SRR-CWDA-2009-00045
Revision 1

F-TANK FARM WASTE TANK CLOSURE INVENTORY FOR USE IN PERFORMANCE ASSESSMENT MODELING

January 26, 2010

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Prepared for U.S. Department of Energy Under Contract No. DE-AC09-09SR22505

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ACRONYMS/ABBREVIATIONS

C&WDA	Closure and Waste Disposal Authority
DOE	U.S. Department of Energy
EPA	United States Environmental Protection Agency
FTF	F-Area Tank Farm
MOP	Member of the Public
NE	Not Estimated
PA	Performance Assessment
SRS	Savannah River Site
WCS	Waste Characterization System

1.0 SUMMARY

The Performance Assessment (PA) for the F-Area Tank Farm (FTF) at the Savannah River Site (SRS) is used to provide the U.S. Department of Energy (DOE) with a reasonable expectation that closure of the FTF Facility will meet defined performance objectives for the protection of the public and the environment. At the heart of the FTF PA is modeling of contaminant release from within operationally closed waste tanks and their impact on various receptors (e.g., a member of the public). Therefore the assumed quantity of contaminants is the starting point of this process. The steps to develop inventory of the residual contaminants are described within this document.

2.0 PURPOSE

The purpose of this document is to develop a reasonably bounding FTF inventory projection while taking into account uncertainties in the effectiveness of future tank cleaning technologies. The FTF inventory projection will be risk-informed to ensure consideration of dose impacts.

3.0 APPROACH

A methodical approach was used to construct estimates of FTF waste tank closure inventories to be used in PA modeling. Independent steps were developed to systematically construct the FTF tank inventories, with each step adjusting inventory either by tank or by radionuclide. The steps used in inventory development were as follows:

1. The initial list of radionuclides and chemicals to be included in the FTF tank inventories was established (Sections 4 and 5).
2. Additional radionuclides were added to the list of radionuclides of concern based on the potential for activation products being present (Section 4).
3. The list of radionuclides to be included was reduced based on short half life (Section 4).
4. The radionuclides and chemical inventories developed for Revision 0 of FTF PA were used as a starting point for the inventory of each individual waste tank. Waste Characterization System (WCS) was utilized in developing the FTF PA Revision 0 inventories. For the Type IV tanks, this included the contribution associated with corrosion products on the walls (excluding contaminant diffusion into the waste tank steel liner).
5. The waste tanks were binned according to waste tank type (Section 6).
6. Within each bin, the inventories were adjusted as applicable within that bin (Sections 6.1-6.4).
7. Within the Type IV Tank bin, the Tank 17 and Tank 20 inventories were left unchanged. The Tank 18 and Tank 19 inventories were revised to account for an increased level of uncertainty surrounding the residual inventories remaining after waste removal.
8. Due to future waste removal uncertainties (e.g., unknowns regarding the effectiveness of tank cleaning technologies), the initial individual tank inventories were increased one order of magnitude for the Type I and Type IIIA waste tanks.
9. To account for uncertainty surrounding future operations and movement of material within the FTF, the maximum concentration associated with an individual tank bin was applied to the other tanks within the bin for the Type I and IIIA waste tanks.

10. For those radionuclides with an individual tank inventory less than 1 Ci, the inventory was typically adjusted up to 1 Ci.
11. The Ra-226 and Th-230 inventories were revised (with respect to the FTF PA Revision 0 inventories) to better reflect the age of waste.

More detail regarding the rationale behind the individual steps and their precise effect on the resulting FTF tank inventory is provided in Section 4 (steps 1 - 3), Section 5 (steps 4 - 6), and Section 6 (steps 7 - 11). For example, while most adjustments were common across bins, not all adjustments were applied to all bins.

4.0 RADIONUCLIDES

The contaminant screening process consisted of several steps to arrive at an appropriate list of isotopes to be included in the FTF waste tank closure inventory estimates to be used in the FTF PA modeling.

An initial radionuclide screening process was developed and performed to evaluate 849 isotopes. [CBU-PIT-2005-00228] Following the steps described in detail in Appendix A, the list of isotopes to be evaluated was reduced to 159 isotopes of concern for the FTF PA modeling. The 159 isotopes are presented in the Table A.0-1

The 159 isotopes resulting from the initial screening were further evaluated to determine which isotopes could be eliminated from the initial inventory. This process eliminated 95 additional isotopes. The elimination process is described in Appendix B and presented in Table B.0-1.

