Project: K-Area Interim Surveillance	**Calculation Number:** S-CLC-K-00208	**Project Number:** SR05.KL19480W.064.XPKCOCFAR
Title: The Consequences of Releases from Postulated Accidents in the 105-K Slug Vault (U)	**Functional Classification:** N/A **Discipline:** Safety	**Sheet:** 1 of 40
Calc Level: [x] Type 1 [ ] Type 2	**Type 1 Calc Status:** [ ] Preliminary [X] Confirmed	
Computer Program No.: Microsoft Excel 2000 MACCS	**Version/Release No.:** 9.0.6926 SP-3 1.5.11.1	

Purpose and Objective:

The purpose of this Engineering Calculation (EC) is to calculate the radiological consequences for various releases in support of the accident analysis for the K-Area Interim Surveillance (KIS) project.

Summary of Conclusion:

The offsite and onsite consequences are summarized in Tables 1-5. These results are valid for the composition given as Item 7 in the Input section of this EC. This composition bounds that of the standards identified to be entering the slug vault (Attachment 1) and that of material residing in KAMS (assumed to have the bounding composition given as Item 9 in the Input section of this EC). The consequences calculated here are used as input to the Master Engineering Calculation (MEC) for the KIS project. The controls necessary to ensure the validity of the analysis contained in this EC are addressed in the MEC.

Revisions

Rev No.	Revision Description
A	Original Issue
0	Closed open item. Revised TRU waste analysis. Added appendices regarding composition.

Sign Off (signatures of previous revision on file)

Rev No.	*Originator (Print) Sign/Date*	*Verification/Checking Method*	*Verifier/Checker (Print) Sign/Date*	*Manager (Print) Sign/Date*
0	D. K. Allison Dai K Alli 5-16-06	Individual Review	S. Chow Stanley Chow 5/16/06	M. K. Gupta MK Gupta 5/17/06

Design Authority – (Print)	Signature	Date
Kevin J Durrwachter	Kevin J Durrwachter	5/16/06
Release to Outside Agency – (Print)	**Signature**	**Date**
NA	NA	NA

Security Classification of the Calculation:

UNCLASSIFIED
DOES NOT CONTAIN
UNCLASSIFIED CONTROLLED
NUCLEAR INFORMATION

ADC & Reviewing Official: Dai K. Allison (wsms)

Date: 5-16-06

RECORD OF REVISION					
Project: K-Area Interim Surveillance				**Calculation No:** S-CLC-K-00208	
Title: The Consequences of Releases from Postulated Accidents in the 105-K Slug Vault (U)					
Originator: D. K. Allison D K Alli	**Date:** 5-16-06	**Checker:** S. Chow Stanley Chow		**Date:** 5/16/06	**Rev. No:** 0

REV. NO.	PAGES REPLACED	PAGES ADDED	. PAGES DELETED	PAGES REVISED	DESCRIPTION OF REVISIONS
A	None	All	None	None	Original Issue
0	All	None	None	All	Closed open item. Revised TRU waste analysis. Added appendices regarding composition.

CALC-NOTE CHECKLIST

REVIEWER(S):

NAME (PRINT OR TYPE)	SIGNATURE	DATE
S. Chow	Stanley Chow	5/16/06

		CIRCLE ONE
1.	Is the Subject and/or Purpose clearly stated?	(Yes) No
2.	Are the required Input Data and their references and source provided and are they consistent with the Calc-note purpose?	(Yes) No
3.	Are the Assumptions clearly identified, valid, and consistent with the Calc-note purpose?	(Yes) No
4.	Is the Analytical Method or Approach Used clearly identified?	(Yes) No
5.	Are all pages consecutively numbered and identified by the Calc-note number?	(Yes) No
6.	Is/are the version(s) of the computer program(s) used identified and QA'd adequately?	(Yes) No N/A
7.	Are input listings for all computer programs documented in this Calc-note, and are they V&Vd and appropriate for the intended use?	(Yes) No N/A
8.	Are the Results and Conclusions clearly stated?	(Yes) No
9.	Are all OUTPUT documents included (or if not part of the calculation, clearly referenced in the Results section?) grammatically correct, clear and consistent with the main Calc-note text?	Yes No (N/A)
10.	Are the results, methods, input, and assumptions compatible with the stated purpose?	(Yes) No

IF NO TO ANY OF THE ABOVE, LIST SHEET NUMBER (S) WITH JUSTIFICATION AND OBTAIN MANAGER'S SIGNATURE BELOW:

____

____

____

Manager's Signature

REVIEWER'S NOTES (use additional pages as necessary)

Review method used: Alternate calculation: ___ Attached: Y ✓ N___

Approximated Originator's steps: ✓

DISCLAIMER

TABLE OF CONTENTS

1.0 OPEN ITEMS

There are no open items associated with this Engineering Calculation (EC).

2.0 REFERENCES

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3.0 INTRODUCTION

This EC provides a calculation of the radiological consequences resulting from various postulated releases from the K-Area Interim Surveillance (KIS) project within Building 105-K. These consequences are used in the Master Engineering Calculation (MEC) to determine the consequences of various scenarios identified in the Hazards Analysis as requiring further analysis. The intent of the present EC is to provide enough information, i.e., provide consequences for various values of inventories, leakpath factors, and pressures, such that the consequences for scenarios analyzed in the MEC can be determined by combining, if needed, results given here.

4.0 INPUTS

1. The Airborne Release Fraction times the Respirable Fraction (ARF*RF) for a pressurized release of powders at pressures below 25 psig is 5E-03*0.4 = 2E-03 (Ref. 2).

2. The ARF*RF for powder under fire conditions (no pressurization) is 6E-03*0.01 = 6E-05 (Ref. 2).

3. The maximum loading of a 3013 container is 4.4 kg Pu and 5.0 kg Pu Oxide (Ref. 38).

4. The maximum amount of Pu Oxide that can be inside the slug vault at one time is 7 kg based on the combined inventory of material in 3013/non 3013 containers, as sources or standards, in glovebox holdup, on HEPA filters, and in TRU waste (Ref. 38).

5. Deleted.

6. The maximum inventory in a TRU waste drum is 450 g Pu-Oxide (Ref. 38).

7. The worst-case composition of a 3013 container is (Ref. 38)

Radionuclide	Weight %	Ci/gram
Am-241	1.714	5.90E-02
Pu-238	0.1002	1.71E-02

Pu-239	76.08	4.72E-02
Pu-240	20.62	4.68E-02
Pu-241	1.815	1.87E+00
Pu-242	1.385	5.44E-05

Note that these weight percents add up to more than 100 because Am-241 has been conservatively added.

8. The isotopic composition of standards that might enter the slug vault is given in Attachment 1 (Ref. 38).

9. The isotopic composition of material stored in K-Area Material Storage (KAMS) is (Ref. 38 and Item MAT-1 in Ref. 45).

Isotope	KAMS Weight Percent
Pu-238	5.00E-01
Pu-241	3.00E-02
Pu-240	6.50E+00
Pu-239	92
Pu-242	9.70E-01

10. The ARF*RF for packaged mixed waste under thermal stress, i.e., in a fire, is 5E-04 (Ref. 2, page 5-1).

11. The ARR (Airborne Release Rate) for resuspension under normal ventilation flow is 4E-5/hr (Ref. 2, page 4-10).

12. The maximum release duration to be used in the analysis of an event is 8 hr (Ref. 46). This duration is used here for resuspension.

5.0 ASSUMPTIONS

1. Assumption: The ARF reduction factor (as defined in Reference 3 for a pressurized release from a 3013 container) is 4 for 3013 containers.

   Basis for this assumption: This factor takes into account five areas in which the ARF used in this situation is overly conservative. The value of 4 is recommended in Reference 3 for powder released from a ruptured 3013 container.

Sensitivity to this Assumption: Value for the dose reduction factor vary from 2 to 32 (Ref. 3). The calculated dose is inversely proportional to the dose reduction factor.

Additional text: None

2. Assumption: All material entering the slug vault is categorized as "high-fired" for the purpose of determining dose factors (Ref. 38).

   Basis for this assumption: According to Ref. 42, the 3013 material meets the definition of "high-fired" material as given in Ref. 24. According to Ref. 44, the standards entering the slug vault (see Attachment 1) have also been fired at temperatures sufficient to be categorized as "high-fired".

   Sensitivity to this Assumption: Non "high-fired" material would require the use of M solubility class TEDEs which are higher than the S-Class TEDEs used for "high-fired" material and would produce higher calculated consequences.

   Additional text: None

3. Assumption: The release of material from the building is at ground level.

   Basis for this assumption: This assumption is conservative because it maximizes the calculated dose factors.

   Sensitivity to this Assumption: An elevated release would make little difference in the offsite dose factors but may significantly reduce the onsite dose factors.

   Additional text: None.

4. Assumption: Material present in the slug vault as holdup (including HEPA filters), TRU waste, or in standards has the same isotopic composition as material residing in a 3013.

   Basis for this assumption: Material present as holdup is expected to have originated in 3013 containers as they are being processed. The composition of standards (see Attachment 1) is bounded by the composition of 3013 material as shown in Appendix D. Uranium and oxygen isotopes present in the standards (Attachment 1) have dose consequences that are negligible compared to the consequences of those isotopes given in the table. (See, e.g., Ref. 39.)

   Sensitivity to this Assumption: The composition of material in 3013 is considered to be conservative. If standards present in the slug vault have a different composition it is expected to lead to lower consequences if these standards are involved in accidents.

   Additional text: None.

5. Assumption: TRU waste residing in drums and pails corresponds to the packaged mixed waste category in Reference 2.

Basis for this assumption: The category of waste for which this ARF*RF applies is described in Reference 2 as "contaminated combustible materials in packages with largely non-contaminated exterior surfaces (e.g., packaged in bags, compact piles, pails, drums)". This description fits the TRU waste in KIS.

