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Radiation Dose Assessment Methodology and Preliminary Dose Estimates to Support U.S. Department of Energy Radiation Control Criteria for Regulated Treatment and Disposal of Hazardous Waste and Materials

July 1995

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
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PNL-9405

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RADIATION DOSE ASSESSMENT METHODOLOGY AND PRELIMINARY DOSE ESTIMATES TO SUPPORT U.S. DEPARTMENT OF ENERGY RADIATION CONTROL CRITERIA FOR REGULATED TREATMENT AND DISPOSAL OF HAZARDOUS WASTES AND MATERIALS

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ABSTRACT

The U.S. Department of Energy (DOE) is evaluating the feasibility of developing radiation control criteria for regulated treatment and disposal of hazardous wastes and hazardous materials from DOE operations. The evaluation is being completed in seven phases. This technical report contributes to the phased effort by outlining a radiation dose assessment methodology, documenting limits and constraints, and providing preliminary dose estimates. The work is being conducted for the Office of Environmental Guidance, Air, Water, and Radiation Division (DOE/EH-232) by Pacific Northwest Laboratory (PNL)[(a)] under the Environmental Protection Support and Assistance Project.

This report provides unit dose to concentration levels that may be used to develop control criteria for radionuclide activity in hazardous waste; if implemented, these criteria would be developed to provide an adequate level of public and worker health protection, for wastes regulated under U.S. Environmental Protection Agency (EPA) requirements (as derived from the Resource Conservation and Recovery Act [RCRA] and/or the Toxic Substances Control Act [TSCA]). Thus, DOE and the U.S. Nuclear Regulatory Commission can fulfill their obligation to protect the public from radiation by ensuring that such wastes are appropriately managed, while simultaneously reducing the current level of dual regulation. In terms of health protection, dual regulation of very small quantities of radionuclides provides no benefit.

The calculations performed for this report examine both the dose to members of the general public residing near an incinerator and the dose to workers at generic incineration and landfill facilities. Doses to the general public within 80 km of the site are estimated using the EPA's CAP88-PC software package and generic data on atmospheric dispersion and population density. The scenarios used to describe doses to workers were developed from

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onsite observations of incineration and landfill operations. Operations within the generic incineration facility are modeled using parameters for stack release and partitioning, time and motion studies, and throughput as found in published literature and RCRA Part B permits.

The unit dose to concentrations presented are based on exposure of 1 millirem/year (mrem/y), 10 mrem/y, and 20 mrem/y to the maximally exposed hazardous waste worker, and 0.1 mrem/y, 1 mrem/y, 5 mrem/y, and 10 mrem/y to the maximally exposed member of the general public. The concentrations are based on the most restrictive concentration for each radionuclide, which may be limited by the dose to either the maximally exposed worker or the maximally exposed offsite individual. Concentrations based on regulatory constraints for transportation and source material are also considered. These concentrations will be used by DOE to further evaluate the final radiation control criteria, as related to release of hazardous materials for incineration and onsite landfilling. The DOE will develop the control criteria with the emphasis on keeping risk as low as reasonably achievable (ALARA).

The analyses for radiation scenarios and pathways are performed for 62 key radionuclides in waste released from DOE facilities that may be contained in the feedstream of a hazardous waste incinerator or treatment facility. The analyses are restricted to RCRA/TSCA facilities that provide waste treatment, waste destruction, and onsite waste disposal services, such as landfilling, where final disposition of residuals is regulated. Recycling or reuse processes, which may result in unregulated release of residuals, are not considered in this analysis.

SUMMARY

The purpose of this subtask of the Environmental Protection Support and Assistance Project, sponsored by the U.S. Department of Energy (DOE), is to calculate the potential range of activity of selected radionuclides that could be accepted in a hazardous waste incineration feedstream. The final control criteria will define the residual levels of radionuclides present in hazardous wastes that can be adequately controlled through regulatory controls implemented through the Resource Conservation and Recovery Act (RCRA) or the Toxic Substances Control Act (TSCA). The results described in this draft report are based on analyses of generic radiation exposure scenarios and pathways and use a list of 62 radionuclides determined to be potentially present in hazardous wastes from DOE facilities. The analysis was based on a rotary kiln incinerator with a capacity of 30,000 t/y, and a landfill with disposal capacity of 150,000 t/y. Doses both to members of the public residing near a 30,000-t/y hazardous waste incinerator and to incinerator and landfill workers are considered.

Table S.1 summarizes the limiting concentrations for individual radionuclides for five examples of possible dose constraints for members of the public (maximally exposed offsite individuals) and for hazardous waste workers. The five sets are 1) offsite individual dose of 0.1 mrem/y and worker dose of 1.0 mrem/y, 2) offsite individual dose of 1 mrem/y and worker dose of 1 mrem/y, 3) offsite individual dose of 0.1 mrem/y and worker dose of 10 mrem/y, 4) all doses to receptors limited to 10 mrem/y, and 5) offsite individual 5 mrem/y and worker dose of 20 mrem/y.

Two further constraints are noted in Table S.1. In cases in which the scenario-derived concentration exceeds 2 nCi/g, the value applied by the U.S. Department of Transportation (DOT) labeling limit is footnoted.

TABLE S.1. Summary of the Limiting Concentrations for Hazardous Waste from Incineration of Mixed Solids and Limiting Scenarios[a] for Five Cases

Nuclide	Case 1 Public 0.1 mrem/y Worker 1 mrem/y Concentration, pCi/g			Case 2 Public 1 mrem/y Worker 1 mrem/y Concentration, pCi/g			Case 3 Public 0.1 mrem/y Worker 10 mrem/y Concentration, pCi/g			Case 4 Public 10 mrem/y Worker 10 mrem/y Concentration, pCi/g			Case 5 Public 5 mrem/y Worker 20 mrem/y Concentration, pCi/g		
^{3}H	6500.	P	*[a,b]	65,000.	P	*	6500.	P	*	650,000.	P	*	320,000.	P	*
^{7}Be	59.	W		59.	W		590.	W		590.	W		1200.	W	
^{14}C	120.	P		1,200.	P		120.	P		12,000.	P	*	6100.	P	*
^{22}Na	0.72	W		0.72	W		7.2	W		7.2	W		14.	W	
^{32}P	1600.	W		1600.	W		3200.	P	*	16,000.	W	*	32,000.	W	*
^{35}S	4000.	P	*	40,000.	P	*	4000.	P	*	400,000.	P	*	200,000.	P	*
^{46}Sc	0.64	W		0.64	W		6.4	W		6.4	W		13.	W	
^{48}V	0.54	W		0.54	W		5.4	W		5.4	W		11.	W	
^{51}Cr	120.	W		120.	W		1200.	W		1200.	W		2400.	W	*
^{54}Mn	2.2	W		2.2	W		22.	W		22.	W		44.	W	
^{55}Fe	1400.	W		1400.	W		14,000.	W	*	14,000.	W	*	28,000.	W	*
^{56}Co	0.24	W		0.24	W		2.4	W		2.4	W		4.8	W	
^{57}Co	66.	W		66.	W		660.	W		660.	W		1300.	W	
^{58}Co	1.9	W		1.9	W		19.	W		19.	W		38.	W	
^{60}Co	0.45	W		0.45	W		4.5	W		4.5	W		9.0	W	
^{63}Ni	61,000.	P	*	170,000.	W	*	61,000.	P	*	1,700,000.	W	*	3,100,000.	P	*
^{65}Zn	1.8	W		1.8	W		18.	W		18.	W		36.	W	
^{68}Ge	290.	W		290.	W		2900.	W	*	2900.	W	*	5800.	W	*
^{74}As	4.2	W		4.2	W		42.	W		42.	W		84.	W	
^{75}Se	16.	W		16.	W		160.	W		160.	W		320.	W	
^{79}Se	1100.	P		5800.	W	*	1100.	P		58,000.	W	*	57,000.	P	*
^{90}Sr	780.	W		780.	W		7500.	P	*	7800.	W	*	16,000.	W	*
$^{90}Sr+D$[c]	360.	W		360.	W		3600.	W	*	3600.	W	*	7200.	W	*
^{88}Y	0.40	W		0.40	W		4.0	W		4.0	W		8.0	W	
^{93}Zr	4,000.	W	*	54,000.	W	*	120,000.	P	*	540,000.	W	*	1,100,000.	W	*
^{94}Nb	1.4	W		1.4	W		14.	W		14.	W		28.	W	
^{99}Tc	50.	P		500.	P		50.	P		5000.	P	*	2500.	P	*
^{106}Ru*	10.	W		10.	W		100.	W		100.	W		200.	W	
^{110m}Ag	0.55	W		0.55	W		5.5	W		5.5	W		11.	W	
^{113}Sn	310.	W		310.	W		3100.	W	*	3100.	W	*	6200.	W	*
$^{113}Sn+D$[d]	18.	W		18.	W		180.	W		180.	W		360.	W	
^{124}Sb	0.57	W		0.57	W		5.7	W		5.7	W		11.	W	
^{125}Sb	6.3	W		6.3	W		63.	W		63.	W		130.	W	
^{125m}Te	220.	W		220.	W		2200.	W	*	2200.	W	*	4400.	W	*
^{125}I	2.5	P		25.	P		2.5	P		250.	P		130.	P	
^{126}I	5.5	W		5.5	W		7.8	P		55.	W		110.	W	
^{129}I	0.11	P		1.1	P		0.11	P		11.	P		5.7	P	
^{131}I	10.	W		10.	W		10.	P		100.	W		200.	W	
^{134}Cs	1.2	W		1.2	W		12.	W		12.	W		24.	W	
^{137}Cs	4.6	W		4.6	W		46.	W		46.	W		92.	W	
^{144}Ce	430.	W		430.	W		4300.	W	*	4300.	W	*	8600.	W	*
$^{144}Ce+D$[e]	25.	W		25.	W		250.	W		250.	W		500.	W	
^{147}Pm	61,000.	W	*	61,000.	W	*	80,000.	P	*	610,000.	W	*	1,200,000.	W	*
^{151}Sm	120,000.	P	*	130,000.	W	*	120,000.	P	*	1,300,000.	W	*	2,600,000.	W	*
^{152}Eu	1.1	W		1.1	W		11.	W		11.	W		22.	W	

TABLE S.1. (contd)

Nuclide	Case 1 Public 0.1 mrem/y Worker 1 mrem/y Concentration pCi/g		Case 2 Public 1 mrem/y Worker 1 mrem/y Concentration pCi/g		Case 3 Public 0.1 mrem/y Worker 10 mrem/y Concentration pCi/g		Case 4 Public 10 mrem/y Worker 10 mrem/y Concentration pCi/g		Case 5 Public 5 mrem/y Worker 20 mrem/y Concentration pCi/g	
^{154}Eu	1.1	W	1.1	W	11.	W	11.	W	22.	W
^{155}Eu	160.	W	160.	W	1600.	W	1600.	W	3200.	W *
^{203}Hg	27.	W	27.	W	270.	W	270.	W	540.	W
^{207}Bi	0.93	W	0.93	W	9.3	W	9.3	W	19.	W
^{226}Ra	54.	P	93.	W	54.	P	930.	W	1900.	W
$^{226}Ra+D$(f)	0.61	W	0.61	W	6.1	W	6.1	W	12.	W
^{228}Th	25.	W	25.	W	31.	P	250.	W	500.	W
^{229}Th	4.4	W	4.4	W	11.	P	44.	W	88.	W
$^{229}Th+D$(g)	3.5	W	3.5	W	11.	P	35.	W	70.	W
^{230}Th	30.	W	30.	W	31.	P	300.	W	600.	W
^{232}Th	6.8	W	6.8	W	22.	P	55.	C	55.	C
$^{232}Th+D$(h)	0.34	W	0.34	W	3.4	W	3.4	W	6.8	W
^{232}U	12.	W	12.	W	16.	P	120.	W	240.	W
^{233}U	56.	P	63.	W	56.	P	630.	W	1300.	W
^{234}U	56.	P	64.	W	56.	P	640.	W	1300.	W
^{235}U	35.	W	35.	W	60.	P	350.	W	700.	W
$^{235}U+D$(i)	34.	W	34.	W	60.	P	340.	W	680.	W
^{238}U	63.	P	69.	W	63.	P	168.	C	168.	C
$^{238}U+D$(j)	50.	W	50.	W	63.	P	168.	C	168.	C
^{237}Np	13.	W	13.	W	22.	P	130.	W	260.	W
$^{237}Np+D$(k)	8.4	W	8.4	W	22.	P	84.	W	170.	W
^{238}Pu	23.	P	28.	W	23.	P	280.	W	560.	W
^{239}Pu	21.	P	25.	W	21.	P	250.	W	500.	W
^{240}Pu	21.	P	25.	W	21.	P	250.	W	500.	W
^{241}Pu	1400.	P	1500.	W	1400.	P	15,000.	W *	30,000.	W *
^{241}Am	12.	W	12.	W	20.	P	120.	W	240.	W

(a) The limiting scenario, based on incineration of mixed solids in a rotary kiln incinerator or other constraint, is indicated as follows:
- W = Worker dose, based on waste or incineration with 70% residue
- P = Maximally exposed offsite individual member of the general public
- C = Concentration of source material; uranium and ^{232}Th at 0.05%.

(b) An asterisk (*) beside the symbol for limiting scenario indicates that the value is greater than the transportation labeling limit of 2 nCi/g (2000 pCi/g).

(c) $^{90}Sr+D$ refers to ^{90}Sr in equilibrium with decay product ^{90}Y.

(d) $^{113}Sn+D$ refers to ^{113}Sn in equilibrium with ^{113m}In.

(e) $^{144}Ce+D$ refers to ^{144}Ce in equilibrium with ^{144m}Pr (branching ratio 0.0143) and ^{144}Pr (branching ratio 0.9857).

(f) $^{226}Ra+D$ refers to ^{226}Ra in equilibrium with decay products ^{222}Rn (with short-lived ^{218}Po, ^{214}Pb, ^{214}Bi, and ^{214}Po), ^{210}Pb, ^{210}Bi, and ^{210}Po.

(g) $^{229}Th+D$ refers to ^{229}Th in equilibrium with decay products ^{225}Ra and ^{225}Ac

(h) $^{232}Th+D$ refers to ^{232}Th in equilibrium with decay products ^{228}Ra, ^{228}Ac, ^{228}Th, ^{224}Ra, ^{220}Rn and ^{216}Po, ^{212}Pb, and ^{212}Bi.

(i) 235U+D refers to 235U in equilibrium with decay product ^{231}Th

(j) $^{238}U+D$ refers to ^{238}U in equilibrium with decay products ^{234}Th, ^{234m}Pa, and ^{234}Pa (with a branching ratio of 0.0016 applied).

(k) $^{237}Np+D$ refers to ^{237}Np in equilibrium with decay product ^{233}Pa.

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Similarly, there are instances in which the U.S. Nuclear Regulatory Commission (NRC) limit of 0.05% for source materials applies to uranium and thorium concentrations.

Table S.1 shows only the most restrictive (lowest scenario-derived) concentration for each radionuclide and case, with a notation identifying the limiting scenario. Limiting scenarios are based on incineration of mixed solids in a rotary kiln incinerator. Incineration of organic liquids in a liquid-only incinerator, which may potentially be more restrictive for some waste streams, is excluded here but included in Appendix I, "Worker Dose for Each Scenario by Radionuclide." The limiting concentrations for the offsite individual are derived by calculating (by radionuclide) the activity released that results in a given dose, and determining the allowable concentration based on the throughput of the facility and the stack release fraction. Limiting concentrations for workers are determined by calculating the potential dose from a given concentration of activity in the feedstream.

ACRONYMS

ALARA	as low as reasonably achievable
BNL	Brookhaven National Laboratory
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EPA	U.S. Environmental Protection Agency
MM	Martin Marietta Co.
NEPA	National Environmental Policy Act
NRC	U.S. Nuclear Regulatory Commission
ORISE	Oak Ridge Institute for Science and Education
PNL	Pacific Northwest Laboratory
RCRA	Resource Conservation and Recovery Act
RES	Rollins Environmental Services, Inc.
SRS	Savannah River Site
TSCA	Toxic Substances Control Act
TSD	treatment, storage, and disposal facilities

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TABLES

1.0 INTRODUCTION

To determine if Resource Conservation and Recovery Act (RCRA) or Toxic Substances Control Act (TSCA) permitted facilities have controls that will adequately limit public and worker radiation doses, the U.S. Department of Energy (DOE) is currently studying the feasibility of radiation control criteria that will limit the concentrations of radionuclides in hazardous waste for commercial processing. The Environmental Protection Support and Assistance Project (under DOE's Office of Environmental Guidance, Air, Water, and Radiation Division [DOE/EH-232]) is being completed in seven phases, which are as follows:

1. identify limits and constraints
2. analyze procedures and controls at treatment, storage, and disposal (TSD) facilities
3. perform pathway and exposure analyses
4. develop screening criteria
5. characterize waste streams
6. conduct as low as reasonably achievable (ALARA) and National Environmental Policy Act (NEPA) analyses
7. determine appropriate action.

The purpose of this report is 1) to provide and document the technical basis for DOE to establish screening criteria used for a data call (request for information from DOE sites) to help characterize DOE waste streams and 2) to provide data and methods to support the ALARA analysis which will be the basis for proposing control criteria. This report provides only preliminary collective dose estimates (scoping level) and does not detail procedures for such calculations. These collective dose procedures must be developed further

before potential control criteria can be adequately assured. Appendix A contains the data call and screening criteria developed by the Office of Environmental Guidance.

This report, prepared by the Pacific Northwest Laboratory (PNL) for DOE, supports Phase 4 (develop screening criteria) and documents parts of Phases 1 and 2. Results described in this report are based on analyses of generic radiation exposure scenarios and pathways and use a list of 62 radionuclides known to be actually, or potentially, present in hazardous wastes from DOE facilities. The calculations examine both doses to offsite residents from a commercial incinerator and doses to workers at an incinerator or landfill.

The waste streams being considered are mixed, i.e., containing both radioactive and hazardous chemical contaminations. Because this assessment examines only the doses associated with radioactive constituents, the concentration limits derived in this study are based on radiation doses only.

Section 1.0 contains information about the radionuclides considered in the evaluation, the identified regulatory limits and constraints, and a characterization of TSD facilities. The methodology and results for the assessment of dose to members of the general public and to hazardous waste workers are presented in Sections 2.0 and 3.0, respectively. Section 4.0 contains a discussion of the results in terms of the most restrictive radionuclide concentration in the incinerator feedstream, as determined by the offsite individual or worker dose estimates. Section 5.0 deals with limitations and uncertainties. The appendices include the DOE data call with screening levels, details of calculation methods, and unabridged tables of results.

1.1 REFERENCE RADIONUCLIDES

Sixty-two radionuclides, as listed in Table 1.1, were selected for consideration in the analyses of radiation exposure scenarios and pathways. These radionuclides represent those that have been listed as actually or potentially occurring in the waste streams of various DOE facilities.

TABLE 1.1. Radionuclides Considered in the Hazardous Waste Incineration Dose Analysis

Radionuclide	Half-life[a]	Radionuclide	Half-life
^{3}H	12.3 y	^{125}Sb	2.8 y
^{7}Be	53.3 d	^{125m}Te	58 d
^{14}C	5720 y	^{125}I	60.1 d
^{15}O	2.6 y	^{126}I	13 d
^{22}Na	14.3 d	^{129}I	1.6E+7 y
^{35}S	87.4 d	^{131}I	8.0 d
^{46}Sc	83.8 d	^{134}Cs	2.1 y
^{48}V	16.2 d	^{137}Cs[c]	30.1 y
^{51}Cr	27.7 d	^{144}Ce[b]	284 d
^{54}Mn	313 d	^{147}Pm	2.6 y
^{55}Fe	2.7 y	^{151}Sm	90.1 y
^{56}Co	78.8 d	^{152}Eu	13.6 y
^{57}Co	271 d	^{154}Eu	8.8 y
^{58}Co	70.8 d	^{155}Eu	5.0 y
^{60}Co	5.3 y	^{203}Hg	46.6 d
^{63}Ni	99.9 y	^{207}Bi	38 y
^{65}Zn	244 d	^{226}Ra[b,c]	1600 y
^{68}Ge	288 d	^{228}Th	1.9 y
^{74}As	17.8 d	^{229}Th[b]	7340 y
^{75}Se	120 d	^{230}Th	7.7E+4 y
^{79}Se	6.5E+4 y	^{232}Th[b]	1.4E+10 y
^{90}Sr[b]	28.5 y	^{232}U	64.6 y
^{88}Y	106.6 d	^{233}U	1.5E+5 y
^{93}Zr	1.5E+6 y	^{234}U	2.3E+5 y
^{94}Nb	2.0E+4 y	^{235}U[b]	7.0E+8 y
^{99}Tc	2.1E+5 y	^{238}U[b]	4.5E+9 y
^{106}Ru[c]	368 d	^{237}Np[b]	2.1E+6 y
^{110m}Ag[c]	250 d	^{238}Pu	87.6 y
^{113}Sn[b]	115 d	^{239}Pu	2.4E+4 y
^{124}Sb	60.2 d	^{240}Pu	6570 y
		^{241}Pu	14.4 y
		^{241}Am	432.6 y

(a) h = hours, d = days, and y = years.
(b) Decay products of this radionuclide were considered separately (see footnotes with Table S.1).
(c) Very short-lived decay products were considered implicitly.

Chau et al.[a] reported a number of radionuclides to be "potentially present" in wastes from Martin Marietta (MM) facilities (Oak Ridge, Tennessee; Paducah, Kentucky; Portsmouth, Ohio); other radionuclides are known to be present in some DOE wastes.[b] Although no rationale was given by Chau et al. for the radionuclides selected as being potentially present in DOE waste, their draft report contains the identified isotopic composition of Savannah River Site waste shipped to the Rollins Environmental Services (RES) facility in Baton Rouge, Louisiana. Waste stream radionuclide data were also obtained for Pacific Northwest Laboratory[c] (PNL) and for Brookhaven National Laboratory (BNL).[d] The composite list was then screened to eliminate the short-lived radionuclides (half-life <7 days) because these would decay to insignificant levels before arrival at an offsite treatment or disposal facility. Selected long-lived radionuclides were also excluded because of their anticipated low concentrations. Table 1.2 compares the radionuclides selected for this analysis with those previously used by Chau et al. and DOE (previously cited). For nine radionuclides (^{90}Sr, ^{113}Sn, ^{144}Ce, ^{226}Ra, ^{229}Th, ^{232}Th, ^{235}U, ^{238}U, and ^{237}Np) decay products in equilibrium were considered in addition to the parent radionuclide alone.

(a) Chau, T. K., R. Shuman, R. D. Baird, and E. A. Jennrich. 1992. Draft Release Limits for Contaminated Sludges and Solids. RAE-9005/7-2, Rodgers and Associates Engineering, Salt Lake City, Utah. Prepared for Martin Marietta Energy Systems K-25 Plant Site, Hwy. 58, Oak Ridge, Tennessee 37831.

(b) U.S. Department of Energy (DOE). April 1992. Revised Dose Evaluation for DOE Waste Disposed at the Rollins Incinerator - Draft. Office of Environmental Guidance, Washington, D.C.

(c) Pacific Northwest Laboratory (PNL). 1992. "Proposed List of Radioisotopes for Mixed Waste Control Criteria Report." Letter from W. E. Kennedy, Jr., to A. Wallo, III, Director, Air, Water, and Radiation Division, EH-232. Letter dated 10 July 1992.

(d) Brookhaven National Laboratory (BNL). 1993. "Accelerator, Medical and Biology Radionuclides...Radionuclides Commonly Detected in BNL Effluent and Radioactive Waste." Letter from R. Miltenberger and G. Schroeder, Radiation Release Criteria Working Group to A. Wallo, III, Director, Air, Water, and Radiation Division, EH-232. Letter dated 5 February 1993.

TABLE 1.2. Comparison of Radionuclides Reported in Waste Streams at Martin Marietta, Pacific Northwest Laboratory, Savannah River, and Brookhaven National Laboratory[a]

Radionuclide	MM	PNL	SRS	BNL	Radionuclides Excluded(*)	Reason for Exclusion
^{3}H	X	X	X	X		
^{7}Be	X			X		
^{14}C	X	X		X		
^{15}O				X	*	SHL[b] (122.24 s)[c]
^{22}Na				X		
^{24}Na				X	*	SHL (15.00 h)
^{32}P	X			X		
^{35}S				X		
^{41}Ar				X	*	Noble gas
^{46}Sc				X		
^{47}Sc				X	*	SHL (3.351 d)
^{48}V				X		
^{51}Cr				X		
^{52}Mn				X	*	SHL (5.591 d)
^{54}Mn			X	X		
^{55}Fe		X				
^{56}Co				X		
^{57}Co	X			X		
^{58}Co				X		
^{60}Co	X	X	X	X		
^{63}Ni	X	X	X			
^{67}Cu				X	*	SHL (61.86 h)
^{65}Zn		X	X	X		
^{68}Ga				X	*	SHL (68.0 m)
^{68}Ge				X		
^{69}Ge				X	*	SHL (39.05 h)
^{74}As				X		
^{75}Se			X	X		
^{79}Se			X			
^{77}Br				X	*	SHL (56 h)
^{82}Br				X	*	SHL (35.3 h)
^{85}Kr	X				*	Noble gas
^{90}Sr	X	X	X	X		
^{88}Y				X		
^{90}Y			X		*	SHL (64 h)
^{93}Zr	X					
^{97}Zr				X	*	SHL (16.90 h)
^{94}Nb			X			
^{97m}Nb				X	*	SHL (60 s)
^{99}Tc	X	X	X			
^{99m}Tc				X	*	SHL (6.02 h)
^{106}Ru	X		X	X		
^{106}Rh			X			with ^{106}Ru
^{110m}Ag			X	X		
^{111}In				X	*	SHL (2.83 d)

TABLE 1.2. (contd)

Radionuclide	MM	PNL	SRS	BNL	Radionuclides Excluded(*)	Reason for Exclusion
^{113}Sn				X		
^{113m}Sn				X	*	SHL (21.4 m)
^{124}Sb				X		
^{125}Sb			X			
^{125m}Te			X			
^{123}I				X	*	SHL (13.2 h)
^{124}I				X	*	SHL (4.18 d)
^{125}I	X			X		
^{126}I				X		
^{129}I		X	X			
^{131}I	X			X		
^{133}I		X			*	SHL (20.3 h)
^{125}Xe				X	*	SHL (17.0 h), Noble gas
^{127}Xe				X	*	Noble gas
^{129}Xe				X	*	Noble gas
^{131}Xe				X	*	Noble gas
^{134}Cs			X	X		
^{137}Cs	X	X	X	X		
^{137m}Ba	X					with ^{137}Cs
^{144}Ce			X			
^{144}Pr			X		*	SHL (17.27 m)
^{147}Pm			X			
^{151}Sm			X			
^{153}Sm				X	*	SHL (46.7 h)
^{152}Eu		X				
^{154}Eu	X		X			
^{155}Eu			X	X		
^{198}Au				X	*	SHL (2.696 d)
^{199}Au				X	*	SHL (3.139 d)
^{203}Hg				X		
^{201}Tl				X	*	SHL (3.044 d)
^{203}Pb				X	*	SHL (52.05 h)
^{206}Bi				X	*	SHL (6.243 d)
^{207}Bi				X		
^{226}Ra	X	X				
^{228}Th	X			X		
^{229}Th	X					
^{230}Th	X	X				
^{232}Th	X	X	X	X		
^{232}U			X	X		
^{233}U			X			
^{234}U	X	X	X			
^{235}U	X	X	X			
^{236}U	X		X		*	^{238}U chosen
^{238}U	X	X	X	X		
^{237}Np	X					
^{238}Pu	X		X			
^{239}Pu	X	X	X			
^{240}Pu	X					

TABLE 1.2. (contd)

Radionuclide	MM	PNL	SRS	BNL	Radionuclides Excluded(*)	Reason for Exclusion
^{241}Pu	X	X	X			
^{242}Pu	X				*	L(e)
^{244}Pu	X				*	L
^{241}Am	X	X	X	X		
^{243}Am	X				*	L
^{243}Cm	X				*	L
^{244}Cm	X		X		*	L
^{248}Cm	X				*	L
^{252}Cf	X				*	SHL (2.646 d)

Sources:

Chau, T. K., R. Shuman, R. D. Baird, and E. A. Jennrich. 1992. Draft Release Limits for Contaminated Sludges and Solids, RAE-9005/7-2. Rodgers and Associates Engineering, Salt Lake City, Utah. Prepared for Martin Marietta Energy Systems K-25 Plant Site, Hwy. 58, Oak Ridge, Tennessee 37831.

Pacific Northwest Laboratory (PNL). 1992. "Proposed List of Radioisotopes for Mixed Waste Control Criteria Report." Letter from W.E. Kennedy, Jr., to A. Wallo, III, Director, Air, Water, and Radiation Division, EH-232. Letter dated 10 July 1992.

Pacific Northwest Laboratory (PNL). 1992. "Radionuclides in Mixed Waste/Incineration Task." Telephone discussion by R.L. Hill with G. Roles DOE/EH-232. Conversation 22 July 1992.

U.S. Department of Energy (DOE). April 1992. In Table 2A, "Isotopic Composition and Stack Releases for Oak Ridge Complex Waste Shipped to Rollins Incinerator," and Table 2B "Isotopic Composition and Releases for Savannah River Site Waste Shipped to Rollins Incinerator," Revised Dose Evaluation for DOE Waste Disposed at the Rollins Incinerator - Draft. Office of Environmental Guidance, Washington, D.C.

Brookhaven National Laboratory (BNL). 1993. "Accelerator, Medical and Biology Radionuclides...Radionuclides Commonly Detected in BNL Effluent and Radioactive Waste." Letter from R. Miltenberger and G. Schroeder, Radiation Release Criteria Working Group to A. Wallo, III, Director, Air, Water, and Radiation Division, EH-232. Letter dated 5 February 1993.

(a) MM Martin Marietta
PNL Pacific Northwest Laboratory
SRS Savanna River
BNL Brookhaven National Laboratory

(b) SHL=short half-life

(c) m=minutes; h=hours; d=days; y=years

(d) Noble gas not retained in waste

(e) L=low occurrence

1.2 REGULATORY LIMITS AND CONSTRAINTS

The regulatory limits and constraints being considered by DOE/EH in assessing the feasibility of radiation control criteria are presented in Table 1.3. This table contains specific dose, risk, or concentration values found in various government agency directives, regulations, and guidance. Appendix B contains a more detailed description of each regulatory citation.

In this assessment, separate sets of dose constraints were chosen for the maximally exposed offsite individual and the maximally exposed hazardous waste worker. Dose constraints were chosen by DOE to be within the range of regulatory limits and constraints identified. In some cases, unit dose concentration values were chosen for cases that limited doses to the public and worker to the same constraint. In other cases, differential levels of protection are assumed. This illustrates how limiting scenarios change for various combinations of allowable worker and population dose. Dose limits for protection levels of 1:1, 10:1, 100:1, and 4:1 are shown. Dose limits of 0.1 mrem/y, 1 mrem/y, 5 mrem/y, and 10 mrem/y to the offsite individual were used to calculate activity screening levels. For the hazardous waste worker, dose limits of 1 mrem/y, 10 mrem/y, and 20 mrem/y were used to calculate the screening levels. These dose limits were next combined into cases that together provide limits for both the individual members of the general public and for hazardous waste workers. The cases considered are

- offsite individual dose of 0.1 mrem/y and worker dose of 1 mrem/y
- offsite individual dose of 1 mrem/y and worker dose of 1 mrem/y
- offsite individual dose of 0.1 mrem/y and worker dose of 10 mrem/y
- offsite individual dose of 10 mrem/y and worker dose of 10 mrem/y
- offsite individual dose of 5 mrem/y and worker dose of 20 mrem/y.

TABLE 1.3. Examples of Regulatory Limits and Constraints

Category Limit	Description	Reference
Dose/Risk Limits		
100 mrem/y	Public - all pathways	DOE - 5400.5 (1990) NRC - 10 CFR 20.1301
10 mrem/y	Public - air pathway	DOE - 5400.5 (1990) EPA - 40 CFR 61.92 (Subpart H)
5 rem/y	Worker - all pathways	DOE - 5480.11 (1989) NRC - 10 CFR 20.1201 EPA - (52 FR 17)
Dose/Risk Constraints		
10 mrem/y	Public - all pathways reporting requirement	DOE - 5400.5 (1990)[a]
0.1 mrem/y	Public - stack-monitoring requirement	DOE - 5400.1 (1988) EPA - 40 CFR 61.93 (Subpart H)
100 mrem/y	Worker restriction for unmonitored workers	DOE - 5480.11 (1989)
2000 mrem/y	Administrative Control Level Worker	Rad. Con. Manual (DOE 1992)
N x rem	Lifetime Control Level Worker (worker age x rem)	Rad. Con. Manual (DOE 1992)[a]
100 person-rem/y	Public - reporting requirement	DOE - 5400.1 (1988)
10 mg/week	Uranium toxicity limit	NRC - 10 CFR 20.1201
Concentration Limits		
0.05% by weight	Source material Uranium and thorium	NRC - 10 CFR 20.1003
2 nCi/g	Labeling requirement	DOT - 49 CFR 173.401 (1988)

(a) The most limiting requirement is likely to be the additional DOE requirement for the application of the ALARA process to the control levels and limits.

Two additional constraints were evaluated in the derivation of the screening levels. First, the U.S. Department of Transportation (DOT) requires that any material having an activity of 2 nCi/g or greater be labeled as radioactive material (49 CFR 173.403). Second, the U.S. Nuclear Regulatory Commission (NRC) has set a concentration limit for thorium and natural uranium of 0.05%, at or above which any material possessed, received, used, transferred, or delivered is generally classified as source material (10 CFR 20).

1.3 TREATMENT, STORAGE, AND DISPOSAL OF HAZARDOUS WASTE

The radiation dose assessments were based on pathway and exposure analyses of processes used for treatment, storage, and disposal (TSD) facilities. Data from site visits and literature reviews were used to develop several scenarios for "generic TSD facilities" employed in the pathway and exposure analyses. To understand and quantify potential exposure pathways, many facility types were initially studied. The effort was then restricted to facilities providing waste-destruction services and/or onsite disposal, such as landfilling. Recycling or reuse processes are not considered in this assessment.[a]

Initially, the operations and types of waste treatment processes provided by over 260 TSD commercial facilities were examined. These facilities were characterized by the services they provided, i.e., incineration, treatment, and/or disposal. Information was collected from many sources, including facility permit applications, company literature and audit packages, trade industry publications, commercial directories, open literature searches, and site visits. The Hazardous Waste Shipment Data Systems, a computer database developed at EG&G Idaho for DOE's Office of Environmental Restoration and Waste Management, was used to add direction to these data collection tasks.

(a) See preliminary draft report, "Radiation Dose Assessments to Support Evaluations of Radiological Control Criteria for Recycling or Reuse of Materials and Equipment," June 1993, for an assessment of dose from recycled materials and equipment.

The site visits, time-and-motion studies, and radiation data collection were conducted for DOE by Oak Ridge Institute for Science and Education (ORISE). Information from site-specific retrospective radiological dose assessment reports was also used (Chew and Associates, 1992, 1993a-e) and data obtained from Chew and Associates.

1.3.1 Thermal Treatment

Data collected on thermal treatment facilities include location, services provided, type of incinerator, waste throughput (permitted and actual), physical and chemical forms of the waste incinerated, waste restrictions, process descriptions, and services provided. For a limited number of facilities, information was also collected on air pollution control equipment, test burns, pre- and post-incineration waste treatment, ash/residuals disposal, industrial hygiene/safety practices, job descriptions, worker population, facility settings, worker time-and-motion studies, regulatory status, and background radioactivity.

Incineration of the wastes is being evaluated because, while it provides environmental, safety, and health benefits, it may also increase certain risks. Incineration results in a large decrease in the volume of waste and the destruction of hazardous organic components, but it also concentrates heavy metals and some radionuclides in ash products. The potential radiation dose consequences of this concentrating action must be addressed when studying the feasibility of radiological control criteria.

During incineration of wastes, elements partition among the primary combustion residues, which may include an ash or a fused slag, the fine particulate matter (fly ash) that is trapped in the burner off-gas, or the airborne fraction that escapes to the atmosphere. The potential radiation dose to workers and the public is affected by the degree of partitioning of radionuclides into the respective waste stream components.

Incineration may change the form of metal fractions in waste streams, but will not destroy the metals. The concern, therefore, centers around

where, and in what physical or chemical form, the metals end up in the combustion system, i.e., as bottom ash, in air pollution control device residues, or in stack emissions. The focus of regulatory concern has traditionally been on stack emissions. However, there are now regulations governing the testing and disposition of residuals from incineration of metal-bearing waste because land disposal of these materials may be restricted.

1.3.2 Landfilling

Landfilling of combustion residues is standard industrial practice. In addition to exposure from routine operations, exposure to workers might potentially occur during a planned remediation activity while digging in the wastes to recover a buried item or to repair landfill liners or leachate collection systems.

Data collected on landfill operations include location, services provided, process description, waste-handling procedures, pre-treatment, disposal procedures, worker time-and-motion studies, regulatory status, environmental release prevention practices, and background radioactivity.

The information compiled was used as the technical basis for development of the generic scenarios for a rotary kiln incinerator and for a landfill on which the radiation dose assessment calculations are based.

The generic facility used as a basis for this assessment is a 30,000-tonnes/year (t/y) rotary kiln incinerator that burns both solids and liquids, which is typical of commercially operated RCRA incinerators. An incinerator of this type could handle most types of waste materials amenable to incineration. Most of the information available concerning worker exposures was based on incinerators that handle some solid materials. The incineration of organic liquids in a liquid-only incinerator was also considered in this study. However, we do not have as much confidence in using the same scenarios for liquid-only incineration because fewer data are available to support the assumptions relating to worker exposure. Appendix I shows results for incineration of organic liquids (designated by scenario description

followed by "OL"), but results are not integrated into the limiting concentrations that are presented in Table S.1 and the tables in Sections 3.0 and 4.0.

It may be necessary to develop a separate set of dose-to-concentration factors for incinerators that process only liquid waste because of the greater volume reduction associated with incineration of liquids compared to solids or sludges. The greater volume reduction results in higher radionuclide concentrations in residual materials; therefore, higher dose-to-concentration factors may result for incineration of liquid wastes. Conversely, reduced dust level and total mass could result in lower dose-to-concentration factors, especially if workers spent less time near the waste.

2.0 DOSE CALCULATIONS FOR MEMBERS OF THE GENERAL PUBLIC

This section describes the calculational approach used to estimate radiation doses from releases from a hazardous waste incinerator receiving DOE wastes containing residual levels of radioactive materials. Using generic population and meteorologic data, doses are estimated for the maximally exposed offsite individual and for the general public within 80 km of the incinerator.

2.1 METHODOLOGY

The flow of radioactive materials inside a typical RCRA incineration facility is apportioned between residue streams from the incinerator furnace and those from stack emissions. The conceptual model used to estimate public doses from incineration of hazardous wastes containing radioactive materials is shown in Figure 2.1. The distribution of the elements in waste streams and emissions is derived from the information in Appendix C, "Element Partitioning in an Incinerator." The U.S. Environmental Protection Agency (EPA) software package, CAP88-PC (Parks 1992), is used to calculate unit emission dose factors (dose per quantity of radionuclide release from the stack) for the maximally exposed offsite individual and for the general population. A PNL-developed program is used to calculate allowable concentrations in waste from these dose factors. A more detailed description of the calculations is given in Appendix D, "Calculation Methodology for Radiation Doses."

The waste throughput of 30,000 t/y was chosen to represent the base case for incinerators in this assessment because that is the capacity of an average rotary kiln incinerator, according to the 1992 Directory of Commercial Hazardous Waste Facilities (McCoy and Associates 1992). Since some commercial incinerators have substantially larger capacities (RES-Deer Park, Texas, has an estimated capacity of 250,000 t/y), a secondary case of 150,000 t/y was

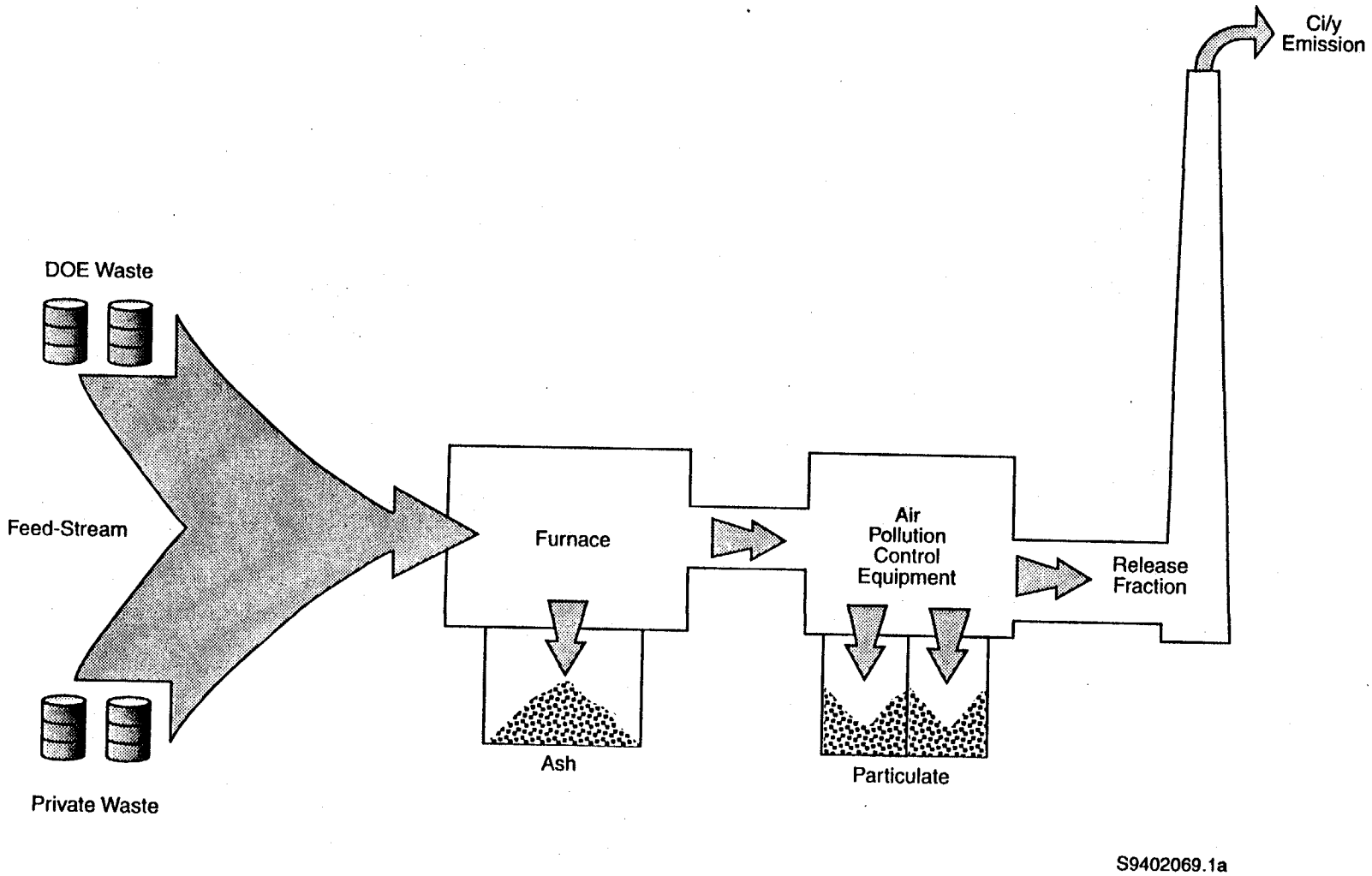

FIGURE 2.1. Generic Incinerator Model

also considered to represent a large facility. The 30,000-t/y incinerator is used as a base case because the assumption of 150,000 t/y of DOE-only waste was assumed to be excessive.

The transport and fate of radioactive air emissions are modeled using CAP88-PC. The calculations account for dispersion in air, deposition on ground surfaces, and subsequent incorporation of radioactive materials in the food chain. The dose to the maximally exposed individual is calculated in terms of mrem per curie released; the dose to the general public within 80 km of the site is given in person-rem per curie released. The emission rate that results in a given dose to the maximally exposed individual is back-calculated from the unit dose factor (dose from a unit release). The population dose corresponding to that emission rate is also calculated in a similar manner.[a] The activity of waste processed (in Ci/y), or concentration at a given throughput (i.e., Ci/t x t/y), is calculated from the emission rate and the assumed stack release factor. The stack release factors used in the analysis are based on literature values and are included in Appendix C, "Element Partitioning in an Incinerator." The following sections describe the assumptions related to atmospheric dispersion, population,and ingestion parameters.

2.2 ATMOSPHERIC DISPERSION

For this analysis, many assumptions concerning atmospheric dispersion are generic in nature. Therefore, the default assumptions resident in CAP88-PC are used for the precipitation, the temperature, and the height of the atmospheric lid. A windfile based on 4-m/s windspeed and Pasquill stability category D is used for all the calculations.

(a) For ^{232}Th, unit dose factors were determined for both ^{232}Th alone and for ^{232}Th in equilibrium with its decay chain (that is, a source term of 1 Ci of ^{232}Th and each of nine decay products). Other decay chains (represented with the +D designation) were assumed to have the same dose factor (for dose to the offsite individual and offsite population) as the parent nuclide alone.

Stack height is an important input parameter for CAP88-PC calculations. Five out of six commercial hazardous waste incineration facilities described by Chau et al. 1992[a] have stacks between 30 and 40 m tall. Four out of these six facilities were also described by Chew and Associates (1992, 1993a; and data obtained from Chew and Associates); the RES Baton Rouge facility (RES-LA) was also described in a report by ORISE (Beck and Foltz 1993).

The predominant types of hazardous incinerator furnace operating in the United States are the liquid injection incinerator and the rotary kiln (Travis and Cook 1989). Because the RES-LA facility has both of these furnace types, and is a typical incineration facility in terms of permitted waste throughput and air pollution control equipment, it was selected to represent a generic model for current hazardous waste incinerator facilities. Thirty meters was therefore chosen to represent stack height of the generic facility.

2.3 POPULATION ASSUMPTIONS

For the analysis of dose to members of the general public, three generic receptor population distributions are examined: a metropolitan site with high-density population, a metropolitan site with low-density population, and a rural site population.

The population density is assumed to be uniformly distributed within a distance of 80 km from the facility. The population densities are based on selected population files included in the CAP88-PC software package and on published population density and distribution patterns for the United States (Rand McNally 1991). The assigned population densities are as follows:

(a) Chau, T. K., R. Shuman, R. D. Baird, and E. A. Jennrich. 1992. Draft Release Limits for Contaminated Sludges and Solids, RAE-9005/7-2. Rodgers and Associates Engineering, Salt Lake City, Utah. Prepared for Martin Marietta Energy Systems K-25 Plant Site, Hwy. 58, Oak Ridge, Tennessee. The facilities described include APTUS in Coffeyville, Kansas; Chemical Waste Management facilities in Chicago, Illinois, and Port Arthur, Texas; ENSCO in El Dorado, Arkansas; and Rollins Environmental Services, Inc. (RES) facilities in Deer Park, Texas and Baton Rouge, Louisiana.

80 people/km^2 metropolitan site-high density (metro-high)

20 people/km^2 metropolitan site-low density (metro-low)

10 people/km^2 rural site.

The maximally exposed individual is located at 500 m from the source for all three population distributions. This selection is based on the maximum concentration for a stack with an effective height of 30 m. Values for both dose and risk are calculated by CAP88-PC for the maximally exposed individual and for the population residing within 80 km of the site.

2.4 INGESTION PARAMETERS

The food source distributions are chosen to be appropriate for each population density. Default food source scenarios from CAP88-PC are selected for the metropolitan site-high density (urban) and rural site population density (rural). For the metropolitan site-low density population, a food source distribution between those of the urban and rural scenarios is used. The food source distributions account for most of the differences between doses to the maximally exposed offsite individual at the three types of sites. The default estimates in CAP88-PC for food production and crop production are based on states representative of the three population densities used for this analysis (i.e., Illinois for metropolitan-high, Kentucky for metropolitan-low, and Utah for rural).

2.5 RESULTS

Table 2.1 presents the concentration of radionuclides in an incinerator feedstream that would result in a dose of 0.1 mrem/y to the maximally exposed individuals based on a 30,000-t/y incinerator throughput. Since the same atmospheric dispersion and the same distance to the nearest resident are assumed for all three population density scenarios, the major differences are related to the consumption rates for locally produced food crops. Because there is a greater contribution to dose from food pathways (except

TABLE 2.1. Limiting Concentration of Radionuclides in Incinerator Feed Based on 0.1 mrem/y to the Maximally Exposed Offsite Individual from a 30,000-t/y Incinerator

Nuclide	Feedstream Concentration, pCi/g	Limiting Exposure Scenario at 0.1 mrem/y
^{3}H	6.5E+03	Rural
^{7}Be	6.1E+05	Rural
^{14}C	1.2E+02	Rural
^{22}Na	9.1E+02	Rural
^{32}P	3.2E+03	Rural
^{35}S	4.0E+03	Rural
^{46}Sc	1.9E+04	Rural
^{48}V	7.9E+03	Rural
^{51}Cr	6.9E+05	Rural
^{54}Mn	3.7E+03	Rural
^{55}Fe	6.1E+04	Rural
^{56}Co	5.9E+02	Rural
^{57}Co	3.9E+03	Rural
^{58}Co	2.1E+03	Rural
^{60}Co	4.9E+01	Rural
^{63}Ni	6.1E+04	Rural
^{65}Zn	3.4E+02	Rural
^{68}Ge	2.7E+04	Rural
^{74}As	7.4E+04	Metro Low
^{75}Se	2.8E+02	Rural
^{79}Se	1.1E+03	Rural
^{90}Sr	7.5E+03	Rural
$^{90}Sr+D$[(a)]	Same	---
^{88}Y	1.6E+04	Rural
^{93}Zr	1.2E+05	Rural
^{94}Nb	1.1E+02	Rural
^{99}Tc	5.0E+01	Rural
^{106}Ru	5.6E+02	Rural
^{110m}Ag	2.5E+03	Rural
^{113}Sn	3.4E+04	Rural
$^{113}Sn+D$[(a)]	Same	---
^{124}Sb	6.7E+02	Rural
^{125}Sb	2.3E+02	Rural
^{125m}Te	9.4E+03	Rural
^{125}I	2.5E+00	Rural
^{126}I	7.8E+00	Rural
^{129}I	1.1E-01	Rural

TABLE 2.1. (contd)

Nuclide	Feedstream Concentration, pCi/g	Limiting Exposure Scenario at 0.1 mrem/y
^{131}I	1.0E+01	Rural
^{134}Cs	5.2E+02	Rural
^{137}Cs	2.4E+02	Rural
^{144}Ce	7.2E+03	Rural
$^{144}Ce+D$[(a)]	Same	---
^{147}Pm	8.0E+04	Rural
^{151}Sm	1.2E+05	Rural
^{152}Eu	4.9E+02	Rural
^{154}Eu	6.2E+02	Rural
^{155}Eu	1.5E+04	Rural
^{203}Hg	6.3E+02	Rural
^{207}Bi	1.3E+02	Rural
^{226}Ra	5.4E+01	Rural
$^{226}Ra+D$[(a)]	Same	---
^{228}Th	3.1E+01	Metro Low
^{229}Th	1.1E+01	Rural
$^{229}Th+D$[(a)]	Same	---
^{230}Th	3.1E+01	Rural
^{232}Th	2.2E+01	Rural
$^{232}Th+D$	9.4E+00	Rural
^{232}U	1.6E+01	Rural
^{233}U	5.6E+01	Rural
^{234}U	5.6E+01	Rural
^{235}U	6.0E+01	Rural
$^{235}U+D$[(a)]	Same	---
^{238}U	6.3E+01	Rural
$^{238}U+D$	None	---
^{237}Np	2.2E+01	Rural
$^{237}Np+D$[(a)]	Same	---
^{238}Pu	2.3E+01	Rural
^{239}Pu	2.1E+01	Rural
^{240}Pu	2.1E+01	Rural
^{241}Pu	1.4E+03	Rural
^{241}Am	2.0E+01	Rural

(a) The dose factor for the decay chain is assumed to have the same dose factor as the parent nuclide alone.

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radionuclides ^{74}As and ^{228}Th, for which the dose factors for all population densities are the same) for rural populations, the maximally exposed individual for this population is always limiting.

Tables 2.2, 2.3, and 2.4 give the limiting concentration of radionuclides in incinerator feed that would result in 0.1 mrem/y and 1.0 mrem/y doses to the maximally exposed offsite individual for both 30,000-t/y and 150,000-t/y incinerator throughput for the metro-high, metro-low, and rural population densities.

Appendix E, "Dose by Radionuclide to Members of the General Public," presents limiting concentrations for the three population densities, and details of the calculation of feedstream concentration that is summarized in Tables 2.2 through 2.4. The tables in Appendix E include, for each radionuclide, dose based on unit emission (unit dose factor), emission based on unit dose, stack release fraction, activity in waste processed (Ci/y) that would produce the unit dose, and concentration of each radionuclide in the feedstream (pCi/g) that would produce a unit dose. These results are presented for an annual throughput of 30,000 t/y, assuming that the entire throughput consists of DOE waste (i.e., no credit is taken for dilution of DOE waste by nonradioactive waste from other sources).

TABLE 2.2. Concentration of Radionuclides (pCi/g) in Incinerator Feed of 100% DOE Waste, Based on Dose to the Maximally Exposed Offsite Individual in the **Metro-High** ($80/km^2$) Population Density

Nuclide	1.0 mrem/y Dose (Individual) 30,000 t/y	1.0 mrem/y Dose (Individual) 150,000 t/y	0.1 mrem/y Dose (Individual) 30,000 t/y	0.1 mrem/y Dose (Individual) 150,000 t/y
^{3}H	1.1E+05	2.2E+04	1.1E+04	2.2E+03
^{7}Be	6.5E+06	1.3E+06	6.5E+05	1.3E+05
^{14}C	2.5E+03	4.9E+02	2.5E+02	4.9E+01
^{22}Na	9.9E+03	2.0E+03	9.9E+02	2.0E+02
^{32}P	5.1E+04	1.0E+04	5.1E+03	1.0E+03
^{35}S	7.0E+04	1.4E+04	7.0E+03	1.4E+03
^{46}Sc	2.1E+05	4.2E+04	2.1E+04	4.2E+03
^{48}V	1.1E+05	2.2E+04	1.1E+04	2.2E+03
^{51}Cr	7.9E+06	1.6E+06	7.9E+05	1.6E+05
^{54}Mn	3.8E+04	7.6E+03	3.8E+03	7.6E+02
^{55}Fe	1.1E+06	2.2E+05	1.1E+05	2.2E+04
^{56}Co	6.6E+03	1.3E+03	6.6E+02	1.3E+02
^{57}Co	4.3E+04	8.7E+03	4.3E+03	8.7E+02
^{58}Co	2.4E+04	4.8E+03	2.4E+03	4.8E+02
^{60}Co	5.0E+02	1.0E+02	5.0E+01	1.0E+01
^{63}Ni	1.1E+06	2.2E+05	1.1E+05	2.2E+04
^{65}Zn	5.5E+03	1.1E+03	5.5E+02	1.1E+02
^{68}Ge	3.6E+05	7.3E+04	3.6E+04	7.3E+03
^{74}As	7.4E+05	1.5E+05	7.4E+04	1.5E+04
^{75}Se	3.0E+03	6.0E+02	3.0E+02	6.0E+01
^{79}Se	1.9E+04	3.9E+03	1.9E+03	3.9E+02
^{90}Sr	1.3E+05	2.5E+04	1.3E+04	2.5E+03
$^{90}Sr+D$[a]	Same	Same	Same	Same
^{88}Y	1.7E+05	3.5E+04	1.7E+04	3.5E+03
^{93}Zr	1.4E+06	2.8E+05	1.4E+05	2.8E+04
^{94}Nb	1.1E+03	2.3E+02	1.1E+02	2.3E+01
^{99}Tc	9.8E+02	2.0E+02	9.8E+01	2.0E+01
^{106}Ru	6.8E+03	1.4E+03	6.8E+02	1.4E+02
^{110m}Ag	2.7E+04	5.4E+03	2.7E+03	5.4E+02
^{113}Sn	6.0E+05	1.2E+05	6.0E+04	1.2E+04
$^{113}Sn+D$[a]	Same	Same	Same	Same
^{124}Sb	7.6E+03	1.5E+03	7.6E+02	1.5E+02
^{125}Sb	2.4E+03	4.8E+02	2.4E+02	4.8E+01
^{125m}Te	1.6E+05	3.1E+04	1.6E+04	3.1E+03
^{125}I	5.1E+01	1.0E+01	5.1E+00	1.0E+00
^{126}I	1.5E+02	2.9E+01	1.5E+01	2.9E+00

TABLE 2.2. (contd)

Nuclide	1.0 mrem/y Dose (Individual) 30,000 t/y	1.0 mrem/y Dose (Individual) 150,000 t/y	0.1 mrem/y Dose (Individual) 30,000 t/y	0.1 mrem/y Dose (Individual) 150,000 t/y
^{129}I	2.2E+00	4.3E-01	2.2E-01	4.3E-02
^{131}I	1.9E+02	3.8E+01	1.9E+01	3.8E+00
^{134}Cs	6.5E+03	1.3E+03	6.5E+02	1.3E+02
^{137}Cs	2.7E+03	5.3E+02	2.7E+02	5.3E+01
^{144}Ce	8.6E+04	1.7E+04	8.6E+03	1.7E+03
$^{144}Ce+D$[(a)]	Same	Same	Same	Same
^{147}Pm	9.0E+05	1.8E+05	9.0E+04	1.8E+04
^{151}Sm	1.2E+06	2.5E+05	1.2E+05	2.5E+04
^{152}Eu	4.9E+03	9.9E+02	4.9E+02	9.9E+01
^{154}Eu	6.2E+03	1.2E+03	6.2E+02	1.2E+02
^{155}Eu	1.5E+05	3.0E+04	1.5E+04	3.0E+03
^{203}Hg	1.0E+04	2.1E+03	1.0E+03	2.1E+02
^{207}Bi	1.3E+03	2.6E+02	1.3E+02	2.6E+01
^{226}Ra	5.6E+02	1.1E+02	5.6E+01	1.1E+01
$^{226}Ra+D$[(a)]	Same	Same	Same	Same
^{228}Th	3.1E+02	6.3E+01	3.1E+01	6.3E+00
^{229}Th	1.1E+02	2.3E+01	1.1E+01	2.3E+00
$^{229}Th+D$[(a)]	Same	Same	Same	Same
^{230}Th	3.2E+02	6.3E+01	3.2E+01	6.3E+00
^{232}Th	2.2E+02	4.4E+01	2.2E+01	4.4E+00
$^{232}Th+D$	9.5E+01	1.9E+01	9.5E+00	1.9E+00
^{232}U	1.6E+02	3.3E+01	1.6E+01	3.3E+00
^{233}U	5.8E+02	1.2E+02	5.8E+01	1.2E+01
^{234}U	5.9E+02	1.2E+02	5.9E+01	1.2E+01
^{235}U	6.2E+02	1.2E+02	6.2E+01	1.2E+01
$^{235}U+D$[(a)]	Same	Same	Same	Same
^{238}U	6.6E+02	1.3E+02	6.6E+01	1.3E+01
$^{238}U+D$	Same	Same	Same	Same
^{237}Np	2.4E+02	4.8E+01	2.4E+01	4.8E+00
$^{237}Np+D$[(a)]	Same	Same	Same	Same
^{238}Pu	2.4E+02	4.8E+01	2.4E+01	4.8E+00
^{239}Pu	2.2E+02	4.5E+01	2.2E+01	4.5E+00
^{240}Pu	2.2E+02	4.5E+01	2.2E+01	4.5E+00
^{241}Pu	1.5E+04	2.9E+03	1.5E+03	2.9E+02
^{241}Am	2.2E+02	4.3E+01	2.2E+01	4.3E+00

(a) The dose factor for the decay chain is assumed to have the same dose factor as the parent nuclide alone.

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TABLE 2.3. Concentration of Radionuclides (pCi/g) in Incinerator Feed of 100% DOE Waste, Based on Dose to the Maximally Exposed Offsite Individual in the **Metro-Low** (20/km^2) Population Density

Nuclide	1.0 mrem/y Dose (Individual) 30,000 t/y	1.0 mrem/y Dose (Individual) 150,000 t/y	0.1 mrem/y Dose (Individual) 30,000 t/y	0.1 mrem/y Dose (Individual) 150,000 t/y
^{3}H	8.1E+04	1.6E+04	8.1E+03	1.6E+03
^{7}Be	6.3E+06	1.3E+06	6.3E+05	1.3E+05
^{14}C	1.6E+03	3.3E+02	1.6E+02	3.3E+01
^{22}Na	9.5E+03	1.9E+03	9.5E+02	1.9E+02
^{32}P	3.9E+04	7.8E+03	3.9E+03	7.8E+02
^{35}S	5.2E+04	1.0E+04	5.2E+03	1.0E+03
^{46}Sc	2.0E+05	4.0E+04	2.0E+04	4.0E+03
^{48}V	9.3E+04	1.9E+04	9.3E+03	1.9E+03
^{51}Cr	7.3E+06	1.5E+06	7.3E+05	1.5E+05
^{54}Mn	3.8E+04	7.5E+03	3.8E+03	7.5E+02
^{55}Fe	8.0E+05	1.6E+05	8.0E+04	1.6E+04
^{56}Co	6.3E+03	1.3E+03	6.3E+02	1.3E+02
^{57}Co	4.1E+04	8.3E+03	4.1E+03	8.3E+02
^{58}Co	2.3E+04	4.5E+03	2.3E+03	4.5E+02
^{60}Co	4.9E+02	9.9E+01	4.9E+01	9.9E+00
^{63}Ni	7.8E+05	1.6E+05	7.8E+04	1.6E+04
^{65}Zn	4.3E+03	8.6E+02	4.3E+02	8.6E+01
^{68}Ge	3.1E+05	6.2E+04	3.1E+04	6.2E+03
^{74}As	7.4E+05	1.5E+05	7.4E+04	1.5E+04
^{75}Se	2.9E+03	5.7E+02	2.9E+02	5.7E+01
^{79}Se	1.4E+04	2.9E+03	1.4E+03	2.9E+02
^{90}Sr	9.4E+04	1.9E+04	9.4E+03	1.9E+03
$^{90}Sr+D$[(a)]	Same	Same	Same	Same
^{88}Y	1.7E+05	3.4E+04	1.7E+04	3.4E+03
^{93}Zr	1.3E+06	2.6E+05	1.3E+05	2.6E+04
^{94}Nb	1.1E+03	2.2E+02	1.1E+02	2.2E+01
^{99}Tc	6.6E+02	1.3E+02	6.6E+01	1.3E+01
^{106}Ru	6.1E+03	1.2E+03	6.1E+02	1.2E+02
^{110m}Ag	2.6E+04	5.2E+03	2.6E+03	5.2E+02
^{113}Sn	4.4E+05	8.9E+04	4.4E+04	8.9E+03
$^{113}Sn+D$[(a)]	Same	Same	Same	Same
^{124}Sb	7.1E+03	1.4E+03	7.1E+02	1.4E+02
^{125}Sb	2.4E+03	4.7E+02	2.4E+02	4.7E+01
^{125m}Te	1.2E+05	2.4E+04	1.2E+04	2.4E+03
^{125}I	3.4E+01	6.8E+00	3.4E+00	6.8E-01
^{126}I	1.0E+02	2.0E+01	1.0E+01	2.0E+00

TABLE 2.3. (contd)

Nuclide	1.0 mrem/y Dose (Individual) 30,000 t/y	1.0 mrem/y Dose (Individual) 150,000 t/y	0.1 mrem/y Dose (Individual) 30,000 t/y	0.1 mrem/y Dose (Individual) 150,000 t/y
^{129}I	1.5E+00	3.0E-01	1.5E-01	3.0E-02
^{131}I	1.3E+02	2.6E+01	1.3E+01	2.6E+00
^{134}Cs	5.8E+03	1.2E+03	5.8E+02	1.2E+02
^{137}Cs	2.5E+03	5.1E+02	2.5E+02	5.1E+01
^{144}Ce	7.8E+04	1.6E+04	7.8E+03	1.6E+03
$^{144}Ce+D$[(a)]	Same	Same	Same	Same
^{147}Pm	8.5E+05	1.7E+05	8.5E+04	1.7E+04
^{151}Sm	1.2E+06	2.4E+05	1.2E+05	2.4E+04
^{152}Eu	4.9E+03	9.9E+02	4.9E+02	9.9E+01
^{154}Eu	6.2E+03	1.2E+03	6.2E+02	1.2E+02
^{155}Eu	1.5E+05	2.9E+04	1.5E+04	2.9E+03
^{203}Hg	8.0E+03	1.6E+03	8.0E+02	1.6E+02
^{207}Bi	1.3E+03	2.6E+02	1.3E+02	2.6E+01
^{226}Ra	5.5E+02	1.1E+02	5.5E+01	1.1E+01
$^{226}Ra+D$[(a)]	Same	Same	Same	Same
^{228}Th	3.1E+02	6.3E+01	3.1E+01	6.3E+00
^{229}Th	1.1E+02	2.3E+01	1.1E+01	2.3E+00
$^{229}Th+D$[(a)]	Same	Same	Same	Same
^{230}Th	3.2E+02	6.3E+01	3.2E+01	6.3E+00
^{232}Th	2.2E+02	4.4E+01	2.2E+01	4.4E+00
$^{232}Th+D$	9.5E+01	1.9E+01	9.5E+00	1.9E+00
^{232}U	1.6E+02	3.2E+01	1.6E+01	3.2E+00
^{233}U	5.7E+02	1.1E+02	5.7E+01	1.1E+01
^{234}U	5.7E+02	1.1E+02	5.7E+01	1.1E+01
^{235}U	6.1E+02	1.2E+02	6.1E+01	1.2E+01
$^{235}U+D$[(a)]	Same	Same	Same	Same
^{238}U	6.5E+02	1.3E+02	6.5E+01	1.3E+01
$^{238}U+D$[(a)]	Same	Same	Same	Same
^{237}Np	2.3E+02	4.6E+01	2.3E+01	4.6E+00
$^{237}Np+D$[(a)]	Same	Same	Same	Same
^{238}Pu	2.4E+02	4.7E+01	2.4E+01	4.7E+00
^{239}Pu	2.2E+02	4.4E+01	2.2E+01	4.4E+00
^{240}Pu	2.2E+02	4.4E+01	2.2E+01	4.4E+00
^{241}Pu	1.4E+04	2.8E+03	1.4E+03	2.8E+02
^{241}Am	2.1E+02	4.2E+01	2.1E+01	4.2E+00

(a) The dose factor for the decay chain is assumed to have the same dose factor as the parent nuclide alone.

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TABLE 2.4. Concentration of Radionuclides (pCi/g) in Incinerator Feed of 100% DOE Waste, Based on Dose to the Maximally Exposed Offsite Individual in the **Rural** (10/km^2) Population Density

Nuclide	1.0 mrem/y Dose (Individual) 30,000 t/y	1.0 mrem/y Dose (Individual) 150,000 t/y	0.1 mrem/y Dose (Individual) 30,000 t/y	0.1 mrem/y Dose (Individual) 150,000 t/y
^{3}H	6.5E+04	1.3E+04	6.5E+03	1.3E+03
^{7}Be	6.1E+06	1.2E+06	6.1E+05	1.2E+05
^{14}C	1.2E+03	2.4E+02	1.2E+02	2.4E+01
^{22}Na	9.1E+03	1.8E+03	9.1E+02	1.8E+02
^{32}P	3.2E+04	6.3E+03	3.2E+03	6.3E+02
^{35}S	4.0E+04	8.0E+03	4.0E+03	8.0E+02
^{46}Sc	1.9E+05	3.8E+04	1.9E+04	3.8E+03
^{48}V	7.9E+04	1.6E+04	7.9E+03	1.6E+03
^{51}Cr	6.9E+06	1.4E+06	6.9E+05	1.4E+05
^{54}Mn	3.7E+04	7.4E+03	3.7E+03	7.4E+02
^{55}Fe	6.1E+05	1.2E+05	6.1E+04	1.2E+04
^{56}Co	5.9E+03	1.2E+03	5.9E+02	1.2E+02
^{57}Co	3.9E+04	7.8E+03	3.9E+03	7.8E+02
^{58}Co	2.1E+04	4.2E+03	2.1E+03	4.2E+02
^{60}Co	4.9E+02	9.7E+01	4.9E+01	9.7E+00
^{63}Ni	6.1E+05	1.2E+05	6.1E+04	1.2E+04
^{65}Zn	3.4E+03	6.9E+02	3.4E+02	6.9E+01
^{68}Ge	2.7E+05	5.5E+04	2.7E+04	5.5E+03
^{74}As	7.4E+05	1.5E+05	7.4E+04	1.5E+04
^{75}Se	2.8E+03	5.5E+02	2.8E+02	5.5E+01
^{79}Se	1.1E+04	2.3E+03	1.1E+03	2.3E+02
^{90}Sr	7.5E+04	1.5E+04	7.5E+03	1.5E+03
$^{90}Sr+D$[a]	Same	Same	Same	Same
^{88}Y	1.6E+05	3.2E+04	1.6E+04	3.2E+03
^{93}Zr	1.2E+06	2.5E+05	1.2E+05	2.5E+04
^{94}Nb	1.1E+03	2.2E+02	1.1E+02	2.2E+01
^{99}Tc	5.0E+02	1.0E+02	5.0E+01	1.0E+01
^{106}Ru	5.6E+03	1.1E+03	5.6E+02	1.1E+02
^{110m}Ag	2.5E+04	5.0E+03	2.5E+03	5.0E+02
^{113}Sn	3.4E+05	6.8E+04	3.4E+04	6.8E+03
$^{113}Sn+D$[a]	Same	Same	Same	Same
^{124}Sb	6.7E+03	1.3E+03	6.7E+02	1.3E+02
^{125}Sb	2.3E+03	4.7E+02	2.3E+02	4.7E+01
^{125m}Te	9.4E+04	1.9E+04	9.4E+03	1.9E+03
^{125}I	2.5E+01	5.1E+00	2.5E+00	5.1E-01
^{126}I	7.8E+01	1.6E+01	7.8E+00	1.6E+00

TABLE 2.4. (contd)

Nuclide	1.0 mrem/y Dose (Individual) 30,000 t/y	1.0 mrem/y Dose (Individual) 150,000 t/y	0.1 mrem/y Dose (Individual) 30,000 t/y	0.1 mrem/y Dose (Individual) 150,000 t/y
^{129}I	1.1E+00	2.3E-01	1.1E-01	2.3E-02
^{131}I	1.0E+02	2.0E+01	1.0E+01	2.0E+00
^{134}Cs	5.2E+03	1.0E+03	5.2E+02	1.0E+02
^{137}Cs	2.4E+03	4.9E+02	2.4E+02	4.9E+01
^{144}Ce	7.2E+04	1.4E+04	7.2E+03	1.4E+03
$^{144}Ce+D$[(a)]	Same	Same	Same	Same
^{147}Pm	8.0E+05	1.6E+05	8.0E+04	1.6E+04
^{151}Sm	1.2E+06	2.3E+05	1.2E+05	2.3E+04
^{152}Eu	4.9E+03	9.8E+02	4.9E+02	9.8E+01
^{154}Eu	6.2E+03	1.2E+03	6.2E+02	1.2E+02
^{155}Eu	1.5E+05	2.9E+04	1.5E+04	2.9E+03
^{203}Hg	6.3E+03	1.3E+03	6.3E+02	1.3E+02
^{207}Bi	1.3E+03	2.6E+02	1.3E+02	2.6E+01
^{226}Ra	5.4E+02	1.1E+02	5.4E+01	1.1E+01
$^{226}Ra+D$[(a)]	Same	Same	Same	Same
^{228}Th	3.1E+02	6.3E+01	3.1E+01	6.3E+00
^{229}Th	1.1E+02	2.2E+01	1.1E+01	2.2E+00
$^{229}Th+D$[(a)]	Same	Same	Same	Same
^{230}Th	3.1E+02	6.3E+01	3.1E+01	6.3E+00
^{232}Th	2.2E+02	4.4E+01	2.2E+01	4.4E+00
$^{232}Th+D$	9.4E+01	1.9E+01	9.4E+00	1.9E+00
^{232}U	1.6E+02	3.2E+01	1.6E+01	3.2E+00
^{233}U	5.6E+02	1.1E+02	5.6E+01	1.1E+01
^{234}U	5.6E+02	1.1E+02	5.6E+01	1.1E+01
^{235}U	6.0E+02	1.2E+02	6.0E+01	1.2E+01
$^{235}U+D$[(a)]	Same	Same	Same	Same
^{238}U	6.3E+02	1.3E+02	6.3E+01	1.3E+01
$^{238}U+D$[(a)]	Same	Same	Same	Same
^{237}Np	2.2E+02	4.5E+01	2.2E+01	4.5E+00
$^{237}Np+D$[(a)]	Same	Same	Same	Same
^{238}Pu	2.3E+02	4.6E+01	2.3E+01	4.6E+00
^{239}Pu	2.1E+02	4.3E+01	2.1E+01	4.3E+00
^{240}Pu	2.1E+02	4.3E+01	2.1E+01	4.3E+00
^{241}Pu	1.4E+04	2.7E+03	1.4E+03	2.7E+02
^{241}Am	2.0E+02	4.1E+01	2.0E+01	4.1E+00

(a) The dose factor for the decay chain is assumed to have the same dose factor as the parent nuclide alone.

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3.0 DOSE CALCULATIONS FOR HAZARDOUS WASTE WORKERS

This section describes the development of methods to calculate potential doses to workers at a hazardous waste incinerator from materials contaminated with radionuclides. As with the dose estimates for members of the general public, dose estimates for workers will be used to determine unit dose to concentrations of radionuclides that may be released for disposal to a RCRA or TSCA facility. The calculations are made assuming that no secondary release of recyclable products, slag, or ash occurs. The calculations are performed for scenarios describing waste transport, treatment, burial (landfilling), and incineration, as well as transport of incinerator slag or ash.

3.1 METHODOLOGY

For workers at an incinerator, the limiting concentration of each radionuclide in waste is calculated from the dose that would result from a unit concentration of the radionuclide in the waste material. The concentration of each radionuclide in each waste residue (waste, fly ash, or slag) is calculated, and exposures are estimated based on various operations performed by the workers. For this study, a scenario is defined as the set of operations that describes the exposure of the worker in a specific occupational setting. Exposure parameters (e.g., external dose factor or dust loading) for each activity (e.g., drum sampling or filter handling) are weighted by the fraction of time spent performing that action (see Chew and Associates, 1992, 1993a-e; Beck and Foltz 1993; and data obtained from Chew and Associates). Effective (weighted) values are used for each scenario (see Appendix G, "Worker Scenario Descriptions").

External dose is based on exposure duration and the applicable external dose factor. For each operation, an external dose factor is calculated based on the geometry, dimensions, and shielding materials associated with the

contaminated waste or residue. Details of the calculation of external dose factors and other exposure parameters are given in Appendix F, "External Dose Calculations for Worker Scenarios."

Inhalation intake is based on breathing of respirable particulate matter present in the air during an activity. An estimate of the respirable particle loading in the air is made, and a reduction factor for protective equipment (mask or half-mask) is applied.

Incidental ingestion of loosely bound contamination associated with waste and residue materials is presumed to occur at a rate of 10 mg/h. Variables include duration of a worker's activities without gloves in a potentially contaminated environment, or a number of other events such as contact with contamination while changing protective clothing. Incidental ingestion of contamination may also be associated with activities such as eating and smoking, which result in the transfer of material from hands to mouth.

3.2 WORKER SCENARIOS

Nine individual worker scenarios and six collective worker cases are examined. The individual worker cases are associated with the operations that are presumed to account for the greatest potential exposures to waste and residual materials. Five of the individual worker scenarios deal with waste, including transport, receiving, disposal, treatment, and excavation into an existing landfill. The other four scenarios deal with the workers' interactions with residual materials generated in the incineration process.

Residual materials are assumed to result either from incineration of miscellaneous solids (the base case for rotary kiln incineration) or from incineration of liquids only. These two sets of incinerator worker scenarios are different because of 1) the difference in mass reduction from incineration of these materials (hence, different residual concentrations) and 2) differences in the quantity of residual materials produced (hence, different exposure durations). For rotary kiln incineration, more information is available,

the exposure scenarios are better defined, and the practice is applicable to more types of waste; therefore, rotary kiln incineration is the base case.

The collective worker dose scenarios assess the dose to the entire worker population at a generic rotary kiln incinerator and at a hazardous waste landfill. Six collective dose scenarios are given and cover workers with high, medium, or low potential for exposure either to waste material or to residues at an incinerator or landfill facility. In addition, the worker population dose is assessed for both the base case incinerator (30,000 t/y) and a larger incinerator (150,000 t/y).

Table 3.1 summarizes exposure parameter values for both individual worker and collective worker scenarios. Worker scenarios are described in Appendix G. Appendix F gives details on the method used for calculating external dose factors. Internal dose factors used in the analysis are given in Appendix H.