Of the 64 isotopes remaining, four additional isotopes were eliminated from the FTF characterization because there is no history of their presence in the FTF. However, they may remain factors in the FTF PA modeling as daughter products from other isotopes in the characterization. Those isotopes are Cf-251, Cf-252, Ra-228, and Th-232. The final characterization contains 60 isotopes and they are presented in Table 4.0-1.

Table 4.0-1: Radionuclides of Concern Identified in FTF PA Revision 0

Ac-227	Cf-249	Cs-135	Ni-59	Pu-241	Sb-126m	Th-230
Al-26	Cm-242	Cs-137	Ni-63	Pu-242	Se-79	U-232
Am-241	Cm-243	Eu-152	Np-237	Pu-244	Sm-151	U-233
Am-242m	Cm-244	Eu-154	Pa-231	Ra-226	Sn-126	U-234
Am-243	Cm-245	Eu-155	Pm-147	Rh-106	Sr-90	U-235
Ba-137m	Cm-247	H-3	Pr-144	Ru-106	Tc-99	U-236
Bk-249	Cm-248	I-129	Pu-238	Sb-125	Te-125m	U-238
C-14	Co-60	Na-22	Pu-239	Sb-126	Th-229	Y-90
Ce-144	Cs-134	Nb-94	Pu-240			

4.1 Radionuclides Added

Several radionuclides were added to the radionuclides listed in Table 4.0-1. These additions were based on the possibility of that these radionuclides may have theoretically been created at various points of production in SRS history and screened against a simplified version of the FTF

Rev. 0 GoldSim model. These radionuclides are Cl-36, K-40, Nb-93m, Pd-107, Pt-193, and Zr-93.

These six radionuclides were added to the list of radionuclides of concern at inventories equivalent to the sample analysis detection capability. Due to the belief that minimal amounts of these radionuclides were created at worst, setting these at the detection capability was felt to be appropriate. This level was approximated at 1.0E-03 Ci.

4.2 Radionuclides Removed

Radionuclides with a half life of less than five years were removed from inventory estimates. This was based on the consideration that active institutional control over the closed waste tanks will be maintained for 100 years. Therefore any radionuclides with less than a five year half life would decrease to insignificant levels due to radioactive decay during the institutional control period. This does not apply to radionuclides that are part of a decay chain with a parent with a greater than five year half life.

The 12 radionuclides removed from further inventory estimates based on the five year half life criteria are as follows: Bk-249, Ce-144, Cm-242, Cs-134, Eu-155, Na-22, Pm-147, Pr-144, Rh-106, Ru-106, Sb-126, and Te-125m.

4.3 Radionuclides Inventories Estimated

Table 4.3-1 shows the radionuclides whose inventories were estimated for Revision 1 of the FTF PA. At the time of tank closure, sampling and analysis will be performed. During residual characterization for closure, radionuclides listed in Table 4.3-1 will be analyzed although it is expected that not all will be quantified. Those that are not detectable or below detection limits will be determined via special analysis (e.g., ratios to other radionuclides or fission yields) in order to conduct an appropriate comparison to the PA estimated residual inventory.

Table 4.3-1: Radionuclides of Concern for FTF PA Revision 1

Ac-227	Cm-243	Eu-154	Pa-231	Ra-226	Th-230
Al-26	Cm-244	H-3	Pd-107	Sb-126	U-232
Am-241	Cm-245	I-129	Pt-193	Sb-126m	U-233
Am-242m	Cm-247	K-40	Pu-238	Se-79	U-234
Am-243	Cm-248	Nb-93m	Pu-239	Sm-151	U-235
Ba-137m	Co-60	Nb-94	Pu-240	Sn-126	U-236
C-14	Cs-135	Ni-59	Pu-241	Sr-90	U-238
Cf-249	Cs-137	Ni-63	Pu-242	Tc-99	Y-90
Cl-36	Eu-152	Np-237	Pu-244	Th-229	Zr-93

5.0 CHEMICALS

This inventory used as a starting point the chemicals included in Revision 0 of the FTF PA. [SRS-REG-2007-00002_OUO] The chemicals of concern are listed in Table 5.0-1. These are the chemicals that will be characterized during final closure for each tank.