Sensitivity to this Assumption: The value used here is the bounding value for this category of material. The calculated source term would not increase if the category remains the same. Other categories, e.g., material in containers that may be pressurized, may experience greater releases in a fire.

Additional text: None.

6.0 ANALYTICAL METHODS AND CALCULATIONS

The methodology for calculating the source term is taken from Reference 2:

$$ST = MAR \times DR \times ARF \times RF \times LPF \qquad (1)$$

where ST = Source Term (curies or grams)

MAR = Material at Risk (curies or grams)

DR = Damage Ratio

ARF = Airborne Release Fraction (or Airborne Release Rate (ARR) x time)

RF = Respirable Fraction

LPF = Leak Path Factor

Therefore, the dose from the source term (ST) for a particular release mechanism (i.e., impact, resuspension, fire) is given by:

$$D_{ij} = ST \times TEDE_{ii} \qquad (2)$$

where D_{ij} = Dose for i^{th} receptor and j^{th} release duration

$TEDE_{ij}$ = TEDE for the i^{th} receptor and j^{th} release duration

In the present application, the MAR is given in terms of a single 3013 container. TEDE's for onsite and offsite receptors have also been developed in terms of a single container. The various factors in equation 1 can be viewed as fractions (with values less than unity) to be applied to the MAR. The TEDE's are calculated in Appendix A based on the composition given as Item 7 of the Input section of this EC. This composition is shown in Appendix E to bound that of material residing in KAMS and in Appendix D to bound that of the standards entering the slug vault.

For a release from a 3013 container, three regimes are considered in this EC, a non-pressurized release, a release at pressures lower than 25 psig, and a release at pressures above 25 psig. The first two regimes utilize ARF*RF values from Reference 2. With the exception of a high-pressure case discussed later, the ARF*RF values for the last regime are based on the methodology presented in Reference 3 as follows:

$$ARF = 1.29E\text{-}03 * P^{0.7}, \qquad (3)$$

where P is the pressure in psig.

RF is 0.7.

These are bounding values and are used for onsite and offsite receptors.

Different ARF*RF's are applied to the burning of TRU waste in pails or drums (see input item 10 and Assumption 5) and to the resuspension of material following the initial event. The latter is calculated by multiplying the ARR of 4E-05 by 8 hours (see input items 11 and 12).

TEDEs are calculated in Appendix A of this EC using the MELCOR Accident Consequence Code System (MACCS) computer code.

With the ARF and RF values mentioned above, equations 1-2 are applied in the present EC using the following values:

MAR (number of containers),

DR (1.0),

LPF (1.0),

ARF Reduction Factor (4 for the 3013 container and 1 for resuspension and for releases from TRU waste drums and pails),

TEDE (For a 3 min release, 1.03E-02 rem/g * 4,400 g = 45.32 rem/container for the MOI and 5.56 rem/g * 4,400 g = 2.45E+04 rem/container for the onsite receptor; for an 8 hr release, 2.96E-03 rem/g * 4,400 g = 13.0 rem/container for the MOI and 1.39 rem/g * 4,400 g = 6.12E+03 rem/container for the onsite receptor),

The ARF Reduction Factor is taken directly from Reference 3. This factor is used in Reference 3 to reduce conservatisms in the experimental results used to establish ARF's. Where applicable, the ARF is divided by this reduction factor.

Table 1 shows the calculation of offsite and onsite doses for the three regimes of interest (zero pressure, less than 25 psig, and greater than 25 psig) for a single container with 4.4 kg of Pu or 5.0 kg of Pu oxide. In Table 1, a container is assumed to have this maximum amount of Pu; hence, one container is entered in Cell A8. For the first two pressure regimes, the bounding ARF*RF is entered directly into cells B13 and B14. For the third regime, the bounding ARF*RF is calculated in column B using equation 3 based on the pressure given in column A. The ARF reduction factor is applied for this regime. The offsite and onsite doses are calculated in columns C and D. The only difference between the calculations in these two columns is the TEDE. A LPF of 1.0 is assumed. i.e., this calculation is for the unmitigated case.

Table 2 repeats the Table 1 calculation for an MAR of 7 kg Pu oxide or 1.4 times the amount used in Table 1. This calculation is used in the MEC to calculate the consequences for a bounding scenario in which the full 7 kg of material that may be present in all forms is assumed to be released via a pressurized release.

Table 3 calculates the consequences of releases from TRU waste residing in a drum or a pail based on the ARF*RF for packaged mixed waste (see Input 8 and Assumption 5). The MAR used in Table 3 is 450 g of PuO2 (4.4/5*450 = 396 g of Pu), which is the maximum MAR for a drum. This value is entered into Table 3 (cell A8) as 450/5000 = 0.09 containers, respectively. The ARF*RF of 5E-04 is entered in cell B8; the LPF in cell C8; and the TEDEs in cells D8 and E8 for the MOI and the 100 m receptor, respectively. The offsite and onsite doses are calculated in cells F8 and G8, respectively.

Table 4 repeats the Table 1 calculation for a specific pressure (200 psig) release involving a TRU drum containing 450 g of material.

Table 5 calculates the consequences of resuspension releases from 7 kg of Pu Oxide. The ARR*time*RF is 4E-05/hr * 8 hr * 1.0 = 3.2E-4.

7.0 RESULTS

The calculated consequences are given in Tables 1-5. As expected, increases in rupture pressure lead to increases in offsite and onsite consequences.

8.0 CONCLUSION

The offsite and onsite consequences resulting from material associated with the KIS project in Building 105-K were calculated as a function of the rupture pressure of the container in which the material is assumed to reside. These doses will be used in the MEC to calculate doses for specific scenarios. The controls necessary to ensure the validity of the analysis contained herein are addressed in the MEC.

Table 1. Calculation of Unmitigated Consequences (LPF=1.0) for 5 kg PuO2 Subject to a Pressurized Release.

	A	B	C	D
6	**MAR**	**LPF**	**TEDE (MOI)**	**TEDE (100m)**
7	(containers)		(rem/cont)	(rem/cont)
8	1	1	45.32	2.45E+04
9				
10				
11	**Failure Pressure**	**ARFxRF**	**Offsite Dose**	**100 m Dose**
12	(psig)		(rem)	(rem)
13	0	6.00E-05	2.72E-03	1.47E+00
14	< 25	2.00E-03	9.06E-02	4.89E+01
15	25	0.002149	0.0973813	5.26E+01
16	50	0.003491	0.1581964	8.54E+01
17	100	0.005671	0.2569908	1.39E+02
18	150	0.007532	0.3413356	1.84E+02
19	200	0.009212	0.4174829	2.25E+02
20	250	0.010769	0.4880628	2.63E+02
21	300	0.012235	0.5545013	2.99E+02
22	350	0.013629	0.6176825	3.33E+02
23	400	0.014965	0.6782029	3.66E+02
24	450	0.016251	0.7364893	3.98E+02
25	500	0.017495	0.7928603	4.28E+02
26	600	0.019876	0.90079	4.86E+02
27	700	0.022141	1.0034282	5.42E+02
28	800	0.02431	1.1017439	5.95E+02
29	900	0.0264	1.1964303	6.46E+02
30	1000	0.02842	1.2880053	6.95E+02

Table 2. Calculation of Unmitigated Consequences (LPF = 1.0) for 7 kg PuO2 Subject to a Pressurized Release.

	A	B	C	D
6	**MAR**	**LPF**	**TEDE (MOI)**	**TEDE (100m)**
7	(containers)		(rem/cont)	(rem/cont)
8	1.4	1	45.32	2.45E+04
9				
10				
11	**Failure Pressure**	**ARFxRF**	**Offsite Dose**	**100 m Dose**
12	(psig)		(rem)	(rem)
13	0	6.00E-05	3.81E-03	2.05E+00
14	< 25	2.00E-03	1.27E-01	6.85E+01
15	25	0.002149	0.1363339	7.36E+01
16	50	0.003491	0.221475	1.20E+02
17	100	0.005671	0.3597872	1.94E+02
18	150	0.007532	0.4778698	2.58E+02
19	200	0.009212	0.584476	3.16E+02
20	250	0.010769	0.6832879	3.69E+02
21	300	0.012235	0.7763018	4.19E+02
22	350	0.013629	0.8647555	4.67E+02
23	400	0.014965	0.9494841	5.13E+02
24	450	0.016251	1.031085	5.57E+02
25	500	0.017495	1.1100044	5.99E+02
26	600	0.019876	1.2611059	6.81E+02
27	700	0.022141	1.4047994	7.58E+02
28	800	0.02431	1.5424414	8.33E+02
29	900	0.0264	1.6750025	9.04E+02
30	1000	0.02842	1.8032075	9.73E+02

Table 3. Calculation of Unmitigated Consequences (LPF = 1.0) for 450 g PuO2 in the Form of TRU Waste Subject to a Fire.

	A	B	C	D	E	F	G
6	**MAR**	**ARFxRF**	**LPF**	**TEDE (MOI)**	**TEDE (100m)**	**Offsite Dose**	**100 m Dose**
7	(containers)			(rem/cont)	(rem/cont)	(rem)	(rem)
8	0.09	5.00E-04	1	45.32	2.45E+04	2.04E-03	1.10E+00

Table 4. Calculation of Unmitigated Consequences (LPF = 1.0) for 450 g PuO2 in the Form of TRU Waste Released at 200 psig.

	A	B	C	D
6	**MAR**	**LPF**	**TEDE (MOI)**	**TEDE (100m)**
7	(containers)		(rem/cont)	(rem/cont)
8	0.09	1	45.32	2.45E+04
9				
10				
11	**Failure Pressure**	**ARFxRF**	**Offsite Dose**	**100 m Dose**
12	(psig)		(rem)	(rem)
13	200	0.036848	0.1502938	8.11E+01

Table 5. Calculation of Unmitigated Consequences (LPF = 1.0) for Resuspension from 7 kg PuO2 Powder.