3.3 WASTE CHARACTERISTICS AND PARTITIONING

For the assessment of exposure to waste residues, the mass flows of the various residue components are required. For the incineration of solid waste with a high refractory content, it is assumed that much of the mass will be in the form of slag. For incineration of contaminated oils, the mass partitioning is also taken to be mostly bottom ash or slag (data obtained from Chew and Associates 1993). The assumed mass fractions for two waste types are given in Table 3.2.

The partitioning of radionuclides into the waste streams based on thermodynamic considerations was investigated. Details of this investigation are given in Appendix C, "Element Partitioning in an Incinerator." Examples of the partitioning values for selected radionuclides are given in Table 3.3.

TABLE 3.1. Worker Exposure Parameters of Scenarios for Maximally Exposed Individuals and Collective Worker Population

Category Number and Scenario	Applicable Medium	Inhalation Duration h	Inhalation Dust Load[a] g/m³	Ingestion Duration,[b] h	External Duration[c] h	Affected Population Size
Maximally Exposed Individuals						
1 Waste Transport (Drums)	Waste	0	0	0	2250	NA[d]
2 Waste Receiving	Waste	2000	5.0E-05	500	2000	
3 Waste Disposal (Landfill)	Waste	2000	1.0E-05	250	1500	
4 Landfill Excavation	Waste	20	1.0E-06	6	20	
5 Waste Treatment	Waste	1500	1.0E-05	250	1500	
6a Incinerator/Bag Filter	Fly ash	2000	8.0E-06	500	2000	
6b Incinerator/Bag Filter [e]	Fly ash	200	8.0E-06	200	200	
7a Incinerator/Wet Scrubber	Fly ash	2000	8.0E-06	500	2000	
7b Incinerator/Wet Scrubber[e]	Fly ash	200	8.0E-06	200	200	
8a Incinerator Maintenance	Slag	2000	9.0E-06	500	2000	
8b Incinerator Maintenance[e]	Slag	500	9.0E-06	100	500	
9a Ash Transport (Dump Truck)	Residue[f]	50[g]	1.0E-04	0	2250	
9b Ash Transport (Dump Truck)[e]	Residue[f]	10[g]	1.0E-04	0	500	
Collective Worker						
Incinerator--High	Waste	2000	1.0E-05	500	2000	30 (60)[h]
Incinerator--Medium	Waste	500	1.0E-06	0	500	50 (90)
Incinerator--Low	Waste	50	1.0E-06	0	50	70 (150)
Landfill--High	Waste	1500	1.0E-05	500	1500	40
Landfill--Medium	Waste	500	1.0E-06	0	500	60
Landfill--Low	Waste	50	1.0E-06	0	50	80

(a) Dust loading is a weighted sum of conditions and protective equipment for each activity constituting the scenario.
(b) Incidental ingestion, at a rate of 10 mg/h (IAEA 1992), is assumed to occur when there is a potential for exposure to contaminated dust and the individual is not wearing two sets of gloves.
(c) Exposure durations are 2000 h/y for occupational exposure, except for landfill and for truck transport where sleep time is included. The time away from a contaminated zone is averaged into the external dose factor except for the landfill and collective worker scenarios. Waste treatment is also based on few exposure hours; batch mode processing is assumed.
(d) Population size not applicable to individual doses.
(e) Exposure parameters for liquid-only incinerator.
(f) Residue is total fly ash plus slag.
(g) Inhalation exposure for dumping load only.
(h) Worker population for 30,000-t/y incinerator; value in parentheses based on 150,000-t/y incinerator. Worker population is based on information from reports by Chew and Associates (1992, 1993a-e), ORISE (Beck and Foltz 1993), and data from Chew and Associates.

TABLE 3.2. Assumed Mass Fractions in Residual Waste Streams

Type of Waste	Residual Mass Fraction of Input: Fly Ash	Slag	Total
Misc. Solids and Sludges	0.2	0.5	0.7
Organic Liquids	0.004	0.016	0.02

TABLE 3.3. Element Partitioning Values for Selected Radionuclides, by Fraction in Effluent Streams

Element	Fly Ash[(a)]	Slag	Stack
H	0.10	0	0.90
C	0.02	0.03	0.95
Co	0.34	0.65	0.01
Zn	0.49	0.50	0.01
Sr	0.05	0.95	0.0001
I	0.68	0.02	0.30
Cs	0.20	0.80	0.002
Ra	0.10	0.90	0.0005
U	0.02	0.98	0.0005
Pu	0.02	0.98	0.0005

(a) Fly ash is defined as all residues from incineration other than slag, including both fine ash particulate material and scrubber blow-down.

3.4 RESULTS

A set of calculations was performed to determine concentrations that would result in a dose of 1 mrem/y to the maximally exposed hazardous waste worker, if the input feedstream were 100% DOE-generated contaminated waste for each scenario. The results of these calculations are reported in Table 3.4. Appendix D presents the methods used in calculating these doses.

Table 3.4 gives the unit dose to concentration for the most limiting scenario for each radionuclide based on dose to the maximally exposed worker for treatment and disposal of waste and incineration at a 30,000-t/y rotary kiln incinerator. Incineration of liquid wastes in a liquid-only incinerator, which makes for very concentrated residual materials, was considered, but not integrated into the summary of dose to concentrations presented in Table S.1. The results shown in Table 3.4 provide the basis for deriving radiation dose to waste concentration for hazardous waste worker scenarios. This table shows the limiting scenario, dominant pathway, and waste form used to determine the

TABLE 3.4. Scenarios, Limiting Concentrations, and Dominant Exposure Pathways Based on Hazardous Waste Worker Dose of 1 mrem/y[a]

Nuclide	Scenario	Waste Form	Limiting Concentration, pCi/g	Dominant Exposure Pathway
^{3}H	Waste Receiving	Waste	3.1E+06	Ingestion
^{7}Be	Waste Disposal	Waste	5.9E+01	External
^{14}C	Waste Receiving	Waste	9.4E+04	Ingestion
^{22}Na	Waste Disposal	Waste	7.2E-01	External
^{32}P	Waste Disposal	Waste	1.6E+03	External
^{35}S	Incineration/Bag Filter	Fly ash	8.2E+04	Ingestion
^{46}Sc	Waste Disposal	Waste	6.4E-01	External
^{48}V	Waste Disposal	Waste	5.4E-01	External
^{51}Cr	Waste Disposal	Waste	1.2E+02	External
^{54}Mn	Waste Disposal	Waste	2.2E+00	External
^{55}Fe	Incineration/Bag Filter	Fly ash	1.4E+03	External
^{56}Co	Waste Disposal	Waste	2.4E-01	External
^{57}Co	Waste Receiving	Waste	6.6E+01	External
^{58}Co	Waste Disposal	Waste	1.9E+00	External
^{60}Co	Waste Disposal	Waste	4.5E-01	External
^{63}Ni	Incineration/Bag Filter	Fly ash	1.7E+05	Ingestion
^{65}Zn	Waste Disposal	Waste	1.8E+00	External
^{68}Ge	Incineration/Bag Filter	Fly ash	2.9E+02	External
^{74}As	Waste Disposal	Waste	4.2E+00	External
^{75}Se	Incineration/Bag Filter	Fly ash	1.6E+01	External
^{79}Se	Incineration/Bag Filter	Fly ash	5.8E+03	Ingestion
^{90}Sr	Incinerator Maintenance	Slag	7.8E+02	Ingestion
$^{90}Sr+D$	Incinerator Maintenance	Slag	3.6E+02	External
^{88}Y	Waste Disposal	Waste	4.0E-01	External
^{93}Zr	Incinerator Maintenance	Slag	5.4E+04	Ingestion
^{94}Nb	Waste Disposal	Waste	1.4E+00	External
^{99}Tc	Incineration/Bag Filter	Fly ash	3.4E+04	Ingestion
^{106}Ru	Waste Disposal	Waste	1.0E+01	External
^{110m}Ag	Waste Disposal	Waste	5.5E-01	External
^{113}Sn	Incinerator Maintenance	Slag	3.1E+02	External
$^{113}Sn+D$	Waste Disposal	Waste	1.8E+01	External
^{124}Sb	Waste Disposal	Waste	5.7E-01	External
^{125}Sb	Waste Disposal	Waste	6.3E+00	External
^{125m}Te	Incineration/Bag Filter	Fly ash	2.2E+02	External
^{125}I	Incineration/Bag Filter	Fly ash	1.2E+02	External
^{126}I	Waste Disposal	Waste	5.5E+00	External
^{129}I	Incineration/Bag Filter	Fly ash	1.1E+02	Ingestion

TABLE 3.4. (contd)

Nuclide	Scenario	Waste Form	Limiting Concentration, pCi/g	Dominant Exposure Pathway
^{131}I	Waste Disposal	Waste	1.0E+01	External
^{134}Cs	Waste Disposal	Waste	1.2E+00	External
^{137}Cs	Waste Disposal	Waste	4.6E+00	External
^{144}Ce	Incinerator Maintenance	Slag	4.3E+02	External
$^{144}Ce+D$	Waste Disposal	Waste	2.5E+01	External
^{147}Pm	Incinerator Maintenance	Slag	6.1E+04	Ingestion
^{151}Sm	Incinerator Maintenance	Slag	1.3E+05	External
^{152}Eu	Waste Disposal	Waste	1.1E+00	External
^{154}Eu	Waste Disposal	Waste	1.1E+00	External
^{155}Eu	Incinerator Maintenance	Slag	1.6E+02	External
^{203}Hg	Incineration/Bag Filter	Fly ash	2.7E+01	External
^{207}Bi	Waste Disposal	Waste	9.3E-01	External
^{226}Ra	Incinerator Maintenance	Slag	9.3E+01	Ingestion
$^{226}Ra+D$	Waste Disposal	Waste	6.1E-01	External
^{228}Th	Waste Receiving	Waste	2.5E+01	Inhalation
^{229}Th	Waste Receiving	Waste	4.4E+00	Inhalation
$^{229}Th+D$	Waste Receiving	Waste	3.5E+00	Inhalation
^{230}Th	Waste Receiving	Waste	3.0E+01	Inhalation
^{232}Th	Waste Receiving	Waste	6.8E+00	Inhalation
$^{232}Th+D$	Waste Disposal	Waste	3.4E-01	External
^{232}U	Waste Receiving	Waste	1.2E+01	Inhalation
^{233}U	Waste Receiving	Waste	6.3E+01	Inhalation
^{234}U	Waste Receiving	Waste	6.4E+01	Inhalation
^{235}U	Waste Receiving	Waste	3.5E+01	Inhalation
$^{235}U+D$	Waste Receiving	Waste	3.4E+01	External
^{238}U	Waste Receiving	Waste	6.9E+01	Inhalation
$^{238}U+D$	Waste Receiving	Waste	5.0E+01	Inhalation
^{237}Np	Waste Receiving	Waste	1.3E+01	Inhalation
$^{237}Np+D$	Waste Receiving	Waste	8.4E+00	Inhalation
^{238}Pu	Waste Receiving	Waste	2.8E+01	Inhalation
^{239}Pu	Waste Receiving	Waste	2.5E+01	Inhalation
^{240}Pu	Waste Receiving	Waste	2.5E+01	Inhalation
^{241}Pu	Waste Receiving	Waste	1.5E+03	Inhalation
^{241}Am	Waste Receiving	Waste	1.2E+01	Inhalation

(a) Based on throughput of 30,000 t/y of mixed solids, 100% DOE waste.

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limiting concentration for each radionuclide considered. The limiting concentrations and dose by pathway for all scenarios for each of the 62 radionuclides are listed in Appendix I, "Worker Dose for Each Scenario by Radionuclide."

Table 3.5 gives population dose (in person-rem) for workers at a generic incinerator and at landfill facilities and the limiting concentration based on the maximally exposed worker from Table 3.4. The worker population dose and the dose to an individual worker, by exposure category, are given in Appendix I, Table I.2. The data presented in Table 3.5 indicate that the collective dose to hazardous waste workers is well below 1 person-rem per year.

For the incineration scenarios, the dose to an individual worker is assumed to be independent of incinerator capacity. The number of workers exposed, however, varies with the incinerator throughput. As shown in Table 3.1, the number of workers at a 150,000-t/y incinerator is assumed to be about twice the number at a 30,000-t/y incinerator.

The incineration of organic liquids in a liquid-only incinerator was also considered in this study. However, we do not have as much confidence in using the same scenarios for liquid-only incineration because fewer data are available to support the assumptions relating to worker exposure. Appendix I includes results for incineration of organic liquids (designated by scenario description followed by "OL"), but these results are not integrated into the unit dose to concentrations that are presented in Table S.1 or tables in Sections 3.0 and 4.0.

To provide some scale to the limiting concentrations, a comparison with natural background is made for ^{232}Th and ^{238}U. The reported concentration of ^{232}Th in soils across the United States and Canada averages 0.98 pCi/g and ranges from 0.10 to 3.4 pCi/g (Myrick et al. 1983). Assuming a 1-mrem/y dose limit, the most limiting concentration derived for ^{232}Th in equilibrium with its decay products for undiluted DOE solid wastes (i.e., 100%) is about 0.34 pCi/g; for ^{232}Th alone, the limiting concentration is 6.8 pCi/g. These

TABLE 3.5. Collective Worker Doses Based on Limiting Concentrations Corresponding to 1 mrem/y to the Maximally Exposed Worker

Nuclide	Concentration Limit, pCi/g	Collective Dose, man-rem
^{3}H	3.1E+06	6.9E-02
^{7}Be	5.9E+01	5.3E-02
^{14}C	9.4E+04	6.9E-02
^{22}Na	7.2E-01	4.9E-02
^{32}P	1.6E+03	6.1E-02
^{35}S	8.2E+04	1.3E-02
^{46}Sc	6.4E-01	4.8E-02
^{48}V	5.4E-01	5.0E-02
^{51}Cr	1.2E+02	5.7E-02
^{54}Mn	2.2E+00	5.1E-02
^{55}Fe	1.4E+03	2.9E-04
^{56}Co	2.4E-01	4.5E-02
^{57}Co	6.6E+01	2.5E-02
^{58}Co	1.9E+00	5.0E-02
^{60}Co	4.5E-01	4.7E-02
^{63}Ni	1.7E+05	3.3E-02
^{65}Zn	1.8E+00	4.8E-02
^{68}Ge	2.9E+02	1.3E-04
^{74}As	4.2E+00	5.2E-02
^{75}Se	1.6E+01	4.4E-02
^{79}Se	5.8E+03	1.7E-02
^{90}Sr	7.8E+02	3.6E-02
$^{90}Sr+D$	3.6E+02	5.0E-02
^{88}Y	4.0E-01	4.7E-02
^{93}Zr	5.4E+04	3.6E-02
^{94}Nb	1.4E+00	5.1E-02
^{99}Tc	3.4E+04	1.7E-02
^{106}Ru	1.0E+01	5.1E-02
^{110m}Ag	5.5E-01	4.9E-02
^{113}Sn	3.1E+02	1.0E-02
$^{113}Sn+D$	1.8E+01	5.7E-02
^{124}Sb	5.7E-01	4.7E-02
^{125}Sb	6.3E+00	5.3E-02
^{125M}Te	2.2E+02	4.9E-04
^{125}I	1.2E+02	1.6E-03

Nuclide	Concentration Limit, Ci/g	Collective Dose, man-rem
^{126}I	5.5E+00	5.3E-02
^{129}I	1.1E+02	1.1E-02
^{131}I	1.0E+01	5.3E-02
^{134}Cs	1.2E+00	5.0E-02
^{137}Cs	4.6E+00	5.2E-02
^{144}Ce	4.3E+02	2.1E-02
$^{144}Ce+D$	2.5E+01	4.8E-02
^{147}Pm	6.1E+04	2.5E-02
^{151}Sm	1.3E+05	2.1E-02
^{152}Eu	1.1E+00	4.7E-02
^{154}Eu	1.1E+00	4.6E-02
^{155}Eu	1.6E+02	1.6E-02
^{203}Hg	2.7E+01	3.5E-02
^{207}Bi	9.3E-01	4.8E-02
^{226}Ra	9.3E+01	3.8E-02
$^{226}Ra+D$	6.1E-01	4.8E-02
^{228}Th	2.5E+01	1.5E-02
^{229}Th	4.4E+00	1.8E-02
$^{229}Th+D$	3.5E+00	3.2E-02
^{230}Th	3.0E+01	1.7E-02
^{232}Th	6.8E+00	1.8E-02
$^{232}Th+D$	3.4E-01	4.7E-02
^{232}U	1.2E+01	1.2E-02
^{233}U	6.3E+01	1.3E-02
^{234}U	6.4E+01	1.3E-02
^{235}U	3.5E+01	2.0E-02
$^{235}U+D$	3.4E+01	2.0E-02
^{238}U	6.9E+01	1.3E-02
$^{238}U+D$	5.0E+01	4.0E-02
^{237}Np	1.3E+01	2.8E-02
$^{237}Np+D$	8.4E+00	4.1E-02
^{238}Pu	2.8E+01	1.3E-02
^{239}Pu	2.5E+01	1.3E-02
^{240}Pu	2.5E+01	1.3E-02
^{241}Pu	1.5E+03	1.3E-02
^{241}Am	1.2E+01	2.8E-02

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values are close to the range of natural background concentration; thus, it may be difficult to detect a difference between natural background and the concentration in the waste stream. For ^{238}U, the average concentration in soils is reported as 1.8 pCi/g (NCRP 1987). For comparison, the limiting concentrations for the most restrictive scenario (waste receiving) is about 69 pCi/g for undiluted wastes. This suggests that it should be possible to distinguish the limiting concentration of ^{238}U from background levels.

It should be noted that the present analysis is a conservative one because it assumes that the entire throughput at the incinerator is mixed waste from DOE facilities. If the input fed into the incinerator includes other (non-DOE) wastes, less restrictive radiation control criteria could be applied, as appropriate, to compensate for dilution of the radioactive waste stream.

4.0 RESULTS

4.1 LIMITING CONCENTRATIONS BASED ON DOSE TO THE GENERAL PUBLIC AND WORKERS

The preliminary radiation dose calculations were performed for both the general public (Section 2.0) and hazardous waste facility workers (Section 3.0). Three exposure scenarios for the general public corresponding to areas with varying population densities were examined. These scenarios consider the release of radioactive contaminants from a generic incinerator stack and the subsequent transport and exposure pathways.

The worker exposure scenarios encompass the direct or ancillary operations of an incineration facility and landfill maintenance and operation. Worker scenarios include transportation, waste handling (receiving and sampling, waste treatment, and direct disposal to a landfill), handling of residual materials, cleaning out the kiln, maintenance operations, and landfilling.

A total of 62 radionuclides were examined in both the general public and the worker scenarios. Limiting concentrations were calculated for each radionuclide and scenario, based on a limiting or allowable dose criterion. Wastes containing mixtures of radionuclides were not considered, but can be indirectly determined using the sum of fractions rule. (The sum of the fraction of limiting concentrations for each radionuclide may not exceed unity.)

This section combines the results of dose calculations for the general public (Section 2.0 and Appendix E) and hazardous waste workers (Section 3.0 and Appendix I) to derive preliminary overall mixed waste limiting concentration for incineration process. The calculated limiting concentrations for waste are presented by radionuclide for the following cases in Tables 4.1 through 4.5:

- Case 1, offsite individual dose of 0.1 mrem/y and worker dose of 1.0 mrem/y (Table 4.1)
- Case 2, offsite individual dose of 1.0 mrem/y and worker dose of 1.0 mrem/y (Table 4.2)

TABLE 4.1. Case 1: Preliminary Limiting Concentrations for Incineration Using a Dose Limit of 0.1 mrem/y for the Maximally Exposed Offsite Individual and Dose Limit of 1 mrem/y for the Maximally Exposed Hazardous Waste Worker

Nuclide	Limiting Public[a] 0.1 mrem/y, pCi/g Waste	Limiting Worker 1 mrem/y, pCi/g Waste	Limiting Worker Scenario
^{3}H	6.5E+03	3.1E+06	Waste Receiving
^{7}Be	6.1E+05	5.9E+01	Waste Disposal
^{14}C	1.2E+02	9.4E+04	Waste Receiving
^{22}Na	9.1E+02	7.2E-01	Waste Disposal
^{32}P	3.2E+03	1.6E+03	Waste Disposal
^{35}S	4.0E+03	8.2E+04	Incineration/Bag Filter
^{46}Sc	1.9E+04	6.4E-01	Waste Disposal
^{48}V	7.9E+03	5.4E-01	Waste Disposal
^{51}Cr	6.9E+05	1.2E+02	Waste Disposal
^{54}Mn	3.7E+03	2.2E+00	Waste Disposal
^{55}Fe	6.1E+04	1.4E+03	Incineration/Bag Filter
^{56}Co	5.9E+02	2.4E-01	Waste Disposal
^{57}Co	3.9E+03	6.6E+01	Waste Receiving
^{58}Co	2.1E+03	1.9E+00	Waste Disposal
^{60}Co	4.9E+01	4.5E-01	Waste Disposal
^{63}Ni	6.1E+04	1.7E+05	Incineration/Bag Filter
^{65}Zn	3.4E+02	1.8E+00	Waste Disposal
^{68}Ge	2.7E+04	2.9E+02	Incineration/Bag Filter
^{74}As	7.4E+04	4.2E+00	Waste Disposal
^{75}Se	2.8E+02	1.6E+01	Incineration/Bag Filter
^{79}Se	1.1E+03	5.8E+03	Incineration/Bag Filter
^{90}Sr	7.5E+03	7.8E+02	Incinerator Maintenance
$^{90}Sr+D$	None	3.6E+02	Incinerator Maintenance
^{88}Y	1.6E+04	4.0E-01	Waste Disposal
^{93}Zr	1.2E+05	5.4E+04	Incinerator Maintenance
^{94}Nb	1.1E+02	1.4E+00	Waste Disposal
^{99}Tc	5.0E+01	3.4E+04	Incineration/Bag Filter
^{106}Ru	5.6E+02	1.0E+01	Waste Disposal
^{110m}Ag	2.5E+03	5.5E-01	Waste Disposal
^{113}Sn	3.4E+04	3.1E+02	Incinerator Maintenance
$^{113}Sn+D$	None	1.8E+01	Waste Disposal
^{124}Sb	6.7E+02	5.7E-01	Waste Disposal
^{125}Sb	2.3E+02	6.3E+00	Waste Disposal
^{125m}Te	9.4E+03	2.2E+02	Incineration/Bag Filter
^{125}I	2.5E+00	1.2E+02	Incineration/Bag Filter

TABLE 4.1. (contd)

Nuclide	Limiting Public[a] 0.1 mrem/y, pCi/g Waste	Limiting Worker 1 mrem/y, pCi/g Waste	Limiting Worker Scenario
^{126}I	7.8E+00	5.5E+00	Waste Disposal
^{129}I	1.1E-01	1.1E+02	Incineration/Bag Filter
^{131}I	1.0E+01	1.0E+01	Waste Disposal
^{134}Cs	5.2E+02	1.2E+00	Waste Disposal
^{137}Cs	2.4E+02	4.6E+00	Waste Disposal
^{144}Ce	7.2E+03	4.3E+02	Incinerator Maintenance
^{144}Ce+D	None	2.5E+01	Waste Disposal
^{147}Pm	8.0E+04	6.1E+04	Incinerator Maintenance
^{151}Sm	1.2E+05	1.3E+05	Incinerator Maintenance
^{152}Eu	4.9E+02	1.1E+00	Waste Disposal
^{154}Eu	6.2E+02	1.1E+00	Waste Disposal
^{155}Eu	1.5E+04	1.6E+02	Incinerator Maintenance
^{203}Hg	6.3E+02	2.7E+01	Incineration/Bag Filter
^{207}Bi	1.3E+02	9.3E-01	Waste Disposal
^{226}Ra	5.4E+01	9.3E+01	Incinerator Maintenance
^{226}Ra+D	None	6.1E-01	Waste Disposal
^{228}Th	3.1E+01	2.5E+01	Waste Receiving
^{229}Th	1.1E+01	4.4E+00	Waste Receiving
^{229}Th+D	None	3.5E+00	Waste Receiving
^{230}Th	3.1E+01	3.0E+01	Waste Receiving
^{232}Th	2.2E+01	6.8E+00	Waste Receiving
^{232}Th+D	9.4E+00	3.4E-01	Waste Disposal
^{232}U	1.6E+01	1.2E+01	Waste Receiving
^{233}U	5.6E+01	6.3E+01	Waste Receiving
^{234}U	5.6E+01	6.4E+01	Waste Receiving
^{235}	6.0E+01	3.5E+01	Waste Receiving
^{235}U+D	None	3.4E+01	Waste Receiving
^{238}U	6.3E+01	6.9E+01	Waste Receiving
^{238}U+D	None	5.0E+01	Waste Receiving
^{237}Np	2.2E+01	1.3E+01	Waste Receiving
^{237}Np+D	None	8.4E+00	Waste Receiving
^{238}Pu	2.3E+01	2.8E+01	Waste Receiving
^{239}Pu	2.1E+01	2.5E+01	Waste Receiving
^{240}Pu	2.1E+01	2.5E+01	Waste Receiving
^{241}Pu	1.4E+03	1.5E+03	Waste Receiving
^{241}Am	2.0E+01	1.2E+01	Waste Receiving

(a) Limiting scenario for public exposure is for rural population.

This file: F:PW1.OUT 15.32 15-DEC-93 Program: INCIN.BAS 14.12 15-DEC-93 Ini file: INCIN.INI 08.22 14-DEC-93

TABLE 4.2. Case 2: Preliminary Limiting Concentrations for Incineration Using a Dose Limit of 1 mrem/y for the Maximally Exposed Offsite Individual and Dose Limit of 1 mrem/y for the Maximally Exposed Hazardous Waste Worker

Nuclide	Limiting Public[a] 0.1 mrem/y, pCi/g Waste	Limiting Worker 1 mrem/y, pCi/g Waste	Limiting Worker Scenario
^{3}H	6.5E+04	3.1E+06	Waste Receiving
^{7}Be	6.1E+06	5.9E+01	Waste Disposal
^{14}C	1.2E+03	9.4E+04	Waste Receiving
^{22}Na	9.1E+03	7.2E-01	Waste Disposal
^{32}P	3.2E+04	1.6E+03	Waste Disposal
^{35}S	4.0E+04	8.2E+04	Incineration/Bag Filter
^{46}Sc	1.9E+05	6.4E-01	Waste Disposal
^{48}V	7.9E+04	5.4E-01	Waste Disposal
^{51}Cr	6.9E+06	1.2E+02	Waste Disposal
^{54}Mn	3.7E+04	2.2E+00	Waste Disposal
^{55}Fe	6.1E+05	1.4E+03	Incineration/Bag Filter
^{56}Co	5.9E+03	2.4E-01	Waste Disposal
^{57}Co	3.9E+04	6.6E+01	Waste Receiving
^{58}Co	2.1E+04	1.9E+00	Waste Disposal
^{60}Co	4.9E+02	4.5E-01	Waste Disposal
^{63}Ni	6.1E+05	1.7E+05	Incineration/Bag Filter
^{65}Zn	3.4E+03	1.8E+00	Waste Disposal
^{68}Ge	2.7E+05	2.9E+02	Incineration/Bag Filter
^{74}As	7.4E+05	4.2E+00	Waste Disposal
^{75}Se	2.8E+03	1.6E+01	Incineration/Bag Filter
^{79}Se	1.1E+04	5.8E+03	Incineration/Bag Filter
^{90}Sr	7.5E+04	7.8E+02	Incinerator Maintenance
$^{90}Sr+D$	None	3.6E+02	Incinerator Maintenance
^{88}Y	1.6E+05	4.0E-01	Waste Disposal
^{93}Zr	1.2E+06	5.4E+04	Incinerator Maintenance
^{94}Nb	1.1E+03	1.4E+00	Waste Disposal
^{99}Tc	5.0E+02	3.4E+04	Incineration/Bag Filter
^{106}Ru	5.6E+03	1.0E+01	Waste Disposal
^{110m}Ag	2.5E+04	5.5E-01	Waste Disposal
^{113}Sn	3.4E+05	3.1E+02	Incinerator Maintenance
$^{113}Sn+D$	None	1.8E+01	Waste Disposal
^{124}Sb	6.7E+03	5.7E-01	Waste Disposal
^{125}Sb	2.3E+03	6.3E+00	Waste Disposal
^{125m}Te	9.4E+04	2.2E+02	Incinceration/Bag Filter
^{125}I	2.5E+01	1.2E+02	Incineration/Bag Filter

TABLE 4.2. (contd)

Nuclide	Limiting Public[a] 0.1 mrem/y, pCi/g Waste	Limiting Worker 1 mrem/y, pCi/g Waste	Limiting Worker Scenario
^{126}I	7.8E+01	5.5E+00	Waste Disposal
^{129}I	1.1E+00	1.1E+02	Incineration/Bag Filter
^{131}I	1.0E+02	1.0E+01	Waste Disposal
^{134}Cs	5.2E+03	1.2E+00	Waste Disposal
^{137}Cs	2.4E+03	4.6E+00	Waste Disposal
^{144}Ce	7.2E+04	4.3E+02	Incinerator Maintenance
$^{144}Ce+D$	None	2.5E+01	Waste Disposal
^{147}Pm	8.0E+05	6.1E+04	Incinerator Maintenance
^{151}Sm	1.2E+06	1.3E+05	Incinerator Maintenance
^{152}Eu	4.9E+03	1.1E+00	Waste Disposal
^{154}Eu	6.2E+03	1.1E+00	Waste Disposal
^{155}Eu	1.5E+05	1.6E+02	Incinerator Maintenance
^{203}Hg	6.3E+03	2.7E+01	Incineration/Bag Filter
^{207}Bi	1.3E+03	9.3E-01	Waste Disposal
^{226}Ra	5.4E+02	9.3E+01	Incinerator Maintenance
$^{226}Ra+D$	None	6.1E-01	Waste Disposal
^{228}Th	3.1E+02	2.5E+01	Waste Receiving
^{229}Th	1.1E+02	4.4E+00	Waste Receiving
$^{229}Th+D$	None	3.5E+00	Waste Receiving
^{230}Th	3.1E+02	3.0E+01	Waste Receiving
^{232}Th	2.2E+02	6.8E+00	Waste Receiving
$^{232}Th+D$	9.4E+01	3.4E-01	Waste Disposal
^{232}U	1.6E+02	1.2E+01	Waste Receiving
^{233}U	5.6E+02	6.3E+01	Waste Receiving
^{234}U	5.6E+02	6.4E+01	Waste Receiving
^{235}U	6.0E+02	3.5E+01	Waste Receiving
$^{235}U+D$	None	3.4E+01	Waste Receiving
^{238}U	6.3E+02	6.9E+01	Waste Receiving
$^{238}U+D$	None	5.0E+01	Waste Receiving
^{237}Np	2.2E+02	1.3E+01	Waste Receiving
$^{237}Np+D$	None	8.4E+00	Waste Receiving
^{238}Pu	2.3E+02	2.8E+01	Waste Receiving
^{239}Pu	2.1E+02	2.5E+01	Waste Receiving
^{240}Pu	2.1E+02	2.5E+01	Waste Receiving
^{241}Pu	1.4E+04	1.5E+03	Waste Receiving
^{241}Am	2.0E+02	1.2E+01	Waste Receiving

(a) Limiting scenario for public exposures is for rural population.

This file: F:PW2.OUT 15:32 15-DEC-93 Program: INCIN.BAS 14:12 15-DEC-93 Ini file: INCIN.INI 08:22 14-DEC-93

TABLE 4.3. Case 3: Preliminary Limiting Concentrations for Incineration Using a Dose Limit of 1 mrem/y for the Maximally Exposed Offsite Individual and Dose Limit of 1 mrem/y for the Maximally Exposed Hazardous Waste Worker

Nuclide	Limiting Public[a] 1 mrem/y, pCi/g Waste	Limiting Worker 1 mrem/y, pCi/g Waste	Limiting Worker Scenario
^{3}H	6.5E+03	3.1E+07	Waste Receiving
^{7}Be	6.1E+05	5.9E+02	Waste Disposal
^{14}C	1.2E+02	9.4E+05	Waste Receiving
^{22}Na	9.1E+02	7.2E+00	Waste DisposaL
^{32}P	3.2E+03	1.6E+04	Waste Disposal
^{35}S	4.0E+03	8.2E+05	Incineration/Bag Filter
^{46}Sc	1.9E+04	6.4E+00	Waste Disposal
^{48}V	7.9E+03	5.4E+00	Waste Disposal
^{51}Cr	6.9E+05	1.2E+03	Waste Disposal
^{54}Mn	3.7E+03	2.2E+01	Waste Disposal
^{55}Fe	6.1E+04	1.4E+04	Incineration/Bag Filter
^{56}Co	5.9E+02	2.4E+00	Waste Disposal
^{57}Co	3.9E+03	6.6E+02	Waste ReceivinG
^{58}Co	2.1E+03	1.9E+01	Waste Disposal
^{60}Co	4.9E+01	4.5E+00	Waste Disposal
^{63}Ni	6.1E+04	1.7E+06	Incineration/Bag Filter
^{65}Zn	3.4E+02	1.8E+01	Waste Disposal
^{68}Ge	2.7E+04	2.9E+03	Incineration/Bag Filter
^{74}As	7.4E+04	4.2E+01	Waste Disposal
^{75}Se	2.8E+02	1.6E+02	Incineration/Bag Filter
^{79}Se	1.1E+03	5.8E+04	Incineration/Bag Filter
^{90}Sr	7.5E+03	7.8E+03	Incinerator Maintenance
$^{90}Sr+D$	None	3.6E+03	Incinerator Maintenance
^{88}Y	1.6E+04	4.0E+00	Waste Disposal
^{93}Zr	1.2E+05	5.4E+05	Incinerator Maintenance
^{94}Nb	1.1E+02	1.4E+01	Waste Disposal
^{99}Tc	5.0E+01	3.4E+05	Incineration/Bag Filter
^{106}Ru	5.6E+02	1.0E+02	Waste Disposal
^{110m}Ag	2.5E+03	5.5E+00	Waste Disposal
^{113}Sn	3.4E+04	3.1E+03	Incinerator Maintenance
$^{113}Sn+D$	None	1.8E+02	Waste Disposal
^{124}Sb	6.7E+02	5.7E+00	Waste Disposal
^{125}Sb	2.3E+02	6.3E+01	Waste Disposal
^{125m}Te	9.4E+03	2.2E+03	Incineration/Bag Filter
^{125}I	2.5E+00	1.2E+03	Incineration/Bag Filter

TABLE 4.3. (contd)

Nuclide	Limiting Public[a] 1 mrem/y, pCi/g Waste	Limiting Worker 1 mrem/y, pCi/g Waste	Limiting Worker Scenario
^{126}I	7.8E+00	5.5E+01	Waste Disposal
^{129}I	1.1E-01	1.1E+03	Incineration/Bag Filter
^{131}I	1.0E+01	1.0E+02	Waste Disposal
^{134}Cs	5.2E+02	1.2E+01	Waste Disposal
^{137}Cs	2.4E+02	4.6E+01	Waste Disposal
^{144}Ce	7.2E+03	4.3E+03	Incinerator Maintenance
$^{144}Ce+D$	None	2.5E+02	Waste Disposal
^{147}Pm	8.0E+04	6.1E+05	Incinerator Maintenance
^{151}Sm	1.2E+05	1.3E+06	Incinerator Maintenance
^{152}Eu	4.9E+02	1.1E+01	Waste Disposal
^{154}Eu	6.2E+02	1.1E+01	Waste Disposal
^{155}Eu	1.5E+04	1.6E+03	Incinerator Maintenance
^{203}Hg	6.3E+02	2.7E+02	Incineration/Bag Filter
^{207}Bi	1.3E+02	9.3E+00	Waste Disposal
^{226}Ra	5.4E+01	9.3E+02	Incinerator Maintenance
$^{226}Ra+D$	None	6.1E+00	Waste Disposal
^{228}Th	3.1E+01	2.5E+02	Waste Receiving
^{229}Th	1.1E+01	4.4E+01	Waste Receiving
$^{229}Th+D$	None	3.5E+01	Waste Receiving
^{230}Th	3.1E+01	3.0E+02	Waste Receiving
^{232}Th	2.2E+01	6.8E+01	Waste Receiving
$^{232}Th+D$	9.4E+00	3.4E+00	Waste Disposal
^{232}U	1.6E+01	1.2E+02	Waste Receiving
^{233}U	5.6E+01	6.3E+02	Waste Receiving
^{234}U	5.6E+01	6.4E+02	Waste Receiving
^{235}U	6.0E+01	3.5E+02	Waste Receiving
$^{235}U+D$	None	3.4E+02	Waste Receiving
^{238}U	6.3E+01	6.9E+02	Waste Receiving
$^{238}U+D$	None	5.0E+02	Waste Receiving
^{237}Np	2.2E+01	1.3E+02	Waste Receiving
$^{237}Np+D$	None	8.4E+01	Waste Receiving
^{238}Pu	2.3E+01	2.8E+02	Waste Receiving
^{239}Pu	2.1E+01	2.5E+02	Waste Receiving
^{240}Pu	2.1E+01	2.5E+02	Waste Receiving
^{241}Pu	1.4E+03	1.5E+04	Waste Receiving
^{241}Am	2.0E+01	1.2E+02	Waste Receiving

(a) Limiting scenario for public exposures is for rural population.

This file: F:PW3.OUT 15:32 15-DEC-93 Program: INCIN.BAS 14:12 15-DEC-93 Ini file: INCIN.INI 08:22 14-DEC-93

TABLE 4.4. Case 4: Preliminary Limiting Concentrations for Incineration Using a Dose Limit of 10 mrem/y for the Maximally Exposed Offsite Individual and for the Maximally Exposed Hazardous Waste Worker

Nuclide	Limiting Public[a] 10 mrem/y, pCi/g Waste	Limiting Worker 10 mrem/y, pCi/g Waste	Limiting Worker Scenario
^{3}H	6.5E+05	3.1E+07	Waste Receiving
^{7}Be	6.1E+07	5.9E+02	Waste Disposal
^{14}C	1.2E+04	9.4E+05	Waste Receiving
^{22}Na	9.1E+04	7.2E+00	Waste Disposal
^{32}P	3.2E+05	1.6E+04	Waste Disposal
^{35}S	4.0E+05	8.2E+05	Incineration/Bag Filter
^{46}Sc	1.9E+06	6.4E+00	Waste Disposal
^{48}V	7.9E+05	5.4E+00	Waste Disposal
^{51}Cr	6.9E+07	1.2E+03	Waste Disposal
^{54}Mn	3.7E+05	2.2E+01	Waste Disposal
^{55}Fe	6.1E+06	1.4E+04	Incineration/Bag Filter
^{56}Co	5.9E+04	2.4E+00	Waste Disposal
^{57}Co	3.9E+05	6.6E+02	Waste Receiving
^{58}Co	2.1E+05	1.9E+01	Waste Disposal
^{60}Co	4.9E+03	4.5E+00	Waste Disposal
^{63}Ni	6.1E+06	1.7E+06	Incineration/Bag Filter
^{65}Zn	3.4E+04	1.8E+01	Waste Disposal
^{68}Ge	2.7E+06	2.9E+03	Incineration/Bag Filter
^{74}As	7.4E+06	4.2E+01	Waste Disposal
^{75}Se	2.8E+04	1.6E+02	Incineration/Bag Filter
^{79}Se	1.1E+05	5.8E+04	Incineration/Bag Filter
^{90}Sr	7.5E+05	7.8E+03	Incinerator Maintenance
$^{90}Sr+D$	None	3.6E+03	Incinerator Maintenance
^{88}Y	1.6E+06	4.0E+00	Waste Disposal
^{93}Zr	1.2E+07	5.4E+05	Incinerator Maintenance
^{94}Nb	1.1E+04	1.4E+01	Waste Disposal
^{99}Tc	5.0E+03	3.4E+05	Incineration/Bag Filter
^{106}Ru	5.6E+04	1.0E+02	Waste Disposal
^{110m}Ag	2.5E+05	5.5E+00	Waste Disposal
^{113}Sn	3.4E+06	3.1E+03	Incinerator Maintenance
$^{113}Sn+D$	None	1.8E+02	Waste Disposal
^{124}Sb	6.7E+04	5.7E+00	Waste Disposal
^{125}Sb	2.3E+04	6.3E+01	Waste Disposal
^{125m}Te	9.4E+05	2.2E+03	Incineration/Bag Filter
^{125}I	2.5E+02	1.2E+03	Incineration/Bag Filter

TABLE 4.4. (contd)

Nuclide	Limiting Public[a] 10 mrem/y, pCi/g Waste	Limiting Worker 10 mrem/y, pCi/g Waste	Limiting Worker Scenario
^{126}I	7.8E+02	5.5E+01	Waste Disposal
^{129}I	1.1E+01	1.1E+03	Incineration/Bag Filter
^{131}I	1.0E+03	1.0E+02	Waste Disposal
^{134}Cs	5.2E+04	1.2E+01	Waste Disposal
^{137}Cs	2.4E+04	4.6E+01	Waste Disposal
^{144}Ce	7.2E+05	4.3E+03	Incinerator Maintenance
^{144}Ce+D	None	2.5E+02	Waste Disposal
^{147}Pm	8.0E+06	6.1E+05	Incinerator Maintenance
^{151}Sm	1.2E+07	1.3E+06	Incinerator Maintenance
^{152}Eu	4.9E+04	1.1E+01	Waste Disposal
^{154}Eu	6.2E+04	1.1E+01	Waste Disposal
^{155}Eu	1.5E+06	1.6E+03	Incinerator Maintenance
^{203}Hg	6.3E+04	2.7E+02	Incineration/Bag Filter
^{207}Bi	1.3E+04	9.3E+00	Waste Disposal
^{226}Ra	5.4E+03	9.3E+02	Incinerator Maintenance
^{226}Ra+D	None	6.1E+00	Waste Disposal
^{228}Th	3.1E+03	2.5E+02	Waste Receiving
^{229}Th	1.1E+03	4.4E+01	Waste Receiving
^{229}Th+D	None	3.5E+01	Waste Receiving
^{230}Th	3.1E+03	3.0E+02	Waste Receiving
^{232}Th	2.2E+03	6.8E+01	Waste Receiving
^{232}Th+D	9.4E+02	3.4E+00	Waste Disposal
^{232}U	1.6E+03	1.2E+02	Waste Receiving
^{233}U	5.6E+03	6.3E+02	Waste Receiving
^{234}U	5.6E+03	6.4E+02	Waste Receiving
^{235}U	6.0E+03	3.5E+02	Waste Receiving
^{235}U+D	None	3.4E+02	Waste Receiving
^{238}U	6.3E+03	6.9E+02	Waste Receiving
^{238}U+D	None	5.0E+02	Waste Receiving
^{237}Np	2.2E+03	1.3E+02	Waste Receiving
^{237}Np+D	None	8.4E+01	Waste Receiving
^{238}Pu	2.3E+03	2.8E+02	Waste Receiving
^{239}Pu	2.1E+03	2.5E+02	Waste Receiving
^{240}Pu	2.1E+03	2.5E+02	Waste Receiving
^{241}Pu	1.4E+05	1.5E+04	Waste Receiving
^{241}Am	2.0E+03	1.2E+02	Waste Receiving

(a) Limiting scenario for public exposures is for rural population.

This file: F:PW4.OUT 15:32 15-DEC-93 Program: INCIN BAS 14:12 15-DEC-93 Ini file: INCIN.INI 08:22 14-DEC-93

TABLE 4.5. Case 5: Preliminary Limiting Concentrations for Incineration Using a Dose Limit of 5 mrem/y for the Maximally Exposed Offsite Individual and 20 mrem/y for the Maximally Exposed Hazardous Waste Worker

Nuclide	Limiting Public[a] 5 mrem/y, pCi/g Waste	Limiting Worker 20 mrem/y, pCi/g Waste	Limiting Worker Scenario
^{3}H	3.2E+05	6.2E+07	Waste Receiving
^{7}Be	3.1E+07	1.2E+03	Waste Disposal
^{14}C	6.1E+03	1.9E+06	Waste Receiving
^{22}Na	4.5E+04	1.4E+01	Waste Disposal
^{32}P	1.6E+05	3.2E+04	Waste Disposal
^{35}S	2.0E+05	1.6E+0	Incineration/Bag Filter
^{46}Sc	9.6E+05	1.3E+01	Waste Disposal
^{48}V	3.9E+05	1.1E+01	Waste Disposal
^{51}Cr	3.4E+07	2.4E+03	Waste Disposal
^{54}Mn	1.9E+05	4.4E+01	Waste Disposal
^{55}Fe	3.1E+06	2.8E+04	Incineration/Bag Filter
^{56}Co	2.9E+04	4.8E+00	Waste Disposal
^{57}Co	2.0E+05	1.3E+03	Waste Receiving
^{58}Co	1.1E+05	3.8E+01	Waste Disposal
^{60}Co	2.4E+03	9.0E+00	Waste Disposal
^{63}Ni	3.1E+06	3.4E+06	Incineration/Bag Filter
^{65}Zn	1.7E+04	3.6E+01	Waste Disposal
^{68}Ge	1.4E+06	5.8E+03	Incineration/Bag Filter
^{74}As	3.7E+06	8.4E+01	Waste Disposal
^{75}Se	1.4E+04	3.2E+02	Incineration/Bag Filter
^{79}Se	5.7E+04	1.2E+05	Incineration/Bag Filter
^{90}Sr	3.8E+05	1.6E+04	Incinerator Maintenance
$^{90}Sr+D$	None	7.2E+03	Incinerator Maintenance
^{88}Y	8.0E+05	8.0E+00	Waste Disposal
^{93}Zr	6.2E+06	1.1E+06	Incinerator Maintenance
^{94}Nb	5.6E+03	2.8E+01	Waste Disposal
^{99}Tc	2.5E+03	6.8E+05	Incineration/Bag Filter
^{106}Ru	2.8E+04	2.0E+02	Waste Disposal
^{110M}Ag	1.2E+05	1.1E+01	Waste Disposal
^{113}Sn	1.7E+06	6.2E+03	Incinerator Maintenance
$^{113}Sn+D$	None	3.6E+02	Waste Disposal
^{124}Sb	3.4E+04	1.1E+01	Waste Disposal
^{125}Sb	1.2E+04	1.3E+02	Waste Disposal
^{125M}Te	4.7E+05	4.4E+03	Incineration/Bag Filter
^{125}I	1.3E+02	2.4E+03	Incineration/Bag Filter

TABLE 4.5. (contd)

Nuclide	Limiting Public[a] 5 mrem/y, pCi/g Waste	Limiting Worker 20 mrem/y, pCi/g Waste	Limiting Worker Scenario
^{126}I	3.9E+02	1.1E+02	Waste Disposal
^{129}I	5.7E+00	2.2E+03	Incineration/Bag Filter
^{131}I	5.1E+02	2.0E+02	Waste Disposal
^{134}Cs	2.6E+04	2.4E+01	Waste Disposal
^{137}Cs	1.2E+04	9.2E+01	Waste Disposal
^{144}Ce	3.6E+05	8.6E+03	Incinerator Maintenance
$^{144}Ce+D$	None	5.0E+02	Waste Disposal
^{147}Pm	4.0E+06	1.2E+06	Incinerator Maintenance
^{151}Sm	5.8E+06	2.6E+06	Incinerator Maintenance
^{152}Eu	2.5E+04	2.2E+01	Waste Disposal
^{154}Eu	3.1E+04	2.2E+01	Waste Disposal
^{155}Eu	7.3E+05	3.2E+03	Incinerator Maintenance
^{203}Hg	3.2E+04	5.4E+02	Incineration/Bag Filter
^{207}Bi	6.5E+03	1.9E+01	Waste Disposal
^{226}Ra	2.7E+03	1.9E+03	Incinerator Maintenance
$^{226}Ra+D$	None	1.2E+01	Waste Disposal
^{228}Th	1.6E+03	5.0E+02	Waste Receiving
^{229}Th	5.6E+02	8.8E+01	Waste Receiving
$^{229}Th+D$	None	7.0E+01	Waste Receiving
^{230}Th	1.6E+03	6.0E+02	Waste Receiving
^{232}Th	1.1E+03	1.4E+02	Waste Receiving
$^{232}Th+D$	4.7E+02	6.8E+00	Waste Disposal
^{232}U	7.9E+02	2.4E+02	Waste Receiving
^{233}U	2.8E+03	1.3E+03	Waste Receiving
^{234}U	2.8E+03	1.3E+03	Waste Receiving
^{235}U	3.0E+03	7.0E+02	Waste Receiving
$^{235}U+D$	None	6.8E+02	Waste Receiving
^{238}U	3.2E+03	1.4E+03	Waste Receiving
$^{238}U+D$	None	1.0E+03	Waste Receiving
^{237}Np	1.1E+03	2.6E+02	Waste Receiving
$^{237}Np+D$	None	1.7E+02	Waste Receiving
^{238}Pu	1.1E+03	5.6E+02	Waste Receiving
^{239}Pu	1.1E+03	5.0E+02	Waste Receiving
^{240}Pu	1.1E+03	5.0E+02	Waste Receiving
^{241}Pu	6.8E+04	3.0E+04	Waste Receiving
^{241}Am	1.0E+03	2.4E+02	Waste Receiving

(a) Limiting scenario for public exposures is for rural population.

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- Case 3, offsite individual dose of 0.1 mrem/y and worker dose of 10 mrem/y (Table 4.3)
- Case 4, offsite individual dose and worker dose of 10 mrem/y (Table 4.4)
- Case 5, offsite individual dose of 5 mrem/y and worker dose of 20 mrem/y (Table 4.5).

4.2 ADDITIONAL CONSTRAINTS ON CONCENTRATION LIMITS

In addition to the most restrictive concentrations for either the maximally exposed offsite individual or worker (from Tables 4.1 through 4.5), two further criteria from the DOT and NRC were considered.

First, if the acceptable concentration exceeded 2 nCi/g (2000 pCi/g), the DOT transportation labeling limit was used.

Second, for uranium and thorium, the NRC limit of 0.05% for source materials was imposed. The NRC has set a thorium and natural uranium concentration limit of 0.05% at, or above, which material that is received, possessed, used, transferred, or delivered is classified as source material (10 CFR 20.1003). The NRC concentration limit of 0.05% is equivalent to 334 pCi/g for natural uranium, 168 pCi/g for ^{238}U, and 55 pCi/g for ^{232}Th. The NRC constraints are limiting only for Case 4 and Case 5 (^{232}Th, ^{238}U, and $^{238}U+D$), which are based on 10 and 20 mrem/y to a hazardous waste worker.

A summary of the limiting concentrations for hazardous waste incineration, including the additional constraints described above, is presented in Table 4.6. This table shows only the most restrictive concentration for each radionuclide and case, with a notation that indicates the limiting scenario (worker or offsite individual) or criterion (transportation or source material limit).

Some of the radionuclides have short half-lives (notably ^{131}I) and will likely decay to low concentrations by the time the waste reaches a treatment

TABLE 4.6. Summary of the Preliminary Limiting Concentrations for Waste Incineration Based on Dose Limits for Cases 1 Through 5

Nuclide	Case 1 Public 0.1 mrem/y Worker 1 mrem/y Concentration, pCi/g	Case 2 Public 1 mrem/y Worker 1 mrem/y Concentration, pCi/g	Case 3 Public 0.1 mrem/y Worker 10 mrem/y Concentration, pCi/g	Case 4 Public 10 mrem/y Worker 10 mrem/y Concentration, pCi/g	Case 5 Public 5 mrem/y Worker 20 mrem/y Concentration, pCi/g
^{3}H	6500. P *(a,b)	65,000. P *	6500. P *	650,000. P *	320,000. P *
^{7}Be	59. W	59. W	590. W	590. W	1200. W
^{14}C	120. P	1,200. P	120. P	12,000. P *	6100. P *
^{22}Na	0.72 W	0.72 W	7.2 W	7.2 W	14. W
^{32}P	1600. W	1600. W	3200. P *	16,000. W *	32,000. W *
^{35}S	4000. P *	40,000. P *	4000. P *	400,000. P *	200,000. P *
^{46}Sc	0.64 W	0.64 W	6.4 W	6.4 W	13. W
^{48}V	0.54 W	0.54 W	5.4 W	5.4 W	11. W
^{51}Cr	120. W	120. W	1200. W	1200. W	2400. W *
^{54}Mn	2.2 W	2.2 W	22. W	22. W	44. W
^{55}Fe	1400. W	1400. W	14,000. W *	14,000. W *	28,000. W *
^{56}Co	0.24 W	0.24 W	2.4 W	2.4 W	4.8 W
^{57}Co	66. W	66. W	660. W	660. W	1300. W
^{58}Co	1.9 W	1.9 W	19. W	19. W	38. W
^{60}Co	0.45 W	0.45 W	4.5 W	4.5 W	9.0 W
^{63}Ni	61,000. P *	170,000. W *	61,000. P *	1,700,000. W *	3,100,000. P *
^{65}Zn	1.8 W	1.8 W	18. W	18. W	36. W
^{68}Ge	290. W	290. W	2900. W *	2900. W *	5800. W *
^{74}As	4.2 W	4.2 W	42. W	42. W	84. W
^{75}Se	16. W	16. W	160. W	160. W	320. W
^{79}Se	1100. P	5800. W *	1100. P	58,000. W *	57,000. P *
^{90}Sr	780. W	780. W	7500. P *	7800. W *	16,000. W *
$^{90}Sr+D$(c)	360. W	360. W	3600. W *	3600. W *	7200. W *
^{88}Y	0.40 W	0.40 W	4.0 W	4.0 W	8.0 W
^{93}Zr	4,000. W *	54,000. W *	120,000. P *	540,000. W *	1,100,000. W *
^{94}Nb	1.4 W	1.4 W	14. W	14. W	28. W
^{99}Tc	50. P	500. P	50. P	5000. P *	2500. P *
^{106}Ru*	10. W	10. W	100. W	100. W	200. W
^{110m}Ag	0.55 W	0.55 W	5.5 W	5.5 W	11. W
^{113}Sn	310. W	310. W	3100. W *	3100. W *	6200. W *
$^{113}Sn+D$(d)	18. W	18. W	180. W	180. W	360. W
^{124}Sb	0.57 W	0.57 W	5.7 W	5.7 W	11. W
^{125}Sb	6.3 W	6.3 W	63. W	63. W	130. W
^{125m}Te	220. W	220. W	2200. W *	2200. W *	4400. W *
^{125}I	2.5 P	25. P	2.5 P	250. P	130. P
^{126}I	5.5 W	5.5 W	7.8 P	55. W	110. W
^{129}I	0.11 P	1.1 P	0.11 P	11. P	5.7 P
^{131}I	10. W	10. W	10. P	100. W	200. W
^{134}Cs	1.2 W	1.2 W	12. W	12. W	24. W
^{137}Cs	4.6 W	4.6 W	46. W	46. W	92. W
^{144}Ce	430. W	430. W	4300. W *	4300. W *	8600. W *
$^{144}Ce+D$(e)	25. W	25. W	250. W	250. W	500. W
^{147}Pm	61,000. W *	61,000. W *	80,000. P *	610,000. W *	1,200,000. W *
^{151}Sm	120,000. P *	130,000. W *	120,000. P *	1,300,000. W *	2,600,000. W *
^{152}Eu	1.1 W	1.1 W	11. W	11. W	22. W

TABLE 4.6. (contd)

Nuclide	Case 1 Public 0.1 mrem/y Worker 1 mrem/y Concentration, pCi/g		Case 2 Public 1 mrem/y Worker 1 mrem/y Concentration, pCi/g		Case 3 Public 0.1 mrem/y Worker 10 mrem/y Concentration, pCi/g		Case 4 Public 10 mrem/y Worker 10 mrem/y Concentration, pCi/g		Case 5 Public 5 mrem/y Worker 20 mrem/y Concentration, pCi/g	
^{154}Eu	1.1	W	1.1	W	11.	W	11.	W	22.	W
^{155}Eu	160.	W	160.	W	1600.	W	1600.	W	3200.	W *
^{203}Hg	27.	W	27.	W	270.	W	270.	W	540.	W
^{207}Bi	0.93	W	0.93	W	9.3	W	9.3	W	19.	W
^{226}Ra	54.	P	93.	W	54.	P	930.	W	1900.	W
$^{226}Ra+D$ (f)	0.61	W	0.61	W	6.1	W	6.1	W	12.	W
^{228}Th	25.	W	25.	W	31.	P	250.	W	500.	W
^{229}Th	4.4	W	4.4	W	11.	P (b)	44.	W	88.	W
$^{229}Th+D$ (g)	3.5	W	3.5	W	11.	P	35.	W	70.	W
^{230}Th	30.	W	30.	W	31.	P	300.	W	600.	W
^{232}Th	6.8	W	6.8	W	22.	P	55.	C	55.	C
$^{232}Th+D$ (h)	0.34	W	0.34	W	3.4	W	3.4	W	6.8	W
^{232}U	12.	W	12.	W	16.	P	120.	W	240.	W
^{233}U	56.	P	63.	W	56.	P	630.	W	1300.	W
^{234}U	56.	P	64.	W	56.	P	640.	W	1300.	W
^{235}U	35.	W	35.	W	60.	P	350.	W	700.	W
$^{235}U+D$ (i)	34.	W	34.	W	60.	P	340.	W	680.	W
^{238}U	63.	P	69.	W	63.	P	168.	C	168.	C
$^{238}U+D$ (j)	50.	W	50.	W	63.	P	168.	C	168.	C
^{237}Np	13.	W	13.	W	22.	P	130.	W	260.	W
$^{237}Np+D$ (k)	8.4	W	8.4	W	22.	P	84.	W	170.	W
^{238}Pu	23.	P	28.	W	23.	P	280.	W	560.	W
^{239}Pu	21.	P	25.	W	21.	P	250.	W	500.	W
^{240}Pu	21.	P	25.	W	21.	P	250.	W	500.	W
^{241}Pu	1400.	P	1500.	W	1400.	P	15,000.	W *	30,000.	W *
^{241}Am	12.	W	12.	W	20.	P	120.	W	240.	W

(a) The limiting scenario, based on incineration of mixed solids in a rotary kiln incinerator or other constraint, is indicated as follows:

W = Worker dose, based on waste or incineration with 70% residue
P = Maximally exposed offsite individual member of the general public
C = Concentration of source material; uranium and ^{232}Th at 0.05%.

(b) An asterisk (*) beside the symbol for limiting scenario indicates that the value is greater than the transportation labeling limit of 2 nCi/g (2000 pCi/g).

(c) $^{90}Sr+D$ refers to ^{90}Sr in equilibrium with decay product ^{90}Y.

(d) $^{113}Sn+D$ refers to ^{113}Sn in equilibrium with ^{113m}In.

(e) $^{144}Ce+D$ refers to ^{144}Ce in equilibrium with ^{144m}Pr (branching ratio 0.0143) and ^{144}Pr (branching ratio 0.9857).

(f) $^{226}Ra+D$ refers to ^{226}Ra in equilibrium with decay products ^{222}Rn (with short-lived ^{218}Po, ^{214}Pb, ^{214}Bi, and ^{214}Po), ^{210}Pb, ^{210}Bi, and ^{210}Po.

(g) $^{229}Th+D$ refers to ^{229}Th in equilibrium with decay products ^{225}Ra and ^{225}Ac

(h) $^{232}Th+D$ refers to ^{232}Th in equilibrium with decay products ^{228}Ra, ^{228}Ac, ^{228}Th, ^{224}Ra, ^{220}Rn and ^{216}Po, ^{212}Pb, and ^{212}Bi.

(i) 235U+D refers to 235U in equilibrium with decay product ^{231}Th

(j) $^{238}U+D$ refers to ^{238}U in equilibrium with decay products ^{234}Th, ^{234m}Pa, and ^{234}Pa (with a branching ratio of 0.0016 applied).

(k) $^{237}Np+D$ refers to ^{237}Np in equilibrium with decay product ^{233}Pa.

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facility. As a result, the dose from short-lived radionuclides should be minimal; therefore, the control criteria for short-lived radionuclides are necessarily conservative.

4.3 COMPARISON OF POPULATION DOSE AND COLLECTIVE WORKER DOSE

Table 4.7 presents both screening estimates for the dose to the general public within 80 km of the site and for the collective worker dose. The population dose is based on the more limiting concentration for Case 1 (0.1 mrem/y to the maximally exposed offsite individual and 1 mrem/y to the maximally exposed worker). The collective worker dose is based on the limiting concentration corresponding to 1 mrem/y to the maximally exposed worker. Both the dose to the general population and the dose to incinerator workers are based on a 30,000-t/y incinerator. The collective dose received by landfill workers is based on the landfill capacity of 180,000 tons of waste per year.

Table 4.7 shows that, for all cases, the population dose is less than 1 person-rem per year. This is two orders of magnitude below the 100 person-rem/y reporting requirement established by DOE Order 5400.1 (DOE 1988). The population dose is considered to be conservative because the most limiting concentration (which is for the rural population density) is used to calculate dose to the general public for all population densities. The collective dose to workers based on these limits is on the order of hundredths of person-rem per year. The dose to the general public ranges from thousandths of person-rem per year to tenths of person-rem per year for most radionuclides.

TABLE 4.7. Population Dose for Three Population Densities[a] and Collective Worker Dose Based on Limiting Concentrations[b]

Nuclide	Population Dose, person-rem			Collective Worker Dose
	Metro-High	Metro-Low	Rural	
^{3}H	7.2E-02	1.6E-02	7.6E-03	6.9E-02
^{7}Be	2.6E-05	6.2E-06	3.0E-06	5.3E-02
^{14}C	2.6E-01	5.9E-02	2.7E-02	6.9E-02
^{22}Na	2.3E-04	5.7E-05	2.8E-05	4.9E-02
^{32}P	1.6E-01	3.7E-02	1.7E-02	6.1E-02
^{35}S	1.9E-01	4.6E-02	2.1E-02	1.3E-02
^{46}Sc	9.1E-06	2.2E-06	1.1E-06	4.8E-02
^{48}V	2.4E-05	5.9E-06	2.8E-06	5.0E-02
^{51}Cr	4.7E-05	1.1E-05	5.4E-06	5.7E-02
^{54}Mn	1.6E-04	3.9E-05	1.9E-05	5.1E-02
^{55}Fe	8.2E-03	1.9E-03	8.7E-04	2.9E-04
^{56}Co	1.1E-04	2.8E-05	1.3E-05	4.5E-02
^{57}Co	4.7E-03	1.1E-03	5.6E-04	2.5E-02
^{58}Co	2.5E-04	6.0E-05	3.0E-05	5.0E-02
^{60}Co	2.5E-03	6.2E-04	3.1E-04	4.7E-02
^{63}Ni	1.0E-02	2.2E-03	1.0E-03	3.3E-02
^{65}Zn	2.0E-03	4.8E-04	2.2E-04	4.8E-02
^{68}Ge	2.7E-03	5.8E-04	2.8E-04	1.3E-04
^{74}As	9.3E-06	2.3E-06	1.2E-06	5.2E-02
^{75}Se	1.6E-02	3.8E-03	1.9E-03	4.4E-02
^{79}Se	3.1E-01	6.5E-02	3.0E-02	1.7E-02
^{90}Sr	3.2E-02	6.6E-03	3.1E-03	3.6E-02
$^{90}Sr+D$	--[c]	--	--	5.0E-02
^{88}Y	6.8E-06	1.7E-06	8.0E-07	4.7E-02
^{93}Zr	3.1E-03	7.3E-04	3.5E-04	3.6E-02
^{94}Nb	3.4E-03	8.5E-04	4.2E-04	5.1E-02
^{99}Tc	3.9E-01	9.1E-02	4.3E-02	1.7E-02
^{106}Ru	3.9E-03	8.6E-04	4.1E-04	5.1E-02
^{110m}Ag	6.1E-05	1.5E-05	7.4E-06	4.9E-02
^{113}Sn	3.5E-03	8.3E-04	3.8E-04	1.0E-02
$^{113}Sn+D$	--	--	--	5.7E-02
^{124}Sb	2.3E-04	5.3E-05	2.6E-05	4.7E-02
^{125}Sb	7.1E-03	1.8E-03	8.8E-04	5.3E-02
^{125m}Te	7.5E-03	1.6E-03	7.5E-04	4.9E-04
^{125}I	8.8E-02	2.0E-02	8.9E-03	1.6E-03
^{126}I	5.9E-02	1.3E-02	6.0E-03	5.3E-02
^{129}I	8.9E-02	2.1E-02	9.3E-03	1.1E-02
^{131}I	8.3E-02	1.9E-02	8.3E-03	5.3E-02
^{134}Cs	7.3E-04	1.8E-04	8.6E-05	5.0E-02
^{137}Cs	5.4E-03	1.3E-03	6.5E-04	5.2E-02
^{144}Ce	1.3E-02	2.8E-03	1.3E-03	2.1E-02
$^{144}Ce+D$	---	---	---	4.8E-02
^{147}Pm	5.0E-03	1.2E-03	5.6E-04	2.5E-02
^{151}Sm	3.1E-03	7.5E-04	3.6E-04	2.1E-02
^{152}Eu	5.9E-04	1.5E-04	7.3E-05	4.7E-02
^{154}Eu	4.7E-04	1.2E-04	5.8E-05	4.6E-02
^{155}Eu	2.8E-03	6.9E-04	3.4E-04	1.6E-02
^{203}Hg	1.6E-02	3.9E-03	1.8E-03	3.5E-02
^{207}Bi	1.9E-03	4.7E-04	2.3E-04	4.8E-02
^{226}Ra	1.7E-01	4.1E-02	2.0E-02	3.8E-02
$^{226}Ra+D$	--	--	--	4.8E-02
^{228}Th	1.2E-01	3.1E-02	1.5E-02	1.5E-02
^{229}Th	6.1E-02	1.5E-02	7.5E-03	1.8E-02
$^{229}Th+D$	--	--	--	3.2E-02
^{230}Th	1.5E-01	3.7E-02	1.8E-02	1.7E-02

TABLE 4.7. (contd)

Nuclide	Population Dose, person-rem			Collective Worker Dose
	Metro-High	Metro-Low	Rural	
^{238}U	1.7E-01	4.0E-02	2.0E-02	1.3E-02
$^{238}U+D$	--	--	--	4.0E-02
^{237}Np	1.0E-01	2.4E-02	1.2E-02	2.8E-02
$^{237}Np+D$	--	--	--	4.1E-02
^{238}Pu	1.7E-01	4.1E-02	2.0E-02	1.3E-02
^{239}Pu	1.7E-01	4.1E-02	2.0E-02	1.3E-02
^{240}Pu	1.7E-01	4.1E-02	2.0E-02	1.3E-02
^{241}Pu	1.8E-01	4.1E-02	2.0E-02	1.3E-02
^{241}Am	1.0E-01	2.4E-02	1.2E-02	2.8E-02

(a) Uniform population densities of 80, 20, and 10 persons/km^2

(b) Population dose is based on the more limiting concentration corresponding to either 0.1 mrem/y to the maximally exposed offsite individual or 1 rem/y to the maximally exposed worker; collective worker dose is based on the limiting concentration corresponding to 1 mrem/y. All doses are based on a 30,000-t/y incinerator.

(c) -- Not calculated

5.0 LIMITATIONS OF STUDY

The waste streams being considered contain both radioactive and hazardous chemical contaminants. Because this assessment examines only the doses associated with radioactive constituents, the concentration limits derived in this study are based on radiation doses only.

The quantity of residue assumed for the generic incineration facility is based on reports by and data obtained from Chew and Associates (1992, 1993a). These generic concentration assumptions, however, may not be representative of the concentration in a particular facility.

The assessment admittedly is based upon somewhat limited information (drawn from interviews, direct observations, reviews of standard operating procedures, and time and motion studies) about the activities of incinerator workers. Refinements in future studies could address the estimates of airborne particulate matter and the incidental ingestion of contaminated material.

The emission factor for stack releases contributes to the uncertainty in the dose to the general public. A generic release factor was used; an actual release, of course, would be dependent upon the air pollution control equipment in use at the particular facility. The dose to the offsite maximally exposed individual and the dose to the general population are directly proportional to the value of the stack emission factor. The assumed removal efficiency ranged from a minimum of 5% for carbon, 10% for hydrogen, and 99.95% for uranium, thorium, and other refactory metals.

Also note that this evaluation assumed 100% of the waste was at the limiting concentration, a conservative assumption that may be improved by waste stream data in the future.

The lower limit of detection (LLD) must also be considered in the application of radiological controls to screen potentially radioactively contaminated wastes. The costs of achieving various detection limits is

a consideration.[a] Practical limits of detection (RLD, the lowest "recommended" detection limit) for routine analyses, are approximately as follows:

- alpha emitters, 1 pCi/g
- beta emitters, 10 to 30 pCi/g
- gamma or beta-gamma emitters, 10 to 30 pCi/g.

In general, the radionuclides requiring very low screening levels are gamma emitters. Meeting required detection limits for these may involve longer counting times than routinely performed for beta-gamma emitters such as ^{22}Na, ^{54}Mn, ^{60}Co, ^{65}Zn, ^{134}Cs, ^{137}Cs, ^{154}Eu. For alpha emitters, however, the capability of detection of 1 to 2 pCi/g is adequate.

(a) Transmittal to Mary Jarvis, PNL, from Andy Wallo, EH-232, U.S. DOE, dated 26 August, 1993. Subject: cost estimates for sampling waste.

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APPENDIX A

DATA CALL AND SCREENING CRITERIA

APPENDIX A

DATA CALL AND SCREENING CRITERIA

The characterization of regulated chemical wastes produced by facilities of the U.S. Department of Energy (DOE) is a key element in establishing the feasibility for establishing control criteria for such regulated wastes. This appendix lists the data call that was sent to DOE facilities in order to evaluate wastes that could potentially be handled by commercial facilities.

ATTACHMENT I

Screening Level Assessment in Support of Radiation Control Criteria for Hazardous Waste

BACKGROUND

The Office of Environmental Guidance is conducting a project to assess the feasibility of establishing radiation control criteria for hazardous waste. The purpose of the project is to determine if it is feasible to define control criteria (concentrations of residual radioactive material) in regulated chemical wastes (e.g., the Resource Conservation and Recovery Act, RCRA) at which regulation of the waste for its chemical properties provide acceptable control of the radioactive portion of the waste. To be feasible, control of radionuclides afforded by RCRA regulations must provide an equivalent level of protection for the public as that provided by Atomic Energy Act based regulation; doses must be as low as in reasonably achievable.

The project is being conducted in a phased approach that, if the control criteria concept is feasible, will result in DOE working with EPA and NRC and other concerned parties to develop and implement radiation control criteria. These phases include:

I **Identify Regulatory Limits and Constraints** applicable to radiological control criteria.

II **Analyze hazardous waste Treatment, Storage and Disposal Facility Procedures and Controls** that would be in place at permitted facilities.

III **Complete Pathway and Exposure Analyses** to identify potential sources of dose and risk.

IV **Develop Screening Criteria** to support characterizing potential waste streams.

V **Characterize Waste Streams** to identify potential source term.

VI **Conduct ALARA and NEPA Analyses** to support the determination as to whether radiological control criteria are feasible and determine possible levels (concentrations).

VII **Determine Appropriate Action** jointly with EPA and NRC.

A key element in the process of estimating potential the doses or risks and completing the ALARA (As Low As is Reasonably Achievable) analysis and the National Environmental Policy Act (NEPA) Analyses for the various alternatives (Phase VI), is determining the quantity of residual radioactive material potentially in waste regulated for its non-radioactive hazardous components (Phase V). In order to calculate expected doses under the various alternative control criteria, it is necessary to identify the potential radioactive source term in hazardous waste. The data requested in the attached document are needed to establish this source term at various screen levels.

Respondents should provide their best estimate of the quantities, characteristics and costs relating to screen criteria identified below. It may not be possible to complete the final phases of the radiation control criteria project without such data. Please provide complete and timely answers to the attached questions.

A. BASE CASE DATA ASSUMPTIONS

Answer the questions listed below assuming that numerical control criteria for radionuclides in hazardous waste materials regulated under RCRA and TSCA were established at the concentrations given in Table 1 (Base Case).

Additional assumptions include:

- Wastes for disposal and waste residues from treatment facilities will ultimately be sent to RCRA or TSCA regulated disposal facilities (not recycle),
- Analytical techniques and equipment are available to measure (or permit the calculation of) radionuclides at least to 50% but ideally 10% or less of the levels given in the Table 1 and data must be reported in a manner consistent with the requirements in Chapter 7 (including 7.3.4) of DOE/EH-173T[1],
- When several radionuclides are present, control criteria shall be determined using the sum of the fractions rule (see DOE 5400.5, Section II.3.a(c)(3)).

WASTE QUANTITY AND RADIONUCLIDE CONTENT

A.1 How much additional hazardous waste (mass and volume) is likely to be shipped (on average) from your site to TSD facilities for disposal during a 12 month period?

A.1.1 If possible, indicate, what proportion of the total amount of waste shipped during the 12 month period will be disposed of directly and what proportion will require treatment.

A.2 What will be the predominant[2] radionuclides present in this incremental portion of hazardous waste to be shipped from your site for disposal?

A.3 What is the best estimate of radionuclide concentrations or the total activity (curie or Bq) amounts of each radionuclide in hazardous waste to be shipped over a 12 month period?

A.4 What will be the typical forms (physical [e.g., aqueous, solid, sludge, liquid] and chemical [e.g., organic, inorganic, acid, base] of hazardous waste shipped from your site?

MEASUREMENTS OF RADIONUCLIDES IN HAZARDOUS WASTE

A.5 Will the radionuclides in hazardous waste for disposal at your facility be detectable at the concentrations given in Table 1 and considering the assumptions stated above?

A.6 Will conventional laboratory techniques be suitable or would significant procedure or method change be required to measure radionuclides in hazardous waste at the concentrations given in Table 1 (and assumptions)? (List those radionuclides or waste forms requiring the new analytical procedures or equipment.)

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1 DOE Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance, 1/91.

2 Radionuclides contributing significantly to the potential dose (> 5% of the total dose). The radionuclides listed should account for at least 90% of the potential dose.

A.7 Will analyses of radionuclides in hazardous waste be performed at an existing onsite DOE laboratory or at a commercial laboratory?

COSTS ASSOCIATED WITH HAZARDOUS WASTE DISPOSAL

A.8 What will be the expected cost saving or increase in cost (separate analytical and disposal) that would result from the establishment of the radionuclide control criteria consistent with concentrations in Table I compared to your current waste disposal and management practices?

A.9 What other benefits or costs would result from establishing radionuclide control criteria at the Base Case levels given in Table 1?

Table 1. Base Case Numerical Control Criteria

Radionuclide	pCi/g	Bq/kg
H-3	6.5E+04	2.4E+06
Be-7	5.9E+01	2.2E+03
C-14	1.2E+03	4.4E+04
Na-22	7.2E-01	2.7E+01
P-32	1.6E+03	5.9E+04
S-35	4.0E+04	1.5E+06
Sc-46	6.4E-01	2.4E+01
V-48	5.4E-01	2.0E+01
Cr-51	1.2E+02	4.4E+03
Mn-54	2.2E+00	8.1E+01
Fe-55	1.4E+03	5.2E+04
Co-56	2.4E-01	8.9E+00
Co-57	6.6E+01	2.4E+03
Co-58	1.9E+00	7.0E+01
Co-60	4.5E-01	1.7E+01
Ni-63	1.7E+05	6.3E+06
Zn-65	1.8E+00	6.7E+01
Ge-68	2.9E+02	1.1E+04
As-74	4.2E+00	1.6E+02
Se-75	1.6E+01	5.9E+02
Se-79	5.8E+03	2.1E+05
Sr-90	7.8E+02	2.9E+04
Sr-90+D	3.8E+02	1.4E+04
Y-88	4.0E-01	1.5E+01

Table 1. (contd)

Radionuclide	pCi/g	Bq/kg
Zr-93	5.4E+04	2.0E+06
Nb-94	1.4E+00	5.2E+01
Tc-99	5.0E+02	1.9E+04
Ru-100	1.0E+01	3.7E+02
Ag-110m	5.5E-01	2.0E+01
Sn-113	3.1E+02	1.1E+04
Sb-124	5.7E-01	2.1E+01
Sb-125	6.3E+00	2.3E+02
Te-125m	2.2E+02	8.1E+03
I-125	2.5E+01	9.3E+02
I-126	5.5E+00	2.0E+02
I-129	1.1E+02	4.1E+03
I-131	1.0E+01	3.7E+02
Cs-134	1.2E+00	4.4E+01
Cs-137	4.6E+00	1.7E+02
Ce-144	4.3E+02	1.6E+04
Pm-147	6.1E+04	2.3E+06
Sm-151	1.3E+05	4.8E+06
Eu-152	1.1E+00	4.1E+01
Eu-154	1.1E+00	4.1E+01
Eu-155	1.6E+02	5.9E+03
Hg-203	2.7E+01	1.0E+03
Bi-207	9.3E-01	3.4E+01
Ra-226	9.3E+01	3.4E+03
Ra-226+D	1.4E+01	5.2E+02
Th-228	2.5E+01	9.3E+02
Th-229	4.4E+00	1.6E+02
Th-230	3.0E+01	1.1E+03
Th-232	6.8E+00	2.5E+02
Th-232+D	3.4E-01	1.3E+01
U-232	1.2E+01	4.4E+02
U-233	6.3E+01	2.3E+03
U-234	6.4E+01	2.4E+03
U-235	3.5E+01	1.3E+03

Table 1. (contd)

Radionuclide	pCi/g	Bq/kg
U-238	6.9E+01	2.6E+03
U-238+D	5.0E+01	1.9E+03
NP-237	1.3E+01	4.8E+02
Np-237+D	8.4E+00	3.1E+02
Pu-238	2.8E+01	1.0E+03
Pu-239	2.5E+01	9.3E+02
Pu-240	2.5E+01	9.3E+02
Pu-241	1.5E+03	5.6E+04
Am-241	1.2E+01	4.4E+02

Sr-90+D refers to Sr-90 in equilibrium with Y-90.
Ra-226+D refers to Ra-226 in equilibrium with Rn-222, Po-218, Pb-214, Bi-214, Po-214, Pb-210, Bi-210, and Po-210.
Th-232+D refers to Th-232 in equilibrium with Ra-228, Ac-228, Th-228, Ra-224, Rn-220, Po-216, Pb-212, and Bi-212.
U-238+D refers to U-238 in equilibrium with Th-234 and Pa-234.
Np-237+D refers to Np-237 in equilibrium with Pa-233.