Table 5.0-1: Chemicals Used in Revision 1

Ag	F	NO_3
As	Fe	Pb
Ba	Hg	Sb
Cd	Mn	Se
Cr	Ni	U
Cu	NO_2	Zn

6.0 TANK GROUPINGS AND ADJUSTMENTS

The waste tanks were grouped based on use and design. Inventory adjustments occurred within the grouping.

The tank type generally had an effect on the type of waste received and therefore guided the group selection. In general, each waste tank was built at approximately the same time as others of the same type. In addition, the tanks built within a specific time frame were built in close proximity to each other.

6.1 Type I

The Type I tank grouping consists of Tanks 1-8. These tanks are the oldest tanks within the FTF and provided the initial storage for SRS following the initial startup.

6.1.1 Residual Inventory Uncertainty

An adjustment to the inventory estimates was made by multiplying by a factor of 10 to provide for greater uncertainties in the residual inventories from the planned waste removal operation. Based on recent waste removal activities in Tanks 5 and 6, there is uncertainty around the projected inventories for the waste tanks remaining to be cleaned. To account for this uncertainty and ensure that the PA would provide a reasonable bounding inventory projection, the existing inventories were multiplied by a factor of 10. This adjustment was made to radionuclides and chemicals.

6.1.2 Nominal Activities for Radionuclides

For a majority of the radionuclides with an adjusted inventory less than 1 Ci, their inventories were adjusted to either 1 Ci or the analytical detection limit (1.0E-03 Ci). To allow for more efficient and cost effective means of confirming concentrations within residual materials for radionuclides with a limited potential impact to dose. For those radionuclides that have been observed (through previous analyses or scoping studies) to have greater potential impact on the overall dose, the inventory was adjusted to the analytical detection limit. The following radionuclides fit into this category, Ac-227, Cm-247, Cm-248, I-129, Nb-94, Pa-231, and Pu-244. Note, those radionuclides with adjusted inventories greater than 1 Ci were not adjusted

in this step. This adjustment only applied to the radionuclide inventories and not the chemical inventories.

The inventory variability proposed to be used for these estimates (which are not adjusted by further steps) in probabilistic analyses is to assume that the inventory uncertainty fits a uniform distribution, with the adjusted reasonably bounding estimate as the maximum and the minimum set two orders of magnitude below than the estimate. Table 9.0-4 lists the estimate variabilities.

6.1.2.1 Ra-226 and Th-230 Equilibriums

The inventory estimates for both Ra-226 and Th-230 were revised from the overly conservative estimates included in Revision 0 of the FTF PA. The initial Revision 0 estimates assumed that these radionuclides were in full transient equilibrium with the parent U-234. This assumption is extremely conservative; therefore a more reasonable estimate was made assuming a decay in-growth period of 70 years. Although this estimate was more reasonable, the resulting inventory value fell below the detection level capability. Therefore, the inventory estimate for both Ra-226 and Th-230 were adjusted to the minimum detection level. [SRS-REG-2007-00002_OUO]

6.1.3 Future Operations

Within the Type I waste tank group, the maximum waste tank inventory for any one tank was used to estimate inventory for the other waste tanks within the grouping. As each waste tank is closed, the waste removed from within the tank during waste removal will be transferred to other tanks. In most cases, this transfer will be to another tank of the same type. So the material in one tank will typically pass through other tanks of the same type prior to exiting the FTF. Due to the uncertain order of tank waste removal and closure activities, the maximum inventory concentrations associated with an individual tank within a tank group were applied to the other tanks within the bin. The maximum adjusted inventory, to this point, was used for all tanks within the Type I waste tank group. This adjustment was made to radionuclides and chemicals.

The inventory variability proposed to be used for these estimates (which are not adjusted by further steps) in probabilistic analyses is to assume that the inventory uncertainty fits a uniform distribution, with the adjusted reasonably bounding estimate as the maximum and the minimum set two orders of magnitude below than the estimate. Table 9.0-4 lists the estimate variabilities.

6.2 Type IV

The Type IV tank grouping consists of Tanks 17-20.