	A	B	C	D	E	F	G
6	**MAR**	**ARFxRF**	**LPF**	**TEDE (MOI)**	**TEDE (100m)**	**Offsite Dose**	**100 m Dose**
7	(containers)			(rem/cont)	(rem/cont)	(rem)	(rem)
8	1.4	3.20E-04	1	13.0	6.12E+03	5.82E-03	2.74E+00

9.0 APPENDICES

APPENDIX A. MACCS CALCULATIONS

This appendix provides a calculation of Total Effective Dose Equivalents (TEDEs) for material released from a 3013 container using MACCS, Version 1.5.11.1 (References 5-8). The receptors of interest are the onsite Occupationally Exposed Person (OEP)[i] at100 meters and the Maximally Exposed Offsite Individual (MOI). The MOI is assumed to be located at the closest site boundary, which corresponds to 8.9 km from the K-Area [Ref. 32]. The OEP dose is reported at the 50th quantile level while the MOI dose is reported at the 95th quantile level. The TEDE includes the 50-year committed effective dose equivalent (CEDE) from inhalation both during and after plume passage, the cloudshine effective dose equivalent (EDE), the groundshine EDE, and the skin absorption EDE. This TEDE calculation does not include the ingestion CEDE from consumption of contaminated water and foodstuffs. For this analysis, the inhalation CEDE will be calculated using values based on Publication 68 and 72 of the International Commission on Radiological Protection (ICRP) (References 9 and 10), as taken from the ICRP Dose Coefficient Database Compact Disc (Reference 11). The receptor population is an adult worker and an adult member of the general public. As discussed in Assumption 7, the released material is assumed to belong to the S lung absorption type, i.e., it is "high fired" material. This material has the following composition

Radionuclide	Weight %	Ci/gm $_{Pu}$
Am-241	1.714	5.90E-02
Pu-238	0.1002	1.71E-02
Pu-239	76.08	4.72E-02
Pu-240	20.62	4.68E-02
Pu-241	1.815	1.87E+00
Pu-242	1.385	5.44E-05

In this appendix, a single gram of this material was released. The TEDEs corresponding to this gram release are multiplied, in the main body of this EC, by the number of grams of material per container to arrive at a TEDE corresponding to the release of an entire container of material.

MACCS Version 1.5.11.1 was developed by Sandia National Laboratories under support of the United States Nuclear Regulatory Commission (USNRC). MACCS Version 1.5.11.1 is a maintenance release version of the MACCS 1.5.11 code, the primary probabilistic consequence assessment (PCA) code used by the USNRC. The maintenance release version corrected minor errors in the original and added a new latent cancer model.

MACCS is executed in a three-step method on the interoffice network of Washington Safety Management Solutions LLC personal computers office in Aiken, SC (Reference 25). Air and ground concentrations, plume size, and timing information for all plume segments as a function of downwind distance are calculated in the first step **ATMOS**. The next step is **EARLY**; this calculation accounts for consequences due to exposure to radiation in the emergency phase (first 7 days) of the accident. The last step is **CHRONC** which is for calculation of consequences due to exposure to radiation subsequent to the emergency phase of the postulated accident and for computing decontamination and other economic impacts incurred because of the accident.

The complete three-step execution of MACCS, including input and output files, is shown in Figure A-1 for a general analysis and in Figure A-2 for this analysis. The post-emergency doses are not items of interest for this analysis; thus, the CHRONC module is not executed. In addition, a uniform population density is assumed, eliminating the need for a separate population input.

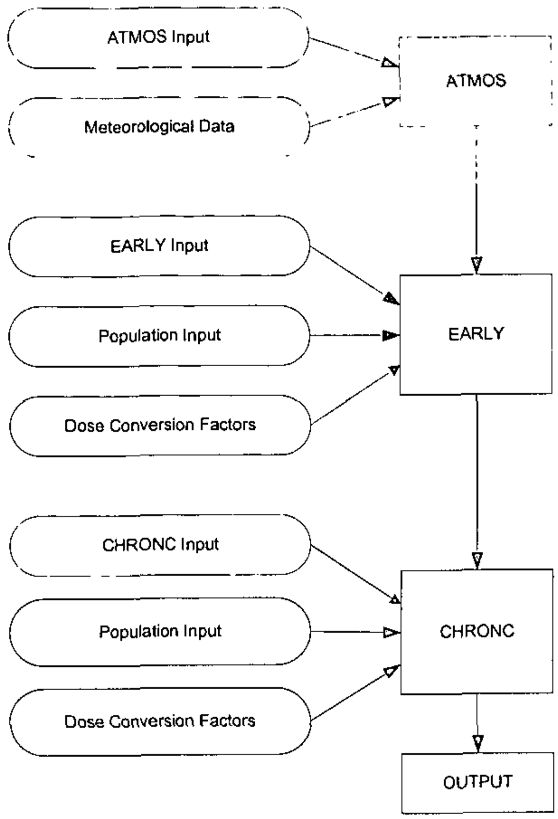

Figure A-1. Flow Chart of the MACCS Three-Step Execution and Input Files

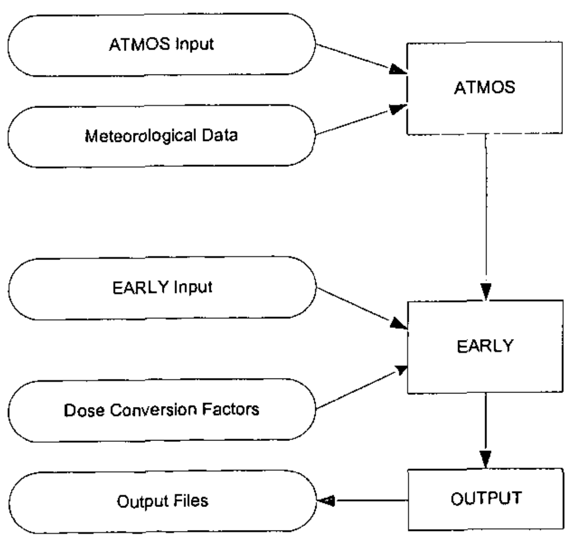

Figure A-2. Flow Chart of the MACCS for Current Analysis

The MACCS input data files associated with the specific analyses performed in this calculation are listed below.

Location	MET YR	ATMOS FILE	MET FILE	EARLY FILE		OUTPUT FILE
MOI	87	A0_9975.INP	MH8710.INP	E0_SRS.INP	SPU_72.INP	SRF72_87.OUT
MOI	88	A0_9975.INP	MH8810.INP	E0_SRS.INP	SPU_72.INP	SRF72_88.OUT
MOI	89	A0_9975.INP	MH8910.INP	E0_SRS.INP	SPU_72.INP	SRF72_89.OUT
MOI	90	A0_9975.INP	MH9010.INP	E0_SRS.INP	SPU_72.INP	SRF72_90.OUT
MOI	91	A0_9975.INP	MH9110.INP	E0_SRS.INP	SPU_72.INP	SRF72_91.OUT
OEP	87	A0_9975.INP	MH8710.INP	E0_SRS.INP	SPU_68.INP	SRF68_87.OUT
OEP	88	A0_9975.INP	MH8810.INP	E0_SRS.INP	SPU_68.INP	SRF68_88.OUT
OEP	89	A0_9975.INP	MH8910.INP	E0_SRS.INP	SPU_68.INP	SRF68_89.OUT
OEP	90	A0_9975.INP	MH9010.INP	E0_SRS.INP	SPU_68.INP	SRF68_90.OUT
OEP	91	A0_9975.INP	MH9110.INP	E0_SRS.INP	SPU_68.INP	SRF68_91.OUT

CODE QA

For this analysis, MACCS Version 1.5.11.1 was used. The process by which MACCS calculates doses and health consequences is described in the Analysis Method and Calculations section of this document and in references (References 6, , 26, 27, and 28). The MACCS code, Version 1.5.11.1, is in compliance with WSMS configuration management procedures for safety analysis software [Ref. 25 and Ref. 29]. Software quality assurance procedures governing the use of MACCS are in compliance with Procedure 4-4 of the WSMS 1Q Quality Assurance Manual [Ref. 30], and are consistent with WSRC QAP 20-1 [Ref. 33]. Application of MACCS software for accident analysis purposes follows procedures in Procedure Manual E7 [Ref. 31].

MACCS ATMOS Input File

The ATMOS module of the MACCS code uses two input files. These files contain the input data needed for the ATMOS module (A0_9975.INP) and a yearly meteorological data file, which contains 365 days of meteorological conditions (MH8710.INP, MH8810.INP, MH8910.INP, MH9010.INP, and MH9110.INP).