B. ALTERNATIVE ONE TO BASE CASE DATA ASSUMPTIONS

Answer the questions listed below assuming that numerical control criteria for radionuclides in hazardous wastes regulated under RCRA and TSCA were established at concentrations 1/100th of the Base Case as given in Table 2 (Alternative One).

Additional assumptions include:

- Wastes for disposal and waste residues from treatment facilities will ultimately be sent to RCRA or TSCA regulated disposal facilities (not recycle),
- Analytical techniques and equipment are available to measure (or permit the calculation of) radionuclides at least to 50% but ideally to 10% or less of the levels given in the Table 2 and data must be reported in a manner consistent with the requirements in Chapter 7 (including 7.3.4) of DOE/EH-173T,
- When several radionuclides are present, control criteria shall be determined using the sum of the fractions rule (see DOE 5400.5, Section II.3.a(c)(3)).

WASTE QUANTITY AND RADIONUCLIDE CONTENT

B.1 How much additional hazardous waste (mass and volume) is likely to be shipped (on average) from your site to TSD facilities for disposal during a 12 month period?

B.1.1 If possible, indicate what proportion of the total amount of waste to be shipped during the 12 month period will be disposed of directly and what proportion will require treatment.

B.2 What will be the predominant radionuclides present in this incremental portion hazardous waste to be shipped from your site for disposal?

B.3 What is the best estimate of radionuclide concentrations or the total activity (curie or Bq) amounts of each radionuclide in hazardous waste to be shipped over a 12 month period?

B.4 What will be the typical forms (physical [e.g., aqueous, solid, sludge, liquid] and chemical [e.g., organic, inorganic, acid, base] of hazardous waste shipped from your site?

MEASUREMENTS OF RADIONUCLIDES IN HAZARDOUS WASTE

B.5 Will the radionuclides in hazardous waste for disposal at your facility be detectable at the concentrations given in Table 2 and considering the assumptions stated above?

B.6 Will conventional laboratory techniques be suitable or would significant procedure or method change be required to measure radionuclides in hazardous waste at the concentrations given in Table 2 (and assumptions)? (List those radionuclides or waste forms requiring the new analytical procedures or equipment.)

B.7 Will analyses of radionuclides in hazardous waste be performed at an existing onsite DOE laboratory or at a commercial laboratory?

COSTS ASSOCIATED WITH HAZARDOUS WASTE DISPOSAL

B.8 What will be the expected cost saving or increase in cost (separate analytical and disposal) that would result from the establishment of the radionuclide control criteria given in Table 2 compared to your current waste disposal and management practices?

B.9 What other benefits or costs would result from establishing radionuclide control criteria at the levels given in Table 2?

B.10 What would be the impact of eliminating the requirement to apply the "sum of the fractions" rule when using radiation control criteria at this level (i.e., each radionuclide concentration applied indepently) ?

Table 2. Alternative One to Base Case Numerical Control Criteria
(Base Case Criteria times 0.01)

Radionuclide	pCi/g	Bq/kg
H-3	6.5E+02	2.4E+04
Be-7	5.9E-01	2.2E+01
C-14	1.2E+01	4.4E+02
Na-22	7.2E-03	2.7E-01
P-32	1.6E+01	5.9E+02
S-35	4.0E+02	1.5E+04
Sc-46	6.4E-03	2.4E-01
V-48	5.4E-03	2.0E-01
Cr-51	1.2E+00	4.4E+01
Mn-54	2.2E-02	8.1E-01
Fe-55	1.4E+01	5.2E+02
Co-56	2.4E-03	8.9E-02
Co-57	6.6E-01	2.4E+01
Co-58	1.9E-02	7.0E-01
Co-60	4.5E-03	1.7E-01
Ni-63	1.7E+03	6.3E+04
Zn-65	1.8E-02	6.7E-01
Ge-68	2.9E+00	1.1E+02
AS-74	4.2E-02	1.6E+00
Se-75	1.6E-01	5.9E+00
Se-79	5.8E+01	2.1E+03
Sr-90	7.8E+00	2.9E+02
Sr-90+D	3.8E+00	1.4E+02
Y-88	4.0E-03	1.5E-01

Table 2. (contd)

Zr-93	5.4E+02	2.0E+04
Nb-94	1.4E-02	5.2E-01
Tc-99	5.0E+00	1.9E+02
Ru-100	1.0E-01	3.7E+00
Ag-110m	5.5E-03	2.0E-01
Sn-113	3.1E+00	1.1E+02
Sb-124	5.7E-03	2.1E-01
Sb-125	6.3E-02	2.3E+00
Te-125m	2.2E+00	8.1E+01
I-125	2.5E-01	9.3E+00
I-126	5.5E-02	2.0E+00
I-129	1.1E+00	4.1E+01
I-131	1.0E-01	3.7E+00
Cs-134	1.2E-02	4.4e-01
Cs-137	4.6e-02	1.7E+00
Ce-144	4.3E+00	1.6E+02
Pm-147	6.1E+02	2.3E+04
Sm-151	1.3E+03	4.8E+04
Eu-152	1.1E-02	4.1E-01
Eu-154	1.1E-02	4.1E-01
Eu-155	1.6E+00	5.9E+01
Hg-203	2.7E-01	1.0E+01
Bi-207	9.3E-03	3.4E-01
Ra-226	9.3E-01	3.4E+01
Ra-226+D	1.4E-01	5.2E+00
Th-228	2.5E-01	9.3E+00
Th-229	4.4E-02	1.6E+00
Th-230	3.0E-01	1.1E+01
Th-232	6.8E-02	2.5E+00
Th-232+D	3.4E-03	1.3E-01
U-232	1.2E-01	4.4E+00
U-233	6.3E-01	2.3E+01
U-234	6.4E-01	2.4E+01
U-235	3.5E-01	1.3E+01
U-238	6.9E-01	2.6E+01

Table 2. (contd)

U-238+D	5.0E-01	1.9E+01
NP-237	1.3E-01	4.8E+00
Np-237+D	8.4E-02	3.1E+00
Pu-238	2.8E-01	1.0E+01
Pu-239	2.5E-01	9.3E+00
Pu-240	2.5E-01	9.3E+00
Pu-241	1.5E+01	5.6E+02
Am-241	1.2E-01	4.4E+00

Sr-90+D refers to Sr-90 in equilibrium with Y-90.
Ra-226+D refers to Ra-226 in equilibrium with Rn-222, Po-218, Pb-214, Bi-214, Po-214, Pb-210, Bi-210, and Po-210.
Th-232+D refers to Th-232 in equilibrium with Ra-228, Ac-228, Th-228, Ra-224, Rn-220, Po-216, Pb-212, and Bi-212.
U-238+D refers to U-238 in equilibrium with Th-234 and Pa-234.
Np-237+D refers to Np-237 in equilibrium with Pa-233.

C. ALTERNATIVE TWO TO BASE CASE DATA ASSUMPTIONS

Answer the questions listed below assuming that numerical control criteria for radionuclides in hazardous wastes regulated under RCRA and TSCA were established at concentrations 10 times the Base Case as given in Table 3 (Alternative Two).

Additional assumptions include:

- Wastes for disposal and waste residues from treatment facilities will ultimately be sent to RCRA or TSCA regulated disposal facilities (not recycle),
- Analytical techniques and equipment are available to measure (or permit the calculation of radionuclides at least to 50% but ideally to 10% or less of the levels given in the Table 3 and data must be reported in a manner consistent with the requirements in Chapter 7 (including 7.3.4) of DOE/EH-173T,
- When several radionuclides are present, control criteria shall be determined using the sum of the fractions rule (see DOE 5400.5, Section II.3.a(c)(3)).

WASTE QUANTITY AND RADIONUCLIDE CONTENT

C.1 How much hazardous waste (mass and volume) is likely to be shipped (on average) from your site to TSD facilities for disposal during a 12 month period?

C.1.1 If possible, indicate what proportion of the total amount of waste to be shipped during the 12 month period will be disposed of directly and what proportion will require treatment at a TSD?

C.2 What will be the predominant radionuclides present in the incremental portion of hazardous waste to be shipped from your site for disposal?

C.3 What is the best estimate of radionuclide concentrations or the total activity (curie or Bq) amounts of each radionuclide in hazardous waste to be shipped over a 12 month period?

C.4 What will be the typical forms (physical [e.g., aqueous, solid, sludge, liquid] and chemical [e.g., organic, inorganic, acid, base] of hazardous waste shipped from your site?

MEASUREMENTS OF RADIONUCLIDES IN HAZARDOUS WASTE

C.5 Will the radionuclides in hazardous waste for disposal at your facility be detectable at the concentrations given in Table 3 and considering the assumptions stated above?

C.6 Will conventional laboratory techniques be suitable or would significant procedure or method change be required to measure radionuclides in hazardous waste at the concentrations given in Table 3 (and assumptions)? (List those radionuclides or waste forms requiring the new analytical procedures equipment.)

C.7 Will analyses of radionuclides in hazardous waste be performed at an existing onsite DOE laboratory or at a commercial laboratory?

COSTS ASSOCIATED WITH HAZARDOUS WASTE DISPOSAL

C.8 What will be the expected cost saving or increase in cost (separate analytical & disposal) that would result from the establishment of the radionuclide control criteria given in Table 3 compared to your current waste disposal and management practices ?

C.9 What other benefits or costs would result from establishing radionuclide control criteria at the levels given in Table 3?

Table 3. Alternative One to Base Case Numerical Control Criteria (Base Case Criteria times 10)

Radionuclide	pCi/g	Bq/kg
H-3	1.3E+06	4.8E+07
Be-7	1.2E+03	4.4E+04
C-14	2.4E+04	8.9E+05
Na-22	1.4E+01	5.3E+02
P-32	3.2E+04	1.2E+06
S-35	8.0E+05	3.0E+07
Sc-46	1.3E+01	4.7E+02
V-48	1.1E+01	4.0E+02
Cr-51	2.4E+03	8.9E+04
Mn-54	4.4E+01	1.6E+03
Fe-55	2.8E+04	1.0E+06
Co-56	4.8E+00	1.8E+02
Co-57	1.3E+03	4.9E+04
Co-58	3.8E+01	1.4E+03
Co-60	9.0E+00	3.3E+02
Ni-63	3.4E+06	1.3E+08
Zn-65	3.6E+01	1.3E+03
Ge-68	5.8E+03	2.1E+05
AS-74	8.4E+01	3.1E+03
Se-75	3.2E+02	1.2E+04
Se-79	1.2E+05	4.3E+06
Sr-90	1.6E+04	5.8E+05
Sr-90+D	7.6E+03	2.8E+05
Y-88	8.0E+00	3.0E+02
Zr-93	1.1E+06	4.0E+07
Nb-94	2.8E+01	1.0E+03

Tc-99	1.0E+04	3.7E+05
Ru-100	2.0E+02	7.4E+03
Ag-110m	1.1E+01	4.1E+02
Sn-113	6.2E+03	2.3E+05
Sb-124	1.1E+01	4.2E+02
Sb-125	1.3E+02	4.7E+03
Te-125m	4.4E+03	1.6E+05
I-125	5.0E+02	1.9E+04
I-126	1.1E+02	4.1E+03
I-129	2.2E+03	8.1E+04
I-131	2.0E+02	7.4E+03
Cs-134	2.4E+01	8.9E+02
Cs-137	9.2E+01	3.4E+03
Ce-144	8.6E+03	3.2E+05
Pm-147	1.2E+06	4.5E+07
Sm-151	2.6E+06	9.6E+07
Eu-152	2.2E+01	8.1E+02
Eu-154	2.2E+01	8.1E+02
Eu-155	3.2E+03	1.2E+05
Hg-203	5.4E+02	2.0E+04
Bi-207	1.9E+01	6.9E+02
Ra-226	1.9E+03	6.9E+04
Ra-226+D	2.8E+02	1.0E+04
Th-228	5.0E+02	1.9E+04
Th-229	8.8E+01	3.3E+03
Th-230	6.0E+02	2.2E+04
Th-232	1.4E+02	5.0E+03
Th-232+D	6.8E+00	2.5E+02
U-232	2.4E+02	8.9E+03
U-233	1.3E+03	4.7E+04
U-234	1.3E+03	4.7E+04
U-235	7.0E+02	2.6E+04
U-238	1.4E+03	5.1E+04
U-238+D	1.0E+03	3.7E+04
NP-237	2.6E+02	9.6E+03
Np-237+D	1.7E+02	6.2E+03

Pu-238	5.6E+02	2.1E+04
Pu-239	5.0E+02	1.9E+04
Pu-240	5.0E+02	1.9E+04
Pu-241	3.0E+04	1.1E+06
Am-241	2.4E+02	8.9E+03

Sr-90+D refers to Sr-90 in equilibrium with Y-90.
Ra-226+D refers to Ra-226 in equilibrium with Rn-222, Po-218, Pb-214, Bi-214, Po-214, Pb-210, Bi-210, and Po-210.
Th-232+D refers to Th-232 in equilibrium with Ra-228, Ac-228, Th-228, Ra-224, Rn-220, Po-216, Pb-212, and Bi-212.
U-238+D refers to U-238 in equilibrium with Th-234 and Pa-234.
Np-237+D refers to Np-237 in equilibrium with Pa-233.

D. CONSIDERATIONS OF OTHER CRITERIA

D.1 What would be the impact on the estimates and data provided for the base case and the two alternative cases if the combined activity in any waste was limited to 2000 pCi/g (7.4×10^4 Bq/kg) as shown in Table 4? This requirement will reduce any individual radionuclide limit that is greater than 2,000 pCi/g to 2,000 pCi/g and further restrict the total activity from all radionuclides to 2,000 pCi/g.

D.2 What would be the impact on the estimates and data provided if uranium and thorium concentrations in the base case and the two alternative cases was limited to 50 ppm as shown in Table 4?

D.3 Is there a "break point" in the numerical control criteria where the quantity of hazardous waste to be shipped for disposal from your facility will significantly change or the where measurement or verification become extremely difficult or impossible?

Table 4. Other Restrictions to be Considered

Type of Restriction	Limit
Total activity limit	2000 pCi/g (7.4×10^4 Bq/kg)
Source Material limited to 500 ppm (e.g., Natural Uranium (500 ppm) ^{232}Th (500 ppm))	 1700 pCi/g (6.2×10^4 Bq/kg) 540 pCi/g (2.0×10^4 Bq/kg)

E. GENERAL QUESTIONS ABOUT HANDLING HAZARDOUS WASTE

E.1 List the commercial TSD facilities that received hazardous waste from your site during the past 12 months, and indicate the proportion of wastes disposed of directly and the proportion treated before disposal.

E.2 Provide your best estimate of the total amount (mass and volume) of hazardous waste shipped from your site during the past 12 months for disposal or treatment. Provide the following descriptions of that waste to the extent possible:

E.2.1 What was the physical form? (e.g., liquid, solid [metal, wood, paper, soil, rubble, building trash], sludge, or gas [compressed or sorbed]). Provide a breakdown if different forms were shipped.

E.2.2 What was the chemical form? (e.g., [organic or inorganic, mixed; acidic or basic, neutral]). List chemical constituents by physical form. Provide volume and mass estimates by RCRA waste designation codes.

E.2.3 What was the treatment method used? (e.g., incineration, fuel substitution, recycle, burial, chemical treatment.) Provide a percentage of the amount of waste shipped (E.2) for each method.

APPENDIX B

CITED REGULATORY LIMITS AND CONSTRAINTS

APPENDIX B

CITED REGULATORY LIMITS AND CONSTRAINTS

10 CFR PART 20.1201 OCCUPATIONAL DOSE LIMITS FOR ADULTS

The licensee shall control the occupational dose to individual adults, except for planned special exposures under § 20.1206, to the following dose limits.

(1) An annual limit, which is the more limiting of

(i) The total effective dose equivalent being equal to 5 rems (0.05 Sv); or

(ii) The sum of the deep-dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 50 rems (0.5 Sv).

In addition to the annual dose limits, the licensee shall limit the soluble uranium intake by an individual to 10 mg/week in consideration of chemical toxicity (see footnote 3 of appendix B to §§ 20.1001-20.2401).

Footnote 3 - For soluble mixtures of U-238, U-234, and U-235 in air, chemical toxicity may be the limiting factor. If the percent by weight (enrichment) of U-235 is not greater than five, the concentration value for a 40-hour workweek is 0.2 milligrams uranium per cubic meter of air average. For any enrichment, the product of the average concentration and time of exposure during a 40-hour workweek shall not exceed 8E-3 (SA) μCi-hr/ml, where SA is the specific activity of the uranium inhaled. The specific activity for natural uranium is 6.77E-7 curies per gram U.

10 CFR PART 20.1301 DOSE LIMITS FOR INDIVIDUAL MEMBERS OF THE PUBLIC

Each licensee shall conduct operations so that

(1) The total effective dose equivalent to individual members of the public from the licensed operation does not exceed 0.1 rem (1 mSv) in a year, exclusive of the dose contribution from the licensee's disposal of radioactive material into sanitary sewerage in accordance with § 20.2003, and

(2) The dose in any unrestricted area from external sources does not exceed 0.002 rem (0.02 mSv) in any one hour.

DOE 5400.5

Public dose means the dose received by member(s) of the public from exposure to radiation and to radioactive material released by a DOE facility or operation, whether the exposure is within a DOE site boundary or off-site. It does not include dose received from occupational exposures, doses received from naturally occurring "background" radiation, doses received as a patient from medical practices, or doses received from consumer products.

The primary public dose limits include consideration of all exposure modes from all DOE activities (including remedial actions). DOE must also comply with legally applicable requirements (e.g., 40 CFR Parts 61, 141, 191, and 192 and 10 CFR Parts 60 and 72; 40 CFR 141 cites a drinking water limit of 4 mrem/yr from man-made beta).

Except as provided by II.1a(4), the exposure of members of the public to radiation except background as a consequence of all routine DOE activities shall not be caused to exceed, in a year, an effective dose equivalent greater than 100 mrem (1 mSv).

In addition, DOE operators are required to report DOE-related effective dose equivalent contributions of 10 mrem (0.10 Msv) or more in a year.

In addition, in DOE Order 5400.5 it is DOE's stated objective that potential exposures to members of the public be as far below the limits as is reasonably achievable (ALARA) and that DOE facilities have the capabilities,

consistent with the types of operations conducted, to monitor routine and nonroutine releases and to assess doses to members of the public. Therefore, the limits specified in DOE 5400.5 are actually the limits plus ALARA and the requirement for the application of ALARA may be the most limiting requirement.

Airborne emissions only, all DOE sources of radionuclides.

The exposure of members of the public to radioactive materials released to the atmosphere as a consequence of routine DOE activities shall not cause members of the public to receive, in a year, an effective dose equivalent greater than 10 mrem (0.1 Msv). Exposures to, and releases of, radon-220, radon-222, and their respective decay products are subject to DOE limits (IV.4b, IV.6).

(IV.4b). Generic guidelines for concentrations of airborne radon decay products shall apply to existing occupied or habitable structures on private property that are intended for release without restriction; structures that will be demolished or buried are excluded. The applicable guideline is 40 CFR Part 192: In any occupied or habitable building, the objective of remedial action shall be, and a reasonable effort shall be made to achieve, an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 WL. In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL. Remedial actions by DOE are not required to comply with this guideline when there is reasonable assurance that residual radioactive material is not the source of the radon concentration.

(IV.6b(2)). Controls shall be designed such that Rn-222 concentrations in the atmosphere above facility surfaces or openings in addition to background levels will not exceed:

(a) 100 pCi/L at any given point
(b) An annual average concentration of 30 pCi/L over the facility site
(c) An annual average concentration of 3 pCi/L at or above any location outside the facility site
(d) Flux rates from the storage of radon producing wastes shall not exceed 20 pCi/m^2s., as required by 40 CFR Part 61.

(IV.6d(1))

(b) Control and stabilization features shall be designed to ... prevent increases in the annual average Rn-222 concentration at or above any location outside the boundary of the contaminated area by more than 0.5 pCi/L.

DOE 5480.11

Radiation Protection Standards for Internal and External Exposure for Occupational Workers.

The exposure of an occupational worker to radiation resulting from routine DOE activities shall not cause the limiting values for assessed dose specified herein to be exceeded:

The limiting value of annual effective dose equivalent from both internal and external sources received in any year by an occupational worker is 5 rem (0.05 Sv).

The limiting value of annual dose equivalent received in any year by an occupational worker, for individual organs and tissues is 15 rem (0.15 Sv) to the lens of the eye or 50 rem (0.50 Sv) to any other organ, tissue (including skin), or extremity of the body.

Occupational workers shall be monitored, as appropriate, to demonstrate compliance with the radiation protection standards and to estimate the dose equivalents received from external and internal sources of radiation. Workplaces shall be routinely monitored, as appropriate, for identification and control of potential exposure sources.

Personnel dosimetry programs shall be adequate to demonstrate compliance with the radiation protection standards. Personnel dosimeters shall be routinely calibrated and maintained and shall meet the requirements of the DOE Laboratory Accreditation Program for Personnel Dosimetry as specified in DOE 5480.15. Personnel dosimetry shall be provided to radiation workers who have the potential to exceed in a year any one of the following from external sources:

a) 100 mrem (0.001 Sv) annual effective dose equivalent to the whole body

b) 5 rem (0.05 Sv) annual dose equivalent to the skin

c) 5 rem (0.05 Sv) annual dose equivalent to any extremity

d) 1.5 rem (0.015) annual dose equivalent to the lens of the eye.

DOE Radiological Control Manual DOE/EH-0256T

For personnel radiation exposure. . .a DOE Administrative Control Level of 2,000 mrem/y per person is established for all DOE activities. . .to administratively control a worker's lifetime occupational radiation exposure, a Lifetime Control Level of N rem shall be established, where N is the age of the person in years (Chapter 2, Part 1, Article 211-212). The DOE Radiological Control Policy also includes the application of ALARA to personal radiation exposure. Therefore, radiation exposure to the workforce and public shall be controlled such that radiation exposures are well below regulatory limits and that there is no radiation exposure without commensurate benefit (Chapter 1, Part 1, Article 1.1.1).

40 CFR PART 61.92 (SUBPART H)

Emissions of radionuclides to the ambient air from Department of Energy facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/year.

40 CFR PART 61.93 (SUBPART H)

Radionuclide emission measurements in conformance with the requirements shall be made at all release points that have the potential to discharge radionuclides into the air in quantities that could cause an effective dose equivalent in excess of 1% of the standard (i.e., 0.1 mrem/year).

PRESIDENTIAL GUIDELINES FOR OCCUPATIONAL EXPOSURE (52 FEDERAL REGISTER, NO. 17)

The ICRP recommends that the effective (i.e., weighted) dose equivalent incurred in any year be limited to 5 rems.

40 CFR PART 61 (SEE PAGE 51656, 54 FEDERAL REGISTER, NO. 240, 12-15-89)

The Agency recognizes that consideration of maximum individual risk (MIR) - the maximum estimated risk of contracting cancer following a lifetime of exposure to the emitted pollutant - must take into account the strengths and weaknesses of this measure of risk. It is estimated based on the assumption of continuous exposure for 24 hours per day for 70 years. As such, it does not necessarily reflect the true risk, but displays a conservative risk level which is an upperbound that is unlikely to be exceeded. The Administrator believes that an MIR of approximately 1 in 10 thousand (10E-4) should ordinarily be the upper end of the range of acceptability.

49 CFR PART 173.403

"Radioactive material" means any material having a specific activity greater than 0.002 microcuries per gram (2 nCi/gram). Each package of radioactive material, unless excepted by 173.421, 173.422, 173.424, 173.425(b) or 173.427, shall be labeled as provided in Subpart E of Part 172 of this subchapter ("RADIOACTIVE MATERIAL").

10 CFR PART 20.2

"Source Material" means: (i) uranium or thorium, or any combination thereof, in any physical or chemical form; or (ii) ores that contain by weight one-twentieth of one percent (0.05%) or more of (a) uranium, (b) thorium, or (c) any combination thereof. Source material does not include special nuclear material.

APPENDIX C

ELEMENT PARTITIONING IN AN INCINERATOR

APPENDIX C

ELEMENT PARTITIONING IN AN INCINERATOR

Element partitioning in an incinerator was investigated as part of this task of the project. The estimates of element partitioning were based on a review of the literature and on thermodynamic calculations.

The behavior of elements in incinerators was researched in the literature. The range of values for seven elements (Cs, Sr, Zr, Co, Zn, Sb, and U) representing a wide variety of chemical properties are given in Table C.1. Inconsistencies in methods and reporting indicated that data available were neither complete nor satisfactory. Therefore, the reported behavior of the elements was considered in light of the physical properties.

In order to assess partitioning of elements into residue streams, the thermodynamics of the incinerator system was investigated. The principal topics examined were species stability and volatility. Water solubility was also considered.

TABLE C.1. Range of Partitioning Values Found in the Literature

Element	Percent of Element Found in Various Waste Streams		
	Bottom Ash/Slag	Fly Ash	Stack Emissions
Cs	60 - 90	30 - 50	0.2
Sr	45 - 95	2 - 20	0.05
Zr	60 - 95	40 - 60	<1
Co	70 - 98	12 - 20	0.5
Zn	30 - 70	20 - 60	1
Sb	10 - 80	20 - 80	1
U	65 - 100	1 - 35	<1

Of the elements in question, some would be moderately volatile as elements, some as oxides, and some as halides. Examining free-energy data for potential compounds permits estimation of the probable species.

Particular attention was given to volatile species because they are the key to determining concentrations of elements of interest in fine particulate matter and off-gas streams. Since halides form relatively volatile compounds with many metals, metal halide formation was examined in detail. The predictions of the stable chemical forms of the elements of interest are based on free-energy calculations.

In addition to thermodynamic stability, other effects were considered: how partitioning is affected by incinerator feed composition, temperature, and other operating variables. Of paramount importance are the design and operation of the off-gas treatment system and the air pollution control devices, such as scrubbers, cyclone separators, electrostatic precipitators, filters, etc. Some of the major variables affecting partitioning include the following:

- temperature and residence time, which are important incinerator operating parameters that determine which compounds will be stable and if equilibrium can be achieved
- the presence of several compounds and elements—HCl, HF, SO_3, H_2O, P_2O_5, O_2, SiO_2, Ca, and Na—which may cause competing reactions
- kinetics—Can favorable reactions actually take place?
- the effect of the condensed phase, including particle size, and the role of surface reactions and diffusion.

Suggested values for partitioning of slag, fly ash, and stack emissions are given in Table C.2.

TABLE C.2. Element Partitioning Assumptions[a]

Element	Partition Fractions			Element	Partition Fractions		
	Fly Ash PF_FA	Slag PF_SL	Stack PF_STACK		Fly Ash PF_FA	Slag PF_SL	Stack PF_STACK
H	0.10	0	0.90	Sb	0.43	0.55	0.02
Be	0.10	0.90	0.001	Te	0.49	0.50	0.01
C	0.02	0.03	0.95	I	0.68	0.02	0.30
Na	0.10	0.90	0.001	Cs	0.20	0.80	0.002
P	0.13	0.85	0.02	Ce	0.05	0.95	0.001
S	0.65	0.30	0.05	Pm	0.05	0.95	0.001
Sc	0.05	0.95	0.0005	Sm	0.05	0.95	0.001
V	0.10	0.90	0.001	Eu	0.05	0.95	0.001
Cr	0.35	0.65	0.002	Hg	0.90	0.05	0.05
Mn	0.35	0.65	0.002	Bi	0.70	0.30	0.005
Fe	0.45	0.55	0.005	Ra	0.10	0.90	0.0005
Co	0.34	0.65	0.01	Th	0.02	0.98	0.0005
Ni	0.40	0.60	0.005	U	0.02	0.98	0.0005
Zn	0.49	0.50	0.01				
Ge	0.50	0.50	0.001	Np	0.02	0.98	0.0005
				Pu	0.02	0.98	0.0005
As	0.50	0.50	0.005				
Se	0.80	0.10	0.10	Am	0.02	0.98	0.0005
Sr	0.05	0.95	0.0001				
Y	0.05	0.95	0.0005				
Zr	0.05	0.95	0.0005				
Nb	0.05	0.95	0.001				
Tc	0.50	0.40	0.10				
Ru	0.59	0.40	0.01				
Ag	0.20	0.80	0.001				
Sn	0.02	0.98	0.001				

(a) Table determines nuclides of concern and stipulates applicable partition fractions between fly ash, slag, and stack emissions. Source: Personal communication from L. L. Burger (PNL), April 19, 1993; April 20, 1993 modifications.

APPENDIX D

CALCULATION METHODOLOGY FOR RADIATION DOSES

APPENDIX D

CALCULATION METHODOLOGY FOR RADIATION DOSES

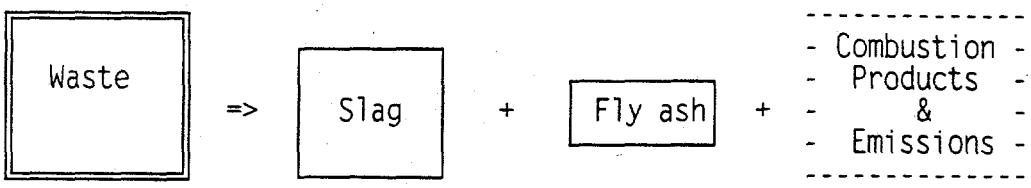
Limiting concentrations are calculated for release of hazardous materials contaminated with low concentrations of radionuclides from hazardous waste facilities (incinerator or landfill). The calculations are based on potential doses to both hazardous waste workers and members of the general public residing within 80 km of the site. The calculations are performed using a BASIC program described in this section.

Potential doses to workers are based on scenarios describing the interaction of workers with waste or with residual material from incineration. In this report, the total solid residue from the primary and secondary combustion chambers of an incinerator is referred to as "slag" or "ash." The fine particulate matter in the gas stream from the secondary combustion chamber that is trapped by the off-gas treatment system is referred to as "fly ash." Contaminants that escape from the air pollution control system are referred to as "stack" releases. This terminology is used for simplicity.

The concentration of each radionuclide in residual materials produced by incineration is based on the mass reduction achieved by incineration and the distribution of the mass of residues between slag and fly ash. In addition, the partitioning of elements between slag and fly ash is considered (see Appendix C, "Element Partitioning in an Incinerator").

Figure D.1 shows the mass balance assumed for the incineration of either solid waste in the generic rotary kiln or organic liquids in a liquid-injection incinerator. As an example, element partitioning for eight selected elements is shown in Table D.1. (The partitioning for all elements considered is given in Appendix C, as noted previously.) Table D.1 gives the activity and concentration of each element in slag and fly ash and the activity in

Material Balance for Incineration



Solid Waste	1 kg	=>	0.5 kg	+	0.2 kg	+	0.3 kg
Organic Liquids	1 kg	=>	0.016 kg	+	0.04 kg	+	0.98 kg

FIGURE D.1. Mass Partitioning Between Waste Streams

stack emissions based on the mass partitioning shown in Figure D.1. The concentrations of radionuclides in waste and residual materials are used to calculate dose to workers. Stack emissions are used to calculate the dose to the offsite individual and collective dose to the general public.

The dose resulting from handling of waste or residues from incineration of waste having unit concentration (i.e., 1 pCi/g) is calculated for all applicable pathways (inhalation, ingestion, and external). The concentration (pCi/g) resulting in a limiting dose is then calculated by dividing the dose limit (mrem) by the unit dose (mrem per pCi/g).

The following sections describe the models used to evaluate doses to workers and to the public.

D.1 CALCULATION METHODOLOGY FOR DOSES TO WORKERS

This section describes and quantifies the simple models used to evaluate doses to individuals in close proximity to materials containing radioactive contaminants. First, the governing equations by pathway are presented as mathematical formulas; then, the equivalent equations are given as used in the program that performs the calculations.

TABLE D.1. Element Partitioning in Incineration Waste Residuals[a] for Selected Elements Based on 1 pCi/g in Waste

Element	Activity and Concentration of Residue: Slag, pCi (pCi/g)	Activity and Concentration of Residue: Fly ash, pCi (pCi/g)	Activity in Stack Emissions, pCi
H	0 (0)	0.10 (0.5)	0.90
C	0.03 (0.06)	0.02 (0.1)	0.95
Co	0.65 (1.3)	0.34 (1.7)	0.01
Zn	0.50 (1.0)	0.49 (2.5)	0.01
Sr	0.95 (1.9)	0.05 (0.2)	0.0001
I	0.02 (0.04)	0.68 (3.4)	0.3
Cs	0.80 (1.6)	0.20 (1.)	0.02
U	0.98 (2.)	0.02 (0.1)	0.0005

(a) Residuals from incineration of mixed solids, 70% residual mass.

D.1.1 Inhalation Dose

The dose from inhalation is based on the concentration in air of respirable particulate matter (aerodynamic diameter of 10 μm or less). The use of respirators or other breathing protection is represented in the model by a reduction in the effective airborne dust concentration. For an individual working in proximity to the raw waste or ash, dose from the inhalation of dust is given by:

$$H_{INH,i} = t_{INH}\ BR\ C_d\ C_i\ DF_{INH,i}\ CF \qquad (D.1)$$

where $H_{INH,i}$ = committed effective dose equivalent from one year's intake of radionuclide i by inhalation, mrem

t_{INH} = duration of inhalation exposure for worker within a year, h

BR = breathing rate of the worker

C_d = airborne dust concentration in respirable particles, g/m^3

C_i = concentration of radionuclide i in the medium of interest (waste, fly ash, or slag), pCi/g

$DF_{INH,i}$ = the committed effective dose equivalent from inhalation mrem/μCi inhaled

CF = conversion factor, μCi/pCi.

D.1.2 Ingestion Dose

Inadvertent ingestion of contaminated materials represents the transfer of loosely bound contamination on surfaces from hands to the mouth. The potential for secondary ingestion is greatest where protective clothing (gloves, etc.) is not required. The general equation for estimating the committed dose by ingestion is given by:

$$H_{ING,i} = I\ t_{ING}\ C_i\ DF_{ING,i}\ CF \qquad (D.2)$$

where $H_{ING,i}$ = the committed effective dose equivalent from one year's intake of radionuclide i by ingestion, mrem

I = secondary ingestion rate (dust on surfaces), g/h

t_{ING} = duration of ingestion exposure for worker within a year, h

C_i = concentration of radionuclide i in the removable dust, pCi/g

$DF_{ING,i}$ = the committed effective dose equivalent from ingestion, mrem/μCi ingested

CF = conversion factor, μCi/pCi.

D.1.3 External Dose

External dose is a function of both the radionuclide contaminants and the geometry involved. The external dose from penetrating radiation is given by:

$$H_{EXT,i} = t_{EXT}\ C_i\ DF_{EXT,i}\ CF\ \rho \qquad (D.3)$$

where $H_{EXT,i}$ = annual effective dose equivalent from external exposure to the radiation emitted by radionuclide i, mrem/y

t_{EXT} = duration of external exposure for worker within a year, h

C_i = concentration of radionuclide i in the waste or residual material, pCi/g

$DF_{EXT,i}$ = the effective dose equivalent from a source contaminated with unit concentration of radionuclide i, based on geometry and shielding specific to the scenario, mrem/h per Ci/m^3

CF = conversion factors, Ci/pCi, cm^3/m^3

ρ = density of waste or residual material, g/cm^3.

A discussion of geometry and shielding and examples of geometry assumptions, are given in Appendix F, "External Dose Calculations for Worker Scenarios."

D.1.4 Total Dose

The dose from all pathways is the sum of the components, or

$$\text{Total dose} = H_{INH,i} + H_{ING,i} + H_{EXT,i} \qquad (D.4)$$

D.1.5 Calculations Programmed

A BASIC computer program was written to calculate doses from worker scenarios and to manipulate results from CAP88-PC (Parks 1992). Calculations for individual workers and collective dose to the worker population are shown in the following equations. Units are shown directly below each equation. Variables and parameters are defined following the equations. Variables and parameters used in the above equations are defined in Table D.2. The calculation of dose to the maximally exposed individual worker (by pathway), based on 1 pCi/g of waste, and the limiting concentration in waste are given in equations C.5 through C.8 for n radionuclides and s scenarios (the fraction of contaminated waste is noted as FCW).

TABLE D.2 Definition of Variables Related to Worker Doses

Variable	Definition, Units
DOSE	Worker dose array, mrem
DOSEPOP	Collective dose array, mrem
CWaste	Concentration in waste, pCi/g
ConS	Concentration in applicable medium, pCi/g (Scenario-dependent)
= CWaste * (PFFA(NUM)/MFracFA)	Concentration in fly ash, pCi/g
= CWaste * (PFSL(NUM)/MFracSL)	Concentration in slag, pCi/g
= CWaste * (PFSL(NUM)+PFFA(NUM))/ (MFracSL + MFracFA)	Concentration in residue, pCi/g
MFracFA	Mass fraction in fly ash
MFracSL	Mass fraction in slag
PFFA	Partition fraction in fly ash
PFSL	Partition fraction in slag
PFStack	Partition fraction for stack releases
CLimit	Limiting worker concentration, pCi/g
ConAir	Air concentration of dust, g/m^3
TInhal	Inhalation exposure time, h
Tinges	Ingestion exposure time, h
TExtern	External exposure time, h
DFInhal	Inhalation dose factors (DFs), mrem/μCi
DFInges	Ingestion DFs, mrem/μCi
DFExt	External DFs, mrem/h per Ci/m^3
POP	Worker populations
FCW	Fraction contaminated waste
RInhal	Inhalation rate, m^3/h
RInges	Dust ingestion rate, g/h
DSlag	Density of slag, g/cm^3
DScreen	Screening dose, mrem/y
Conversion factors:	
CM3perM3 = 1E6	cm^3/m^3
uCIperpCI = 1E-6	μCi/pCi
PCIperCI = 1E+12	pCi/Ci
CIperPCI = 1 / PCIperCI	Ci/pCi

Dose to the Individual Worker

Inhalation

$$\underset{\text{mrem}}{DOSE(N, S, 1)} = \underset{\text{pCi/g}}{ConS} * \underset{\text{g/m3}}{ConAir} * \underset{\text{h}}{TInhal} * \underset{\text{m3/h}}{RInhal} * \underset{\text{mrem/uCi}}{DFInhal(N)} * \underset{\text{uCi/pCi}}{uCIperpCI} * \underset{-}{FCW} \quad (D.5)$$

Ingestion

$$\underset{\text{mrem}}{DOSE(N, S, 2)} = \underset{\text{pCi/g}}{ConS} * \underset{\text{h}}{Tinges} * \underset{\text{g/h}}{RInges} * \underset{\text{mrem/uCi}}{DFInges(N)} * \underset{\text{uCi/pCi}}{uCIperpCI} * \underset{-}{FCW} \quad (D.6)$$

External

$$\underset{\text{mrem}}{DOSE(N, S, 3)} = \underset{\text{pCi/g}}{ConS} * \underset{\text{h}}{TExtern} * \underset{\text{mrem/h per Ci/m3}}{DFExt(NUM, SN)} * \underset{-}{FCW} * \underset{\text{g/cm3}}{DSlag} * \underset{\text{Ci/pCi}}{CIperPCI} * \underset{\text{cm3/m3}}{CM3perM3} \quad (D.7)$$

Total dose for a nuclide and scenario, then, is

$$Sumdose = DOSE(N, S, 1) + DOSE(N, S, 2) + DOSE(N, S, 3) \quad (D.8)$$

D.1.6 Concentration Limit

The concentration limit is, then, the screening value (allowable dose) divided by the total dose:

$$\underset{\text{pCi/g}}{CLimit} = \underset{\text{mrem}}{DScreen} / \underset{\text{mrem/pCi/g}}{Sumdose} \quad (D.9)$$

The fraction of contaminated waste (FCW) may be incorporated into the calculations. This parameter, represents dilution of radioactively contaminated waste by waste with a nonradioactive component. It is used as a modification factor to the concentration. For this analysis FCW has been set to unity.

The calculation of collective dose to the worker population (by pathway), based on the limiting concentration in waste, is shown in the following equations.

Collective Dose to the Worker Population

Inhalation

$$\text{DOSEPOP}(N, S, 1) = \text{CLimit}(N) \times \text{ConAir} \times \text{TInhal} \times \text{RInhal} \times \text{DFInhal}(N) \times \text{FCW} \times \text{uCIperpCI} \times \text{POP}(S) \quad \text{(D.10)}$$

man-mrem								
pCi/g	g/m3	h	m3/h	mrem/uCi	-	uCi/pCi	man

Ingestion

$$\text{DOSEPOP}(N, S, 2) = \text{CLimit}(N) \times \text{Tinges} \times \text{RInges} \times \text{DFInges}(N) \times \text{FCW} \times \text{uCIperpCI} \times \text{POP}(S) \quad \text{(D.11)}$$

man-mrem							
pCi/g	h	g/h	mrem/uCi	-	uCi/pCi	man

External

$$\text{DOSEPOP}(N, S, 3) = \text{CLimit}(N) \times \text{TExtern} \times \text{DFExtP}(N, S) \times \text{FCW} \times \text{DSlag} \times \text{CIperPCI} \times \text{CM3perM3} \times \text{POP}(S) \quad \text{(D.12)}$$

man-mrem								
pCi/g	h	mrem/h per Ci/m3	-	g/cm3	Ci/pCi	cm3/m3	man

D.2 CALCULATION METHODOLOGY FOR DOSES TO THE PUBLIC

The EPA-developed program CAP88-PC was used to calculate dose to the general public from unit release of radionuclide emissions from an incinerator. The procedure used is described in Section 2.0, "Dose Calculations for Members of the General Public." CAP88-PC is used to calculate both the dose to the maximally exposed individual member of the population and the dose to the total population.

The dose to the maximally exposed individual from unit release (1 Ci/y) of each radionuclide of interest is calculated using CAP88-PC. For brevity, the dose from unit release, or unit dose factor, will be referred to as DF (mrem per Ci/y). The other parameters of interest are the stack release fraction, SRF, and the facility throughput, T (t/y). The emission from the stack that would result in 1 mrem/y dose to an individual is then 1/DF (Ci).

The activity in the processed waste material that would result in a dose of 1 mrem would be 1/(DF·SRF) in Ci. The concentration of the incinerator feed that would produce a dose of 1 mrem to the maximally exposed individual would be the activity in the processed waste divided by the throughput of the

facility, converted to the proper units. In terms defined above, then, the concentration in the incinerator feed is calculated as follows:

$$\frac{\frac{1}{DF \times SRF} \times 10^{12}}{T \times 10^{6}} = \text{Allowable Concentration} \qquad \text{(D.13)}$$

where the conversion from Ci to pCi is 10^{12}, and the conversion from t to g is 10^{6}.

The BASIC program written for this task takes the unit dose factors generated by CAP88-PC, converts the values to concentration, as described above, and formats the results into the tables reported in this document.

The dose to the population resulting from unit release (unit dose factor for population) for each radionuclide is used to calculate the potential dose to the population, based on the concentration for the most limiting scenario for individual exposure (the more limiting concentration for each radionuclide listed for Case 1, Table 4.1). The release rate (in Ci/y) based on the concentration for the limiting scenario is calculated limiting concentration * throughput * SRF and multiplied by the unit population dose factor.

The unit dose conversion factors for both the maximally exposed offsite individual and the general public within 80 km are given in Table E.4, Appendix E, "Dose by Radionuclide for Members of the General Public."

The BASIC program calculation of activity released, activity in incinerator feed, and concentration in feed are shown in the following equations:

$C_{Air} = D_{Allow}1/DF_{Air}(n, s)$ Ci/y in release per 1 mrem/y (D.14)

$C_{Feed}D = C_{Air}/PF_{Stack}(N)$ Ci/y in feed per 1 mrem/y (D.15)

$CFeedE = C_{Feed}D/R_{Thruput}1$ * PCI per CI pCi/g in feed per 1 mrem/y (D.16)

where DF_{Air} = mrem/Ci released (calculated by CAP88-PC)

C_{Air} = Ci/y in release per 1 mrem/y

$D_{Allow}1$ = 1 mrem allowable dose

$R_{Thruput}1$ = 3E+10: $R_{Thruput}2$ = 1.5E+11 throughputs, g/y, for 30,000 and 150,000 Mg/y

Surrogate radionuclides were used to model radionuclides not included in the CAP88-PC library. These radionuclides, surrogates, and multipliers for the dose factors are given in Table D.3.

TABLE D.3. Dose Factor Surrogates for Radionuclides Not Included in CAP88-PC Library

Radionuclide	Surrogate	Multiplier[(a)]
^{48}V	^{95}Nb	3.5
^{56}Co	^{58}Co	3.6
^{68}Ge	^{235}U	7.0E-03
^{74}As	^{76}As (class W)	1.9
^{75}Se	^{46}Se	0.35
^{79}Se	^{63}Ni (class D)	2.5
^{88}Y	^{46}Se	1.2
^{126}I	^{131}I	1.3
^{207}Bi	^{133}Ba	2.5

(a) Multipliers based on relative magnitude of internal and external dose factors as listed in DOE (1988a) and DOE (1988b).

D.3 REFERENCES

Parks, S. B. 1992. User's Guide for CAP88-PC Version 1.0. 402-B-92-001, U.S. Environmental Protection Agency, Office of Radiation Programs, Las Vegas, Nevada.

U.S. Department of Energy (DOE). 1988a. External Dose-Rate Conversion Factors for Calculation of Dose to the Public. DOE/EH-0070, DOE, Washington, D.C.

U.S. Department of Energy (DOE). 1988b. Internal Dose Conversion Factors for Calculation of Dose to the Public. DOE/EH-0071, DOE, Washington, D.C.

APPENDIX E

DOSE BY RADIONUCLIDE TO MEMBERS OF THE GENERAL PUBLIC

APPENDIX E

DOSE BY RADIONUCLIDE TO MEMBERS OF THE GENERAL PUBLIC

Tables E.1 through E.3 give the activity in an incinerator feedstream corresponding to 1 mrem/y to the maximally exposed individual for three sets of population and ingestion assumptions. Table E.1 is for the metro-high population density, E.2 is for metro-low, and E.3 is for rural population density. These tables are all based on emissions from a 30,000-t/y incinerator handling 100% DOE waste.

Tables E.1 through E.3 are designed to show the calculation, from the dose factor to the allowable feedstream concentration. The first numeric column is the unit dose factor (DF) from CAP88-PC (mrem/y per Ci) for the maximally exposed individual at 500-m downwind from a 30-m stack. The second numeric column is the emission rate that would result in 1 mrem/y dose to the individual (1/DF). The third numeric column is the Stack Release Fraction (SRF) (see Appendix C); the fourth is the activity in incinerator feed that would result in a 1-mrem/y dose to the individual (Column 2 /SRF). The final column is the activity in the feedstream for a 30,000-t/y incinerator that would result in 1-mrem/y dose to the maximally exposed individual. This value is calculated from Column 4, converted from pCi to Ci (multiplied by 1E+12), and divided by the incinerator capacity in grams (3E+10).

Table E.4 summarizes the unit dose factors calculated using CAP88-PC. The first three numeric columns are dose factors (mrem/y per Ci/y) for metro-high, metro-low, and rural population densities, respectively. These dose factors are used to calculate the limiting concentration based on the maximally exposed offsite individual, presented in Tables E.1 through E.3. The last three columns are the unit collective dose factor (person-rem/y per Ci/y) for the three population densities. The collective dose factor is used to calculate the dose to the population residing within 80 km of the site.

TABLE E.1. Activity in Incinerator Feedstream Corresponding to 1 mrem/y Dose to the Maximally Exposed Individual Based on Metro-High (80/km^2) Population Density for a 30,000-t/y Incinerator

Nuclide	Dose at 1 Ci/y Emission, mrem/y	Ci/y in Emission at 1 mrem/y Dose	Stack Release Fraction	Ci/y in Feedstream at 1 mrem/y Dose	pCi/g in Feedstream for 1 mrem/y Dose
^{3}H	3.4E-04	3.0E+03	9.0E-01	3.3E+03	1.1E+05
^{7}Be	5.1E-03	2.0E+02	1.0E-03	2.0E+05	6.5E+06
^{14}C	1.4E-02	7.0E+01	9.5E-01	7.4E+01	2.5E+03
^{22}Na	3.4E+00	3.0E-01	1.0E-03	3.0E+02	9.9E+03
^{32}P	3.3E-02	3.1E+01	2.0E-02	1.5E+03	5.1E+04
^{35}S	9.5E-03	1.1E+02	5.0E-02	2.1E+03	7.0E+04
^{46}Sc	3.2E-01	3.1E+00	5.0E-04	6.3E+03	2.1E+05
^{48}V	3.0E-01	3.3E+00	1.0E-03	3.3E+03	1.1E+05
^{51}Cr	2.1E-03	4.7E+02	2.0E-03	2.4E+05	7.9E+06
^{54}Mn	4.4E-01	2.3E+00	2.0E-03	1.1E+03	3.8E+04
^{55}Fe	6.1E-03	1.6E+02	5.0E-03	3.3E+04	1.1E+06
^{56}Co	5.0E-01	2.0E+00	1.0E-02	2.0E+02	6.6E+03
^{57}Co	7.7E-02	1.3E+01	1.0E-02	1.3E+03	4.3E+04
^{58}Co	1.4E-01	7.1E+00	1.0E-02	7.1E+02	2.4E+04
^{60}Co	6.7E+00	1.5E-01	1.0E-02	1.5E+01	5.0E+02
^{63}Ni	6.2E-03	1.6E+02	5.0E-03	3.2E+04	1.1E+06
^{65}Zn	6.1E-01	1.7E+00	1.0E-02	1.7E+02	5.5E+03
^{68}Ge	9.2E-02	1.1E+01	1.0E-03	1.1E+04	3.6E+05
^{74}As	9.0E-03	1.1E+02	5.0E-03	2.2E+04	7.4E+05
^{75}Se	1.1E-01	9.0E+00	1.0E-01	9.0E+01	3.0E+03
^{79}Se	1.7E-02	5.8E+01	1.0E-01	5.8E+02	1.9E+04
^{90}Sr	2.6E+00	3.8E-01	1.0E-04	3.8E+03	1.3E+05
$^{90}Sr+D$[(a)]	None	None	1.0E-04	None	None
^{88}Y	3.8E-01	2.6E+00	5.0E-04	5.2E+03	1.7E+05
^{93}Zr	4.8E-02	2.1E+01	5.0E-04	4.2E+04	1.4E+06
^{94}Nb	3.0E+01	3.4E-02	1.0E-03	3.4E+01	1.1E+03
^{99}Tc	3.4E-01	2.9E+00	1.0E-01	2.9E+01	9.8E+02
^{106}Ru	4.9E-01	2.0E+00	1.0E-02	2.0E+02	6.8E+03
^{110m}Ag	1.2E+00	8.1E-01	1.0E-03	8.1E+02	2.7E+04
^{113}Sn	5.5E-02	1.8E+01	1.0E-03	1.8E+04	6.0E+05
$^{113}Sn+D$[(a)]	None	None	1.0E-03	None	None
^{124}Sb	2.2E-01	4.5E+00	2.0E-02	2.3E+02	7.6E+03
^{125}Sb	7.0E-01	1.4E+00	2.0E-02	7.2E+01	2.4E+03
^{125m}Te	2.1E-02	4.7E+01	1.0E-02	4.7E+03	1.6E+05
^{125}I	2.2E+00	4.6E-01	3.0E-01	1.5E+00	5.1E+01
^{126}I	7.6E-01	1.3E+00	3.0E-01	4.4E+00	1.5E+02

TABLE E.1. (contd)

Nuclide	Dose at 1 Ci/y Emission, mrem/y	Ci/y in Emission at 1 mrem/y Dose	Stack Release Fraction	Ci/y in Feedstream at 1 mrem/y Dose	pCi/g in Feedstream for 1 mrem/y Dose
^{129}I	5.1E+01	2.0E-02	3.0E-01	6.5E-02	2.2E+00
^{131}I	5.8E-01	1.7E+00	3.0E-01	5.7E+00	1.9E+02
^{134}Cs	2.5E+00	3.9E-01	2.0E-03	2.0E+02	6.5E+03
^{137}Cs	6.3E+00	1.6E-01	2.0E-03	8.0E+01	2.7E+03
^{144}Ce	3.9E-01	2.6E+00	1.0E-03	2.6E+03	8.6E+04
$^{144}Ce+D$[(a)]	None	None	1.0E-03	None	None
^{147}Pm	3.7E-02	2.7E+01	1.0E-03	2.7E+04	9.0E+05
^{151}Sm	2.7E-02	3.7E+01	1.0E-03	3.7E+04	1.2E+06
^{152}Eu	6.7E+00	1.5E-01	1.0E-03	1.5E+02	4.9E+03
^{154}Eu	5.4E+00	1.9E-01	1.0E-03	1.9E+02	6.2E+03
^{155}Eu	2.2E-01	4.5E+00	1.0E-03	4.5E+03	1.5E+05
^{203}Hg	6.5E-02	1.5E+01	5.0E-02	3.1E+02	1.0E+04
^{207}Bi	5.1E+00	2.0E-01	5.0E-03	3.9E+01	1.3E+03
^{226}Ra	1.2E+02	8.4E-03	5.0E-04	1.7E+01	5.6E+02
$^{226}Ra+D$	None	None	5.0E-04	None	None
^{228}Th	2.1E+02	4.7E-03	5.0E-04	9.4E+00	3.1E+02
^{229}Th	5.9E+02	1.7E-03	5.0E-04	3.4E+00	1.1E+02
$^{229}Th+D$	None	None	5.0E-04	None	None
^{230}Th	2.1E+02	4.8E-03	5.0E-04	9.5E+00	3.2E+02
^{232}Th	3.0E+02	3.3E-03	5.0E-04	6.6E+00	2.2E+02
$^{232}Th+D$	7.0E+02	1.4E-03	5.0E-04	2.9E+00	9.5E+01
^{232}U	4.1E+02	2.4E-03	5.0E-04	4.9E+00	1.6E+02
^{233}U	1.2E+02	8.7E-03	5.0E-04	1.7E+01	5.8E+02
^{234}U	1.1E+02	8.8E-03	5.0E-04	1.8E+01	5.9E+02
^{235}U	1.1E+02	9.3E-03	5.0E-04	1.9E+01	6.2E+02
$^{235}U+D$	None	None	5.0E-04	None	None
^{238}U	1.0E+02	9.9E-03	5.0E-04	2.0E+01	6.6E+02
$^{238}U+D$	None	None	5.0E-04	None	None
^{237}Np	2.8E+02	3.6E-03	5.0E-04	7.1E+00	2.4E+02
$^{237}Np+D$	None	None	5.0E-04	None	None
^{238}Pu	2.8E+02	3.6E-03	5.0E-04	7.2E+00	2.4E+02
^{239}Pu	3.0E+02	3.4E-03	5.0E-04	6.7E+00	2.2E+02
^{240}Pu	3.0E+02	3.4E-03	5.0E-04	6.7E+00	2.2E+02
^{241}Pu	4.6E+00	2.2E-01	5.0E-04	4.4E+02	1.5E+04
^{241}Am	3.1E+02	3.2E-03	5.0E-04	6.5E+00	2.2E+02

(a) The dose factor for the decay chain is assumed to have the same dose factor as the parent nuclide alone.

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TABLE E.2. Activity in Incinerator Feedstream Corresponding to 1 mrem/y Dose to the Maximally Exposed Offsite Individual Based on Metro-Low (20/km^2) Population Density

Nuclide	Dose at 1 Ci/y Emission, mrem/y	Ci/y in Emission at 1 mrem/y Dose	Stack Release Fraction	Ci/y in Feedstream at 1 mrem/y Dose	pCi/g in Feedstream for 1 mrem/y Dose
^{3}H	4.6E-04	2.2E+03	9.0E-01	2.4E+03	8.1E+04
^{7}Be	5.3E-03	1.9E+02	1.0E-03	1.9E+05	6.3E+06
^{14}C	2.1E-02	4.7E+01	9.5E-01	4.9E+01	1.6E+03
^{22}Na	3.5E+00	2.8E-01	1.0E-03	2.8E+02	9.5E+03
^{32}P	4.3E-02	2.4E+01	2.0E-02	1.2E+03	3.9E+04
^{35}S	1.3E-02	7.8E+01	5.0E-02	1.6E+03	5.2E+04
^{46}Sc	3.3E-01	3.0E+00	5.0E-04	6.0E+03	2.0E+05
^{48}V	3.6E-01	2.8E+00	1.0E-03	2.8E+03	9.3E+04
^{51}Cr	2.3E-03	4.4E+02	2.0E-03	2.2E+05	7.3E+06
^{54}Mn	4.4E-01	2.3E+00	2.0E-03	1.1E+03	3.8E+04
^{55}Fe	8.4E-03	1.2E+02	5.0E-03	2.4E+04	8.0E+05
^{56}Co	5.3E-01	1.9E+00	1.0E-02	1.9E+02	6.3E+03
^{57}Co	8.1E-02	1.2E+01	1.0E-02	1.2E+03	4.1E+04
^{58}Co	1.5E-01	6.8E+00	1.0E-02	6.8E+02	2.3E+04
^{60}Co	6.8E+00	1.5E-01	1.0E-02	1.5E+01	4.9E+02
^{63}Ni	8.6E-03	1.2E+02	5.0E-03	2.3E+04	7.8E+05
^{65}Zn	7.7E-01	1.3E+00	1.0E-02	1.3E+02	4.3E+03
^{68}Ge	1.1E-01	9.3E+00	1.0E-03	9.3E+03	3.1E+05
^{74}As	9.0E-03	1.1E+02	5.0E-03	2.2E+04	7.4E+05
^{75}Se	1.2E-01	8.6E+00	1.0E-01	8.6E+01	2.9E+03
^{79}Se	2.3E-02	4.3E+01	1.0E-01	4.3E+02	1.4E+04
^{90}Sr	3.5E+00	2.8E-01	1.0E-04	2.8E+03	9.4E+04
$^{90}Sr+D^{(a)}$	None	None	1.0E-04	None	None
^{88}Y	4.0E-01	2.5E+00	5.0E-04	5.0E+03	1.7E+05
^{93}Zr	5.1E-02	2.0E+01	5.0E-04	3.9E+04	1.3E+06
^{94}Nb	3.0E+01	3.4E-02	1.0E-03	3.4E+01	1.1E+03
^{99}Tc	5.0E-01	2.0E+00	1.0E-01	2.0E+01	6.6E+02
^{106}Ru	5.5E-01	1.8E+00	1.0E-02	1.8E+02	6.1E+03
^{110m}Ag	1.3E+00	7.8E-01	1.0E-03	7.8E+02	2.6E+04
^{113}Sn	7.5E-02	1.3E+01	1.0E-03	1.3E+04	4.4E+05
$^{113}Sn+D^{(a)}$	None	None	1.0E-03	None	None
^{124}Sb	2.3E-01	4.3E+00	2.0E-02	2.1E+02	7.1E+03
^{125}Sb	7.0E-01	1.4E+00	2.0E-02	7.1E+01	2.4E+03
^{125m}Te	2.8E-02	3.5E+01	1.0E-02	3.5E+03	1.2E+05
^{125}I	3.3E+00	3.0E-01	3.0E-01	1.0E+00	3.4E+01
^{126}I	1.1E+00	9.1E-01	3.0E-01	3.0E+00	1.0E+02

TABLE E.2. (contd)

Nuclide	Dose at 1 Ci/y Emission, mrem/y	Ci/y in Emission at 1 mrem/y Dose	Stack Release Fraction	Ci/y in Feedstream at 1 mrem/y Dose	pCi/g in Feedstream for 1 mrem/y Dose
^{129}I	7.5E+01	1.3E-02	3.0E-01	4.5E-02	1.5E+00
^{131}I	8.5E-01	1.2E+00	3.0E-01	3.9E+00	1.3E+02
^{134}Cs	2.9E+00	3.5E-01	2.0E-03	1.7E+02	5.8E+03
^{137}Cs	6.6E+00	1.5E-01	2.0E-03	7.6E+01	2.5E+03
^{144}Ce	4.3E-01	2.3E+00	1.0E-03	2.3E+03	7.8E+04
$^{144}Ce+D$	None	None	1.0E-03	None	None
^{147}Pm	3.9E-02	2.5E+01	1.0E-03	2.5E+04	8.5E+05
^{151}Sm	2.8E-02	3.6E+01	1.0E-03	3.6E+04	1.2E+06
^{152}Eu	6.8E+00	1.5E-01	1.0E-03	1.5E+02	4.9E+03
^{154}Eu	5.4E+00	1.9E-01	1.0E-03	1.9E+02	6.2E+03
^{155}Eu	2.3E-01	4.4E+00	1.0E-03	4.4E+03	1.5E+05
^{203}Hg	8.3E-02	1.2E+01	5.0E-02	2.4E+02	8.0E+03
^{207}Bi	5.1E+00	2.0E-01	5.0E-03	3.9E+01	1.3E+03
^{226}Ra	1.2E+02	8.2E-03	5.0E-04	1.6E+01	5.5E+02
$^{226}Ra+D$	None	None	5.0E-04	None	None
^{228}Th	2.1E+02	4.7E-03	5.0E-04	9.4E+00	3.1E+02
^{229}Th	5.9E+02	1.7E-03	5.0E-04	3.4E+00	1.1E+02
$^{229}Th+D$	None	None	5.0E-04	None	None
^{230}Th	2.1E+02	4.7E-03	5.0E-04	9.5E+00	3.2E+02
^{232}Th	3.0E+02	3.3E-03	5.0E-04	6.6E+00	2.2E+02
$^{232}Th+D$	7.0E+02	1.4E-03	5.0E-04	2.8E+00	9.5E+01
^{232}U	4.2E+02	2.4E-03	5.0E-04	4.8E+00	1.6E+02
^{233}U	1.2E+02	8.5E-03	5.0E-04	1.7E+01	5.7E+02
^{234}U	1.2E+02	8.6E-03	5.0E-04	1.7E+01	5.7E+02
^{235}U	1.1E+02	9.1E-03	5.0E-04	1.8E+01	6.1E+02
$^{235}U+D$	None	None	5.0E-04	None	None
^{238}U	1.0E+02	9.7E-03	5.0E-04	1.9E+01	6.5E+02
$^{238}U+D$	None	None	5.0E-04	None	None
^{237}Np	2.9E+02	3.5E-03	5.0E-04	6.9E+00	2.3E+02
$^{237}Np+D$	None	None	5.0E-04	None	None
^{238}Pu	2.8E+02	3.5E-03	5.0E-04	7.1E+00	2.4E+02
^{239}Pu	3.1E+02	3.3E-03	5.0E-04	6.6E+00	2.2E+02
^{240}Pu	3.1E+02	3.3E-03	5.0E-04	6.6E+00	2.2E+02
^{241}Pu	4.8E+00	2.1E-01	5.0E-04	4.2E+02	1.4E+04
^{241}Am	3.2E+02	3.1E-03	5.0E-04	6.3E+00	2.1E+02

(a) The dose factor for the decay chain is assumed to have the same dose factor as the parent nuclide alone.

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TABLE E.3. Activity in Incinerator Feedstream Corresponding to 1 mrem/y Dose to the Maximally Exposed Individual Based on Rural (10/km^2) Population Density for a 30,000-t/y Incinerator

Nuclide	Dose at 1 Ci/y Emission, mrem/y	Ci/y in Emission at 1 mrem/y Dose	Stack Release Fraction	Ci/y in Feedstream at 1 mrem/y Dose	pCi/g in Feedstream for 1 mrem/y Dose
^{3}H	5.7E-04	1.7E+03	9.0E-01	1.9E+03	6.5E+04
^{7}Be	5.4E-03	1.8E+02	1.0E-03	1.8E+05	6.1E+06
^{14}C	2.9E-02	3.5E+01	9.5E-01	3.6E+01	1.2E+03
^{22}Na	3.7E+00	2.7E-01	1.0E-03	2.7E+02	9.1E+03
^{32}P	5.3E-02	1.9E+01	2.0E-02	9.5E+02	3.2E+04
^{35}S	1.7E-02	6.0E+01	5.0E-02	1.2E+03	4.0E+04
^{46}Sc	3.5E-01	2.9E+00	5.0E-04	5.8E+03	1.9E+05
^{48}V	4.2E-01	2.4E+00	1.0E-03	2.4E+03	7.9E+04
^{51}Cr	2.4E-03	4.1E+02	2.0E-03	2.1E+05	6.9E+06
^{54}Mn	4.5E-01	2.2E+00	2.0E-03	1.1E+03	3.7E+04
^{55}Fe	1.1E-02	9.2E+01	5.0E-03	1.8E+04	6.1E+05
^{56}Co	5.6E-01	1.8E+00	1.0E-02	1.8E+02	5.9E+03
^{57}Co	8.5E-02	1.2E+01	1.0E-02	1.2E+03	3.9E+04
^{58}Co	1.6E-01	6.4E+00	1.0E-02	6.4E+02	2.1E+04
^{60}Co	6.9E+00	1.5E-01	1.0E-02	1.5E+01	4.9E+02
^{63}Ni	1.1E-02	9.2E+01	5.0E-03	1.8E+04	6.1E+05
^{65}Zn	9.7E-01	1.0E+00	1.0E-02	1.0E+02	3.4E+03
^{68}Ge	1.2E-01	8.2E+00	1.0E-03	8.2E+03	2.7E+05
^{74}As	9.0E-03	1.1E+02	5.0E-03	2.2E+04	7.4E+05
^{75}Se	1.2E-01	8.3E+00	1.0E-01	8.3E+01	2.8E+03
^{79}Se	2.9E-02	3.4E+01	1.0E-01	3.4E+02	1.1E+04
^{90}Sr	4.4E+00	2.3E-01	1.0E-04	2.3E+03	7.5E+04
$^{90}Sr+D$[(a)]	None	None	1.0E-04	None	None
^{88}Y	4.2E-01	2.4E+00	5.0E-04	4.8E+03	1.6E+05
^{93}Zr	5.4E-02	1.9E+01	5.0E-04	3.7E+04	1.2E+06
^{94}Nb	3.0E+01	3.3E-02	1.0E-03	3.3E+01	1.1E+03
^{99}Tc	6.7E-01	1.5E+00	1.0E-01	1.5E+01	5.0E+02
^{106}Ru	6.0E-01	1.7E+00	1.0E-02	1.7E+02	5.6E+03
^{110M}Ag	1.3E+00	7.5E-01	1.0E-03	7.5E+02	2.5E+04
^{113}Sn	9.8E-02	1.0E+01	1.0E-03	1.0E+04	3.4E+05
$^{113}Sn+D$[(a)]	None	None	1.0E-03	None	None
^{124}Sb	2.5E-01	4.0E+00	2.0E-02	2.0E+02	6.7E+03
^{125}Sb	7.1E-01	1.4E+00	2.0E-02	7.0E+01	2.3E+03
^{125M}Te	3.6E-02	2.8E+01	1.0E-02	2.8E+03	9.4E+04
^{125}I	4.4E+00	2.3E-01	3.0E-01	7.6E-01	2.5E+01
^{126}I	1.4E+00	7.0E-01	3.0E-01	2.3E+00	7.8E+01

TABLE E.3. (contd)

Nuclide	Dose at 1 Ci/y Emission, mrem/y	Ci/y in Emission at 1 mrem/y Dose	Stack Release Fraction	Ci/y in Feedstream at 1 mrem/y Dose	pCi/g in Feedstream for 1 mrem/y Dose
^{129}I	9.8E+01	1.0E-02	3.0E-01	3.4E-02	1.1E+00
^{131}I	1.1E+00	9.1E-01	3.0E-01	3.0E+00	1.0E+02
^{134}Cs	3.2E+00	3.1E-01	2.0E-03	1.6E+02	5.2E+03
^{137}Cs	6.8E+00	1.5E-01	2.0E-03	7.3E+01	2.4E+03
^{144}Ce	4.6E-01	2.2E+00	1.0E-03	2.2E+03	7.2E+04
^{144}Ce+D	None	None	1.0E-03	None	None
^{147}Pm	4.2E-02	2.4E+01	1.0E-03	2.4E+04	8.0E+05
^{151}Sm	2.9E-02	3.5E+01	1.0E-03	3.5E+04	1.2E+06
^{152}Eu	6.8E+00	1.5E-01	1.0E-03	1.5E+02	4.9E+03
^{154}Eu	5.4E+00	1.8E-01	1.0E-03	1.8E+02	6.2E+03
^{155}Eu	2.3E-01	4.4E+00	1.0E-03	4.4E+03	1.5E+05
^{203}Hg	1.0E-01	9.5E+00	5.0E-02	1.9E+02	6.3E+03
^{207}Bi	5.1E+00	2.0E-01	5.0E-03	3.9E+01	1.3E+03
^{226}Ra	1.2E+02	8.1E-03	5.0E-04	1.6E+01	5.4E+02
^{226}Ra+D	None	None	5.0E-04	None	None
^{228}Th	2.1E+02	4.7E-03	5.0E-04	9.4E+00	3.1E+02
^{229}Th	5.9E+02	1.7E-03	5.0E-04	3.4E+00	1.1E+02
^{229}Th+D	None	None	5.0E-04	None	None
^{230}Th	2.1E+02	4.7E-03	5.0E-04	9.4E+00	3.1E+02
^{232}Th	3.0E+02	3.3E-03	5.0E-04	6.6E+00	2.2E+02
^{232}Th+D	7.1E+02	1.4E-03	5.0E-04	2.8E+00	9.4E+01
^{232}U	4.2E+02	2.4E-03	5.0E-04	4.8E+00	1.6E+02
^{233}U	1.2E+02	8.4E-03	5.0E-04	1.7E+01	5.6E+02
^{234}U	1.2E+02	8.5E-03	5.0E-04	1.7E+01	5.6E+02
^{235}U	1.1E+02	8.9E-03	5.0E-04	1.8E+01	6.0E+02
^{235}U+D	None	None	5.0E-04	None	None
^{238}U	1.1E+02	9.5E-03	5.0E-04	1.9E+01	6.3E+02
^{238}U+D	None	None	5.0E-04	None	None
^{237}Np	3.0E+02	3.4E-03	5.0E-04	6.7E+00	2.2E+02
^{237}Np+D	None	None	5.0E-04	None	None
^{238}Pu	2.9E+02	3.4E-03	5.0E-04	6.9E+00	2.3E+02
^{239}Pu	3.1E+02	3.2E-03	5.0E-04	6.4E+00	2.1E+02
^{240}Pu	3.1E+02	3.2E-03	5.0E-04	6.4E+00	2.1E+02
^{241}Pu	4.9E+00	2.0E-01	5.0E-04	4.1E+02	1.4E+04
^{241}Am	3.3E+02	3.1E-03	5.0E-04	6.1E+00	2.0E+02

(a) The dose factor for the decay chain is assumed to have the same dose factor as the parent nuclide alone.

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TABLE E.4. Dose Factors for Maximum Individual and Population Doses

Nuclide	Individual at 500 m DF (mrem/y per Ci/y)			Collective Dose for Generic Population Distribution DF (person-rem/y per Ci/y)			
	Metro-High	Metro-Low	Rural	$80/km^2$ High	$20/km^2$ Medium	$10/km^2$ Low	
H-3	3.36E-04	4.55E-04	5.72E-04	1.33E-03	3.01E-04	1.41E-04	
BE-7	5.09E-03	5.27E-03	5.43E-03	1.45E-02	3.49E-03	1.72E-03	
C-14	1.43E-02	2.14E-02	2.89E-02	7.43E-02	1.70E-02	7.85E-03	
NA-22	3.37E+00	3.51E+00	3.67E+00	1.06E+01	2.65E+00	1.30E+00	
P-32	3.26E-02	4.25E-02	5.26E-02	1.68E-01	3.82E-02	1.80E-02	
S-35	9.48E-03	1.28E-02	1.67E-02	6.31E-02	1.53E-02	7.11E-03	
SC-46	3.18E-01	3.32E-01	3.47E-01	9.47E-01	2.29E-01	1.12E-01	
V-48	3.02E-01	3.57E-01	4.24E-01	1.48E+00	3.64E-01	1.72E-01	
CR-51	2.11E-03	2.28E-03	2.43E-03	6.58E-03	1.53E-03	7.47E-04	
MN-54	4.37E-01	4.43E-01	4.48E-01	1.19E+00	2.94E-01	1.46E-01	
FE-55	6.09E-03	8.38E-03	1.09E-02	3.92E-02	8.91E-03	4.13E-03	
CO-56	5.04E-01	5.33E-01	5.65E-01	1.59E+00	3.82E-01	1.87E-01	
CO-57	7.67E-02	8.08E-02	8.52E-02	2.38E-01	5.79E-02	2.83E-02	
CO-58	1.40E-01	1.48E-01	1.57E-01	4.41E-01	1.06E-01	5.20E-02	
CO-60	6.65E+00	6.76E+00	6.87E+00	1.85E+01	4.60E+00	2.27E+00	
NI-63	6.16E-03	8.55E-03	1.09E-02	3.50E-02	7.26E-03	3.37E-03	
ZN-65	6.06E-01	7.73E-01	9.67E-01	3.63E+00	8.86E-01	4.16E-01	
GE-68	9.17E-02	1.07E-01	1.22E-01	3.13E-01	6.69E-02	3.19E-02	
AS-74	9.04E-03	9.04E-03	9.04E-03	1.48E-02	3.69E-03	1.83E-03	
SE-75	1.11E-01	1.16E-01	1.21E-01	3.31E-01	8.02E-02	3.92E-02	
SE-79	1.73E-02	2.33E-02	2.90E-02	9.03E-02	1.89E-02	8.80E-03	
SR-90	2.62E+00	3.54E+00	4.42E+00	1.35E+01	2.80E+00	1.31E+00	
Y-88	3.82E-01	3.98E-01	4.16E-01	1.14E+00	2.75E-01	1.34E-01	
ZR-93	4.80E-02	5.07E-02	5.35E-02	1.04E-01	2.43E-02	1.18E-02	
NB-94	2.95E+01	2.97E+01	3.00E+01	8.09E+01	2.02E+01	1.00E+01	
TC-99	3.39E-01	5.02E-01	6.69E-01	2.61E+00	6.12E-01	2.88E-01	
RU-106	4.90E-01	5.45E-01	5.98E-01	1.30E+00	2.86E-01	1.37E-01	
AG-110m	1.24E+00	1.29E+00	1.34E+00	3.69E+00	9.15E-01	4.51E-01	
SN-113	5.54E-02	7.51E-02	9.81E-02	3.73E-01	8.92E-02	4.13E-02	
SB-124	2.20E-01	2.34E-01	2.48E-01	6.69E-01	1.56E-01	7.65E-02	
SB-125	6.99E-01	7.05E-01	7.11E-01	1.88E+00	4.67E-01	2.32E-01	
TE-125m	2.12E-02	2.83E-02	3.55E-02	1.14E-01	2.44E-02	1.14E-02	
I-125	2.17E+00	3.29E+00	4.39E+00	3.87E+00	8.71E-01	3.89E-01	
I-126	7.57E-01	1.10E+00	1.43E+00	1.20E+00	2.68E-01	1.21E-01	
I-129	5.12E+01	7.46E+01	9.80E+01	8.73E+01	2.05E+01	9.14E+00	
I-131	5.82E-01	8.46E-01	1.10E+00	9.25E-01	2.06E-01	9.27E-02	
CS-134	2.55E+00	2.87E+00	3.22E+00	1.02E+01	2.46E+00	1.19E+00	
CS-137	6.28E+00	6.55E+00	6.84E+00	1.95E+01	4.80E+00	2.36E+00	' Includes Ba-137
CE-144	3.87E-01	4.27E-01	4.64E-01	9.88E-01	2.17E-01	1.04E-01	

TABLE E.4. (contd)

Nuclide	Individual at 500 m DF (mrem/y per Ci/y)			Collective Dose for Generic Population Distribution DF (person-rem/y per Ci/y)			
	Metro-High	Metro-Low	Rural	80/km^2 High	20/km^2 Medium	10/km^2 Low	
PM-147	3.69E-02	3.94E-02	4.19E-02	8.38E-02	1.94E-02	9.35E-03	
SM-151	2.69E-02	2.79E-02	2.89E-02	5.23E-02	1.25E-02	6.08E-03	
EU-152	6.74E+00	6.75E+00	6.77E+00	1.78E+01	4.43E+00	2.20E+00	
EU-154	5.37E+00	5.40E+00	5.42E+00	1.42E+01	3.53E+00	1.75E+00	
EU-155	2.22E-01	2.26E-01	2.29E-01	5.81E-01	1.43E-01	7.08E-02	
HG-203	6.49E-02	8.30E-02	1.05E-01	3.95E-01	9.63E-02	4.49E-02	
BI-207	5.08E+00	5.08E+00	5.10E+00	1.36E+01	3.38E+00	1.68E+00	
RA-226	1.19E+02	1.22E+02	1.24E+02	2.10E+02	5.04E+01	2.47E+01	
TH-228	2.12E+02	2.12E+02	2.12E+02	3.30E+02	8.22E+01	4.07E+01	
TH-229	5.89E+02	5.91E+02	5.93E+02	9.25E+02	2.30E+02	1.14E+02	
TH-230	2.10E+02	2.11E+02	2.12E+02	3.34E+02	8.27E+01	4.09E+01	
TH-232	3.02E+02	3.03E+03	3.04E+04	4.74E+02	1.18E+02	5.84E+01	
TH-232+D	7.01E+02	7.04E+02	7.07E+02	1.15E+03	2.87E+02	1.42E+02	' Includes Daughters
U-232	4.09E+02	4.15E+02	4.21E+02	6.89E+02	1.68E+02	8.27E+01	
U-233	1.15E+02	1.17E+02	1.19E+02	1.99E+02	4.81E+01	2.37E+01	
U-234	1.13E+02	1.16E+02	1.18E+02	1.97E+02	4.76E+01	2.34E+01	
U-235	1.08E+02	1.10E+02	1.12E+02	1.91E+02	4.62E+01	2.27E+01	
U-238	1.01E+02	1.03E+02	1.05E+02	1.75E+02	4.23E+01	2.08E+01	
NP-237	2.80E+02	2.89E+02	2.98E+02	5.18E+02	1.22E+02	5.99E+01	
PU-238	2.76E+02	2.83E+02	2.90E+02	4.95E+02	1.18E+02	5.79E+01	
PU-239	2.97E+02	3.05E+02	3.13E+02	5.36E+02	1.28E+02	6.25E+01	
PU-240	2.97E+02	3.05E+02	3.13E+02	5.36E+02	1.27E+02	6.25E+01	
PU-241	4.59E+00	4.76E+00	4.92E+00	8.66E+00	2.03E+00	9.94E-01	
AM-241	3.10E+02	3.18E+02	3.26E+02	5.59E+02	1.33E+02	6.52E+01	

APPENDIX F

EXTERNAL DOSE CALCULATIONS FOR WORKER SCENARIOS

APPENDIX F

EXTERNAL DOSE CALCULATIONS FOR WORKER SCENARIOS

Doses to workers are based on scenarios that describe the interaction of workers with waste or with residual materials from incineration. The external exposure for each scenario depends on the size and shape of the radioactive source, its distance from the worker, and the shielding between the source and the worker.