6.2.1 Tanks 17 and 20

Tanks 17 and 20 have been closed and grouted. During closure activities, the residual material within Tanks 17 and 20 was sampled and analyzed. This analysis provided the basis for estimates of the residual material. The Tanks 17 and 20 residual estimates were used exclusively, with no other adjustments were made.

The inventory variability proposed to be used for Tanks 17 and 20 in probabilistic analyses is to assume that the inventory uncertainty fits a normal distribution, with the estimate set as the mean and the standard deviation set at 0.5. Table 9.0-4 lists the estimate variabilities.

6.2.2 Tanks 18 and 19

The Tanks 18 and 19 inventory estimates are based on concentrations documented in residual characterization reports (U-TR-F-00005 and WSRC-TR-2002-00052), with the total final inventories adjusted to reflect the bounding waste residual estimates (i.e., 5,000 gallon for Tank 18 and 3,000 gallon for Tank 19). The final inventory estimates for Tanks 18 and 19 apply the bounding waste residual floor estimates while allowing the corrosion product estimates to remain unchanged from Revision 0 of the FTF PA.

Calculating the inventory contained within the corrosion products (excluding contaminant diffusion into the waste tank steel liner) required an estimate of the K_d value used for estimating the uranium content in the tank walls' corrosion products. This value was 600 L/kg. An evaluation was performed to determine the appropriate value to use for the SRS tanks not cleaned with oxalic acid. [WSRC-STI-2007-00684] Due to the high pH environment present in the waste tanks, high ionic strength, and moderately high carbonate concentrations, the adsorption of the uranium ion to the rust surfaces was expected to be two or three orders of magnitude less than the 6,000 L/kg value previous used. In the absence of additional data, a decrease of only one order of magnitude was chosen to provide a conservative uranium inventory in the corrosion products.

Diffusion of contaminates into the steel liners was consider negligible. A comparison of the amount of material diffused into the transfer lines to the amount of material estimated in the corrosion products was performed. This comparison demonstrated the estimate quantity of material in the corrosion products exceeded that which diffused into the steel liners. Therefore there was no estimate of material diffused into the steel liners.

The inventory variability proposed to be used for Tanks 18 and 19 in probabilistic analyses is to assume that the inventory uncertainty fits a uniform distribution, with the adjusted reasonably bounding estimate with the maximum twice that of the estimate and the minimum half of the estimate. Table 9.0-4 lists the estimate variabilities.

6.2.2.1 Nominal Activities for Radionuclides

For a majority of the radionuclides with an adjusted inventory less than 1 Ci, their inventories were adjusted to either 1 Ci or the analytical detection limit (1.0E-03 Ci). This allows for more efficient and cost effective means of confirming concentrations within residual materials for radionuclides with a limited potential impact to dose. For those radionuclides that have been observed (through previous analyses or scoping studies) to have greater potential impact on the overall dose, the inventory was adjusted to the analytical detection limit. The following radionuclides fit into this category, Ac-227, Cm-247, Cm-248, I-129, Nb-94, Pa-231, and Pu-244. Note, those radionuclides with adjusted inventories greater than 1 Ci were not adjusted in this step. This adjustment only applied to the radionuclide inventories and not the chemical inventories.

Based on recent preliminary sample results, the estimates for Am-243, Cs-135, and Np-237 (Tank 18 only) were further adjusted higher to insure the estimates used are reasonably bounding.

The inventory variability used for these estimates (which are not adjusted by further steps) in probabilistic analyses is to assume that the inventory uncertainty fits a uniform distribution, with the adjusted reasonably bounding estimate as the maximum and the minimum set two orders of magnitude below than the estimate. Table 9.0-4 lists the estimate variabilities.

6.2.2.1.1 Ra-226 and Th-230 Equilibriums

The inventory estimates for both Ra-226 and Th-230 were revised from the overly conservative estimates included in Revision 0 of the FTF PA. The initial Revision 0 estimates assumed that these radionuclides were in full transient equilibrium with the parent U-234. This assumption is extremely conservative; therefore a more reasonable estimate was made assuming a decay in-growth period of 70 years. Although this estimate was more reasonable, the resulting inventory value fell below the detection level capability. Therefore, the inventory estimate for both Ra-226 and Th-230 were adjusted to the minimum detection level.

