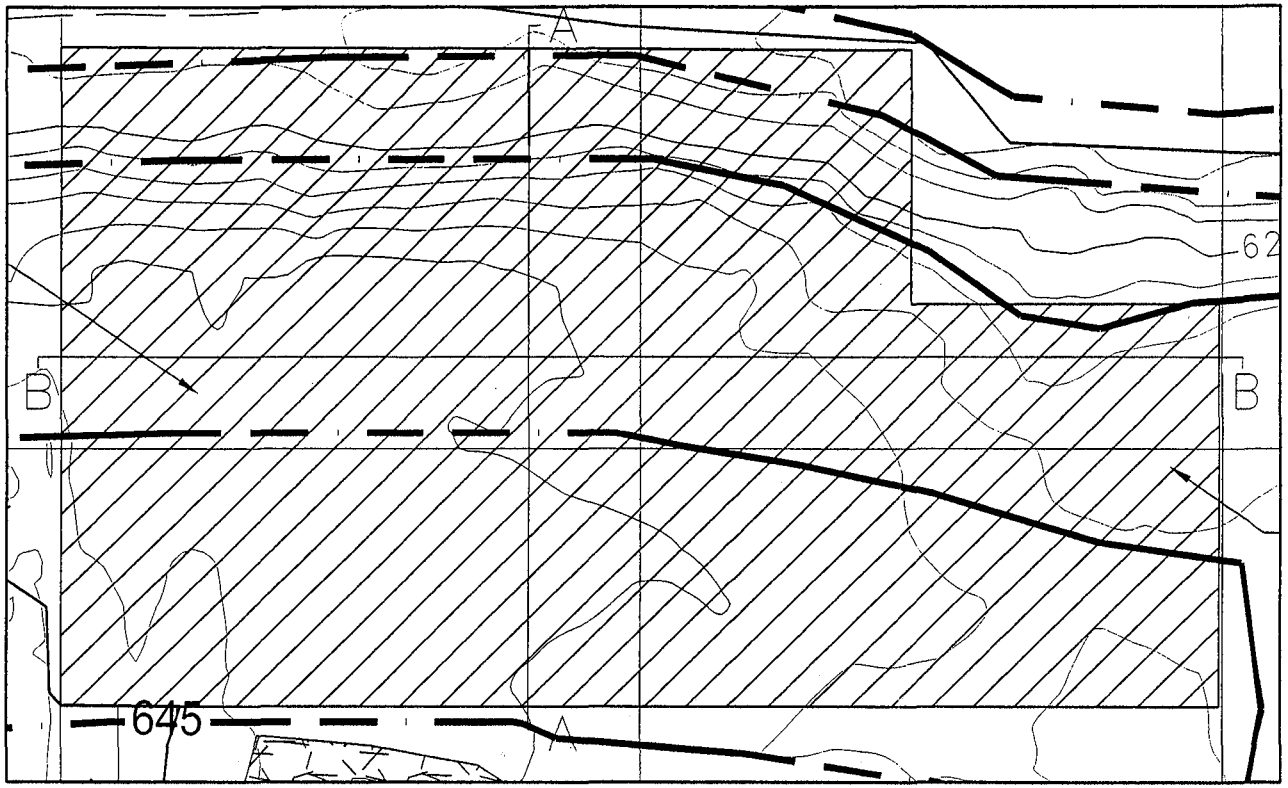
EnSol, Inc. Environmental Solutions	TITLE: AGM GRADING PLAN
	PROJECT: TOWN OF TONAWANDA LANDFILL CLOSURE
	PREPARED FOR: TOWN OF TONAWANDA
	TOWN OF TONAWANDA / COUNTY OF ERIE
	STATE OF NY
	REVISION / BY / DATE
	SHEET 3 OF 3
	DATE / SCALE / DWG / DESIGNED BY / PROJ. NO.



Area "B"



Area "C"



Area "A"

AREAS OF AMERICIUM-241 DISPOSAL

EnSol, Inc.
Environmental Solutions
452 THIRD STREET
NIAGARA FALLS, NY 14301
PHONE (716) 278-3020
FAX (716) 285-2980

JOHN E. SITTNER, P.E.
NY LICENSE NO. 070341

TITLE: AM-241 AREAS

PROJECT: TOWN OF TONAWANDA LANDFILL CLOSURE

PREPARED FOR: TOWN OF TONAWANDA

TOWN OF TONAWANDA | COUNTY OF ERIE

STATE OF NY

REVISION	BY	DATE

SHEET 2 OF 3

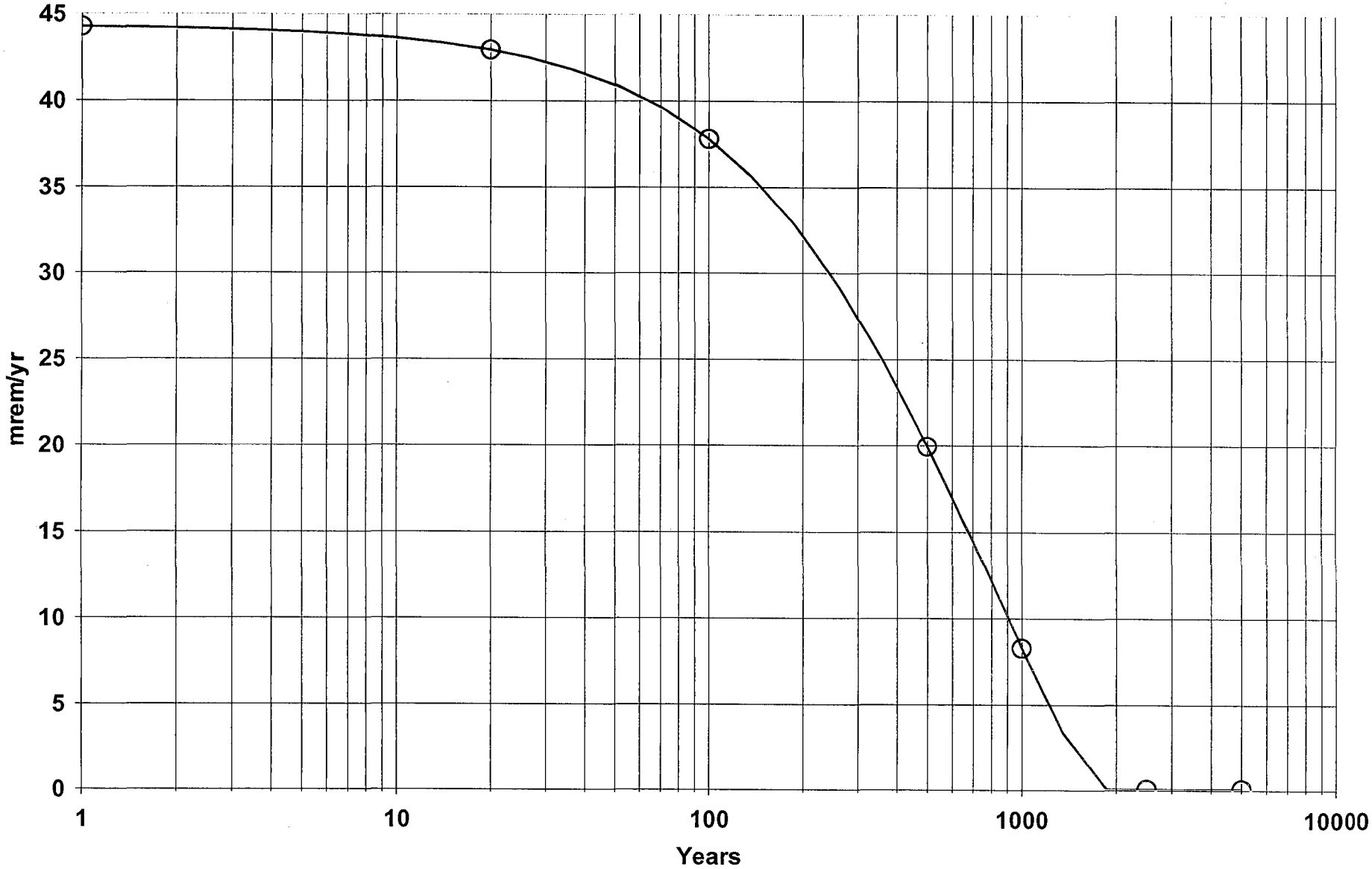
DATE	SCALE	DWG	CHECKED BY	PROJ. NO.
10/31/02	1:50	AM241.DWG		00-0031