The ATMOS input data file is given in Appendix C. The following are the major assumptions associated with this analysis:

1) The radial ring endpoints are at 0.2, 0.3, 0.40, 0.58, 0.62, 0.66, 0.80, 1.00, 1.40, 1.80, 2.20, 2.60, 3.00, 3.40, 3.80, 4.20, 4.60, 5.00, 5.40, 6.00, 6.40, 6.80, 7.20, 7.60, 8.20, 8.60, 9.20, 9.60, 10.40, 11.00, 12.00, 13.00, 15.00, 20.00, and 30.00 km
2) The wake effects of the building are not included. The building height and width are set equal to there lowest allowable value of 1.0 m (Reference 5)
3) The inventory given in Table 1 was released from ground-level without sensible heat
4) The inventories are released over a three-minute, fifteen-minute, twenty-minute, one-hour, two-hour, and eight-hour period. MACCS uses the Gifford model to adjust the sigma y for plume meander due to varying averaging times. This model is only valid from the averaging time of the experimental basis for the sigma y (three minutes) to an averaging time of 100 hours (Reference 12). The MACCS code conservatively limits the time period used in the calculation of the relative downwind air concentration to ten hours Reference 5.
5) The inventory scaling factor (CORSCA) has been set equal to 3.7×10^{10} to convert the inventory units from curies to becquerels
6) For non-noble gas radionuclides, only dry deposition is assumed (no wet deposition is assumed). The particulates are assumed to have a deposition velocity of 0.01 m/s consistent with an unfiltered release. This dry deposition velocity corresponds to a particle with an aerodynamic equivalent diameter (AED) of 2 to 4 microns (Reference 13).. The particles are deposited on the ground based on a modified Chamberlain's source model (References 6, 14, 15, and 16).
7) Surface roughness is assumed to be 100 cm, which combines the urban attributes of the operational area with the forested features of the site (Reference 6). MACCS (Reference 6) incorporates the change in the surface roughness using the model proposed in (Reference 17). In this model, the sigma z parameter is adjusted by applying the one-fifth law to the quotient of the new surface roughness divided by the Prairie Grass surface roughness (3 cm) (Reference 18).

The site meteorological data files are composed of hourly H-Area data for the calendar years 1987 through 1991, at a measured windspeed height of 10 meters (Reference 19). The meteorological data files are given in their entirety in Appendix A of Reference 19. All five data files will be used in this analysis. The highest TEDE from the five years will be reported in the Conclusions Section.

MACCS EARLY Input File

The EARLY module of the MACCS code uses two different input files, the file that contains the input data needed for the EARLY module (E0_SRS.INP) and the dose conversion factor file (SPU_68.INP and SPU_72.INP).

The EARLY input data file is given in Appendix C. The following are the major assumptions associated with this analysis:

1) The assumed breathing rate is 3.33×10^{-4} cubic meters per second which is the DOE occupational breathing rate (Reference 20)
2) A uniform population distribution of 0.0 people per square kilometer is assumed
3) No shielding is assumed
4) No evacuation and/or sheltering is assumed
5) Results of interest are the centerline TEDE at 100 m, 640 m, and 8.9 km

The last file needed by the EARLY module is the dose conversion factor file. The cloudshine and groundshine dose conversion factors (DCFs) within this file are based on Federal Guidance Report 12

(Reference 21). The inhalation and ingestion CEDE DCFs within the DCF files are based on ICRP Publication 68 and 72 as taken from the ICRP Dose Coefficient Database Compact Disc (Reference 11). The receptor population will be an adult worker and an adult member of the general public.

ICRP Publications 68 and 72 give inhalation DCFs for the worker and general public, respectively. These values are based on the ICRP's 1990 recommendations on radiation protection standards in Publication 60 (Reference 22) as well as the revised kinetic and dosimetric model of the respiratory tract in Publication 66 (Reference 23). Since the issuance of ICRP Publications 68 and 72, the ICRP has issued a compact disc with a dose coefficient database (Reference 11) using the same models. The database gives both organ and effective dose coefficients. Additionally, the database gives the user greater flexibility by including dose coefficients for ten particle sizes.

For a workplace population, ICRP Publication 68 recommends a particle size of 5 μm AMAD as a default value. For members of the general public, ICRP Publication 71 (Reference 24) recommends a particle size of 1 μm AMAD as a default value. In this EC, calculations are performed for the general; public using a particle size of 1 μm AMAD. Calculations are performed for the workplace population using particle sizes of 1 μm AMAD to be consistent with previous and other analyses.

The DCF input files also list the lung absorption type for each radionuclide that is the basis for the inhalation DCFs. Because plutonium isotopes are typically significant, if not the dominant, contributors to doses with SRS inventories, the selection of lung absorption type is especially important. Plutonium can exist either in the insoluble oxide form (type S) or in other chemical compound forms (type M) as identified in Annexe F of ICRP Publication 68 for the purpose of determining the lung absorption type and associated inhalation DCFs. The basis for S-type DCFs for plutonium is that it exists as insoluble oxide, which according to ICRP Publication 71 is achieved through high-fired oxidation (i.e., ~1000 °C for sufficient time for complete oxidation to occur). For the plutonium in this analysis, the lower DCFs that are associated with lung absorption type S corresponding to insoluble plutonium oxide are used since the scope of this analysis is limited to plutonium oxide that is known to be high fired. The inhalation DCF for Am-241, the only other radionuclide in the inventory besides the plutonium isotopes, is based on M lung absorption type (to be used for all compound forms according to Annexe F of ICRP Publication 68.

From the ICRP Dose Coefficient Database, the inhalation CEDE DCFs for the worker receptor group and the adult general public groups were extracted for the unfiltered release. These values are given in two separate dose conversion factor files (SPU_68.INP and SPU_72.INP) in Appendix C.

Results

The calculated TEDEs in units of rem/gram released are summarized in Table A-1. MACCS produces TEDE values in units of Sieverts. Multiplying Sieverts by 100 gives rem. Although results are presented for several release times, only those for a three minute release time are used in the main body of this EC.

Table A-1. TEDEs for one gram Pu release (rem/g).

	A	B	C	D	E	F	G	H
2	**9975 Composition**							
3								
4								
5	**Onsite**		**1987**	**1988**	**1989**	**1990**	**1991**	**Max**
6	**100 m**	**3 min**	5.49E+00	5.56E+00	3.95E+00	4.77E+00	3.35E+00	5.56E+00
7	**50%**	**15 min**	3.56E+00	3.72E+00	2.87E+00	3.50E+00	2.66E+00	3.72E+00
8	**S Class**	**20 min**	3.46E+00	3.46E+00	2.84E+00	3.22E+00	2.40E+00	3.46E+00
9	**ICRP68**	**1 hr**	2.65E+00	3.12E+00	2.21E+00	2.65E+00	1.87E+00	3.12E+00
10		**2 hr**	2.19E+00	2.21E+00	1.59E+00	1.91E+00	1.42E+00	2.21E+00
11		**8 hr**	1.33E+00	1.39E+00	1.06E+00	1.20E+00	9.35E-01	1.39E+00
12								
13								
14								
15	**Offsite**		**1987**	**1988**	**1989**	**1990**	**1991**	**Max**
16		**3 min**	1.01E-02	8.47E-03	8.28E-03	1.03E-02	8.48E-03	1.03E-02
17	**8.9 km**	**15 min**	7.39E-03	6.23E-03	5.95E-03	7.34E-03	6.17E-03	7.39E-03
18	**95%**	**20 min**	6.56E-03	5.57E-03	5.49E-03	7.07E-03	5.89E-03	7.07E-03
19	**S Class**	**1 hr**	5.63E-03	4.72E-03	4.27E-03	5.40E-03	4.57E-03	5.63E-03
20	**ICRP72**	**2 hr**	3.99E-03	3.14E-03	2.95E-03	3.63E-03	3.42E-03	3.99E-03
21		**8 hr**	2.72E-03	2.26E-03	2.24E-03	2.96E-03	2.35E-03	2.96E-03

APPENDIX B. SPREADSHEET FORMULAS

	A	B	C	D
6	**MAR**	**LPF**	**TEDE (MOI)**	**TEDE (100m)**
7	(containers)		(rem/cont)	(rem/cont)
8	1	1	45.32	24464
9				
10				
11	**Failure Pressure**	**ARFxRF**	**Offsite Dose**	**100 m Dose**
12	(psig)		(rem)	(rem)
13	0	0.00006	=$A$8*B13*$B$8*$C$8	=$A$8*B13*$B$8*$D$8
14	< 25	0.002	=$A$8*B14*$B$8*$C$8	=$A$8*B14*$B$8*$D$8
15	25	=0.00129*A15^0.7*0.7/4	=$A$8*B15*$B$8*$C$8	=$A$8*B15*$B$8*$D$8
16	=A15+25	=0.00129*A16^0.7*0.7/4	=$A$8*B16*$B$8*$C$8	=$A$8*B16*$B$8*$D$8
17	=A16+50	=0.00129*A17^0.7*0.7/4	=$A$8*B17*$B$8*$C$8	=$A$8*B17*$B$8*$D$8
18	=A17+50	=0.00129*A18^0.7*0.7/4	=$A$8*B18*$B$8*$C$8	=$A$8*B18*$B$8*$D$8
19	=A18+50	=0.00129*A19^0.7*0.7/4	=$A$8*B19*$B$8*$C$8	=$A$8*B19*$B$8*$D$8
20	=A19+50	=0.00129*A20^0.7*0.7/4	=$A$8*B20*$B$8*$C$8	=$A$8*B20*$B$8*$D$8
21	=A20+50	=0.00129*A21^0.7*0.7/4	=$A$8*B21*$B$8*$C$8	=$A$8*B21*$B$8*$D$8
22	=A21+50	=0.00129*A22^0.7*0.7/4	=$A$8*B22*$B$8*$C$8	=$A$8*B22*$B$8*$D$8
23	=A22+50	=0.00129*A23^0.7*0.7/4	=$A$8*B23*$B$8*$C$8	=$A$8*B23*$B$8*$D$8
24	=A23+50	=0.00129*A24^0.7*0.7/4	=$A$8*B24*$B$8*$C$8	=$A$8*B24*$B$8*$D$8
25	=A24+50	=0.00129*A25^0.7*0.7/4	=$A$8*B25*$B$8*$C$8	=$A$8*B25*$B$8*$D$8
26	=A25+100	=0.00129*A26^0.7*0.7/4	=$A$8*B26*$B$8*$C$8	=$A$8*B26*$B$8*$D$8
27	=A26+100	=0.00129*A27^0.7*0.7/4	=$A$8*B27*$B$8*$C$8	=$A$8*B27*$B$8*$D$8
28	=A27+100	=0.00129*A28^0.7*0.7/4	=$A$8*B28*$B$8*$C$8	=$A$8*B28*$B$8*$D$8
29	=A28+100	=0.00129*A29^0.7*0.7/4	=$A$8*B29*$B$8*$C$8	=$A$8*B29*$B$8*$D$8
30	=A29+100	=0.00129*A30^0.7*0.7/4	=$A$8*B30*$B$8*$C$8	=$A$8*B30*$B$8*$D$8