6.3 Type IIIA

The Type IIIA tank grouping consists of Tanks 25-28 and 44-47.

6.3.1 Residual Inventories Uncertainty

An adjustment to the inventory estimates was made by multiplying by a factor of 10 to provide for greater uncertainties in the residual inventories from the planned waste removal operation. Based on recent waste removal activities in Tanks 5 and 6, there is uncertainty around the projected inventories for the waste tanks remaining to be cleaned. To account for this uncertainty and ensure that the PA would provide a reasonable bounding inventory projection, the existing inventories were multiplied by a factor of 10. This adjustment was made to radionuclides and chemicals.

6.3.2 Nominal Activities for Radionuclides

For a majority of the radionuclides with an adjusted inventory less than 1 Ci, their inventories were adjusted to either 1 Ci or the analytical detection limit (1.0E-03 Ci). To allow for more efficient and cost effective means of confirming concentrations within residual materials for radionuclides with a limited potential impact to dose. For those radionuclides that have been observed (through previous analyses or scoping studies) to have greater potential impact on the overall dose, the inventory was adjusted to the analytical detection limit. The following radionuclides fit into this category, Ac-227, Cm-247, Cm-248, I-129, Nb-94, Pa-231, and Pu-244. Note, those radionuclides with adjusted inventories greater than 1 Ci were not adjusted in this step. This adjustment only applied to the radionuclide inventories and not the chemical inventories.

The inventory variability proposed to be used for these estimates (which are not adjusted by further steps) in probabilistic analyses is to assume that the inventory uncertainty fits a uniform distribution, with the adjusted reasonably bounding estimate as the maximum and

the minimum set two orders of magnitude below than the estimate. Table 9.0-4 lists the estimate variabilities.

6.3.2.1 Ra-226 and Th-230 Equilibriums

The inventory estimates for both Ra-226 and Th-230 were revised from the overly conservative estimates included in Revision 0 of the FTF PA. The initial Revision 0 estimates assumed that these radionuclides were in full transient equilibrium with the parent U-234. This assumption is extremely conservative; therefore a more reasonable estimate was made assuming a decay in-growth period of 70 years. Although this estimate was more reasonable, the resulting inventory value fell below the detection level capability. Therefore, the inventory estimate for both Ra-226 and Th-230 were adjusted to the minimum detection level.

6.3.3 Future Operations

Within the Type IIIA waste tank group, the maximum waste tank inventory for any one tank was used to estimate inventory for the other waste tanks within the grouping. As each waste tank is closed, the waste removed from within the tank during waste removal will be transferred to other tanks. In most case, this transfer will be to another tank of the same type. So the material in one tank will typically pass through other tanks of the same type prior to exiting the FTF. Due to the uncertain order of tank waste removal and closure activities, the maximum inventory concentrations associated with an individual tank within a tank group were applied to the other tanks within the bin. The maximum adjusted inventory, to this point, was used for all tanks within the Type IIIA waste tank group. This adjustment was made to radionuclides and chemicals.

The inventory variability proposed to be used for these estimates (which are not adjusted by further steps) in probabilistic analyses is to assume that the inventory uncertainty fits a uniform distribution, with the adjusted reasonably bounding estimate as the maximum and the minimum set two orders of magnitude below than the estimate. Table 9.0-4 lists the estimate variabilities.

6.4 Type III

The Type III tank grouping consists of Tanks 33 and 34.

6.4.1 Nominal Activities for Radionuclides

For a majority of the radionuclides with an adjusted inventory less than 1 Ci, their inventories were adjusted to either 1 Ci or the analytical detection limit (1.0E-03 Ci). To allow for more efficient and cost effective means of confirming concentrations within residual materials for radionuclides with a limited potential impact to dose. For those radionuclides that have been observed (through previous analyses or scoping studies) to have greater potential impact on the overall dose, the inventory was adjusted to the analytical detection limit. The following radionuclides fit into this category, Ac-227, Cm-247, Cm-248, I-129, Nb-94, Pa-231, and Pu-244. Note, those radionuclides with adjusted inventories greater than 1 Ci were not adjusted in this step. This adjustment only applied to the radionuclide inventories and not the chemical inventories.