Attachment 5

No-Cover Scenario

Graph of RESRAD Dose Estimates, All Pathways Summed

DOSE: Am-241, All Pathways Summed



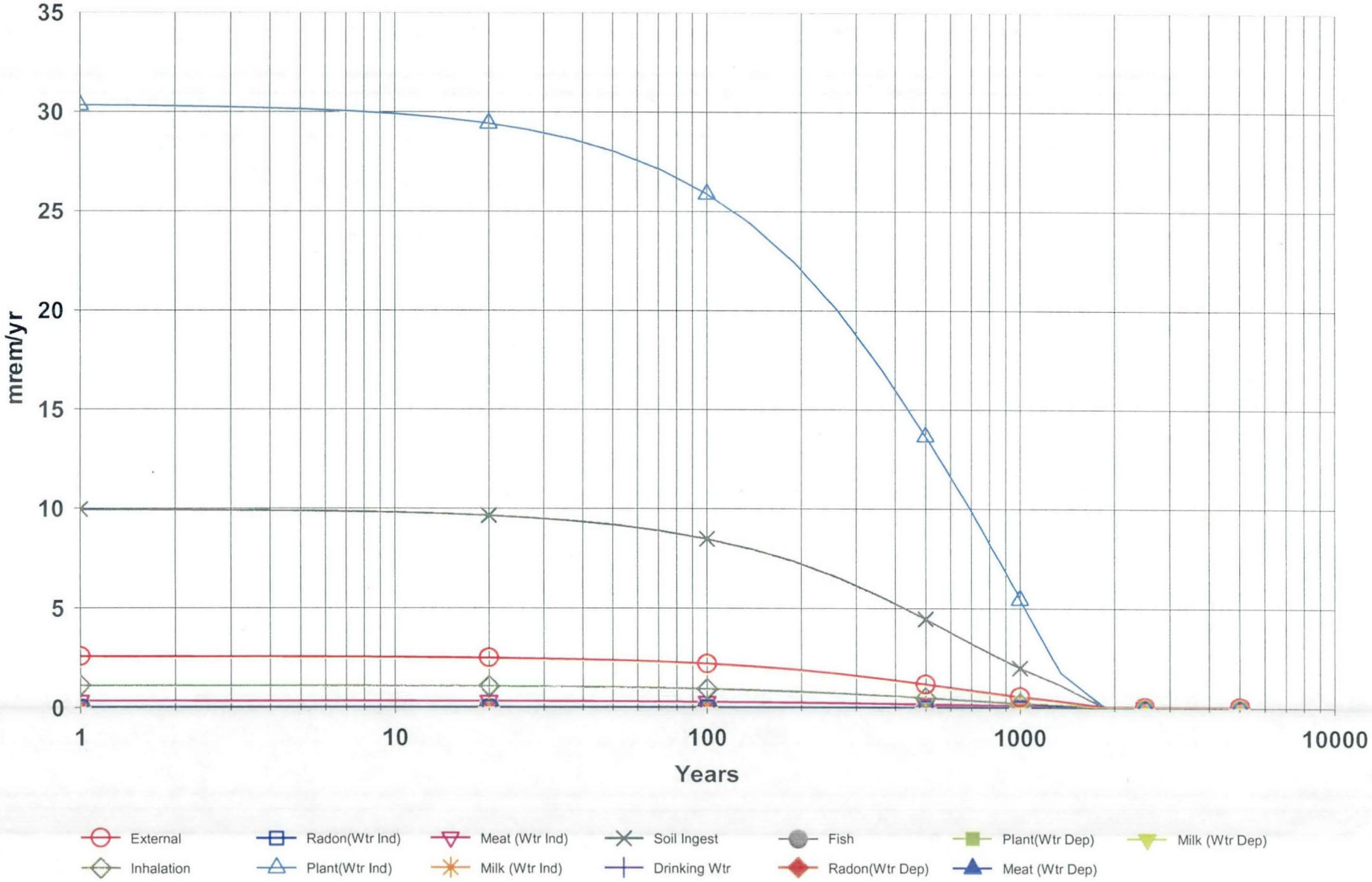
F TLF 3b No Cover.RAD 05/27/2005 12:56 Includes All Pathways

Attachment 6

No-Cover Scenario

Graph of RESRAD Dose Estimates, Component Pathways

DOSE: Am-241, Component Pathways



F TLF 3b No Cover.RAD 05/27/2005 12:56

Attachment 7

No-Cover Scenario

RESRAD Summary Report

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Time = 2.000E+01 11
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Dose Conversion Factor (and Related) Parameter Summary
File: FGR 13 Morbidity

Menu	Parameter	Current Value	Default	Parameter Name
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Am-241	4.440E-01	4.440E-01	DCF2(1)
B-1	Np-237+D	5.400E-01	5.400E-01	DCF2(2)
B-1	Th-229+D	2.160E+00	2.160E+00	DCF2(3)
B-1	U-233	1.350E-01	1.350E-01	DCF2(4)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Am-241	3.640E-03	3.640E-03	DCF3(1)
D-1	Np-237+D	4.440E-03	4.440E-03	DCF3(2)
D-1	Th-229+D	4.030E-03	4.030E-03	DCF3(3)
D-1	U-233	2.890E-04	2.890E-04	DCF3(4)
D-34	Food transfer factors:			
D-34	Am-241 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(1,1)
D-34	Am-241 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	5.000E-05	5.000E-05	RTF(1,2)
D-34	Am-241 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-06	2.000E-06	RTF(1,3)
D-34				
D-34	Np-237+D , plant/soil concentration ratio, dimensionless	2.000E-02	2.000E-02	RTF(2,1)
D-34	Np-237+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(2,2)
D-34	Np-237+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(2,3)
D-34				
D-34	Th-229+D , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(3,1)
D-34	Th-229+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(3,2)
D-34	Th-229+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(3,3)
D-34				
D-34	U-233 , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(4,1)
D-34	U-233 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(4,2)
D-34	U-233 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(4,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Am-241 , fish	3.000E+01	3.000E+01	BIOFAC(1,1)
D-5	Am-241 , crustacea and mollusks	1.000E+03	1.000E+03	BIOFAC(1,2)
D-5				
D-5	Np-237+D , fish	3.000E+01	3.000E+01	BIOFAC(2,1)
D-5	Np-237+D , crustacea and mollusks	4.000E+02	4.000E+02	BIOFAC(2,2)
D-5				
D-5	Th-229+D , fish	1.000E+02	1.000E+02	BIOFAC(3,1)
D-5	Th-229+D , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(3,2)
D-5				
D-5	U-233 , fish	1.000E+01	1.000E+01	BIOFAC(4,1)
D-5	U-233 , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(4,2)

Site-Specific Parameter Summary

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	8.800E+03	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	1.800E+00	2.000E+00	---	THICK0
R011	Length parallel to aquifer flow (m)	1.524E+02	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	2.500E+01	2.500E+01	---	BRDL
R011	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+00	1.000E+00	---	T(2)
R011	Times for calculations (yr)	2.000E+01	3.000E+00	---	T(3)
R011	Times for calculations (yr)	1.000E+02	1.000E+01	---	T(4)
R011	Times for calculations (yr)	5.000E+02	3.000E+01	---	T(5)
R011	Times for calculations (yr)	1.000E+03	1.000E+02	---	T(6)
R011	Times for calculations (yr)	2.500E+03	3.000E+02	---	T(7)
R011	Times for calculations (yr)	5.000E+03	1.000E+03	---	T(8)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(9)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): Am-241	1.000E+02	0.000E+00	---	S1(1)
R012	Concentration in groundwater (pCi/L): Am-241	not used	0.000E+00	---	W1(1)
R013	Cover depth (m)	0.000E+00	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	not used	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	not used	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.300E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	4.400E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	2.000E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	3.150E+03	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	1.040E+01	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	5.800E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	6.300E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	9.600E-01	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	4.800E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.400E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	1.550E+07	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	1.000E-03	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	1.300E+00	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	5.000E-01	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	1.200E-01	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	2.000E-01	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	3.150E-01	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	4.000E-02	2.000E-02	---	HGWT
R014	Saturated zone b parameter	1.040E+01	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	1.500E+00	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	6.100E+00	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	ND	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	2.500E+02	2.500E+02	---	UW
R015	Number of unsaturated zone strata	0	1	---	NS