	A	B	C	D	E	F	G	H
2	**9975 Con**							
3								
4								
5	**Onsite**		**1987**	**1988**	**1989**	**1990**	**1991**	**Max**
6	**100 m**	**3 min**	=C29*100	=D29*100	=E29*100	=F29*100	=G29*100	=H29*100
7	**0.5**	**15 min**	=C30*100	=D30*100	=E30*100	=F30*100	=G30*100	=H30*100
8	**S Class**	**20 min**	=C31*100	=D31*100	=E31*100	=F31*100	=G31*100	=H31*100
9	**ICRP68**	**1 hr**	=C32*100	=D32*100	=E32*100	=F32*100	=G32*100	=H32*100
10		**2 hr**	=C33*100	=D33*100	=E33*100	=F33*100	=G33*100	=H33*100
11		**8 hr**	=C34*100	=D34*100	=E34*100	=F34*100	=G34*100	=H34*100
12								
13								
14								
15	**Offsite**		**1987**	**1988**	**1989**	**1990**	**1991**	**Max**
16		**3 min**	=C39*100	=D39*100	=E39*100	=F39*100	=G39*100	=H39*100
17	**8.9 km**	**15 min**	=C40*100	=D40*100	=E40*100	=F40*100	=G40*100	=H40*100
18	**0.95**	**20 min**	=C41*100	=D41*100	=E41*100	=F41*100	=G41*100	=H41*100
19	**S Class**	**1 hr**	=C42*100	=D42*100	=E42*100	=F42*100	=G42*100	=H42*100
20	**ICRP72**	**2 hr**	=C43*100	=D43*100	=E43*100	=F43*100	=G43*100	=H43*100
21		**8 hr**	=C44*100	=D44*100	=E44*100	=F44*100	=G44*100	=H44*100
22								
23								
24								
25	9975 Con							
26								
27								
28	Onsite		1987	1988	1989	1990	1991	Max
29	100 m	3 min	0.0549	0.0556	0.0395	0.0477	0.0335	=MAX(C29:G29)
30	0.5	15 min	0.0356	0.0372	0.0287	0.035	0.0266	=MAX(C30:G30)
31	S Class	20 min	0.0346	0.0346	0.0284	0.0322	0.024	=MAX(C31:G31)
32	ICRP68	1 hr	0.0265	0.0312	0.0221	0.0265	0.0187	=MAX(C32:G32)
33		2 hr	0.0219	0.0221	0.0159	0.0191	0.0142	=MAX(C33:G33)
34		8 hr	0.0133	0.0139	0.0106	0.012	0.00935	=MAX(C34:G34)
35								
36								
37								
38			1987	1988	1989	1990	1991	Max
39	Offsite	3 min	0.000101	0.0000847	0.0000828	0.000103	0.0000848	=MAX(C39:G39)
40	0.95	15 min	0.0000739	0.0000623	0.0000595	0.0000734	0.0000617	=MAX(C40:G40)
41	S Class	20 min	0.0000656	0.0000557	0.0000549	0.0000707	0.0000589	=MAX(C41:G41)
42	ICRP72	1 hr	0.0000563	0.0000472	0.0000427	0.000054	0.0000457	=MAX(C42:G42)
43	Distance	2 hr	0.0000399	0.0000314	0.0000295	0.0000363	0.0000342	=MAX(C43:G43)
44	8.9 km	8 hr	0.0000272	0.0000226	0.0000224	0.0000296	0.0000235	=MAX(C44:G44)

	A	B	C	D
6	**MAR**	**LPF**	**TEDE (MOI)**	**TEDE (100m)**
7	(container s)		(rem/cont)	(rem/cont)
8	0.09	1	45.32	24464
9				
10				
11	**Failure Pressure**	**ARFxRF**	**Offsite Dose**	**100 m Dose**
12	(psig)		(rem)	(rem)
13	200	=0.00129*A13^0.7*0.7	=$A$8*B13*$B$8*$C$8	=$A$8*B13*$B$8*$D$8

	A	B	C	D	E	F	G
6	**MAR**	**ARFxRF**	**LPF**	**TEDE (MOI)**	**TEDE (100m)**	**Offsite Dose**	**100 m Dose**
7	(contai			(rem/cont)	(rem/cont)	(rem)	(rem)
8	0.09	0.0005	1	45.32	24464	=A8*B8*C8*D8	=A8*B8*C8*E8