The inventory variability proposed to be used for these estimates (which are not adjusted by further steps) in probabilistic analyses is to assume that the inventory uncertainty fits a uniform distribution, with the adjusted reasonably bounding estimate as the maximum and the minimum set two orders of magnitude below than the estimate. Table 9.0-4 lists the estimate variabilities.

6.4.1.1 Ra-226 and Th-230 Equilibriums

The inventory estimates for both Ra-226 and Th-230 were revised from the overly conservative estimates included in Revision 0 of the FTF PA. The initial Revision 0 estimates assumed that these radionuclides were in full transient equilibrium with the parent U-234. This assumption is extremely conservative; therefore a more reasonable estimate was made assuming a decay in-growth period of 70 years. Although this estimate was more reasonable, the resulting inventory value fell below the detection level capability. Therefore, the inventory estimate for both Ra-226 and Th-230 were adjusted to the minimum detection level.

7.0 DECAY DATE

All waste tank inventories have been decayed to September 30, 2020, which is reasonable based on current planning bases for FTF.

8.0 INTRUDER INVENTORY FOR SENSITIVITY RUN

For the intruder sensitivity scenarios, an inventory was estimated using Tank 18 has the basis tank. The residual material was assumed to be uniformly distributed across the tank floor and have a volume of 5,000 gallon. The well diameter was assumed to be 8 inches. The waste tank inventory used for well drilling scenarios for the sensitivity case is provided in Table 9.0-3.

9.0 INVENTORY TABLES

The FTF radionuclide inventories used for the FTF modeling activities are listed in Table 9.0-1 and the FTF chemical inventories are listed in Table 9.0-2.

Table 9.0-1: FTF Radionuclide Inventories (Ci)