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R016	Distribution coefficients for Am-241				
R016	Contaminated zone (cm**3/g)	7.600E+04	2.000E+01	---	DCNUCC(1)
R016	Saturated zone (cm**3/g)	7.600E+04	2.000E+01	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.517E-06	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R016	Distribution coefficients for daughter Np-237				
R016	Contaminated zone (cm**3/g)	5.000E+01	-1.000E+00	---	DCNUCC(2)
R016	Saturated zone (cm**3/g)	5.000E+01	-1.000E+00	---	DCNUCS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.807E-03	ALEACH(2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)
R016	Distribution coefficients for daughter Th-229				
R016	Contaminated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCC(3)
R016	Saturated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCS(3)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.188E-06	ALEACH(3)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(3)
R016	Distribution coefficients for daughter U-233				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(4)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(4)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.807E-03	ALEACH(4)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(4)
R017	Inhalation rate (m**3/yr)	8.400E+03	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	1.000E-04	1.000E-04	---	MLINH
R017	Exposure duration	3.000E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	7.000E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	5.000E-01	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	2.500E-01	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	1.000E+00	1.000E+00	>0 shows circular AREA.	FS
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE(1
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE(2
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE(3
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE(4
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE(5
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE(6
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE(7
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE(8
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE(9
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA(1)
R017	Ring 2	not used	2.732E-01	---	FRACA(2)
R017	Ring 3	not used	0.000E+00	---	FRACA(3)
R017	Ring 4	not used	0.000E+00	---	FRACA(4)
R017	Ring 5	not used	0.000E+00	---	FRACA(5)
R017	Ring 6	not used	0.000E+00	---	FRACA(6)
R017	Ring 7	not used	0.000E+00	---	FRACA(7)
R017	Ring 8	not used	0.000E+00	---	FRACA(8)
R017	Ring 9	not used	0.000E+00	---	FRACA(9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)
R018	Fruits, vegetables and grain consumption (kg/yr)	1.600E+02	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	7.000E+00	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	9.200E+01	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	6.300E+01	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	5.400E+00	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	9.000E-01	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	3.650E+01	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	5.100E+02	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	1.000E+00	1.000E+00	---	FDW
R018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	1.000E+00	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	1.000E+00	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	1.000E-02	5.000E-01	---	FR9
R018	Contamination fraction of plant food	-1	-1	0.500E+00	FPLANT
R018	Contamination fraction of meat	-1	-1	0.440E+00	FMEAT
R018	Contamination fraction of milk	0.000E+00	-1	---	FMILK
R019	Livestock fodder intake for meat (kg/day)	6.800E+01	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	5.500E+01	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	5.000E+01	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	1.600E+02	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	5.000E-01	5.000E-01	---	LSI
R019	Mass loading for foliar deposition (g/m**3)	1.000E-04	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
R019	Depth of roots (m)	9.000E-01	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	1.000E+00	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	1.000E+00	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	1.000E+00	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	7.000E-01	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	1.500E+00	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	1.100E+00	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	1.700E-01	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	2.500E-01	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	8.000E-02	8.000E-02	---	TE(3)
R19B	Translocation Factor for Non-Leafy	1.000E-01	1.000E-01	---	TIV(1)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R19B	Translocation Factor for Leafy	1.000E+00	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	1.000E+00	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	2.000E+01	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
C14	DCF correction factor for gaseous forms of C14	not used	8.894E+01	---	CO2F
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS
TITL	Maximum number of integration points for dose	17	---	---	LYMAX

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
TITL	Maximum number of integration points for risk	257	---	---	KYMAX

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	active
2 -- inhalation (w/o radon)	active
3 -- plant ingestion	active
4 -- meat ingestion	active
5 -- milk ingestion	active
6 -- aquatic foods	active
7 -- drinking water	active
8 -- soil ingestion	active
9 -- radon	suppressed
Find peak pathway doses	active

Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	8800.00 square meters	Am-241	1.000E+02
Thickness:	1.80 meters		
Cover Depth:	0.00 meters		

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 2.500E+01 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	2.000E+01	1.000E+02	5.000E+02	1.000E+03	2.500E+03	5.000E+03
TDOSE(t):	4.426E+01	4.419E+01	4.286E+01	3.771E+01	1.986E+01	8.218E+00	0.000E+00	0.000E+00
M(t):	1.770E+00	1.767E+00	1.714E+00	1.508E+00	7.944E-01	3.287E-01	0.000E+00	0.000E+00

Maximum TDOSE(t): 4.426E+01 mrem/yr at t = 0.000E+00 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	2.534E+00	0.0573	1.097E+00	0.0248	0.000E+00	0.0000	3.038E+01	0.6865	2.864E-01	0.0065	0.000E+00	0.0000	9.957E+00	0.2250
Total	2.534E+00	0.0573	1.097E+00	0.0248	0.000E+00	0.0000	3.038E+01	0.6865	2.864E-01	0.0065	0.000E+00	0.0000	9.957E+00	0.2250

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.426E+01	1.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.426E+01	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	2.530E+00	0.0573	1.095E+00	0.0248	0.000E+00	0.0000	3.033E+01	0.6865	2.859E-01	0.0065	0.000E+00	0.0000	9.941E+00	0.2250
Total	2.530E+00	0.0573	1.095E+00	0.0248	0.000E+00	0.0000	3.033E+01	0.6865	2.859E-01	0.0065	0.000E+00	0.0000	9.941E+00	0.2250

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.419E+01	1.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.419E+01	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 2.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	2.455E+00	0.0573	1.062E+00	0.0248	0.000E+00	0.0000	2.943E+01	0.6865	2.775E-01	0.0065	0.000E+00	0.0000	9.642E+00	0.2249
Total	2.455E+00	0.0573	1.062E+00	0.0248	0.000E+00	0.0000	2.943E+01	0.6865	2.775E-01	0.0065	0.000E+00	0.0000	9.642E+00	0.2249

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 2.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.286E+01	1.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.286E+01	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	2.160E+00	0.0573	9.341E-01	0.0248	0.000E+00	0.0000	2.589E+01	0.6866	2.445E-01	0.0065	0.000E+00	0.0000	8.479E+00	0.2249
Total	2.160E+00	0.0573	9.341E-01	0.0248	0.000E+00	0.0000	2.589E+01	0.6866	2.445E-01	0.0065	0.000E+00	0.0000	8.479E+00	0.2249

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.771E+01	1.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.771E+01	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	1.138E+00	0.0573	4.913E-01	0.0247	0.000E+00	0.0000	1.364E+01	0.6869	1.293E-01	0.0065	0.000E+00	0.0000	4.460E+00	0.2246
Total	1.138E+00	0.0573	4.913E-01	0.0247	0.000E+00	0.0000	1.364E+01	0.6869	1.293E-01	0.0065	0.000E+00	0.0000	4.460E+00	0.2246

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.986E+01	1.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.986E+01	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	5.101E-01	0.0621	2.201E-01	0.0268	0.000E+00	0.0000	5.433E+00	0.6611	5.724E-02	0.0070	0.000E+00	0.0000	1.998E+00	0.2431
Total	5.101E-01	0.0621	2.201E-01	0.0268	0.000E+00	0.0000	5.433E+00	0.6611	5.724E-02	0.0070	0.000E+00	0.0000	1.998E+00	0.2431

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.218E+00	1.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.218E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 2.500E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 2.500E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

*Sum of all water independent and dependent pathways.

Dose/Source Ratios Summed Over All Pathways
Parent and Progeny Principal Radionuclide Contributions Indicated

Parent (i)	Product (j)	Branch Fraction*	DSR(j,t) (mrem/yr)/(pCi/g) t= 0.000E+00	1.000E+00	2.000E+01	1.000E+02	5.000E+02	1.000E+03	2.500E+03	5.000E+03
Am-241	Am-241	1.000E+00	4.426E-01	4.419E-01	4.286E-01	3.769E-01	1.982E-01	8.198E-02	0.000E+00	0.000E+00
Am-241	Np-237	1.000E+00	1.278E-06	3.971E-06	5.270E-05	2.087E-04	3.695E-04	1.982E-04	0.000E+00	0.000E+00
Am-241	U-233	1.000E+00	2.806E-14	1.562E-13	2.120E-11	3.921E-10	2.930E-09	2.551E-09	0.000E+00	0.000E+00
Am-241	Th-229	1.000E+00	8.557E-18	1.216E-16	2.593E-13	2.536E-11	1.310E-09	3.847E-09	0.000E+00	0.000E+00
Am-241	∑DSR(j)		4.426E-01	4.419E-01	4.286E-01	3.771E-01	1.986E-01	8.218E-02	0.000E+00	0.000E+00

*Branch Fraction is the cumulative factor for the j't principal radionuclide daughter: CUMBRF(j) = BRF(1)*BRF(2)* ... BRF(j).
The DSR includes contributions from associated (half-life ≤ 0.5 yr) daughters.

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 2.500E+01 mrem/yr

Nuclide (i)	t= 0.000E+00	1.000E+00	2.000E+01	1.000E+02	5.000E+02	1.000E+03	2.500E+03	5.000E+03
Am-241	5.649E+01	5.658E+01	5.833E+01	6.630E+01	1.259E+02	3.042E+02	*3.430E+12	*3.430E+12

*At specific activity limit

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 0.000E+00 years

Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Am-241	1.000E+02	0.000E+00	4.426E-01	5.649E+01	4.426E-01	5.649E+01

Individual Nuclide Dose Summed Over All Pathways
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	BRF(i)	DOSE(j,t), mrem/yr t= 0.000E+00	1.000E+00	2.000E+01	1.000E+02	5.000E+02	1.000E+03	2.500E+03	5.000E+03
Am-241	Am-241	1.000E+00	4.426E+01	4.419E+01	4.286E+01	3.769E+01	1.982E+01	8.198E+00	0.000E+00	0.000E+00
Np-237	Am-241	1.000E+00	1.278E-04	3.971E-04	5.270E-03	2.087E-02	3.695E-02	1.982E-02	0.000E+00	0.000E+00
U-233	Am-241	1.000E+00	2.806E-12	1.562E-11	2.120E-09	3.921E-08	2.930E-07	2.551E-07	0.000E+00	0.000E+00
Th-229	Am-241	1.000E+00	8.557E-16	1.216E-14	2.593E-11	2.536E-09	1.310E-07	3.847E-07	0.000E+00	0.000E+00

BRF(i) is the branch fraction of the parent nuclide.