APPENDIX C. MACCS FILES

ATMOS File

```
*****************************************************************************
*
*        SAV RIVER ATMOS FILE
*
RIATNAM1001  'MACCS - SRS - 235F Standards Unit Ci Analysis - Ground Release'
*****************************************************************************
* GEOMETRY DATA BLOCK, LOADED BY INPGEO, STORED IN /GEOM/
*
* NUMBER OF RADIAL SPATIAL ELEMENTS
GENUMRAD001 35
*
* ENDPOINT DISTANCES TO RADIAL SPATIAL ELEMENTS (KILOMETERS)
GESPAEND001    0.20   0.30   0.40   0.58   0.62   0.66   0.80
GESPAEND002    1.00   1.40   1.80   2.20   2.60   3.00   3.40
GESPAEND003    3.80   4.20   4.60   5.00   5.40   6.00   6.40
GESPAEND004    6.80   7.20   7.60   8.20   8.60   9.20   9.60
GESPAEND005   10.40  11.00  12.00  13.00  15.00  20.00  30.00
*****************************************************************************
* ISOTOPE DATA BLOCK, LOADED BY INPISO, STORED IN /ISOGRP/, /ISONAM/
*
* NUMBER OF ISOTOPES
ISNUMISO001 6
*
* NUMBER OF ISOTOPE GROUPS
ISMAXGRP001 3
*
* WET AND DRY DEPOSITION FLAGS FOR EACH ISOTOPE GROUP
*              WETDEP     DRYDEP
ISDEPFLA001   .FALSE.   .FALSE.
ISDEPFLA002   .FALSE.    .TRUE.
ISDEPFLA003   .FALSE.    .TRUE.
*
* ISOTOPE GROUP DATA FOR 3 ISOTOPE GROUPS
*               NUCNAM      PARENT   IGROUP  HAFLIF
*             Radionuclide   Parent   Group T 1/2 (s)
ISOTPGRP001     AM-241       PU-241   2      1.36E+10
ISOTPGRP002     PU-238       NONE     2      2.77E+09
ISOTPGRP003     PU-239       NONE     2      7.59E+11
ISOTPGRP004     PU-240       NONE     2      2.06E+11
ISOTPGRP005     PU-241       NONE     2      4.54E+08
ISOTPGRP006     PU-242       NONE     2      1.19E+13
*
*****************************************************************************
* WET DEPOSITION DATA BLOCK, LOADED BY INPWET, STORED IN /WETCON/
*
* WASHOUT COEFFICIENT NUMBER ONE, LINEAR FACTOR
WDCWASH1001  9.5E-5
*
* WASHOUT COEFFICIENT NUMBER TWO, EXPONENTIAL FACTOR
WDCWASH2001  0.8
*****************************************************************************
* DRY DEPOSITION DATA BLOCK, LOADED BY INPDRY, STORED IN /DRYCON/
*
* NUMBER OF PARTICLE SIZE GROUPS
DDNPSGRP001  3
*
* DEPOSITION VELOCITY OF EACH PARTICLE SIZE GROUP (M/S)
DDVDEPOS001  0.001  0.005  0.01
*****************************************************************************
* DISPERSION PARAMETER DATA BLOCK, LOADED BY INPDIS, STORED IN /DISPY/, /DISPZ/
*
* STABILITY CLASS: A         B         C         D         E         F
*
* LINEAR TERM OF THE EXPRESSION FOR SIGMA-Y, 6 STABILITY CLASSES
DPCYSIGA001   0.3658   0.2751   0.2089   0.1474   0.1046   0.0722
*
* EXPONENTIAL TERM OF THE EXPRESSION FOR SIGMA-Y, 6 STABILITY CLASSES
DPCYSIGB001    .9031    .9031    .9031    .9031    .9031    .9031
```

```
*
* LINEAR TERM OF THE EXPRESSION FOR SIGMA-Z, 6 STABILITY CLASSES
DPCZSIGA001   2.5E-4   1.9E-3      .2       .3       .4       .2
*
* EXPONENTIAL TERM OF THE EXPRESSION FOR SIGMA-Z, 6 STABILITY CLASSES
DPCZSIGB001   2.125   1.6021    .8543    .6532    .6021    .6020
*
*  LINEAR SCALING FACTOR FOR SIGMA-Y FUNCTION, NORMALLY 1
DPYSCALE001   1.
*
*  LINEAR SCALING FACTOR FOR SIGMA-Z FUNCTION,
*  NORMALLY USED FOR SURFACE ROUGHNESS LENGTH CORRECTION.
*  (Z1 / Z0) ** .2,   FOR SRS Z1=100 CM, THEREFORE (100/3)**.2=2.02
DPZSCALE001   2.02
*********************************************************************** *
* EXPANSION FACTOR DATA BLOCK, LOADED BY INPEXP, STORED IN /EXPAND/
*
* TIME BASE FOR EXPANSION FACTOR (SECONDS)
PMTIMBAS001  180.
*
* BREAK POINT FOR FORMULA CHANGE (SECONDS)
PMBRKPNT001  3600.
*
* EXPONENTIAL EXPANSION FACTOR NUMBER 1
PMXPFAC1001   .2
*
* EXPONENTIAL EXPANSION FACTOR NUMBER 2
PMXPFAC2001   .25
************************************************************************
* PLUME RISE DATA BLOCK, LOADED BY INPLRS, STORED IN /PLUMRS/
*
* SCALING FACTOR FOR THE CRITICAL WIND SPEED FOR ENTRAINMENT OF A BOUYANT PLUME
* (USED BY FUNCTION CAUGHT)
PRSCLCRW001  1.
*
* SCALING FACTOR FOR THE A-D STABILITY PLUME RISE FORMULA
* (USED BY FUNCTION PLMRIS)
PRSCLADP001  1.
*
* SCALING FACTOR FOR THE E-F STABILITY PLUME RISE FORMULA
* (USED BY FUNCTION PLMRIS)
PRSCLEFP001  1.
************************************************************************
* WAKE EFFECTS DATA BLOCK, LOADED BY INPWAK, STORED IN /BILWAK/
*
* BUILDING WIDTH (METERS)
WEBUILDW001  1.
*
* BUILDING HEIGHT (METERS)
WEBUILDH001  1.
************************************************************************
* OUTPUT CONTROL DATA BLOCK, LOADED BY INPOPT, STORED IN /STOPME/, /ATMOPT/
*
* FLAG TO INDICATE THAT THIS IS THE LAST PROGRAM IN THE SERIES TO BE RUN
OCENDAT1001  .FALSE. (SET THIS VALUE TO .TRUE. TO SKIP EARLY AND CHRONC)
OCIDEBUG001  0
*
* NAME OF THE NUCLIDE TO BE LISTED ON THE DISPERSION LISTINGS
*OCNUCOUT001  PU-239
************************************************************************
* METEOROLOGICAL SAMPLING DATA BLOCK
*
* METEOROLOGICAL SAMPLING OPTION CODE:
* METCOD = 1, USER SPECIFIED DAY AND HOUR IN THE YEAR (FROM MET FILE),
*          2, WEATHER CATEGORY BIN SAMPLING,
*          3, 120 HOURS OF WEATHER SPECIFIED ON THE ATMOS USER INPUT FILE,
*          4, CONSTANT MET (BOUNDARY WEATHER USED FROM THE START),
*          5, STRATIFIED RANDOM SAMPLES FOR EACH DAY OF THE YEAR.
M1METCOD001  2
*
* LAST SPATIAL INTERVAL FOR MEASURED WEATHER
M2LIMSPA001  35
*
* BOUNDARY WEATHER MIXING LAYER HEIGHT
```

```
M2BNDMXH001  1000.  (METERS)
*
* BOUNDARY WEATHER STABILITY CLASS INDEX
M2IBDSTB001  4      (D-STABILITY)
*
* BOUNDARY WEATHER RAIN RATE
M2BNDRAN001  5.     (MM/HR)
*
* BOUNDARY WEATHER WIND SPEED
M2BNDWND001  5.    (M/S)
*
* NUMBER OF RAIN DISTANCE INTERVALS FOR BINNING
M4NRNINT001  5
*
* ENDPOINTS OF THE RAIN DISTANCE INTERVALS (KILOMETERS)
* NOTE: THESE MUST BE CHOSEN TO MATCH THE SPATIAL ENDPOINT DISTANCES
*       SPECIFIED FOR THE ARRAY SPAEND (10 % ERROR IS ALLOWED).
M4RNDSTS001  3.0  6.0 11.0  20.0  32.0
*
* NUMBER OF RAIN INTENSITIY BREAKPOINTS
M4NRINTN001   3
*
* RAIN INTENSITY BREAKPOINTS FOR WEATHER BINNING (MILLIMETERS PER HOUR)
M4RNRATE001   2.  4.  6.
*
* NUMBER OF SAMPLES PER BIN
*
M4NSMPLS001  10
*
* INITIAL SEED FOR RANDOM NUMBER GENERATOR
M4IRSEED001   5
*****************************************************************************
* RELEASE DATA BLOCK, LOADED BY INPREL, STORED IN /ATNAM2/, /MULREL/
*
* PLUME SPECIFIC INFORMATION
RDATNAM2001 '9975 S-Pu Oxide unit gram; 3-min Ground-Level Unfiltered  - YR'
*
* TIME AFTER ACCIDENT INITIATION WHEN THE ACCIDENT REACHES GENERAL EMERGENCY
* CONDITIONS (AS DEFINED IN NUREG-0654), OR WHEN PLANT PERSONNEL CAN RELIABLY
* PREDICT THAT GENERAL EMERGENCY CONDITIONS WILL BE ATTAINED
*
RDOALARM001    0.00E+00
*
* NUMBER OF PLUME SEGMENTS THAT ARE RELEASED
RDNUMREL001      1
*
* SELECTION OF RISK DOMINANT PLUME
RDMAXRIS001      1
*
* REFERENCE TIME FOR DISPERSION AND RADIOACTIVE DECAY
RDREFTIM001        0.00       0.00     0.00  0.00
* CORRESPONDING TO LEADING EDGE WEATHER
*
* HEAT CONTENT OF THE RELEASE SEGMENTS (WATTS)
* A VALUE SPECIFIED FOR EACH OF THE RELEASE SEGMENTS
RDPLHEAT001    0.0E+00
*
* HEIGHT OF THE PLUME SEGMENTS AT RELEASE (METERS)
* A VALUE SPECIFIED FOR EACH OF THE RELEASE SEGMENTS
RDPLHITE001  0.0
*
* DURATION OF THE PLUME SEGMENTS (SECONDS)
* A VALUE SPECIFIED FOR EACH OF THE RELEASE SEGMENTS
RDPLUDUR001    180.0
*
* TIME OF RELEASE FOR EACH PLUME (SECS FROM SCRAM)
* A VALUE SPECIFIED FOR EACH OF THE RELEASE SEGMENTS
RDPDELAY001    0.0
*
* PARTICLE SIZE DISTRIBUTION OF EACH ISOTOPE GROUP
* YOU MUST SPECIFY A COLUMN OF DATA FOR EACH OF THE PARTICLE SIZE GROUPS
*
*  V dep = 0.001 is for a filtered release
*  V dep = 0.005 is for HTO only
```

```
*  V dep = 0.010 is for an unfiltered release
*
*               0.001  0.005  0.010
RDPSDIST001     0.000  0.000  1.000
RDPSDIST002     0.000  0.000  1.000
RDPSDIST003     0.000  1.000  0.000
*
*                 NUCNAM       CORINV(BQ)
*               Radionuclide  Inv (Ci)
RDCORINV001      AM-241        5.90E-02
RDCORINV002      PU-238        1.71E-03
RDCORINV003      PU-239        4.72E-02
RDCORINV004      PU-240        4.68E-02
RDCORINV005      PU-241        1.87E+00
RDCORINV006      PU-242        5.44E-05
*
*  SCALING FACTOR TO ADJUST THE CORE INVENTORY
RDCORSCA001  3.7E+10 (Conversion of Ci to Bq)
*
* RELEASE FRACTIONS FOR ISOTOPE GROUPS IN RELEASE
* GROUP    NOBLE PART. TRIT
RDRELFRC001 1.00 1.00 1.00
********************************************************************************
.
********************************************************************************
* RELEASE DATA BLOCK, LOADED BY INPREL, STORED IN /ATNAM2/, /MULREL/
*
RDATNAM2001 '9975 S-Pu Oxide unit gram; 15-min Ground-Level Unfiltered  - YR'
RDPLUDUR001   900.0
********************************************************************************
.
********************************************************************************
* RELEASE DATA BLOCK, LOADED BY INPREL, STORED IN /ATNAM2/, /MULREL/
*
RDATNAM2001 '9975 S-Pu Oxide unit gram; 20-min Ground-Level Unfiltered  - YR'
RDPLUDUR001   1200.0
********************************************************************************
.
********************************************************************************
* RELEASE DATA BLOCK, LOADED BY INPREL, STORED IN /ATNAM2/, /MULREL/
*
RDATNAM2001 '9975 S-Pu Oxide unit gram; 1-hr Ground-Level Unfiltered  - YR'