External dose factors are calculated for conditions that represent either a specific task or the assumed orientation of the worker with respect to a radioactive source. The dose factor for a scenario may be a composite dose factor for specific tasks, weighted by the assumed exposure time for each, or may be calculated from a single geometry.

The exposure scenarios and assumptions about time distribution among worker activities, are listed in Table F.1.

Assumptions related to the geometry, dimensions, and shielding used in the calculation of external dose factors for each scenario (by activity) are given in Table F.2. Many of the distance and shielding assumptions are those taken from reports and data compiled by M.H. Chew & Associates for the Department of Energy, EM-30.

Table F.3 describes the assumptions used in calculating external dose factors for collective worker scenarios.

External dose factors are calculated using EXTDF, an adaptation of ISOSHLD (Engel et al. 1966) in GENII software system (Napier et al. 1988). EXTDF generates a dose factor library for each case. Composite dose factors, or dose factors for specific tasks, weighted by exposure time, are calculated using a spreadsheet.

TABLE F.1. Development of External Exposure Assumptions Used for Worker Scenarios

Scenario No.	Scenario Description	Activity	External Exposure		
			Geometry File [a]	Time, h/d	Fraction of Time
1	Waste transport	Driving	truck300	10[b]	0.56
		Sleeping	sleep150	8	0.44
2	Waste receiving	Sampling	drumtop	4	0.5
		Near drums	array150	2	0.25
			remote	2	0.25
3	Waste disposal	1 m from area source	lfil_cr	1.0	
4	Landfill excavation	1 m from area source	Lfil_cr	20 h total	1E-3
5	Waste treatment	1.5 m from drum array	array150	2	0.25
		1.5 m from bin	Bin150	4	0.5
6	Incinerator/wet scrub	10 cm from bag filter	filter10	1	0.1
		2 m from filter	filter2m	5	0.5
		10 m from source	Tank_10m	4	0.15
			remote	2	0.25
7	Incinerator/bag filter	Filter press	fp_1m	2	0.25
		10 m from sludge tank	Tank_10m	4	0.5
			remote	2	0.25
8	Incinerator maintenance	Kiln clean-out	kiln [c]	0.67	0.084
		1.5 m from slag bin	bin150	6.33	0.791
			remote	1	0.12
9	Ash transport	Driving	dumpt300	10[b]	0.56
		Sleeping	sleep150	8	0.44

(a) Filenames of external dose factor libraries created using EXTDF.

(b) For the transport scenarios, it is assumed that the driver spends half time with an empty or noncontaminated load. The applicable exposure time for an external exposure is 18 h/d x 250 d/y x 0.5 = 2250 h/y. For other scenarios, the exposure duration is 8 h/d x 250 d/y = 2000 h/y.

(c) 168 h/y kiln maintenance

TABLE F.2. Geometry, Dimensions, and Shielding Assumptions Used to Calculate External Dose Factors for Each Worker Scenario

Filename	Description	Geometry	Dimensions	Shield	Distance
1 Transport (Waste)					
TRUCK300	Truck (drums: 2 wide x 2 high)	Rectangular	1.1 x 1.7 x 4.4 m	0.8 cm	3 m
SLEEP300	Same	Same	Same	Same	1.5 m
2 Waste Receiving and Sampling (Waste)					
DRUMTOP	55-gal drum	Cylinder end	28 cm radius x cm	0.16 cm	10 cm
ARRAY150	Array of drums 2 wide x 2 high x 10 across	Rectangular	168 cm x 560 cm x 88.4 cm	0.16 cm	1.5 m
3 Waste Disposal (Landfill) (Waste)					
LFIL_CR	Landfill	Rectangular slab	1 m x 100 m x 100 m	15 cm (soil)	1 m
4 Landfill Excavation (Waste)					
LFIL_CR	Landfill	Rectangular slab	1 m x 100 m x 100 m	15 cm (soil)	1 m
5 Waste Treatment (Waste)					
ARRAY150	Array of drums 2 wide x 2 high x 10 across	Rectangular	168 cm x 560 cm x 88.4 cm	0.16 cm	1.5 m
BIN150	Slag bin	Rectangular	1.2 m x 2.1 m	1.3 cm	150 cm
6 Incinerator Worker/Bag Filter (Fly Ash)					
Filter10	Bag filter (changing)	Rectangular	2.1 m x 1 m x 28 cm	-	10 cm
Filter2m	Bag filter (transport)	Rectangular	2.1 m x 1 m x 28 cm	1.3 cm	150 cm
DUMPT300	Dump truck[a]	Rectangular	9.1 m x 2.1 m x 1.5 m	1.3 cm	3 m

TABLE F.2. (contd)

Filename	Description	Geometry	Dimensions	Shield	Distance
1 Transport (Waste)					
7 Incinerator Worker/Wet Scrub (Fly Ash)					
FP_1M	Filter press	Rectangular	5 m x 2 m x 50 cm	0.5 cm	100 cm
LTANK10M	Large tank[b]	Cylinder side	8-m diameter x 8 m high	1.5 cm	1000 cm
8 Incinerator Maintenance[c] (Slag)					
KILN15	Kiln interior	Rectangular slab; width = radius	3 m x 10 m x 15 cm	-	15 cm
KILN135	Kiln interior	Rectangular slab; width = radius	3 m x 10 m x 15 cm	-	135 cm
KILN255	Kiln interior	Rectangular slab; width = radius	3 m x 10 m x 15 cm	-	255 cm
BIN150	Slag bin	Rectangular	1.2 m high x 2.1 m wide	1.3 cm	150 cm
9 Transport (Ash)					
DUMPT300	Dump truck	Rectangular	9.1 m x 2.1 m x 1.5 m	1.3 cm	3 m
SLPDT300	Same	Same	Same	Same	1.5 m

(a) Transportation scenario geometry (dump truck) was used as a surrogate for large equipment in this scenario.
(b) Exposure time for large tank was reduced by a factor of 10 to compensate for dilution of contents.
(c) The dose rate for exposure inside a rotary kiln is estimated as a combination of dose factors from the sides: KILN15 + 2(KILN135) + KILN255.

TABLE F.3. Exposure Parameters Used for Collective Worker Dose

No.	Scenario	Filename	Description	Geometry	Dimensions	Shield	Distance, m
1	Incinerator -- High-exposure	ARRAY15O	Array of drums 2 deep x 2 high x 10 across	Rectangular	168 cm x 560 cm x 88.4 cm	0.16 cm (steel)	1.5
2	Incinerator -- Medium-exposure	ARRAY10M	Array of drums	Rectangular	Same	same	10
3	Incinerator -- Low-exposure	ARRAY15S	Array of drums	Rectangular	Same	0.16 cm steel + 15 cm concrete	15
4	Landfill -- High-exposure	LFIL_CR	Rectangular area	Rectangular slab	100 m x 100 m x 1 m thick	15 cm soil	1
5	Landfill -- Medium-exposure	LFIL_1M	Rectangular area	Rectangular slab	Same	1 m soil	1
6	Landfill -- Low-exposure	LFIL_10M	Rectangular area	Rectangular slab	Same	10 m soil	1

Seven radionuclides of interest were not supported by the GENII libraries. Surrogates for these radionuclides were chosen based on the similarity of the gamma spectrum (the fraction of the total energy release in each of six energy bins).[(a)] External dose factors for these radionuclides are calculated as the product of the dose factor for the surrogate and the ratio of total energy emission per disintegration. Surrogates and multipliers are shown in Table F.4.

The composite dose factors for individual worker scenarios are presented in Table F.5. Dose factors for collective worker scenarios are presented in Table F.6. The file from which each set of dose factors (column) is taken is listed in the column heading.

(a) The energy bins and energy released per decay are defined in GENII file GAMEN.DAT. Comparison with other nuclides is based on information found in ICRP 38 (ICRP 1983).

TABLE F.4. External Dose Factor Surrogates for Radionuclides Not Included in the GENII Libraries

Radionuclide	Surrogate (GENII-supported) Radionuclide	Multiplier
^{68}Ge	^{41}Ca	10
^{74}As	^{122}Sb	1.15
^{126}I	^{127}Sb	0.69
^{207}Bi	^{154}Ge	1.23
^{56}Co	^{89}Rb	1.72
^{88}Y	^{140}La	1.16
^{48}V	^{76}As	6.77

TABLE F.5. External Dose Factors Developed for Worker Scenarios, mrem/h per Ci/m^3

NUCLIDE El	iso	#	HL (d)	Waste Transport	Waste Receiving	Incinerator Wet Scrubber	Incinerator Bag Filter	Incinerator Maintenance	Ash Trans Dumptruck	Waste Disp Landfill	Waste Treatment
Scenario Numbers ---->				1 TRANS_W	2 RECV_W	7 & 8 INCIN_1	5 & 6 INCIN_2	9 & 10 INCIN_M	11 & 12 TRANS_A	3 lfil_cr	4 PROCESS
1	2	3	4	5	6	7	8	9	10	11	12
H	3	1	4.49E+03	0.00E+00	1.10E-33	0.00E+00	3.36E-08	3.07E-08	0.00E+00	0.00E+00	3.97E-34
BE	7	4	5.33E+01	3.52E-01	3.45E+00	5.78E-01	8.62E-01	1.83E+00	2.72E-01	7.47E+00	7.75E-01
BE	10	4	5.84E+08	2.90E-04	6.40E-03	5.48E-04	6.57E-03	8.65E-03	1.58E-04	2.76E-03	9.94E-04
C	14	6	2.09E+06	1.43E-07	2.96E-05	4.78E-07	4.66E-04	4.98E-04	2.22E-08	1.76E-06	3.69E-06
N	13	7	6.92E-03	6.74E+00	6.62E+01	1.11E+01	1.65E+01	3.52E+01	5.20E+00	1.43E+02	1.48E+01
F	18	9	7.62E-02	6.51E+00	6.43E+01	1.07E+01	1.60E+01	3.41E+01	5.04E+00	1.39E+02	1.44E+01
NA	22	11	9.50E+02	2.14E+01	1.83E+02	3.43E+01	4.41E+01	9.47E+01	1.87E+01	6.21E+02	4.41E+01
NA	24	11	6.25E-01	6.92E+01	4.92E+02	1.09E+02	1.22E+02	2.56E+02	6.80E+01	3.08E+03	1.38E+02
SI	31	14	1.09E-01	2.04E-02	2.15E-01	3.35E-02	6.69E-02	1.26E-01	1.66E-02	5.10E-01	4.61E-02
P	32	15	1.43E+01	1.48E-02	1.86E-01	2.50E-02	6.26E-02	1.13E-01	1.07E-02	2.71E-01	3.63E-02
P	33	15	2.54E+01	5.74E-06	2.77E-04	1.26E-05	1.35E-03	1.49E-03	2.36E-06	3.93E-05	3.74E-05
S	35	16	8.74E+01	2.21E-07	3.90E-05	7.03E-07	5.14E-04	5.53E-04	4.05E-08	2.57E-06	4.90E-06
CL	36	17	1.10E+08	7.24E-04	1.36E-02	1.32E-03	9.72E-03	1.39E-02	4.29E-04	8.34E-03	2.24E-03
K	40	19	4.67E+11	2.19E+00	1.71E+01	3.48E+00	4.09E+00	8.72E+00	2.05E+00	7.87E+01	4.39E+00
AR	39	18	9.83E+04	2.96E-04	6.46E-03	5.58E-04	6.53E-03	8.63E-03	1.63E-04	2.85E-03	1.01E-03
AR	41	18	7.61E-02	1.52E+01	1.23E+02	2.41E+01	2.91E+01	6.25E+01	1.39E+01	4.89E+02	3.06E+01
CA	41	20	3.67E+07	0.00E+00	1.49E-27	0.00E+00	4.56E-02	4.16E-02	0.00E+00	0.00E+00	5.40E-28
CA	45	20	1.63E+02	6.59E-06	3.05E-04	1.43E-05	1.40E-03	1.54E-03	2.73E-06	4.45E-05	4.14E-05
SC	46	21	8.38E+01	2.34E+01	1.98E+02	3.73E+01	4.64E+01	9.97E+01	2.10E+01	6.98E+02	4.78E+01
V	48	23	16.2	31.7	276	50.8	67.6	144	27.4	8.26E+02	65.5
CR	51	24	2.77E+01	2.06E-01	2.18E+00	3.43E-01	6.41E-01	1.25E+00	1.50E-01	3.74E+00	4.69E-01
MN	54	25	3.13E+02	8.15E+00	7.36E+01	1.31E+01	1.72E+01	3.69E+01	7.01E+00	2.05E+02	1.68E+01
MN	56	25	1.07E-01	2.30E+01	1.79E+02	3.65E+01	4.34E+01	9.22E+01	2.15E+01	8.56E+02	4.65E+01
FE	55	26	9.86E+02	0.00E+00	3.41E-27	0.00E+00	1.04E-01	9.53E-02	0.00E+00	0.00E+00	1.23E-27
FE	59	26	4.46E+01	1.32E+01	1.08E+02	2.10E+01	2.58E+01	5.55E+01	1.19E+01	4.22E+02	2.68E+01
CO	56	27	78.8	48.2	368	76.5	90.0	191	45.1	1.82E+03	97.0
CO	57	27	2.71E+02	2.26E-01	5.04E+00	4.38E-01	1.76E+00	2.86E+00	1.10E-01	1.40E+00	7.55E-01
CO	58	27	7.08E+01	9.31E+00	8.45E+01	1.49E+01	1.99E+01	4.28E+01	7.94E+00	2.32E+02	1.94E+01
CO	60	27	1.92E+03	3.06E+01	2.48E+02	4.85E+01	5.86E+01	1.26E+02	2.80E+01	9.85E+02	6.18E+01
NI	59	28	2.74E+07	0.00E+00	4.15E-27	0.00E+00	1.27E-01	1.16E-01	0.00E+00	0.00E+00	1.50E-27
NI	63	28	3.65E+04	4.36E-13	2.29E-08	9.50E-12	4.52E-05	4.44E-05	1.42E-15	2.03E-11	2.83E-09
NI	65	28	1.05E-01	7.44E+00	5.89E+01	1.18E+01	1.41E+01	3.01E+01	6.88E+00	2.57E+02	1.50E+01
CU	64	29	5.29E-01	1.28E+00	1.24E+01	2.10E+00	3.16E+00	6.68E+00	1.00E+00	2.80E+01	2.81E+00
ZN	65	30	2.44E+02	7.86E+00	6.40E+01	1.25E+01	1.52E+01	3.25E+01	7.18E+00	2.52E+02	1.59E+01
ZN	69M	30	5.73E-01	3.20E+00	3.14E+01	5.25E+00	7.86E+00	1.67E+01	2.47E+00	6.80E+01	7.06E+00
ZN	69	30	3.86E-02	1.70E-03	2.77E-02	3.03E-03	1.69E-02	2.49E-02	1.08E-03	2.32E-02	4.83E-03
GA	72	31	5.87E-01	3.72E+01	2.85E+02	5.90E+01	6.96E+01	1.47E+02	3.49E+01	1.41E+03	7.49E+01
GE	68	32	288	0	1.49E-26	0	4.56E-01	4.16E-01	0	0	5.40E-27
AS	74	33	17.8	4.97	45.3	7.99	11.2	23.7	4.13	106	10.45
AS	76	33	1.10E+00	4.68E+00	4.07E+01	7.50E+00	9.98E+00	2.12E+01	4.05E+00	1.22E+02	9.68E+00

TABLE F.5. (contd)

NUCLIDE El	iso	#	HL (d)	Waste Transport	Waste Receiving	Incinerator Wet Scrubber	Incinerator Bag Filter	Incinerator Maintenance	Ash Trans Dumptruck	Waste Disp Landfill	Waste Treatment
Scenario Numbers ---->				1	2	7 & 8	5 & 6	9 & 10	11 & 12	3	4
				TRANS_W	RECV_W	INCIN_1	INCIN_2	INCIN_M	TRANS_A	lfil_cr	PROCESS
1	2	3	4	5	6	7	8	9	10	11	12
SE	75	34	1.20E+02	1.34E+00	1.89E+01	2.35E+00	5.29E+00	1.00E+01	8.70E-01	1.85E+01	3.48E+00
SE	79	34	2.37E+07	8.21E-08	1.89E-05	2.80E-07	3.66E-04	3.88E-04	1.21E-08	1.03E-06	2.35E-06
BR	82	35	1.47E+00	2.79E+01	2.42E+02	4.45E+01	5.78E+01	1.24E+02	2.42E+01	7.56E+02	5.73E+01
BR	83	35	9.96E-02	4.91E-02	4.93E-01	8.08E-02	1.33E-01	2.72E-01	3.77E-02	1.03E+00	1.09E-01
KR	83M	36	7.63E-02	7.46E-21	1.46E-07	1.86E-15	8.64E-02	7.90E-02	1.28E-30	5.23E-13	2.08E-08
BR	*84*	35	2.21E-02	2.67E+01	1.91E+02	4.20E+01	4.81E+01	1.01E+02	2.57E+01	1.17E+03	5.33E+01
KR	85M	36	1.87E-01	4.64E-01	7.02E+00	8.23E-01	2.00E+00	3.74E+00	2.96E-01	6.31E+00	1.25E+00
KR	85	36	3.91E+03	1.52E-02	1.55E-01	2.50E-02	4.51E-02	8.91E-02	1.17E-02	3.18E-01	3.41E-02
KR	87	36	5.30E-02	1.12E+01	8.54E+01	1.79E+01	2.13E+01	4.48E+01	1.06E+01	4.53E+02	2.28E+01
SR	87M	38	1.17E-01	1.72E+00	1.82E+01	2.88E+00	4.71E+00	9.81E+00	1.26E+00	3.13E+01	3.94E+00
RB	87	37	1.73E+13	8.56E-06	3.63E-04	1.84E-05	1.47E-03	1.63E-03	3.63E-06	5.66E-05	4.97E-05
KR	88	36	1.18E-01	2.96E+01	2.15E+02	4.68E+01	5.32E+01	1.12E+02	2.86E+01	1.25E+03	5.90E+01
RB	88	37	1.24E-02	1.03E+01	7.57E+01	1.63E+01	1.89E+01	3.97E+01	9.87E+00	4.26E+02	2.06E+01
KR	89	36	2.20E-03	2.56E+01	1.92E+02	4.05E+01	4.77E+01	1.00E+02	2.42E+01	1.04E+03	5.16E+01
RB	89	37	1.07E-02	2.80E+01	2.14E+02	4.45E+01	5.23E+01	1.11E+02	2.62E+01	1.06E+03	5.64E+01
SR	89	38	5.06E+01	1.07E-02	1.34E-01	1.81E-02	5.36E-02	9.07E-02	7.85E-03	2.08E-01	2.63E-02
KR	90	36	3.74E-04	1.55E+01	1.26E+02	2.48E+01	3.06E+01	6.48E+01	1.42E+01	5.32E+02	3.16E+01
RB	90M	37	2.99E-03	4.86E+01	3.51E+02	7.68E+01	8.78E+01	1.84E+02	4.68E+01	2.13E+03	9.75E+01
RB	90	37	1.82E-03	3.21E+01	2.14E+02	5.05E+01	5.58E+01	1.15E+02	3.17E+01	1.60E+03	6.39E+01
SR	90	38	1.04E+04	2.28E-04	5.12E-03	4.33E-04	5.63E-03	7.33E-03	1.24E-04	2.14E-03	7.93E-04
Y	88	39	106.6	32.0	2.58E+02	50.8	61.7	132	29.4	1.10E+03	64.8
Y	90	39	2.67E+00	3.48E-02	4.04E-01	5.85E-02	1.36E-01	2.45E-01	2.65E-02	7.19E-01	8.24E-02
RB	86	37	1.87E+01	1.04E+00	8.57E+00	1.66E+00	2.10E+00	4.49E+00	9.13E-01	3.27E+01	2.13E+00
SR	85	38	6.48E+01	3.35E+00	3.29E+01	5.50E+00	8.45E+00	1.77E+01	2.59E+00	7.12E+01	7.38E+00
SR	91	38	3.96E-01	6.94E+00	5.90E+01	1.11E+01	1.44E+01	3.08E+01	6.03E+00	1.98E+02	1.43E+01
Y	91M	39	3.45E-02	5.20E+00	4.78E+01	8.38E+00	1.18E+01	2.50E+01	4.30E+00	1.07E+02	1.10E+01
Y	91	39	5.85E+01	5.58E-02	5.03E-01	8.98E-02	1.42E-01	2.79E-01	4.90E-02	1.65E+00	1.18E-01
SR	92	38	1.13E-01	1.95E+01	1.52E+02	3.08E+01	3.63E+01	7.76E+01	1.82E+01	6.94E+02	3.90E+01
Y	92	39	1.48E-01	3.31E+00	2.72E+01	5.28E+00	6.61E+00	1.41E+01	2.95E+00	1.07E+02	6.77E+00
Y	93	39	4.21E-01	1.15E+00	9.33E+00	1.84E+00	2.35E+00	4.91E+00	1.05E+00	4.16E+01	2.37E+00
MO	93	42	1.28E+06	0.00E+00	7.98E-27	0.00E+00	2.44E-01	2.23E-01	0.00E+00	0.00E+00	2.88E-27
ZR	93	40	5.58E+08	8.19E-14	8.80E-09	1.96E-12	3.67E-05	3.58E-05	2.52E-16	4.02E-12	1.10E-09
NB	93M	41	5.33E+03	1.30E-43	3.90E-16	1.82E-31	5.06E-02	4.62E-02	0.00E+00	0.00E+00	6.55E-17
ZR	95	40	6.40E+01	6.92E+00	6.28E+01	1.11E+01	1.49E+01	3.19E+01	5.86E+00	1.63E+02	1.44E+01
NB	95M	41	3.61E+00	2.24E-01	3.19E+00	3.93E-01	9.96E-01	1.79E+00	1.39E-01	2.62E+00	5.80E-01
NB	95	41	3.51E+01	8.15E+00	7.36E+01	1.30E+01	1.71E+01	3.68E+01	7.00E+00	2.05E+02	1.68E+01
ZR	97	40	7.04E-01	2.02E+00	1.70E+01	3.23E+00	4.12E+00	8.76E+00	1.80E+00	6.32E+01	4.17E+00
NB	97M	41	6.94E-04	5.36E+00	4.92E+01	8.65E+00	1.21E+01	2.58E+01	4.43E+00	1.10E+02	1.13E+01
NB	97	41	5.01E-02	5.59E+00	5.12E+01	9.00E+00	1.26E+01	2.68E+01	4.63E+00	1.17E+02	1.18E+01
NB	94	41	7.41E+06	1.36E+01	1.24E+02	2.19E+01	2.95E+01	6.32E+01	1.16E+01	3.18E+02	2.84E+01

TABLE F.5. (contd)

NUCLIDE El	iso	#	HL (d)	Waste Transport	Waste Receiving	Incinerator Wet Scrubber	Incinerator Bag Filter	Incinerator Maintenance	Ash Trans Dumptruck	Waste Disp Landfill	Waste Treatment
Scenario Numbers ---->				1	2	7 & 8	5 & 6	9 & 10	11 & 12	3	4
				TRANS_W	RECV_W	INCIN_1	INCIN_2	INCIN_M	TRANS_A	lfil_cr	PROCESS
1	2	3	4	5	6	7	8	9	10	11	12
MO	99	42	2.75E+00	1.14E+00	1.08E+01	1.85E+00	2.68E+00	5.63E+00	9.50E-01	2.49E+01	2.44E+00
TC	99M	43	2.51E-01	2.00E-01	4.59E+00	3.93E-01	1.41E+00	2.43E+00	9.50E-02	1.11E+00	6.81E-01
TC	99	43	7.77E+07	1.26E-05	4.94E-04	2.65E-05	1.67E-03	1.88E-03	5.45E-06	8.28E-05	6.83E-05
TC	101	43	9.86E-03	2.31E+00	2.41E+01	3.83E+00	6.18E+00	1.29E+01	1.71E+00	4.33E+01	5.22E+00
RU	103	44	3.94E+01	3.37E+00	3.29E+01	5.53E+00	8.20E+00	1.75E+01	2.62E+00	7.13E+01	7.40E+00
PD	103	46	1.70E+01	6.44E-04	6.83E-03	1.08E-03	3.35E-01	3.97E-01	4.72E-04	1.17E-02	1.47E-03
RH	103M	45	3.90E-02	1.04E-20	2.06E-07	2.60E-15	5.03E-02	5.58E-02	1.78E-30	7.27E-13	2.93E-08
RU	105	44	1.85E-01	6.06E+00	5.73E+01	9.83E+00	1.45E+01	3.03E+01	4.93E+00	1.29E+02	1.30E+01
RH	105	45	1.47E+00	5.12E-01	5.42E+00	8.53E-01	1.40E+00	2.91E+00	3.73E-01	9.29E+00	1.17E+00
RU	106	44	3.68E+02	1.82E+00	1.68E+01	2.95E+00	4.21E+00	8.90E+00	1.50E+00	4.39E+01	3.89E+00
PD	107	46	2.37E+09	1.77E-42	5.34E-15	2.49E-30	3.37E-06	3.11E-06	0.00E+00	0.00E+00	8.98E-16
PD	109	46	5.61E-01	7.54E-03	1.33E-01	1.34E-02	2.36E-01	3.04E-01	5.22E-03	1.38E-01	2.35E-02
AG	110M	47	2.50E+02	2.90E+01	2.49E+02	4.63E+01	5.96E+01	1.28E+02	2.54E+01	8.13E+02	5.95E+01
AG	111	47	7.46E+00	1.56E-01	1.70E+00	2.60E-01	4.48E-01	9.22E-01	1.13E-01	2.77E+00	3.61E-01
CD	109	48	4.64E+02	6.28E-36	1.89E-08	8.83E-24	3.19E-01	3.74E-01	0.00E+00	2.55E-36	3.17E-09
CD	113M	48	5.00E+03	2.96E-04	6.35E-03	5.58E-04	6.25E-03	8.32E-03	1.64E-04	2.92E-03	1.00E-03
CD	115M	48	4.46E+01	2.74E-01	2.30E+00	4.38E-01	5.77E-01	1.22E+00	2.42E-01	8.52E+00	5.65E-01
CD	115	48	2.23E+00	1.30E+00	1.29E+01	2.14E+00	3.25E+00	6.88E+00	9.98E-01	2.73E+01	2.87E+00
IN	115M	49	1.82E-01	9.78E-01	1.04E+01	1.63E+00	2.82E+00	5.75E+00	7.16E-01	1.78E+01	2.24E+00
IN	111	49	2.83E+00	1.03E+00	1.65E+01	1.86E+00	4.92E+00	9.04E+00	6.15E-01	1.09E+01	2.85E+00
IN	114M	49	5.00E+01	8.39E-01	8.25E+00	1.37E+00	2.29E+00	4.56E+00	6.82E-01	1.71E+01	1.82E+00
SN	113	50	1.15E+02	1.72E-02	2.45E-01	3.03E-02	4.20E-01	5.43E-01	1.07E-02	2.02E-01	4.45E-02
IN	113M	49	6.91E-02	1.36E+00	1.44E+01	2.26E+00	3.79E+00	7.85E+00	9.92E-01	2.47E+01	3.10E+00
SN	117M	50	1.40E+01	1.99E-01	4.56E+00	3.90E-01	1.70E+00	2.77E+00	9.44E-02	1.10E+00	6.75E-01
SN	119M	50	2.93E+02	6.85E-08	8.79E-05	5.25E-07	2.44E-01	2.78E-01	1.43E-09	1.51E-06	1.04E-05
SN	121M	50	2.01E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SN	121	50	1.13E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SN	123	50	1.29E+02	8.10E-02	7.02E-01	1.30E-01	1.88E-01	3.85E-01	7.01E-02	2.47E+00	1.70E-01
SN	125	50	9.64E+00	3.67E+00	2.97E+01	5.85E+00	7.23E+00	1.55E+01	3.30E+00	1.23E+02	7.48E+00
SB	125	51	1.01E+03	3.39E+00	3.23E+01	5.50E+00	8.27E+00	1.73E+01	2.71E+00	7.01E+01	7.31E+00
TE	125M	52	5.80E+01	6.34E-04	1.46E-02	1.24E-03	6.14E-01	7.25E-01	3.01E-04	3.53E-03	2.17E-03
SN	126	50	3.65E+07	5.76E-03	6.50E-01	1.83E-02	5.93E-01	8.27E-01	7.81E-04	6.93E-02	8.55E-02
SB	126M	51	1.32E-02	1.28E+01	1.19E+02	2.08E+01	2.95E+01	6.28E+01	1.05E+01	2.72E+02	2.73E+01
SB	126	51	1.24E+01	2.27E+01	2.09E+02	3.68E+01	5.14E+01	1.10E+02	1.88E+01	4.94E+02	4.80E+01
SB	122	51	2.70E+00	4.32E+00	3.94E+01	6.95E+00	9.74E+00	2.06E+01	3.59E+00	9.17E+01	9.09E+00
SB	124	51	6.02E+01	2.33E+01	1.88E+02	3.70E+01	4.55E+01	9.66E+01	2.12E+01	7.73E+02	4.71E+01
SB	127	51	3.85E+00	5.35E+00	5.02E+01	8.68E+00	1.23E+01	2.62E+01	4.39E+00	1.18E+02	1.14E+01
TE	127M	52	1.09E+02	6.38E-04	7.75E-03	1.05E-03	2.05E-01	2.40E-01	5.19E-04	1.30E-02	1.57E-03
TE	127	52	3.90E-01	3.70E-02	3.74E-01	6.10E-02	1.00E-01	2.06E-01	2.83E-02	7.67E-01	8.28E-02
SB	129	51	1.83E-01	1.57E+01	1.33E+02	2.50E+01	3.17E+01	6.81E+01	1.38E+01	4.71E+02	3.22E+01

TABLE F.5. (contd)

NUCLIDE El iso #	HL (d)	Waste Transport	Waste Receiving	Incinerator Wet Scrubber	Incinerator Bag Filter	Incinerator Maintenance	Ash Trans Dumptruck	Waste Disp Landfill	Waste Treatment
Scenario Numbers ---->		1	2	7 & 8	5 & 6	9 & 10	11 & 12	3	4
		TRANS_W	RECV_W	INCIN_1	INCIN_2	INCIN_M	TRANS_A	lfil_cr	PROCESS
1 2 3	4	5	6	7	8	9	10	11	12
TE 129M 52	3.36E+01	2.48E-01	2.30E+00	4.00E-01	7.21E-01	1.38E+00	2.05E-01	5.10E+00	5.25E-01
TE 129 52	4.83E-02	4.17E-01	4.01E+00	6.80E-01	1.11E+00	2.24E+00	3.32E-01	9.61E+00	9.07E-01
I 129 53	5.73E+09	9.13E-08	8.00E-05	3.10E-07	3.90E-01	4.61E-01	1.35E-08	1.14E-06	1.10E-05
TE 123M 52	1.20E+02	1.89E-01	4.33E+00	3.70E-01	1.57E+00	2.57E+00	8.94E-02	1.05E+00	6.43E-01
TE 131M 52	1.25E+00	1.53E+01	1.33E+02	2.45E+01	3.17E+01	6.76E+01	1.34E+01	4.41E+02	3.16E+01
TE 131 52	1.74E-02	3.28E+00	3.10E+01	5.33E+00	7.84E+00	1.62E+01	2.74E+00	8.67E+01	7.07E+00
I 131 53	8.04E+00	2.28E+00	2.37E+01	3.78E+00	6.06E+00	1.27E+01	1.71E+00	4.24E+01	5.14E+00
XE 131M 54	1.18E+01	4.40E-03	1.01E-01	8.60E-03	3.12E-01	3.83E-01	2.09E-03	2.45E-02	1.50E-02
TE 132 52	3.26E+00	7.90E-01	1.13E+01	1.38E+00	3.37E+00	6.31E+00	4.89E-01	9.18E+00	2.05E+00
I 132 53	9.58E-02	2.31E+01	2.02E+02	3.70E+01	4.86E+01	1.04E+02	2.00E+01	6.18E+02	4.79E+01
TE 133M 52	3.85E-02	2.54E+01	2.12E+02	4.05E+01	5.15E+01	1.10E+02	2.25E+01	7.97E+02	5.21E+01
TE 133 52	8.65E-03	9.45E+00	8.23E+01	1.52E+01	2.01E+01	4.28E+01	8.19E+00	2.77E+02	1.98E+01
I 133 53	8.67E-01	4.40E+00	4.15E+01	7.18E+00	1.02E+01	2.18E+01	3.55E+00	1.03E+02	9.49E+00
XE 133M 54	2.19E+00	9.12E-02	1.30E+00	1.60E-01	6.30E-01	1.01E+00	5.68E-02	1.07E+00	2.37E-01
XE 133 54	5.25E+00	4.73E-03	4.90E-01	1.47E-02	5.17E-01	7.18E-01	7.08E-04	5.56E-02	6.49E-02
TE 134 52	2.90E-02	6.75E+00	6.52E+01	1.10E+01	1.62E+01	3.40E+01	5.53E+00	1.50E+02	1.46E+01
I 134 53	3.65E-02	2.75E+01	2.38E+02	4.40E+01	5.64E+01	1.21E+02	2.42E+01	7.94E+02	5.68E+01
XE 122 54	8.38E-02	7.48E+00	7.11E+01	1.22E+01	1.83E+01	3.83E+01	5.98E+00	1.71E+02	1.63E+01
XE 125 54	7.00E-01	9.67E-01	1.17E+01	1.64E+00	3.62E+00	6.71E+00	7.16E-01	1.96E+01	2.32E+00
I 125 53	6.01E+01	4.69E-18	9.21E-05	1.17E-12	7.23E-01	8.52E-01	8.06E-28	3.29E-10	1.31E-05
I 126 53	13.0	3.69	34.6	5.99	8.49	18.1	3.03	81.4	7.87
CS 134M 55	1.21E-01	2.90E-02	6.65E-01	5.68E-02	4.17E-01	5.93E-01	1.37E-02	1.61E-01	9.87E-02
CS 134 55	7.53E+02	1.54E+01	1.39E+02	2.47E+01	3.32E+01	7.10E+01	1.31E+01	3.66E+02	3.20E+01
I 130 53	5.15E-01	1.68E+01	1.55E+02	2.73E+01	3.82E+01	8.13E+01	1.38E+01	3.75E+02	3.57E+01
I 135 53	2.75E-01	2.05E+01	1.63E+02	3.25E+01	3.89E+01	8.33E+01	1.89E+01	7.04E+02	4.12E+01
XE 135M 54	1.07E-02	2.74E+00	2.68E+01	4.50E+00	6.77E+00	1.44E+01	2.11E+00	5.81E+01	6.01E+00
XE 135 54	3.80E-01	9.85E-01	1.31E+01	1.70E+00	3.45E+00	6.83E+00	6.49E-01	1.32E+01	2.46E+00
CS 135 55	8.40E+08	1.03E-06	8.60E-05	2.55E-06	6.65E-04	7.29E-04	3.48E-07	8.59E-06	1.12E-05
XE 137 54	2.66E-03	1.89E+00	1.71E+01	3.08E+00	4.31E+00	9.09E+00	1.58E+00	5.26E+01	4.04E+00
CS 137 55	1.10E+04	4.66E+00	4.28E+01	7.50E+00	1.06E+01	2.25E+01	3.85E+00	9.58E+01	9.82E+00
XE 138 54	9.81E-03	1.56E+01	1.19E+02	2.49E+01	2.95E+01	6.21E+01	1.47E+01	6.17E+02	3.16E+01
CS 138 55	2.24E-02	3.31E+01	2.54E+02	5.25E+01	6.18E+01	1.31E+02	3.10E+01	1.25E+03	6.65E+01
CS 139 55	6.53E-03	4.45E+00	3.40E+01	7.05E+00	8.35E+00	1.77E+01	4.18E+00	1.69E+02	8.94E+00
BA 139 56	5.77E-02	1.45E-01	1.85E+00	2.47E-01	5.53E-01	1.01E+00	1.12E-01	3.47E+00	3.58E-01
BA 140 56	1.28E+01	1.15E+00	1.16E+01	1.90E+00	3.06E+00	6.33E+00	8.84E-01	2.40E+01	2.57E+00
LA 140 57	1.68E+00	2.76E+01	2.22E+02	4.38E+01	5.32E+01	1.14E+02	2.53E+01	9.45E+02	5.59E+01
CS 136 55	1.32E+01	2.17E+01	1.89E+02	3.48E+01	4.52E+01	9.68E+01	1.88E+01	6.18E+02	4.50E+01
BA 141 56	1.27E-02	7.79E+00	6.99E+01	1.26E+01	1.73E+01	3.63E+01	6.70E+00	2.23E+02	1.65E+01
LA 141 57	1.64E-01	6.83E-01	5.44E+00	1.09E+00	1.34E+00	2.81E+00	6.36E-01	2.42E+01	1.38E+00
CE 141 58	3.25E+01	1.09E-01	2.50E+00	2.13E-01	8.49E-01	1.42E+00	5.16E-02	6.05E-01	3.72E-01

TABLE F.5. (contd)

NUCLIDE El iso	#	HL (d)	Waste Transport	Waste Receiving	Incinerator Wet Scrubber	Incinerator Bag Filter	Incinerator Maintenance	Ash Trans Dumptruck	Waste Disp Landfill	Waste Treatment
Scenario Numbers ---->			1	2	7 & 8	5 & 6	9 & 10	11 & 12	3	4
			TRANS_W	RECV_W	INCIN_1	INCIN_2	INCIN_M	TRANS_A	lfil_cr	PROCESS
1 2	3	4	5	6	7	8	9	10	11	12
BA 142	56	7.43E-03	9.44E+00	8.10E+01	1.51E+01	1.96E+01	4.17E+01	8.32E+00	2.84E+02	1.95E+01
LA 142	57	6.63E-02	4.21E+01	3.01E+02	6.65E+01	7.56E+01	1.59E+02	4.06E+01	1.83E+03	8.40E+01
CE 143	58	1.38E+00	1.31E+00	1.42E+01	2.17E+00	3.97E+00	7.85E+00	9.97E-01	2.43E+01	2.97E+00
PR 143	59	1.36E+01	1.71E-03	2.79E-02	3.05E-03	1.68E-02	2.49E-02	1.09E-03	2.33E-02	4.86E-03
CE 144	58	2.84E+02	2.45E-02	5.79E-01	4.80E-02	2.32E-01	3.72E-01	1.15E-02	1.37E-01	8.56E-02
PR 144M	59	5.00E-03	9.87E-09	1.75E-03	2.65E-07	1.89E-01	2.21E-01	3.00E-11	5.19E-07	2.17E-04
PR 144	59	1.20E-02	4.96E-01	3.97E+00	7.90E-01	1.03E+00	2.12E+00	4.55E-01	1.80E+01	1.02E+00
PR 142	59	7.97E-01	7.86E-01	6.19E+00	1.25E+00	1.51E+00	3.21E+00	7.30E-01	2.78E+01	1.58E+00
ND 147	60	1.10E+01	6.32E-01	6.71E+00	1.05E+00	2.04E+00	3.98E+00	4.84E-01	1.31E+01	1.45E+00
PM 147	61	9.58E+02	8.55E-06	2.82E-04	1.75E-05	9.51E-04	1.07E-03	3.86E-06	5.17E-05	3.96E-05
SM 147	62	3.87E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PM 148M	61	4.13E+01	1.85E+01	1.67E+02	2.98E+01	4.12E+01	8.77E+01	1.54E+01	4.29E+02	3.89E+01
PM 148	61	5.37E+00	7.32E+00	5.96E+01	1.17E+01	1.44E+01	3.07E+01	6.62E+00	2.37E+02	1.49E+01
PM 149	61	2.21E+00	5.48E-02	6.56E-01	9.25E-02	1.80E-01	3.53E-01	3.95E-02	9.07E-01	1.30E-01
PM 151	61	1.18E+00	2.01E+00	2.11E+01	3.33E+00	5.51E+00	1.13E+01	1.54E+00	3.98E+01	4.52E+00
SM 151	62	3.29E+04	1.10E-11	1.13E-07	1.30E-10	5.96E-04	5.87E-04	1.70E-13	3.25E-10	1.35E-08
SM 153	62	1.95E+00	7.37E-02	1.62E+00	1.42E-01	8.54E-01	1.29E+00	3.78E-02	5.62E-01	2.46E-01
EU 152M	63	3.88E-01	3.25E+00	2.80E+01	5.20E+00	6.87E+00	1.45E+01	2.83E+00	9.39E+01	6.69E+00
EU 152	63	4.96E+03	1.28E+01	1.07E+02	2.04E+01	2.62E+01	5.55E+01	1.14E+01	4.00E+02	2.62E+01
EU 154	63	3.21E+03	1.30E+01	1.10E+02	2.08E+01	2.67E+01	5.69E+01	1.16E+01	3.88E+02	2.67E+01
EU 155	63	1.81E+03	5.03E-02	1.49E+00	1.03E-01	6.99E-01	1.09E+00	2.25E-02	3.04E-01	2.14E-01
EU 156	63	1.52E+01	1.81E+01	1.40E+02	2.88E+01	3.41E+01	7.25E+01	1.69E+01	6.68E+02	3.65E+01
GD 153	64	2.42E+02	5.98E-02	1.79E+00	1.24E-01	1.34E+00	1.91E+00	2.57E-02	3.83E-01	2.59E-01
GD 159	64	7.73E-01	1.87E-01	2.01E+00	3.13E-01	6.16E-01	1.20E+00	1.36E-01	3.38E+00	4.30E-01
TB 160	65	7.23E+01	1.13E+01	9.61E+01	1.80E+01	2.32E+01	4.94E+01	9.94E+00	3.36E+02	2.32E+01
TB 161	65	6.91E+00	4.36E-04	9.98E-02	1.55E-03	2.82E-01	3.62E-01	1.02E-04	5.67E-03	1.24E-02
DY 165	66	9.73E-02	1.37E-01	1.40E+00	2.25E-01	4.28E-01	8.24E-01	1.09E-01	2.72E+00	3.05E-01
HO 166M	67	4.38E+05	1.27E+01	1.19E+02	2.05E+01	2.91E+01	6.14E+01	1.06E+01	2.97E+02	2.69E+01
HO 166	67	1.12E+00	2.87E-01	2.38E+00	4.58E-01	6.95E-01	1.35E+00	2.65E-01	1.00E+01	5.91E-01
ER 169	68	9.40E+00	3.08E-05	9.81E-04	6.28E-05	2.81E-03	3.12E-03	1.42E-05	2.06E-04	1.40E-04
ER 171	68	3.13E-01	1.91E+00	2.18E+01	3.20E+00	5.93E+00	1.19E+01	1.37E+00	3.38E+01	4.48E+00
TA 182	73	1.15E+02	1.52E+01	1.26E+02	2.42E+01	3.04E+01	6.45E+01	1.39E+01	4.86E+02	3.09E+01
W 181	74	1.21E+02	3.68E-04	1.60E-01	1.10E-03	4.32E-01	5.34E-01	1.50E-04	3.06E-03	1.90E-02
W 185	74	7.51E+01	1.24E-04	3.16E-03	2.44E-04	3.72E-03	4.71E-03	6.05E-05	8.53E-04	4.67E-04
W 187	74	9.93E-01	3.59E+00	3.40E+01	5.83E+00	8.58E+00	1.80E+01	2.93E+00	7.59E+01	7.69E+00
RE 187	75	1.72E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
OS 185	76	9.36E+01	5.63E+00	5.19E+01	9.08E+00	1.31E+01	2.74E+01	4.69E+00	1.20E+02	1.19E+01
OS 191	76	1.54E+01	5.86E-02	1.63E+00	1.17E-01	8.78E-01	1.29E+00	2.76E-02	3.32E-01	2.33E-01
IR 192	77	7.40E+01	5.46E+00	5.60E+01	9.03E+00	1.43E+01	2.99E+01	4.13E+00	1.05E+02	1.22E+01
HG 203	80	4.66E+01	6.86E-01	9.93E+00	1.20E+00	2.70E+00	5.22E+00	4.26E-01	8.03E+00	1.79E+00

TABLE F.5. (contd)

NUCLIDE El iso	#	HL (d)	Waste Transport	Waste Receiving	Incinerator Wet Scrubber	Incinerator Bag Filter	Incinerator Maintenance	Ash Trans Dumptruck	Waste Disp Landfill	Waste Treatment
Scenario Numbers ---->			1	2	7 & 8	5 & 6	9 & 10	11 & 12	3	4
			TRANS_W	RECV_W	INCIN_1	INCIN_2	INCIN_M	TRANS_A	lfil_cr	PROCESS
1 2	3	4	5	6	7	8	9	10	11	12
BI 207	83	1.39E+04	16.0	1.35E+02	25.6	32.8	70.0	14.3	477	32.8
TH 230	90	2.81E+07	1.56E-04	5.19E-03	3.13E-04	3.43E-02	3.32E-02	7.33E-05	8.88E-04	7.20E-04
RA 226	88	5.84E+05	7.61E-03	1.79E-01	1.50E-02	5.89E-02	9.90E-02	3.61E-03	4.46E-02	2.66E-02
RN 222	86	3.82E+00	2.13E+01	1.72E+02	3.40E+01	4.20E+01	8.89E+01	1.95E+01	7.23E+02	4.33E+01
PB 210	82	8.12E+03	1.89E-10	1.03E-03	4.70E-08	1.10E-01	1.07E-01	5.72E-15	5.79E-08	1.29E-04
BI 210	83	5.01E+00	3.34E-03	4.93E-02	5.83E-03	2.51E-02	3.91E-02	2.25E-03	5.10E-02	8.97E-03
PO 210	84	1.38E+02	8.63E-05	7.78E-04	1.38E-04	1.81E-04	3.89E-04	7.44E-05	2.18E-03	1.78E-04
PU 236	94	1.04E+03	2.81E-07	3.62E-04	2.15E-06	4.87E-02	4.47E-02	5.88E-09	6.22E-06	4.28E-05
U 232	92	2.36E+04	1.64E-04	4.12E-03	3.20E-04	4.67E-02	4.39E-02	7.78E-05	9.11E-04	6.00E-04
TH 232	90	5.13E+12	9.44E-05	2.50E-03	1.85E-04	3.27E-02	3.08E-02	4.47E-05	5.25E-04	3.60E-04
RA 228	88	2.10E+03	8.28E-26	1.66E-12	2.07E-20	7.07E-06	6.58E-06	1.42E-35	5.80E-18	2.35E-13
AC 228	89	2.55E-01	1.06E+01	8.86E+01	1.69E+01	2.16E+01	4.61E+01	9.32E+00	3.30E+02	2.18E+01
TH 228	90	6.98E+02	2.81E-03	5.85E-02	5.23E-03	5.56E-02	6.77E-02	1.59E-03	2.96E-02	9.42E-03
RA 224	88	3.62E+00	3.91E-02	5.44E-01	6.80E-02	1.45E-01	2.85E-01	2.48E-02	4.95E-01	1.00E-01
PB 212	82	4.43E-01	4.70E-01	6.75E+00	8.23E-01	1.98E+00	3.74E+00	2.99E-01	5.96E+00	1.24E+00
BI 212	83	4.20E-02	2.19E+01	1.58E+02	3.45E+01	3.96E+01	8.28E+01	2.12E+01	9.50E+02	4.38E+01
U 234	92	8.29E+07	9.01E-05	2.28E-03	1.76E-04	4.01E-02	3.73E-02	4.27E-05	5.01E-04	3.31E-04
U 236	92	8.55E+09	3.80E-07	4.89E-04	2.90E-06	3.75E-02	3.45E-02	7.94E-09	8.41E-06	5.78E-05
U 235	92	2.57E+11	2.22E-01	4.72E+00	4.25E-01	1.53E+00	2.60E+00	1.12E-01	1.56E+00	7.24E-01
TH 231	90	1.06E+00	4.55E-03	2.09E-01	1.04E-02	4.26E-01	4.74E-01	1.70E-03	3.39E-02	2.90E-02
PA 231	91	1.36E+07	1.52E-01	1.74E+00	2.55E-01	6.64E-01	1.14E+00	1.08E-01	2.60E+00	3.58E-01
AC 227	89	7.95E+03	2.20E-04	5.06E-03	4.33E-04	5.93E-03	6.67E-03	1.05E-04	1.23E-03	7.51E-04
TH 227	90	1.87E+01	3.89E-01	5.18E+00	6.73E-01	1.58E+00	2.93E+00	2.56E-01	5.45E+00	9.81E-01
FR 223	87	1.51E-02	1.33E-01	1.71E+00	2.24E-01	7.81E-01	1.27E+00	9.62E-02	2.42E+00	3.31E-01
RA 223	88	1.14E+01	1.45E+00	1.64E+01	2.42E+00	4.50E+00	8.96E+00	1.08E+00	2.79E+01	3.39E+00
PU 237	94	4.53E+01	7.20E-02	1.81E+00	1.44E-01	7.91E-01	1.19E+00	3.31E-02	4.21E-01	2.66E-01
U 237	92	6.75E+00	3.28E-01	5.67E+00	5.95E-01	2.06E+00	3.46E+00	1.91E-01	3.45E+00	9.52E-01
NP 237	93	7.81E+08	1.20E-02	4.55E-01	2.60E-02	4.74E-01	5.89E-01	4.92E-03	9.33E-02	6.45E-02
PA 233	91	2.70E+01	1.17E+00	1.31E+01	1.96E+00	3.66E+00	7.28E+00	8.47E-01	2.11E+01	2.74E+00
U 233	92	5.58E+07	4.08E-04	9.37E-03	7.98E-04	1.73E-02	1.82E-02	1.93E-04	2.27E-03	1.39E-03
TH 229	90	2.68E+06	9.51E-02	2.41E+00	1.87E-01	1.18E+00	1.76E+00	4.76E-02	7.52E-01	3.62E-01
RA 225	88	1.48E+01	2.26E-05	8.69E-03	4.68E-05	2.13E-01	2.46E-01	1.03E-05	1.53E-04	1.09E-03
AC 225	89	1.00E+01	1.73E+00	1.68E+01	2.83E+00	4.35E+00	8.97E+00	1.40E+00	4.27E+01	3.77E+00
U 238	92	1.63E+12	3.32E-07	4.27E-04	2.55E-06	3.32E-02	3.06E-02	6.94E-09	7.35E-06	5.05E-05
TH 234	90	2.41E+01	1.60E-01	1.55E+00	2.60E-01	4.85E-01	9.15E-01	1.36E-01	4.59E+00	3.53E-01
PA 234	91	2.79E-01	1.96E+01	1.71E+02	3.15E+01	4.18E+01	8.84E+01	1.71E+01	5.64E+02	4.06E+01
AM 242M	95	5.55E+04	3.71E-04	8.56E-03	7.25E-04	1.16E-01	1.08E-01	1.75E-04	2.06E-03	1.26E-03
AM 242	95	6.68E-01	2.09E-02	5.22E-01	4.18E-02	2.90E-01	4.01E-01	9.63E-03	1.24E-01	7.69E-02
CM 242	96	1.63E+02	4.53E-09	6.96E-05	9.25E-08	4.29E-02	3.92E-02	1.41E-11	2.05E-07	8.08E-06
PU 242	94	1.37E+08	5.19E-09	7.98E-05	1.06E-07	3.40E-02	3.11E-02	1.62E-11	2.35E-07	9.25E-06

TABLE F.5. (contd)

NUCLIDE El iso #	HL (d)	Waste Transport	Waste Receiving	Incinerator Wet Scrubber	Incinerator Bag Filter	Incinerator Maintenance	Ash Trans Dumptruck	Waste Disp Landfill	Waste Treatment
Scenario Numbers ---->		1 TRANS_W	2 RECV_W	7 & 8 INCIN_1	5 & 6 INCIN_2	9 & 10 INCIN_M	11 & 12 TRANS_A	3 lfil_cr	4 PROCESS
1 2 3	4	5	6	7	8	9	10	11	12
NP 238 93	2.12E+00	6.33E+00	5.22E+01	1.01E+01	1.28E+01	2.73E+01	5.60E+00	2.01E+02	1.30E+01
PU 238 94	3.20E+04	5.55E-09	8.49E-05	1.14E-07	4.31E-02	3.94E-02	1.73E-11	2.51E-07	9.90E-06
CM 244 96	6.61E+03	3.33E-09	5.11E-05	6.80E-08	3.83E-02	3.50E-02	1.04E-11	1.51E-07	5.95E-06
PU 244 94	3.01E+10	1.32E-12	7.25E-06	3.28E-10	2.95E-02	2.69E-02	3.94E-17	4.04E-10	8.98E-07
U 240 92	5.88E-01	3.40E+00	3.01E+01	5.45E+00	7.65E+00	1.59E+01	2.90E+00	8.57E+01	7.09E+00
PU 240 94	2.40E+06	6.16E-09	9.45E-05	1.26E-07	4.10E-02	3.76E-02	1.92E-11	2.78E-07	1.10E-05
CM 245 96	3.10E+06	1.05E-01	2.57E+00	2.08E-01	1.04E+00	1.61E+00	4.86E-02	6.05E-01	3.80E-01
PU 241 94	5.26E+03	0.00E+00	3.65E-33	0.00E+00	1.12E-07	1.02E-07	0.00E+00	0.00E+00	1.32E-33
AM 241 95	1.58E+05	4.83E-06	6.56E-02	9.08E-05	3.58E-01	4.02E-01	2.60E-08	2.04E-04	7.60E-03
CM 246 96	1.73E+06	1.29E-12	7.08E-06	3.20E-10	3.41E-02	3.11E-02	3.84E-17	3.94E-10	8.75E-07
CM 247 96	5.69E+09	2.52E+00	2.51E+01	4.15E+00	6.32E+00	1.34E+01	1.94E+00	5.29E+01	5.58E+00
CM 243 96	1.04E+04	3.36E-01	5.67E+00	6.08E-01	1.83E+00	3.20E+00	1.95E-01	3.45E+00	9.60E-01
PU 243 94	1.92E-01	1.88E-02	4.96E-01	3.60E-02	2.66E-01	4.07E-01	1.17E-02	3.05E-01	7.88E-02
AM 243 95	2.69E+06	3.39E-03	5.83E-01	1.13E-02	5.98E-01	7.94E-01	8.45E-04	3.69E-02	7.33E-02
NP 239 93	2.36E+00	4.70E-01	7.76E+00	8.48E-01	2.44E+00	4.32E+00	2.80E-01	5.19E+00	1.33E+00
PU 239 94	8.81E+06	1.07E-04	2.45E-03	2.09E-04	1.70E-02	1.62E-02	5.07E-05	5.94E-04	3.63E-04
CM 248 96	1.24E+08	3.08E-09	4.72E-05	6.30E-08	2.70E-02	2.47E-02	9.60E-12	1.39E-07	5.48E-06
CF 252 98	9.63E+02	9.16E-08	1.18E-04	7.03E-07	2.71E-02	2.48E-02	1.92E-09	2.03E-06	1.40E-05

TABLE F.6. External Dose Factors Developed for Collective Worker Scenarios, mrem/h per Ci/m^3

				Incinerator			Landfill		
El	iso	at. #	HL(days)	Hi ARRAY150	Med ARRAY10M	Lo ARRAY15S	Hi LFIL_CR	Med LFIL_1M	Lo LFIL_10
1	2	3	4	5	6	7	8	9	10
H	3	1	4.49E+03	1.59E-33	1.76E-35	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BE	7	4	5.33E+01	2.44E+00	1.18E-01	2.12E-03	7.47E+00	1.43E-05	4.48E-07
BE	10	4	5.84E+08	3.59E-03	1.70E-04	4.20E-07	2.76E-03	4.25E-10	1.32E-11
C	14	6	2.09E+06	1.47E-05	7.57E-07	5.15E-11	1.76E-06	2.79E-19	7.95E-21
N	13	7	6.92E-03	4.66E+01	2.26E+00	4.07E-02	1.43E+02	2.74E-04	8.59E-06
F	18	9	7.62E-02	4.52E+01	2.19E+00	3.94E-02	1.39E+02	2.65E-04	8.32E-06
NA	22	11	9.50E+02	1.31E+02	6.52E+00	2.60E-01	6.21E+02	4.34E-02	1.47E-03
NA	24	11	6.25E-01	3.87E+02	1.99E+01	1.88E+00	3.08E+03	4.06E+00	1.58E-01
SI	31	14	1.09E-01	1.44E-01	7.04E-03	2.01E-04	5.10E-01	3.13E-05	1.06E-06
P	32	15	1.43E+01	1.19E-01	5.74E-03	7.82E-05	2.71E-01	3.34E-06	1.11E-07
P	33	15	2.54E+01	1.44E-04	7.04E-06	2.42E-09	3.93E-05	2.65E-16	7.69E-18
S	35	16	8.74E+01	1.95E-05	9.95E-07	8.17E-11	2.57E-06	1.44E-18	4.15E-20
CL	36	17	1.10E+08	7.91E-03	3.75E-04	1.56E-06	8.34E-03	3.57E-09	1.11E-10
K	40	19	4.67E+11	1.26E+01	6.38E-01	3.93E-02	7.87E+01	1.57E-02	5.44E-04
AR	39	18	9.83E+04	3.64E-03	1.73E-04	4.39E-07	2.85E-03	4.75E-10	1.47E-11
AR	41	18	7.61E-02	8.87E+01	4.46E+00	2.22E-01	4.89E+02	4.29E-02	1.45E-03
CA	41	20	3.67E+07	2.16E-27	2.39E-29	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CA	45	20	1.63E+02	1.59E-04	7.73E-06	2.78E-09	4.45E-05	4.27E-16	1.25E-17
SC	46	21	8.38E+01	1.40E+02	6.98E+00	2.98E-01	6.98E+02	4.58E-02	1.55E-03
V	48	23	16.2	196	9.68	3.32E-01	826	1.37E-01	5.02E-03
CR	51	24	2.77E+01	1.51E+00	7.25E-02	9.10E-04	3.74E+00	1.83E-06	5.65E-08
MN	54	25	3.13E+02	5.03E+01	2.49E+00	7.48E-02	2.05E+02	2.66E-03	8.66E-05
MN	56	25	1.07E-01	1.34E+02	6.78E+00	4.60E-01	8.56E+02	5.75E-01	2.16E-02
FE	55	26	9.86E+02	4.93E-27	5.47E-29	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FE	59	26	4.46E+01	7.86E+01	3.94E+00	1.86E-01	4.22E+02	3.13E-02	1.06E-03
CO	56	27	78.8	279	14.2	9.82E-01	1.82E+03	1.35	5.21E-02
CO	57	27	2.71E+02	2.75E+00	1.28E-01	1.54E-04	1.40E+00	5.58E-07	1.76E-08
CO	58	27	7.08E+01	5.82E+01	2.87E+00	8.38E-02	2.32E+02	4.24E-03	1.43E-04
CO	60	27	1.92E+03	1.79E+02	8.98E+00	4.47E-01	9.85E+02	8.63E-02	2.92E-03
NI	59	28	2.74E+07	5.99E-27	6.64E-29	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NI	63	28	3.65E+04	1.13E-08	7.29E-10	1.42E-17	2.03E-11	7.34E-34	2.00E-35
NI	65	28	1.05E-01	4.31E+01	2.18E+00	1.25E-01	2.57E+02	4.34E-02	1.50E-03
CU	64	29	5.29E-01	8.79E+00	4.27E-01	8.38E-03	2.80E+01	2.60E-04	8.70E-06
ZN	65	30	2.44E+02	4.60E+01	2.31E+00	1.14E-01	2.52E+02	2.19E-02	7.42E-04
ZN	69M	30	5.73E-01	2.22E+01	1.07E+00	1.93E-02	6.80E+01	1.30E-04	4.08E-06
ZN	69	30	3.86E-02	1.67E-02	7.93E-04	5.06E-06	2.32E-02	2.00E-08	6.26E-10
GA	72	31	5.87E-01	2.15E+02	1.09E+01	7.84E-01	1.41E+03	1.21E+00	4.61E-02
GE	68	32	288	2.16E-26	2.39E-28	0	0	0	0
AS	74	33	17.8	31.7	1.54	3.34E-02	106	1.06E-03	3.53E-05
AS	76	33	1.10E+00	2.89E+01	1.43E+00	4.91E-02	1.22E+02	2.03E-02	7.41E-04
SE	75	34	1.20E+02	1.18E+01	5.58E-01	3.94E-03	1.85E+01	1.60E-05	5.02E-07
SE	79	34	2.37E+07	9.37E-06	4.84E-07	2.89E-11	1.03E-06	1.04E-19	2.93E-21
BR	82	35	1.47E+00	1.70E+02	8.44E+00	3.03E-01	7.56E+02	4.85E-02	1.66E-03
BR	83	35	9.96E-02	3.45E-01	1.67E-02	2.91E-04	1.03E+00	1.94E-06	6.10E-08
KR	83M	36	7.63E-02	8.31E-08	7.93E-09	3.11E-24	5.23E-13	0.00E+00	0.00E+00

TABLE F.6. (contd)

El	iso	at. #	HL(days)	Incinerator Hi ARRAY15O	Incinerator Med ARRAY1OM	Incinerator Lo ARRAY15S	Landfill Hi LFIL_CR	Landfill Med LFIL_1M	Landfill Lo LFIL_10
1	2	3	4	5	6	7	8	9	10
BR	84	35	2.21E-02	1.51E+02	7.77E+00	7.27E-01	1.17E+03	2.47E+00	1.02E-01
KR	85M	36	1.87E-01	4.28E+00	2.02E-01	1.38E-03	6.31E+00	2.68E-06	8.28E-08
KR	85	36	3.91E+03	1.08E-01	5.22E-03	8.97E-05	3.18E-01	5.97E-07	1.88E-08
KR	87	36	5.30E-02	6.56E+01	3.34E+00	2.62E-01	4.53E+02	5.29E-01	2.06E-02
SR	87M	38	1.17E-01	1.27E+01	6.07E-01	7.61E-03	3.13E+01	1.53E-05	4.72E-07
RB	87	37	1.73E+13	1.90E-04	9.22E-06	3.69E-09	5.66E-05	4.67E-15	1.40E-16
KR	88	36	1.18E-01	1.67E+02	8.54E+00	7.28E-01	1.25E+03	1.07E+00	4.02E-02
RB	88	37	1.24E-02	5.88E+01	3.00E+00	2.45E-01	4.26E+02	3.92E-01	1.51E-02
KR	89	36	2.20E-03	1.48E+02	7.53E+00	6.11E-01	1.04E+03	1.73E+00	7.15E-02
RB	89	37	1.07E-02	1.62E+02	8.24E+00	5.71E-01	1.06E+03	7.86E-01	3.03E-02
SR	89	38	5.06E+01	8.62E-02	4.15E-03	6.49E-05	2.08E-01	4.38E-06	1.46E-07
KR	90	36	3.74E-04	9.22E+01	4.64E+00	2.64E-01	5.32E+02	2.39E-01	9.29E-03
RB	90M	37	2.99E-03	2.77E+02	1.42E+01	1.32E+00	2.13E+03	4.74E+00	1.97E-01
RB	90	37	1.82E-03	1.79E+02	9.30E+00	1.09E+00	1.60E+03	5.24E+00	2.22E-01
SR	90	38	1.04E+04	2.87E-03	1.36E-04	3.18E-07	2.14E-03	2.90E-10	8.95E-12
Y	88	39	106.6	188	9.48	5.36E-01	1.10E+03	3.02E-01	1.09E-02
Y	90	39	2.67E+00	2.65E-01	1.28E-02	2.37E-04	7.19E-01	2.64E-05	9.07E-07
RB	86	37	1.87E+01	6.29E+00	3.14E-01	1.40E-02	3.27E+01	1.97E-03	6.58E-05
SR	85	38	6.48E+01	2.32E+01	1.12E+00	2.03E-02	7.12E+01	1.36E-04	4.28E-06
SR	91	38	3.96E-01	4.27E+01	2.11E+00	8.06E-02	1.98E+02	1.17E-02	3.96E-04
Y	91M	39	3.45E-02	3.34E+01	1.62E+00	3.25E-02	1.07E+02	3.08E-04	9.75E-06
Y	91	39	5.85E+01	3.51E-01	1.75E-02	7.18E-04	1.65E+00	1.31E-04	4.43E-06
SR	92	38	1.13E-01	1.12E+02	5.68E+00	3.45E-01	6.94E+02	1.34E-01	4.66E-03
Y	92	39	1.48E-01	1.99E+01	9.96E-01	4.84E-02	1.07E+02	1.48E-02	5.19E-04
Y	93	39	4.21E-01	6.92E+00	3.49E-01	2.17E-02	4.16E+01	1.97E-02	7.21E-04
MO	93	42	1.28E+06	1.15E-26	1.28E-28	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ZR	93	40	5.58E+08	4.38E-09	2.95E-10	2.59E-18	4.02E-12	2.70E-38	0.00E+00
NB	93M	41	5.33E+03	2.62E-16	3.55E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ZR	95	40	6.40E+01	4.32E+01	2.12E+00	5.64E-02	1.63E+02	1.61E-03	5.24E-05
NB	95M	41	3.61E+00	1.98E+00	9.37E-02	4.18E-04	2.62E+00	4.34E-08	1.34E-09
NB	95	41	3.51E+01	5.03E+01	2.49E+00	7.47E-02	2.05E+02	2.65E-03	8.65E-05
ZR	97	40	7.04E-01	1.23E+01	6.12E-01	2.88E-02	6.32E+01	1.11E-02	3.93E-04
NB	97M	41	6.94E-04	3.44E+01	1.67E+00	3.35E-02	1.10E+02	3.18E-04	1.01E-05
NB	97	41	5.01E-02	3.58E+01	1.74E+00	3.65E-02	1.17E+02	8.13E-04	2.69E-05
NB	94	41	7.41E+06	8.54E+01	4.19E+00	1.09E-01	3.18E+02	2.98E-03	9.69E-05
MO	99	42	2.75E+00	7.43E+00	3.62E-01	8.07E-03	2.49E+01	1.65E-04	5.35E-06
TC	99M	43	2.51E-01	2.49E+00	1.16E-01	8.64E-05	1.11E+00	1.15E-11	3.35E-13
TC	99	43	7.77E+07	2.60E-04	1.25E-05	5.73E-09	8.28E-05	3.07E-14	9.23E-16
TC	101	43	9.86E-03	1.67E+01	8.05E-01	1.11E-02	4.33E+01	7.06E-05	2.28E-06
RU	103	44	3.94E+01	2.32E+01	1.12E+00	2.04E-02	7.13E+01	1.43E-04	4.50E-06
PD	103	46	1.70E+01	4.74E-03	2.27E-04	2.85E-06	1.17E-02	5.74E-09	1.77E-10
RH	103M	45	3.90E-02	1.17E-07	1.12E-08	4.32E-24	7.27E-13	0.00E+00	0.00E+00
RU	105	44	1.85E-01	3.99E+01	1.94E+00	4.05E-02	1.29E+02	1.22E-03	4.01E-05
RH	105	45	1.47E+00	3.76E+00	1.80E-01	2.26E-03	9.29E+00	4.53E-06	1.40E-07
RU	106	44	3.68E+02	1.19E+01	5.82E-01	1.55E-02	4.39E+01	2.21E-03	7.71E-05
PD	107	46	2.37E+09	3.59E-15	4.86E-16	0.00E+00	0.00E+00	0.00E+00	0.00E+00

TABLE F.6. (contd)

				Incinerator			Landfill		
		at.		Hi	Med	Lo	Hi	Med	Lo
El	iso	#	HL(days)	ARRAY150	ARRAY10M	ARRAY15S	LFIL_CR	LFIL_1M	LFIL_10
1	2	3	4	5	6	7	8	9	10
PD	109	46	5.61E-01	8.11E-02	3.91E-03	3.59E-05	1.38E-01	2.26E-07	7.12E-09
AG	110M	47	2.50E+02	1.76E+02	8.75E+00	3.37E-01	8.13E+02	7.34E-02	2.53E-03
AG	111	47	7.46E+00	1.17E+00	5.59E-02	6.65E-04	2.77E+00	1.46E-06	4.53E-08
CD	109	48	4.64E+02	1.27E-08	1.73E-09	0.00E+00	2.55E-36	0.00E+00	0.00E+00
CD	113M	48	5.00E+03	3.60E-03	1.71E-04	4.63E-07	2.92E-03	5.84E-10	1.81E-11
CD	115M	48	4.46E+01	1.67E+00	8.34E-02	3.68E-03	8.52E+00	5.77E-04	1.94E-05
CD	115	48	2.23E+00	9.05E+00	4.38E-01	7.74E-03	2.73E+01	5.17E-05	1.62E-06
IN	115M	49	1.82E-01	7.20E+00	3.45E-01	4.33E-03	1.78E+01	8.77E-06	2.70E-07
IN	111	49	2.83E+00	9.89E+00	4.67E-01	1.64E-03	1.09E+01	9.16E-08	2.75E-09
IN	114M	49	5.00E+01	5.62E+00	2.72E-01	5.29E-03	1.71E+01	1.36E-04	4.49E-06
SN	113	50	1.15E+02	1.52E-01	7.20E-03	3.23E-05	2.02E-01	5.03E-09	1.56E-10
IN	113M	49	6.91E-02	9.98E+00	4.79E-01	6.01E-03	2.47E+01	1.21E-05	3.73E-07
SN	117M	50	1.40E+01	2.47E+00	1.15E-01	8.59E-05	1.10E+00	1.14E-11	3.33E-13
SN	119M	50	2.93E+02	4.17E-05	2.15E-06	6.78E-12	1.51E-06	1.33E-26	3.62E-28
SN	121M	50	2.01E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SN	121	50	1.13E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SN	123	50	1.29E+02	5.08E-01	2.53E-02	1.04E-03	2.47E+00	1.43E-04	4.78E-06
SN	125	50	9.64E+00	2.19E+01	1.10E+00	5.86E-02	1.23E+02	3.93E-02	1.44E-03
SB	125	51	1.01E+03	2.26E+01	1.09E+00	2.07E-02	7.01E+01	1.72E-04	5.43E-06
TE	125M	52	5.80E+01	7.96E-03	3.73E-04	2.75E-07	3.53E-03	3.66E-14	1.06E-15
SN	126	50	3.65E+07	3.40E-01	1.65E-02	1.94E-06	6.93E-02	1.00E-15	2.84E-17
SB	126M	51	1.32E-02	8.37E+01	4.07E+00	8.37E-02	2.72E+02	1.99E-03	6.59E-05
SB	126	51	1.24E+01	1.46E+02	7.13E+00	1.58E-01	4.94E+02	5.38E-03	1.78E-04
SB	122	51	2.70E+00	2.76E+01	1.34E+00	2.90E-02	9.17E+01	9.23E-04	3.07E-05
SB	124	51	6.02E+01	1.37E+02	6.89E+00	3.80E-01	7.73E+02	2.35E-01	8.44E-03
SB	127	51	3.85E+00	3.49E+01	1.70E+00	3.77E-02	1.18E+02	1.01E-03	3.32E-05
TE	127M	52	1.09E+02	5.02E-03	2.46E-04	3.89E-06	1.30E-02	3.66E-08	1.16E-09
TE	127	52	3.90E-01	2.62E-01	1.26E-02	2.15E-04	7.67E-01	1.38E-06	4.34E-08
SB	129	51	1.83E-01	9.52E+01	4.75E+00	2.03E-01	4.71E+02	6.08E-02	2.15E-03
TE	129M	52	3.36E+01	1.60E+00	7.78E-02	1.55E-03	5.10E+00	1.51E-05	4.78E-07
TE	129	52	4.83E-02	2.82E+00	1.37E-01	3.14E-03	9.61E+00	1.96E-04	6.55E-06
I	129	53	5.73E+09	4.40E-05	3.76E-06	3.22E-11	1.14E-06	1.18E-19	3.32E-21
TE	123M	52	1.20E+02	2.35E+00	1.09E-01	8.16E-05	1.05E+00	1.09E-11	3.16E-13
TE	131M	52	1.25E+00	9.34E+01	4.65E+00	1.88E-01	4.41E+02	7.27E-02	2.64E-03
TE	131	52	1.74E-02	2.16E+01	1.06E+00	3.40E-02	8.67E+01	4.59E-03	1.55E-04
I	131	53	8.04E+00	1.64E+01	7.88E-01	1.09E-02	4.24E+01	4.58E-05	1.44E-06
XE	131M	54	1.18E+01	5.48E-02	2.55E-03	1.90E-06	2.45E-02	2.53E-13	7.36E-15
TE	132	52	3.26E+00	7.00E+00	3.32E-01	1.46E-03	9.18E+00	8.58E-08	2.58E-09
I	132	53	9.58E-02	1.43E+02	7.06E+00	2.47E-01	6.18E+02	6.76E-02	2.42E-03
TE	133M	52	3.85E-02	1.54E+02	7.70E+00	3.57E-01	7.97E+02	1.57E-01	5.67E-03
TE	133	52	8.65E-03	5.92E+01	2.94E+00	1.20E-01	2.77E+02	5.11E-02	1.84E-03
I	133	53	8.67E-01	2.93E+01	1.43E+00	3.44E-02	1.03E+02	2.37E-03	7.98E-05
XE	133M	54	2.19E+00	8.07E-01	3.83E-02	1.70E-04	1.07E+00	1.00E-08	3.02E-10
XE	133	54	5.25E+00	2.58E-01	1.25E-02	1.62E-06	5.56E-02	3.38E-13	1.02E-14
TE	134	52	2.90E-02	4.48E+01	2.19E+00	4.92E-02	1.50E+02	1.49E-03	4.89E-05

TABLE F.6. (contd)