	1	2	3	4	5	6	7	8
Ac-227	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Al-26	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Am-241	6.0E+02	6.0E+02	6.0E+02	6.0E+02	6.0E+02	6.0E+02	6.0E+02	6.0E+02
Am-242m	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Am-243	1.4E+00	1.4E+00	1.4E+00	1.4E+00	1.4E+00	1.4E+00	1.4E+00	1.4E+00
Ba-137m	8.7E+03	8.7E+03	8.7E+03	8.7E+03	8.7E+03	8.7E+03	8.7E+03	8.7E+03
C-14	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Cf-249	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Cl-36	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Cm-243	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Cm-244	1.2E+02	1.2E+02	1.2E+02	1.2E+02	1.2E+02	1.2E+02	1.2E+02	1.2E+02
Cm-245	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Cm-247	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Cm-248	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Co-60	1.8E+01	1.8E+01	1.8E+01	1.8E+01	1.8E+01	1.8E+01	1.8E+01	1.8E+01
Cs-135	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Cs-137	9.2E+03	9.2E+03	9.2E+03	9.2E+03	9.2E+03	9.2E+03	9.2E+03	9.2E+03
Eu-152	1.9E+01	1.9E+01	1.9E+01	1.9E+01	1.9E+01	1.9E+01	1.9E+01	1.9E+01
Eu-154	1.3E+02	1.3E+02	1.3E+02	1.3E+02	1.3E+02	1.3E+02	1.3E+02	1.3E+02
H-3	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
I-129	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
K-40	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Nb-93m	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Nb-94	1.0E+00	1.0E-03	1.0E-03	1.0E-03	1.0E+00	1.0E+00	1.0E-03	1.0E-03
Ni-59	6.3E+00	6.3E+00	6.3E+00	6.3E+00	6.3E+00	6.3E+00	6.3E+00	6.3E+00
Ni-63	4.9E+02	4.9E+02	4.9E+02	4.9E+02	4.9E+02	4.9E+02	4.9E+02	4.9E+02
Np-237	2.3E-01	2.3E-01	2.3E-01	2.3E-01	2.3E-01	2.3E-01	2.3E-01	2.3E-01
Pa-231	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Pd-107	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Pt-193	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Pu-238	1.4E+02	1.4E+02	1.4E+02	1.4E+02	1.4E+02	1.4E+02	1.4E+02	1.4E+02
Pu-239	3.2E+01	3.2E+01	3.2E+01	3.2E+01	3.2E+01	3.2E+01	3.2E+01	3.2E+01
Pu-240	7.2E+00	7.2E+00	7.2E+00	7.2E+00	7.2E+00	7.2E+00	7.2E+00	7.2E+00
Pu-241	3.2E+01	3.2E+01	3.2E+01	3.2E+01	3.2E+01	3.2E+01	3.2E+01	3.2E+01
Pu-242	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Pu-244	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Ra-226	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Sb-126	9.4E-02	2.5E-02	2.1E-02	2.5E-02	9.9E-02	1.2E-01	3.0E-03	7.1E-03
Sb-126m	6.7E-01	1.8E-01	1.5E-01	1.8E-01	7.1E-01	8.4E-01	2.1E-02	5.1E-02
Se-79	4.5E+00	4.5E+00	4.5E+00	4.5E+00	4.5E+00	4.5E+00	4.5E+00	4.5E+00
Sm-151	1.2E+04	1.2E+04	1.2E+04	1.2E+04	1.2E+04	1.2E+04	1.2E+04	1.2E+04
Sn-126	6.7E-01	1.8E-01	1.5E-01	1.8E-01	7.1E-01	8.4E-01	2.1E-02	5.1E-02
Sr-90	1.3E+05	1.3E+05	1.3E+05	1.3E+05	1.3E+05	1.3E+05	1.3E+05	1.3E+05
Tc-99	7.9E+01	7.9E+01	7.9E+01	7.9E+01	7.9E+01	7.9E+01	7.9E+01	7.9E+01
Th-229	2.4E-01	2.4E-01	2.4E-01	2.4E-01	2.4E-01	2.4E-01	2.4E-01	2.4E-01
Th-230	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
U-232	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
U-233	2.3E-01	2.3E-01	2.3E-01	2.3E-01	2.3E-01	2.3E-01	2.3E-01	2.3E-01
U-234	1.7E-01	1.7E-01	1.7E-01	1.7E-01	1.7E-01	1.7E-01	1.7E-01	1.7E-01
U-235	5.8E-03	5.8E-03	5.8E-03	5.8E-03	5.8E-03	5.8E-03	5.8E-03	5.8E-03
U-236	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
U-238	1.7E-01	1.7E-01	1.7E-01	1.7E-01	1.7E-01	1.7E-01	1.7E-01	1.7E-01
Y-90	1.3E+05	1.3E+05	1.3E+05	1.3E+05	1.3E+05	1.3E+05	1.3E+05	1.3E+05
Zr-93	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03

Table 9.0-1: FTF Radionuclide Inventories (Ci) (Continued)