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	BRF(i)	S(j,t), pCi/g t= 0.000E+00	1.000E+00	2.000E+01	1.000E+02	5.000E+02	1.000E+03	2.500E+03	5.000E+03
Am-241	Am-241	1.000E+00	1.000E+02	9.984E+01	9.684E+01	8.516E+01	4.479E+01	2.006E+01	1.803E+00	3.251E-02
Np-237	Am-241	1.000E+00	0.000E+00	3.230E-05	6.137E-04	2.476E-03	4.398E-03	2.625E-03	2.642E-04	4.783E-06
U-233	Am-241	1.000E+00	0.000E+00	7.061E-11	2.664E-08	5.214E-07	3.941E-06	3.783E-06	5.121E-07	9.482E-09
Th-229	Am-241	1.000E+00	0.000E+00	2.224E-15	1.702E-11	1.770E-09	9.255E-08	2.796E-07	4.715E-07	3.943E-07

BRF(i) is the branch fraction of the parent nuclide.

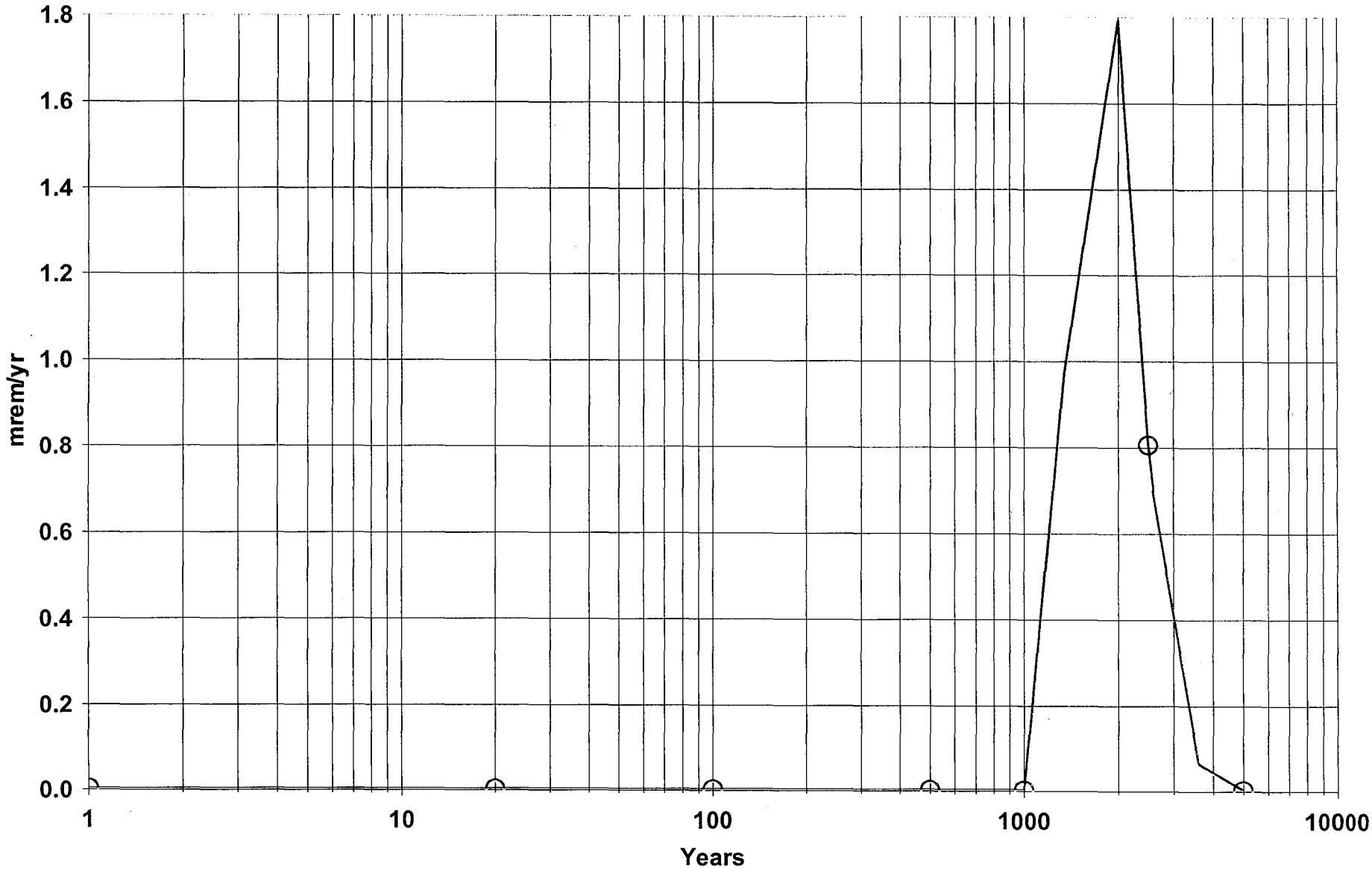
RESCALC.EXE execution time = 0.41 seconds

Attachment 8

Two-Meter Cover Scenario

Graph of RESRAD Dose Estimates, All Pathways Summed

DOSE: Am-241, All Pathways Summed

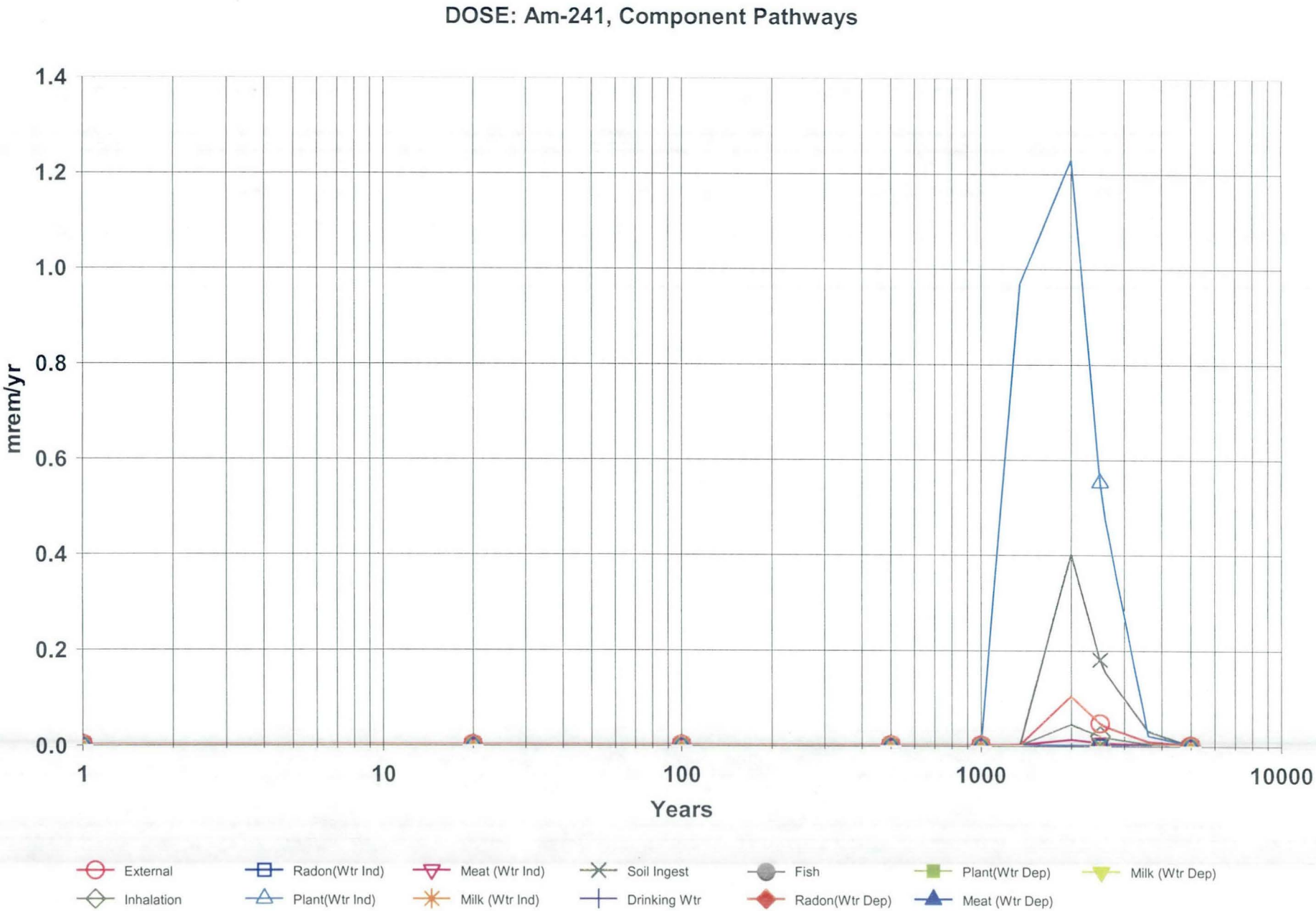


F TLF9c Two M Cover.RAD 05/27/2005 12:58 Includes All Pathways

Attachment 9

Two-Meter Cover Scenario

Graph of RESRAD Dose Estimates, Component Pathways



F TLF9c Two M Cover.RAD 05/27/2005 12:58

Attachment 10

Two-Meter Cover Scenario

RESRAD Summary Report

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Dose Conversion Factor (and Related) Parameter Summary
File: FGR 13 Morbidity