				Incinerator			Landfill		
		at.		Hi	Med	Lo	Hi	Med	Lo
El	iso	#	HL(days)	ARRAY150	ARRAY10M	ARRAY15S	LFIL_CR	LFIL_1M	LFIL_10
1	2	3	4	5	6	7	8	9	10
I	134	53	3.65E-02	1.68E+02	8.35E+00	3.37E-01	7.94E+02	1.19E-01	4.27E-03
XE	122	54	8.38E-02	5.05E+01	2.46E+00	5.64E-02	1.71E+02	1.60E-02	5.86E-04
XE	125	54	7.00E-01	7.53E+00	3.63E-01	6.69E-03	1.96E+01	7.25E-04	2.44E-05
I	125	53	6.01E+01	5.23E-05	4.99E-06	1.96E-21	3.29E-10	0.00E+00	0.00E+00
I	126	53	13.0	24.1	1.17	2.60E-02	81.4	6.97E-04	2.29E-05
CS	134M	55	1.21E-01	3.61E-01	1.68E-02	1.25E-05	1.61E-01	1.67E-12	4.85E-14
CS	134	55	7.53E+02	9.62E+01	4.73E+00	1.29E-01	3.66E+02	8.36E-03	2.83E-04
I	130	53	5.15E-01	1.09E+02	5.31E+00	1.23E-01	3.75E+02	7.03E-03	2.37E-04
I	135	53	2.75E-01	1.19E+02	6.02E+00	3.43E-01	7.04E+02	1.65E-01	5.93E-03
XE	135M	54	1.07E-02	1.89E+01	9.17E-01	1.65E-02	5.81E+01	1.11E-04	3.49E-06
XE	135	54	3.80E-01	8.27E+00	3.94E-01	2.65E-03	1.32E+01	1.07E-05	3.38E-07
CS	135	55	8.40E+08	4.39E-05	2.19E-06	4.19E-10	8.59E-06	3.42E-17	9.94E-19
XE	137	54	2.66E-03	1.23E+01	6.06E-01	2.23E-02	5.26E+01	2.82E-02	1.16E-03
CS	137	55	1.10E+04	2.99E+01	1.45E+00	2.91E-02	9.58E+01	2.76E-04	8.73E-06
XE	138	54	9.81E-03	9.07E+01	4.61E+00	3.44E-01	6.17E+02	4.12E-01	1.52E-02
CS	138	55	2.24E-02	1.91E+02	9.70E+00	6.68E-01	1.25E+03	7.75E-01	2.94E-02
CS	139	55	6.53E-03	2.56E+01	1.30E+00	9.11E-02	1.69E+02	1.25E-01	4.89E-03
BA	139	56	5.77E-02	1.16E+00	5.60E-02	1.50E-03	3.47E+00	4.80E-04	1.66E-05
BA	140	56	1.28E+01	8.12E+00	3.93E-01	6.73E-03	2.40E+01	4.32E-05	1.36E-06
LA	140	57	1.68E+00	1.62E+02	8.17E+00	4.62E-01	9.45E+02	2.60E-01	9.42E-03
CS	136	55	1.32E+01	1.34E+02	6.64E+00	2.50E-01	6.18E+02	2.90E-02	9.71E-04
BA	141	56	1.27E-02	4.95E+01	2.45E+00	9.67E-02	2.23E+02	4.20E-02	1.51E-03
LA	141	57	1.64E-01	3.99E+00	2.02E-01	1.21E-02	2.42E+01	5.11E-03	1.78E-04
CE	141	58	3.25E+01	1.36E+00	6.31E-02	4.71E-05	6.05E-01	1.69E-10	5.21E-12
BA	142	56	7.43E-03	5.78E+01	2.88E+00	1.21E-01	2.84E+02	2.11E-02	7.15E-04
LA	142	57	6.63E-02	2.38E+02	1.22E+01	1.12E+00	1.83E+03	3.00E+00	1.22E-01
CE	143	58	1.38E+00	9.43E+00	4.55E-01	6.99E-03	2.43E+01	2.23E-04	7.45E-06
PR	143	59	1.36E+01	1.68E-02	7.99E-04	5.06E-06	2.33E-02	2.04E-08	6.39E-10
CE	144	58	2.84E+02	3.14E-01	1.46E-02	1.06E-05	1.37E-01	1.48E-12	4.32E-14
PR	144M	59	5.00E-03	8.67E-04	5.77E-05	3.09E-13	5.19E-07	3.13E-33	8.37E-35
PR	144	59	1.20E-02	2.96E+00	1.49E-01	9.65E-03	1.80E+01	1.17E-02	4.35E-04
PR	142	59	7.97E-01	4.56E+00	2.30E-01	1.38E-02	2.78E+01	5.44E-03	1.89E-04
ND	147	60	1.10E+01	4.64E+00	2.24E-01	3.66E-03	1.31E+01	2.43E-05	7.64E-07
PM	147	61	9.58E+02	1.49E-04	7.14E-06	3.66E-09	5.17E-05	4.57E-16	1.33E-17
SM	147	62	3.87E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PM	148M	61	4.13E+01	1.18E+02	5.76E+00	1.47E-01	4.29E+02	9.18E-03	3.06E-04
PM	148	61	5.37E+00	4.34E+01	2.18E+00	1.10E-01	2.37E+02	3.54E-02	1.23E-03
PM	149	61	2.21E+00	4.24E-01	2.03E-02	2.39E-04	9.07E-01	3.74E-06	1.21E-07
PM	151	61	1.18E+00	1.43E+01	6.90E-01	1.16E-02	3.98E+01	2.30E-04	7.50E-06
SM	151	62	3.29E+04	5.41E-08	3.28E-09	8.64E-16	3.25E-10	1.83E-29	5.05E-31
SM	153	62	1.95E+00	8.92E-01	4.19E-02	8.55E-05	5.62E-01	3.83E-07	1.20E-08
EU	152M	63	3.88E-01	1.99E+01	9.90E-01	3.85E-02	9.39E+01	5.09E-03	1.72E-04
EU	152	63	4.96E+03	7.72E+01	3.86E+00	1.79E-01	4.00E+02	4.55E-02	1.56E-03
EU	154	63	3.21E+03	7.89E+01	3.93E+00	1.66E-01	3.88E+02	2.83E-02	9.58E-04
EU	155	63	1.81E+03	8.00E-01	3.77E-02	2.14E-05	3.04E-01	2.67E-12	7.77E-14

TABLE F.6. (contd)

				Incinerator			Landfill		
		at.		Hi	Med	Lo	Hi	Med	Lo
El	iso	#	HL(days)	ARRAY150	ARRAY10M	ARRAY15S	LFIL_CR	LFIL_1M	LFIL_10
1	2	3	4	5	6	7	8	9	10
EU	156	63	1.52E+01	1.05E+02	5.31E+00	3.51E-01	6.68E+02	3.47E-01	1.28E-02
GD	153	64	2.42E+02	9.72E-01	4.59E-02	2.61E-05	3.83E-01	2.90E-12	8.43E-14
GD	159	64	7.73E-01	1.39E+00	6.65E-02	8.20E-04	3.38E+00	1.66E-06	5.11E-08
TB	160	65	7.23E+01	6.85E+01	3.42E+00	1.42E-01	3.36E+02	2.09E-02	7.02E-04
TB	161	65	6.91E+00	4.94E-02	2.51E-03	2.55E-07	5.67E-03	1.57E-10	4.84E-12
DY	165	66	9.73E-02	9.55E-01	4.62E-02	7.89E-04	2.72E+00	6.77E-06	2.14E-07
HO	166M	67	4.38E+05	8.19E+01	4.01E+00	1.03E-01	2.97E+02	5.12E-03	1.71E-04
HO	166	67	1.12E+00	1.72E+00	8.68E-02	4.97E-03	1.00E+01	2.02E-03	7.03E-05
ER	169	68	9.40E+00	5.24E-04	2.50E-05	1.74E-08	2.06E-04	3.28E-13	9.86E-15
ER	171	68	3.13E-01	1.46E+01	7.00E-01	8.60E-03	3.38E+01	1.81E-04	5.99E-06
TA	182	73	1.15E+02	9.01E+01	4.52E+00	2.20E-01	4.86E+02	4.22E-02	1.43E-03
W	181	74	1.21E+02	7.55E-02	4.03E-03	1.41E-07	3.06E-03	1.81E-14	5.27E-16
W	185	74	7.51E+01	1.72E-03	8.12E-05	8.66E-08	8.53E-04	1.70E-11	5.23E-13
W	187	74	9.93E-01	2.36E+01	1.15E+00	2.33E-02	7.59E+01	3.03E-04	9.70E-06
RE	187	75	1.72E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
OS	185	76	9.36E+01	3.60E+01	1.76E+00	3.80E-02	1.20E+02	5.95E-04	1.92E-05
OS	191	76	1.54E+01	8.63E-01	4.08E-02	2.52E-05	3.32E-01	3.35E-12	9.73E-14
IR	192	77	7.40E+01	3.88E+01	1.87E+00	2.82E-02	1.05E+02	1.62E-04	5.11E-06
HG	203	80	4.66E+01	6.13E+00	2.91E-01	1.28E-03	8.03E+00	7.53E-08	2.26E-09
BI	207	83	1.39E+04	97.0	4.83	2.04E-01	477	3.48E-02	1.17E-03
TH	230	90	2.81E+07	2.70E-03	1.30E-04	6.70E-08	8.88E-04	8.91E-15	2.59E-16
RA	226	88	5.84E+05	9.75E-02	4.55E-03	3.84E-06	4.46E-02	1.24E-09	3.83E-11
RN	222	86	3.82E+00	1.26E+02	6.34E+00	3.60E-01	7.23E+02	2.75E-01	1.01E-02
PB	210	82	8.12E+03	5.14E-04	3.39E-05	5.50E-16	5.79E-08	8.99E-39	0.00E+00
BI	210	83	5.01E+00	3.04E-02	1.45E-03	1.22E-05	5.10E-02	9.46E-08	3.03E-09
PO	210	84	1.38E+02	5.33E-04	2.64E-05	7.93E-07	2.18E-03	2.81E-08	9.18E-10
PU	236	94	1.04E+03	1.71E-04	8.83E-06	2.79E-11	6.22E-06	5.46E-26	1.49E-27
U	232	92	2.36E+04	2.21E-03	1.04E-04	7.07E-08	9.11E-04	9.42E-15	2.74E-16
TH	232	90	5.13E+12	1.33E-03	6.34E-05	4.07E-08	5.25E-04	5.43E-15	1.58E-16
RA	228	88	2.10E+03	9.41E-13	9.05E-14	3.45E-29	5.80E-18	0.00E+00	0.00E+00
AC	228	89	2.55E-01	6.44E+01	3.22E+00	1.44E-01	3.30E+02	3.28E-02	1.13E-03
TH	228	90	6.98E+02	3.38E-02	1.61E-03	4.23E-06	2.96E-02	2.33E-10	7.00E-12
RA	224	88	3.62E+00	3.40E-01	1.62E-02	8.97E-05	4.95E-01	2.07E-07	6.54E-09
PB	212	82	4.43E-01	4.21E+00	2.00E-01	1.05E-03	5.96E+00	6.78E-07	2.09E-08
BI	212	83	4.20E-02	1.24E+02	6.36E+00	5.87E-01	9.50E+02	1.42E+00	5.52E-02
U	234	92	8.29E+07	1.22E-03	5.76E-05	3.89E-08	5.01E-04	5.18E-15	1.50E-16
U	236	92	8.55E+09	2.31E-04	1.19E-05	3.77E-11	8.41E-06	7.91E-26	2.16E-27
U	235	92	2.57E+11	2.62E+00	1.22E-01	1.69E-04	1.56E+00	5.66E-09	1.70E-10
TH	231	90	1.06E+00	1.12E-01	5.33E-03	1.87E-06	3.39E-02	2.07E-13	6.04E-15
PA	231	91	1.36E+07	1.17E+00	5.62E-02	6.10E-04	2.60E+00	1.16E-06	3.59E-08
AC	227	89	7.95E+03	2.75E-03	1.28E-04	9.53E-08	1.23E-03	1.27E-14	3.69E-16
TH	227	90	1.87E+01	3.30E+00	1.57E-01	1.09E-03	5.45E+00	1.33E-06	4.09E-08
FR	223	87	1.51E-02	1.09E+00	5.28E-02	6.78E-04	2.42E+00	1.22E-05	3.96E-07
RA	223	88	1.14E+01	1.09E+01	5.28E-01	7.82E-03	2.79E+01	1.20E-04	3.88E-06
PU	237	94	4.53E+01	9.83E-01	4.59E-02	3.12E-05	4.21E-01	3.93E-12	1.14E-13

TABLE F.6. (contd)

El 1	iso 2	at. # 3	HL(days) 4	Incinerator Hi ARRAY150 5	Incinerator Med ARRAY10M 6	Incinerator Lo ARRAY15S 7	Landfill Hi LFIL_CR 8	Landfill Med LFIL_1M 9	Landfill Lo LFIL_10 10
U	237	92	6.75E+00	3.34E+00	1.58E-01	5.45E-04	3.45E+00	2.70E-07	8.32E-09
NP	237	93	7.81E+08	2.46E-01	1.17E-02	7.08E-06	9.33E-02	1.56E-10	4.70E-12
PA	233	91	2.70E+01	8.91E+00	4.27E-01	5.13E-03	2.11E+01	1.18E-05	3.66E-07
U	233	92	5.58E+07	5.08E-03	2.37E-04	1.76E-07	2.27E-03	2.35E-14	6.83E-16
TH	229	90	2.68E+06	1.33E+00	6.29E-02	8.38E-05	7.52E-01	3.32E-09	9.99E-11
RA	225	88	1.48E+01	4.34E-03	2.79E-04	1.26E-08	1.53E-04	2.42E-13	7.29E-15
AC	225	89	1.00E+01	1.17E+01	5.73E-01	1.58E-02	4.27E+01	3.42E-03	1.18E-04
U	238	92	1.63E+12	2.02E-04	1.04E-05	3.29E-11	7.35E-06	6.62E-26	1.81E-27
TH	234	90	2.41E+01	1.08E+00	5.34E-02	1.87E-03	4.59E+00	2.41E-04	8.06E-06
PA	234	91	2.79E-01	1.21E+02	6.02E+00	2.36E-01	5.64E+02	5.40E-02	1.88E-03
AM	242M	95	5.55E+04	4.63E-03	2.16E-04	1.60E-07	2.06E-03	2.13E-14	6.19E-16
AM	242	95	6.68E-01	2.84E-01	1.33E-02	9.48E-06	1.24E-01	9.61E-10	2.99E-11
CM	242	96	1.63E+02	3.23E-05	1.78E-06	1.45E-13	2.05E-07	1.47E-33	3.95E-35
PU	242	94	1.37E+08	3.70E-05	2.05E-06	1.67E-13	2.35E-07	1.69E-33	4.53E-35
NP	238	93	2.12E+00	3.84E+01	1.92E+00	8.60E-02	2.01E+02	1.20E-02	4.03E-04
PU	238	94	3.20E+04	3.96E-05	2.18E-06	1.78E-13	2.51E-07	1.81E-33	4.84E-35
CM	244	96	6.61E+03	2.38E-05	1.31E-06	1.07E-13	1.51E-07	1.09E-33	2.90E-35
PU	244	94	3.01E+10	3.59E-06	2.37E-07	3.83E-18	4.04E-10	0.00E+00	0.00E+00
U	240	92	5.88E-01	2.13E+01	1.05E+00	3.26E-02	8.57E+01	5.51E-03	1.90E-04
PU	240	94	2.40E+06	4.39E-05	2.42E-06	1.98E-13	2.78E-07	2.00E-33	5.36E-35
CM	245	96	3.10E+06	1.40E+00	6.51E-02	4.54E-05	6.05E-01	5.81E-12	1.69E-13
PU	241	94	5.26E+03	5.28E-33	5.86E-35	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AM	241	95	1.58E+05	3.04E-02	1.68E-03	1.96E-10	2.04E-04	1.26E-25	3.43E-27
CM	246	96	1.73E+06	3.50E-06	2.31E-07	3.74E-18	3.94E-10	0.00E+00	0.00E+00
CM	247	96	5.69E+09	1.76E+01	8.54E-01	1.49E-02	5.29E+01	9.90E-05	3.11E-06
CM	243	96	1.04E+04	3.36E+00	1.58E-01	5.09E-04	3.45E+00	2.79E-08	8.40E-10
PU	243	94	1.92E-01	2.87E-01	1.38E-02	6.51E-05	3.05E-01	1.28E-07	3.93E-09
AM	243	95	2.69E+06	2.91E-01	1.44E-02	1.04E-06	3.69E-02	8.79E-14	2.55E-15
NP	239	93	2.36E+00	4.63E+00	2.18E-01	8.78E-04	5.19E+00	7.03E-07	2.17E-08
PU	239	94	8.81E+06	1.33E-03	6.19E-05	4.62E-08	5.94E-04	6.15E-15	1.79E-16
CM	248	96	1.24E+08	2.19E-05	1.21E-06	9.88E-14	1.39E-07	1.00E-33	2.68E-35
CF	252	98	9.63E+02	5.59E-05	2.88E-06	9.11E-12	2.03E-06	1.79E-26	4.87E-28

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APPENDIX G

WORKER SCENARIO DESCRIPTIONS

APPENDIX G

WORKER SCENARIO DESCRIPTIONS

Potential doses to workers are based on scenarios that describe the interaction of workers with waste or with residual material (slag and fly ash) from incineration. The individual worker scenarios describe the activities that have potential to result in the highest radiation exposures. Collective worker dose is estimated using generic exposure scenarios, including high-, medium-, and low-exposure categories for both incineration and landfill activities.

There are nine scenarios describing activities performed by individual workers. Five scenarios deal with the transport and handling of waste, including landfilling, and eight scenarios deal with incineration: four distinct scenarios for two different types of incinerators. The base case incinerator is a rotary kiln, which is assumed to treat mostly solid waste. The residual material is assumed to contain 70% of the initial mass of the treated waste. The second type of incinerator considered is a liquid-injection incinerator, which is assumed to produce 2% residual ash. (Percentages based on reports by Chew and Associates [1992, 1993a-e] and data from Chew and Associates.)

Table G.1 lists the scenarios for individual workers, the applicable exposure medium, and the assumed waste form, as modeled in the dose calculation program. The program is described in Appendix D, "Calculation Methodology for Radiation Doses." Generic scenario parameters used in the program are listed in Table G.2.

The nine individual worker scenarios are for the maximum exposed worker and are described in the following paragraphs, followed by a summary of scenario values presented in Table G.3. The individual scenarios were developed based on conditions assumed to be encountered in the workplace.

TABLE G.1. Scenarios Used to Calculate Doses to Individual Workers

No.	Scenario Description	Medium	Waste Form
1	Waste transport	Waste	Waste in drums
2	Waste receiving	Waste	Waste in drums
3	Waste disposal	Waste	Bulk waste
4	Landfill excavation	Waste	Waste in drums or bulk
5	Waste treatment	Waste	Bulk waste
6a	Incineration/bag filter	Fly ash	Misc. solids (residue 70%)
6b	Incineration/bag filter	Fly ash	Organic liquids (2% ash)
7a	Incineration/wet scrubber	Fly ash	Misc. solids (residue 70%)
7b	Incineration/wet scrubber	Fly ash	Organic liquids (2% ash)
8a	Incinerator maintenance	Slag	Misc. solids (residue 70%)
8b	Incinerator maintenance	Slag	Organic liquids (2% ash)
9a	Ash Transport (dump truck)	All residue	Misc. solids (residue 70%)
9b	Ash transport (dump truck)	All residue	Organic liquids (2% ash)

TABLE G.2. Generic Scenario Parameters

Parameter	Value	Definition, Units
C_{Waste}	1.0	Waste concentration, pCi/g
FCW	1.0	Fraction contaminated waste
R_{Inhal}	1.2	Inhalation rate, m^3/h
R_{Inges}	0.01	Dust ingestion rate, g/h
D_{Slag}	1.5	Density of slag, g/cm^3

TABLE G.3. Exposure Parameters for Individual Workers

No.	Scenario	Medium	Inhalation		Ingestion	External
			t_{INH}, h	C_d, g/m^3[a]	t_{ING}, h[b]	t_{EXT}, h[c]
1	Waste transport	Waste	0	0	0	2250
2	Waste receiving	Waste	2000	5.0E-05	500	2000
3	Waste disposal	Waste	2000	1.0E-05	250	1500
4	Landfill excavation	Waste	20	1.0E-06	6	20
5	Waste treatment	Waste	1500	1.0E-05	250	1500
6a	Incinerator/bag filter	Fly ash	2000	8.0E-06	500	2000
6b	Incinerator/bag filter [d]	Fly ash	200	8.0E-06	200	200
7a	Incinerator/wet scrubber	Fly ash	2000	8.0E-06	500	2000
7b	Incinerator/wet scrubber[d]	Fly ash	200	8.0E-06	200	200
8a	Incinerator maintenance	Slag	2000	9.0E-06	500	2000
8b	Incinerator maintenance[d]	Slag	500	9.0E-06	100	500
9a	Ash transport (dump truck)	Residue[e]	50	1.0E-04	0	2250
9b	Ash transport (dump truck)[d]	Residue[e]	10	1.0E-04	0	500

(a) Dust loading is a weighted sum of conditions and protective equipment for each activity constituting the scenario.
(b) Secondary or incidental ingestion, at a rate of 10 mg/h, is assumed to occur when there is potential for exposure to contaminated dust and the individual is not wearing two sets of gloves.
(c) Exposure durations are 2000 h/y for occupational exposure, except for truck transport where sleeping time is included, and landfill. The time away from a contaminated zone for the landfill scenarios (#3 and #4) is not averaged into the external dose factor.
(d) Exposure parameters for liquid-only incinerator.
(e) Residue = total fly ash plus slag.

1. Waste Transport. This scenario describes external radiation doses to a long-haul truck driver carrying a load of waste in drums from a DOE facility to the incineration or landfill facility. It is assumed that there is no potential for inhalation or secondary ingestion of contaminated material.

2. Waste Receiving. This scenario describes an individual sampling the waste and preparing it for incineration. The dose factor used to calculate external dose is based on exposure to contaminated materials over 6-hours per 8-hour workday. The individual receives both external radiation exposure and internal radiation exposure by inhalation of and incidental ingestion of particulate material.

3. Waste Disposal in Landfill. This scenario describes a worker transporting miscellaneous solids to a landfill. The individual is assumed to receive both external radiation exposure and internal radiation exposure by inhalation and ingestion of particulate material. Incidental ingestion is assumed to occur only 1 h/d (or one event per day) because protective clothing is worn.

4. Landfill Excavation. This scenario describes a worker excavating previously buried waste to recover an item. The excavation is assumed to take 20 hours, during which there is external radiation exposure and inhalation of particulate matter. Respiratory protection provided by a full mask is assumed. Incidental ingestion is assumed to occur 2 hours per work day, or a total of 6 hours. The incidental ingestion exposure is minimized (two events per day) because protective clothing is worn. The external dose factor for the landfill scenario (Scenario 3, above) is used.

5. Waste Treatment. This scenario describes treatment of miscellaneous solid waste materials in a generic manner. The scenario may apply to bulk mixing of waste materials with stabilizers. The external dose factor is based on proximity to process equipment for 6 hours per day. Again, incidental ingestion is minimized (one event per day) because protective clothing is worn. The inhalation dose is based on exposure to high dust levels (100 mg/m^3), but with a full-face respirator for 10% of the workday.

6a. Bag Filter Operations (Solids Incineration). This scenario describes a worker servicing the air filtration system who is exposed to fly ash from incineration of solid hazardous waste. The dose factor used to calculate external dose is based on exposure to contaminated materials 6 hours per 8-hour workday. This worker is assumed to receive internal radiation exposure via inhalation and incidental ingestion of particulate material.

6b. Bag Filter Operations (Liquids Incineration). This scenario is identical to Scenario 6a, above, except the concentration of residue is

greater and the exposure hours are reduced. The differences result from greater mass reduction and less residual material from a liquids-only incinerator, as noted previously.

7a. Wet Scrubber Operations (Solids Incineration). This scenario describes a worker servicing the filter press and other equipment associated with sludge containing contaminated fly ash. Sludge containing fine particulate matter would be produced by an air pollution control system that includes a wet scrubber. The dose factor used to calculate external dose is based on exposure to contaminated materials 6 hours per 8-hour workday. This worker is assumed to receive internal radiation exposure via inhalation and ingestion of particulate matter.

7b. Wet Scrubber Operations (Liquids Incineration). This scenario is identical to scenario 7a, above, except the concentration of residue is greater and the exposure hours are reduced. Differences between the two scenarios result from differences in the mass reduction ratio and in the quantity of residual material, as noted previously.

8a. Incinerator Maintenance (Solids Incineration). This scenario describes a worker who participates in clean-out of the rotary kiln or afterburner chamber during shutdowns for periodic routine maintenance. During operation of the incinerator, the worker is also assumed to be exposed to incinerator residues. Exposure pathways include external radiation exposure and internal radiation exposure via inhalation and incidental ingestion of particulate matter.

8b. Incinerator Maintenance (Liquids Incineration). This scenario is identical to Scenario 8a, above, except the concentration of residue is greater and the exposure hours are reduced. Differences between the two scenarios result from differences in the mass reduction ratio and in the quantity of residual material, as noted previously.

9a. Transport of Ash (Solids Incineration). This scenario describes a driver operating a dump truck to haul the residues from a hazardous waste

incinerator to a landfill disposal site. The residue materials are assumed to be a composite of slag and fly ash produced by the incineration of solid waste. The exposure pathways considered are external radiation exposure and internal exposure via inhalation of particulate matter. A limited amount of inhalation exposure is assumed to result from the dumping of bulk residue materials.

9b. Transport of Ash (Liquids Incineration). This scenario is identical to Scenario 9a, above, except the concentration of residue is greater and the exposure hours are reduced. Differences between the two scenarios result from differences in the mass reduction ratio and in the quantity of residual material, as noted above.

Table G.4 shows scenario assumptions, including time distribution used to calculate external dose factors and dust concentrations, based on worker activities. A more detailed description of the calculations performed to produce the external dose factors is given in Appendix E, "External Dose Calculations for Worker Scenarios."

Exposure parameters were developed primarily for waste-handling and residue-handling based on incineration of solid materials with a large fraction of residual ash. The same external dose factors are used for the scenarios based on liquid-injection incineration, but exposure hours are reduced to compensate for the reduced amount of material. In addition, such a facility would require fewer workers to handle wastes and residues.

Collective worker dose is estimated using generic exposure scenarios. Six generic scenarios, including high-, medium-, and low-exposure categories for both incineration and landfill activities, are described below. Details of the external dose factors developed for these scenarios are described in Appendix E, "External Dose Calculations for Worker Scenarios."

1. Incinerator--High-Exposure. This scenario describes generic work activities with a high potential for exposure to waste or residual materials. The exposure to external radiation and inhalation of particulate material is

TABLE G.4. Development of Exposure Parameters Used for Worker Scenarios

Scenario No.	Scenario Description	Activity	External[a] Time, h/d	External[a] Fraction of Time	External[a] Dust, g/m³	Inhalation Reduction Factor	Inhalation Effective Conc.,[b] g/m³
1	Waste transport	Driving Sleeping	10[c] 8	0.56 0.44	NA[d] NA	NA NA	- -
2	Waste receiving	Sampling Near drums Remote from source	4 2 2	0.5 0.25 0.25	1E-3 1E-5 NA	0.1 - - Total	5E-5 2.5E-6 - 5E-5
3	Waste disposal	1 m from area source	8.0	1.0	0.1	1E-5 Total	1E-6 1E-6
4	Landfill excavation	1 m from area source	20 h total	1E-3	0.001	1E-6	1E-6 (20 h)
5	Waste treatment	1.5 m from drum array 1.5 m from bin Stabilizing (mixing)	2 4	0.25 0.5 0.1	- - 0.1	- - 1E-3 Total	- - 1E-5 1E-5
6	Incineration/bag filter	10 cm from bag filter 2 m from filter 10 m from source Remote from source	1 5 4 2	0.1 0.5 0.15 0.25	1E-5 1E-5 1E-5 NA	- - - - Total	1.E-6 5.E-6 1.5E-6 - 7.5E-6(8E-6)
7	Incineration/wet scrub	Filter press 10 m from sludge tank Remote from source	2 4 2	0.25 0.5 0.25	1E-5 1E-5 NA	- - - Total	2.5E-6 5.E-6 - 7.5E-6(8E-6)
8	Incinerator maintenance	Kiln clean-out[e] 1.5 m from slag bin Remote from source	0.67 6.33 1	0.084 0.791 0.12	1E-2 1E-5	0.001 - Total	8.4E-7 7.9E-6 - - 8.7E-6(9E-6)
9	Ash transport	Driving Sleeping	10[c] 8	0.56 0.44	1E-4 NA	NA NA	1E-4[f] NA

(a) For description of external dose factor calculations, see Appendix E, "External Dose Calculations for Worker Scenarios."
(b) The weighted concentration is the sum of the fractional duration x dust loading x protection factor for the activity.
(c) For the transport scenarios, it is assumed that the driver spends 1/2 time with empty or noncontaminated load. The applicable exposure time for external exposure is 18 h/d x 250 d/y x 0.5 = 2250 h/y. For other scenarios, the exposure duration is 8 h/d x 250 d/y = 2000 h/y.
(d) NA - Not applicable to this activity.
(e) Kiln maintenance is assumed to account for 168 h/y to an individual worker.
(f) Inhalation from ash transport is based on exposure while dumping load only. Exposure time is taken to be 50 h/y for the base-case incinerator.

assumed to be 2000 h/y, with ingestion based on 500 h/y of exposure. The worker population in this category is taken to be 30 individuals for a 30,000-t/y incinerator, or 60 individuals for a 150,000-t/y facility.

2. Incinerator--Medium-Exposure. This scenario describes generic activities for hazardous waste workers with a moderate potential for exposure to waste or residual materials. Exposure to external radiation and inhalation of particulate material is assumed to be 500 h/y. The concentration of respirable particulate is assumed to be lower than for the high exposure group, above. No potential for ingestion exposure is assumed. The worker population in this category is taken to be 50 individuals for a 30,000-t/y incinerator, or 90 individuals for a 150,000-t/y facility.

3. Incinerator--Low-Exposure. This scenario describes generic work activities of nonhazardous waste workers (such as clerical staff) who work at a hazardous waste incinerator. External exposure and inhalation of particulate material are assumed to be limited to 50 h/y (1 hour per week), based on limited access to waste-processing operations. No potential for ingestion exposure is assumed. The worker population in this category is taken to be 70 individuals for a 30,000-t/y incinerator, or 150 individuals for a 150,000-t/y facility.

4. Landfill--High-Exposure. This scenario describes generic work activities at a hazardous waste landfill that have a high potential for exposure to waste or residual materials. External exposure and inhalation of particulate material are assumed to be 1500 h/y, with ingestion based on 500 h/y of exposure. The worker population in this category is taken to be 40 individuals for a 180,000-t/y landfill.

5. Landfill--Medium Exposure. This scenario describes generic work activities for hazardous waste workers with a moderate potential for exposure to waste or residual materials. External exposure and inhalation of particulate material are assumed to be 500 h/y. The concentration of respirable

particulate is assumed to be lower than for the high-exposure group, above. No potential for ingestion exposure is assumed. The worker population in this category is taken to be 60 individuals.

6. Landfill--Low-Exposure. This scenario describes generic work activities of nonhazardous waste workers (such as clerical staff) who work at a hazardous waste landfill. External exposure and inhalation of particulate material are assumed to be limited to 50 h/y (1 hour per week), based on limited access to waste-processing operations. No potential for ingestion exposure is assumed. The worker population in this category is taken to be 80 individuals.

Table G.5 gives a summary of exposure parameter values for the six collective scenarios.

TABLE G.5. Exposure Parameters for Collective Worker Dose

No.	Scenario	Inhalation, h	Dust Loading, g/m3	Ingestion, h	External, h	Population, persons
1	Incinerator -- High-exposure	2000	1.0E-05	500	2000	30 (60)[a]
2	Incinerator -- Medium-exposure	500	1.0E-06	0	500	50 (90)
3	Incinerator -- Low-exposure	50	1.0E-06	0	50	70 (150)
4	Landfill -- High-exposure	1500	1.0E-05	500	1500	40
5	Landfill -- Medium-exposure	500	1.0E-06	0	500	60
6	Landfill -- Low-exposure	50	1.0E-06	0	50	80

(a) Worker population for 30,000-t/y incinerator; value in parentheses based on 150,000-t/y incinerator.

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APPENDIX H

INTERNAL DOSE FACTORS FOR WORKER SCENARIOS

APPENDIX H

INTERNAL DOSE FACTORS FOR WORKER SCENARIOS

The internal dose factor library used in the calculations is given in Table H.1. The dose factors are from Internal Dose Conversion Factors for Calculation of Dose to the Public, DOE/EH-0071. The file lists the radionuclides, ingestion dose factors, and inhalation dose factors for each solubility class. For each radionuclide, the dose factors used are those for the least soluble compound, so that they will correspond to incineration products, which are mostly relatively insoluble oxides.

The numbers listed under the two sets of "Index" columns (to the right of the table proper) refer to the columns giving the appropriate ingestion and inhalation dose factors. The first set of "Index" columns indicate the columns listing the dose factors used for the calculations reported in this document. The second set of Index columns, labeled "Maximums," indicates the columns displaying the highest dose factors, which are not currently used.

TABLE H.1. Internal Dose Factors

Units: rem/uCi Intake

Nuclide	-- Ingestion -- 1	2	------- Inhalation ------ 1 (D)	2 (W)	3 (Y)	----- (a) -----				--Index- Ing	Inh	Maximums --Index- Ing	Inh
H 3	6.3E-05	0.0E+00	0.0E+00	6.3E-05	0.0E+00	0	1	0	(WATER)	1	2	1	2
BE 7	1.1E-04	0.0E+00	0.0E+00	2.3E-04	2.7E-04	0	1	1		1	3	1	3
BE 10	4.2E-03	0.0E+00	0.0E+00	3.3E-02	3.5E-01	0	1	1					
C 11	1.2E-05	0.0E+00	0.0E+00	1.2E-05	0.0E+00	0	1	0	(ORG)				
C 11	0.0E+00	0.0E+00	0.0E+00	4.5E-06	0.0E+00	0	0	0	(CO)				
C 11	0.0E+00	0.0E+00	0.0E+00	8.0E-06	0.0E+00	0	0	0	(CO-2)				
C 14	2.1E-03	0.0E+00	0.0E+00	2.1E-03	0.0E+00	0	1	0	(ORG)	1	-	1	-
C 14	0.0E+00	0.0E+00	0.0E+00	2.9E-06	0.0E+00	0	0	0	(CO)				
C 14	0.0E+00	0.0E+00	0.0E+00	2.4E-05	0.0E+00	0	0	0	(CO-2)	-	2	-	2
F 18	1.0E-04	0.0E+00	7.0E-05	5.8E-05	6.2E-05	1	1	1					
NA 22	1.2E-02	0.0E+00	8.0E-03	0.0E+00	0.0E+00	1	0	0		1	1	1	1
NA 24	1.4E-03	0.0E+00	9.5E-04	0.0E+00	0.0E+00	1	0	0					
MG 28	7.5E-03	0.0E+00	3.1E-03	4.0E-03	0.0E+00	1	1	0					
AL 26	1.3E-02	0.0E+00	7.9E-02	5.9E-02	0.0E+00	1	1	0					
SI 31	5.4E-04	0.0E+00	2.0E-04	1.6E-04	1.9E-04	1	1	1					
SI 32	1.7E-03	0.0E+00	2.1E-02	4.4E-02	1.0E+00	1	1	1					
P 32	7.7E-03	0.0E+00	5.5E-03	1.3E-02	0.0E+00	1	1	0		1	2	1	2
P 33	8.8E-04	0.0E+00	6.1E-04	1.9E-03	0.0E+00	1	1	0					
S 35	4.3E-04	6.5E-04	2.9E-04	2.3E-03	0.0E+00	1	1	0		1	2	2	2
S 35	0.0E+00	0.0E+00	0.0E+00	3.5E-04	0.0E+00	0	0	0	(GAS)				
CL 36	3.0E-03	0.0E+00	2.1E-03	2.0E-02	0.0E+00	1	1	0		1	2	1	1
CL 38	2.0E-04	0.0E+00	1.2E-04	1.1E-04	0.0E+00	1	1	0					
CL 39	1.4E-04	0.0E+00	9.7E-05	8.9E-05	0.0E+00	1	1	0					
K 40	1.9E-02	0.0E+00	1.2E-02	0.0E+00	0.0E+00	1	0	0					
K 42	1.1E-03	0.0E+00	1.1E-03	0.0E+00	0.0E+00	1	0	0					
K 43	7.8E-04	0.0E+00	5.6E-04	0.0E+00	0.0E+00	1	0	0					
K 44	1.5E-04	0.0E+00	7.6E-05	0.0E+00	0.0E+00	1	0	0					
K 45	9.3E-05	0.0E+00	4.6E-05	0.0E+00	0.0E+00	1	0	0					
CA 41	1.2E-03	0.0E+00	0.0E+00	1.3E-03	0.0E+00	0	1	0		1	2	1	2
CA 45	3.0E-03	0.0E+00	0.0E+00	6.1E-03	0.0E+00	0	1	0					
CA 47	6.2E-03	0.0E+00	0.0E+00	5.5E-03	0.0E+00	0	1	0					
SC 43	7.3E-04	0.0E+00	0.0E+00	0.0E+00	2.2E-04	0	0	1					
SC 44M	9.9E-03	0.0E+00	0.0E+00	0.0E+00	7.1E-03	0	0	1					
SC 44	1.4E-03	0.0E+00	0.0E+00	0.0E+00	4.2E-04	0	0	1					
SC 46	5.6E-03	0.0E+00	0.0E+00	0.0E+00	2.0E-02	0	0	1		1	3	1	3
SC 47	1.9E-03	0.0E+00	0.0E+00	0.0E+00	1.7E-03	0	0	1					
SC 48	6.4E-03	0.0E+00	0.0E+00	0.0E+00	3.6E-03	0	0	1					
SC 49	2.4E-04	0.0E+00	0.0E+00	0.0E+00	9.3E-05	0	0	1					
TI 44	1.9E-02	0.0E+00	4.5E-01	1.7E-01	8.9E-01	1	1	1					
TI 45	5.7E-04	0.0E+00	2.0E-04	1.5E-04	1.7E-04	1	1	1					
V 47	1.6E-04	0.0E+00	6.0E-05	5.3E-05	0.0E+00	1	1	0					
V 48	7.5E-03	0.0E+00	4.6E-03	8.0E-03	0.0E+00	1	1	0		1	2	1	2
V 49	5.4E-05	0.0E+00	1.5E-04	2.8E-04	0.0E+00	1	1	0					
CR 48	8.2E-04	8.6E-04	4.4E-04	6.8E-04	7.1E-04	1	1	1					
CR 49	1.7E-04	1.7E-04	6.1E-05	4.9E-05	5.3E-05	1	1	1					
CR 51	1.3E-04	1.3E-04	1.1E-04	2.1E-04	2.6E-04	1	1	1		1	3	1	3
MN 51	2.5E-04	0.0E+00	1.0E-04	8.4E-05	0.0E+00	1	1	0					
MN 52M	1.5E-04	0.0E+00	5.5E-05	4.9E-05	0.0E+00	1	1	0					
MN 52	6.9E-03	0.0E+00	4.5E-03	5.6E-03	0.0E+00	1	1	0					
MN 53	9.9E-05	0.0E+00	2.1E-04	4.3E-04	0.0E+00	1	1	0					
MN 54	2.7E-03	0.0E+00	5.4E-03	6.4E-03	0.0E+00	1	1	0		1	2	1	2
MN 56	9.5E-04	0.0E+00	3.3E-04	2.4E-04	0.0E+00	1	1	0					
FE 52	5.4E-03	0.0E+00	1.7E-03	2.0E-03	0.0E+00	1	1	0					
FE 55	5.8E-04	0.0E+00	2.6E-03	1.2E-03	0.0E+00	1	1	0		1	2	1	1
FE 59	6.6E-03	0.0E+00	1.5E-02	9.9E-03	0.0E+00	1	1	0					
FE 60	1.5E-01	0.0E+00	7.6E-01	2.7E-01	0.0E+00	1	1	0					
CO 55	4.1E-03	3.3E-03	0.0E+00	1.7E-03	1.9E-03	0	1	1					

TABLE H.1. (contd)

Nuclide	Units: rem/uCi Intake -- Ingestion -- 1	2	------- Inhalation ------ 1 (D)	2 (W)	3 (Y)	----- (a) -----				--Index- Ing	Inh	Maximums --Index- Ing	Inh
CO 56	9.7E-03	1.2E-02	0.0E+00	1.6E-02	2.6E-02	0	1	1		1	3	2	3
CO 57	6.6E-04	1.1E-03	0.0E+00	1.8E-03	7.5E-03	0	1	1		1	3	2	3
CO 58M	8.8E-05	7.4E-05	0.0E+00	5.4E-05	7.5E-05	0	1	1					
CO 58	2.8E-03	3.5E-03	0.0E+00	4.6E-03	7.1E-03	0	1	1		1	3	2	3
CO 60M	3.6E-06	3.6E-06	0.0E+00	1.3E-06	1.9E-06	0	1	1					
CO 60	1.0E-02	2.6E-02	0.0E+00	3.0E-02	1.5E-01	0	1	1		1	3	2	3
CO 61	2.6E-04	2.4E-04	0.0E+00	8.0E-05	8.9E-05	0	1	1					
CO 62M	9.6E-05	9.5E-05	0.0E+00	3.0E-05	3.2E-05	0	1	1					
NI 56	3.5E-03	0.0E+00	2.5E-03	3.8E-03	0.0E+00	1	1	0	(IN)				
NI 56	0.0E+00	0.0E+00	0.0E+00	4.2E-03	0.0E+00	0	0	0	(VAP)				
NI 57	3.3E-03	0.0E+00	1.0E-03	1.7E-03	0.0E+00	1	1	0	(IN)				
NI 57	0.0E+00	0.0E+00	0.0E+00	7.9E-04	0.0E+00	0	0	0	(VAP)				
NI 59	2.0E-04	0.0E+00	1.3E-03	7.0E-04	0.0E+00	1	1	0	(IN)				
NI 59	0.0E+00	0.0E+00	0.0E+00	2.7E-03	0.0E+00	0	0	0	(VAP)				
NI 63	5.4E-04	0.0E+00	3.0E-03	1.9E-03	0.0E+00	1	1	0	(IN)	1	2	1	1
NI 63	0.0E+00	0.0E+00	0.0E+00	6.3E-03	0.0E+00	0	0	0	(VAP)				
NI 65	6.1E-04	0.0E+00	2.1E-04	1.7E-04	0.0E+00	1	1	0	(IN)				
NI 65	0.0E+00	0.0E+00	0.0E+00	3.0E-04	0.0E+00	0	0	0	(VAP)				
NI 66	1.1E-02	0.0E+00	3.1E-03	8.0E-03	0.0E+00	1	1	0	(IN)				
NI 66	0.0E+00	0.0E+00	0.0E+00	1.7E-03	0.0E+00	0	0	0	(VAP)				
CU 60	1.7E-04	0.0E+00	5.4E-05	4.4E-05	4.9E-05	1	1	1					
CU 61	4.1E-04	0.0E+00	1.7E-04	1.2E-04	1.4E-04	1	1	1					
CU 64	4.3E-04	0.0E+00	1.6E-04	2.2E-04	2.3E-04	1	1	1					
CU 67	1.1E-03	0.0E+00	6.6E-04	9.8E-04	1.1E-03	1	1	1					
ZN 62	3.4E-03	0.0E+00	0.0E+00	0.0E+00	1.8E-03	0	0	1					
ZN 63	2.0E-04	0.0E+00	0.0E+00	0.0E+00	7.1E-05	0	0	1					
ZN 65	1.4E-02	0.0E+00	0.0E+00	0.0E+00	1.8E-02	0	0	1		1	3	1	3
ZN 69M	1.2E-03	0.0E+00	0.0E+00	0.0E+00	6.9E-04	0	0	1					
ZN 69	8.5E-05	0.0E+00	0.0E+00	0.0E+00	3.6E-05	0	0	1					
ZN 71M	8.3E-04	0.0E+00	0.0E+00	0.0E+00	3.0E-04	0	0	1					
ZN 72	4.9E-03	0.0E+00	0.0E+00	0.0E+00	4.2E-03	0	0	1					
GA 65	7.8E-05	0.0E+00	2.9E-05	2.6E-05	0.0E+00	1	1	0					
GA 66	4.7E-03	0.0E+00	1.5E-03	0.0E+00	1.7E-03	1	0	1					
GA 67	7.2E-04	0.0E+00	3.5E-04	4.8E-04	0.0E+00	1	1	0					
GA 68	3.3E-04	0.0E+00	1.2E-04	9.3E-05	0.0E+00	1	1	0					
GA 70	7.1E-05	0.0E+00	2.9E-05	2.5E-05	0.0E+00	1	1	0					
GA 72	4.4E-03	0.0E+00	1.4E-03	1.7E-03	0.0E+00	1	1	0					
GA 73	1.0E-03	0.0E+00	3.3E-04	3.3E-04	0.0E+00	1	1	0					
GE 66	2.1E-04	0.0E+00	1.9E-04	2.5E-04	0.0E+00	1	1	0					
GE 67	1.1E-04	0.0E+00	5.4E-05	4.9E-05	0.0E+00	1	1	0					
GE 68	1.1E-03	0.0E+00	1.3E-03	4.9E-02	0.0E+00	1	1	0		1	2	1	2
GE 69	3.6E-04	0.0E+00	3.3E-04	6.2E-04	0.0E+00	1	1	0					
GE 71	9.6E-06	0.0E+00	1.1E-05	1.2E-04	0.0E+00	1	1	0					
GE 75	7.3E-05	0.0E+00	6.3E-05	6.2E-05	0.0E+00	1	1	0					
GE 77	5.6E-04	0.0E+00	4.9E-04	8.9E-04	0.0E+00	1	1	0					
GE 78	2.1E-04	0.0E+00	2.2E-04	2.4E-04	0.0E+00	1	1	0					
AS 69	1.1E-04	0.0E+00	0.0E+00	4.2E-05	0.0E+00	0	1	0					
AS 70	3.4E-04	0.0E+00	0.0E+00	9.8E-05	0.0E+00	0	1	0					
AS 71	1.3E-03	0.0E+00	0.0E+00	1.1E-03	0.0E+00	0	1	0					
AS 72	5.6E-03	0.0E+00	0.0E+00	3.5E-03	0.0E+00	0	1	0					
AS 73	6.1E-04	0.0E+00	0.0E+00	3.1E-03	0.0E+00	0	1	0					
AS 74	3.3E-03	0.0E+00	0.0E+00	6.5E-03	0.0E+00	0	1	0		1	2	1	2
AS 76	4.8E-03	0.0E+00	0.0E+00	3.4E-03	0.0E+00	0	1	0					
AS 77	1.1E-03	0.0E+00	0.0E+00	9.9E-04	0.0E+00	0	1	0					
AS 78	6.5E-04	0.0E+00	0.0E+00	2.3E-04	0.0E+00	0	1	0					
SE 70	3.0E-04	4.8E-04	1.3E-04	1.2E-04	0.0E+00	1	1	0					
SE 73M	7.6E-05	1.5E-04	3.3E-05	3.4E-05	0.0E+00	1	1	0					

TABLE H.1. (contd)

Units: rem/uCi Intake

Nuclide	-- Ingestion -- 1	2	------- Inhalation ------ 1 (D)	2 (W)	3 (Y)	----- (a) -----			--Index- Ing	Inh	Maximums --Index- Ing	Inh
SE 73	7.2E-04	1.5E-03	3.8E-04	3.2E-04	0.0E+00	1	1	0				
SE 75	8.8E-03	1.7E-03	7.1E-03	8.2E-03	0.0E+00	1	1	0	1	2	1	2
SE 79	8.3E-03	1.1E-03	6.2E-03	8.9E-03	0.0E+00	1	1	0	1	2	1	2
SE 81M	1.4E-04	2.1E-04	7.4E-05	7.1E-05	0.0E+00	1	1	0				
SE 81	5.7E-05	6.1E-05	2.4E-05	2.1E-05	0.0E+00	1	1	0				
SE 83	1.1E-04	1.5E-04	4.3E-05	4.0E-05	0.0E+00	1	1	0				
BR 74M	2.2E-04	0.0E+00	1.4E-04	1.2E-04	0.0E+00	1	1	0				
BR 74	1.4E-04	0.0E+00	7.2E-05	6.2E-05	0.0E+00	1	1	0				
BR 75	1.3E-04	0.0E+00	1.1E-04	1.0E-04	0.0E+00	1	1	0				
BR 76	1.4E-03	0.0E+00	1.1E-03	1.2E-03	0.0E+00	1	1	0				
BR 77	3.1E-04	0.0E+00	2.1E-04	2.6E-04	0.0E+00	1	1	0				
BR 80M	2.3E-04	0.0E+00	2.8E-04	3.5E-04	0.0E+00	1	1	0				
BR 80	5.5E-05	0.0E+00	2.7E-05	2.4E-05	0.0E+00	1	1	0				
BR 82	1.7E-03	0.0E+00	1.2E-03	1.3E-03	0.0E+00	1	1	0				
BR 83	7.3E-05	0.0E+00	7.6E-05	8.0E-05	0.0E+00	1	1	0				
BR 84	1.5E-04	0.0E+00	8.7E-05	7.5E-05	0.0E+00	1	1	0				
RB 79	8.7E-05	0.0E+00	4.3E-05	0.0E+00	0.0E+00	1	0	0				
RB 81M	1.8E-05	0.0E+00	1.5E-05	0.0E+00	0.0E+00	1	0	0				
RB 81	1.3E-04	0.0E+00	1.0E-04	0.0E+00	0.0E+00	1	0	0				
RB 82M	4.2E-04	0.0E+00	2.8E-04	0.0E+00	0.0E+00	1	0	0				
RB 83	7.7E-03	0.0E+00	4.9E-03	0.0E+00	0.0E+00	1	0	0				
RB 84	1.0E-02	0.0E+00	6.5E-03	0.0E+00	0.0E+00	1	0	0				
RB 86	9.4E-03	0.0E+00	6.6E-03	0.0E+00	0.0E+00	1	0	0				
RB 87	4.8E-03	0.0E+00	3.3E-03	0.0E+00	0.0E+00	1	0	0				
RB 88	1.6E-04	0.0E+00	8.0E-05	0.0E+00	0.0E+00	1	0	0				
RB 89	8.0E-05	0.0E+00	3.7E-05	0.0E+00	0.0E+00	1	0	0				
SR 80	4.9E-06	5.2E-06	2.3E-06	0.0E+00	2.1E-06	1	0	2				
SR 81	1.9E-04	2.2E-04	6.5E-05	0.0E+00	6.7E-05	1	0	2				
SR 83	1.8E-03	2.3E-03	7.2E-04	0.0E+00	1.4E-03	1	0	2				
SR 85M	2.2E-05	2.4E-05	8.2E-06	0.0E+00	5.9E-06	1	0	2				
SR 85	1.9E-03	1.3E-03	1.9E-03	0.0E+00	3.2E-03	1	0	2				
SR 87M	1.1E-04	1.2E-04	3.8E-05	0.0E+00	3.2E-05	1	0	2				
SR 89	8.2E-03	8.7E-03	5.9E-03	0.0E+00	3.7E-02	1	0	2				
SR 90	1.3E-01	1.2E-02	2.3E-01	0.0E+00	1.3E+00	1	0	2	1	1	1	1
SR 91	2.4E-03	3.0E-03	8.4E-04	0.0E+00	1.4E-03	1	0	2				
SR 92	1.6E-03	1.9E-03	5.4E-04	0.0E+00	7.7E-04	1	0	2				
Y 86M	2.4E-04	0.0E+00	0.0E+00	8.4E-05	9.1E-05	0	1	1				
Y 86	4.1E-03	0.0E+00	0.0E+00	1.5E-03	1.6E-03	0	1	1				
Y 87	2.2E-03	0.0E+00	0.0E+00	1.5E-03	1.6E-03	0	1	1				
Y 88	5.2E-03	0.0E+00	0.0E+00	2.0E-02	2.1E-02	0	1	1	1	3	1	3
Y 90M	6.6E-04	0.0E+00	0.0E+00	4.0E-04	4.4E-04	0	1	1				
Y 90	1.0E-02	0.0E+00	0.0E+00	7.4E-03	8.2E-03	0	1	1	1	3	1	3
Y 91M	3.9E-05	0.0E+00	0.0E+00	2.1E-05	3.1E-05	0	1	1				
Y 91	8.9E-03	0.0E+00	0.0E+00	2.9E-02	4.4E-02	0	1	1				
Y 92	1.9E-03	0.0E+00	0.0E+00	6.0E-04	6.2E-04	0	1	1				
Y 93	4.5E-03	0.0E+00	0.0E+00	1.8E-03	2.1E-03	0	1	1				
Y 94	1.8E-04	0.0E+00	0.0E+00	6.2E-05	6.7E-05	0	1	1				
Y 95	9.7E-05	0.0E+00	0.0E+00	3.3E-05	3.6E-05	0	1	1				
ZR 86	3.5E-03	0.0E+00	1.3E-03	1.9E-03	2.1E-03	1	1	1				
ZR 88	1.3E-03	0.0E+00	2.2E-02	1.0E-02	1.7E-02	1	1	1				
ZR 89	3.1E-03	0.0E+00	1.4E-03	2.0E-03	2.1E-03	1	1	1				
ZR 93	1.6E-03	0.0E+00	3.2E-01	8.1E-02	7.4E-02	1	1	1	1	3	1	1
ZR 95	3.4E-03	0.0E+00	1.9E-02	1.3E-02	1.8E-02	1	1	1				
ZR 97	8.0E-03	0.0E+00	2.5E-03	3.6E-03	4.0E-03	1	1	1				
NB 88	7.2E-05	0.0E+00	0.0E+00	2.2E-05	2.4E-05	0	1	1				
NB 89	4.6E-04	0.0E+00	0.0E+00	1.2E-04	1.3E-04	0	1	1	(66 M)			
NB 89	1.0E-03	0.0E+00	0.0E+00	2.7E-04	3.2E-04	0	1	1	(122 M)			

TABLE H.1. (contd)

Nuclide	Units: rem/uCi Intake -- Ingestion -- 1	2	------- Inhalation ------ 1 (D)	2 (W)	3 (Y)	----- (a) -----			--Index- Ing	Inh	Maximums --Index- Ing	Inh
NB 90	4.9E-03	0.0E+00	0.0E+00	1.9E-03	2.1E-03	0	1	1				
NB 93M	5.3E-04	0.0E+00	0.0E+00	4.1E-03	2.8E-02	0	1	1				
NB 94	5.1E-03	0.0E+00	0.0E+00	2.6E-02	3.3E-01	0	1	1	1	3	1	3
NB 95M	2.0E-03	0.0E+00	0.0E+00	1.9E-03	2.2E-03	0	1	1				
NB 95	2.2E-03	0.0E+00	0.0E+00	3.9E-03	4.5E-03	0	1	1				
NB 96	4.4E-03	0.0E+00	0.0E+00	1.9E-03	2.0E-03	0	1	1				
NB 97	2.3E-04	0.0E+00	0.0E+00	6.2E-05	7.1E-05	0	1	1				
NB 98	3.4E-04	0.0E+00	0.0E+00	9.3E-05	1.0E-04	0	1	1				
MO 90	1.0E-03	2.5E-03	6.9E-04	0.0E+00	1.1E-03	1	0	2				
MO 93M	5.0E-04	1.1E-03	2.8E-04	0.0E+00	3.6E-04	1	0	2				
MO 93	1.3E-03	2.2E-04	9.2E-04	0.0E+00	2.8E-02	1	0	2				
MO 99	2.9E-03	4.4E-03	2.0E-03	0.0E+00	3.6E-03	1	0	2				
MO 101	8.6E-05	9.2E-05	3.6E-05	0.0E+00	3.3E-05	1	0	2				
TC 93M	7.1E-05	0.0E+00	3.2E-05	1.7E-05	0.0E+00	1	1	0				
TC 93	1.6E-04	0.0E+00	7.1E-05	4.8E-05	0.0E+00	1	1	0				
TC 94M	2.5E-04	0.0E+00	1.2E-04	8.8E-05	0.0E+00	1	1	0				
TC 94	5.8E-04	0.0E+00	2.7E-04	2.0E-04	0.0E+00	1	1	0				
TC 96M	3.1E-05	0.0E+00	1.8E-05	2.1E-05	0.0E+00	1	1	0				
TC 96	2.7E-03	0.0E+00	1.6E-03	2.4E-03	0.0E+00	1	1	0				
TC 97M	1.1E-03	0.0E+00	7.0E-04	4.2E-03	0.0E+00	1	1	0				
TC 97	1.5E-04	0.0E+00	1.0E-04	8.9E-04	0.0E+00	1	1	0				
TC 98	4.8E-03	0.0E+00	3.1E-03	1.7E-02	0.0E+00	1	1	0				
TC 99M	6.0E-05	0.0E+00	3.2E-05	2.1E-05	0.0E+00	1	1	0				
TC 99	1.3E-03	0.0E+00	8.4E-04	7.5E-03	0.0E+00	1	1	0	1	2	1	2
TC 101	3.8E-05	0.0E+00	1.6E-05	1.3E-05	0.0E+00	1	1	0				
TC 104	1.6E-04	0.0E+00	6.8E-05	5.8E-05	0.0E+00	1	1	0				
RU 94	3.3E-04	0.0E+00	1.2E-04	8.0E-05	8.4E-05	1	1	1				
RU 97	6.4E-04	0.0E+00	2.6E-04	3.9E-04	4.2E-04	1	1	1				
RU 103	2.7E-03	0.0E+00	3.0E-03	5.1E-03	7.8E-03	1	1	1				
RU 105	1.0E-03	0.0E+00	3.4E-04	3.5E-04	4.1E-04	1	1	1				
RU 106	2.1E-02	0.0E+00	5.7E-02	9.3E-02	4.4E-01	1	1	1	1	3	1	3
RH 99M	2.8E-04	0.0E+00	8.6E-05	6.7E-05	7.4E-05	1	1	1				
RH 99	2.0E-03	0.0E+00	1.7E-03	2.3E-03	2.6E-03	1	1	1				
RH 100	3.1E-03	0.0E+00	9.8E-04	1.3E-03	1.4E-03	1	1	1				
RH 101M	8.8E-04	0.0E+00	4.2E-04	6.1E-04	6.7E-04	1	1	1				
RH 101	2.3E-03	0.0E+00	1.0E-02	6.4E-03	3.2E-02	1	1	1				
RH 102M	3.5E-03	0.0E+00	1.0E-02	1.3E-02	4.2E-02	1	1	1				
RH 102	8.5E-03	0.0E+00	5.4E-02	2.8E-02	8.7E-02	1	1	1				
RH 103M	1.1E-05	0.0E+00	4.6E-06	3.9E-06	4.2E-06	1	1	1				
RH 105	1.4E-03	0.0E+00	4.2E-04	8.1E-04	8.9E-04	1	1	1				
RH 106M	6.1E-04	0.0E+00	2.0E-04	1.3E-04	1.5E-04	1	1	1				
RH 107	5.4E-05	0.0E+00	2.1E-05	1.9E-05	2.0E-05	1	1	1				
PD 100	3.8E-03	0.0E+00	3.4E-03	3.9E-03	3.4E-03	1	1	1				
PD 101	3.8E-04	0.0E+00	1.6E-04	1.5E-04	1.7E-04	1	1	1				
PD 103	6.9E-04	0.0E+00	7.9E-04	1.1E-03	1.4E-03	1	1	1				
PD 107	1.4E-04	0.0E+00	2.3E-04	6.7E-04	1.3E-02	1	1	1				
PD 109	2.1E-03	0.0E+00	7.9E-04	9.2E-04	1.1E-03	1	1	1				
AG 102	7.9E-05	0.0E+00	2.8E-05	2.4E-05	2.5E-05	1	1	1				
AG 103	1.4E-04	0.0E+00	5.1E-05	3.8E-05	4.1E-05	1	1	1				
AG 104M	1.5E-04	0.0E+00	5.3E-05	3.9E-05	4.2E-05	1	1	1				
AG 104	2.3E-04	0.0E+00	7.0E-05	3.4E-05	3.4E-05	1	1	1				
AG 105	1.9E-03	0.0E+00	4.7E-03	2.9E-03	3.1E-03	1	1	1				
AG 106M	6.1E-03	0.0E+00	7.1E-03	5.7E-03	5.4E-03	1	1	1				
AG 106	7.6E-05	0.0E+00	2.8E-05	2.4E-05	2.6E-05	1	1	1				
AG 108M	7.5E-03	0.0E+00	2.8E-02	1.9E-02	2.0E-01	1	1	1				
AG 110M	1.1E-02	0.0E+00	3.8E-02	2.7E-02	5.3E-02	1	1	1	1	3	1	3
AG 111	4.5E-03	0.0E+00	3.1E-03	5.6E-03	5.9E-03	1	1	1				

TABLE H.1. (contd)

Units: rem/uCi Intake

Nuclide	Ingestion 1	Ingestion 2	Inhalation 1 (D)	Inhalation 2 (W)	Inhalation 3 (Y)	(a)				Index Ing	Index Inh	Maximums Index Ing	Maximums Index Inh
AG 112	1.6E-03	0.0E+00	6.2E-04	5.0E-04	5.5E-04	1	1	1					
AG 115	1.5E-04	0.0E+00	5.5E-05	6.0E-05	6.1E-05	1	1	1					
CD 104	2.3E-04	0.0E+00	7.4E-05	4.3E-05	4.6E-05	1	1	1					
CD 107	2.4E-04	0.0E+00	9.3E-05	8.3E-05	1.0E-04	1	1	1					
CD 109	1.2E-02	0.0E+00	1.0E-01	3.6E-02	4.2E-02	1	1	1					
CD 113M	1.5E-01	0.0E+00	1.4E+00	4.2E-01	3.8E-01	1	1	1					
CD 113	1.6E-01	0.0E+00	1.6E+00	4.7E-01	3.7E-01	1	1	1					
CD 115M	1.5E-02	0.0E+00	6.5E-02	3.9E-02	3.5E-02	1	1	1					
CD 115	4.7E-03	0.0E+00	3.6E-03	3.8E-03	3.8E-03	1	1	1					
CD 117M	1.1E-03	0.0E+00	4.1E-04	2.9E-04	3.4E-04	1	1	1					
CD 117	1.1E-03	0.0E+00	4.3E-04	3.0E-04	3.6E-04	1	1	1					
IN 109	2.7E-04	0.0E+00	1.1E-04	7.6E-05	0.0E+00	1	1	0					
IN 110	3.3E-04	0.0E+00	1.1E-04	8.4E-05	0.0E+00	1	1	0	(69M)				
IN 110	1.0E-03	0.0E+00	3.0E-04	2.5E-04	0.0E+00	1	1	0	(5H)				
IN 111	1.2E-03	0.0E+00	7.7E-04	7.6E-04	0.0E+00	1	1	0					
IN 112	2.1E-05	0.0E+00	8.0E-06	7.1E-06	0.0E+00	1	1	0					
IN 113M	1.0E-04	0.0E+00	3.4E-05	2.6E-05	0.0E+00	1	1	0					
IN 114M	1.5E-02	0.0E+00	7.8E-02	4.9E-02	0.0E+00	1	1	0					
IN 115M	3.4E-04	0.0E+00	1.2E-04	1.0E-04	0.0E+00	1	1	0					
IN 115	1.4E-01	0.0E+00	3.4E+00	9.3E-01	0.0E+00	1	1	0					
IN 116M	2.1E-04	0.0E+00	6.4E-05	4.1E-05	0.0E+00	1	1	0					
IN 117M	4.2E-04	0.0E+00	1.5E-04	1.2E-04	0.0E+00	1	1	0					
IN 117	8.7E-05	0.0E+00	3.0E-05	2.4E-05	0.0E+00	1	1	0					
IN 119M	1.0E-04	0.0E+00	4.0E-05	3.6E-05	0.0E+00	1	1	0					
SN 110	1.5E-03	0.0E+00	4.3E-04	4.3E-04	0.0E+00	1	1	0					
SN 111	6.7E-05	0.0E+00	2.2E-05	1.9E-05	0.0E+00	1	1	0					
SN 113	2.7E-03	0.0E+00	3.9E-03	8.9E-03	0.0E+00	1	1	0		1	2	1	2
SN 117M	2.6E-03	0.0E+00	2.3E-03	3.4E-03	0.0E+00	1	1	0					
SN 119M	1.2E-03	0.0E+00	2.1E-03	5.3E-03	0.0E+00	1	1	0					
SN 121M	1.3E-03	0.0E+00	5.8E-03	8.9E-03	0.0E+00	1	1	0					
SN 121	8.9E-04	0.0E+00	3.2E-04	4.7E-04	0.0E+00	1	1	0					
SN 123M	1.0E-04	0.0E+00	4.2E-05	3.5E-05	0.0E+00	1	1	0					
SN 123	7.7E-03	0.0E+00	7.9E-03	3.0E-02	0.0E+00	1	1	0					
SN 125	1.1E-02	0.0E+00	5.4E-03	1.4E-02	0.0E+00	1	1	0					
SN 126	1.7E-02	0.0E+00	8.6E-02	7.4E-02	0.0E+00	1	1	0					
SN 127	7.4E-04	0.0E+00	2.6E-04	2.7E-04	0.0E+00	1	1	0					
SN 128	5.2E-04	0.0E+00	1.8E-04	1.4E-04	0.0E+00	1	1	0					
SB 115	6.3E-05	6.3E-05	2.1E-05	1.7E-05	0.0E+00	1	2	0					
SB 116M	2.4E-04	2.4E-04	7.2E-05	3.7E-05	0.0E+00	1	2	0					
SB 116	5.6E-05	5.6E-05	1.8E-05	1.6E-05	0.0E+00	1	2	0					
SB 117	7.0E-05	7.4E-05	2.3E-05	1.7E-05	0.0E+00	1	2	0					
SB 118M	8.9E-04	9.3E-04	2.6E-04	2.3E-04	0.0E+00	1	2	0					
SB 119	3.1E-04	3.4E-04	1.1E-04	1.9E-04	0.0E+00	1	2	0					
SB 120	3.0E-05	3.0E-05	1.1E-05	1.0E-05	0.0E+00	1	2	0	(16M)				
SB 120	5.0E-03	5.4E-03	2.2E-03	3.5E-03	0.0E+00	1	2	0	(6D)				
SB 122	5.7E-03	6.3E-03	2.2E-03	4.7E-03	0.0E+00	1	2	0					
SB 124M	1.9E-05	2.0E-05	6.1E-06	8.4E-06	0.0E+00	1	2	0					
SB 124	8.7E-03	9.3E-03	5.5E-03	2.1E-02	0.0E+00	1	2	0		2	2	2	2
SB 125	2.4E-03	2.6E-03	2.1E-03	9.8E-03	0.0E+00	1	2	0		2	2	2	2
SB 126M	7.3E-05	7.3E-05	2.8E-05	2.5E-05	0.0E+00	1	2	0					
SB 126	9.0E-03	9.6E-03	4.6E-03	1.0E-02	0.0E+00	1	2	0					
SB 127	6.0E-03	6.6E-03	2.3E-03	5.4E-03	0.0E+00	1	2	0					
SB 128	4.0E-03	4.3E-03	1.2E-03	1.6E-03	0.0E+00	1	2	0	(9H)				
SB 128	5.0E-05	5.0E-05	1.4E-05	1.2E-05	0.0E+00	1	2	0	(10M)				
SB 129	1.7E-03	1.7E-03	5.6E-04	5.7E-04	0.0E+00	1	2	0					
SB 130	2.5E-04	2.6E-04	8.1E-05	6.2E-05	0.0E+00	1	2	0					
SB 131	2.9E-04	2.9E-04	1.3E-04	1.2E-04	0.0E+00	1	2	0					

TABLE H.1. (contd)

Units: rem/uCi Intake

Nuclide	-- Ingestion -- 1	2	------- Inhalation ------ 1 (D)	2 (W)	3 (Y)	----- (a) -----			--Index- Ing	Inh	Maximums --Index- Ing	Inh
TE 116	6.7E-04	0.0E+00	2.4E-04	1.7E-04	0.0E+00	1	1	0				
TE 121M	6.7E-03	0.0E+00	1.3E-02	1.2E-02	0.0E+00	1	1	0				
TE 121	1.5E-03	0.0E+00	1.2E-03	1.6E-03	0.0E+00	1	1	0				
TE 123M	5.1E-03	0.0E+00	9.3E-03	9.5E-03	0.0E+00	1	1	0				
TE 123	4.1E-03	0.0E+00	1.1E-02	4.6E-03	0.0E+00	1	1	0				
TE 125M	3.4E-03	0.0E+00	4.9E-03	6.7E-03	0.0E+00	1	1	0	1	2	1	2
TE 127M	7.9E-03	0.0E+00	1.2E-02	1.9E-02	0.0E+00	1	1	0				
TE 127	6.9E-04	0.0E+00	2.2E-04	2.9E-04	0.0E+00	1	1	0				
TE 129M	9.9E-03	0.0E+00	8.0E-03	2.0E-02	0.0E+00	1	1	0				
TE 129	1.9E-04	0.0E+00	7.7E-05	6.7E-05	0.0E+00	1	1	0				
TE 131M	8.3E-03	0.0E+00	4.1E-03	5.5E-03	0.0E+00	1	1	0				
TE 131	8.5E-04	0.0E+00	4.0E-04	4.3E-04	0.0E+00	1	1	0				
TE 132	7.4E-03	0.0E+00	6.5E-03	7.7E-03	0.0E+00	1	1	0				
TE 133M	7.6E-04	0.0E+00	3.7E-04	3.8E-04	0.0E+00	1	1	0				
TE 133	1.6E-04	0.0E+00	8.5E-05	8.6E-05	0.0E+00	1	1	0				
TE 134	2.1E-04	0.0E+00	1.0E-04	9.8E-05	0.0E+00	1	1	0				
I 120M	3.9E-04	0.0E+00	2.2E-04	0.0E+00	0.0E+00	1	0	0				
I 120	6.7E-04	0.0E+00	4.1E-04	0.0E+00	0.0E+00	1	0	0				
I 121	1.8E-04	0.0E+00	1.0E-04	0.0E+00	0.0E+00	1	0	0				
I 123	4.9E-04	0.0E+00	2.7E-04	0.0E+00	0.0E+00	1	0	0				
I 124	3.1E-02	0.0E+00	1.9E-02	0.0E+00	0.0E+00	1	0	0				
I 125	3.8E-02	0.0E+00	2.4E-02	0.0E+00	0.0E+00	1	0	0	1	1	1	1
I 126	7.1E-02	0.0E+00	4.3E-02	0.0E+00	0.0E+00	1	0	0	1	1	1	1
I 128	8.5E-05	0.0E+00	4.5E-05	0.0E+00	0.0E+00	1	0	0				
I 129	2.8E-01	0.0E+00	1.8E-01	0.0E+00	0.0E+00	1	0	0	1	1	1	1
I 130	4.3E-03	0.0E+00	2.5E-03	0.0E+00	0.0E+00	1	0	0				
I 131	5.3E-02	0.0E+00	3.2E-02	0.0E+00	0.0E+00	1	0	0	1	1	1	1
I 132M	4.7E-04	0.0E+00	2.6E-04	0.0E+00	0.0E+00	1	0	0				
I 132	5.7E-04	0.0E+00	3.3E-04	0.0E+00	0.0E+00	1	0	0				
I 133	1.0E-02	0.0E+00	5.4E-03	0.0E+00	0.0E+00	1	0	0	1	1	1	1
I 134	1.9E-04	0.0E+00	1.1E-04	0.0E+00	0.0E+00	1	0	0				
I 135	2.0E-03	0.0E+00	1.1E-03	0.0E+00	0.0E+00	1	0	0				
CS 125	5.5E-05	0.0E+00	3.4E-05	0.0E+00	0.0E+00	1	0	0				
CS 127	8.0E-05	0.0E+00	5.2E-05	0.0E+00	0.0E+00	1	0	0				
CS 129	2.2E-04	0.0E+00	1.5E-04	0.0E+00	0.0E+00	1	0	0				
CS 130	4.9E-05	0.0E+00	2.6E-05	0.0E+00	0.0E+00	1	0	0				
CS 131	2.4E-04	0.0E+00	1.6E-04	0.0E+00	0.0E+00	1	0	0				
CS 132	1.9E-03	0.0E+00	1.2E-03	0.0E+00	0.0E+00	1	0	0				
CS 134M	4.2E-05	0.0E+00	3.6E-05	0.0E+00	0.0E+00	1	0	0				
CS 134	7.4E-02	0.0E+00	4.7E-02	0.0E+00	0.0E+00	1	0	0	1	1	1	1
CS 135M	4.9E-05	0.0E+00	2.6E-05	0.0E+00	0.0E+00	1	0	0				
CS 135	7.1E-03	0.0E+00	4.5E-03	0.0E+00	0.0E+00	1	0	0				
CS 136	1.1E-02	0.0E+00	7.5E-03	0.0E+00	0.0E+00	1	0	0				
CS 137	5.0E-02	0.0E+00	3.2E-02	0.0E+00	0.0E+00	1	0	0	1	1	1	1
CS 138	1.6E-04	0.0E+00	8.8E-05	0.0E+00	0.0E+00	1	0	0				
BA 126	9.0E-04	0.0E+00	3.3E-04	0.0E+00	0.0E+00	1	0	0				
BA 128	1.0E-02	0.0E+00	2.9E-03	0.0E+00	0.0E+00	1	0	0				
BA 131M	9.7E-06	0.0E+00	3.8E-06	0.0E+00	0.0E+00	1	0	0				
BA 131	1.6E-03	0.0E+00	6.7E-04	0.0E+00	0.0E+00	1	0	0				
BA 133M	2.0E-03	0.0E+00	5.6E-04	0.0E+00	0.0E+00	1	0	0				
BA 133	3.2E-03	0.0E+00	6.9E-03	0.0E+00	0.0E+00	1	0	0				
BA 135M	1.6E-03	0.0E+00	4.4E-04	0.0E+00	0.0E+00	1	0	0				
BA 139	3.9E-04	0.0E+00	1.6E-04	0.0E+00	0.0E+00	1	0	0				
BA 140	8.4E-03	0.0E+00	3.6E-03	0.0E+00	0.0E+00	1	0	0				
BA 141	2.0E-04	0.0E+00	7.4E-05	0.0E+00	0.0E+00	1	0	0				
BA 142	1.0E-04	0.0E+00	3.6E-05	0.0E+00	0.0E+00	1	0	0				

TABLE H.1. (contd)

Nuclide	Units: rem/uCi Intake -- Ingestion -- 1	2	------- Inhalation ------ 1 (D)	2 (W)	3 (Y)	----- (a) -----			--Index- Ing	Inh	Maximums --Index- Ing	Inh
LA 131	1.1E-04	0.0E+00	4.5E-05	3.0E-05	0.0E+00	1	1	0				
LA 132	1.5E-03	0.0E+00	5.1E-04	4.5E-04	0.0E+00	1	1	0				
LA 135	1.3E-04	0.0E+00	4.7E-05	5.2E-05	0.0E+00	1	1	0				
LA 137	4.3E-04	0.0E+00	7.3E-02	1.9E-02	0.0E+00	1	1	0				
LA 138	5.9E-03	0.0E+00	1.4E+00	3.7E-01	0.0E+00	1	1	0				
LA 140	7.7E-03	0.0E+00	3.4E-03	4.4E-03	0.0E+00	1	1	0				
LA 141	1.4E-03	0.0E+00	5.4E-04	4.5E-04	0.0E+00	1	1	0				
LA 142	6.3E-04	0.0E+00	2.2E-04	1.6E-04	0.0E+00	1	1	0				
LA 143	1.4E-04	0.0E+00	4.8E-05	5.5E-05	0.0E+00	1	1	0				
CE 134	8.9E-03	0.0E+00	0.0E+00	6.7E-03	7.4E-03	0	1	1				
CE 135	3.2E-03	0.0E+00	0.0E+00	1.3E-03	1.4E-03	0	1	1				
CE 137M	2.0E-03	0.0E+00	0.0E+00	1.1E-03	1.3E-03	0	1	1				
CE 137	9.8E-05	0.0E+00	0.0E+00	3.5E-05	3.9E-05	0	1	1				
CE 139	1.1E-03	0.0E+00	0.0E+00	6.4E-03	7.5E-03	0	1	1				
CE 141	2.6E-03	0.0E+00	0.0E+00	7.1E-03	8.5E-03	0	1	1				
CE 143	4.2E-03	0.0E+00	0.0E+00	2.8E-03	3.2E-03	0	1	1				
CE 144	2.0E-02	0.0E+00	0.0E+00	1.9E-01	3.5E-01	0	1	1	1	3	1	3
PR 136	6.8E-05	0.0E+00	0.0E+00	2.1E-05	2.2E-05	0	1	1				
PR 137	1.3E-04	0.0E+00	0.0E+00	3.3E-05	3.6E-05	0	1	1				
PR 138M	4.9E-04	0.0E+00	0.0E+00	9.1E-05	1.2E-04	0	1	1				
PR 139	1.2E-04	0.0E+00	0.0E+00	4.2E-05	4.7E-05	0	1	1				
PR 142M	6.3E-05	0.0E+00	0.0E+00	3.1E-05	3.6E-05	0	1	1				
PR 142	5.1E-03	0.0E+00	0.0E+00	2.4E-03	2.7E-03	0	1	1				
PR 143	4.5E-03	0.0E+00	0.0E+00	6.2E-03	7.3E-03	0	1	1				
PR 144	1.1E-04	0.0E+00	0.0E+00	3.9E-05	4.2E-05	0	1	1				
PR 145	1.5E-03	0.0E+00	0.0E+00	5.4E-04	6.4E-04	0	1	1				
PR 147	5.7E-05	0.0E+00	0.0E+00	2.5E-05	2.7E-05	0	1	1				
ND 136	3.3E-04	0.0E+00	0.0E+00	8.4E-05	9.3E-05	0	1	1				
ND 138	2.5E-03	0.0E+00	0.0E+00	7.8E-04	9.4E-04	0	1	1				
ND 139M	1.0E-03	0.0E+00	0.0E+00	3.0E-04	3.5E-04	0	1	1				
ND 139	5.7E-05	0.0E+00	0.0E+00	1.5E-05	1.7E-05	0	1	1				
ND 141	3.2E-05	0.0E+00	0.0E+00	6.9E-06	8.2E-06	0	1	1				
ND 147	3.9E-03	0.0E+00	0.0E+00	5.3E-03	6.2E-03	0	1	1				
ND 149	4.6E-04	0.0E+00	0.0E+00	1.8E-04	2.0E-04	0	1	1				
ND 151	7.4E-05	0.0E+00	0.0E+00	2.5E-05	2.6E-05	0	1	1				
PM 141	8.4E-05	0.0E+00	0.0E+00	2.7E-05	2.9E-05	0	1	1				
PM 143	9.5E-04	0.0E+00	0.0E+00	8.3E-03	7.1E-03	0	1	1				
PM 144	3.9E-03	0.0E+00	0.0E+00	4.4E-02	4.1E-02	0	1	1				
PM 145	4.6E-04	0.0E+00	0.0E+00	2.3E-02	2.7E-02	0	1	1				
PM 146	3.2E-03	0.0E+00	0.0E+00	1.0E-01	1.1E-01	0	1	1				
PM 147	9.5E-04	0.0E+00	0.0E+00	2.5E-02	3.4E-02	0	1	1	1	3	1	3
PM 148M	7.0E-03	0.0E+00	0.0E+00	1.7E-02	1.6E-02	0	1	1				
PM 148	9.5E-03	0.0E+00	0.0E+00	9.4E-03	1.0E-02	0	1	1				
PM 149	3.6E-03	0.0E+00	0.0E+00	2.6E-03	2.8E-03	0	1	1				
PM 150	9.8E-04	0.0E+00	0.0E+00	2.6E-04	2.9E-04	0	1	1				
PM 151	2.8E-03	0.0E+00	0.0E+00	1.4E-03	1.6E-03	0	1	1				
SM 141M	1.8E-04	0.0E+00	0.0E+00	4.9E-05	0.0E+00	0	1	0				
SM 141	8.4E-05	0.0E+00	0.0E+00	2.8E-05	0.0E+00	0	1	0				
SM 142	6.0E-04	0.0E+00	0.0E+00	1.9E-04	0.0E+00	0	1	0				
SM 145	8.5E-04	0.0E+00	0.0E+00	1.0E-02	0.0E+00	0	1	0				
SM 146	2.0E-01	0.0E+00	0.0E+00	7.8E+01	0.0E+00	0	1	0				
SM 147	1.8E-01	0.0E+00	0.0E+00	7.1E+01	0.0E+00	0	1	0				
SM 151	3.4E-04	0.0E+00	0.0E+00	2.9E-02	0.0E+00	0	1	0	1	2	1	2
SM 153	2.6E-03	0.0E+00	0.0E+00	1.7E-03	0.0E+00	0	1	0				
SM 155	6.6E-05	0.0E+00	0.0E+00	2.4E-05	0.0E+00	0	1	0				
SM 156	1.0E-03	0.0E+00	0.0E+00	5.7E-04	0.0E+00	0	1	0				