RDPLUDUR001   3600.0
********************************************************************************
.
********************************************************************************
* RELEASE DATA BLOCK, LOADED BY INPREL, STORED IN /ATNAM2/, /MULREL/
*
RDATNAM2001 '9975 S-Pu Oxide unit gram; 2-hr Ground-Level Unfiltered  - YR'
RDPLUDUR001   7200.0
********************************************************************************
.
********************************************************************************
* RELEASE DATA BLOCK, LOADED BY INPREL, STORED IN /ATNAM2/, /MULREL/
*
RDATNAM2001 '9975 S-Pu Oxide unit gram; 8-hr Ground-Level Unfiltered  - YR'
RDPLUDUR001   28800.0
********************************************************************************
.
```

```
EARLY File
*******************************************************************************
* GENERAL DESCRIPTIVE TITLE DESCRIBING THIS "EARLY" INPUT FILE
MIEANAM1001  'SRS - MACCS - SAR ASSUMPTIONS - ICRP 68/72 FGR 12 - F_grnd'
*
* FLAG TO INDICATE THAT THIS IS THE LAST PROGRAM IN THE SERIES TO BE RUN
MIENDAT2001  .TRUE.    (SET THIS VALUE TO .TRUE. TO SKIP CHRONC)
*
* DISPERSION MODEL OPTION CODE:  1  *  STRAIGHT LINE
*                                2  *  WIND-SHIFT WITH ROTATION
*                                3  *  WIND-SHIFT WITHOUT ROTATION
MIIPLUME001  1
*
* NUMBER OF FINE GRID SUBDIVISIONS USED BY THE MODEL
MINUMFIN001  7    (3, 5 OR 7 ALLOWED)
*
* LEVEL OF DEBUG OUTPUT REQUIRED, NORMAL RUNS SHOULD SPECIFY ZERO
MIIPRINT001  0
*
* LOGICAL FLAG SIGNIFYING THAT THE BREAKDOWN OF RISK BY WEATHER CATEGORY
* BIN ARE TO BE PRESENTED TO SHOW THEIR RELATIVE CONTRIBUTION TO THE MEAN
*            RISBIN
MIRISCAT001   .FALSE.
*
* FLAG INDICATING IF WIND-ROSES FROM ATMOS ARE TO BE OVERRIDDEN
MIOVRRID001  .FALSE.  (USE THE WIND ROSE CALCULATED FOR EACH WEATHER BIN)
*******************************************************************************
* POPULATION DISTRIBUTION DATA BLOCK, LOADED BY INPOPU, STORED IN /POPDAT/
*
PDPOPFLG001  UNIFORM
PDIBEGIN001  1   (SPATIAL INTERVAL AT WHICH POPULATION BEGINS)
PDPOPDEN001  0. (POPULATION DENSITY (PEOPLE PER SQUARE KILOMETER))
*******************************************************************************
* ORGAN DEFINITION DATA BLOCK, LOADED BY INORGA, STORED IN /EARDIM/ AND /ORGNAM/
*
* NUMBER OF ORGANS DEFINED FOR HEALTH EFFECTS
ODNUMORG001   2
*
* NAMES OF THE ORGANS DEFINED FOR HEALTH EFFECTS
ODORGNAM001 'SKIN', 'EFFECTIVE'
*******************************************************************************
* SHIELDING AND EXPOSURE FACTORS, LOADED BY INDFAC, STORED IN /EADFAC/
* THREE VALUES OF EACH PROTECTION FACTOR ARE SUPPLIED,
* ONE FOR EACH TYPE OF ACTIVTY:
*
* ACTIVITY TYPE:
*      1 - EVACUEES WHILE MOVING
*      2 - NORMAL ACTIVITY IN SHELTERING AND EVACUATION ZONE
*      3 - SHELTERED ACTIVITY
*
*            EVACUEES  NORMAL  SHELTER
* CLOUD SHIELDING FACTOR
SECSFACT001      1.      1.      1.
*
* PROTECTION FACTOR FOR INHALATION
SEPROTIN001      1.      1.      1.
*
* BREATHING RATE (CUBIC METERS PER SECOND)
SEBRRATE001  3.33E-4  3.33E-4  3.33E-4
*
* SKIN PROTECTION FACTOR
SESKPFAC001      1.      1.      1.
*
* GROUND SHIELDING FACTOR
SEGSHFAC001      1.0     1.0     1.0
*
* RESUSPENSION INHALATION MODEL CONCENTRATION COEFFICIENT (/METER)
*   RESCON = 1.E-4 IS APPROPRIATE FOR MECHANICAL RESUSPENSION BY VEHICLES.
*   RESHAF = 2.11 DAYS CAUSES 1.E-4 TO DECAY IN ONE WEEK TO 1.E-5, THE VALUE
*   OF RESCON USED IN THE FIRST TERM OF THE LONG-TERM RESUSPENSION EQUATION
*   USED IN CHRONC.
SERESCON001   1.0E-4     (RESUSPENSION IS TURNED ON)
*
* RESUSPENSION CONCENTRATION COEFFICIENT HALF-LIFE (SEC)
```

```
SERESHAF001   1.825E5  (2.11 DAYS)
*********************************************************************************
* EVACUATION ZONE DATA BLOCK, LOADED BY EVNETW, STORED IN /NETWOR/, /EOPTIO/
* SPECIFIC DESCRIPTION OF THE EMERGENCY RESPONSE SCENARIO BEING USED
EZEANAM2001  'NO EVACUATION OR SHELTERING'
*
* THE TYPE OF WEIGHTING TO BE APPLIED TO THE EMERGENCY RESPONSE SCENARIOS
* YOU MUST SUPPLY A VALUE OF 'TIME' OR 'PEOPLE'
EZWTNAME001  'PEOPLE'
*
* WEIGHTING FRACTION APPLICABLE TO THIS SCENARIO
EZWTFRAC001  1.000
*
* LAST RING IN THE MOVEMENT ZONE
EZLASMOV001     0     (NO EVACUATION)
************************************************************************
* SHELTER AND RELOCATION ZONE DATA BLOCK, LOADED BY INPEMR,
*                                         STORED IN /INPSRZ/, /RELOCA/
*
* TIME TO TAKE SHELTER IN THE INNER SHELTER ZONE (SECONDS FROM OALARM)
SRTTOSH1001      0.     (THERE IS NO INNER SHELTER ZONE)
*
* SHELTER DURATION IN THE INNER SHELTER ZONE (SECONDS FROM TAKING SHELTER)
SRSHELT1001      0.     (THERE IS NO INNER SHELTER ZONE)
*
* LAST RING OF THE OUTER SHELTER ZONE
SRLASHE2001      0      (THERE IS NO OUTER SHELTER ZONE)
*
* TIME TO TAKE SHELTER IN THE OUTER SHELTER ZONE (SECONDS FROM OALARM)
SRTTOSH2001      0.     (THERE IS NO OUTER SHELTER ZONE)
*
* SHELTER DURATION IN THE OUTER SHELTER ZONE (SECONDS FROM TAKING SHELTER)
SRSHELT2001      0.     (THERE IS NO OUTER SHELTER ZONE)
*
* DURATION OF THE EMERGENCY PHASE (SECONDS FROM PLUME ARRIVAL)
SRENDEMP001  86400.   (ONE DAY - min. value, conservative for 8 hrs per 3009)
*
* CRITICAL ORGAN FOR RELOCATION DECISIONS
SRCRIORG001 'EFFECTIVE'
*
* HOT SPOT RELOCATION TIME (SECONDS FROM PLUME ARRIVAL)
SRTIMHOT001  43200.    (ONE-HALF DAY)
*
* NORMAL RELOCATION TIME (SECONDS FROM PLUME ARRIVAL)
SRTIMNRM001  86400.    (ONE DAY)
*
* HOT SPOT RELOCATION DOSE CRITERION THRESHOLD (SIEVERTS)
SRDOSHOT001  0.50  (50 REM DOSE TO RBM IN 1 WEEK TRIGGERS RELOCATION)
*
* NORMAL RELOCATION DOSE CRITERION THRESHOLD (SIEVERTS)
SRDOSNRM001  0.25   (25 REM DOSE TO RBM IN 1 WEEK TRIGGERS RELOCATION)
*********************************************************************************
* EARLY FATALITY MODEL PARAMETERS, LOADED BY INEFAT, STORED IN /EFATAL/
* NUMBER OF EARLY FATALITY EFFECTS
EFNUMEFA001   0
*********************************************************************************
* EARLY INJURY MODEL PARAMETERS, LOADED BY INEINJ, STORED IN /EINJUR/
*
* NUMBER OF EARLY INJURY EFFECTS
EINUMEIN001  0
*********************************************************************************
* ACUTE EXPOSURE CANCER PARAMETERS, LOADED BY INACAN STORED IN /ACANCR/.
*
* NUMBER OF ACUTE EXPOSURE CANCER EFFECTS
LCNUMACA001   1
*
* THRESHOLD DOSE FOR APPLYING THE DOSE DEPENDENT REDUCTION FACTOR
LCDDTHRE001   0.0  (LOWEST DOSE FOR WHICH DDREFA WILL BE APPLIED)
*
* DOSE THRESHOLD FOR LINEAR DOSE RESPONSE (Sv)
LCACTHRE001   0.0  (LINEAR-QUADRATIC MODEL IS NOT BEING USED)
*
*             ACNAME       ORGNAM  ACSUSC  DOSEFA DOSEFB  CFRISK  CIRISK  DDREFA
LCANCERS001 'ICRP 60'  'EFFECTIVE' 1.0    1.0     0.0    5.0E-2  7.3E-2   1.0
```

```
*******************************************************************************
* RESULT 1 OPTIONS BLOCK, LOADED BY INOUT1, STORED IN /INOUT1/
* TOTAL NUMBER OF A GIVEN EFFECT (LATENT CANCER, EARLY DEATH, EARLY INJURY)
*
* NUMBER OF DESIRED RESULTS OF THIS TYPE
TYPE1NUMBER    0
******************************************************************************
* RESULT 2 OPTIONS BLOCK, LOADED BY INOUT2, STORED IN /INOUT2/
* FURTHEST DISTANCE AT WHICH A GIVEN RISK OF EARLY DEATH IS EXCEEDED.
*
* NUMBER OF DESIRED RESULTS OF THIS TYPE
TYPE2NUMBER  0
*******************************************************************************
* RESULT 3 OPTIONS BLOCK, LOADED BY INOUT3, STORED IN /INOUT3/
* NUMBER OF PEOPLE WHOSE DOSE TO A GIVEN ORGAN EXCEEDS A GIVEN THRESHOLD.
*
* NUMBER OF DESIRED RESULTS OF THIS TYPE
TYPE3NUMBER  0
*******************************************************************************
* RESULT 4 OPTIONS BLOCK, LOADED BY INOUT4, STORED IN /INOUT4/
* 360 DEGREE AVERAGE RISK OF A GIVEN EFFECT AT A GIVEN DISTANCE.
*
* NUMBER OF DESIRED RESULTS OF THIS TYPE
TYPE4NUMBER  0
*******************************************************************************
* RESULT 5 OPTIONS BLOCK, LOADED BY INOUT5, STORED IN /INOUT5/
* TOTAL POPULATION DOSE TO A GIVEN ORGAN BETWEEN TWO DISTANCES.
*
* NUMBER OF DESIRED RESULTS OF THIS TYPE
TYPE5NUMBER     0
*******************************************************************************
* RESULT 6 OPTIONS BLOCK, LOADED BY INOUT6, STORED IN /INOUT6/
* CENTERLINE DOSE TO AN ORGAN VS DIST BY PATHWAY, PATHWAY NAMES ARE AS FOLLOWS:
*
*  PATHWAY NAME:
*    'TOT LIF' - "LIFETIME DOSE COMMITMENT" FROM ALL PATHWAYS
*
* NUMBER OF DESIRED RESULTS OF THIS TYPE
TYPE6NUMBER     3
*
*             ORGNAM         PATHNM      I1DIS6   I2DIS6
TYPE6OUT001  'EFFECTIVE'    'TOT LIF'      1        1
TYPE6OUT002  'EFFECTIVE'    'TOT LIF'      6        6
TYPE6OUT003  'EFFECTIVE'    'TOT LIF'      27       28
*******************************************************************************
* RESULT 7 OPTIONS BLOCK, LOADED BY INOUT7, STORED IN /INOUT7/
* CENTERLINE RISK OF A GIVEN EFFECT VS DISTANCE
*
* NUMBER OF DESIRED RESULTS OF THIS TYPE
TYPE7NUMBER  0
*******************************************************************************
* RESULT 8 OPTIONS BLOCK, LOADED BY INOUT8, STORED IN /INOUT8/
* POPULATION WEIGHTED FATALITY RISK BETWEEN 2 DISTANCES
*
* NUMBER OF DESIRED RESULTS OF THIS TYPE
TYPE8NUMBER  0
*******************************************************************************
```