Menu	Parameter	Current Value	Default	Parameter Name
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Am-241	4.440E-01	4.440E-01	DCF2(1)
B-1	Np-237+D	5.400E-01	5.400E-01	DCF2(2)
B-1	Th-229+D	2.160E+00	2.160E+00	DCF2(3)
B-1	U-233	1.350E-01	1.350E-01	DCF2(4)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Am-241	3.640E-03	3.640E-03	DCF3(1)
D-1	Np-237+D	4.440E-03	4.440E-03	DCF3(2)
D-1	Th-229+D	4.030E-03	4.030E-03	DCF3(3)
D-1	U-233	2.890E-04	2.890E-04	DCF3(4)
D-34	Food transfer factors:			
D-34	Am-241 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(1,1)
D-34	Am-241 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	5.000E-05	5.000E-05	RTF(1,2)
D-34	Am-241 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-06	2.000E-06	RTF(1,3)
D-34				
D-34	Np-237+D , plant/soil concentration ratio, dimensionless	2.000E-02	2.000E-02	RTF(2,1)
D-34	Np-237+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(2,2)
D-34	Np-237+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(2,3)
D-34				
D-34	Th-229+D , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(3,1)
D-34	Th-229+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(3,2)
D-34	Th-229+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(3,3)
D-34				
D-34	U-233 , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(4,1)
D-34	U-233 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(4,2)
D-34	U-233 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(4,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Am-241 , fish	3.000E+01	3.000E+01	BIOFAC(1,1)
D-5	Am-241 , crustacea and mollusks	1.000E+03	1.000E+03	BIOFAC(1,2)
D-5				
D-5	Np-237+D , fish	3.000E+01	3.000E+01	BIOFAC(2,1)
D-5	Np-237+D , crustacea and mollusks	4.000E+02	4.000E+02	BIOFAC(2,2)
D-5				
D-5	Th-229+D , fish	1.000E+02	1.000E+02	BIOFAC(3,1)
D-5	Th-229+D , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(3,2)
D-5				
D-5	U-233 , fish	1.000E+01	1.000E+01	BIOFAC(4,1)
D-5	U-233 , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(4,2)

Site-Specific Parameter Summary

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	8.800E+03	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	1.800E+00	2.000E+00	---	THICK0
R011	Length parallel to aquifer flow (m)	1.524E+02	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	2.500E+01	2.500E+01	---	BRDL
R011	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+00	1.000E+00	---	T(2)
R011	Times for calculations (yr)	2.000E+01	3.000E+00	---	T(3)
R011	Times for calculations (yr)	1.000E+02	1.000E+01	---	T(4)
R011	Times for calculations (yr)	5.000E+02	3.000E+01	---	T(5)
R011	Times for calculations (yr)	1.000E+03	1.000E+02	---	T(6)
R011	Times for calculations (yr)	2.500E+03	3.000E+02	---	T(7)
R011	Times for calculations (yr)	5.000E+03	1.000E+03	---	T(8)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(9)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): Am-241	1.000E+02	0.000E+00	---	S1(1)
R012	Concentration in groundwater (pCi/L): Am-241	not used	0.000E+00	---	W1(1)
R013	Cover depth (m)	2.000E+00	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	1.300E+00	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.300E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	4.400E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	2.000E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	3.150E+03	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	1.040E+01	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	5.800E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	6.900E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	9.600E-01	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	4.800E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.800E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	1.550E+07	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	1.000E-03	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	1.300E+00	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	5.000E-01	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	1.200E-01	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	2.000E-01	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	3.150E-01	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	4.000E-02	2.000E-02	---	HGWT
R014	Saturated zone b parameter	1.040E+01	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	1.500E+00	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	6.100E+00	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	ND	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	2.500E+02	2.500E+02	---	UW
R015	Number of unsaturated zone strata	0	1	---	NS

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R016	Distribution coefficients for Am-241				
R016	Contaminated zone (cm**3/g)	7.600E+04	2.000E+01	---	DCNUCC(1)
R016	Saturated zone (cm**3/g)	7.600E+04	2.000E+01	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.042E-06	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R016	Distribution coefficients for daughter Np-237				
R016	Contaminated zone (cm**3/g)	5.000E+01	-1.000E+00	---	DCNUCC(2)
R016	Saturated zone (cm**3/g)	5.000E+01	-1.000E+00	---	DCNUCS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.089E-03	ALEACH(2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)
R016	Distribution coefficients for daughter Th-229				
R016	Contaminated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCC(3)
R016	Saturated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCS(3)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.586E-06	ALEACH(3)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(3)
R016	Distribution coefficients for daughter U-233				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(4)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(4)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.089E-03	ALEACH(4)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(4)
R017	Inhalation rate (m**3/yr)	8.400E+03	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	1.000E-04	1.000E-04	---	MLINH
R017	Exposure duration	3.000E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	7.000E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	5.000E-01	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	2.500E-01	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	1.000E+00	1.000E+00	>0 shows circular AREA.	FS
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE(4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE(6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE(7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA(1)
R017	Ring 2	not used	2.732E-01	---	FRACA(2)
R017	Ring 3	not used	0.000E+00	---	FRACA(3)
R017	Ring 4	not used	0.000E+00	---	FRACA(4)
R017	Ring 5	not used	0.000E+00	---	FRACA(5)
R017	Ring 6	not used	0.000E+00	---	FRACA(6)
R017	Ring 7	not used	0.000E+00	---	FRACA(7)
R017	Ring 8	not used	0.000E+00	---	FRACA(8)
R017	Ring 9	not used	0.000E+00	---	FRACA(9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)
R018	Fruits, vegetables and grain consumption (kg/yr)	1.600E+02	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	7.000E+00	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	9.200E+01	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	6.300E+01	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	5.400E+00	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	9.000E-01	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	3.650E+01	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	5.100E+02	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	1.000E+00	1.000E+00	---	FDW
R018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	1.000E+00	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	1.000E+00	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	1.000E-02	5.000E-01	---	FR9
R018	Contamination fraction of plant food	-1	-1	0.500E+00	FPLANT
R018	Contamination fraction of meat	-1	-1	0.440E+00	FMEAT
R018	Contamination fraction of milk	0.000E+00	-1	---	FMILK
R019	Livestock fodder intake for meat (kg/day)	6.800E+01	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	5.500E+01	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	5.000E+01	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	1.600E+02	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	5.000E-01	5.000E-01	---	LSI
R019	Mass loading for foliar deposition (g/m**3)	1.000E-04	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
R019	Depth of roots (m)	9.000E-01	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	1.000E+00	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	1.000E+00	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	1.000E+00	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	7.000E-01	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	1.500E+00	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	1.100E+00	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	1.700E-01	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	2.500E-01	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	8.000E-02	8.000E-02	---	TE(3)
R19B	Translocation Factor for Non-Leafy	1.000E-01	1.000E-01	---	TIV(1)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R19B	Translocation Factor for Leafy	1.000E+00	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	1.000E+00	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	2.000E+01	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
C14	DCF correction factor for gaseous forms of C14	not used	8.894E+01	---	CO2F
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS
TITL	Maximum number of integration points for dose	17	---	---	LYMAX

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
TITL	Maximum number of integration points for risk	257	---	---	KYMAX

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	active
2 -- inhalation (w/o radon)	active
3 -- plant ingestion	active
4 -- meat ingestion	active
5 -- milk ingestion	active
6 -- aquatic foods	active
7 -- drinking water	active
8 -- soil ingestion	active
9 -- radon	suppressed
Find peak pathway doses	active

Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	8800.00 square meters	Am-241	1.000E+02
Thickness:	1.80 meters		
Cover Depth:	2.00 meters		

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 2.500E+01 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	2.000E+01	1.000E+02	5.000E+02	1.000E+03	2.500E+03	5.000E+03
TDOSE(t):	1.290E-19	3.919E-19	6.936E-18	1.014E-16	1.210E-13	2.373E-10	8.021E-01	0.000E+00
M(t):	5.162E-21	1.567E-20	2.774E-19	4.054E-18	4.839E-15	9.491E-12	3.209E-02	0.000E+00

Maximum TDOSE(t): 1.790E+00 mrem/yr at t = 2000 ± 4 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 2.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Nuclide														
Am-241	1.026E-01	0.0573	4.421E-02	0.0247	0.000E+00	0.0000	1.230E+00	0.6873	1.173E-02	0.0066	0.000E+00	0.0000	4.013E-01	0.2242
Total	1.026E-01	0.0573	4.421E-02	0.0247	0.000E+00	0.0000	1.230E+00	0.6873	1.173E-02	0.0066	0.000E+00	0.0000	4.013E-01	0.2242

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 2.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Nuclide														
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.790E+00	1.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.790E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	1.290E-19	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.290E-19	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.290E-19	1.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.290E-19	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	3.919E-19	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	3.919E-19	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.919E-19	1.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.919E-19	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 2.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	6.936E-18	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	6.936E-18	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 2.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.936E-18	1.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.936E-18	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	1.014E-16	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.014E-16	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.014E-16	1.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.014E-16	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	1.210E-13	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.210E-13	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.210E-13	1.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.210E-13	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	2.373E-10	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.373E-10	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.373E-10	1.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.373E-10	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 2.500E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	4.599E-02	0.0573	1.980E-02	0.0247	0.000E+00	0.0000	5.513E-01	0.6873	5.258E-03	0.0066	0.000E+00	0.0000	1.798E-01	0.2241
Total	4.599E-02	0.0573	1.980E-02	0.0247	0.000E+00	0.0000	5.513E-01	0.6873	5.258E-03	0.0066	0.000E+00	0.0000	1.798E-01	0.2241

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 2.500E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.021E-01	1.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.021E-01	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

*Sum of all water independent and dependent pathways.

Dose/Source Ratios Summed Over All Pathways
Parent and Progeny Principal Radionuclide Contributions Indicated

Parent (i)	Product (j)	Branch Fraction*	DSR(j,t) (mrem/yr)/(pCi/g) t= 0.000E+00	1.000E+00	2.000E+01	1.000E+02	5.000E+02	1.000E+03	2.500E+03	5.000E+03
Am-241	Am-241	1.000E+00	1.015E-37	1.055E-37	2.218E-37	5.057E-36	3.115E-29	9.561E-21	7.989E-03	0.000E+00
Am-241	Np-237	1.000E+00	1.290E-21	3.919E-21	6.936E-20	1.014E-18	1.209E-15	2.371E-12	3.228E-05	0.000E+00
Am-241	U-233	1.000E+00	3.596E-32	2.551E-31	6.157E-29	5.105E-27	6.268E-23	6.028E-19	7.609E-10	0.000E+00
Am-241	Th-229	1.000E+00	8.585E-31	1.302E-29	3.804E-26	1.241E-23	2.579E-19	1.346E-15	1.000E-08	0.000E+00
Am-241	∑DSR(j)		1.290E-21	3.919E-21	6.936E-20	1.014E-18	1.210E-15	2.373E-12	8.021E-03	0.000E+00

*Branch Fraction is the cumulative factor for the j't principal radionuclide daughter: CUMBRF(j) = BRF(1)*BRF(2)* ... BRF(j).
The DSR includes contributions from associated (half-life ≤ 0.5 yr) daughters.

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 2.500E+01 mrem/yr

Nuclide (i)	t= 0.000E+00	1.000E+00	2.000E+01	1.000E+02	5.000E+02	1.000E+03	2.500E+03	5.000E+03
Am-241	*3.430E+12	*3.430E+12	*3.430E+12	*3.430E+12	*3.430E+12	*3.430E+12	3.117E+03	*3.430E+12

*At specific activity limit

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 2000 ± 4 years

Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Am-241	1.000E+02	2000 ± 4	1.790E-02	1.396E+03	1.790E-02	1.396E+03

Individual Nuclide Dose Summed Over All Pathways
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	BRF(i)	DOSE(j,t), mrem/yr t= 0.000E+00	1.000E+00	2.000E+01	1.000E+02	5.000E+02	1.000E+03	2.500E+03	5.000E+03
Am-241	Am-241	1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.115E-27	9.561E-19	7.989E-01	0.000E+00
Np-237	Am-241	1.000E+00	1.290E-19	3.919E-19	6.936E-18	1.014E-16	1.209E-13	2.371E-10	3.228E-03	0.000E+00
U-233	Am-241	1.000E+00	0.000E+00	0.000E+00	6.157E-27	5.105E-25	6.268E-21	6.028E-17	7.609E-08	0.000E+00
Th-229	Am-241	1.000E+00	0.000E+00	1.302E-27	3.804E-24	1.241E-21	2.579E-17	1.346E-13	1.000E-06	0.000E+00

BRF(i) is the branch fraction of the parent nuclide.

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	BRF(i)	S(j,t), pCi/g t= 0.000E+00	1.000E+00	2.000E+01	1.000E+02	5.000E+02	1.000E+03	2.500E+03	5.000E+03
Am-241	Am-241	1.000E+00	1.000E+02	9.984E+01	9.684E+01	8.516E+01	4.480E+01	2.007E+01	1.805E+00	3.259E-02
Np-237	Am-241	1.000E+00	0.000E+00	3.231E-05	6.181E-04	2.564E-03	5.123E-03	3.389E-03	3.845E-04	7.111E-06
U-233	Am-241	1.000E+00	0.000E+00	7.064E-11	2.690E-08	5.466E-07	4.912E-06	5.635E-06	1.026E-06	2.081E-08
Th-229	Am-241	1.000E+00	0.000E+00	2.225E-15	1.715E-11	1.833E-09	1.082E-07	3.653E-07	7.080E-07	6.075E-07

BRF(i) is the branch fraction of the parent nuclide.

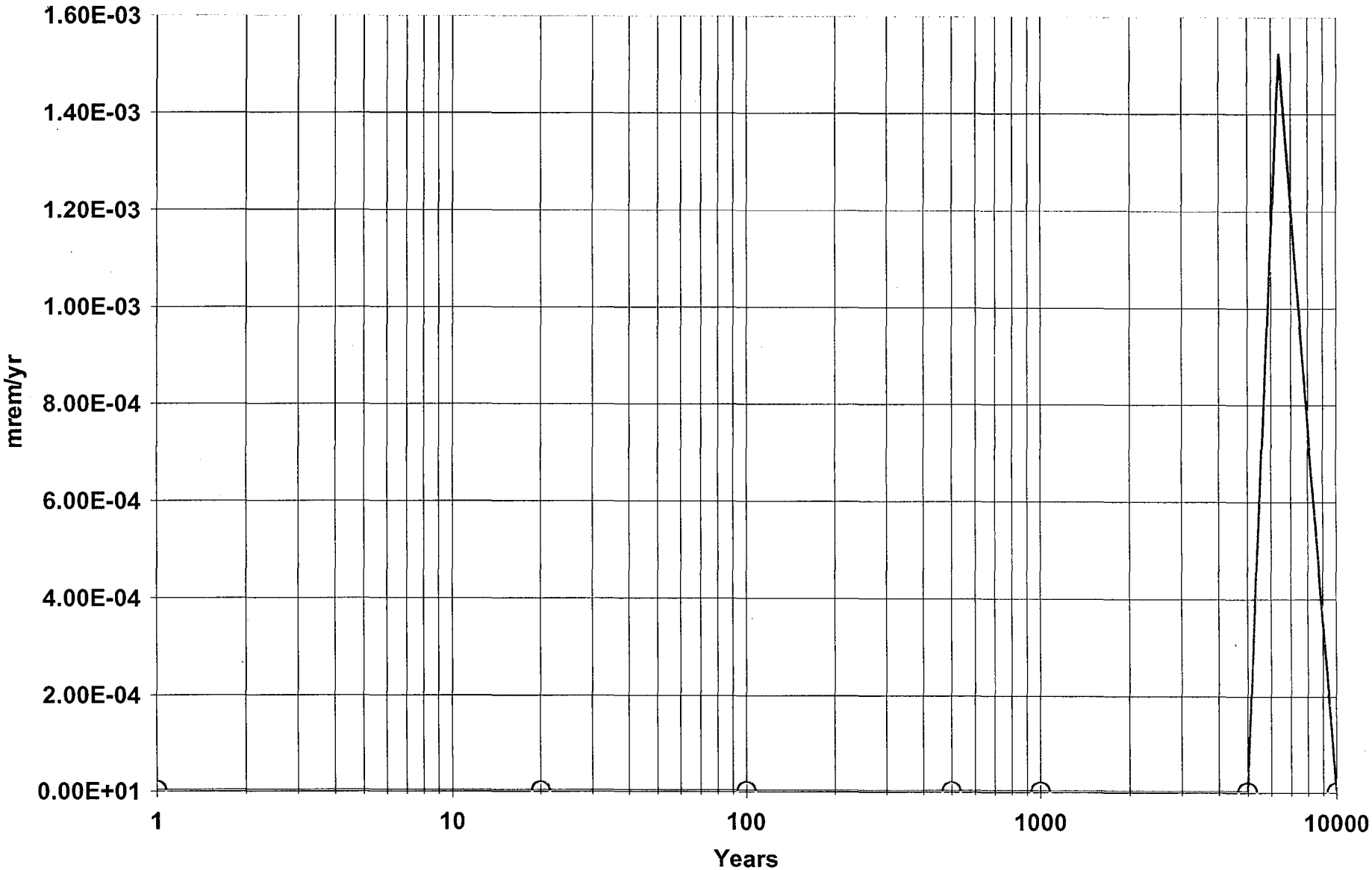
RESCALC.EXE execution time = 0.88 seconds