TABLE H.1. (contd)

Units: rem/uCi Intake

Nuclide	-- Ingestion -- 1	2	------- Inhalation ------ 1 (D)	2 (W)	3 (Y)	----- (a) -----				--Index- Ing	Inh	Maximums --Index- Ing	Inh
EU 145	3.2E-03	0.0E+00	0.0E+00	2.6E-03	0.0E+00	0	1	0					
EU 146	5.1E-03	0.0E+00	0.0E+00	3.8E-03	0.0E+00	0	1	0					
EU 147	1.8E-03	0.0E+00	0.0E+00	3.0E-03	0.0E+00	0	1	0					
EU 148	5.2E-03	0.0E+00	0.0E+00	1.4E-02	0.0E+00	0	1	0					
EU 149	4.2E-04	0.0E+00	0.0E+00	1.6E-03	0.0E+00	0	1	0					
EU 150	1.5E-03	0.0E+00	0.0E+00	6.1E-04	0.0E+00	0	1	0	(12H)				
EU 150	6.2E-03	0.0E+00	0.0E+00	2.7E-01	0.0E+00	0	1	0	(34Y)				
EU 152M	1.9E-03	0.0E+00	0.0E+00	7.6E-04	0.0E+00	0	1	0					
EU 152	6.0E-03	0.0E+00	0.0E+00	2.2E-01	0.0E+00	0	1	0		1	2	1	2
EU 154	9.1E-03	0.0E+00	0.0E+00	2.6E-01	0.0E+00	0	1	0		1	2	1	2
EU 155	1.3E-03	0.0E+00	0.0E+00	3.9E-02	0.0E+00	0	1	0		1	2	1	2
EU 156	8.7E-03	0.0E+00	0.0E+00	1.1E-02	0.0E+00	0	1	0		1	2	1	2
EU 157	2.3E-03	0.0E+00	0.0E+00	1.0E-03	0.0E+00	0	1	0					
EU 158	2.6E-04	0.0E+00	0.0E+00	8.4E-05	0.0E+00	0	1	0					
GD 145	1.1E-04	0.0E+00	3.2E-05	3.0E-05	0.0E+00	1	1	0					
GD 146	3.8E-03	0.0E+00	3.8E-02	1.8E-02	0.0E+00	1	1	0					
GD 147	2.6E-03	0.0E+00	1.2E-03	1.4E-03	0.0E+00	1	1	0					
GD 148	2.1E-01	0.0E+00	3.3E+02	8.4E+01	0.0E+00	1	1	0					
GD 149	1.8E-03	0.0E+00	2.3E-03	2.0E-03	0.0E+00	1	1	0					
GD 151	7.7E-04	0.0E+00	7.9E-03	4.1E-03	0.0E+00	1	1	0					
GD 152	1.5E-01	0.0E+00	2.4E+02	6.1E+01	0.0E+00	1	1	0					
GD 153	1.1E-03	0.0E+00	2.1E-02	8.4E-03	0.0E+00	1	1	0					
GD 159	1.9E-03	0.0E+00	6.4E-04	8.9E-04	0.0E+00	1	1	0					
TB 147	5.6E-04	0.0E+00	0.0E+00	1.6E-04	0.0E+00	0	1	0					
TB 149	9.5E-04	0.0E+00	0.0E+00	6.7E-03	0.0E+00	0	1	0					
TB 150	9.7E-04	0.0E+00	0.0E+00	2.3E-04	0.0E+00	0	1	0					
TB 151	1.4E-03	0.0E+00	0.0E+00	5.5E-04	0.0E+00	0	1	0					
TB 153	9.9E-04	0.0E+00	0.0E+00	7.0E-04	0.0E+00	0	1	0					
TB 154	2.8E-03	0.0E+00	0.0E+00	1.2E-03	0.0E+00	0	1	0					
TB 155	8.2E-04	0.0E+00	0.0E+00	6.7E-04	0.0E+00	0	1	0					
TB 156M	7.0E-04	0.0E+00	0.0E+00	6.6E-04	0.0E+00	0	1	0	(24H)				
TB 156M	3.2E-04	0.0E+00	0.0E+00	1.9E-04	0.0E+00	0	1	0	(5H)				
TB 156	4.6E-03	0.0E+00	0.0E+00	3.6E-03	0.0E+00	0	1	0					
TB 157	1.0E-04	0.0E+00	0.0E+00	9.0E-03	0.0E+00	0	1	0					
TB 158	4.0E-03	0.0E+00	0.0E+00	2.5E-01	0.0E+00	0	1	0					
TB 160	6.4E-03	0.0E+00	0.0E+00	2.2E-02	0.0E+00	0	1	0					
TB 161	2.6E-03	0.0E+00	0.0E+00	3.1E-03	0.0E+00	0	1	0					
DY 155	5.6E-04	0.0E+00	0.0E+00	2.0E-04	0.0E+00	0	1	0					
DY 157	2.7E-04	0.0E+00	0.0E+00	7.6E-05	0.0E+00	0	1	0					
DY 159	4.0E-04	0.0E+00	0.0E+00	2.1E-03	0.0E+00	0	1	0					
DY 165	3.6E-04	0.0E+00	0.0E+00	1.1E-04	0.0E+00	0	1	0					
DY 166	6.2E-03	0.0E+00	0.0E+00	6.9E-03	0.0E+00	0	1	0					
HO 155	1.2E-04	0.0E+00	0.0E+00	3.2E-05	0.0E+00	0	1	0					
HO 157	1.9E-05	0.0E+00	0.0E+00	3.7E-06	0.0E+00	0	1	0					
HO 159	2.3E-05	0.0E+00	0.0E+00	4.9E-06	0.0E+00	0	1	0					
HO 161	4.7E-05	0.0E+00	0.0E+00	1.2E-05	0.0E+00	0	1	0					
HO 162M	9.0E-05	0.0E+00	0.0E+00	1.9E-05	0.0E+00	0	1	0					
HO 162	6.7E-06	0.0E+00	0.0E+00	2.1E-06	0.0E+00	0	1	0					
HO 164M	4.9E-05	0.0E+00	0.0E+00	1.7E-05	0.0E+00	0	1	0					
HO 164	2.4E-05	0.0E+00	0.0E+00	8.0E-06	0.0E+00	0	1	0					
HO 166M	7.8E-03	0.0E+00	0.0E+00	7.2E-01	0.0E+00	0	1	0					
HO 166	5.5E-03	0.0E+00	0.0E+00	2.8E-03	0.0E+00	0	1	0					
HO 167	3.2E-04	0.0E+00	0.0E+00	8.5E-05	0.0E+00	0	1	0					
ER 161	3.3E-04	0.0E+00	0.0E+00	7.9E-05	0.0E+00	0	1	0					
ER 165	7.9E-05	0.0E+00	0.0E+00	2.7E-05	0.0E+00	0	1	0					
ER 169	1.4E-03	0.0E+00	0.0E+00	2.0E-03	0.0E+00	0	1	0					

TABLE H.1. (contd)

Units: rem/uCi Intake

Nuclide	-- Ingestion -- 1	2	------- Inhalation ------ 1 (D)	2 (W)	3 (Y)	----- (a) -----	--Index- Ing	Inh	Maximums --Index- Ing	Inh
ER 171	1.4E-03	0.0E+00	0.0E+00	5.0E-04	0.0E+00	0	1	0		
ER 172	3.7E-03	0.0E+00	0.0E+00	3.5E-03	0.0E+00	0	1	0		
TM 162	7.0E-05	0.0E+00	0.0E+00	1.8E-05	0.0E+00	0	1	0		
TM 166	1.2E-03	0.0E+00	0.0E+00	3.5E-04	0.0E+00	0	1	0		
TM 167	2.1E-03	0.0E+00	0.0E+00	2.6E-03	0.0E+00	0	1	0		
TM 170	5.0E-03	0.0E+00	0.0E+00	2.3E-02	0.0E+00	0	1	0		
TM 171	3.9E-04	0.0E+00	0.0E+00	8.6E-03	0.0E+00	0	1	0		
TM 172	6.0E-03	0.0E+00	0.0E+00	4.3E-03	0.0E+00	0	1	0		
TM 173	1.2E-03	0.0E+00	0.0E+00	4.3E-04	0.0E+00	0	1	0		
TM 175	5.4E-05	0.0E+00	0.0E+00	2.0E-05	0.0E+00	0	1	0		
YB 162	7.0E-05	0.0E+00	0.0E+00	1.7E-05	1.8E-05	0	1	1		
YB 166	3.8E-03	0.0E+00	0.0E+00	2.5E-03	2.8E-03	0	1	1		
YB 167	1.7E-05	0.0E+00	0.0E+00	6.5E-06	7.0E-06	0	1	1		
YB 169	2.8E-03	0.0E+00	0.0E+00	6.1E-03	7.0E-03	0	1	1		
YB 175	1.6E-03	0.0E+00	0.0E+00	1.5E-03	1.5E-03	0	1	1		
YB 177	3.1E-04	0.0E+00	0.0E+00	1.0E-04	1.1E-04	0	1	1		
YB 178	3.9E-04	0.0E+00	0.0E+00	1.2E-04	1.4E-04	0	1	1		
LU 169	2.0E-03	0.0E+00	0.0E+00	1.1E-03	1.2E-03	0	1	1		
LU 170	4.3E-03	0.0E+00	0.0E+00	2.3E-03	2.5E-03	0	1	1		
LU 171	2.6E-03	0.0E+00	0.0E+00	2.6E-03	2.6E-03	0	1	1		
LU 172	5.0E-03	0.0E+00	0.0E+00	4.2E-03	4.4E-03	0	1	1		
LU 173	9.7E-04	0.0E+00	0.0E+00	1.1E-02	1.9E-02	0	1	1		
LU 174M	1.8E-03	0.0E+00	0.0E+00	1.6E-02	2.3E-02	0	1	1		
LU 174	9.9E-04	0.0E+00	0.0E+00	2.1E-02	3.2E-02	0	1	1		
LU 176M	6.3E-04	0.0E+00	0.0E+00	2.0E-04	2.2E-04	0	1	1		
LU 176	6.6E-03	0.0E+00	0.0E+00	4.4E-01	6.3E-01	0	1	1		
LU 177M	6.8E-03	0.0E+00	0.0E+00	4.1E-02	6.2E-02	0	1	1		
LU 177	2.0E-03	0.0E+00	0.0E+00	2.3E-03	2.3E-03	0	1	1		
LU 178M	8.8E-05	0.0E+00	0.0E+00	2.8E-05	2.9E-05	0	1	1		
LU 178	1.2E-04	0.0E+00	0.0E+00	4.1E-05	4.4E-05	0	1	1		
LU 179	8.1E-04	0.0E+00	0.0E+00	2.7E-04	3.2E-04	0	1	1		
HF 170	1.9E-03	0.0E+00	8.5E-04	1.1E-03	0.0E+00	1	1	0		
HF 172	4.1E-03	0.0E+00	2.7E-01	9.1E-02	0.0E+00	1	1	0		
HF 173	9.6E-04	0.0E+00	4.0E-04	4.4E-04	0.0E+00	1	1	0		
HF 175	1.6E-03	0.0E+00	4.9E-03	4.5E-03	0.0E+00	1	1	0		
HF 177M	2.5E-04	0.0E+00	8.7E-05	5.8E-05	0.0E+00	1	1	0		
HF 178M	2.0E-02	0.0E+00	2.0E+00	5.6E-01	0.0E+00	1	1	0		
HF 179M	4.8E-03	0.0E+00	8.6E-03	8.3E-03	0.0E+00	1	1	0		
HF 180M	6.9E-04	0.0E+00	2.2E-04	2.0E-04	0.0E+00	1	1	0		
HF 181	4.3E-03	0.0E+00	1.3E-02	1.1E-02	0.0E+00	1	1	0		
HF 182M	1.4E-04	0.0E+00	5.7E-05	3.4E-05	0.0E+00	1	1	0		
HF 182	1.4E-02	0.0E+00	2.8E+00	7.1E-01	0.0E+00	1	1	0		
HF 183	2.5E-04	0.0E+00	1.1E-04	9.1E-05	0.0E+00	1	1	0		
HF 184	2.1E-03	0.0E+00	6.5E-04	7.9E-04	0.0E+00	1	1	0		
TA 172	1.4E-04	0.0E+00	0.0E+00	4.0E-05	4.9E-05	0	1	1		
TA 173	7.4E-04	0.0E+00	0.0E+00	2.6E-04	2.9E-04	0	1	1		
TA 174	1.9E-04	0.0E+00	0.0E+00	5.3E-05	5.8E-05	0	1	1		
TA 175	8.8E-04	0.0E+00	0.0E+00	3.1E-04	3.4E-04	0	1	1		
TA 176	1.3E-03	0.0E+00	0.0E+00	4.1E-04	4.2E-04	0	1	1		
TA 177	4.1E-04	0.0E+00	0.0E+00	2.6E-04	2.8E-04	0	1	1		
TA 178	2.9E-04	0.0E+00	0.0E+00	5.4E-05	7.0E-05	0	1	1		
TA 179	2.5E-04	0.0E+00	0.0E+00	9.4E-04	5.8E-03	0	1	1		
TA 180M	2.1E-04	0.0E+00	0.0E+00	7.4E-05	8.5E-05	0	1	1		
TA 180	3.3E-03	0.0E+00	0.0E+00	1.2E-02	2.1E-01	0	1	1		
TA 182M	2.4E-05	0.0E+00	0.0E+00	9.3E-06	1.2E-05	0	1	1		
TA 182	6.0E-03	0.0E+00	0.0E+00	1.6E-02	3.7E-02	0	1	1		

TABLE H.1. (contd)

Units: rem/uCi Intake

Nuclide	Ingestion 1	Ingestion 2	Inhalation 1 (D)	Inhalation 2 (W)	Inhalation 3 (Y)	(a)			Index Ing	Index Inh	Maximums Index Ing	Maximums Index Inh
TA 183	4.6E-03	0.0E+00	0.0E+00	4.4E-03	4.8E-03	0	1	1				
TA 184	2.7E-03	0.0E+00	0.0E+00	9.3E-04	1.1E-03	0	1	1				
TA 185	2.0E-04	0.0E+00	0.0E+00	6.7E-05	7.5E-05	0	1	1				
TA 186	6.7E-05	0.0E+00	0.0E+00	2.2E-05	2.3E-05	0	1	1				
W 176	4.8E-04	3.7E-04	9.4E-05	0.0E+00	0.0E+00	2	0	0				
W 177	2.4E-04	2.1E-04	5.8E-05	0.0E+00	0.0E+00	2	0	0				
W 178	9.3E-04	6.7E-04	2.6E-04	0.0E+00	0.0E+00	2	0	0				
W 179	9.0E-06	8.7E-06	3.0E-06	0.0E+00	0.0E+00	2	0	0				
W 181	3.1E-04	2.7E-04	1.5E-04	0.0E+00	0.0E+00	2	0	0				
W 185	1.9E-03	1.3E-03	7.5E-04	0.0E+00	0.0E+00	2	0	0				
W 187	2.6E-03	1.9E-03	5.3E-04	0.0E+00	0.0E+00	2	0	0				
W 188	9.0E-03	6.8E-03	4.1E-03	0.0E+00	0.0E+00	2	0	0				
RE 177	4.4E-05	0.0E+00	1.9E-05	1.4E-05	0.0E+00	1	1	0				
RE 178	4.8E-05	0.0E+00	1.9E-05	1.8E-05	0.0E+00	1	1	0				
RE 181	1.0E-03	0.0E+00	5.8E-04	5.7E-04	0.0E+00	1	1	0				
RE 182	3.4E-03	0.0E+00	2.0E-03	2.3E-03	0.0E+00	1	1	0	(64H)			
RE 182	7.4E-04	0.0E+00	4.0E-04	3.3E-04	0.0E+00	1	1	0	(12H)			
RE 184M	2.4E-03	0.0E+00	1.7E-03	1.2E-02	0.0E+00	1	1	0				
RE 184	2.2E-03	0.0E+00	1.4E-03	3.6E-03	0.0E+00	1	1	0				
RE 186M	3.3E-03	0.0E+00	2.3E-03	3.3E-02	0.0E+00	1	1	0				
RE 186	2.6E-03	0.0E+00	1.7E-03	3.0E-03	0.0E+00	1	1	0				
RE 187	8.3E-06	0.0E+00	5.5E-06	4.9E-05	0.0E+00	1	1	0				
RE 188M	6.2E-05	0.0E+00	3.6E-05	3.7E-05	0.0E+00	1	1	0				
RE 188	2.8E-03	0.0E+00	1.8E-03	1.8E-03	0.0E+00	1	1	0				
RE 189	1.5E-03	0.0E+00	9.8E-04	1.1E-03	0.0E+00	1	1	0				
OS 180	4.7E-05	0.0E+00	1.4E-05	1.0E-05	1.1E-05	1	1	1				
OS 181	3.5E-04	0.0E+00	1.1E-04	1.1E-04	1.2E-04	1	1	1				
OS 182	2.2E-03	0.0E+00	8.4E-04	1.2E-03	1.3E-03	1	1	1				
OS 185	2.1E-03	0.0E+00	1.0E-02	6.4E-03	6.2E-03	1	1	1				
OS 189M	6.6E-05	0.0E+00	2.2E-05	2.4E-05	2.9E-05	1	1	1				
OS 191M	3.6E-04	0.0E+00	1.8E-04	2.4E-04	2.8E-04	1	1	1				
OS 191	2.0E-03	0.0E+00	2.4E-03	3.1E-03	3.7E-03	1	1	1				
OS 193	3.1E-03	0.0E+00	1.1E-03	1.7E-03	1.9E-03	1	1	1				
OS 194	9.1E-03	0.0E+00	1.2E-01	8.7E-02	6.7E-01	1	1	1				
IR 182	1.2E-04	0.0E+00	3.5E-05	3.3E-05	3.9E-05	1	1	1				
IR 184	6.4E-04	0.0E+00	2.0E-04	1.6E-04	1.9E-04	1	1	1				
IR 185	1.1E-03	0.0E+00	4.0E-04	4.3E-04	4.9E-04	1	1	1				
IR 186	2.1E-03	0.0E+00	6.5E-04	7.9E-04	8.6E-04	1	1	1				
IR 187	4.8E-04	0.0E+00	1.6E-04	1.7E-04	1.9E-04	1	1	1				
IR 188	2.7E-03	0.0E+00	1.1E-03	1.4E-03	1.5E-03	1	1	1				
IR 189	9.3E-04	0.0E+00	1.0E-03	1.3E-03	1.4E-03	1	1	1				
IR 190M	3.0E-05	0.0E+00	2.6E-05	2.4E-05	2.6E-05	1	1	1				
IR 190	4.9E-03	0.0E+00	5.4E-03	4.9E-03	5.4E-03	1	1	1				
IR 192M	1.5E-03	0.0E+00	5.4E-02	2.3E-02	3.3E-01	1	1	1				
IR 192	5.3E-03	0.0E+00	1.8E-02	1.3E-02	2.3E-02	1	1	1				
IR 194M	8.1E-03	0.0E+00	5.3E-02	3.1E-02	4.9E-02	1	1	1				
IR 194	5.1E-03	0.0E+00	1.7E-03	2.4E-03	2.7E-03	1	1	1				
IR 195M	6.4E-04	0.0E+00	2.1E-04	1.8E-04	2.3E-04	1	1	1				
IR 195	3.4E-04	0.0E+00	1.2E-04	9.8E-05	1.2E-04	1	1	1				
PT 186	3.7E-04	0.0E+00	1.3E-04	0.0E+00	0.0E+00	1	0	0				
PT 188	3.0E-03	0.0E+00	3.1E-03	0.0E+00	0.0E+00	1	0	0				
PT 189	4.9E-04	0.0E+00	1.7E-04	0.0E+00	0.0E+00	1	0	0				
PT 191	1.3E-03	0.0E+00	6.0E-04	0.0E+00	0.0E+00	1	0	0				
PT 193M	1.7E-03	0.0E+00	8.3E-04	0.0E+00	0.0E+00	1	0	0				
PT 193	1.1E-04	0.0E+00	2.1E-04	0.0E+00	0.0E+00	1	0	0				
PT 195M	2.2E-03	0.0E+00	1.2E-03	0.0E+00	0.0E+00	1	0	0				

TABLE H.1. (contd)

Nuclide	Units: rem/uCi Intake -- Ingestion -- 1	2	------- Inhalation ------ 1 (D)	2 (W)	3 (Y)	----- (a) -----			--Index- Ing	Inh	Maximums --Index- Ing	Inh
PT 197M	3.1E-04	0.0E+00	1.2E-04	0.0E+00	0.0E+00	1	0	0				
PT 197	1.5E-03	0.0E+00	5.2E-04	0.0E+00	0.0E+00	1	0	0				
PT 199	1.0E-04	0.0E+00	3.6E-05	0.0E+00	0.0E+00	1	0	0				
PT 200	4.5E-03	0.0E+00	1.5E-03	0.0E+00	0.0E+00	1	0	0				
AU 193	6.0E-04	0.0E+00	3.6E-04	2.9E-04	2.9E-04	1	1	1				
AU 194	2.0E-03	0.0E+00	1.3E-03	4.2E+15	1.1E-03	1	1	1				
AU 195	1.1E-03	0.0E+00	1.1E-03	3.5E-03	1.2E-02	1	1	1				
AU 198M	5.7E-03	0.0E+00	4.5E-03	5.0E-03	4.9E-03	1	1	1				
AU 198	2.3E-03	0.0E+00	2.9E-03	2.0E-03	1.8E-03	1	1	1				
AU 199	1.8E-03	0.0E+00	1.5E-03	1.5E-03	1.5E-03	1	1	1				
AU 200M	4.6E-03	0.0E+00	2.7E-03	2.2E-03	2.1E-03	1	1	1				
AU 200	1.9E-04	0.0E+00	1.3E-04	8.1E-05	7.1E-05	1	1	1				
AU 201	5.7E-05	0.0E+00	3.6E-05	2.5E-05	2.2E-05	1	1	1				
HG 193M	5.4E-04	1.2E-03	3.8E-04	0.0E+00	0.0E+00	1	0	0	(ORG)			
HG 193M	1.6E-03	0.0E+00	5.6E-04	6.3E-04	0.0E+00	1	1	0	(IN)			
HG 193M	0.0E+00	0.0E+00	0.0E+00	5.8E-04	0.0E+00	0	0	0	(VAP)			
HG 193	1.1E-04	2.5E-04	7.7E-05	0.0E+00	0.0E+00	1	0	0	(ORG)			
HG 193	3.3E-04	0.0E+00	1.1E-04	1.2E-04	0.0E+00	1	1	0	(IN)			
HG 193	0.0E+00	0.0E+00	0.0E+00	1.6E-04	0.0E+00	0	0	0	(VAP)			
HG 194	2.8E-01	1.1E-01	1.8E-01	0.0E+00	0.0E+00	1	0	0	(ORG)			
HG 194	6.0E-03	0.0E+00	1.2E-01	4.2E-02	0.0E+00	1	1	0	(IN)			
HG 194	0.0E+00	0.0E+00	0.0E+00	1.7E-01	0.0E+00	0	0	0	(VAP)			
HG 195M	1.1E-03	1.7E-03	8.2E-04	0.0E+00	0.0E+00	1	0	0	(ORG)			
HG 195M	2.2E-03	0.0E+00	9.5E-04	1.3E-03	0.0E+00	1	1	0	(IN)			
HG 195M	0.0E+00	0.0E+00	0.0E+00	1.3E-03	0.0E+00	0	0	0	(VAP)			
HG 195	1.4E-04	3.0E-04	1.1E-04	0.0E+00	0.0E+00	1	0	0	(ORG)			
HG 195	3.8E-04	0.0E+00	1.4E-04	1.5E-04	0.0E+00	1	1	0	(IN)			
HG 195	0.0E+00	0.0E+00	0.0E+00	1.7E-04	0.0E+00	0	0	0	(VAP)			
HG 197M	7.1E-04	1.3E-03	5.5E-04	0.0E+00	0.0E+00	1	0	0	(ORG)			
HG 197M	1.7E-03	0.0E+00	6.9E-04	1.0E-03	0.0E+00	1	1	0	(IN)			
HG 197M	0.0E+00	0.0E+00	0.0E+00	9.8E-04	0.0E+00	0	0	0	(VAP)			
HG 197	5.3E-04	7.3E-04	3.7E-04	0.0E+00	0.0E+00	1	0	0	(ORG)			
HG 197	9.1E-04	0.0E+00	4.3E-04	5.9E-04	0.0E+00	1	1	0	(IN)			
HG 197	0.0E+00	0.0E+00	0.0E+00	6.3E-05	0.0E+00	0	0	0	(VAP)			
HG 199M	4.9E-05	8.1E-05	3.1E-05	0.0E+00	0.0E+00	1	0	0	(ORG)			
HG 199M	8.5E-05	0.0E+00	3.4E-05	2.8E-05	0.0E+00	1	1	0	(IN)			
HG 199M	0.0E+00	0.0E+00	0.0E+00	6.7E-05	0.0E+00	0	0	0	(VAP)			
HG 203	1.0E-02	5.6E-03	6.5E-03	0.0E+00	0.0E+00	1	0	0	(ORG)			
HG 203	2.1E-03	0.0E+00	4.0E-03	4.5E-03	0.0E+00	1	1	0	(IN)	1 -	1	-
HG 203	0.0E+00	0.0E+00	0.0E+00	6.2E-03	0.0E+00	0	0	0	(VAP)	- 2	-	2
TL 194M	7.1E-05	0.0E+00	3.3E-05	0.0E+00	0.0E+00	1	0	0				
TL 194	1.9E-05	0.0E+00	8.4E-06	0.0E+00	0.0E+00	1	0	0				
TL 195	7.7E-05	0.0E+00	4.0E-05	0.0E+00	0.0E+00	1	0	0				
TL 197	6.9E-05	0.0E+00	4.3E-05	0.0E+00	0.0E+00	1	0	0				
TL 198M	1.6E-04	0.0E+00	9.1E-05	0.0E+00	0.0E+00	1	0	0				
TL 198	2.6E-04	0.0E+00	1.6E-04	0.0E+00	0.0E+00	1	0	0				
TL 199	8.2E-05	0.0E+00	6.1E-05	0.0E+00	0.0E+00	1	0	0				
TL 200	6.7E-04	0.0E+00	4.6E-04	0.0E+00	0.0E+00	1	0	0				
TL 201	2.9E-04	0.0E+00	2.3E-04	0.0E+00	0.0E+00	1	0	0				
TL 202	1.5E-03	0.0E+00	9.8E-04	0.0E+00	0.0E+00	1	0	0				
TL 204	3.2E-03	0.0E+00	2.3E-03	0.0E+00	0.0E+00	1	0	0				
PB 195M	8.5E-05	0.0E+00	2.5E-05	0.0E+00	0.0E+00	1	0	0				
PB 198	1.6E-04	0.0E+00	7.7E-05	0.0E+00	0.0E+00	1	0	0				
PB 199	2.2E-04	0.0E+00	7.0E-05	0.0E+00	0.0E+00	1	0	0				
PB 200	1.5E-03	0.0E+00	7.9E-04	0.0E+00	0.0E+00	1	0	0				
PB 201	6.7E-04	0.0E+00	2.4E-04	0.0E+00	0.0E+00	1	0	0				

TABLE H.1. (contd)

Nuclide	Units: rem/uCi Intake -- Ingestion -- 1	2	Inhalation 1 (D)	2 (W)	3 (Y)	(a)			--Index- Ing	Inh	Maximums --Index- Ing	Inh
PB 202M	5.5E-04	0.0E+00	1.7E-04	0.0E+00	0.0E+00	1	0	0				
PB 202	3.9E-02	0.0E+00	9.9E-02	0.0E+00	0.0E+00	1	0	0				
PB 203	9.6E-04	0.0E+00	5.2E-04	0.0E+00	0.0E+00	1	0	0				
PB 205	1.5E-03	0.0E+00	3.7E-03	0.0E+00	0.0E+00	1	0	0				
PB 209	2.1E-04	0.0E+00	9.0E-05	0.0E+00	0.0E+00	1	0	0				
PB 210	5.1E+00	0.0E+00	1.3E+01	0.0E+00	0.0E+00	1	0	0	1	1	1	1
PB 211	4.4E-04	0.0E+00	8.0E-03	0.0E+00	0.0E+00	1	0	0				
PB 212	4.1E-02	0.0E+00	1.6E-01	0.0E+00	0.0E+00	1	0	0	1	1	1	1
PB 214	5.8E-04	0.0E+00	6.7E-03	0.0E+00	0.0E+00	1	0	0				
BI 200	1.7E-04	0.0E+00	6.1E-05	5.1E-05	0.0E+00	1	1	0				
BI 201	4.5E-04	0.0E+00	1.8E-04	1.3E-04	0.0E+00	1	1	0				
BI 202	3.6E-04	0.0E+00	1.2E-04	6.6E-05	0.0E+00	1	1	0				
BI 203	2.1E-03	0.0E+00	7.4E-04	8.2E-04	0.0E+00	1	1	0				
BI 205	3.7E-03	0.0E+00	2.0E-03	3.9E-03	0.0E+00	1	1	0				
BI 206	8.0E-03	0.0E+00	3.7E-03	5.9E-03	0.0E+00	1	1	0				
BI 207	4.9E-03	0.0E+00	2.9E-03	1.4E-02	0.0E+00	1	1	0	1	2	1	2
BI 210M	8.6E-02	0.0E+00	8.0E-01	7.5E+00	0.0E+00	1	1	0				
BI 210	5.9E-03	0.0E+00	1.3E-02	1.9E-01	0.0E+00	1	1	0	1	2	1	2
BI 212	9.9E-04	0.0E+00	2.1E-02	1.7E-02	0.0E+00	1	1	0	1	1	1	1
BI 213	6.8E-04	0.0E+00	1.7E-02	1.4E-02	0.0E+00	1	1	0				
BI 214	2.4E-04	0.0E+00	6.3E-03	5.8E-03	0.0E+00	1	1	0				
PO 203	2.0E-04	0.0E+00	7.9E-05	5.9E-05	0.0E+00	1	1	0				
PO 205	2.4E-04	0.0E+00	1.3E-04	7.0E-05	0.0E+00	1	1	0				
PO 207	6.1E-04	0.0E+00	2.0E-04	1.7E-04	0.0E+00	1	1	0				
PO 210	1.6E+00	0.0E+00	8.0E+00	8.1E+00	0.0E+00	1	1	0	1	2	1	2
AT 207	8.9E-04	0.0E+00	1.9E-03	2.3E-03	0.0E+00	1	1	0				
AT 211	4.1E-02	0.0E+00	6.7E-02	9.3E-02	0.0E+00	1	1	0				
FR 222	2.5E-03	0.0E+00	1.1E-02	0.0E+00	0.0E+00	1	0	0				
FR 223	8.6E-03	0.0E+00	6.1E-03	0.0E+00	0.0E+00	1	0	0				
RA 223	5.5E-01	0.0E+00	0.0E+00	7.5E+00	0.0E+00	0	1	0				
RA 224	3.3E-01	0.0E+00	0.0E+00	2.9E+00	0.0E+00	0	1	0	1	2	1	2
RA 225	3.1E-01	0.0E+00	0.0E+00	7.5E+00	0.0E+00	0	1	0				
RA 226	1.1E+00	0.0E+00	0.0E+00	7.9E+00	0.0E+00	0	1	0	1	2	1	2
RA 227	2.2E-04	0.0E+00	0.0E+00	2.7E-04	0.0E+00	0	1	0				
RA 228	1.2E+00	0.0E+00	0.0E+00	4.2E+00	0.0E+00	0	1	0	1	2	1	2
AC 224	2.6E-03	0.0E+00	1.3E-01	1.0E-01	1.1E-01	1	1	1				
AC 225	9.5E-02	0.0E+00	1.0E+01	7.5E+00	8.0E+00	1	1	1				
AC 226	4.0E-02	0.0E+00	1.3E+00	1.0E+00	1.1E+00	1	1	1				
AC 227	1.4E+01	0.0E+00	6.7E+03	1.7E+03	1.2E+03	1	1	1				
AC 228	2.1E-03	0.0E+00	2.9E-01	8.7E-02	1.1E-01	1	1	1	1	1	1	1
TH 226	9.2E-04	0.0E+00	0.0E+00	3.2E-02	3.5E-02	0	1	1				
TH 227	3.6E-02	0.0E+00	0.0E+00	1.5E+01	1.6E+01	0	1	1				
TH 228	3.8E-01	0.0E+00	0.0E+00	2.5E+02	3.1E+02	0	1	1	1	3	1	3
TH 229	3.5E+00	0.0E+00	0.0E+00	2.0E+03	1.7E+03	0	1	1	1	3	1	2
TH 230	5.3E-01	0.0E+00	0.0E+00	3.2E+02	2.6E+02	0	1	1	1	3	1	2
TH 231	1.3E-03	0.0E+00	0.0E+00	8.1E-04	7.7E-04	0	1	1				
TH 232	2.8E+00	0.0E+00	0.0E+00	1.6E+03	1.1E+03	0	1	1	1	3	1	2
TH 234	1.3E-02	0.0E+00	0.0E+00	2.5E-02	3.3E-02	0	1	1	1	3	1	3
PA 227	1.3E-03	0.0E+00	0.0E+00	4.4E-02	4.9E-02	0	1	1				
PA 228	4.0E-03	0.0E+00	0.0E+00	2.3E-01	4.1E-01	0	1	1				
PA 230	5.6E-03	0.0E+00	0.0E+00	1.1E+00	1.5E+00	0	1	1				
PA 231	1.1E+01	0.0E+00	0.0E+00	1.3E+03	8.6E+02	0	1	1				
PA 232	3.4E-03	0.0E+00	0.0E+00	8.9E-02	6.8E-02	0	1	1				
PA 233	3.3E-03	0.0E+00	0.0E+00	7.1E-03	8.6E-03	0	1	1	1	3	1	3
PA 234	2.1E-03	0.0E+00	0.0E+00	6.5E-04	7.4E-04	0	1	1	1	3	1	3
U 230	8.4E-01	1.2E-01	8.4E+00	1.4E+01	2.0E+01	1	1	2				

TABLE H.1. (contd)

Nuclide	Units: rem/uCi Intake -- Ingestion -- 1	2	------- Inhalation ------ 1 (D)	2 (W)	3 (Y)	----- (a) -----				--Index- Ing	Inh	Maximums --Index- Ing	Inh
U 231	1.1E-03	1.1E-03	6.3E-04	8.8E-04	1.1E-03	1	1	2					
U 231	1.1E-03	1.1E-03	6.3E-04	8.8E-04	1.1E-03	1	1	2					
U 232	1.3E+00	6.8E-02	1.2E+01	1.3E+01	6.7E+02	1	1	2		2	3	1	3
U 233	2.7E-01	2.5E-02	2.7E+00	7.1E+00	1.3E+02	1	1	2		2	3	1	3
U 234	2.6E-01	2.5E-02	2.7E+00	7.1E+00	1.3E+02	1	1	2		2	3	1	3
U 235	2.5E-01	2.5E-02	2.5E+00	6.7E+00	1.2E+02	1	1	2		2	3	1	3
U 236	2.5E-01	2.4E-02	2.5E+00	6.7E+00	1.2E+02	1	1	2					
U 237	2.6E-03	2.7E-03	1.8E-03	2.9E-03	3.3E-03	1	1	2					
U 238	2.3E-01	2.3E-02	2.4E+00	6.2E+00	1.2E+02	1	1	2		2	3	1	3
U 239	7.5E-05	7.6E-05	2.7E-05	3.0E-05	3.3E-05	1	1	2					
U 240	3.9E-03	4.1E-03	1.4E-03	1.8E-03	2.1E-03	1	1	2					
NP 232	2.4E-05	0.0E+00	0.0E+00	1.1E-03	0.0E+00	0	1	0					
NP 233	5.6E-06	0.0E+00	0.0E+00	1.5E-06	0.0E+00	0	1	0					
NP 234	1.7E-03	0.0E+00	0.0E+00	1.9E-03	0.0E+00	0	1	0					
NP 235	2.1E-04	0.0E+00	0.0E+00	3.8E-03	0.0E+00	0	1	0					
NP 236	7.9E-01	0.0E+00	0.0E+00	9.9E+01	0.0E+00	0	1	0	(1E5Y)				
NP 236	9.5E-04	0.0E+00	0.0E+00	7.1E-02	0.0E+00	0	1	0	(22H)				
NP 237	3.9E+00	0.0E+00	0.0E+00	4.9E+02	0.0E+00	0	1	0		1	2	1	2
NP 238	3.4E-03	0.0E+00	0.0E+00	3.1E-02	0.0E+00	0	1	0					
NP 239	2.9E-03	0.0E+00	0.0E+00	2.2E-03	0.0E+00	0	1	0					
NP 240	2.0E-04	0.0E+00	0.0E+00	6.3E-05	0.0E+00	0	1	0					
PU 234	1.2E-03	5.5E-04	0.0E+00	2.4E-02	2.7E-02	0	1	2					
PU 235	1.4E-05	5.9E-06	0.0E+00	1.7E-06	2.0E-06	0	1	2					
PU 236	1.3E+00	3.0E-02	0.0E+00	1.6E+02	1.3E+02	0	1	2					
PU 237	1.0E-03	4.0E-04	0.0E+00	1.6E-03	1.6E-03	0	1	2					
PU 238	3.8E+00	5.4E-02	0.0E+00	4.6E+02	3.0E+02	0	1	2		2	3	1	2
PU 239	4.3E+00	5.8E-02	0.0E+00	5.1E+02	3.3E+02	0	1	2		2	3	1	2
PU 240	4.3E+00	5.8E-02	0.0E+00	5.1E+02	3.3E+02	0	1	2		2	3	1	2
PU 241	8.6E-02	9.2E-04	0.0E+00	1.0E+01	5.7E+00	0	1	2		2	3	1	2
PU 242	4.1E+00	5.6E-02	0.0E+00	4.8E+02	3.1E+02	0	1	2					
PU 243	3.3E-04	3.3E-04	0.0E+00	1.5E-04	1.4E-04	0	1	2					
PU 244	4.0E+00	6.4E-02	0.0E+00	4.8E+02	3.1E+02	0	1	2					
PU 245	2.4E-03	2.4E-03	0.0E+00	1.1E-03	1.2E-03	0	1	2					
AM 237	7.4E-05	0.0E+00	0.0E+00	1.8E-05	0.0E+00	0	1	0					
AM 238	1.7E-04	0.0E+00	0.0E+00	9.6E-04	0.0E+00	0	1	0					
AM 239	1.0E-03	0.0E+00	0.0E+00	4.0E-04	0.0E+00	0	1	0					
AM 240	2.9E-03	0.0E+00	0.0E+00	1.8E-03	0.0E+00	0	1	0					
AM 241	4.5E+00	0.0E+00	0.0E+00	5.2E+02	0.0E+00	0	1	0		1	2	1	2
AM 242M	4.2E+00	0.0E+00	0.0E+00	5.1E+02	0.0E+00	0	1	0					
AM 242	1.2E-03	0.0E+00	0.0E+00	6.1E-02	0.0E+00	0	1	0					
AM 243	4.5E+00	0.0E+00	0.0E+00	5.2E+02	0.0E+00	0	1	0					
AM 244M	6.8E-05	0.0E+00	0.0E+00	8.0E-04	0.0E+00	0	1	0					
AM 244	2.0E-03	0.0E+00	0.0E+00	1.7E-02	0.0E+00	0	1	0					
AM 245	1.8E-04	0.0E+00	0.0E+00	6.6E-05	0.0E+00	0	1	0					
AM 246M	8.4E-05	0.0E+00	0.0E+00	2.9E-05	0.0E+00	0	1	0					
AM 246	1.5E-04	0.0E+00	0.0E+00	4.9E-05	0.0E+00	0	1	0					
CM 238	3.6E-04	0.0E+00	0.0E+00	4.7E-03	0.0E+00	0	1	0					
CM 240	6.3E-02	0.0E+00	0.0E+00	8.3E+00	0.0E+00	0	1	0					
CM 241	4.6E-03	0.0E+00	0.0E+00	1.6E-01	0.0E+00	0	1	0					
CM 242	1.1E-01	0.0E+00	0.0E+00	1.7E+01	0.0E+00	0	1	0					
CM 243	2.9E+00	0.0E+00	0.0E+00	3.5E+02	0.0E+00	0	1	0					
CM 244	2.3E+00	0.0E+00	0.0E+00	2.7E+02	0.0E+00	0	1	0					
CM 245	4.5E+00	0.0E+00	0.0E+00	5.4E+02	0.0E+00	0	1	0					
CM 246	4.5E+00	0.0E+00	0.0E+00	5.4E+02	0.0E+00	0	1	0					
CM 247	4.1E+00	0.0E+00	0.0E+00	4.9E+02	0.0E+00	0	1	0					
CM 248	1.6E+01	0.0E+00	0.0E+00	1.9E+03	0.0E+00	0	1	0					

TABLE H.1. (contd)

Nuclide	Units: rem/uCi Intake -- Ingestion -- 1	2	------- Inhalation ------ 1 (D)	2 (W)	3 (Y)	----- (a) -----			--Index- Ing	Inh	Maximums --Index- Ing	Inh
CM 249	9.5E-05	0.0E+00	0.0E+00	2.2E-04	0.0E+00	0	1	0				
BK 245	2.3E-03	0.0E+00	0.0E+00	3.8E-03	0.0E+00	0	1	0				
BK 246	1.9E-03	0.0E+00	0.0E+00	1.7E-03	0.0E+00	0	1	0				
BK 247	2.3E+00	0.0E+00	0.0E+00	5.5E+02	0.0E+00	0	1	0				
BK 249	6.0E-03	0.0E+00	0.0E+00	1.3E+00	0.0E+00	0	1	0				
BK 250	5.0E-04	0.0E+00	0.0E+00	6.9E-03	0.0E+00	0	1	0				
CF 244	1.5E-04	0.0E+00	0.0E+00	8.5E-03	8.9E-03	0	1	1				
CF 246	1.2E-02	0.0E+00	0.0E+00	4.9E-01	5.8E-01	0	1	1				
CF 248	2.8E-01	0.0E+00	0.0E+00	3.8E+01	4.3E+01	0	1	1				
CF 249	4.6E+00	0.0E+00	0.0E+00	5.5E+02	3.6E+02	0	1	1				
CF 250	1.9E+00	0.0E+00	0.0E+00	2.2E+02	1.9E+02	0	1	1				
CF 251	4.6E+00	0.0E+00	0.0E+00	5.6E+02	3.7E+02	0	1	1				
CF 252	9.4E-01	0.0E+00	0.0E+00	1.2E+02	1.3E+02	0	1	1				
CF 253	9.2E-03	0.0E+00	0.0E+00	2.5E+00	3.0E+00	0	1	1				
CF 254	2.5E+00	0.0E+00	0.0E+00	2.2E+02	2.8E+02	0	1	1				
ES 250	9.5E-05	0.0E+00	0.0E+00	4.2E-03	0.0E+00	0	1	0				
ES 251	6.7E-04	0.0E+00	0.0E+00	4.3E-03	0.0E+00	0	1	0				
ES 253	2.4E-02	0.0E+00	0.0E+00	3.3E+00	0.0E+00	0	1	0				
ES 254M	1.5E-02	0.0E+00	0.0E+00	4.7E-01	0.0E+00	0	1	0				
ES 254	1.5E-01	0.0E+00	0.0E+00	3.6E+01	0.0E+00	0	1	0				
FM 252	9.9E-03	0.0E+00	0.0E+00	3.8E-01	0.0E+00	0	1	0				
FM 253	3.5E-03	0.0E+00	0.0E+00	4.8E-01	0.0E+00	0	1	0				
FM 254	1.6E-03	0.0E+00	0.0E+00	4.9E-02	0.0E+00	0	1	0				
FM 255	9.7E-03	0.0E+00	0.0E+00	2.3E-01	0.0E+00	0	1	0				
FM 257	7.3E-02	0.0E+00	0.0E+00	2.1E+01	0.0E+00	0	1	0				
MD 257	5.4E-04	0.0E+00	0.0E+00	5.2E-02	0.0E+00	0	1	0				
MD 258	6.1E-02	0.0E+00	0.0E+00	1.5E+01	0.0E+00	0	1	0				
EOF	----------											

(a) Columns without headings are part of the original data file, but were not pertinent to this document.

APPENDIX I

WORKER DOSE FOR EACH SCENARIO BY RADIONUCLIDE

APPENDIX I

WORKER DOSE FOR EACH SCENARIO BY RADIONUCLIDE

Doses by radionuclide for individual and collective worker scenarios are presented in Tables I.1 and I.2. Table I.1 lists the exposure scenario, waste form, limiting concentration, dominant exposure pathway, and dose by pathway for each radionuclide. The scenarios are listed from the most restrictive to least restrictive (lowest to highest limiting concentration).

Table I.2 presents worker collective doses by exposure category for each radionuclide. For each category, the number for workers, total dose (man-rem), dominant exposure pathway, and the dose to the average individual worker are given. These doses are based on the limiting concentration from the most restrictive worker scenario for each radionuclide listed in Table I.1. The scenarios that apply to the incineration of organic liquids in a liquid-only incinerator (residue 2%) are specified with "(OL)" following the scenario description. The "(OL)" scenarios are provided here only for interest; they are not used in the overall summary evaluations. Scenarios and concentrations in **boldface** are the bases for the limiting concentrations noted in Table S.1 and the tables in Sections 3.0 and 4.0.

TABLE I.1. Radionuclide Concentration in Waste That Results in 1 mrem/y Dose to a Worker, Sorted from Most Restrictive to Least Restrictive Scenario for Each Radionuclide

Nuclide/ Scenario	Waste Form	Limiting Concentration, pCi/g	Dominant Exposure Pathway	Dose, mrem Based on 1 pCi/g in Waste			
				Inhalation	Ingestion	External	Total
^{3}H							
Incineration/Bag Filter (OL)	Fly ash	3.2E+05	Ingestion	3.0E-09	3.1E-06	2.5E-10	3.2E-06
Incineration/Wet Scrubber (OL)	Fly ash	3.2E+05	Ingestion	3.0E-09	3.1E-06	Zero	3.2E-06
Waste Receiving	**Waste**	**3.1E+06**[a]	Ingestion	7.6E-09	3.1E-07	3.3E-36	3.2E-07
Waste Disposal	Waste	6.3E+06	Ingestion	1.5E-09	1.6E-07	Zero	1.6E-07
Waste Treatment	Waste	6.3E+06	Ingestion	1.1E-09	1.6E-07	8.9E-37	1.6E-07
Incineration/Bag Filter	Fly ash	6.3E+06	Ingestion	6.0E-10	1.6E-07	5.0E-11	1.6E-07
Incineration/Wet Scrubber	Fly ash	6.3E+06	Ingestion	6.0E-10	1.6E-07	Zero	1.6E-07
Landfill Excavation	Waste	2.6E+08	Ingestion	1.5E-12	3.8E-09	Zero	3.8E-09
Ash Transport (Dump truck) (OL)	Slag	2.6E+09	Inhalation	3.8E-10	Zero	Zero	3.8E-10
Ash Transport (Dump truck)	Slag	1.9E+10	Inhalation	5.4E-11	Zero	Zero	5.4E-11
Waste Transport	Waste	None	Ingestion	Zero	Zero	Zero	Zero
Incinerator Maintenance	Slag	None	Ingestion	Zero	Zero	Zero	Zero
Incinerator Maintenance (OL)	Slag	None	Ingestion	Zero	Zero	Zero	Zero
^{7}Be							
Incinerator Maintenance (OL)	Slag	1.3E+01	External	8.2E-08	6.2E-06	7.7E-02	7.7E-02
Waste Disposal	**Waste**	**5.9E+01**	External	6.5E-09	2.7E-07	1.7E-02	1.7E-02
Waste Receiving	Waste	9.7E+01	External	3.2E-08	5.5E-07	1.0E-02	1.0E-02
Ash Transport (Dump truck) (OL)	Slag	9.8E+01	External	1.6E-08	Zero	1.0E-02	1.0E-02
Incinerator Maintenance	Slag	1.0E+02	External	1.0E-08	9.9E-07	9.9E-03	9.9E-03
Incineration/Bag Filter (OL)	Fly ash	1.5E+02	External	1.3E-08	5.5E-06	6.5E-03	6.5E-03
Incineration/Wet Scrubber (OL)	Fly ash	2.3E+02	External	1.3E-08	5.5E-06	4.3E-03	4.3E-03
Waste Treatment	Waste	5.7E+02	External	4.9E-09	2.7E-07	1.7E-03	1.7E-03
Ash Transport (Dump truck)	Slag	7.6E+02	External	2.3E-09	Zero	1.3E-03	1.3E-03
Incineration/Bag Filter	Fly ash	7.7E+02	External	2.6E-09	2.7E-07	1.3E-03	1.3E-03
Waste Transport	Waste	8.4E+02	External	Zero	Zero	1.2E-03	1.2E-03
Incineration/Wet Scrubber	Fly ash	1.2E+03	External	2.6E-09	2.7E-07	8.7E-04	8.7E-04
Landfill Excavation	Waste	4.5E+03	External	6.5E-12	6.6E-09	2.2E-04	2.2E-04
^{14}C							
Incineration/Bag Filter (OL)	Fly ash	4.6E+04	Ingestion	2.3E-10	2.1E-05	7.0E-07	2.2E-05
Incineration/Wet Scrubber (OL)	Fly ash	4.8E+04	Ingestion	2.3E-10	2.1E-05	7.2E-10	2.1E-05
Waste Receiving	**Waste**	**9.4E+04**	Ingestion	2.9E-09	1.0E-05	8.9E-08	1.1E-05
Waste Disposal	Waste	1.9E+05	Ingestion	5.8E-10	5.2E-06	4.0E-09	5.3E-06
Waste Treatment	Waste	1.9E+05	Ingestion	4.3E-10	5.2E-06	8.3E-09	5.3E-06
Incinerator Maintenance (OL)	Slag	2.2E+05	Ingestion	2.4E-10	3.9E-06	7.0E-07	4.6E-06
Incineration/Bag Filter	Fly ash	8.4E+05	Ingestion	4.6E-11	1.0E-06	1.4E-07	1.2E-06
Incineration/Wet Scrubber	Fly ash	9.5E+05	Ingestion	4.6E-11	1.0E-06	1.4E-10	1.1E-06
Incinerator Maintenance	Slag	1.4E+06	Ingestion	3.1E-11	6.3E-07	9.0E-08	7.2E-07
Landfill Excavation	Waste	7.9E+06	Ingestion	5.8E-13	1.3E-07	5.3E-11	1.3E-07
Waste Transport	Waste	2.1E+09	External	Zero	Zero	4.8E-10	4.8E-10
Ash Transport (Dump truck) (OL)	Slag	8.8E+09	Inhalation	7.2E-11	Zero	4.2E-11	1.1E-10
Ash Transport (Dump truck)	Slag	6.4E+10	Inhalation	1.0E-11	Zero	5.4E-12	1.6E-11

TABLE I.1. (contd)

Nuclide/ Scenario	Waste Form	Limiting Concentration, pCi/g	Dominant Exposure Pathway	Dose, mrem Based on 1 pCi/g in Waste			
				Inhalation	Ingestion	External	Total
^{22}Na							
Incinerator Maintenance (OL)	Slag	2.5E-01	External	2.4E-06	6.7E-04	4.0E+00	4.0E+00
Waste Disposal	**Waste**	**7.2E-01**	External	1.9E-07	3.0E-05	1.4E+00	1.4E+00
Ash Transport (Dump truck) (OL)	Slag	1.4E+00	External	4.8E-07	Zero	7.0E-01	7.0E-01
Waste Receiving	Waste	1.8E+00	External	9.6E-07	6.0E-05	5.5E-01	5.5E-01
Incinerator Maintenance	Slag	2.0E+00	External	3.1E-07	1.1E-04	5.1E-01	5.1E-01
Incineration/Bag Filter (OL)	Fly ash	3.0E+00	External	3.8E-07	6.0E-04	3.3E-01	3.3E-01
Incineration/Wet Scrubber (OL)	Fly ash	3.9E+00	External	3.8E-07	6.0E-04	2.6E-01	2.6E-01
Waste Treatment	Waste	1.0E+01	External	1.4E-07	3.0E-05	9.9E-02	9.9E-02
Ash Transport (Dump truck)	Slag	1.1E+01	External	6.9E-08	Zero	9.0E-02	9.0E-02
Waste Transport	Waste	1.4E+01	External	Zero	Zero	7.2E-02	7.2E-02
Incineration/Bag Filter	Fly ash	1.5E+01	External	7.7E-08	3.0E-05	6.6E-02	6.6E-02
Incineration/Wet Scrubber	Fly ash	1.9E+01	External	7.7E-08	3.0E-05	5.1E-02	5.1E-02
Landfill Excavation	Waste	5.4E+01	External	1.9E-10	7.2E-07	1.9E-02	1.9E-02
^{32}P							
Incinerator Maintenance (OL)	Slag	2.0E+02	External	3.7E-06	4.1E-04	4.5E-03	4.9E-03
Incineration/Bag Filter (OL)	Fly ash	9.0E+02	External	8.1E-07	5.0E-04	6.1E-04	1.1E-03
Incineration/Wet Scrubber (OL)	Fly ash	1.3E+03	Ingestion	8.1E-07	5.0E-04	2.4E-04	7.5E-04
Waste Disposal	**Waste**	**1.6E+03**	External	3.1E-07	1.9E-05	6.1E-04	6.3E-04
Incinerator Maintenance	Slag	1.6E+03	External	4.8E-07	6.5E-05	5.8E-04	6.4E-04
Waste Receiving	Waste	1.7E+03	External	1.6E-06	3.8E-05	5.6E-04	6.0E-04
Ash Transport (Dump truck) (OL)	Slag	2.5E+03	External	7.6E-07	Zero	3.9E-04	3.9E-04
Incineration/Bag Filter	Fly ash	6.8E+03	External	1.6E-07	2.5E-05	1.2E-04	1.5E-04
Waste Treatment	Waste	9.9E+03	External	2.3E-07	1.9E-05	8.2E-05	1.0E-04
Incineration/Wet Scrubber	Fly ash	1.4E+04	External	1.6E-07	2.5E-05	4.9E-05	7.4E-05
Waste Transport	Waste	2.0E+04	External	Zero	Zero	5.0E-05	5.0E-05
Ash Transport (Dump truck)	Slag	2.0E+04	External	1.1E-07	Zero	5.1E-05	5.1E-05
Landfill Excavation	Waste	1.2E+05	External	3.1E-10	4.6E-07	8.1E-06	8.6E-06
^{35}S							
Incineration/Bag Filter (OL)	Fly ash	6.0E+03	Ingestion	7.2E-07	1.4E-04	2.5E-05	1.7E-04
Incineration/Wet Scrubber (OL)	Fly ash	7.1E+03	Ingestion	7.2E-07	1.4E-04	3.4E-08	1.4E-04
Incinerator Maintenance (OL)	Slag	6.2E+04	Ingestion	2.3E-07	8.1E-06	7.8E-06	1.6E-05
Incineration/Bag Filter	**Fly ash**	**8.2E+04**	Ingestion	1.4E-07	7.0E-06	5.0E-06	1.2E-05
Incineration/Wet Scrubber	Fly ash	1.4E+05	Ingestion	1.4E-07	7.0E-06	6.9E-09	7.1E-06
Waste Receiving	Waste	3.9E+05	Ingestion	2.8E-07	2.2E-06	1.2E-07	2.5E-06
Incinerator Maintenance	Slag	4.3E+05	Ingestion	3.0E-08	1.3E-06	1.0E-06	2.3E-06
Waste Disposal	Waste	8.8E+05	Ingestion	5.5E-08	1.1E-06	5.8E-09	1.1E-06
Waste Treatment	Waste	8.9E+05	Ingestion	4.1E-08	1.1E-06	1.1E-08	1.1E-06
Ash Transport (Dump truck) (OL)	Slag	7.5E+06	Inhalation	1.3E-07	Zero	1.4E-09	1.3E-07
Landfill Excavation	Waste	3.9E+07	Ingestion	5.5E-11	2.6E-08	7.7E-11	2.6E-08
Ash Transport (Dump truck)	Slag	5.3E+07	Inhalation	1.9E-08	Zero	1.9E-10	1.9E-08
Waste Transport	Waste	1.3E+09	External	Zero	Zero	7.5E-10	7.5E-10

TABLE I.1. (contd)

Nuclide/ Scenario	Waste Form	Limiting Concentration, pCi/g	Dominant Exposure Pathway	Dose, mrem Based on 1 pCi/g in Waste			
				Inhalation	Ingestion	External	Total
^{46}Sc							
Incinerator Maintenance (OL)	Slag	2.3E-01	External	6.4E-06	3.3E-04	4.4E+00	4.4E+00
Waste Disposal	**Waste**	**6.4E-01**	External	4.8E-07	1.4E-05	1.6E+00	1.6E+00
Ash Transport (Dump truck) (OL)	Slag	1.3E+00	External	1.2E-06	Zero	7.9E-01	7.9E-01
Waste Receiving	Waste	1.7E+00	External	2.4E-06	2.8E-05	5.9E-01	5.9E-01
Incinerator Maintenance	Slag	1.8E+00	External	8.2E-07	5.3E-05	5.7E-01	5.7E-01
Incineration/Bag Filter (OL)	Fly ash	5.7E+00	External	4.8E-07	1.4E-04	1.7E-01	1.7E-01
Incineration/Wet Scrubber (OL)	Fly ash	7.1E+00	External	4.8E-07	1.4E-04	1.4E-01	1.4E-01
Waste Treatment	Waste	9.3E+00	External	3.6E-07	1.4E-05	1.1E-01	1.1E-01
Ash Transport (Dump truck)	Slag	9.9E+00	External	1.7E-07	Zero	1.0E-01	1.0E-01
Waste Transport	Waste	1.3E+01	External	Zero	Zero	7.9E-02	7.9E-02
Incineration/Bag Filter	Fly ash	2.9E+01	External	9.6E-08	7.0E-06	3.5E-02	3.5E-02
Incineration/Wet Scrubber	Fly ash	3.6E+01	External	9.6E-08	7.0E-06	2.8E-02	2.8E-02
Landfill Excavation	Waste	4.8E+01	External	4.8E-10	3.4E-07	2.1E-02	2.1E-02
^{48}V							
Incinerator Maintenance (OL)	Slag	1.6E-01	External	2.4E-06	4.2E-04	6.1E+00	6.1E+00
Waste Disposal	**Waste**	**5.4E-01**	External	1.9E-07	1.9E-05	1.9E+00	1.9E+00
Ash Transport (Dump truck) (OL)	Slag	9.7E-01	External	4.8E-07	Zero	1.0E+00	1.0E+00
Waste Receiving	Waste	1.2E+00	External	9.6E-07	3.7E-05	8.3E-01	8.3E-01
Incinerator Maintenance	Slag	1.3E+00	External	3.1E-07	6.7E-05	7.8E-01	7.8E-01
Incineration/Bag Filter (OL)	Fly ash	2.0E+00	External	3.8E-07	3.8E-04	5.1E-01	5.1E-01
Incineration/Wet Scrubber (OL)	Fly ash	2.6E+00	External	3.8E-07	3.8E-04	3.8E-01	3.8E-01
Waste Treatment	Waste	6.8E+00	External	1.4E-07	1.9E-05	1.5E-01	1.5E-01
Ash Transport (Dump truck)	Slag	7.6E+00	External	6.9E-08	Zero	1.3E-01	1.3E-01
Waste Transport	Waste	9.3E+00	External	Zero	Zero	1.1E-01	1.1E-01
Incineration/Bag Filter	Fly ash	9.9E+00	External	7.7E-08	1.9E-05	1.0E-01	1.0E-01
Incineration/Wet Scrubber	Fly ash	1.3E+01	External	7.7E-08	1.9E-05	7.6E-02	7.6E-02
Landfill Excavation	Waste	4.0E+01	External	1.9E-10	4.5E-07	2.5E-02	2.5E-02
^{51}Cr							
Incinerator Maintenance (OL)	Slag	2.6E+01	External	5.7E-08	5.3E-06	3.8E-02	3.8E-02
Incineration/Bag Filter (OL)	Fly ash	5.9E+01	External	4.4E-08	2.3E-05	1.7E-02	1.7E-02
Incineration/Wet Scrubber (OL)	Fly ash	1.1E+02	External	4.4E-08	2.3E-05	9.0E-03	9.0E-03
Waste Disposal	**Waste**	**1.2E+02**	External	6.2E-09	3.2E-07	8.4E-03	8.4E-03
Waste Receiving	Waste	1.5E+02	External	3.1E-08	6.5E-07	6.5E-03	6.5E-03
Ash Transport (Dump truck) (OL)	Slag	1.8E+02	External	1.6E-08	Zero	5.6E-03	5.6E-03
Incinerator Maintenance	Slag	2.1E+02	External	7.3E-09	8.4E-07	4.9E-03	4.9E-03
Incineration/Bag Filter	Fly ash	3.0E+02	External	8.7E-09	1.1E-06	3.4E-03	3.4E-03
Incineration/Wet Scrubber	Fly ash	5.5E+02	External	8.7E-09	1.1E-06	1.8E-03	1.8E-03
Waste Treatment	Waste	9.5E+02	External	4.7E-09	3.2E-07	1.1E-03	1.1E-03
Waste Transport	Waste	1.4E+03	External	Zero	Zero	7.0E-04	7.0E-04
Ash Transport (Dump truck)	Slag	1.4E+03	External	2.2E-09	Zero	7.2E-04	7.2E-04
Landfill Excavation	Waste	8.9E+03	External	6.2E-12	7.8E-09	1.1E-04	1.1E-04

TABLE I.1. (contd)

Nuclide/ Scenario	Waste Form	Limiting Concentration, pCi/g	Dominant Exposure Pathway	Dose, mrem Based on 1 pCi/g in Waste			
				Inhalation	Ingestion	External	Total
^{54}Mn							
Incinerator Maintenance (OL)	Slag	8.9E-01	External	1.4E-06	1.1E-04	1.1E+00	1.1E+00
Waste Disposal	**Waste**	**2.2E+00**	External	1.5E-07	6.8E-06	4.6E-01	4.6E-01
Incineration/Bag Filter (OL)	Fly ash	2.2E+00	External	1.1E-06	4.7E-04	4.5E-01	4.5E-01
Incineration/Wet Scrubber (OL)	Fly ash	2.9E+00	External	1.1E-06	4.7E-04	3.4E-01	3.4E-01
Ash Transport (Dump truck) (OL)	Slag	3.8E+00	External	3.8E-07	Zero	2.6E-01	2.6E-01
Waste Receiving	Waste	4.5E+00	External	7.7E-07	1.4E-05	2.2E-01	2.2E-01
Incinerator Maintenance	Slag	6.9E+00	External	1.8E-07	1.8E-05	1.4E-01	1.4E-01
Incineration/Bag Filter	Fly ash	1.1E+01	External	2.2E-07	2.4E-05	9.0E-02	9.0E-02
Incineration/Wet Scrubber	Fly ash	1.5E+01	External	2.2E-07	2.4E-05	6.9E-02	6.9E-02
Waste Treatment	Waste	2.6E+01	External	1.2E-07	6.8E-06	3.8E-02	3.8E-02
Ash Transport (Dump truck)	Slag	3.0E+01	External	5.5E-08	Zero	3.4E-02	3.4E-02
Waste Transport	Waste	3.6E+01	External	Zero	Zero	2.8E-02	2.8E-02
Landfill Excavation	Waste	1.6E+02	External	1.5E-10	1.6E-07	6.1E-03	6.2E-03
^{55}Fe							
Incineration/Bag Filter (OL)	Fly ash	2.7E+02	External	2.6E-07	1.3E-04	3.5E-03	3.6E-03
Incinerator Maintenance (OL)	Slag	4.0E+02	External	2.2E-07	2.0E-05	2.5E-03	2.5E-03
Incineration/Bag Filter	**Fly ash**	**1.4E+03**	External	5.2E-08	6.5E-06	7.0E-04	7.1E-04
Incinerator Maintenance	Slag	3.1E+03	External	2.9E-08	3.2E-06	3.1E-04	3.2E-04
Incineration/Wet Scrubber (OL)	Fly ash	7.6E+03	Ingestion	2.6E-07	1.3E-04	Zero	1.3E-04
Incineration/Wet Scrubber	Fly ash	1.5E+05	Ingestion	5.2E-08	6.5E-06	Zero	6.6E-06
Waste Receiving	Waste	3.3E+05	Ingestion	1.4E-07	2.9E-06	1.0E-29	3.0E-06
Waste Disposal	Waste	6.8E+05	Ingestion	2.9E-08	1.4E-06	Zero	1.5E-06
Waste Treatment	Waste	6.8E+05	Ingestion	2.2E-08	1.4E-06	2.8E-30	1.5E-06
Ash Transport (Dump truck) (OL)	Slag	1.4E+07	Inhalation	7.2E-08	Zero	Zero	7.2E-08
Landfill Excavation	Waste	2.9E+07	Ingestion	2.9E-11	3.5E-08	Zero	3.5E-08
Ash Transport (Dump truck)	Slag	9.7E+07	Inhalation	1.0E-08	Zero	Zero	1.0E-08
Waste Transport	Waste	None	Ingestion	Zero	Zero	Zero	Zero
^{56}Co							
Incinerator Maintenance (OL)	Slag	1.7E-01	External	5.7E-06	3.9E-04	5.8E+00	5.8E+00
Waste Disposal	**Waste**	**2.4E-01**	External	6.2E-07	2.4E-05	4.1E+00	4.1E+00
Incineration/Bag Filter (OL)	Fly ash	4.4E-01	External	4.2E-06	1.6E-03	2.3E+00	2.3E+00
Incineration/Wet Scrubber (OL)	Fly ash	5.1E-01	External	4.2E-06	1.6E-03	2.0E+00	2.0E+00
Ash Transport (Dump truck) (OL)	Slag	6.0E-01	External	1.5E-06	Zero	1.7E+00	1.7E+00
Waste Receiving	Waste	9.1E-01	External	3.1E-06	4.8E-05	1.1E+00	1.1E+00
Incinerator Maintenance	Slag	1.3E+00	External	7.3E-07	6.3E-05	7.4E-01	7.4E-01
Incineration/Bag Filter	Fly ash	2.2E+00	External	8.5E-07	8.2E-05	4.6E-01	4.6E-01
Incineration/Wet Scrubber	Fly ash	2.6E+00	External	8.5E-07	8.2E-05	3.9E-01	3.9E-01
Waste Treatment	Waste	4.6E+00	External	4.7E-07	2.4E-05	2.2E-01	2.2E-01
Ash Transport (Dump truck)	Slag	4.6E+00	External	2.2E-07	Zero	2.2E-01	2.2E-01
Waste Transport	Waste	6.1E+00	External	Zero	Zero	1.6E-01	1.6E-01
Landfill Excavation	Waste	1.8E+01	External	6.2E-10	5.8E-07	5.5E-02	5.5E-02

TABLE I.1. (contd)

Nuclide/ Scenario	Waste Form	Limiting Concentration, pCi/g	Dominant Exposure Pathway	Dose, mrem Based on 1 pCi/g in Waste			
				Inhalation	Ingestion	External	Total
^{57}Co							
Incinerator Maintenance (OL)	Slag	1.1E+01	External	1.6E-06	2.7E-05	8.7E-02	8.7E-02
Incineration/Bag Filter (OL)	Fly ash	2.2E+01	External	1.2E-06	1.1E-04	4.5E-02	4.5E-02
Waste Receiving	**Waste**	**6.6E+01**	External	9.0E-07	3.3E-06	1.5E-02	1.5E-02
Incineration/Wet Scrubber (OL)	Fly ash	8.9E+01	External	1.2E-06	1.1E-04	1.1E-02	1.1E-02
Incinerator Maintenance	Slag	9.0E+01	External	2.1E-07	4.3E-06	1.1E-02	1.1E-02
Incineration/Bag Filter	Fly ash	1.1E+02	External	2.4E-07	5.6E-06	9.0E-03	9.0E-03
Ash Transport (Dump truck) (OL)	Slag	2.4E+02	External	4.5E-07	Zero	4.1E-03	4.1E-03
Waste Disposal	Waste	3.2E+02	External	1.8E-07	1.7E-06	3.2E-03	3.2E-03
Incineration/Wet Scrubber	Fly ash	4.5E+02	External	2.4E-07	5.6E-06	2.2E-03	2.2E-03
Waste Treatment	Waste	5.9E+02	External	1.4E-07	1.7E-06	1.7E-03	1.7E-03
Waste Transport	Waste	1.3E+03	External	Zero	Zero	7.6E-04	7.6E-04
Ash Transport (Dump truck)	Slag	1.9E+03	External	6.4E-08	Zero	5.3E-04	5.3E-04
Landfill Excavation	Waste	2.4E+04	External	1.8E-10	4.0E-08	4.2E-05	4.2E-05
^{58}Co							
Incinerator Maintenance (OL)	Slag	7.7E-01	External	1.6E-06	1.1E-04	1.3E+00	1.3E+00
Waste Disposal	**Waste**	**1.9E+00**	External	1.7E-07	7.0E-06	5.2E-01	5.2E-01
Incineration/Bag Filter (OL)	Fly ash	2.0E+00	External	1.2E-06	4.8E-04	5.1E-01	5.1E-01
Incineration/Wet Scrubber (OL)	Fly ash	2.6E+00	External	1.2E-06	4.8E-04	3.8E-01	3.8E-01
Ash Transport (Dump truck) (OL)	Slag	3.4E+00	External	4.2E-07	Zero	2.9E-01	2.9E-01
Waste Receiving	Waste	3.9E+00	External	8.5E-07	1.4E-05	2.5E-01	2.5E-01
Incinerator Maintenance	Slag	6.0E+00	External	2.0E-07	1.8E-05	1.7E-01	1.7E-01
Incineration/Bag Filter	Fly ash	9.9E+00	External	2.3E-07	2.4E-05	1.0E-01	1.0E-01
Incineration/Wet Scrubber	Fly ash	1.3E+01	External	2.3E-07	2.4E-05	7.6E-02	7.6E-02
Waste Treatment	Waste	2.3E+01	External	1.3E-07	7.0E-06	4.4E-02	4.4E-02
Ash Transport (Dump truck)	Slag	2.6E+01	External	6.0E-08	Zero	3.8E-02	3.8E-02
Waste Transport	Waste	3.2E+01	External	Zero	Zero	3.1E-02	3.1E-02
Landfill Excavation	Waste	1.4E+02	External	1.7E-10	1.7E-07	7.0E-03	7.0E-03
^{60}Co							
Incinerator Maintenance (OL)	Slag	2.6E-01	External	3.3E-05	4.1E-04	3.8E+00	3.8E+00
Waste Disposal	**Waste**	**4.5E-01**	External	3.6E-06	2.5E-05	2.2E+00	2.2E+00
Incineration/Bag Filter (OL)	Fly ash	6.7E-01	External	2.4E-05	1.7E-03	1.5E+00	1.5E+00
Incineration/Wet Scrubber (OL)	Fly ash	8.1E-01	External	2.4E-05	1.7E-03	1.2E+00	1.2E+00
Ash Transport (Dump truck) (OL)	Slag	9.6E-01	External	8.9E-06	Zero	1.0E+00	1.0E+00
Waste Receiving	Waste	1.3E+00	External	1.8E-05	5.0E-05	7.4E-01	7.4E-01
Incinerator Maintenance	Slag	2.0E+00	External	4.2E-06	6.5E-05	4.9E-01	4.9E-01
Incineration/Bag Filter	Fly ash	3.3E+00	External	4.9E-06	8.5E-05	3.0E-01	3.0E-01
Incineration/Wet Scrubber	Fly ash	4.0E+00	External	4.9E-06	8.5E-05	2.5E-01	2.5E-01
Waste Treatment	Waste	7.2E+00	External	2.7E-06	2.5E-05	1.4E-01	1.4E-01
Ash Transport (Dump truck)	Slag	7.5E+00	External	1.3E-06	Zero	1.3E-01	1.3E-01
Waste Transport	Waste	9.7E+00	External	Zero	Zero	1.0E-01	1.0E-01
Landfill Excavation	Waste	3.4E+01	External	3.6E-09	6.0E-07	3.0E-02	3.0E-02

TABLE I.1. (contd)