APPENDIX D. DETERMINATION OF BOUNDING STANDARDS COMPOSITION AND COMPARISON TO ASSUMED COMPOSITION

The isotopic composition of the standards that may enter the slug vault are given in Attachment 1. This appendix takes the data given in Attachment 1, derives a bounding composition, and shows that this composition is bounded by the composition given as Item 7 in the main body of this EC.

The following table ranks the isotopes present according to dose potential:

Table D-1. Dose Potential.

Isotope	ICRP 72 Dose Factor (Sv/Bq)	Specific Activity (Ci/g)	Dose Potential Normalized to Pu-238 per gram
Pu-238	0.000046	17.1	1
Am-241	0.000042	3.44	0.1836766
Pu-241	9E-07	103	0.117849
Pu-240	0.00005	0.227	0.0144292
Pu-239	0.00005	0.0621	0.0039474
Pu-242	0.000048	0.00393	0.0002398

The dose potential in the last column is calculated by multiplying the ICRP dose factor (Ref. 40) by the specific activity (Ref. 41) for each isotope, respectively.

An examination of the data presented in Attachment 1 in conjunction with the relative dose potentials given in Table D-1 shows that the 15% Pu-240 standards, e.g., STD 15-3, have the worst isotopic composition of the standards listed in Attachment 1. This composition is reproduced below:

Table D-2. Bounding Standards Composition.

Standard			Weight Percent			
	Pu-238	Pu-239	Pu-240	Pu-241	Pu-242	Am-241*
STD 15-3	0.1644	82.36	15.4491	1.3131	0.7134	1.167346
* Am-241 percent calculated assuming secular equilibrium with Pu-241.						

As mentioned in Table D-2, the Am-241 content was calculated assuming secular equilibrium with Pu-241. At equilibrium, the fraction of Pu-241 that has been converted to Am-241 is 0.889 (Ref. 43, p. 12).

Table D-3 gives a comparison of the assumed KIS composition (Item 7 in the Input section of this EC) to the bounding standards composition (Table D-2) with respect to relative dose potential.

Table D-3. Comparison of KIS Composition to Standards Composition.

Comparison of Compositions					
	Assumed Weight Percent	Weight Percent times Dose Potential		Worst Average Standards Weight Percent	Weight Percent times Dose Potential
Pu-238	0.1002	0.1002		0.1644	0.1644
Am-241	1.714	0.314822		1.167346	0.214414
Pu-241	1.815	0.213896		1.3131	0.154747
Pu-240	20.62	0.29753		15.4491	0.222918
Pu-239	76.08	0.300316		82.36	0.325105
Pu-242	1.385	0.000332		0.7134	0.000171
Total		**1.2271**			**1.0818**

Based on the calculation shown in this table, the worst-case standards composition is bounded by the assumed KIS composition.

APPENDIX E. COMPARISON OF ASSUMED COMPOSITION TO K-AREA MATERIAL STORAGE (KAMS) COMPOSITION

The purpose of this appendix is to show that the assumed isotopic composition (Input Item 7) is bounding with respect to the composition used in the KAMS DSA. The KAMS composition (Table E-1) is taken from Ref. 45, with an Am-241 weight percent calculated as 0.889 times the Pu-241 weight percent per Ref. 43.

Table E-1. KAMS Composition.

Isotope	KAMS Weight Percent
Pu-238	5.00E-01
Am-241	2.67E-02
Pu-241	3.00E-02
Pu-240	6.50E+00
Pu-239	92
Pu-242	9.70E-01

Table E-2 repeats the calculation shown in Table D-3 with the KAMS composition. The KAMS composition is clearly bounded by the assumed KIS composition.

Table E-2. Comparison of the assumed KIS Composition with the KAMS composition.

Comparison of Compositions					
	Assumed Weight Percent	Weight Percent times Dose Potential		KAMS Weight Percent	Weight Percent times Dose Potential
Pu-238	0.1002	0.1002		5.00E-01	0.5
Am-241	1.714	0.314822		2.67E-02	0.004899
Pu-241	1.815	0.213896		3.00E-02	0.003535
Pu-240	20.62	0.29753		6.50E+00	0.09379
Pu-239	76.08	0.300316		92	0.363158
Pu-242	1.385	0.000332		9.70E-01	0.000233
Total		**1.2271**			**0.9656**

10.0 ATTACHMENT 1

Isotopic Composition of Standards

This table is reproduced from Ref. 38.

	A	B	C	D	E	F	G
1	**Composition of Standards**						
2							
3	**Standard**			**Weight Percent**			
4		**Pu-238**	**Pu-239**	**Pu-240**	**Pu-241**	**Pu-242**	**Am-241***
5							
6	**STD 12-3**	0.0565	87.1285	11.8226	0.7705	0.2219	0.684975
7	**STD 15-3**	0.1644	82.36	15.4491	1.3131	0.7134	1.167346
8	**STD 3-3**	0.0063	96.3204	3.5618	0.0935	0.0181	0.083122
9	**STD 6-3**	0.0137	93.5539	6.1307	0.2452	0.0565	0.217983
10	**STD 6-5**	0.0137	93.5539	6.1307	0.2452	0.0565	0.217983
11	**STD 6-6**	0.0137	93.5539	6.1307	0.2452	0.0565	0.217983
12	**STD 6-7**	0.0137	93.5539	6.1307	0.2452	0.0565	0.217983
13	**STD 6-8**	0.0137	93.5539	6.1307	0.2452	0.0565	0.217983
14	**STD 9-3**	0.0206	92.6783	6.89	0.3379	0.0732	0.300393
15	**STD B15**	0.1644	82.36	15.4491	1.3131	0.7134	1.167346
16	**STD B6**	0.0137	93.5539	6.1307	0.2452	0.0565	0.217983
17	**STD BM12**	0.0565	87.1285	11.8226	0.7705	0.2219	0.684975
18	**STD BM15**	0.1644	82.36	15.4491	1.3131	0.7134	1.167346
19	**STD BM3**	0.0063	96.3204	3.5618	0.0935	0.0181	0.083122
20	**STD BM6**	0.0137	93.5539	6.1307	0.2452	0.0565	0.217983
21	**STD T9**	0.0206	92.6783	6.89	0.3379	0.0732	0.300393
22	**STD TM12**	0.0565	87.1285	11.8226	0.7705	0.2219	0.684975
23	**STD TM3**	0.0063	96.3204	3.5618	0.0935	0.0181	0.083122
24	**STD TM9**	0.0206	92.6783	6.89	0.3379	0.0732	0.300393
25	**SR 1979 COLOR STDS**	0.011	93.73	5.861	0.37	0.027	0.32893
26	**LL 1979 COLOR STDS**	0.011	93.73	5.861	0.37	0.027	0.32893
27	**STD 12%-1**	0.0853	86.5424	12.1691	1.0085	0.2067	0.896557
28	**STD 12%-2**	0.0853	86.5424	12.1691	1.0085	0.2067	0.896557
29	**SRPSTDPUEU1**	0.0144	93.778	5.8618	0.2798	0.0658	0.248742
30	**SRPSTDPUEU2**	0.0144	93.778	5.8618	0.2798	0.0658	0.248742
31	**SRPSTDPUEU3**	0.0144	93.778	5.8618	0.2798	0.0658	0.248742
32	**SRPSTDPUEU4**	0.0144	93.778	5.8618	0.2798	0.0658	0.248742
33	**SRPSTDPUEU5**	0.0144	93.778	5.8618	0.2798	0.0658	0.248742
34	**SRPSTDPUEU6**	0.0144	93.778	5.8618	0.2798	0.0658	0.248742
35	**SRPSTDPUEU7**	0.0144	93.778	5.8618	0.2798	0.0658	0.248742
36	**STDSGMC-4**	0.0063	96.320	3.562	0.094	0.018	0.083566
37	**STDSGB-10**	0.0063	96.320	3.562	0.094	0.018	0.083566
38	**STDSGB-100**	0.0063	96.320	3.562	0.094	0.018	0.083566
39	**STDSGB-200**	0.0063	96.320	3.562	0.094	0.018	0.083566
40	**STDSGB-30**	0.0063	96.320	3.562	0.094	0.018	0.083566
41							
42	*** Am-241 percent calculated assuming secular equilibrium with Pu-241.**						