Attachment 11

6.4- Meter Cover Scenario

Graph of RESRAD Dose Estimates, All Pathways Summed

DOSE: Am-241, All Pathways Summed

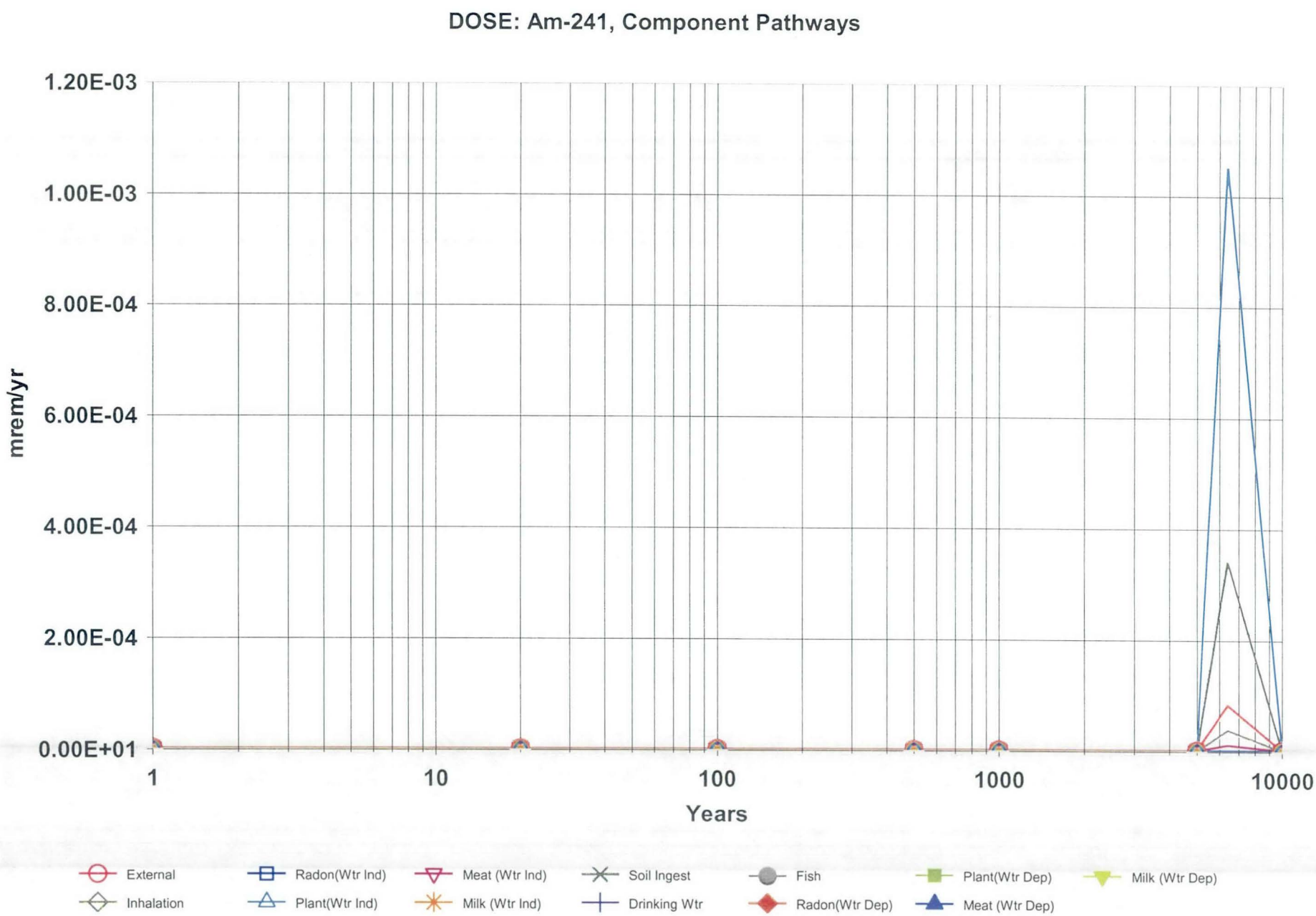


TLF 6c Six M Cover 10k y.RAD 05/27/2005 13:02 Includes All Pathways

Attachment 12

6.4- Meter Cover Scenario

Graph of RESRAD Dose Estimates, Component Pathways



TLF 6c Six M Cover 10k y.RAD 05/27/2005 13:02

Attachment 13

6.4- Meter Cover Scenario

RESRAD Summary Report

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Dose Conversion Factor (and Related) Parameter Summary
File: FGR 13 Morbidity

Menu	Parameter	Current Value	Default	Parameter Name
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Am-241	4.440E-01	4.440E-01	DCF2(1)
B-1	Np-237+D	5.400E-01	5.400E-01	DCF2(2)
B-1	Th-229+D	2.160E+00	2.160E+00	DCF2(3)
B-1	U-233	1.350E-01	1.350E-01	DCF2(4)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Am-241	3.640E-03	3.640E-03	DCF3(1)
D-1	Np-237+D	4.440E-03	4.440E-03	DCF3(2)
D-1	Th-229+D	4.030E-03	4.030E-03	DCF3(3)
D-1	U-233	2.890E-04	2.890E-04	DCF3(4)
D-34	Food transfer factors:			
D-34	Am-241 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(1,1)
D-34	Am-241 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	5.000E-05	5.000E-05	RTF(1,2)
D-34	Am-241 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-06	2.000E-06	RTF(1,3)
D-34				
D-34	Np-237+D , plant/soil concentration ratio, dimensionless	2.000E-02	2.000E-02	RTF(2,1)
D-34	Np-237+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(2,2)
D-34	Np-237+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(2,3)
D-34				
D-34	Th-229+D , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(3,1)
D-34	Th-229+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(3,2)
D-34	Th-229+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(3,3)
D-34				
D-34	U-233 , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(4,1)
D-34	U-233 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(4,2)
D-34	U-233 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(4,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Am-241 , fish	3.000E+01	3.000E+01	BIOFAC(1,1)
D-5	Am-241 , crustacea and mollusks	1.000E+03	1.000E+03	BIOFAC(1,2)
D-5				
D-5	Np-237+D , fish	3.000E+01	3.000E+01	BIOFAC(2,1)
D-5	Np-237+D , crustacea and mollusks	4.000E+02	4.000E+02	BIOFAC(2,2)
D-5				
D-5	Th-229+D , fish	1.000E+02	1.000E+02	BIOFAC(3,1)
D-5	Th-229+D , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(3,2)
D-5				
D-5	U-233 , fish	1.000E+01	1.000E+01	BIOFAC(4,1)
D-5	U-233 , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(4,2)

Site-Specific Parameter Summary

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	8.800E+03	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	1.800E+00	2.000E+00	---	THICK0
R011	Length parallel to aquifer flow (m)	1.524E+02	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	2.500E+01	2.500E+01	---	BRDL
R011	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+00	1.000E+00	---	T(2)
R011	Times for calculations (yr)	2.000E+01	3.000E+00	---	T(3)
R011	Times for calculations (yr)	1.000E+02	1.000E+01	---	T(4)
R011	Times for calculations (yr)	5.000E+02	3.000E+01	---	T(5)
R011	Times for calculations (yr)	1.000E+03	1.000E+02	---	T(6)
R011	Times for calculations (yr)	5.000E+03	3.000E+02	---	T(7)
R011	Times for calculations (yr)	1.000E+04	1.000E+03	---	T(8)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(9)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): Am-241	1.000E+02	0.000E+00	---	S1(1)
R012	Concentration in groundwater (pCi/L): Am-241	not used	0.000E+00	---	W1(1)
R013	Cover depth (m)	6.400E+00	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	1.300E+00	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.300E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	4.400E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	2.000E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	3.150E+03	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	1.040E+01	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	5.800E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	6.900E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	9.600E-01	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	4.800E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.800E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	1.550E+07	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	1.000E-03	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	1.300E+00	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	5.000E-01	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	1.200E-01	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	2.000E-01	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	3.150E-01	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	4.000E-02	2.000E-02	---	HGWT
R014	Saturated zone b parameter	1.040E+01	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	1.500E+00	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	6.100E+00	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	ND	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	2.500E+02	2.500E+02	---	UW
R015	Number of unsaturated zone strata	0	1	---	NS