Nuclide/ Scenario	Waste Form	Limiting Concentration, pCi/g	Dominant Exposure Pathway	Dose, mrem Based on 1 pCi/g in Waste			
				Inhalation	Ingestion	External	Total
^{63}Ni							
Incineration/Bag Filter (OL)	Fly ash	9.1E+03	Ingestion	3.6E-07	1.1E-04	1.4E-06	1.1E-04
Incineration/Wet Scrubber (OL)	Fly ash	9.2E+03	Ingestion	3.6E-07	1.1E-04	2.8E-13	1.1E-04
Incinerator Maintenance (OL)	Slag	4.6E+04	Ingestion	3.8E-07	2.0E-05	1.2E-06	2.2E-05
Incineration/Bag Filter	**Fly ash**	**1.7E+05**	Ingestion	7.3E-08	5.4E-06	2.7E-07	5.7E-06
Incineration/Wet Scrubber	Fly ash	1.8E+05	Ingestion	7.3E-08	5.4E-06	5.7E-14	5.5E-06
Incinerator Maintenance	Slag	2.9E+05	Ingestion	4.9E-08	3.2E-06	1.6E-07	3.4E-06
Waste Receiving	Waste	3.4E+05	Ingestion	2.3E-07	2.7E-06	6.9E-11	2.9E-06
Waste Disposal	Waste	7.2E+05	Ingestion	4.6E-08	1.4E-06	4.6E-14	1.4E-06
Waste Treatment	Waste	7.2E+05	Ingestion	3.4E-08	1.4E-06	6.4E-12	1.4E-06
Ash Transport (Dump truck) (OL)	Slag	8.8E+06	Inhalation	1.1E-07	Zero	5.3E-17	1.1E-07
Landfill Excavation	Waste	3.1E+07	Ingestion	4.6E-11	3.2E-08	6.1E-16	3.2E-08
Ash Transport (Dump truck)	Slag	6.1E+07	Inhalation	1.6E-08	Zero	6.8E-18	1.6E-08
Waste Transport	Waste	6.8E+14	External	Zero	Zero	1.5E-15	1.5E-15
^{65}Zn							
Incinerator Maintenance (OL)	Slag	1.3E+00	External	3.0E-06	4.4E-04	7.6E-01	7.6E-01
Waste Disposal	**Waste**	**1.8E+00**	External	4.3E-07	3.5E-05	5.7E-01	5.7E-01
Incineration/Bag Filter (OL)	Fly ash	1.8E+00	External	4.2E-06	3.4E-03	5.6E-01	5.6E-01
Incineration/Wet Scrubber (OL)	Fly ash	2.2E+00	External	4.2E-06	3.4E-03	4.6E-01	4.6E-01
Ash Transport (Dump truck) (OL)	Slag	3.8E+00	External	1.1E-06	Zero	2.7E-01	2.7E-01
Waste Receiving	Waste	5.2E+00	External	2.2E-06	7.0E-05	1.9E-01	1.9E-01
Incineration/Bag Filter	Fly ash	8.9E+00	External	8.5E-07	1.7E-04	1.1E-01	1.1E-01
Incinerator Maintenance	Slag	1.0E+01	External	3.9E-07	7.0E-05	9.7E-02	9.8E-02
Incineration/Wet Scrubber	Fly ash	1.1E+01	External	8.5E-07	1.7E-04	9.2E-02	9.2E-02
Waste Treatment	Waste	2.8E+01	External	3.2E-07	3.5E-05	3.6E-02	3.6E-02
Ash Transport (Dump truck)	Slag	2.9E+01	External	1.5E-07	Zero	3.4E-02	3.4E-02
Waste Transport	Waste	3.8E+01	External	Zero	Zero	2.7E-02	2.7E-02
Landfill Excavation	Waste	1.3E+02	External	4.3E-10	8.4E-07	7.6E-03	7.6E-03
^{68}Ge							
Incineration/Bag Filter (OL)	Fly ash	5.8E+01	External	1.2E-05	2.7E-04	1.7E-02	1.7E-02
Incinerator Maintenance (OL)	Slag	1.0E+02	External	8.3E-06	3.4E-05	9.7E-03	9.8E-03
Incineration/Bag Filter	**Fly ash**	**2.9E+02**	External	2.4E-06	1.4E-05	3.4E-03	3.4E-03
Incinerator Maintenance	Slag	8.0E+02	External	1.1E-06	5.5E-06	1.2E-03	1.3E-03
Incineration/Wet Scrubber (OL)	Fly ash	3.5E+03	Ingestion	1.2E-05	2.7E-04	Zero	2.9E-04
Incineration/Wet Scrubber	Fly ash	6.2E+04	Ingestion	2.4E-06	1.4E-05	Zero	1.6E-05
Waste Receiving	Waste	8.8E+04	Inhalation	5.9E-06	5.5E-06	4.5E-29	1.1E-05
Waste Disposal	Waste	2.5E+05	Ingestion	1.2E-06	2.8E-06	Zero	3.9E-06
Waste Treatment	Waste	2.8E+05	Ingestion	8.8E-07	2.8E-06	1.2E-29	3.6E-06
Ash Transport (Dump truck) (OL)	Slag	3.4E+05	Inhalation	2.9E-06	Zero	Zero	2.9E-06
Ash Transport (Dump truck)	Slag	2.4E+06	Inhalation	4.2E-07	Zero	Zero	4.2E-07
Landfill Excavation	Waste	1.5E+07	Ingestion	1.2E-09	6.6E-08	Zero	6.7E-08
Waste Transport	Waste	None	Ingestion	Zero	Zero	Zero	Zero

TABLE I.1. (contd)

Nuclide/ Scenario	Waste Form	Limiting Concentration, pCi/g	Dominant Exposure Pathway	Dose, mrem Based on 1 pCi/g in Waste			
				Inhalation	Ingestion	External	Total
^{74}As							
Incinerator Maintenance (OL)	Slag	1.8E+00	External	1.1E-06	1.0E-04	5.6E-01	5.6E-01
Incineration/Bag Filter (OL)	Fly ash	2.4E+00	External	1.6E-06	8.2E-04	4.2E-01	4.2E-01
Incineration/Wet Scrubber (OL)	Fly ash	3.3E+00	External	1.6E-06	8.2E-04	3.0E-01	3.0E-01
Waste Disposal	**Waste**	**4.2E+00**	External	1.6E-07	8.3E-06	2.4E-01	2.4E-01
Ash Transport (Dump truck) (OL)	Slag	6.5E+00	External	3.9E-07	Zero	1.5E-01	1.5E-01
Waste Receiving	Waste	7.4E+00	External	7.8E-07	1.7E-05	1.4E-01	1.4E-01
Incineration/Bag Filter	Fly ash	1.2E+01	External	3.1E-07	4.1E-05	8.4E-02	8.4E-02
Incinerator Maintenance	Slag	1.4E+01	External	1.4E-07	1.7E-05	7.1E-02	7.1E-02
Incineration/Wet Scrubber	Fly ash	1.7E+01	External	3.1E-07	4.1E-05	6.0E-02	6.0E-02
Waste Treatment	Waste	4.3E+01	External	1.2E-07	8.3E-06	2.4E-02	2.4E-02
Ash Transport (Dump truck)	Slag	5.0E+01	External	5.6E-08	Zero	2.0E-02	2.0E-02
Waste Transport	Waste	6.0E+01	External	Zero	Zero	1.7E-02	1.7E-02
Landfill Excavation	Waste	3.1E+02	External	1.6E-10	2.0E-07	3.2E-03	3.2E-03
^{75}Se							
Incineration/Bag Filter (OL)	Fly ash	3.1E+00	External	3.1E-06	3.5E-03	3.2E-01	3.2E-01
Incineration/Wet Scrubber (OL)	Fly ash	6.9E+00	External	3.1E-06	3.5E-03	1.4E-01	1.4E-01
Incineration/Bag Filter	**Fly ash**	**1.6E+01**	External	6.3E-07	1.8E-04	6.3E-02	6.4E-02
Waste Receiving	Waste	1.8E+01	External	9.8E-07	4.4E-05	5.7E-02	5.7E-02
Incinerator Maintenance (OL)	Slag	2.1E+01	External	2.8E-07	5.5E-05	4.7E-02	4.7E-02
Waste Disposal	Waste	2.4E+01	External	2.0E-07	2.2E-05	4.2E-02	4.2E-02
Ash Transport (Dump truck) (OL)	Slag	3.4E+01	External	4.4E-07	Zero	2.9E-02	2.9E-02
Incineration/Wet Scrubber	Fly ash	3.5E+01	External	6.3E-07	1.8E-04	2.8E-02	2.8E-02
Waste Treatment	Waste	1.3E+02	External	1.5E-07	2.2E-05	7.8E-03	7.9E-03
Incinerator Maintenance	Slag	1.7E+02	External	3.5E-08	8.8E-06	6.0E-03	6.0E-03
Waste Transport	Waste	2.2E+02	External	Zero	Zero	4.5E-03	4.5E-03
Ash Transport (Dump truck)	Slag	2.6E+02	External	6.3E-08	Zero	3.8E-03	3.8E-03
Landfill Excavation	Waste	1.8E+03	External	2.0E-10	5.3E-07	5.5E-04	5.6E-04
^{79}Se							
Incineration/Bag Filter (OL)	Fly ash	3.0E+02	Ingestion	3.4E-06	3.3E-03	2.2E-05	3.3E-03
Incineration/Wet Scrubber (OL)	Fly ash	3.0E+02	Ingestion	3.4E-06	3.3E-03	1.7E-08	3.3E-03
Incineration/Bag Filter	**Fly ash**	**5.8E+03**	Ingestion	6.8E-07	1.7E-04	4.4E-06	1.7E-04
Incineration/Wet Scrubber	Fly ash	6.0E+03	Ingestion	6.8E-07	1.7E-04	3.4E-09	1.7E-04
Incinerator Maintenance (OL)	Slag	1.9E+04	Ingestion	3.0E-07	5.2E-05	1.8E-06	5.4E-05
Waste Receiving	Waste	2.3E+04	Ingestion	1.1E-06	4.1E-05	5.7E-08	4.3E-05
Waste Disposal	Waste	4.8E+04	Ingestion	2.1E-07	2.1E-05	2.3E-09	2.1E-05
Waste Treatment	Waste	4.8E+04	Ingestion	1.6E-07	2.1E-05	5.3E-09	2.1E-05
Incinerator Maintenance	Slag	1.2E+05	Ingestion	3.8E-08	8.3E-06	2.3E-07	8.6E-06
Landfill Excavation	Waste	2.0E+06	Ingestion	2.1E-10	5.0E-07	3.1E-11	5.0E-07
Ash Transport (Dump truck) (OL)	Slag	2.1E+06	Inhalation	4.8E-07	Zero	4.1E-10	4.8E-07
Ash Transport (Dump truck)	Slag	1.5E+07	Inhalation	6.9E-08	Zero	5.3E-11	6.9E-08
Waste Transport	Waste	3.6E+09	External	Zero	Zero	2.8E-10	2.8E-10

TABLE I.1. (contd)

Nuclide/ Scenario	Waste Form	Limiting Concentration, pCi/g	Dominant Exposure Pathway	Dose, mrem Based on 1 pCi/g in Waste			
				Inhalation	Ingestion	External	Total
^{88}Y							
Incinerator Maintenance (OL)	Slag	1.7E-01	External	6.7E-06	3.1E-04	5.9E+00	5.9E+00
Waste Disposal	**Waste**	**4.0E-01**	External	5.0E-07	1.3E-05	2.5E+00	2.5E+00
Ash Transport (Dump truck) (OL)	Slag	9.1E-01	External	1.3E-06	Zero	1.1E+00	1.1E+00
Waste Receiving	Waste	1.3E+00	External	2.5E-06	2.6E-05	7.7E-01	7.7E-01
Incinerator Maintenance	Slag	1.3E+00	External	8.6E-07	4.9E-05	7.5E-01	7.5E-01
Incineration/Bag Filter (OL)	Fly ash	4.3E+00	External	5.0E-07	1.3E-04	2.3E-01	2.3E-01
Incineration/Wet Scrubber (OL)	Fly ash	5.2E+00	External	5.0E-07	1.3E-04	1.9E-01	1.9E-01
Waste Treatment	Waste	6.9E+00	External	3.8E-07	1.3E-05	1.5E-01	1.5E-01
Ash Transport (Dump truck)	Slag	7.1E+00	External	1.8E-07	Zero	1.4E-01	1.4E-01
Waste Transport	Waste	9.3E+00	External	Zero	Zero	1.1E-01	1.1E-01
Incineration/Bag Filter	Fly ash	2.2E+01	External	1.0E-07	6.5E-06	4.6E-02	4.6E-02
Incineration/Wet Scrubber	Fly ash	2.6E+01	External	1.0E-07	6.5E-06	3.8E-02	3.8E-02
Landfill Excavation	Waste	3.0E+01	External	5.0E-10	3.1E-07	3.3E-02	3.3E-02
^{90}Sr							
Incinerator Maintenance (OL)	Slag	1.2E+02	Ingestion	7.4E-05	7.7E-03	3.3E-04	8.1E-03
Incineration/Bag Filter (OL)	Fly ash	3.1E+02	Ingestion	5.5E-06	3.2E-03	2.1E-05	3.3E-03
Incineration/Wet Scrubber (OL)	Fly ash	3.1E+02	Ingestion	5.5E-06	3.2E-03	1.6E-06	3.3E-03
Incinerator Maintenance	**Slag**	**7.8E+02**	Ingestion	9.4E-06	1.2E-03	4.2E-05	1.3E-03
Waste Receiving	Waste	1.4E+03	Ingestion	2.8E-05	6.5E-04	1.5E-05	6.9E-04
Waste Disposal	Waste	3.0E+03	Ingestion	5.5E-06	3.3E-04	4.8E-06	3.4E-04
Waste Treatment	Waste	3.0E+03	Ingestion	4.1E-06	3.3E-04	1.8E-06	3.3E-04
Incineration/Bag Filter	Fly ash	6.0E+03	Ingestion	1.1E-06	1.6E-04	4.2E-06	1.7E-04
Incineration/Wet Scrubber	Fly ash	6.1E+03	Ingestion	1.1E-06	1.6E-04	3.2E-07	1.6E-04
Ash Transport (Dump truck) (OL)	Slag	5.4E+04	Inhalation	1.4E-05	Zero	4.6E-06	1.8E-05
Landfill Excavation	Waste	1.3E+05	Ingestion	5.5E-09	7.8E-06	6.4E-08	7.9E-06
Ash Transport (Dump truck)	Slag	3.9E+05	Inhalation	2.0E-06	Zero	6.0E-07	2.6E-06
Waste Transport	Waste	1.3E+06	External	Zero	Zero	7.7E-07	7.7E-07
$^{90}Sr+D$							
Incinerator Maintenance (OL)	Slag	5.1E+01	External	7.6E-05	8.3E-03	1.1E-02	2.0E-02
Incineration/Bag Filter (OL)	Fly ash	2.5E+02	Ingestion	5.7E-06	3.5E-03	5.3E-04	4.0E-03
Incineration/Wet Scrubber (OL)	Fly ash	2.7E+02	Ingestion	5.7E-06	3.5E-03	2.2E-04	3.7E-03
Incinerator Maintenance	**Slag**	**3.6E+02**	External	9.8E-06	1.3E-03	1.4E-03	2.8E-03
Waste Receiving	Waste	5.1E+02	External	2.9E-05	7.0E-04	1.2E-03	2.0E-03
Waste Disposal	Waste	5.1E+02	External	5.7E-06	3.5E-04	1.6E-03	2.0E-03
Ash Transport (Dump truck) (OL)	Slag	9.9E+02	External	1.4E-05	Zero	1.0E-03	1.0E-03
Waste Treatment	Waste	1.8E+03	Ingestion	4.3E-06	3.5E-04	1.9E-04	5.4E-04
Incineration/Bag Filter	Fly ash	3.5E+03	Ingestion	1.1E-06	1.7E-04	1.1E-04	2.8E-04
Incineration/Wet Scrubber	Fly ash	4.5E+03	Ingestion	1.1E-06	1.7E-04	4.4E-05	2.2E-04
Ash Transport (Dump truck)	Slag	7.7E+03	External	2.0E-06	Zero	1.3E-04	1.3E-04
Waste Transport	Waste	8.5E+03	External	Zero	Zero	1.2E-04	1.2E-04
Landfill Excavation	Waste	3.3E+04	External	5.7E-09	8.4E-06	2.2E-05	3.0E-05

TABLE I.1. (contd)

Nuclide/ Scenario	Waste Form	Limiting Concentration, pCi/g	Dominant Exposure Pathway	Dose, mrem Based on 1 pCi/g in Waste Inhalation	Ingestion	External	Total
^{93}Zr							
Incinerator Maintenance (OL)	Slag	8.3E+03	Ingestion	2.4E-05	9.5E-05	1.6E-06	1.2E-04
Incineration/Bag Filter (OL)	Fly ash	2.4E+04	Ingestion	1.8E-06	4.0E-05	1.4E-07	4.2E-05
Incineration/Wet Scrubber (OL)	Fly ash	2.4E+04	Ingestion	1.8E-06	4.0E-05	7.4E-15	4.2E-05
Incinerator Maintenance	**Slag**	**5.4E+04**	Ingestion	3.0E-06	1.5E-05	2.0E-07	1.8E-05
Waste Receiving	Waste	5.9E+04	Inhalation	8.9E-06	8.0E-06	2.6E-11	1.7E-05
Waste Disposal	Waste	1.7E+05	Ingestion	1.8E-06	4.0E-06	9.0E-15	5.8E-06
Waste Treatment	Waste	1.9E+05	Ingestion	1.3E-06	4.0E-06	2.5E-12	5.3E-06
Ash Transport (Dump truck) (OL)	Slag	2.3E+05	Inhalation	4.4E-06	Zero	9.4E-18	4.4E-06
Incineration/Bag Filter	Fly ash	4.2E+05	Ingestion	3.6E-07	2.0E-06	2.8E-08	2.4E-06
Incineration/Wet Scrubber	Fly ash	4.2E+05	Ingestion	3.6E-07	2.0E-06	1.5E-15	2.4E-06
Ash Transport (Dump truck)	Slag	1.6E+06	Inhalation	6.3E-07	Zero	1.2E-18	6.3E-07
Landfill Excavation	Waste	1.0E+07	Ingestion	1.8E-09	9.6E-08	1.2E-16	9.8E-08
Waste Transport	Waste	3.6E+15	External	Zero	Zero	2.8E-16	2.8E-16
^{94}Nb							
Incinerator Maintenance (OL)	Slag	3.6E-01	External	1.1E-04	3.0E-04	2.8E+00	2.8E+00
Waste Disposal	**Waste**	**1.4E+00**	External	7.9E-06	1.3E-05	7.2E-01	7.2E-01
Ash Transport (Dump truck) (OL)	Slag	2.3E+00	External	2.0E-05	Zero	4.3E-01	4.4E-01
Waste Receiving	Waste	2.7E+00	External	4.0E-05	2.5E-05	3.7E-01	3.7E-01
Incinerator Maintenance	Slag	2.8E+00	External	1.4E-05	4.8E-05	3.6E-01	3.6E-01
Incineration/Bag Filter (OL)	Fly ash	9.0E+00	External	7.9E-06	1.3E-04	1.1E-01	1.1E-01
Incineration/Wet Scrubber (OL)	Fly ash	1.2E+01	External	7.9E-06	1.3E-04	8.2E-02	8.2E-02
Waste Treatment	Waste	1.6E+01	External	5.9E-06	1.3E-05	6.4E-02	6.4E-02
Ash Transport (Dump truck)	Slag	1.8E+01	External	2.8E-06	Zero	5.6E-02	5.6E-02
Waste Transport	Waste	2.2E+01	External	Zero	Zero	4.6E-02	4.6E-02
Incineration/Bag Filter	Fly ash	4.5E+01	External	1.6E-06	6.4E-06	2.2E-02	2.2E-02
Incineration/Wet Scrubber	Fly ash	6.1E+01	External	1.6E-06	6.4E-06	1.6E-02	1.6E-02
Landfill Excavation	Waste	1.0E+02	External	7.9E-09	3.1E-07	9.5E-03	9.5E-03
^{99}Tc							
Incineration/Bag Filter (OL)	Fly ash	2.6E+03	Ingestion	1.8E-06	3.2E-04	6.3E-05	3.9E-04
Incineration/Wet Scrubber (OL)	Fly ash	3.1E+03	Ingestion	1.8E-06	3.2E-04	9.9E-07	3.3E-04
Incinerator Maintenance (OL)	Slag	1.5E+04	External	1.0E-06	3.2E-05	3.5E-05	6.9E-05
Incineration/Bag Filter	**Fly ash**	**3.4E+04**	Ingestion	3.6E-07	1.6E-05	1.3E-05	2.9E-05
Incineration/Wet Scrubber	Fly ash	5.9E+04	Ingestion	3.6E-07	1.6E-05	2.0E-07	1.7E-05
Incinerator Maintenance	Slag	1.0E+05	Ingestion	1.3E-07	5.2E-06	4.5E-06	9.8E-06
Waste Receiving	Waste	1.1E+05	Ingestion	9.0E-07	6.5E-06	1.5E-06	8.9E-06
Waste Disposal	Waste	2.8E+05	Ingestion	1.8E-07	3.2E-06	1.9E-07	3.6E-06
Waste Treatment	Waste	2.8E+05	Ingestion	1.4E-07	3.2E-06	1.5E-07	3.5E-06
Ash Transport (Dump truck) (OL)	Slag	1.7E+06	Inhalation	4.1E-07	Zero	1.8E-07	5.9E-07
Ash Transport (Dump truck)	Slag	1.2E+07	Inhalation	5.8E-08	Zero	2.4E-08	8.2E-08
Landfill Excavation	Waste	1.2E+07	Ingestion	1.8E-10	7.8E-08	2.5E-09	8.1E-08
Waste Transport	Waste	2.4E+07	External	Zero	Zero	4.3E-08	4.3E-08

TABLE I.1. (contd)

Nuclide/ Scenario	Waste Form	Limiting Concentration, pCi/g	Dominant Exposure Pathway	Dose, mrem Based on 1 pCi/g in Waste Inhalation	Ingestion	External	Total
^{106}Ru							
Incineration/Bag Filter (OL)	Fly ash	5.2E+00	External	1.2E-04	6.2E-03	1.9E-01	1.9E-01
Incinerator Maintenance (OL)	Slag	6.0E+00	External	5.9E-05	5.2E-04	1.7E-01	1.7E-01
Incineration/Wet Scrubber (OL)	Fly ash	7.3E+00	External	1.2E-04	6.2E-03	1.3E-01	1.4E-01
Waste Disposal	**Waste**	**1.0E+01**	External	1.1E-05	5.2E-05	9.9E-02	9.9E-02
Ash Transport (Dump truck) (OL)	Slag	1.8E+01	External	2.6E-05	Zero	5.6E-02	5.6E-02
Waste Receiving	Waste	2.0E+01	External	5.3E-05	1.0E-04	5.0E-02	5.1E-02
Incineration/Bag Filter	Fly ash	2.7E+01	External	2.5E-05	3.1E-04	3.7E-02	3.8E-02
Incineration/Wet Scrubber	Fly ash	3.8E+01	External	2.5E-05	3.1E-04	2.6E-02	2.6E-02
Incinerator Maintenance	Slag	4.7E+01	External	7.6E-06	8.4E-05	2.1E-02	2.1E-02
Waste Treatment	Waste	1.1E+02	External	7.9E-06	5.2E-05	8.8E-03	8.8E-03
Ash Transport (Dump truck)	Slag	1.4E+02	External	3.7E-06	Zero	7.2E-03	7.2E-03
Waste Transport	Waste	1.6E+02	External	Zero	Zero	6.1E-03	6.1E-03
Landfill Excavation	Waste	7.6E+02	External	1.1E-08	1.3E-06	1.3E-03	1.3E-03
^{110m}Ag							
Incinerator Maintenance (OL)	Slag	2.1E-01	External	1.4E-05	5.5E-04	4.8E+00	4.8E+00
Waste Disposal	**Waste**	**5.5E-01**	External	1.3E-06	2.8E-05	1.8E+00	1.8E+00
Ash Transport (Dump truck) (OL)	Slag	1.0E+00	External	3.2E-06	Zero	9.5E-01	9.5E-01
Incineration/Bag Filter (OL)	Fly ash	1.1E+00	External	5.1E-06	1.1E-03	8.9E-01	9.0E-01
Waste Receiving	Waste	1.3E+00	External	6.4E-06	5.5E-05	7.5E-01	7.5E-01
Incineration/Wet Scrubber (OL)	Fly ash	1.4E+00	External	5.1E-06	1.1E-03	6.9E-01	7.0E-01
Incinerator Maintenance	Slag	1.6E+00	External	1.8E-06	8.8E-05	6.1E-01	6.1E-01
Incineration/Bag Filter	Fly ash	5.6E+00	External	1.0E-06	5.5E-05	1.8E-01	1.8E-01
Incineration/Wet Scrubber	Fly ash	7.2E+00	External	1.0E-06	5.5E-05	1.4E-01	1.4E-01
Waste Treatment	Waste	7.5E+00	External	9.5E-07	2.8E-05	1.3E-01	1.3E-01
Ash Transport (Dump truck)	Slag	8.2E+00	External	4.5E-07	Zero	1.2E-01	1.2E-01
Waste Transport	Waste	1.0E+01	External	Zero	Zero	9.8E-02	9.8E-02
Landfill Excavation	Waste	4.1E+01	External	1.3E-09	6.6E-07	2.4E-02	2.4E-02
^{113}Sn							
Incinerator Maintenance (OL)	Slag	4.0E+01	External	2.9E-06	1.7E-04	2.5E-02	2.5E-02
Incinerator Maintenance	**Slag**	**3.1E+02**	External	3.8E-07	2.6E-05	3.2E-03	3.2E-03
Waste Receiving	Waste	1.3E+03	External	1.1E-06	1.4E-05	7.4E-04	7.5E-04
Incineration/Bag Filter (OL)	Fly ash	1.5E+03	External	8.5E-08	2.7E-05	6.3E-04	6.6E-04
Waste Disposal	Waste	2.2E+03	External	2.1E-07	6.8E-06	4.5E-04	4.6E-04
Ash Transport (Dump truck) (OL)	Slag	2.5E+03	External	5.3E-07	Zero	4.0E-04	4.0E-04
Incineration/Bag Filter	Fly ash	7.9E+03	External	1.7E-08	1.3E-06	1.3E-04	1.3E-04
Waste Treatment	Waste	9.3E+03	External	1.6E-07	6.8E-06	1.0E-04	1.1E-04
Incineration/Wet Scrubber (OL)	Fly ash	1.4E+04	External	8.5E-08	2.7E-05	4.5E-05	7.3E-05
Waste Transport	Waste	1.7E+04	External	Zero	Zero	5.8E-05	5.8E-05
Ash Transport (Dump truck)	Slag	1.9E+04	External	7.6E-08	Zero	5.2E-05	5.2E-05
Incineration/Wet Scrubber	Fly ash	9.6E+04	External	1.7E-08	1.3E-06	9.1E-06	1.0E-05
Landfill Excavation	Waste	1.6E+05	External	2.1E-10	1.6E-07	6.1E-06	6.2E-06

TABLE I.1. (contd)

Nuclide/ Scenario	Waste Form	Limiting Concentration, pCi/g	Dominant Exposure Pathway	Dose, mrem Based on 1 pCi/g in Waste			
				Inhalation	Ingestion	External	Total
$^{113}Sn+D$							
Waste Disposal	Waste	1.8E+01	External	2.1E-07	7.0E-06	5.6E-02	5.6E-02
Incinerator Maintenance	Slag	2.0E+01	External	3.8E-07	2.7E-05	4.9E-02	4.9E-02
Waste Receiving	Waste	2.3E+01	External	1.1E-06	1.4E-05	4.4E-02	4.4E-02
Waste Treatment	Waste	1.4E+02	External	1.6E-07	7.0E-06	7.1E-03	7.1E-03
Ash Transport (Dump truck)	Slag	2.1E+02	External	7.7E-08	Zero	4.8E-03	4.8E-03
Waste Transport	Waste	2.2E+02	External	Zero	Zero	4.6E-03	4.6E-03
Incineration/Bag Filter	Fly ash	7.9E+02	External	1.7E-08	1.4E-06	1.3E-03	1.3E-03
Landfill Excavation	Waste	1.3E+03	External	2.1E-10	1.7E-07	7.5E-04	7.5E-04
Incineration/Wet Scrubber	Fly ash	1.5E+03	External	1.7E-08	1.4E-06	6.9E-04	6.9E-04
^{124}Sb							
Incinerator Maintenance (OL)	Slag	4.0E-01	External	3.9E-06	3.2E-04	2.5E+00	2.5E+00
Waste Disposal	**Waste**	**5.7E-01**	External	5.0E-07	2.3E-05	1.7E+00	1.7E+00
Incineration/Bag Filter (OL)	Fly ash	6.8E-01	External	4.3E-06	2.0E-03	1.5E+00	1.5E+00
Incineration/Wet Scrubber (OL)	Fly ash	8.4E-01	External	4.3E-06	2.0E-03	1.2E+00	1.2E+00
Ash Transport (Dump truck) (OL)	Slag	1.3E+00	External	1.2E-06	Zero	7.8E-01	7.8E-01
Waste Receiving	Waste	1.8E+00	External	2.5E-06	4.7E-05	5.6E-01	5.6E-01
Incinerator Maintenance	Slag	3.1E+00	External	5.0E-07	5.1E-05	3.2E-01	3.2E-01
Incineration/Bag Filter	Fly ash	3.4E+00	External	8.7E-07	1.0E-04	2.9E-01	2.9E-01
Incineration/Wet Scrubber	Fly ash	4.2E+00	External	8.7E-07	1.0E-04	2.4E-01	2.4E-01
Waste Treatment	Waste	9.4E+00	External	3.8E-07	2.3E-05	1.1E-01	1.1E-01
Ash Transport (Dump truck)	Slag	1.0E+01	External	1.8E-07	Zero	1.0E-01	1.0E-01
Waste Transport	Waste	1.3E+01	External	Zero	Zero	7.9E-02	7.9E-02
Landfill Excavation	Waste	4.3E+01	External	5.0E-10	5.6E-07	2.3E-02	2.3E-02
^{125}Sb							
Incinerator Maintenance (OL)	Slag	2.2E+00	External	1.8E-06	8.9E-05	4.5E-01	4.5E-01
Incineration/Bag Filter (OL)	Fly ash	3.7E+00	External	2.0E-06	5.6E-04	2.7E-01	2.7E-01
Incineration/Wet Scrubber (OL)	Fly ash	5.6E+00	External	2.0E-06	5.6E-04	1.8E-01	1.8E-01
Waste Disposal	**Waste**	**6.3E+00**	External	2.4E-07	6.5E-06	1.6E-01	1.6E-01
Waste Receiving	Waste	1.0E+01	External	1.2E-06	1.3E-05	9.7E-02	9.7E-02
Ash Transport (Dump truck) (OL)	Slag	1.0E+01	External	5.8E-07	Zero	1.0E-01	1.0E-01
Incinerator Maintenance	Slag	1.8E+01	External	2.3E-07	1.4E-05	5.7E-02	5.7E-02
Incineration/Bag Filter	Fly ash	1.9E+01	External	4.0E-07	2.8E-05	5.3E-02	5.3E-02
Incineration/Wet Scrubber	Fly ash	2.8E+01	External	4.0E-07	2.8E-05	3.5E-02	3.6E-02
Waste Treatment	Waste	6.1E+01	External	1.8E-07	6.5E-06	1.6E-02	1.6E-02
Ash Transport (Dump truck)	Slag	7.8E+01	External	8.2E-08	Zero	1.3E-02	1.3E-02
Waste Transport	Waste	8.7E+01	External	Zero	Zero	1.1E-02	1.1E-02
Landfill Excavation	Waste	4.8E+02	External	2.4E-10	1.6E-07	2.1E-03	2.1E-03
^{125m}Te							
Incineration/Bag Filter (OL)	Fly ash	4.3E+01	External	1.6E-06	8.3E-04	2.3E-02	2.3E-02
Incinerator Maintenance (OL)	Slag	5.8E+01	External	1.1E-06	1.1E-04	1.7E-02	1.7E-02
Incineration/Bag Filter	**Fly ash**	**2.2E+02**	External	3.2E-07	4.2E-05	4.5E-03	4.6E-03
Incinerator Maintenance	Slag	4.6E+02	External	1.4E-07	1.7E-05	2.2E-03	2.2E-03
Incineration/Wet Scrubber (OL)	Fly ash	1.1E+03	Ingestion	1.6E-06	8.3E-04	4.6E-05	8.8E-04
Waste Receiving	Waste	1.6E+04	External	8.0E-07	1.7E-05	4.4E-05	6.2E-05
Incineration/Wet Scrubber	Fly ash	2.0E+04	Ingestion	3.2E-07	4.2E-05	9.1E-06	5.1E-05
Waste Disposal	Waste	6.0E+04	Ingestion	1.6E-07	8.5E-06	7.9E-06	1.7E-05
Waste Treatment	Waste	7.4E+04	Ingestion	1.2E-07	8.5E-06	4.9E-06	1.4E-05
Ash Transport (Dump truck) (OL)	Slag	8.6E+04	External	4.0E-07	Zero	1.1E-05	1.2E-05
Waste Transport	Waste	4.7E+05	External	Zero	Zero	2.1E-06	2.1E-06
Ash Transport (Dump truck)	Slag	6.7E+05	External	5.7E-08	Zero	1.4E-06	1.5E-06
Landfill Excavation	Waste	3.2E+06	Ingestion	1.6E-10	2.0E-07	1.1E-07	3.1E-07

TABLE I.1. (contd)

Nuclide/ Scenario	Waste Form	Limiting Concentration, pCi/g	Dominant Exposure Pathway	Dose, mrem Based on 1 pCi/g in Waste			
				Inhalation	Ingestion	External	Total
^{125}I							
Incineration/Bag Filter (OL)	Fly ash	2.0E+01	External	7.8E-06	1.3E-02	3.7E-02	5.0E-02
Incineration/Wet Scrubber (OL)	Fly ash	7.7E+01	Ingestion	7.8E-06	1.3E-02	6.0E-14	1.3E-02
Incineration/Bag Filter	**Fly ash**	**1.2E+02**	External	1.6E-06	6.5E-04	7.4E-03	8.0E-03
Incinerator Maintenance (OL)	Slag	1.2E+03	External	1.6E-07	4.7E-05	8.0E-04	8.5E-04
Incineration/Wet Scrubber	Fly ash	1.5E+03	Ingestion	1.6E-06	6.5E-04	1.2E-14	6.5E-04
Waste Receiving	Waste	5.2E+03	Ingestion	2.9E-06	1.9E-04	2.8E-07	1.9E-04
Incinerator Maintenance	Slag	9.1E+03	External	2.1E-08	7.6E-06	1.0E-04	1.1E-04
Waste Disposal	Waste	1.0E+04	Ingestion	5.8E-07	9.5E-05	7.4E-13	9.6E-05
Waste Treatment	Waste	1.0E+04	Ingestion	4.3E-07	9.5E-05	2.9E-08	9.5E-05
Landfill Excavation	Waste	4.4E+05	Ingestion	5.8E-10	2.3E-06	9.9E-15	2.3E-06
Ash Transport (Dump truck) (OL)	Slag	9.9E+05	Inhalation	1.0E-06	Zero	2.1E-29	1.0E-06
Ash Transport (Dump truck)	Slag	6.9E+06	Inhalation	1.4E-07	Zero	2.7E-30	1.4E-07
Waste Transport	Waste	6.3E+19	External	Zero	Zero	1.6E-20	1.6E-20
^{126}I							
Incineration/Bag Filter (OL)	Fly ash	2.2E+00	External	1.4E-05	2.4E-02	4.3E-01	4.6E-01
Incineration/Wet Scrubber (OL)	Fly ash	3.0E+00	External	1.4E-05	2.4E-02	3.1E-01	3.3E-01
Waste Disposal	**Waste**	**5.5E+00**	External	1.0E-06	1.8E-04	1.8E-01	1.8E-01
Waste Receiving	Waste	9.6E+00	External	5.2E-06	3.5E-04	1.0E-01	1.0E-01
Incineration/Bag Filter	Fly ash	1.1E+01	External	2.8E-06	1.2E-03	8.7E-02	8.8E-02
Ash Transport (Dump truck) (OL)	Slag	1.3E+01	External	1.8E-06	Zero	8.0E-02	8.0E-02
Incineration/Wet Scrubber	Fly ash	1.6E+01	External	2.8E-06	1.2E-03	6.1E-02	6.2E-02
Waste Treatment	Waste	5.6E+01	External	7.7E-07	1.8E-04	1.8E-02	1.8E-02
Incinerator Maintenance (OL)	Slag	5.9E+01	External	2.9E-07	8.9E-05	1.7E-02	1.7E-02
Waste Transport	Waste	8.0E+01	External	Zero	Zero	1.2E-02	1.2E-02
Ash Transport (Dump truck)	Slag	9.8E+01	External	2.6E-07	Zero	1.0E-02	1.0E-02
Landfill Excavation	Waste	4.1E+02	External	1.0E-09	4.3E-06	2.4E-03	2.4E-03
Incinerator Maintenance	Slag	4.6E+02	External	3.7E-08	1.4E-05	2.2E-03	2.2E-03
^{129}I							
Incineration/Bag Filter (OL)	Fly ash	8.7E+00	Ingestion	5.9E-05	9.5E-02	2.0E-02	1.2E-01
Incineration/Wet Scrubber (OL)	Fly ash	1.0E+01	Ingestion	5.9E-05	9.5E-02	1.6E-08	9.5E-02
Incineration/Bag Filter	**Fly ash**	**1.1E+02**	Ingestion	1.2E-05	4.8E-03	4.0E-03	8.7E-03
Incineration/Wet Scrubber	Fly ash	2.1E+02	Ingestion	1.2E-05	4.8E-03	3.2E-09	4.8E-03
Waste Receiving	Waste	7.0E+02	Ingestion	2.2E-05	1.4E-03	2.4E-07	1.4E-03
Incinerator Maintenance (OL)	Slag	1.3E+03	External	1.2E-06	3.5E-04	4.3E-04	7.8E-04
Waste Disposal	Waste	1.4E+03	Ingestion	4.3E-06	7.0E-04	2.6E-09	7.0E-04
Waste Treatment	Waste	1.4E+03	Ingestion	3.2E-06	7.0E-04	2.5E-08	7.0E-04
Incinerator Maintenance	Slag	9.0E+03	Ingestion	1.6E-07	5.6E-05	5.5E-05	1.1E-04
Landfill Excavation	Waste	6.0E+04	Ingestion	4.3E-09	1.7E-05	3.4E-11	1.7E-05
Ash Transport (Dump truck) (OL)	Slag	1.3E+05	Inhalation	7.6E-06	Zero	3.5E-10	7.6E-06
Ash Transport (Dump truck)	Slag	9.3E+05	Inhalation	1.1E-06	Zero	4.6E-11	1.1E-06
Waste Transport	Waste	3.2E+09	External	Zero	Zero	3.1E-10	3.1E-10

TABLE I.1. (contd)

Nuclide/ Scenario	Waste Form	Limiting Concentration, pCi/g	Dominant Exposure Pathway	Dose, mrem Based on 1 pCi/g in Waste			
				Inhalation	Ingestion	External	Total
^{131}I							
Incineration/Bag Filter (OL)	Fly ash	3.1E+00	External	1.0E-05	1.8E-02	3.1E-01	3.3E-01
Incineration/Wet Scrubber (OL)	Fly ash	4.7E+00	External	1.0E-05	1.8E-02	1.9E-01	2.1E-01
Waste Disposal	**Waste**	**1.0E+01**	External	7.7E-07	1.3E-04	9.5E-02	9.6E-02
Waste Receiving	Waste	1.4E+01	External	3.8E-06	2.6E-04	7.1E-02	7.1E-02
Incineration/Bag Filter	Fly ash	1.6E+01	External	2.1E-06	9.0E-04	6.2E-02	6.3E-02
Ash Transport (Dump truck) (OL)	Slag	2.2E+01	External	1.3E-06	Zero	4.5E-02	4.5E-02
Incineration/Wet Scrubber	Fly ash	2.5E+01	External	2.1E-06	9.0E-04	3.9E-02	3.9E-02
Incinerator Maintenance (OL)	Slag	8.4E+01	External	2.2E-07	6.6E-05	1.2E-02	1.2E-02
Waste Treatment	Waste	8.5E+01	External	5.8E-07	1.3E-04	1.2E-02	1.2E-02
Waste Transport	Waste	1.3E+02	External	Zero	Zero	7.7E-03	7.7E-03
Ash Transport (Dump truck)	Slag	1.7E+02	External	1.9E-07	Zero	5.8E-03	5.8E-03
Incinerator Maintenance	Slag	6.5E+02	External	2.8E-08	1.1E-05	1.5E-03	1.5E-03
Landfill Excavation	Waste	7.8E+02	External	7.7E-10	3.2E-06	1.3E-03	1.3E-03
^{134}Cs							
Incinerator Maintenance (OL)	Slag	3.8E-01	External	1.3E-05	3.7E-03	2.7E+00	2.7E+00
Waste Disposal	**Waste**	**1.2E+00**	External	1.1E-06	1.8E-04	8.2E-01	8.2E-01
Incineration/Bag Filter (OL)	Fly ash	2.0E+00	External	4.5E-06	7.4E-03	5.0E-01	5.1E-01
Ash Transport (Dump truck) (OL)	Slag	2.0E+00	External	2.8E-06	Zero	4.9E-01	4.9E-01
Waste Receiving	Waste	2.4E+00	External	5.6E-06	3.7E-04	4.2E-01	4.2E-01
Incineration/Wet Scrubber (OL)	Fly ash	2.6E+00	External	4.5E-06	7.4E-03	3.7E-01	3.8E-01
Incinerator Maintenance	Slag	2.9E+00	External	1.6E-06	5.9E-04	3.4E-01	3.4E-01
Incineration/Bag Filter	Fly ash	1.0E+01	External	9.0E-07	3.7E-04	1.0E-01	1.0E-01
Incineration/Wet Scrubber	Fly ash	1.3E+01	External	9.0E-07	3.7E-04	7.4E-02	7.4E-02
Waste Treatment	Waste	1.4E+01	External	8.5E-07	1.8E-04	7.2E-02	7.2E-02
Ash Transport (Dump truck)	Slag	1.6E+01	External	4.0E-07	Zero	6.3E-02	6.3E-02
Waste Transport	Waste	1.9E+01	External	Zero	Zero	5.2E-02	5.2E-02
Landfill Excavation	Waste	9.1E+01	External	1.1E-09	4.4E-06	1.1E-02	1.1E-02
^{137}Cs							
Incinerator Maintenance (OL)	Slag	1.2E+00	External	8.6E-06	2.5E-03	8.4E-01	8.5E-01
Waste Disposal	**Waste**	**4.6E+00**	External	7.7E-07	1.2E-04	2.2E-01	2.2E-01
Incineration/Bag Filter (OL)	Fly ash	6.1E+00	External	3.1E-06	5.0E-03	1.6E-01	1.6E-01
Ash Transport (Dump truck) (OL)	Slag	6.9E+00	External	1.9E-06	Zero	1.4E-01	1.4E-01
Waste Receiving	Waste	7.8E+00	External	3.8E-06	2.5E-04	1.3E-01	1.3E-01
Incineration/Wet Scrubber (OL)	Fly ash	8.5E+00	External	3.1E-06	5.0E-03	1.1E-01	1.2E-01
Incinerator Maintenance	Slag	9.2E+00	External	1.1E-06	4.0E-04	1.1E-01	1.1E-01
Incineration/Bag Filter	Fly ash	3.1E+01	External	6.1E-07	2.5E-04	3.2E-02	3.2E-02
Incineration/Wet Scrubber	Fly ash	4.4E+01	External	6.1E-07	2.5E-04	2.2E-02	2.3E-02
Waste Treatment	Waste	4.5E+01	External	5.8E-07	1.2E-04	2.2E-02	2.2E-02
Ash Transport (Dump truck)	Slag	5.4E+01	External	2.7E-07	Zero	1.9E-02	1.9E-02
Waste Transport	Waste	6.4E+01	External	Zero	Zero	1.6E-02	1.6E-02
Landfill Excavation	Waste	3.5E+02	External	7.7E-10	3.0E-06	2.9E-03	2.9E-03

TABLE I.1. (contd)

Nuclide/ Scenario	Waste Form	Limiting Concentration, pCi/g	Dominant Exposure Pathway	Dose, mrem Based on 1 pCi/g in Waste			
				Inhalation	Ingestion	External	Total
^{144}Ce							
Incinerator Maintenance (OL)	Slag	5.6E+01	External	1.1E-04	1.2E-03	1.7E-02	1.8E-02
Incinerator Maintenance	**Slag**	**4.3E+02**	External	1.4E-05	1.9E-04	2.1E-03	2.3E-03
Waste Receiving	Waste	5.3E+02	External	4.2E-05	1.0E-04	1.7E-03	1.9E-03
Incineration/Bag Filter (OL)	Fly ash	7.3E+02	External	8.4E-06	5.0E-04	8.7E-04	1.4E-03
Incineration/Wet Scrubber (OL)	Fly ash	1.5E+03	Ingestion	8.4E-06	5.0E-04	1.8E-04	6.9E-04
Ash Transport (Dump truck) (OL)	Slag	2.2E+03	External	2.1E-05	Zero	4.3E-04	4.5E-04
Waste Disposal	Waste	2.7E+03	External	8.4E-06	5.0E-05	3.1E-04	3.7E-04
Waste Treatment	Waste	4.0E+03	External	6.3E-06	5.0E-05	1.9E-04	2.5E-04
Incineration/Bag Filter	Fly ash	5.0E+03	External	1.7E-06	2.5E-05	1.7E-04	2.0E-04
Waste Transport	Waste	1.2E+04	External	Zero	Zero	8.3E-05	8.3E-05
Incineration/Wet Scrubber	Fly ash	1.6E+04	External	1.7E-06	2.5E-05	3.6E-05	6.3E-05
Ash Transport (Dump truck)	Slag	1.7E+04	External	3.0E-06	Zero	5.5E-05	5.8E-05
Landfill Excavation	Waste	1.9E+05	External	8.4E-09	1.2E-06	4.1E-06	5.3E-06
$^{144}Ce+D$							
Waste Disposal	Waste	2.5E+01	External	8.4E-06	5.0E-05	4.0E-02	4.0E-02
Incinerator Maintenance	Slag	7.0E+01	External	1.4E-05	1.9E-04	1.4E-02	1.4E-02
Waste Receiving	Waste	7.3E+01	External	4.2E-05	1.0E-04	1.3E-02	1.4E-02
Waste Treatment	Waste	4.0E+02	External	6.3E-06	5.0E-05	2.5E-03	2.5E-03
Ash Transport (Dump truck)	Slag	4.5E+02	External	3.0E-06	Zero	2.2E-03	2.2E-03
Waste Transport	Waste	5.8E+02	External	Zero	Zero	1.7E-03	1.7E-03
Incineration/Bag Filter	Fly ash	1.0E+03	External	1.7E-06	2.5E-05	9.4E-04	9.6E-04
Incineration/Wet Scrubber	Fly ash	1.5E+03	External	1.7E-06	2.5E-05	6.2E-04	6.5E-04
Landfill Excavation	Waste	1.9E+03	External	8.4E-09	1.2E-06	5.4E-04	5.4E-04
^{147}Pm							
Incinerator Maintenance (OL)	Slag	8.7E+03	Ingestion	1.1E-05	5.6E-05	4.8E-05	1.1E-04
Incineration/Bag Filter (OL)	Fly ash	3.6E+04	Ingestion	8.2E-07	2.4E-05	3.6E-06	2.8E-05
Incineration/Wet Scrubber (OL)	Fly ash	4.1E+04	Ingestion	8.2E-07	2.4E-05	6.6E-08	2.5E-05
Incinerator Maintenance	**Slag**	**6.1E+04**	Ingestion	1.4E-06	9.0E-06	6.1E-06	1.7E-05
Waste Receiving	Waste	1.0E+05	Ingestion	4.1E-06	4.7E-06	8.5E-07	9.7E-06
Waste Disposal	Waste	3.0E+05	Ingestion	8.2E-07	2.4E-06	1.2E-07	3.3E-06
Waste Treatment	Waste	3.3E+05	Ingestion	6.1E-07	2.4E-06	8.9E-08	3.1E-06
Ash Transport (Dump truck) (OL)	Slag	4.6E+05	Inhalation	2.0E-06	Zero	1.4E-07	2.2E-06
Incineration/Bag Filter	Fly ash	4.8E+05	Ingestion	1.6E-07	1.2E-06	7.1E-07	2.1E-06
Incineration/Wet Scrubber	Fly ash	7.3E+05	Ingestion	1.6E-07	1.2E-06	1.3E-08	1.4E-06
Ash Transport (Dump truck)	Slag	3.2E+06	Inhalation	2.9E-07	Zero	1.9E-08	3.1E-07
Landfill Excavation	Waste	1.7E+07	Ingestion	8.2E-10	5.7E-08	1.6E-09	5.9E-08
Waste Transport	Waste	3.5E+07	External	Zero	Zero	2.9E-08	2.9E-08
^{151}Sm							
Incinerator Maintenance (OL)	Slag	1.8E+04	External	9.3E-06	2.0E-05	2.6E-05	5.6E-05
Incineration/Bag Filter (OL)	Fly ash	8.7E+04	Ingestion	7.0E-07	8.5E-06	2.2E-06	1.1E-05
Incineration/Wet Scrubber (OL)	Fly ash	1.1E+05	Ingestion	7.0E-07	8.5E-06	4.9E-13	9.2E-06
Incinerator Maintenance	**Slag**	**1.3E+05**	External	1.2E-06	3.2E-06	3.3E-06	7.8E-06
Waste Receiving	Waste	1.9E+05	Inhalation	3.5E-06	1.7E-06	3.4E-10	5.2E-06
Ash Transport (Dump truck) (OL)	Slag	5.7E+05	Inhalation	1.7E-06	Zero	6.4E-15	1.7E-06
Waste Disposal	Waste	6.5E+05	Ingestion	7.0E-07	8.5E-07	7.3E-13	1.5E-06
Waste Treatment	Waste	7.3E+05	Ingestion	5.2E-07	8.5E-07	3.0E-11	1.4E-06
Incineration/Bag Filter	Fly ash	9.9E+05	External	1.4E-07	4.2E-07	4.5E-07	1.0E-06
Incineration/Wet Scrubber	Fly ash	1.8E+06	Ingestion	1.4E-07	4.2E-07	9.7E-14	5.6E-07
Ash Transport (Dump truck)	Slag	4.0E+06	Inhalation	2.5E-07	Zero	8.2E-16	2.5E-07
Landfill Excavation	Waste	4.7E+07	Ingestion	7.0E-10	2.0E-08	9.7E-15	2.1E-08
Waste Transport	Waste	2.7E+13	External	Zero	Zero	3.7E-14	3.7E-14

TABLE I.1. (contd)

Nuclide/ Scenario	Waste Form	Limiting Concentration, pCi/g	Dominant Exposure Pathway	Dose, mrem Based on 1 pCi/g in Waste			
				Inhalation	Ingestion	External	Total
^{152}Eu							
Incinerator Maintenance (OL)	Slag	4.0E-01	External	7.1E-05	3.6E-04	2.5E+00	2.5E+00
Waste Disposal	**Waste**	**1.1E+00**	External	5.3E-06	1.5E-05	9.0E-01	9.0E-01
Ash Transport (Dump truck) (OL)	Slag	2.3E+00	External	1.3E-05	Zero	4.3E-01	4.3E-01
Waste Receiving	Waste	3.1E+00	External	2.6E-05	3.0E-05	3.2E-01	3.2E-01
Incinerator Maintenance	Slag	3.2E+00	External	9.0E-06	5.7E-05	3.2E-01	3.2E-01
Incineration/Bag Filter (OL)	Fly ash	1.0E+01	External	5.3E-06	1.5E-04	9.8E-02	9.8E-02
Incineration/Wet Scrubber (OL)	Fly ash	1.3E+01	External	5.3E-06	1.5E-04	7.6E-02	7.7E-02
Waste Treatment	Waste	1.7E+01	External	4.0E-06	1.5E-05	5.9E-02	5.9E-02
Ash Transport (Dump truck)	Slag	1.8E+01	External	1.9E-06	Zero	5.5E-02	5.5E-02
Waste Transport	Waste	2.3E+01	External	Zero	Zero	4.3E-02	4.3E-02
Incineration/Bag Filter	Fly ash	5.1E+01	External	1.1E-06	7.5E-06	2.0E-02	2.0E-02
Incineration/Wet Scrubber	Fly ash	6.5E+01	External	1.1E-06	7.5E-06	1.5E-02	1.5E-02
Landfill Excavation	Waste	8.3E+01	External	5.3E-09	3.6E-07	1.2E-02	1.2E-02
^{154}Eu							
Incinerator Maintenance (OL)	Slag	3.9E-01	External	8.3E-05	5.4E-04	2.5E+00	2.5E+00
Waste Disposal	**Waste**	**1.1E+00**	External	6.2E-06	2.3E-05	8.7E-01	8.7E-01
Ash Transport (Dump truck) (OL)	Slag	2.3E+00	External	1.6E-05	Zero	4.3E-01	4.4E-01
Waste Receiving	Waste	3.0E+00	External	3.1E-05	4.6E-05	3.3E-01	3.3E-01
Incinerator Maintenance	Slag	3.1E+00	External	1.1E-05	8.6E-05	3.2E-01	3.2E-01
Incineration/Bag Filter (OL)	Fly ash	1.0E+01	External	6.2E-06	2.3E-04	1.0E-01	1.0E-01
Incineration/Wet Scrubber (OL)	Fly ash	1.3E+01	External	6.2E-06	2.3E-04	7.8E-02	7.8E-02
Waste Treatment	Waste	1.7E+01	External	4.7E-06	2.3E-05	6.0E-02	6.0E-02
Ash Transport (Dump truck)	Slag	1.8E+01	External	2.2E-06	Zero	5.6E-02	5.6E-02
Waste Transport	Waste	2.3E+01	External	Zero	Zero	4.4E-02	4.4E-02
Incineration/Bag Filter	Fly ash	5.0E+01	External	1.2E-06	1.1E-05	2.0E-02	2.0E-02
Incineration/Wet Scrubber	Fly ash	6.4E+01	External	1.2E-06	1.1E-05	1.6E-02	1.6E-02
Landfill Excavation	Waste	8.6E+01	External	6.2E-09	5.5E-07	1.2E-02	1.2E-02
^{155}Eu							
Incinerator Maintenance (OL)	Slag	2.1E+01	External	1.3E-05	7.7E-05	4.9E-02	4.9E-02
Incinerator Maintenance	**Slag**	**1.6E+02**	External	1.6E-06	1.2E-05	6.2E-03	6.2E-03
Waste Receiving	Waste	2.2E+02	External	4.7E-06	6.5E-06	4.5E-03	4.5E-03
Incineration/Bag Filter (OL)	Fly ash	3.8E+02	External	9.4E-07	3.2E-05	2.6E-03	2.7E-03
Ash Transport (Dump truck) (OL)	Slag	1.2E+03	External	2.3E-06	Zero	8.4E-04	8.5E-04
Waste Disposal	Waste	1.5E+03	External	9.4E-07	3.2E-06	6.8E-04	6.9E-04
Incineration/Bag Filter	Fly ash	1.9E+03	External	1.9E-07	1.6E-06	5.2E-04	5.3E-04
Waste Treatment	Waste	2.1E+03	External	7.0E-07	3.2E-06	4.8E-04	4.9E-04
Incineration/Wet Scrubber (OL)	Fly ash	2.4E+03	External	9.4E-07	3.2E-05	3.9E-04	4.2E-04
Waste Transport	Waste	5.9E+03	External	Zero	Zero	1.7E-04	1.7E-04
Ash Transport (Dump truck)	Slag	9.2E+03	External	3.3E-07	Zero	1.1E-04	1.1E-04
Incineration/Wet Scrubber	Fly ash	1.3E+04	External	1.9E-07	1.6E-06	7.7E-05	7.9E-05
Landfill Excavation	Waste	1.1E+05	External	9.4E-10	7.8E-08	9.1E-06	9.2E-06

TABLE I.1. (contd)

Nuclide/ Scenario	Waste Form	Limiting Concentration, pCi/g	Dominant Exposure Pathway	Dose, mrem Based on 1 pCi/g in Waste			
				Inhalation	Ingestion	External	Total
^{203}Hg							
Incineration/Bag Filter (OL)	Fly ash	5.5E+00	External	2.7E-06	9.4E-04	1.8E-01	1.8E-01
Incineration/Wet Scrubber (OL)	Fly ash	1.2E+01	External	2.7E-06	9.4E-04	8.1E-02	8.2E-02
Incineration/Bag Filter	**Fly ash**	**2.7E+01**	External	5.4E-07	4.7E-05	3.6E-02	3.6E-02
Waste Receiving	Waste	3.4E+01	External	7.4E-07	1.0E-05	3.0E-02	3.0E-02
Waste Disposal	Waste	5.5E+01	External	1.5E-07	5.2E-06	1.8E-02	1.8E-02
Incineration/Wet Scrubber	Fly ash	6.2E+01	External	5.4E-07	4.7E-05	1.6E-02	1.6E-02
Ash Transport (Dump truck) (OL)	Slag	6.6E+01	External	3.5E-07	Zero	1.5E-02	1.5E-02
Incinerator Maintenance (OL)	Slag	8.2E+01	External	1.0E-07	6.6E-06	1.2E-02	1.2E-02
Waste Treatment	Waste	2.5E+02	External	1.1E-07	5.2E-06	4.0E-03	4.0E-03
Waste Transport	Waste	4.3E+02	External	Zero	Zero	2.3E-03	2.3E-03
Ash Transport (Dump truck)	Slag	5.1E+02	External	5.0E-08	Zero	2.0E-03	2.0E-03
Incinerator Maintenance	Slag	6.4E+02	External	1.3E-08	1.0E-06	1.6E-03	1.6E-03
Landfill Excavation	Waste	4.1E+03	External	1.5E-10	1.3E-07	2.4E-04	2.4E-04
^{207}Bi							
Incineration/Bag Filter (OL)	Fly ash	5.8E-01	External	4.7E-06	1.7E-03	1.7E+00	1.7E+00
Incineration/Wet Scrubber (OL)	Fly ash	7.4E-01	External	4.7E-06	1.7E-03	1.3E+00	1.3E+00
Waste Disposal	**Waste**	**9.3E-01**	External	3.4E-07	1.2E-05	1.1E+00	1.1E+00
Incinerator Maintenance (OL)	Slag	1.0E+00	External	1.4E-06	9.2E-05	9.8E-01	9.8E-01
Ash Transport (Dump truck) (OL)	Slag	1.9E+00	External	8.4E-07	Zero	5.4E-01	5.4E-01
Waste Receiving	Waste	2.5E+00	External	1.7E-06	2.4E-05	4.1E-01	4.1E-01
Incineration/Bag Filter	Fly ash	2.9E+00	External	9.4E-07	8.6E-05	3.4E-01	3.4E-01
Incineration/Wet Scrubber	Fly ash	3.7E+00	External	9.4E-07	8.6E-05	2.7E-01	2.7E-01
Incinerator Maintenance	Slag	7.9E+00	External	1.8E-07	1.5E-05	1.3E-01	1.3E-01
Waste Treatment	Waste	1.4E+01	External	2.5E-07	1.2E-05	7.4E-02	7.4E-02
Ash Transport (Dump truck)	Slag	1.5E+01	External	1.2E-07	Zero	6.9E-02	6.9E-02
Waste Transport	Waste	1.9E+01	External	Zero	Zero	5.4E-02	5.4E-02
Landfill Excavation	Waste	7.0E+01	External	3.4E-10	2.9E-07	1.4E-02	1.4E-02
^{226}Ra							
Incinerator Maintenance (OL)	Slag	1.5E+01	Ingestion	2.4E-03	6.2E-02	4.2E-03	6.8E-02
Incineration/Bag Filter (OL)	Fly ash	1.8E+01	Ingestion	3.8E-04	5.5E-02	4.4E-04	5.6E-02
Incineration/Wet Scrubber (OL)	Fly ash	1.8E+01	Ingestion	3.8E-04	5.5E-02	1.1E-04	5.5E-02
Incinerator Maintenance	**Slag**	**9.3E+01**	Ingestion	3.1E-04	9.9E-03	5.3E-04	1.1E-02
Waste Receiving	Waste	1.4E+02	Ingestion	9.5E-04	5.5E-03	5.4E-04	7.0E-03
Waste Disposal	Waste	3.3E+02	Ingestion	1.9E-04	2.7E-03	1.0E-04	3.0E-03
Waste Treatment	Waste	3.4E+02	Ingestion	1.4E-04	2.7E-03	6.0E-05	3.0E-03
Incineration/Bag Filter	Fly ash	3.4E+02	Ingestion	7.6E-05	2.7E-03	8.8E-05	2.9E-03
Incineration/Wet Scrubber	Fly ash	3.5E+02	Ingestion	7.6E-05	2.7E-03	2.2E-05	2.8E-03
Ash Transport (Dump truck) (OL)	Slag	1.6E+03	Inhalation	4.7E-04	Zero	1.4E-04	6.1E-04
Ash Transport (Dump truck)	Slag	1.2E+04	Inhalation	6.8E-05	Zero	1.7E-05	8.5E-05
Landfill Excavation	Waste	1.5E+04	Ingestion	1.9E-07	6.6E-05	1.3E-06	6.8E-05
Waste Transport	Waste	3.9E+04	External	Zero	Zero	2.6E-05	2.6E-05

TABLE I.1. (contd)

Nuclide/ Scenario	Waste Form	Limiting Concentration, pCi/g	Dominant Exposure Pathway	Dose, mrem Based on 1 pCi/g in Waste Inhalation	Ingestion	External	Total
$^{226}Ra+D$							
Incinerator Maintenance (OL)	Slag	2.4E-01	External	8.9E-03	4.4E-01	3.8E+00	4.2E+00
Waste Disposal	**Waste**	**6.1E-01**	**External**	**7.0E-04**	**2.0E-02**	**1.6E+00**	**1.6E+00**
Incineration/Bag Filter (OL)	Fly ash	1.4E+00	Ingestion	1.4E-03	3.9E-01	3.2E-01	7.1E-01
Ash Transport (Dump truck) (OL)	Slag	1.4E+00	External	1.8E-03	Zero	7.3E-01	7.3E-01
Incineration/Wet Scrubber (OL)	Fly ash	1.5E+00	Ingestion	1.4E-03	3.9E-01	2.6E-01	6.5E-01
Waste Receiving	Waste	1.8E+00	External	3.5E-03	3.9E-02	5.2E-01	5.6E-01
Incinerator Maintenance	Slag	1.8E+00	External	1.1E-03	7.0E-02	4.8E-01	5.5E-01
Waste Treatment	Waste	8.5E+00	External	5.3E-04	2.0E-02	9.8E-02	1.2E-01
Ash Transport (Dump truck)	Slag	1.1E+01	External	2.5E-04	Zero	9.4E-02	9.4E-02
Incineration/Bag Filter	Fly ash	1.2E+01	External	2.8E-04	2.0E-02	6.3E-02	8.3E-02
Waste Transport	Waste	1.4E+01	External	Zero	Zero	7.2E-02	7.2E-02
Incineration/Wet Scrubber	Fly ash	1.4E+01	External	2.8E-04	2.0E-02	5.1E-02	7.1E-02
Landfill Excavation	Waste	4.5E+01	External	7.0E-07	4.7E-04	2.2E-02	2.2E-02
^{228}Th							
Incinerator Maintenance (OL)	Slag	7.8E+00	Inhalation	1.0E-01	2.3E-02	3.1E-03	1.3E-01
Waste Receiving	**Waste**	**2.5E+01**	Inhalation	3.7E-02	1.9E-03	1.8E-04	3.9E-02
Ash Transport (Dump truck) (OL)	Slag	5.4E+01	Inhalation	1.9E-02	Zero	6.0E-05	1.9E-02
Incinerator Maintenance	Slag	5.8E+01	Inhalation	1.3E-02	3.7E-03	4.0E-04	1.7E-02
Waste Disposal	Waste	1.2E+02	Inhalation	7.4E-03	9.5E-04	6.7E-05	8.5E-03
Waste Treatment	Waste	1.5E+02	Inhalation	5.6E-03	9.5E-04	2.1E-05	6.6E-03
Incineration/Bag Filter (OL)	Fly ash	1.5E+02	Ingestion	3.0E-03	3.8E-03	8.3E-05	6.9E-03
Incineration/Wet Scrubber (OL)	Fly ash	1.5E+02	Ingestion	3.0E-03	3.8E-03	7.8E-06	6.8E-03
Ash Transport (Dump truck)	Slag	3.8E+02	Inhalation	2.7E-03	Zero	7.7E-06	2.7E-03
Incineration/Bag Filter	Fly ash	1.2E+03	Inhalation	6.0E-04	1.9E-04	1.7E-05	8.0E-04
Incineration/Wet Scrubber	Fly ash	1.3E+03	Inhalation	6.0E-04	1.9E-04	1.6E-06	7.9E-04
Landfill Excavation	Waste	3.2E+04	Ingestion	7.4E-06	2.3E-05	8.9E-07	3.1E-05
Waste Transport	Waste	1.1E+05	External	Zero	Zero	9.5E-06	9.5E-06
^{229}Th							
Incinerator Maintenance (OL)	Slag	1.2E+00	Inhalation	5.6E-01	2.1E-01	8.1E-02	8.6E-01
Waste Receiving	**Waste**	**4.4E+00**	Inhalation	2.0E-01	1.8E-02	7.2E-03	2.3E-01
Incinerator Maintenance	Slag	8.6E+00	Inhalation	7.2E-02	3.4E-02	1.0E-02	1.2E-01
Ash Transport (Dump truck) (OL)	Slag	9.6E+00	Inhalation	1.0E-01	Zero	1.8E-03	1.0E-01
Incineration/Bag Filter (OL)	Fly ash	1.9E+01	Ingestion	1.6E-02	3.5E-02	1.8E-03	5.3E-02
Incineration/Wet Scrubber (OL)	Fly ash	1.9E+01	Ingestion	1.6E-02	3.5E-02	2.8E-04	5.2E-02
Waste Disposal	Waste	2.0E+01	Inhalation	4.1E-02	8.8E-03	1.7E-03	5.1E-02
Waste Treatment	Waste	2.5E+01	Inhalation	3.1E-02	8.8E-03	8.1E-04	4.0E-02
Ash Transport (Dump truck)	Slag	6.8E+01	Inhalation	1.5E-02	Zero	2.3E-04	1.5E-02
Incineration/Bag Filter	Fly ash	1.9E+02	Inhalation	3.3E-03	1.7E-03	3.5E-04	5.4E-03
Incineration/Wet Scrubber	Fly ash	2.0E+02	Inhalation	3.3E-03	1.7E-03	5.6E-05	5.1E-03
Waste Transport	Waste	3.1E+03	External	Zero	Zero	3.2E-04	3.2E-04
Landfill Excavation	Waste	3.7E+03	Ingestion	4.1E-05	2.1E-04	2.3E-05	2.7E-04

TABLE I.1. (contd)

Nuclide/ Scenario	Waste Form	Limiting Concentration, pCi/g	Dominant Exposure Pathway	Dose, mrem Based on 1 pCi/g in Waste			
				Inhalation	Ingestion	External	Total
^{229}Th+D							
Waste Receiving	Waste	3.5E+00	Inhalation	2.1E-01	2.0E-02	5.8E-02	2.8E-01
Incinerator Maintenance	Slag	5.7E+00	Inhalation	7.3E-02	3.8E-02	6.5E-02	1.8E-01
Waste Disposal	Waste	6.7E+00	External	4.1E-02	9.8E-03	9.8E-02	1.5E-01
Waste Treatment	Waste	2.0E+01	Inhalation	3.1E-02	9.8E-03	9.3E-03	5.0E-02
Ash Transport (Dump truck)	Slag	4.6E+01	Inhalation	1.5E-02	Zero	7.0E-03	2.2E-02
Incineration/Bag Filter	Fly ash	1.4E+02	Inhalation	3.3E-03	2.0E-03	1.7E-03	7.0E-03
Waste Transport	Waste	1.6E+02	External	Zero	Zero	6.2E-03	6.2E-03
Incineration/Wet Scrubber	Fly ash	1.6E+02	Inhalation	3.3E-03	2.0E-03	9.1E-04	6.2E-03
Landfill Excavation	Waste	6.3E+02	External	4.1E-05	2.3E-04	1.3E-03	1.6E-03
^{230}Th							
Incinerator Maintenance (OL)	Slag	8.3E+00	Inhalation	8.6E-02	3.2E-02	1.5E-03	1.2E-01
Waste Receiving	**Waste**	**3.0E+01**	Inhalation	3.1E-02	2.6E-03	1.6E-05	3.4E-02
Incinerator Maintenance	Slag	6.1E+01	Inhalation	1.1E-02	5.2E-03	2.0E-04	1.6E-02
Ash Transport (Dump truck) (OL)	Slag	6.4E+01	Inhalation	1.6E-02	Zero	2.7E-06	1.6E-02
Waste Disposal	Waste	1.3E+02	Inhalation	6.2E-03	1.3E-03	2.0E-06	7.6E-03
Incineration/Bag Filter (OL)	Fly ash	1.3E+02	Ingestion	2.5E-03	5.3E-03	5.1E-05	7.8E-03
Incineration/Wet Scrubber (OL)	Fly ash	1.3E+02	Ingestion	2.5E-03	5.3E-03	4.7E-07	7.8E-03
Waste Treatment	Waste	1.7E+02	Inhalation	4.7E-03	1.3E-03	1.6E-06	6.0E-03
Ash Transport (Dump truck)	Slag	4.5E+02	Inhalation	2.2E-03	Zero	3.5E-07	2.2E-03
Incineration/Bag Filter	Fly ash	1.3E+03	Inhalation	5.0E-04	2.6E-04	1.0E-05	7.7E-04
Incineration/Wet Scrubber	Fly ash	1.3E+03	Inhalation	5.0E-04	2.6E-04	9.4E-08	7.6E-04
Landfill Excavation	Waste	2.6E+04	Ingestion	6.2E-06	3.2E-05	2.7E-08	3.8E-05
Waste Transport	Waste	1.9E+06	External	Zero	Zero	5.3E-07	5.3E-07
^{232}Th							
Incinerator Maintenance (OL)	Slag	1.9E+00	Inhalation	3.6E-01	1.7E-01	1.4E-03	5.4E-01
Waste Receiving	**Waste**	**6.8E+00**	Inhalation	1.3E-01	1.4E-02	7.5E-06	1.5E-01
Incinerator Maintenance	Slag	1.3E+01	Inhalation	4.7E-02	2.7E-02	1.8E-04	7.4E-02
Ash Transport (Dump truck) (OL)	Slag	1.5E+01	Inhalation	6.6E-02	Zero	1.7E-06	6.6E-02
Incineration/Bag Filter (OL)	Fly ash	2.6E+01	Ingestion	1.1E-02	2.8E-02	4.9E-05	3.9E-02
Incineration/Wet Scrubber (OL)	Fly ash	2.6E+01	Ingestion	1.1E-02	2.8E-02	2.8E-07	3.9E-02
Waste Disposal	Waste	3.0E+01	Inhalation	2.6E-02	7.0E-03	1.2E-06	3.3E-02
Waste Treatment	Waste	3.7E+01	Inhalation	2.0E-02	7.0E-03	8.1E-07	2.7E-02
Ash Transport (Dump truck)	Slag	1.1E+02	Inhalation	9.4E-03	Zero	2.2E-07	9.4E-03
Incineration/Bag Filter	Fly ash	2.8E+02	Inhalation	2.1E-03	1.4E-03	9.8E-06	3.5E-03
Incineration/Wet Scrubber	Fly ash	2.8E+02	Inhalation	2.1E-03	1.4E-03	5.5E-08	3.5E-03
Landfill Excavation	Waste	5.1E+03	Ingestion	2.6E-05	1.7E-04	1.6E-08	1.9E-04
Waste Transport	Waste	3.1E+06	External	Zero	Zero	3.2E-07	3.2E-07
^{232}Th+D							
Incinerator Maintenance (OL)	Slag	1.5E-01	External	4.7E-01	2.9E-01	6.1E+00	6.9E+00
Waste Disposal	**Waste**	**3.4E-01**	External	3.4E-02	1.2E-02	2.9E+00	2.9E+00
Ash Transport (Dump truck) (OL)	Slag	8.1E-01	External	8.5E-02	Zero	1.2E+00	1.2E+00
Waste Receiving	Waste	1.0E+00	External	1.7E-01	2.4E-02	7.6E-01	9.6E-01
Incinerator Maintenance	Slag	1.1E+00	External	6.0E-02	4.7E-02	7.8E-01	8.9E-01
Waste Treatment	Waste	5.3E+00	External	2.6E-02	1.2E-02	1.5E-01	1.9E-01
Ash Transport (Dump truck)	Slag	6.2E+00	External	1.2E-02	Zero	1.5E-01	1.6E-01
Incineration/Bag Filter (OL)	Fly ash	6.4E+00	External	1.4E-02	4.8E-02	9.5E-02	1.6E-01
Incineration/Wet Scrubber (OL)	Fly ash	7.2E+00	External	1.4E-02	4.8E-02	7.8E-02	1.4E-01
Waste Transport	Waste	9.0E+00	External	Zero	Zero	1.1E-01	1.1E-01
Landfill Excavation	Waste	2.6E+01	External	3.4E-05	2.9E-04	3.9E-02	3.9E-02
Incineration/Bag Filter	Fly ash	4.1E+01	External	2.7E-03	2.4E-03	1.9E-02	2.4E-02
Incineration/Wet Scrubber	Fly ash	4.8E+01	External	2.7E-03	2.4E-03	1.6E-02	2.1E-02

TABLE I.1. (contd)

Nuclide/ Scenario	Waste Form	Limiting Concentration, pCi/g	Dominant Exposure Pathway	Dose, mrem Based on 1 pCi/g in Waste Inhalation	Ingestion	External	Total
^{232}U							
Incinerator Maintenance (OL)	Slag	4.4E+00	Inhalation	2.2E-01	4.2E-03	2.0E-03	2.3E-01
Waste Receiving	**Waste**	**1.2E+01**	Inhalation	8.0E-02	3.4E-04	1.2E-05	8.1E-02
Ash Transport (Dump truck) (OL)	Slag	2.5E+01	Inhalation	4.0E-02	Zero	2.9E-06	4.0E-02
Incinerator Maintenance	Slag	3.4E+01	Inhalation	2.8E-02	6.7E-04	2.6E-04	2.9E-02
Waste Disposal	Waste	6.2E+01	Inhalation	1.6E-02	1.7E-04	2.0E-06	1.6E-02
Waste Treatment	Waste	8.2E+01	Inhalation	1.2E-02	1.7E-04	1.4E-06	1.2E-02
Incineration/Bag Filter (OL)	Fly ash	1.4E+02	Inhalation	6.4E-03	6.8E-04	7.0E-05	7.2E-03
Incineration/Wet Scrubber (OL)	Fly ash	1.4E+02	Inhalation	6.4E-03	6.8E-04	4.8E-07	7.1E-03
Ash Transport (Dump truck)	Slag	1.7E+02	Inhalation	5.7E-03	Zero	3.8E-07	5.7E-03
Incineration/Bag Filter	Fly ash	7.5E+02	Inhalation	1.3E-03	3.4E-05	1.4E-05	1.3E-03
Incineration/Wet Scrubber	Fly ash	7.6E+02	Inhalation	1.3E-03	3.4E-05	9.6E-08	1.3E-03
Landfill Excavation	Waste	5.0E+04	Inhalation	1.6E-05	4.1E-06	2.7E-08	2.0E-05
Waste Transport	Waste	1.8E+06	External	Zero	Zero	5.5E-07	5.5E-07
^{233}U							
Incinerator Maintenance (OL)	Slag	2.2E+01	Inhalation	4.3E-02	1.5E-03	8.4E-04	4.5E-02
Waste Receiving	**Waste**	**6.3E+01**	Inhalation	1.6E-02	1.2E-04	2.8E-05	1.6E-02
Ash Transport (Dump truck) (OL)	Slag	1.3E+02	Inhalation	7.8E-03	Zero	7.2E-06	7.8E-03
Incinerator Maintenance	Slag	1.7E+02	Inhalation	5.5E-03	2.5E-04	1.1E-04	5.9E-03
Waste Disposal	Waste	3.1E+02	Inhalation	3.1E-03	6.2E-05	5.1E-06	3.2E-03
Waste Treatment	Waste	4.2E+02	Inhalation	2.3E-03	6.2E-05	3.1E-06	2.4E-03
Incineration/Bag Filter (OL)	Fly ash	6.6E+02	Inhalation	1.2E-03	2.5E-04	2.6E-05	1.5E-03
Incineration/Wet Scrubber (OL)	Fly ash	6.7E+02	Inhalation	1.2E-03	2.5E-04	1.2E-06	1.5E-03
Ash Transport (Dump truck)	Slag	9.0E+02	Inhalation	1.1E-03	Zero	9.3E-07	1.1E-03
Incineration/Bag Filter	Fly ash	3.7E+03	Inhalation	2.5E-04	1.2E-05	5.2E-06	2.7E-04
Incineration/Wet Scrubber	Fly ash	3.8E+03	Inhalation	2.5E-04	1.2E-05	2.4E-07	2.6E-04
Landfill Excavation	Waste	2.1E+05	Inhalation	3.1E-06	1.5E-06	6.8E-08	4.7E-06
Waste Transport	Waste	7.3E+05	External	Zero	Zero	1.4E-06	1.4E-06
^{234}U							
Incinerator Maintenance (OL)	Slag	2.2E+01	Inhalation	4.3E-02	1.5E-03	1.7E-03	4.6E-02
Waste Receiving	**Waste**	**6.4E+01**	Inhalation	1.6E-02	1.2E-04	6.8E-06	1.6E-02
Ash Transport (Dump truck) (OL)	Slag	1.3E+02	Inhalation	7.8E-03	Zero	1.6E-06	7.8E-03
Incinerator Maintenance	Slag	1.7E+02	Inhalation	5.5E-03	2.5E-04	2.2E-04	6.0E-03
Waste Disposal	Waste	3.1E+02	Inhalation	3.1E-03	6.2E-05	1.1E-06	3.2E-03
Waste Treatment	Waste	4.2E+02	Inhalation	2.3E-03	6.2E-05	7.4E-07	2.4E-03
Incineration/Bag Filter (OL)	Fly ash	6.4E+02	Inhalation	1.2E-03	2.5E-04	6.0E-05	1.6E-03
Incineration/Wet Scrubber (OL)	Fly ash	6.7E+02	Inhalation	1.2E-03	2.5E-04	2.6E-07	1.5E-03
Ash Transport (Dump truck)	Slag	9.0E+02	Inhalation	1.1E-03	Zero	2.1E-07	1.1E-03
Incineration/Bag Filter	Fly ash	3.6E+03	Inhalation	2.5E-04	1.2E-05	1.2E-05	2.7E-04
Incineration/Wet Scrubber	Fly ash	3.8E+03	Inhalation	2.5E-04	1.2E-05	5.3E-08	2.6E-04
Landfill Excavation	Waste	2.2E+05	Inhalation	3.1E-06	1.5E-06	1.5E-08	4.6E-06
Waste Transport	Waste	3.3E+06	External	Zero	Zero	3.0E-07	3.0E-07

TABLE I.1. (contd)