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R016	Distribution coefficients for Am-241				
R016	Contaminated zone (cm**3/g)	7.600E+04	2.000E+01	---	DCNUCC(1)
R016	Saturated zone (cm**3/g)	7.600E+04	2.000E+01	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.042E-06	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R016	Distribution coefficients for daughter Np-237				
R016	Contaminated zone (cm**3/g)	5.000E+01	-1.000E+00	---	DCNUCC(2)
R016	Saturated zone (cm**3/g)	5.000E+01	-1.000E+00	---	DCNUCS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.089E-03	ALEACH(2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)
R016	Distribution coefficients for daughter Th-229				
R016	Contaminated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCC(3)
R016	Saturated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCS(3)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.586E-06	ALEACH(3)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(3)
R016	Distribution coefficients for daughter U-233				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(4)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(4)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.089E-03	ALEACH(4)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(4)
R017	Inhalation rate (m**3/yr)	8.400E+03	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	1.000E-04	1.000E-04	---	MLINH
R017	Exposure duration	3.000E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	7.000E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	5.000E-01	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	2.500E-01	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	1.000E+00	1.000E+00	>0 shows circular AREA.	FS
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE(4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE(6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE(7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA(1)
R017	Ring 2	not used	2.732E-01	---	FRACA(2)
R017	Ring 3	not used	0.000E+00	---	FRACA(3)
R017	Ring 4	not used	0.000E+00	---	FRACA(4)
R017	Ring 5	not used	0.000E+00	---	FRACA(5)
R017	Ring 6	not used	0.000E+00	---	FRACA(6)
R017	Ring 7	not used	0.000E+00	---	FRACA(7)
R017	Ring 8	not used	0.000E+00	---	FRACA(8)
R017	Ring 9	not used	0.000E+00	---	FRACA(9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)
R018	Fruits, vegetables and grain consumption (kg/yr)	1.600E+02	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	7.000E+00	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	9.200E+01	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	6.300E+01	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	5.400E+00	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	9.000E-01	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	3.650E+01	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	5.100E+02	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	1.000E+00	1.000E+00	---	FDW
R018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	1.000E+00	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	1.000E+00	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	1.000E-02	5.000E-01	---	FR9
R018	Contamination fraction of plant food	-1	-1	0.500E+00	FPLANT
R018	Contamination fraction of meat	-1	-1	0.440E+00	FMEAT
R018	Contamination fraction of milk	0.000E+00	-1	---	FMILK
R019	Livestock fodder intake for meat (kg/day)	6.800E+01	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	5.500E+01	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	5.000E+01	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	1.600E+02	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	5.000E-01	5.000E-01	---	LSI
R019	Mass loading for foliar deposition (g/m**3)	1.000E-04	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
R019	Depth of roots (m)	9.000E-01	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	1.000E+00	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	1.000E+00	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	1.000E+00	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	7.000E-01	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	1.500E+00	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	1.100E+00	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	1.700E-01	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	2.500E-01	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	8.000E-02	8.000E-02	---	TE(3)
R19B	Translocation Factor for Non-Leafy	1.000E-01	1.000E-01	---	TIV(1)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R19B	Translocation Factor for Leafy	1.000E+00	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	1.000E+00	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	2.000E+01	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
C14	DCF correction factor for gaseous forms of C14	not used	8.894E+01	---	CO2F
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS
TITL	Maximum number of integration points for dose	17	---	---	LYMAX

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
TITL	Maximum number of integration points for risk	257	---	---	KYMAX

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	active
2 -- inhalation (w/o radon)	active
3 -- plant ingestion	active
4 -- meat ingestion	active
5 -- milk ingestion	active
6 -- aquatic foods	active
7 -- drinking water	active
8 -- soil ingestion	active
9 -- radon	suppressed
Find peak pathway doses	active

Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	8800.00 square meters	Am-241	1.000E+02
Thickness:	1.80 meters		
Cover Depth:	6.40 meters		

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 2.500E+01 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	2.000E+01	1.000E+02	5.000E+02	1.000E+03	5.000E+03	1.000E+04
TDOSE(t):	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.458E-15	0.000E+00
M(t):	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.831E-17	0.000E+00

Maximum TDOSE(t): 1.523E-03 mrem/yr at t = 6398 ± * years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 6.398E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Nuclide														
Am-241	8.156E-05	0.0536	3.756E-05	0.0247	0.000E+00	0.0000	1.053E-03	0.6914	9.977E-06	0.0066	0.000E+00	0.0000	3.407E-04	0.2238
Total	8.156E-05	0.0536	3.756E-05	0.0247	0.000E+00	0.0000	1.053E-03	0.6914	9.977E-06	0.0066	0.000E+00	0.0000	3.407E-04	0.2238

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 6.398E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Nuclide														
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.523E-03	1.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.523E-03	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 2.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 2.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	1.458E-15	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.458E-15	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.458E-15	1.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.458E-15	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+04 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+04 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

*Sum of all water independent and dependent pathways.

Dose/Source Ratios Summed Over All Pathways
Parent and Progeny Principal Radionuclide Contributions Indicated

Parent (i)	Product (j)	Branch Fraction*	DSR(j,t) (mrem/yr)/(pCi/g) t= 0.000E+00	1.000E+00	2.000E+01	1.000E+02	5.000E+02	1.000E+03	5.000E+03	1.000E+04
Am-241	Am-241	1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.325E-30	0.000E+00
Am-241	Np-237	1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.614E-43	8.300E-18	0.000E+00
Am-241	U-233	1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.616E-24	0.000E+00
Am-241	Th-229	1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.149E-43	6.277E-18	0.000E+00
Am-241	∑DSR(j)		0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	7.763E-43	1.458E-17	0.000E+00

*Branch Fraction is the cumulative factor for the j't principal radionuclide daughter: CUMBRF(j) = BRF(1)*BRF(2)* ... BRF(j).
The DSR includes contributions from associated (half-life ≤ 0.5 yr) daughters.

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 2.500E+01 mrem/yr

Nuclide (i)	t= 0.000E+00	1.000E+00	2.000E+01	1.000E+02	5.000E+02	1.000E+03	5.000E+03	1.000E+04
Am-241	*3.430E+12	*3.430E+12	*3.430E+12	*3.430E+12	*3.430E+12	*3.430E+12	*3.430E+12	*3.430E+12

*At specific activity limit

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 6398 ± * years

Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Am-241	1.000E+02	6398 ± *	1.523E-05	1.642E+06	1.523E-05	1.642E+06

Individual Nuclide Dose Summed Over All Pathways
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	BRF(i)	DOSE(j,t), mrem/yr t= 0.000E+00	1.000E+00	2.000E+01	1.000E+02	5.000E+02	1.000E+03	5.000E+03	1.000E+04
Am-241	Am-241	1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.325E-28	0.000E+00
Np-237	Am-241	1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	8.300E-16	0.000E+00
U-233	Am-241	1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.616E-22	0.000E+00
Th-229	Am-241	1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.277E-16	0.000E+00

BRF(i) is the branch fraction of the parent nuclide.

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	BRF(i)	S(j,t), pCi/g t= 0.000E+00	1.000E+00	2.000E+01	1.000E+02	5.000E+02	1.000E+03	5.000E+03	1.000E+04
Am-241	Am-241	1.000E+00	1.000E+02	9.984E+01	9.684E+01	8.516E+01	4.480E+01	2.007E+01	3.259E-02	1.062E-05
Np-237	Am-241	1.000E+00	0.000E+00	3.231E-05	6.181E-04	2.564E-03	5.123E-03	3.389E-03	7.111E-06	2.319E-09
U-233	Am-241	1.000E+00	0.000E+00	7.064E-11	2.690E-08	5.466E-07	4.912E-06	5.635E-06	2.081E-08	6.817E-12
Th-229	Am-241	1.000E+00	0.000E+00	2.225E-15	1.715E-11	1.833E-09	1.082E-07	3.653E-07	6.075E-07	3.748E-07

BRF(i) is the branch fraction of the parent nuclide.

RESCALC.EXE execution time = 0.74 seconds