Nuclide/ Scenario	Waste Form	Limiting Concentration, pCi/g	Dominant Exposure Pathway	Dose, mrem Based on 1 pCi/g in Waste Inhalation	Ingestion	External	Total
^{235}U							
Incinerator Maintenance (OL)	Slag	6.2E+00	External	4.0E-02	1.5E-03	1.2E-01	1.6E-01
Waste Receiving	**Waste**	**3.5E+01**	Inhalation	1.4E-02	1.2E-04	1.4E-02	2.9E-02
Incinerator Maintenance	Slag	4.9E+01	External	5.1E-03	2.5E-04	1.5E-02	2.1E-02
Ash Transport (Dump truck) (OL)	Slag	8.8E+01	Inhalation	7.2E-03	Zero	4.2E-03	1.1E-02
Waste Disposal	Waste	1.5E+02	External	2.9E-03	6.2E-05	3.5E-03	6.5E-03
Waste Treatment	Waste	2.6E+02	Inhalation	2.2E-03	6.2E-05	1.6E-03	3.9E-03
Incineration/Bag Filter (OL)	Fly ash	2.7E+02	External	1.2E-03	2.5E-04	2.3E-03	3.7E-03
Incineration/Wet Scrubber (OL)	Fly ash	4.9E+02	Inhalation	1.2E-03	2.5E-04	6.4E-04	2.0E-03
Ash Transport (Dump truck)	Slag	6.4E+02	Inhalation	1.0E-03	Zero	5.4E-04	1.6E-03
Waste Transport	Waste	1.3E+03	External	Zero	Zero	7.5E-04	7.5E-04
Incineration/Bag Filter	Fly ash	1.4E+03	External	2.3E-04	1.2E-05	4.6E-04	7.0E-04
Incineration/Wet Scrubber	Fly ash	2.7E+03	Inhalation	2.3E-04	1.2E-05	1.3E-04	3.7E-04
Landfill Excavation	Waste	2.0E+04	External	2.9E-06	1.5E-06	4.7E-05	5.1E-05
$^{235}U+D$							
Waste Receiving	Waste	3.4E+01	External	1.4E-02	1.3E-04	1.5E-02	2.9E-02
Incinerator Maintenance	Slag	4.3E+01	External	5.1E-03	2.6E-04	1.8E-02	2.3E-02
Waste Disposal	Waste	1.5E+02	External	2.9E-03	6.6E-05	3.6E-03	6.5E-03
Waste Treatment	Waste	2.6E+02	Inhalation	2.2E-03	6.6E-05	1.7E-03	3.9E-03
Ash Transport (Dump truck)	Slag	6.3E+02	Inhalation	1.0E-03	Zero	5.5E-04	1.6E-03
Incineration/Bag Filter	Fly ash	1.2E+03	External	2.3E-04	1.3E-05	5.9E-04	8.3E-04
Waste Transport	Waste	1.3E+03	External	Zero	Zero	7.6E-04	7.6E-04
Incineration/Wet Scrubber	Fly ash	2.7E+03	Inhalation	2.3E-04	1.3E-05	1.3E-04	3.7E-04
Landfill Excavation	Waste	1.9E+04	External	2.9E-06	1.6E-06	4.8E-05	5.2E-05
^{238}U							
Incinerator Maintenance (OL)	Slag	2.4E+01	Inhalation	4.0E-02	1.4E-03	1.4E-03	4.3E-02
Waste Receiving	**Waste**	**6.9E+01**	Inhalation	1.4E-02	1.1E-04	1.3E-06	1.5E-02
Ash Transport (Dump truck) (OL)	Slag	1.4E+02	Inhalation	7.2E-03	Zero	2.6E-10	7.2E-03
Incinerator Maintenance	Slag	1.8E+02	Inhalation	5.1E-03	2.3E-04	1.8E-04	5.5E-03
Waste Disposal	Waste	3.4E+02	Inhalation	2.9E-03	5.7E-05	1.7E-08	2.9E-03
Waste Treatment	Waste	4.5E+02	Inhalation	2.2E-03	5.7E-05	1.1E-07	2.2E-03
Incineration/Bag Filter (OL)	Fly ash	7.0E+02	Inhalation	1.2E-03	2.3E-04	5.0E-05	1.4E-03
Incineration/Wet Scrubber (OL)	Fly ash	7.2E+02	Inhalation	1.2E-03	2.3E-04	3.8E-09	1.4E-03
Ash Transport (Dump truck)	Slag	9.7E+02	Inhalation	1.0E-03	Zero	3.3E-11	1.0E-03
Incineration/Bag Filter	Fly ash	4.0E+03	Inhalation	2.3E-04	1.1E-05	1.0E-05	2.5E-04
Incineration/Wet Scrubber	Fly ash	4.1E+03	Inhalation	2.3E-04	1.1E-05	7.6E-10	2.4E-04
Landfill Excavation	Waste	2.3E+05	Inhalation	2.9E-06	1.4E-06	2.2E-10	4.3E-06
Waste Transport	Waste	8.9E+08	External	Zero	Zero	1.1E-09	1.1E-09
$^{238}U+D$							
Incinerator Maintenance (OL)	Slag	1.1E+01	External	4.0E-02	2.2E-03	5.0E-02	9.2E-02
Waste Receiving	**Waste**	**5.0E+01**	Inhalation	1.4E-02	1.8E-04	5.5E-03	2.0E-02
Waste Disposal	Waste	6.5E+01	External	2.9E-03	9.0E-05	1.2E-02	1.5E-02
Ash Transport (Dump truck) (OL)	Slag	7.5E+01	Inhalation	7.2E-03	Zero	6.1E-03	1.3E-02
Incinerator Maintenance	Slag	8.5E+01	External	5.1E-03	3.5E-04	6.4E-03	1.2E-02
Waste Treatment	Waste	3.1E+02	Inhalation	2.2E-03	9.0E-05	9.4E-04	3.2E-03
Incineration/Bag Filter (OL)	Fly ash	4.2E+02	Inhalation	1.2E-03	3.6E-04	8.8E-04	2.4E-03
Incineration/Wet Scrubber (OL)	Fly ash	5.1E+02	Inhalation	1.2E-03	3.6E-04	4.7E-04	2.0E-03
Ash Transport (Dump truck)	Slag	5.5E+02	Inhalation	1.0E-03	Zero	7.9E-04	1.8E-03
Waste Transport	Waste	1.5E+03	External	Zero	Zero	6.5E-04	6.5E-04
Incineration/Bag Filter	Fly ash	2.4E+03	Inhalation	2.3E-04	1.8E-05	1.8E-04	4.2E-04
Incineration/Wet Scrubber	Fly ash	2.9E+03	Inhalation	2.3E-04	1.8E-05	9.3E-05	3.4E-04
Landfill Excavation	Waste	5.9E+03	External	2.9E-06	2.2E-06	1.6E-04	1.7E-04

TABLE I.1. (contd)

Nuclide/ Scenario	Waste Form	Limiting Concentration, pCi/g	Dominant Exposure Pathway	Dose, mrem Based on 1 pCi/g in Waste			
				Inhalation	Ingestion	External	Total
^{237}Np							
Incinerator Maintenance (OL)	Slag	2.3E+00	Ingestion	1.6E-01	2.4E-01	2.7E-02	4.3E-01
Waste Receiving	**Waste**	**1.3E+01**	Inhalation	5.9E-02	2.0E-02	1.4E-03	8.0E-02
Incinerator Maintenance	Slag	1.6E+01	Ingestion	2.1E-02	3.8E-02	3.5E-03	6.2E-02
Incineration/Bag Filter (OL)	Fly ash	2.3E+01	Ingestion	4.7E-03	3.9E-02	7.1E-04	4.4E-02
Incineration/Wet Scrubber (OL)	Fly ash	2.3E+01	Ingestion	4.7E-03	3.9E-02	3.9E-05	4.4E-02
Ash Transport (Dump truck) (OL)	Slag	3.4E+01	Inhalation	2.9E-02	Zero	1.8E-04	3.0E-02
Waste Disposal	Waste	4.6E+01	Inhalation	1.2E-02	9.8E-03	2.1E-04	2.2E-02
Waste Treatment	Waste	5.3E+01	Ingestion	8.8E-03	9.8E-03	1.5E-04	1.9E-02
Ash Transport (Dump truck)	Slag	2.4E+02	Inhalation	4.2E-03	Zero	2.4E-05	4.2E-03
Incineration/Bag Filter	Fly ash	3.3E+02	Ingestion	9.4E-04	1.9E-03	1.4E-04	3.0E-03
Incineration/Wet Scrubber	Fly ash	3.4E+02	Ingestion	9.4E-04	1.9E-03	7.8E-06	2.9E-03
Landfill Excavation	Waste	4.0E+03	Ingestion	1.2E-05	2.3E-04	2.8E-06	2.5E-04
Waste Transport	Waste	2.5E+04	External	Zero	Zero	4.0E-05	4.0E-05
$^{237}Np+D$							
Incinerator Maintenance (OL)	Slag	1.3E+00	External	1.6E-01	2.4E-01	3.6E-01	7.6E-01
Waste Receiving	**Waste**	**8.4E+00**	Inhalation	5.9E-02	2.0E-02	4.1E-02	1.2E-01
Incinerator Maintenance	Slag	9.5E+00	External	2.1E-02	3.8E-02	4.6E-02	1.1E-01
Waste Disposal	Waste	1.4E+01	External	1.2E-02	9.8E-03	4.8E-02	6.9E-02
Ash Transport (Dump truck) (OL)	Slag	1.6E+01	External	2.9E-02	Zero	3.2E-02	6.1E-02
Incineration/Bag Filter (OL)	Fly ash	2.0E+01	Ingestion	4.7E-03	3.9E-02	6.2E-03	5.0E-02
Incineration/Wet Scrubber (OL)	Fly ash	2.1E+01	Ingestion	4.7E-03	3.9E-02	3.0E-03	4.7E-02
Waste Treatment	Waste	4.0E+01	Ingestion	8.8E-03	9.8E-03	6.3E-03	2.5E-02
Ash Transport (Dump truck)	Slag	1.2E+02	Inhalation	4.2E-03	Zero	4.1E-03	8.3E-03
Incineration/Bag Filter	Fly ash	2.4E+02	Ingestion	9.4E-04	2.0E-03	1.2E-03	4.1E-03
Waste Transport	Waste	2.5E+02	External	Zero	Zero	4.0E-03	4.0E-03
Incineration/Wet Scrubber	Fly ash	2.9E+02	Ingestion	9.4E-04	2.0E-03	6.0E-04	3.5E-03
Landfill Excavation	Waste	1.1E+03	External	1.2E-05	2.3E-04	6.4E-04	8.8E-04
^{238}Pu							
Incinerator Maintenance (OL)	Slag	9.6E+00	Inhalation	9.9E-02	3.3E-03	1.8E-03	1.0E-01
Waste Receiving	**Waste**	**2.8E+01**	Inhalation	3.6E-02	2.7E-04	2.5E-07	3.6E-02
Ash Transport (Dump truck) (OL)	Slag	5.6E+01	Inhalation	1.8E-02	Zero	6.5E-13	1.8E-02
Incinerator Maintenance	Slag	7.4E+01	Inhalation	1.3E-02	5.3E-04	2.3E-04	1.3E-02
Waste Disposal	Waste	1.4E+02	Inhalation	7.2E-03	1.3E-04	5.6E-10	7.3E-03
Waste Treatment	Waste	1.8E+02	Inhalation	5.4E-03	1.3E-04	2.2E-08	5.5E-03
Incineration/Bag Filter (OL)	Fly ash	2.9E+02	Inhalation	2.9E-03	5.4E-04	6.5E-05	3.5E-03
Incineration/Wet Scrubber (OL)	Fly ash	2.9E+02	Inhalation	2.9E-03	5.4E-04	1.7E-10	3.4E-03
Ash Transport (Dump truck)	Slag	3.9E+02	Inhalation	2.6E-03	Zero	8.3E-14	2.6E-03
Incineration/Bag Filter	Fly ash	1.6E+03	Inhalation	5.8E-04	2.7E-05	1.3E-05	6.2E-04
Incineration/Wet Scrubber	Fly ash	1.7E+03	Inhalation	5.8E-04	2.7E-05	3.4E-11	6.0E-04
Landfill Excavation	Waste	9.6E+04	Inhalation	7.2E-06	3.2E-06	7.5E-12	1.0E-05
Waste Transport	Waste	5.3E+10	External	Zero	Zero	1.9E-11	1.9E-11

TABLE I.1. (contd)

Nuclide/ Scenario	Waste Form	Limiting Concentration, pCi/g	Dominant Exposure Pathway	Dose, mrem Based on 1 pCi/g in Waste			
				Inhalation	Ingestion	External	Total
^{239}Pu							
Incinerator Maintenance (OL)	Slag	8.8E+00	Inhalation	1.1E-01	3.6E-03	7.4E-04	1.1E-01
Waste Receiving	**Waste**	**2.5E+01**	Inhalation	4.0E-02	2.9E-04	7.4E-06	4.0E-02
Ash Transport (Dump truck) (OL)	Slag	5.1E+01	Inhalation	2.0E-02	Zero	1.9E-06	2.0E-02
Incinerator Maintenance	Slag	6.8E+01	Inhalation	1.4E-02	5.7E-04	9.5E-05	1.5E-02
Waste Disposal	Waste	1.2E+02	Inhalation	7.9E-03	1.4E-04	1.3E-06	8.1E-03
Waste Treatment	Waste	1.6E+02	Inhalation	5.9E-03	1.4E-04	8.2E-07	6.1E-03
Incineration/Bag Filter (OL)	Fly ash	2.7E+02	Inhalation	3.2E-03	5.8E-04	2.5E-05	3.8E-03
Incineration/Wet Scrubber (OL)	Fly ash	2.7E+02	Inhalation	3.2E-03	5.8E-04	3.1E-07	3.7E-03
Ash Transport (Dump truck)	Slag	3.5E+02	Inhalation	2.8E-03	Zero	2.4E-07	2.8E-03
Incineration/Bag Filter	Fly ash	1.5E+03	Inhalation	6.3E-04	2.9E-05	5.1E-06	6.7E-04
Incineration/Wet Scrubber	Fly ash	1.5E+03	Inhalation	6.3E-04	2.9E-05	6.3E-08	6.6E-04
Landfill Excavation	Waste	8.8E+04	Inhalation	7.9E-06	3.5E-06	1.8E-08	1.1E-05
Waste Transport	Waste	2.8E+06	External	Zero	Zero	3.6E-07	3.6E-07
^{240}Pu							
Incinerator Maintenance (OL)	Slag	8.7E+00	Inhalation	1.1E-01	3.6E-03	1.7E-03	1.1E-01
Waste Receiving	**Waste**	**2.5E+01**	Inhalation	4.0E-02	2.9E-04	2.8E-07	4.0E-02
Ash Transport (Dump truck) (OL)	Slag	5.1E+01	Inhalation	2.0E-02	Zero	7.2E-13	2.0E-02
Incinerator Maintenance	Slag	6.8E+01	Inhalation	1.4E-02	5.7E-04	2.2E-04	1.5E-02
Waste Disposal	Waste	1.2E+02	Inhalation	7.9E-03	1.4E-04	6.3E-10	8.1E-03
Waste Treatment	Waste	1.6E+02	Inhalation	5.9E-03	1.4E-04	2.5E-08	6.1E-03
Incineration/Bag Filter (OL)	Fly ash	2.6E+02	Inhalation	3.2E-03	5.8E-04	6.1E-05	3.8E-03
Incineration/Wet Scrubber (OL)	Fly ash	2.7E+02	Inhalation	3.2E-03	5.8E-04	1.9E-10	3.7E-03
Ash Transport (Dump truck)	Slag	3.5E+02	Inhalation	2.8E-03	Zero	9.3E-14	2.8E-03
Incineration/Bag Filter	Fly ash	1.5E+03	Inhalation	6.3E-04	2.9E-05	1.2E-05	6.7E-04
Incineration/Wet Scrubber	Fly ash	1.5E+03	Inhalation	6.3E-04	2.9E-05	3.8E-11	6.6E-04
Landfill Excavation	Waste	8.8E+04	Inhalation	7.9E-06	3.5E-06	8.3E-12	1.1E-05
Waste Transport	Waste	4.8E+10	External	Zero	Zero	2.1E-11	2.1E-11

TABLE I.1. (contd)

Nuclide/ Scenario	Waste Form	Limiting Concentration, pCi/g	Dominant Exposure Pathway	Dose, mrem Based on 1 pCi/g in Waste			
				Inhalation	Ingestion	External	Total
^{241}Pu							
Incinerator Maintenance (OL)	Slag	5.2E+02	Inhalation	1.9E-03	5.6E-05	4.7E-09	1.9E-03
Waste Receiving	**Waste**	**1.5E+03**	Inhalation	6.8E-04	4.6E-06	1.1E-35	6.9E-04
Ash Transport (Dump truck) (OL)	Slag	2.9E+03	Inhalation	3.4E-04	Zero	Zero	3.4E-04
Incinerator Maintenance	Slag	4.0E+03	Inhalation	2.4E-04	9.0E-06	6.0E-10	2.5E-04
Waste Disposal	Waste	7.2E+03	Inhalation	1.4E-04	2.3E-06	Zero	1.4E-04
Waste Treatment	Waste	9.5E+03	Inhalation	1.0E-04	2.3E-06	3.0E-36	1.0E-04
Incineration/Bag Filter (OL)	Fly ash	1.6E+04	Inhalation	5.5E-05	9.2E-06	1.7E-10	6.4E-05
Incineration/Wet Scrubber (OL)	Fly ash	1.6E+04	Inhalation	5.5E-05	9.2E-06	Zero	6.4E-05
Ash Transport (Dump truck)	Slag	2.0E+04	Inhalation	4.9E-05	Zero	Zero	4.9E-05
Incineration/Bag Filter	Fly ash	8.8E+04	Inhalation	1.1E-05	4.6E-07	3.4E-11	1.1E-05
Incineration/Wet Scrubber	Fly ash	8.8E+04	Inhalation	1.1E-05	4.6E-07	Zero	1.1E-05
Landfill Excavation	Waste	5.2E+06	Inhalation	1.4E-07	5.5E-08	Zero	1.9E-07
Waste Transport	Waste	None	Ingestion	Zero	Zero	Zero	Zero
^{241}Am							
Incinerator Maintenance (OL)	Slag	2.1E+00	Ingestion	1.7E-01	2.8E-01	1.8E-02	4.7E-01
Waste Receiving	**Waste**	**1.2E+01**	Inhalation	6.2E-02	2.2E-02	2.0E-04	8.5E-02
Incinerator Maintenance	Slag	1.5E+01	Ingestion	2.2E-02	4.4E-02	2.4E-03	6.8E-02
Incineration/Bag Filter (OL)	Fly ash	2.0E+01	Ingestion	5.0E-03	4.5E-02	5.4E-04	5.1E-02
Incineration/Wet Scrubber (OL)	Fly ash	2.0E+01	Ingestion	5.0E-03	4.5E-02	1.4E-07	5.0E-02
Ash Transport (Dump truck) (OL)	Slag	3.2E+01	Inhalation	3.1E-02	Zero	9.7E-10	3.1E-02
Waste Disposal	Waste	4.2E+01	Inhalation	1.2E-02	1.1E-02	4.6E-07	2.4E-02
Waste Treatment	Waste	4.8E+01	Ingestion	9.4E-03	1.1E-02	1.7E-05	2.1E-02
Ash Transport (Dump truck)	Slag	2.2E+02	Inhalation	4.5E-03	Zero	1.3E-10	4.5E-03
Incineration/Bag Filter	Fly ash	3.0E+02	Ingestion	1.0E-03	2.2E-03	1.1E-04	3.4E-03
Incineration/Wet Scrubber	Fly ash	3.1E+02	Ingestion	1.0E-03	2.2E-03	2.7E-08	3.2E-03
Landfill Excavation	Waste	3.5E+03	Ingestion	1.2E-05	2.7E-04	6.1E-09	2.8E-04
Waste Transport	Waste	6.1E+07	External	Zero	Zero	1.6E-08	1.6E-08

(a) Scenarios and concentrations in **bold** face are the bases for the limiting concentrations noted in Table S.1 and the tables in Sections 3 and 4. Scenarios involving incineration of organic liquids in a liquid-only incinerator (designated by [OL]) were not considered in the selection of limiting concentrations.

TABLE I.2. Collective Worker Doses Based on Limiting Concentrations Corresponding to 1 mrem/y to the Maximally Exposed Worker

Nuclide	Scenario	Number of Workers	Total Dose, man-rem	Dominant Exposure Pathway	Average Individual Worker Dose, mrem, Based on Concentration Limit, pCi/g in Waste		
					Inhalation	Ingestion	External
^{3}H	Worker Concentration Limit: 3,100,000. pCi/g						
	Incinerator--High exposure	30.	2.9E-02	Ingestion	4.7E-03	9.8E-01	1.5E-29
	Incinerator--Med exposure	50.	5.9E-06	Inhalation	1.2E-04	Zero	4.1E-32
	Incinerator--Low exposure	70.	8.2E-07	Inhalation	1.2E-05	Zero	Zero
	Landfill--High exposure	40.	3.9E-02	Ingestion	3.5E-03	9.8E-01	Zero
	Landfill--Med exposure	60.	7.0E-06	Inhalation	1.2E-04	Zero	Zero
	Landfill--Low exposure	80.	9.4E-07	Inhalation	1.2E-05	Zero	Zero
	Total		6.9E-02				
^{7}Be	Worker Concentration Limit: 59. pCi/g						
	Incinerator--High exposure	30.	1.3E-02	External	3.8E-07	3.2E-05	4.3E-01
	Incinerator--Med exposure	50.	2.6E-04	External	9.6E-09	Zero	5.2E-03
	Incinerator--Low exposure	70.	6.6E-07	External	9.6E-10	Zero	9.4E-06
	Landfill--High exposure	40.	4.0E-02	External	2.9E-07	3.2E-05	9.9E-01
	Landfill--Med exposure	60.	3.9E-08	External	9.6E-09	Zero	6.3E-07
	Landfill--Low exposure	80.	2.4E-10	External	9.6E-10	Zero	2.0E-09
	Total		5.3E-02				
^{14}C	Worker Concentration Limit: 94,000. pCi/g						
	Incinerator--High exposure	30.	3.0E-02	Ingestion	5.4E-05	9.9E-01	4.1E-03
	Incinerator--Med exposure	50.	2.7E-06	External	1.4E-06	Zero	5.3E-05
	Incinerator--Low exposure	70.	9.5E-09	Inhalation	1.4E-07	Zero	3.6E-10
	Landfill--High exposure	40.	3.9E-02	Ingestion	4.1E-05	9.9E-01	3.7E-04
	Landfill--Med exposure	60.	8.1E-08	Inhalation	1.4E-06	Zero	2.0E-17
	Landfill--Low exposure	80.	1.1E-08	Inhalation	1.4E-07	Zero	5.6E-20
	Total		6.9E-02				
^{22}Na	Worker Concentration Limit: 0.72 pCi/g						
	Incinerato--High exposure	30.	8.5E-03	External	1.4E-07	4.3E-05	2.8E-01
	Incinerator--Med exposure	50.	1.8E-04	External	3.5E-09	Zero	3.5E-03
	Incinerator--Low exposure	70.	9.8E-07	External	3.5E-10	Zero	1.4E-05
	Landfill--High exposure	40.	4.0E-02	External	1.0E-07	4.3E-05	1.0E+00
	Landfill--Med exposure	60.	1.4E-06	External	3.5E-09	Zero	2.3E-05
	Landfill--Low exposure	80.	6.4E-09	External	3.5E-10	Zero	7.9E-08
	Total		4.9E-02				
^{32}P	Worker Concentration Limit:1600. pCi/g						
	Incinerator--High exposure	30.	1.9E-02	External	5.0E-04	6.2E-02	5.7E-01
	Incinerator--Med exposure	50.	3.5E-04	External	1.2E-05	Zero	6.9E-03
	Incinerator--Low exposure	70.	7.4E-07	External	1.2E-06	Zero	9.4E-06
	Landfill--High exposure	40.	4.2E-02	External	3.7E-04	6.2E-02	9.8E-01
	Landfill--Med exposure	60.	9.9E-07	Inhalation	1.2E-05	Zero	4.0E-06
	Landfill--Low exposure	80.	1.0E-07	Inhalation	1.2E-06	Zero	1.3E-08
	Total		6.1E-02				

TABLE I.2. (contd)

Nuclide	Scenario	Number of Workers	Total Dose, man-rem	Dominant Exposure Pathway	Average Individual Worker Dose, mrem, Based on Concentration Limit, pCi/g in Waste		
					Inhalation	Ingestion	External
^{35}S	Worker Concentration Limit: 82,000. pCi/g						
	Incinerator--High exposure	30.	5.6E-03	Ingestion	4.5E-03	1.8E-01	4.8E-03
	Incinerator--Med exposure	50.	8.7E-06	Inhalation	1.1E-04	Zero	6.1E-05
	Incinerator--Low exposure	70.	7.9E-07	Inhalation	1.1E-05	Zero	5.0E-10
	Landfill--High exposure	40.	7.2E-03	Ingestion	3.4E-03	1.8E-01	4.7E-04
	Landfill--Med exposure	60.	6.8E-06	Inhalation	1.1E-04	Zero	8.9E-17
	Landfill--Low exposure	80.	9.1E-07	Inhalation	1.1E-05	Zero	2.6E-19
	Total		1.3E-02				
^{46}Sc	Worker Concentration Limit: 0.64 pCi/g						
	Incinerator--High exposure	30.	8.1E-03	External	3.1E-07	1.8E-05	2.7E-01
	Incinerator--Med exposure	50.	1.7E-04	External	7.7E-09	Zero	3.4E-03
	Incinerator--Low exposure	70.	1.0E-06	External	7.7E-10	Zero	1.4E-05
	Landfill--High exposure	40.	4.0E-02	External	2.3E-07	1.8E-05	1.0E+00
	Landfill--Med exposure	60.	1.3E-06	External	7.7E-09	Zero	2.2E-05
	Landfill--Low exposure	80.	6.0E-09	External	7.7E-10	Zero	7.4E-08
	Total		4.8E-02				
^{48}V	Worker Concentration Limit: 0.54 pCi/g						
	Incinerator--High exposure	30.	9.5E-03	External	1.0E-07	2.0E-05	3.2E-01
	Incinerator--Med exposure	50.	2.0E-04	External	2.6E-09	Zero	3.9E-03
	Incinerator--Low exposure	70.	9.4E-07	External	2.6E-10	Zero	1.3E-05
	Landfill--High exposure	40.	4.0E-02	External	7.8E-08	2.0E-05	1.0E+00
	Landfill--Med exposure	60.	3.3E-06	External	2.6E-09	Zero	5.5E-05
	Landfill--Low exposure	80.	1.6E-08	External	2.6E-10	Zero	2.0E-07
	Total		5.0E-02				
^{51}Cr	Worker Concentration Limit: 120. pCi/g						
	Incinerator--High exposure	30.	1.6E-02	External	7.5E-07	7.8E-05	5.4E-01
	Incinerator--Med exposure	50.	3.3E-04	External	1.9E-08	Zero	6.5E-03
	Incinerator--Low exposure	70.	5.7E-07	External	1.9E-09	Zero	8.2E-06
	Landfill--High exposure	40.	4.0E-02	External	5.6E-07	7.8E-05	1.0E+00
	Landfill--Med exposure	60.	1.1E-08	External	1.9E-08	Zero	1.6E-07
	Landfill--Low exposure	80.	1.9E-10	Inhalation	1.9E-09	Zero	5.1E-10
	Total		5.7E-02				
^{54}Mn	Worker Concentration Limit: 2.2 pCi/g						
	Incinerator--High exposure	30.	1.0E-02	External	3.4E-07	3.0E-05	3.3E-01
	Incinerator--Med exposure	50.	2.1E-04	External	8.4E-09	Zero	4.1E-03
	Incinerator--Low exposure	70.	8.6E-07	External	8.4E-10	Zero	1.2E-05
	Landfill--High exposure	40.	4.1E-02	External	2.5E-07	3.0E-05	1.0E+00
	Landfill--Med exposure	60.	2.6E-07	External	8.4E-09	Zero	4.4E-06
	Landfill--Low exposure	80.	1.2E-09	External	8.4E-10	Zero	1.4E-08
	Total		5.1E-02				

TABLE I.2. (contd)

Nuclide	Scenario	Number of Workers	Total Dose, man-rem	Dominant Exposure Pathway	Average Individual Worker Dose, mrem, Based on Concentration Limit, pCi/g in Waste		
					Inhalation	Ingestion	External
^{55}Fe	Worker Concentration Limit: 1400. pCi/g						
	Incinerator--High exposure	30.	1.2E-04	Ingestion	4.0E-05	4.1E-03	2.1E-26
	Incinerator--Med exposure	50.	5.0E-08	Inhalation	1.0E-06	Zero	5.7E-29
	Incinerator--Low exposure	70.	7.1E-09	Inhalation	1.0E-07	Zero	Zero
	Landfill--High exposure	40.	1.6E-04	Ingestion	3.0E-05	4.1E-03	Zero
	Landfill--Med exposure	60.	6.0E-08	Inhalation	1.0E-06	Zero	Zero
	Landfill--Low exposure	80.	8.1E-09	Inhalation	1.0E-07	Zero	Zero
	Total		2.9E-04				
^{56}Co	Worker Concentration Limit: 0.24 pCi/g						
	Incinerator--High exposure	30.	6.0E-03	External	1.5E-07	1.2E-05	2.0E-01
	Incinerator--Med exposure	50.	1.3E-04	External	3.7E-09	Zero	2.6E-03
	Incinerator--Low exposure	70.	1.2E-06	External	3.7E-10	Zero	1.8E-05
	Landfill--High exposure	40.	3.9E-02	External	1.1E-07	1.2E-05	9.8E-01
	Landfill--Med exposure	60.	1.5E-05	External	3.7E-09	Zero	2.4E-04
	Landfill--Low exposure	80.	7.5E-08	External	3.7E-10	Zero	9.4E-07
	Total		4.5E-02				
^{57}Co	Worker Concentration Limit: 66. pCi/g						
	Incinerator--High exposure	30.	1.6E-02	External	1.2E-05	2.2E-04	5.4E-01
	Incinerator--Med exposure	50.	3.2E-04	External	3.0E-07	Zero	6.3E-03
	Incinerator--Low exposure	70.	5.5E-08	External	3.0E-08	Zero	7.6E-07
	Landfill--High exposure	40.	8.3E-03	External	8.9E-06	2.2E-04	2.1E-01
	Landfill--Med exposure	60.	1.9E-08	Inhalation	3.0E-07	Zero	2.8E-08
	Landfill--Low exposure	80.	2.4E-09	Inhalation	3.0E-08	Zero	8.7E-11
	Total		2.5E-02				
^{58}Co	Worker Concentration Limit: 1.9 pCi/g						
	Incinerator--High exposure	30.	1.0E-02	External	3.2E-07	2.7E-05	3.3E-01
	Incinerator--Med exposure	50.	2.0E-04	External	8.1E-09	Zero	4.1E-03
	Incinerator--Low exposure	70.	8.4E-07	External	8.1E-10	Zero	1.2E-05
	Landfill--High exposure	40.	4.0E-02	External	2.4E-07	2.7E-05	9.9E-01
	Landfill--Med exposure	60.	3.6E-07	External	8.1E-09	Zero	6.0E-06
	Landfill--Low exposure	80.	1.7E-09	External	8.1E-10	Zero	2.0E-08
	Total		5.0E-02				

TABLE I.2. (contd)

Nuclide	Scenario	Number of Workers	Total Dose, man-rem	Dominant Exposure Pathway	Average Individual Worker Dose, mrem, Based on Concentration Limit, pCi/g in Waste		
					Inhalation	Ingestion	External
^{60}Co	Worker Concentration Limit: 0.45 pCi/g						
	Incinerator--High exposure	30.	7.3E-03	External	1.6E-06	2.2E-05	2.4E-01
	Incinerator--Med exposure	50.	1.5E-04	External	4.0E-08	Zero	3.0E-03
	Incinerator--Low exposure	70.	1.1E-06	External	4.0E-09	Zero	1.5E-05
	Landfill--High exposure	40.	4.0E-02	External	1.2E-06	2.2E-05	1.0E+00
	Landfill--Med exposure	60.	1.8E-06	External	4.0E-08	Zero	2.9E-05
	Landfill--Low exposure	80.	8.2E-09	External	4.1E-09	Zero	9.9E-08
	Total		4.7E-02				
^{63}Ni	Worker Concentration Limit: 170,000. pCi/g						
	Incinerator--High exposure	30.	1.4E-02	Ingestion	7.8E-03	4.6E-01	5.8E-06
	Incinerator--Med exposure	50.	9.7E-06	Inhalation	1.9E-04	Zero	9.3E-08
	Incinerator--Low exposure	70.	1.4E-06	Inhalation	1.9E-05	Zero	1.8E-16
	Landfill--High exposure	40.	1.9E-02	Ingestion	5.8E-03	4.6E-01	7.8E-09
	Landfill--Med exposure	60.	1.2E-05	Inhalation	1.9E-04	Zero	9.4E-32
	Landfill--Low exposure	80.	1.6E-06	Inhalation	1.9E-05	Zero	2.6E-34
	Total		3.3E-02				
^{65}Zn	Worker Concentration Limit: 1.8 pCi/g						
	Incinerator--High exposure	30.	7.5E-03	External	7.8E-07	1.3E-04	2.5E-01
	Incinerator--Med exposure	50.	1.6E-04	External	1.9E-08	Zero	3.1E-03
	Incinerator--Low exposure	70.	1.1E-06	External	1.9E-09	Zero	1.5E-05
	Landfill--High exposure	40.	4.1E-02	External	5.8E-07	1.3E-04	1.0E+00
	Landfill--Med exposure	60.	1.8E-06	External	1.9E-08	Zero	3.0E-05
	Landfill--Low exposure	80.	8.2E-09	External	1.9E-09	Zero	1.0E-07
	Total		4.8E-02				
^{68}Ge	Worker Concentration Limit: 290. pCi/g						
	Incinerator--High exposure	30.	5.8E-05	Ingestion	3.4E-04	1.6E-03	1.9E-26
	Incinerator--Med exposure	50.	4.3E-07	Inhalation	8.5E-06	Zero	5.2E-29
	Incinerator--Low exposure	70.	6.0E-08	Inhalation	8.5E-07	Zero	Zero
	Landfill--High exposure	40.	7.4E-05	Ingestion	2.6E-04	1.6E-03	Zero
	Landfill--Med exposure	60.	5.1E-07	Inhalation	8.5E-06	Zero	Zero
	Landfill--Low exposure	80.	6.8E-08	Inhalation	8.5E-07	Zero	Zero
	Total		1.3E-04				
^{74}As	Worker Concentration Limit: 4.2 pCi/g						
	Incinerator--High exposure	30.	1.2E-02	External	6.6E-07	6.9E-05	4.0E-01
	Incinerator--Med exposure	50.	2.4E-04	External	1.6E-08	Zero	4.9E-03
	Incinerator--Low exposure	70.	7.4E-07	External	1.6E-09	Zero	1.1E-05
	Landfill--High exposure	40.	4.0E-02	External	4.9E-07	6.9E-05	1.0E+00
	Landfill--Med exposure	60.	2.0E-07	External	1.6E-08	Zero	3.3E-06
	Landfill--Low exposure	80.	1.0E-09	External	1.6E-09	Zero	1.1E-08
	Total		5.2E-02				

TABLE I.2. (contd)

Nuclide	Scenario	Number of Workers	Total Dose, man-rem	Dominant Exposure Pathway	Average Individual Worker Dose, mrem, Based on Concentration Limit, pCi/g in Waste: Inhalation	Ingestion	External
^{75}Se	Worker Concentration Limit: 16. pCi/g						
	Incinerator--High exposure	30.	1.7E-02	External	3.1E-06	7.0E-04	5.7E-01
	Incinerator--Med exposure	50.	3.3E-04	External	7.9E-08	Zero	6.7E-03
	Incinerator--Low exposure	70.	3.3E-07	External	7.9E-09	Zero	4.7E-06
	Landfill--High exposure	40.	2.7E-02	External	2.4E-06	7.0E-04	6.7E-01
	Landfill--Med exposure	60.	1.6E-08	External	7.9E-08	Zero	1.9E-07
	Landfill--Low exposure	80.	6.8E-10	Inhalation	7.9E-09	Zero	6.0E-10
	Total		4.4E-02				
^{79}Se	Worker Concentration Limit:5800. pCi/g						
	Incinerator--High exposure	30.	7.3E-03	Ingestion	1.2E-03	2.4E-01	1.6E-04
	Incinerator--Med exposure	50.	1.7E-06	Inhalation	3.1E-05	Zero	2.1E-06
	Incinerator--Low exposure	70.	2.2E-07	Inhalation	3.1E-06	Zero	1.3E-11
	Landfill--High exposure	40.	9.7E-03	Ingestion	9.3E-04	2.4E-01	1.3E-05
	Landfill--Med exposure	60.	1.9E-06	Inhalation	3.1E-05	Zero	4.5E-19
	Landfill--Low exposure	80.	2.5E-07	Inhalation	3.1E-06	Zero	1.3E-21
	Total		1.7E-02				
^{88}Y	Worker Concentration Limit: 0.40 pCi/g						
	Incinerator--High exposure	30.	6.8E-03	External	2.0E-07	1.0E-05	2.3E-01
	Incinerator--Med exposure	50.	1.4E-04	External	5.0E-09	Zero	2.8E-03
	Incinerator--Low exposure	70.	1.1E-06	External	5.0E-10	Zero	1.6E-05
	Landfill--High exposure	40.	4.0E-02	External	1.5E-07	1.0E-05	9.9E-01
	Landfill--Med exposure	60.	5.4E-06	External	5.0E-09	Zero	9.1E-05
	Landfill--Low exposure	80.	2.6E-08	External	5.0E-10	Zero	3.3E-07
	Total		4.7E-02				
^{90}Sr	Worker Concentration Limit: 780. pCi/g						
	Incinerator--High exposure	30.	1.6E-02	Ingestion	4.3E-03	5.1E-01	6.7E-03
	Incinerator--Med exposure	50.	9.4E-06	Inhalation	1.1E-04	Zero	8.0E-05
	Incinerator--Low exposure	70.	7.5E-07	Inhalation	1.1E-05	Zero	1.9E-08
	Landfill--High exposure	40.	2.1E-02	Ingestion	3.2E-03	5.1E-01	3.8E-03
	Landfill--Med exposure	60.	6.5E-06	Inhalation	1.1E-04	Zero	1.7E-10
	Landfill--Low exposure	80.	8.6E-07	Inhalation	1.1E-05	Zero	5.2E-13
	Total		3.6E-02				
^{90}Sr+D	Worker Concentration Limit: 360. pCi/g						
	Incinerator--High exposure	30.	1.6E-02	External	2.1E-03	2.5E-01	2.9E-01
	Incinerator--Med exposure	50.	1.8E-04	External	5.1E-05	Zero	3.5E-03
	Incinerator--Low exposure	70.	8.1E-07	External	5.1E-06	Zero	6.4E-06
	Landfill--High exposure	40.	3.4E-02	External	1.5E-03	2.5E-01	5.8E-01
	Landfill--Med exposure	60.	3.5E-06	Inhalation	5.1E-05	Zero	7.1E-06
	Landfill--Low exposure	80.	4.1E-07	Inhalation	5.1E-06	Zero	2.4E-08
	Total		5.0E-02				

TABLE I.2. (contd)

Nuclide	Scenario	Number of Workers	Total Dose, man-rem	Dominant Exposure Pathway	Average Individual Worker Dose, mrem, Based on Concentration Limit, pCi/g in Waste		
					Inhalation	Ingestion	External
^{93}Zr	Worker Concentration Limit: 54,000. pCi/g						
	Incinerator--High exposure	30.	1.6E-02	Ingestion	9.6E-02	4.3E-01	7.1E-07
	Incinerator--Med exposure	50.	1.2E-04	Inhalation	2.4E-03	Zero	1.2E-08
	Incinerator--Low exposure	70.	1.7E-05	Inhalation	2.4E-04	Zero	1.0E-17
	Landfill--High exposure	40.	2.0E-02	Ingestion	7.2E-02	4.3E-01	4.9E-10
	Landfill--Med exposure	60.	1.4E-04	Inhalation	2.4E-03	Zero	1.1E-36
	Landfill--Low exposure	80.	1.9E-05	Inhalation	2.4E-04	Zero	Zero
	Total		3.6E-02				
^{94}Nb	Worker Concentration Limit: 1.4 pCi/g						
	Incinerator--High exposure	30.	1.1E-02	External	1.1E-05	3.6E-05	3.6E-01
	Incinerator--Med exposure	50.	2.2E-04	External	2.8E-07	Zero	4.4E-03
	Incinerator--Low exposure	70.	8.0E-07	External	2.8E-08	Zero	1.1E-05
	Landfill--High exposure	40.	4.0E-02	External	8.3E-06	3.6E-05	1.0E+00
	Landfill--Med exposure	60.	2.0E-07	External	2.8E-07	Zero	3.1E-06
	Landfill--Low exposure	80.	3.0E-09	Inhalation	2.8E-08	Zero	1.0E-08
	Total		5.1E-02				
^{99}Tc	Worker Concentration Limit: 34,000. pCi/g						
	Incinerator--High exposure	30.	7.6E-03	Ingestion	6.1E-03	2.2E-01	2.7E-02
	Incinerator--Med exposure	50.	2.4E-05	External	1.5E-04	Zero	3.2E-04
	Incinerator--Low exposure	70.	1.1E-06	Inhalation	1.5E-05	Zero	1.5E-08
	Landfill--High exposure	40.	9.3E-03	Ingestion	4.6E-03	2.2E-01	6.3E-03
	Landfill--Med exposure	60.	9.2E-06	Inhalation	1.5E-04	Zero	7.8E-13
	Landfill--Low exposure	80.	1.2E-06	Inhalation	1.5E-05	Zero	2.4E-15
	Total		1.7E-02				
^{106}Ru	Worker Concentration Limit: 10. pCi/g						
	Incinerator--High exposure	30.	1.1E-02	External	1.1E-04	1.0E-03	3.6E-01
	Incinerator--Med exposure	50.	2.2E-04	External	2.6E-06	Zero	4.4E-03
	Incinerator--Low exposure	70.	8.3E-07	External	2.6E-07	Zero	1.2E-05
	Landfill--High exposure	40.	4.0E-02	External	7.9E-05	1.0E-03	9.9E-01
	Landfill--Med exposure	60.	1.2E-06	External	2.6E-06	Zero	1.7E-05
	Landfill--Low exposure	80.	2.6E-08	Inhalation	2.6E-07	Zero	5.8E-08
	Total		5.1E-02				
^{110M}Ag	Worker Concentration Limit: 0.55 pCi/g						
	Incinerator--High exposure	30.	8.7E-03	External	7.0E-07	3.0E-05	2.9E-01
	Incinerator--Med exposure	50.	1.8E-04	External	1.7E-08	Zero	3.6E-03
	Incinerator--Low exposure	70.	9.7E-07	External	1.7E-09	Zero	1.4E-05
	Landfill--High exposure	40.	4.0E-02	External	5.2E-07	3.0E-05	1.0E+00
	Landfill--Med exposure	60.	1.8E-06	External	1.7E-08	Zero	3.0E-05
	Landfill--Low exposure	80.	8.5E-09	External	1.7E-09	Zero	1.0E-07
	Total		4.9E-02				

TABLE I.2. (contd)

Nuclide	Scenario	Number of Workers	Total Dose, man-rem	Dominant Exposure Pathway	Average Individual Worker Dose, mrem, Based on Concentration Limit, pCi/g in Waste		
					Inhalation	Ingestion	External
^{113}Sn	Worker Concentration Limit: 310. pCi/g						
	Incinerator--High exposure	30.	4.4E-03	External	6.6E-05	4.2E-03	1.4E-01
	Incinerator--Med exposure	50.	8.4E-05	External	1.7E-06	Zero	1.7E-03
	Incinerator--Low exposure	70.	6.4E-08	External	1.7E-07	Zero	7.5E-07
	Landfill--High exposure	40.	5.8E-03	External	5.0E-05	4.2E-03	1.4E-01
	Landfill--Med exposure	60.	9.9E-08	Inhalation	1.7E-06	Zero	1.2E-09
	Landfill--Low exposure	80.	1.3E-08	Inhalation	1.7E-07	Zero	3.6E-12
	Total		1.0E-02				
^{113}Sn+D	Worker Concentration Limit: 18. pCi/g						
	Incinerator--High exposure	30.	1.6E-02	External	3.9E-06	2.5E-04	5.5E-01
	Incinerator--Med exposure	50.	3.3E-04	External	9.6E-08	Zero	6.6E-03
	Incinerator--Low exposure	70.	5.7E-07	External	9.6E-09	Zero	8.2E-06
	Landfill--High exposure	40.	4.0E-02	External	2.9E-06	2.5E-04	1.0E+00
	Landfill--Med exposure	60.	1.6E-08	External	9.6E-08	Zero	1.6E-07
	Landfill--Low exposure	80.	8.1E-10	Inhalation	9.6E-09	Zero	5.0E-10
	Total		5.7E-02				
^{124}Sb	Worker Concentration Limit: 0.57 pCi/g						
	Incinerator--High exposure	30.	7.0E-03	External	2.9E-07	2.7E-05	2.3E-01
	Incinerator--Med exposure	50.	1.5E-04	External	7.2E-09	Zero	2.9E-03
	Incinerator--Low exposure	70.	1.1E-06	External	7.2E-10	Zero	1.6E-05
	Landfill--High exposure	40.	4.0E-02	External	2.2E-07	2.7E-05	9.9E-01
	Landfill--Med exposure	60.	6.0E-06	External	7.2E-09	Zero	1.0E-04
	Landfill--Low exposure	80.	2.9E-08	External	7.2E-10	Zero	3.6E-07
	Total		4.7E-02				
^{125}Sb	Worker Concentration Limit: 6.3 pCi/g						
	Incinerator--High exposure	30.	1.3E-02	External	1.5E-06	8.2E-05	4.3E-01
	Incinerator--Med exposure	50.	2.6E-04	External	3.7E-08	Zero	5.2E-03
	Incinerator--Low exposure	70.	6.8E-07	External	3.7E-09	Zero	9.8E-06
	Landfill--High exposure	40.	4.0E-02	External	1.1E-06	8.2E-05	9.9E-01
	Landfill--Med exposure	60.	5.1E-08	External	3.7E-08	Zero	8.1E-07
	Landfill--Low exposure	80.	5.0E-10	Inhalation	3.7E-09	Zero	2.6E-09
	Total		5.3E-02				
^{125M}Te	Worker Concentration Limit: 220. pCi/g						
	Incinerator--High exposure	30.	2.7E-04	External	3.5E-05	3.7E-03	5.3E-03
	Incinerator--Med exposure	50.	3.1E-06	External	8.8E-07	Zero	6.2E-05
	Incinerator--Low exposure	70.	6.5E-09	Inhalation	8.8E-08	Zero	4.5E-09
	Landfill--High exposure	40.	2.2E-04	Ingestion	2.7E-05	3.7E-03	1.7E-03
	Landfill--Med exposure	60.	5.3E-08	Inhalation	8.8E-07	Zero	6.0E-15
	Landfill--Low exposure	80.	7.1E-09	Inhalation	8.8E-08	Zero	1.7E-17
	Total		4.9E-04				

TABLE I.2. (contd)

Nuclide	Scenario	Number of Workers	Total Dose, man-rem	Dominant Exposure Pathway	Average Individual Worker Dose, mrem, Based on Concentration Limit, pCi/g in Waste		
					Inhalation	Ingestion	External
^{125}I	Worker Concentration Limit: 120. pCi/g						
	Incinerator--High exposure	30.	6.9E-04	Ingestion	6.9E-05	2.3E-02	1.9E-05
	Incinerator--Med exposure	50.	1.1E-07	Inhalation	1.7E-06	Zero	4.5E-07
	Incinerator--Low exposure	70.	1.2E-08	Inhalation	1.7E-07	Zero	1.8E-23
	Landfill--High exposure	40.	9.1E-04	Ingestion	5.2E-05	2.3E-02	8.9E-11
	Landfill--Med exposure	60.	1.0E-07	Inhalation	1.7E-06	Zero	Zero
	Landfill--Low exposure	80.	1.4E-08	Inhalation	1.7E-07	Zero	Zero
	Total		1.6E-03				
^{126}I	Worker Concentration Limit: 5.5 pCi/g						
	Incinerator--High exposure	30.	1.2E-02	External	5.7E-06	2.0E-03	4.0E-01
	Incinerator--Med exposure	50.	2.4E-04	External	1.4E-07	Zero	4.8E-03
	Incinerator--Low exposure	70.	7.5E-07	External	1.4E-08	Zero	1.1E-05
	Landfill--High exposure	40.	4.0E-02	External	4.3E-06	2.0E-03	1.0E+00
	Landfill--Med exposure	60.	1.8E-07	External	1.4E-07	Zero	2.9E-06
	Landfill--Low exposure	80.	1.9E-09	Inhalation	1.4E-08	Zero	9.4E-09
	Total		5.3E-02				
^{129}I	Worker Concentration Limit: 110. pCi/g						
	Incinerator--High exposure	30.	4.6E-03	Ingestion	4.8E-04	1.5E-01	1.5E-05
	Incinerator--Med exposure	50.	6.1E-07	Inhalation	1.2E-05	Zero	3.1E-07
	Incinerator--Low exposure	70.	8.3E-08	Inhalation	1.2E-06	Zero	2.7E-13
	Landfill--High exposure	40.	6.2E-03	Ingestion	3.6E-04	1.5E-01	2.8E-07
	Landfill--Med exposure	60.	7.1E-07	Inhalation	1.2E-05	Zero	9.7E-21
	Landfill--Low exposure	80.	9.5E-08	Inhalation	1.2E-06	Zero	2.7E-23
	Total		1.1E-02				
^{131}I	Worker Concentration Limit: 10. pCi/g						
	Incinerator--High exposure	30.	1.5E-02	External	7.7E-06	2.6E-03	4.9E-01
	Incinerator--Med exposure	50.	3.0E-04	External	1.9E-07	Zero	5.9E-03
	Incinerator--Low exposure	70.	5.7E-07	External	1.9E-08	Zero	8.2E-06
	Landfill--High exposure	40.	3.8E-02	External	5.8E-06	2.6E-03	9.5E-01
	Landfill--Med exposure	60.	3.2E-08	External	1.9E-07	Zero	3.4E-07
	Landfill--Low exposure	80.	1.6E-09	Inhalation	1.9E-08	Zero	1.1E-09
	Total		5.3E-02				
^{134}Cs	Worker Concentration Limit: 1.2 pCi/g						
	Incinerator--High exposure	30.	1.0E-02	External	1.4E-06	4.4E-04	3.5E-01
	Incinerator--Med exposure	50.	2.1E-04	External	3.4E-08	Zero	4.3E-03
	Incinerator--Low exposure	70.	8.1E-07	External	3.4E-09	Zero	1.2E-05
	Landfill--High exposure	40.	4.0E-02	External	1.0E-06	4.4E-04	9.9E-01
	Landfill--Med exposure	60.	4.5E-07	External	3.4E-08	Zero	7.5E-06
	Landfill--Low exposure	80.	2.3E-09	External	3.4E-09	Zero	2.5E-08
	Total		5.0E-02				

TABLE I.2. (contd)

Nuclide	Scenario	Number of Workers	Total Dose, man-rem	Dominant Exposure Pathway	Average Individual Worker Dose, mrem, Based on Concentration Limit, pCi/g in Waste		
					Inhalation	Ingestion	External
^{137}Cs	Worker Concentration Limit: 4.6 pCi/g						
	Incinerator--High exposure	30.	1.2E-02	External	3.5E-06	1.2E-03	4.1E-01
	Incinerator--Med exposure	50.	2.5E-04	External	8.8E-08	Zero	5.0E-03
	Incinerator--Low exposure	70.	7.0E-07	External	8.8E-09	Zero	1.0E-05
	Landfill--High exposure	40.	4.0E-02	External	2.6E-06	1.1E-03	9.9E-01
	Landfill--Med exposure	60.	6.2E-08	External	8.8E-08	Zero	9.5E-07
	Landfill--Low exposure	80.	9.5E-10	Inhalation	8.8E-09	Zero	3.0E-09
	Total		5.2E-02				
^{144}Ce	Worker Concentration Limit: 430. pCi/g						
	Incinerator--High exposure	30.	1.4E-02	External	3.6E-03	4.3E-02	4.1E-01
	Incinerator--Med exposure	50.	2.4E-04	External	9.0E-05	Zero	4.7E-03
	Incinerator--Low exposure	70.	6.6E-07	Inhalation	9.0E-06	Zero	3.4E-07
	Landfill--High exposure	40.	7.1E-03	External	2.7E-03	4.3E-02	1.3E-01
	Landfill--Med exposure	60.	5.4E-06	Inhalation	9.0E-05	Zero	4.8E-13
	Landfill--Low exposure	80.	7.2E-07	Inhalation	9.0E-06	Zero	1.4E-15
	Total		2.1E-02				
^{144}Ce+D	Worker Concentration Limit: 25. pCi/g						
	Incinerator--High exposure	30.	7.4E-03	External	2.1E-04	2.5E-03	2.4E-01
	Incinerator--Med exposure	50.	1.5E-04	External	5.3E-06	Zero	3.0E-03
	Incinerator--Low exposure	70.	1.3E-06	External	5.3E-07	Zero	1.8E-05
	Landfill--High exposure	40.	4.0E-02	External	1.6E-04	2.5E-03	1.0E+00
	Landfill--Med exposure	60.	1.3E-05	External	5.3E-06	Zero	2.2E-04
	Landfill--Low exposure	80.	1.1E-07	External	5.3E-07	Zero	8.0E-07
	Total		4.8E-02				
^{147}Pm	Worker Concentration Limit: 61,000. pCi/g						
	Incinerator--High exposure	30.	1.1E-02	Ingestion	5.0E-02	2.9E-01	2.7E-02
	Incinerator--Med exposure	50.	7.9E-05	Inhalation	1.2E-03	Zero	3.3E-04
	Incinerator--Low exposure	70.	8.7E-06	Inhalation	1.2E-04	Zero	1.7E-08
	Landfill--High exposure	40.	1.3E-02	Ingestion	3.7E-02	2.9E-01	7.1E-03
	Landfill--Med exposure	60.	7.5E-05	Inhalation	1.2E-03	Zero	2.1E-14
	Landfill--Low exposure	80.	1.0E-05	Inhalation	1.2E-04	Zero	6.1E-17
	Total		2.5E-02				
^{151}Sm	Worker Concentration Limit: 130,000. pCi/g						
	Incinerator--High exposure	30.	9.3E-03	Ingestion	9.0E-02	2.2E-01	2.1E-05
	Incinerator--Med exposure	50.	1.1E-04	Inhalation	2.3E-03	Zero	3.2E-07
	Incinerator--Low exposure	70.	1.6E-05	Inhalation	2.3E-04	Zero	8.4E-15
	Landfill--High exposure	40.	1.2E-02	Ingestion	6.8E-02	2.2E-01	9.5E-08
	Landfill--Med exposure	60.	1.4E-04	Inhalation	2.3E-03	Zero	1.8E-27
	Landfill--Low exposure	80.	1.8E-05	Inhalation	2.3E-04	Zero	4.9E-30
	Total		2.1E-02				

TABLE I.2. (contd)

Nuclide	Scenario	Number of Workers	Total Dose, man-rem	Dominant Exposure Pathway	Average Individual Worker Dose, mrem, Based on Concentration Limit, pCi/g in Waste		
					Inhalation	Ingestion	External
^{152}Eu	Worker Concentration Limit: 1.1 pCi/g						
	Incinerator--High exposure	30.	7.6E-03	External	5.8E-06	3.3E-05	2.5E-01
	Incinerator--Med exposure	50.	1.6E-04	External	1.5E-07	Zero	3.2E-03
	Incinerator--Low exposure	70.	1.0E-06	External	1.5E-08	Zero	1.5E-05
	Landfill--High exposure	40.	4.0E-02	External	4.4E-06	3.3E-05	9.9E-01
	Landfill--Med exposure	60.	2.3E-06	External	1.5E-07	Zero	3.8E-05
	Landfill--Low exposure	80.	1.1E-08	External	1.5E-08	Zero	1.3E-07
	Total		4.7E-02				
^{154}Eu	Worker Concentration Limit: 1.1 pCi/g						
	Incinerator--High exposure	30.	7.8E-03	External	6.9E-06	5.0E-05	2.6E-01
	Incinerator--Med exposure	50.	1.6E-04	External	1.7E-07	Zero	3.2E-03
	Incinerator--Low exposure	70.	9.6E-07	External	1.7E-08	Zero	1.4E-05
	Landfill--High exposure	40.	3.8E-02	External	5.1E-06	5.0E-05	9.6E-01
	Landfill--Med exposure	60.	1.4E-06	External	1.7E-07	Zero	2.3E-05
	Landfill--Low exposure	80.	7.7E-09	External	1.7E-08	Zero	7.9E-08
	Total		4.6E-02				
^{155}Eu	Worker Concentration Limit: 160. pCi/g						
	Incinerator--High exposure	30.	1.2E-02	External	1.5E-04	1.0E-03	3.8E-01
	Incinerator--Med exposure	50.	2.3E-04	External	3.7E-06	Zero	4.5E-03
	Incinerator--Low exposure	70.	4.4E-08	Inhalation	3.7E-07	Zero	2.6E-07
	Landfill--High exposure	40.	4.4E-03	External	1.1E-04	1.0E-03	1.1E-01
	Landfill--Med exposure	60.	2.2E-07	Inhalation	3.7E-06	Zero	3.2E-13
	Landfill--Low exposure	80.	3.0E-08	Inhalation	3.7E-07	Zero	9.3E-16
	Total		1.6E-02				
^{203}Hg	Worker Concentration Limit: 27. pCi/g						
	Incinerator--High exposure	30.	1.5E-02	External	4.0E-06	2.8E-04	5.0E-01
	Incinerator--Med exposure	50.	2.9E-04	External	1.0E-07	Zero	5.9E-03
	Incinerator--Low exposure	70.	1.8E-07	External	1.0E-08	Zero	2.6E-06
	Landfill--High exposure	40.	2.0E-02	External	3.0E-06	2.8E-04	4.9E-01
	Landfill--Med exposure	60.	6.1E-09	Inhalation	1.0E-07	Zero	1.5E-09
	Landfill--Low exposure	80.	8.0E-10	Inhalation	1.0E-08	Zero	4.6E-12
	Total		3.5E-02				
^{207}Bi	Worker Concentration Limit: 0.93 pCi/g						
	Incinerator--High exposure	30.	8.1E-03	External	3.1E-07	2.3E-05	2.7E-01
	Incinerator--Med exposure	50.	1.7E-04	External	7.8E-09	Zero	3.4E-03
	Incinerator--Low exposure	70.	1.0E-06	External	7.8E-10	Zero	1.4E-05
	Landfill--High exposure	40.	4.0E-02	External	2.3E-07	2.3E-05	1.0E+00
	Landfill--Med exposure	60.	1.5E-06	External	7.8E-09	Zero	2.4E-05
	Landfill--Low exposure	80.	6.6E-09	External	7.8E-10	Zero	8.2E-08
	Total		4.8E-02				

TABLE I.2. (contd)

Nuclide	Scenario	Number of Workers	Total Dose, man-rem	Dominant Exposure Pathway	Average Individual Worker Dose, mrem, Based on Concentration Limit, pCi/g in Waste		
					Inhalation	Ingestion	External
^{226}Ra	Worker Concentration Limit: 93. pCi/g						
	Incinerator--High exposure	30.	1.7E-02	Ingestion	1.8E-02	5.1E-01	2.7E-02
	Incinerator--Med exposure	50.	3.8E-05	Inhalation	4.4E-04	Zero	3.2E-04
	Incinerator--Low exposure	70.	3.1E-06	Inhalation	4.4E-05	Zero	2.7E-08
	Landfill--High exposure	40.	2.1E-02	Ingestion	1.3E-02	5.1E-01	9.3E-03
	Landfill--Med exposure	60.	2.6E-05	Inhalation	4.4E-04	Zero	8.6E-11
	Landfill--Low exposure	80.	3.5E-06	Inhalation	4.4E-05	Zero	2.7E-13
	Total		3.8E-02				
^{226}Ra+D	Worker Concentration Limit: 0.61 pCi/g						
	Incinerator--High exposure	30.	7.7E-03	External	4.3E-04	2.4E-02	2.3E-01
	Incinerator--Med exposure	50.	1.5E-04	External	1.1E-05	Zero	2.9E-03
	Incinerator--Low exposure	70.	1.2E-06	External	1.1E-06	Zero	1.6E-05
	Landfill--High exposure	40.	4.1E-02	External	3.2E-04	2.4E-02	9.9E-01
	Landfill--Med exposure	60.	8.2E-06	External	1.1E-05	Zero	1.3E-04
	Landfill--Low exposure	80.	1.2E-07	Inhalation	1.1E-06	Zero	4.6E-07
	Total		4.8E-02				
^{228}Th	Worker Concentration Limit: 25. pCi/g						
	Incinerator--High exposure	30.	7.1E-03	Inhalation	1.9E-01	4.7E-02	2.5E-03
	Incinerator--Med exposure	50.	2.3E-04	Inhalation	4.7E-03	Zero	3.0E-05
	Incinerator--Low exposure	70.	3.3E-05	Inhalation	4.6E-04	Zero	7.9E-09
	Landfill--High exposure	40.	7.5E-03	Inhalation	1.4E-01	4.7E-02	1.7E-03
	Landfill--Med exposure	60.	2.8E-04	Inhalation	4.7E-03	Zero	4.4E-12
	Landfill--Low exposure	80.	3.7E-05	Inhalation	4.6E-04	Zero	1.3E-14
	Total		1.5E-02				
^{229}Th	Worker Concentration Limit: 4.4 pCi/g						
	Incinerator--High exposure	30.	8.2E-03	Inhalation	1.8E-01	7.7E-02	1.8E-02
	Incinerator--Med exposure	50.	2.3E-04	Inhalation	4.5E-03	Zero	2.1E-04
	Incinerator--Low exposure	70.	3.1E-05	Inhalation	4.5E-04	Zero	2.8E-08
	Landfill--High exposure	40.	8.8E-03	Inhalation	1.3E-01	7.7E-02	7.4E-03
	Landfill--Med exposure	60.	2.7E-04	Inhalation	4.5E-03	Zero	1.1E-11
	Landfill--Low exposure	80.	3.6E-05	Inhalation	4.5E-04	Zero	3.3E-14
	Total		1.8E-02				
^{229}Th+D	Worker Concentration Limit: 3.5 pCi/g						
	Incinerator--High exposure	30.	1.0E-02	Inhalation	1.4E-01	6.8E-02	1.4E-01
	Incinerator--Med exposure	50.	2.6E-04	Inhalation	3.6E-03	Zero	1.7E-03
	Incinerator--Low exposure	70.	2.6E-05	Inhalation	3.6E-04	Zero	4.2E-06
	Landfill--High exposure	40.	2.1E-02	External	1.1E-01	6.8E-02	3.4E-01
	Landfill--Med exposure	60.	2.2E-04	Inhalation	3.6E-03	Zero	9.0E-06
	Landfill--Low exposure	80.	2.9E-05	Inhalation	3.6E-04	Zero	3.1E-08
	Total		3.2E-02				

TABLE I.2. (contd)

Nuclide	Scenario	Number of Workers	Total Dose, man-rem	Dominant Exposure Pathway	Average Individual Worker Dose, mrem, Based on Concentration Limit, pCi/g in Waste		
					Inhalation	Ingestion	External
^{230}Th	Worker Concentration Limit: 30. pCi/g						
	Incinerator--High exposure	30.	8.0E-03	Inhalation	1.9E-01	7.9E-02	2.4E-04
	Incinerator--Med exposure	50.	2.3E-04	Inhalation	4.7E-03	Zero	2.9E-06
	Incinerator--Low exposure	70.	3.3E-05	Inhalation	4.7E-04	Zero	1.5E-10
	Landfill--High exposure	40.	8.8E-03	Inhalation	1.4E-01	7.9E-02	6.0E-05
	Landfill--Med exposure	60.	2.8E-04	Inhalation	4.7E-03	Zero	2.0E-16
	Landfill--Low exposure	80.	3.7E-05	Inhalation	4.7E-04	Zero	5.8E-19
	Total		1.7E-02				
^{232}Th	Worker Concentration Limit: 6.8 pCi/g						
	Incinerator--High exposure	30.	8.2E-03	Inhalation	1.8E-01	9.5E-02	2.7E-05
	Incinerator--Med exposure	50.	2.2E-04	Inhalation	4.5E-03	Zero	3.2E-07
	Incinerator--Low exposure	70.	3.1E-05	Inhalation	4.5E-04	Zero	2.1E-11
	Landfill--High exposure	40.	9.2E-03	Inhalation	1.3E-01	9.5E-02	8.0E-06
	Landfill--Med exposure	60.	2.7E-04	Inhalation	4.5E-03	Zero	2.8E-17
	Landfill--Low exposure	80.	3.6E-05	Inhalation	4.5E-04	Zero	8.1E-20
	Total		1.8E-02				
^{232}Th+D	Worker Concentration Limit: 0.34 pCi/g						
	Incinerator--High exposure	30.	6.5E-03	External	1.2E-02	8.1E-03	2.0E-01
	Incinerator--Med exposure	50.	1.4E-04	External	2.9E-04	Zero	2.5E-03
	Incinerator--Low exposure	70.	3.3E-06	Inhalation	2.9E-05	Zero	1.9E-05
	Landfill--High exposure	40.	4.0E-02	External	8.7E-03	8.1E-03	9.8E-01
	Landfill--Med exposure	60.	4.0E-05	External	2.9E-04	Zero	3.7E-04
	Landfill--Low exposure	80.	2.4E-06	Inhalation	2.9E-05	Zero	1.4E-06
	Total		4.7E-02				
^{232}U	Worker Concentration Limit: 12. pCi/g						
	Incinerator--High exposure	30.	5.9E-03	Inhalation	1.9E-01	4.1E-03	8.0E-05
	Incinerator--Med exposure	50.	2.4E-04	Inhalation	4.8E-03	Zero	9.4E-07
	Incinerator--Low exposure	70.	3.4E-05	Inhalation	4.8E-04	Zero	6.4E-11
	Landfill--High exposure	40.	6.0E-03	Inhalation	1.4E-01	4.1E-03	2.5E-05
	Landfill--Med exposure	60.	2.9E-04	Inhalation	4.8E-03	Zero	8.5E-17
	Landfill--Low exposure	80.	3.9E-05	Inhalation	4.8E-04	Zero	2.5E-19
	Total		1.2E-02				
^{233}U	Worker Concentration Limit: 63. pCi/g						
	Incinerator--High exposure	30.	6.2E-03	Inhalation	2.0E-01	7.9E-03	9.6E-04
	Incinerator--Med exposure	50.	2.5E-04	Inhalation	4.9E-03	Zero	1.1E-05
	Incinerator--Low exposure	70.	3.4E-05	Inhalation	4.9E-04	Zero	8.3E-10
	Landfill--High exposure	40.	6.2E-03	Inhalation	1.5E-01	7.9E-03	3.2E-04
	Landfill--Med exposure	60.	2.9E-04	Inhalation	4.9E-03	Zero	1.1E-15
	Landfill--Low exposure	80.	3.9E-05	Inhalation	4.9E-04	Zero	3.2E-18
	Total		1.3E-02				

TABLE I.2. (contd)

Nuclide	Scenario	Number of Workers	Total Dose, man-rem	Dominant Exposure Pathway	Average Individual Worker Dose, mrem, Based on Concentration Limit, pCi/g in Waste		
					Inhalation	Ingestion	External
^{234}U	Worker Concentration Limit: 64. pCi/g						
	Incinerator--High exposure	30.	6.2E-03	Inhalation	2.0E-01	8.0E-03	2.3E-04
	Incinerator--Med exposure	50.	2.5E-04	Inhalation	5.0E-03	Zero	2.8E-06
	Incinerator--Low exposure	70.	3.5E-05	Inhalation	5.0E-04	Zero	1.9E-10
	Landfill--High exposure	40.	6.3E-03	Inhalation	1.5E-01	8.0E-03	7.2E-05
	Landfill--Med exposure	60.	3.0E-04	Inhalation	5.0E-03	Zero	2.5E-16
	Landfill--Low exposure	80.	4.0E-05	Inhalation	5.0E-04	Zero	7.2E-19
	Total		1.3E-02				
^{235}U	Worker Concentration Limit: 35. pCi/g						
	Incinerator--High exposure	30.	1.1E-02	External	1.0E-01	4.4E-03	2.8E-01
	Incinerator--Med exposure	50.	2.9E-04	External	2.5E-03	Zero	3.2E-03
	Incinerator--Low exposure	70.	1.8E-05	Inhalation	2.5E-04	Zero	4.4E-07
	Landfill--High exposure	40.	8.1E-03	External	7.6E-02	4.4E-03	1.2E-01
	Landfill--Med exposure	60.	1.5E-04	Inhalation	2.5E-03	Zero	1.5E-10
	Landfill--Low exposure	80.	2.0E-05	Inhalation	2.5E-04	Zero	4.5E-13
	Total		2.0E-02				
$^{235}U+D$	Worker Concentration Limit: 34. pCi/g						
	Incinerator--High exposure	30.	1.1E-02	External	9.8E-02	4.5E-03	2.8E-01
	Incinerator--Med exposure	50.	2.8E-04	External	2.4E-03	Zero	3.2E-03
	Incinerator--Low exposure	70.	1.7E-05	Inhalation	2.4E-04	Zero	4.4E-07
	Landfill--High exposure	40.	8.0E-03	External	7.3E-02	4.5E-03	1.2E-01
	Landfill--Med exposure	60.	1.5E-04	Inhalation	2.4E-03	Zero	1.4E-10
	Landfill--Low exposure	80.	2.0E-05	Inhalation	2.4E-04	Zero	4.3E-13
	Total		2.0E-02				
^{237}Np	Worker Concentration Limit: 13. pCi/g						
	Incinerator--High exposure	30.	1.2E-02	Ingestion	1.5E-01	2.5E-01	9.6E-03
	Incinerator--Med exposure	50.	2.0E-04	Inhalation	3.8E-03	Zero	1.1E-04
	Incinerator--Low exposure	70.	2.7E-05	Inhalation	3.8E-04	Zero	6.9E-09
	Landfill--High exposure	40.	1.5E-02	Ingestion	1.1E-01	2.5E-01	2.7E-03
	Landfill--Med exposure	60.	2.3E-04	Inhalation	3.8E-03	Zero	1.5E-12
	Landfill--Low exposure	80.	3.1E-05	Inhalation	3.8E-04	Zero	4.6E-15
	Total		2.8E-02				
$^{237}Np+D$	Worker Concentration Limit: 8.4 pCi/g						
	Incinerator--High exposure	30.	1.5E-02	External	9.9E-02	1.6E-01	2.3E-01
	Incinerator--Med exposure	50.	2.6E-04	External	2.5E-03	Zero	2.8E-03
	Incinerator--Low exposure	70.	1.8E-05	Inhalation	2.5E-04	Zero	3.2E-06
	Landfill--High exposure	40.	2.6E-02	External	7.4E-02	1.6E-01	4.0E-01
	Landfill--Med exposure	60.	1.5E-04	Inhalation	2.5E-03	Zero	7.4E-08
	Landfill--Low exposure	80.	2.0E-05	Inhalation	2.5E-04	Zero	2.3E-10
	Total		4.1E-02				

TABLE I.2. (contd)

Nuclide	Scenario	Number of Workers	Total Dose, man-rem	Dominant Exposure Pathway	Average Individual Worker Dose, mrem, Based on Concentration Limit, pCi/g in Waste		
					Inhalation	Ingestion	External
^{238}U	Worker Concentration Limit: 69. pCi/g						
	Incinerator--High exposure	30.	6.2E-03	Inhalation	2.0E-01	7.9E-03	4.2E-05
	Incinerator--Med exposure	50.	2.5E-04	Inhalation	5.0E-03	Zero	5.4E-07
	Incinerator--Low exposure	70.	3.5E-05	Inhalation	5.0E-04	Zero	1.7E-13
	Landfill--High exposure	40.	6.3E-03	Inhalation	1.5E-01	7.9E-03	1.1E-06
	Landfill--Med exposure	60.	3.0E-04	Inhalation	5.0E-03	Zero	3.4E-27
	Landfill--Low exposure	80.	4.0E-05	Inhalation	5.0E-04	Zero	9.4E-30
	Total		1.3E-02				
$^{238}U+D$	Worker Concentration Limit: 50. pCi/g						
	Incinerator--High exposure	30.	1.0E-02	External	1.4E-01	9.0E-03	1.9E-01
	Incinerator--Med exposure	50.	3.0E-04	Inhalation	3.6E-03	Zero	2.4E-03
	Incinerator--Low exposure	70.	2.6E-05	Inhalation	3.6E-04	Zero	8.4E-06
	Landfill--High exposure	40.	2.9E-02	External	1.1E-01	9.0E-03	6.2E-01
	Landfill--Med exposure	60.	2.2E-04	Inhalation	3.6E-03	Zero	1.2E-05
	Landfill--Low exposure	80.	2.9E-05	Inhalation	3.6E-04	Zero	4.2E-08
	Total		4.0E-02				
^{238}Pu	Worker Concentration Limit: 28. pCi/g						
	Incinerator--High exposure	30.	6.3E-03	Inhalation	2.0E-01	7.6E-03	3.3E-06
	Incinerator--Med exposure	50.	2.5E-04	Inhalation	5.0E-03	Zero	4.6E-08
	Incinerator--Low exposure	70.	3.5E-05	Inhalation	5.0E-04	Zero	3.7E-16
	Landfill--High exposure	40.	6.4E-03	Inhalation	1.5E-01	7.6E-03	1.6E-08
	Landfill--Med exposure	60.	3.0E-04	Inhalation	5.0E-03	Zero	3.8E-35
	Landfill--Low exposure	80.	4.0E-05	Inhalation	5.0E-04	Zero	1.0E-37
	Total		1.3E-02				
^{239}Pu	Worker Concentration Limit: 25. pCi/g						
	Incinerator--High exposure	30.	6.2E-03	Inhalation	2.0E-01	7.2E-03	1.0E-04
	Incinerator--Med exposure	50.	2.5E-04	Inhalation	4.9E-03	Zero	1.2E-06
	Incinerator--Low exposure	70.	3.5E-05	Inhalation	5.0E-04	Zero	8.7E-11
	Landfill--High exposure	40.	6.2E-03	Inhalation	1.5E-01	7.2E-03	3.3E-05
	Landfill--Med exposure	60.	3.0E-04	Inhalation	4.9E-03	Zero	1.2E-16
	Landfill--Low exposure	80.	4.0E-05	Inhalation	4.9E-04	Zero	3.4E-19
	Total		1.3E-02				
^{240}Pu	Worker Concentration Limit: 25. pCi/g						
	Incinerator--High exposure	30.	6.2E-03	Inhalation	2.0E-01	7.2E-03	3.3E-06
	Incinerator--Med exposure	50.	2.5E-04	Inhalation	4.9E-03	Zero	4.5E-08
	Incinerator--Low exposure	70.	3.5E-05	Inhalation	5.0E-04	Zero	3.7E-16
	Landfill--High exposure	40.	6.2E-03	Inhalation	1.5E-01	7.2E-03	1.6E-08
	Landfill--Med exposure	60.	3.0E-04	Inhalation	4.9E-03	Zero	3.7E-35
	Landfill--Low exposure	80.	4.0E-05	Inhalation	4.9E-04	Zero	1.0E-37
	Total		1.3E-02				

TABLE I.2. (contd)

Nuclide	Scenario	Number of Workers	Total Dose, man-rem	Dominant Exposure Pathway	Average Individual Worker Dose, mrem, Based on Concentration Limit, pCi/g in Waste		
					Inhalation	Ingestion	External
^{241}Pu	Worker Concentration Limit: 1500. pCi/g						
	Incinerator--High exposure	30.	6.4E-03	Inhalation	2.1E-01	6.9E-03	2.4E-32
	Incinerator--Med exposure	50.	2.6E-04	Inhalation	5.1E-03	Zero	6.6E-35
	Incinerator--Low exposure	70.	3.6E-05	Inhalation	5.1E-04	Zero	Zero
	Landfill--High exposure	40.	6.4E-03	Inhalation	1.5E-01	6.9E-03	Zero
	Landfill--Med exposure	60.	3.1E-04	Inhalation	5.1E-03	Zero	Zero
	Landfill--Low exposure	80.	4.1E-05	Inhalation	5.1E-04	Zero	Zero
	Total		1.3E-02				
^{241}Am	Worker Concentration Limit: 12. pCi/g						
	Incinerator--High exposure	30.	1.3E-02	Ingestion	1.5E-01	2.7E-01	1.1E-03
	Incinerator--Med exposure	50.	1.9E-04	Inhalation	3.7E-03	Zero	1.5E-05
	Incinerator--Low exposure	70.	2.6E-05	Inhalation	3.7E-04	Zero	1.8E-13
	Landfill--High exposure	40.	1.5E-02	Ingestion	1.1E-01	2.7E-01	5.5E-06
	Landfill--Med exposure	60.	2.2E-04	Inhalation	3.7E-03	Zero	1.1E-27
	Landfill--Low exposure	80.	3.0E-05	Inhalation	3.7E-04	Zero	3.1E-30
	Total		2.8E-02				

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