	17	18	19	20	25	26	27	28
Ac-227	NE	1.0E-03	1.0E-03	NE	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Al-26	NE	1.0E+00	1.0E+00	NE	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Am-241	8.4E+00	8.2E+01	2.3E+00	1.6E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Am-242m	NE	1.0E+00	1.0E+00	NE	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Am-243	NE	1.0E-01	1.0E-01	NE	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Ba-137m	1.0E+01	9.1E+03	6.2E+03	2.3E+01	4.9E+03	4.9E+03	4.9E+03	4.9E+03
C-14	3.1E-03	1.0E+00	1.0E+00	6.6E-04	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Cf-249	NE	1.0E+00	1.0E+00	NE	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Cl-36	NE	1.0E-03	1.0E-03	NE	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Cm-243	NE	1.0E+00	1.0E+00	NE	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Cm-244	2.9E-04	1.0E+02	1.0E+00	NE	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Cm-245	4.4E-10	1.0E+00	1.0E+00	NE	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Cm-247	NE	1.0E-03	1.0E-03	NE	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Cm-248	NE	1.0E-03	1.0E-03	NE	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Co-60	3.4E-02	1.0E+00	1.0E+00	4.8E-03	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Cs-135	1.7E-04	1.0E+00	1.0E+00	3.6E-05	1.0E+00	1.0E-03	1.0E+00	1.0E-03
Cs-137	1.1E+01	9.7E+03	6.5E+03	2.4E+01	5.2E+03	5.2E+03	5.2E+03	5.2E+03
Eu-152	NE	1.0E+00	1.0E+00	NE	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Eu-154	2.3E-02	3.2E+00	1.0E+00	1.6E-01	2.9E+00	2.9E+00	2.9E+00	2.9E+00
H-3	5.8E+00	1.0E+00	1.0E+00	NE	1.0E+00	1.0E+00	1.0E+00	1.0E+00
I-129	1.3E-06	1.0E-03	1.0E-03	2.6E-07	1.0E-03	1.0E-03	1.0E-03	1.0E-03
K-40	NE	1.0E-03	1.0E-03	NE	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Nb-93m	NE	1.0E-03	1.0E-03	NE	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Nb-94	NE	1.0E-03	1.0E-03	NE	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Ni-59	1.8E-01	1.0E+00	1.0E+00	3.9E-02	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Ni-63	NE	8.2E+01	1.4E+01	NE	2.4E+01	2.4E+01	2.4E+01	2.4E+01
Np-237	1.4E-02	2.4E-01	2.2E-03	7.2E-04	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Pa-231	NE	1.0E-03	1.0E-03	NE	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Pd-107	NE	1.0E-03	1.0E-03	NE	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Pt-193	NE	1.0E-03	1.0E+00	NE	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Pu-238	5.4E+01	7.0E+01	4.4E+00	6.1E+00	1.2E+02	1.2E+02	1.2E+02	1.2E+02
Pu-239	1.5E+01	1.6E+02	6.4E+00	8.5E-01	2.2E+01	2.2E+01	2.2E+01	2.2E+01
Pu-240	3.4E+00	4.9E+01	2.3E+00	1.8E-01	4.8E+00	4.8E+00	4.8E+00	4.8E+00
Pu-241	9.3E+01	1.3E+02	4.6E+00	1.6E+01	5.4E+01	5.4E+01	5.4E+01	5.4E+01
Pu-242	5.3E-03	1.0E+00	1.0E+00	1.6E-03	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Pu-244	NE	1.0E-03	1.0E-03	NE	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Ra-226	NE	1.9E-03	1.1E-03	NE	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Sb-126	4.0E-03	2.3E-02	3.6E-03	8.3E-04	3.3E-04	5.9E-04	2.7E-04	5.9E-04
Sb-126m	2.8E-02	1.6E-01	2.6E-02	5.9E-03	2.4E-03	4.2E-03	2.0E-03	4.2E-03
Se-79	1.6E-02	1.0E+00	1.0E+00	3.2E-03	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Sm-151	NE	4.6E+01	1.0E+00	NE	7.1E+01	7.1E+01	7.1E+01	7.1E+01
Sn-126	2.8E-02	1.6E-01	2.6E-02	5.9E-03	2.4E-03	4.2E-03	2.0E-03	4.2E-03
Sr-90	6.6E+01	1.1E+03	5.2E+00	2.3E+01	1.0E+03	1.0E+03	1.0E+03	1.0E+03
Tc-99	9.0E-01	1.0E+00	1.4E+00	8.5E-01	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Th-229	NE	2.6E-03	1.0E-03	NE	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Th-230	NE	1.9E-03	1.1E-03	NE	1.0E-03	1.0E-03	1.0E-03	1.0E-03
U-232	3.7E-05	1.0E+00	1.0E+00	8.0E-06	1.0E+00	1.0E+00	1.0E+00	1.0E+00
U-233	NE	1.1E+00	1.9E-01	NE	1.0E-03	1.0E-03	1.0E-03	1.0E-03
U-234	NE	3.8E-01	1.1E-02	NE	2.6E-02	2.6E-02	2.6E-02	2.6E-02
U-235	3.0E-04	8.4E-03	2.6E-04	1.9E-05	1.0E-03	1.0E-03	1.0E-03	1.0E-03
U-236	NE	1.0E+00	1.0E+00	2.7E-05	1.0E+00	1.0E+00	1.0E+00	1.0E+00
U-238	6.4E-03	2.2E-01	8.7E-03	5.6E-04	2.6E-02	2.6E-02	2.6E-02	2.6E-02
Y-90	6.6E+01	1.1E+03	5.2E+00	2.3E+01	1.0E+03	1.0E+03	1.0E+03	1.0E+03
Zr-93	NE	1.0E-03	1.0E-03	NE	1.0E-03	1.0E-03	1.0E-03	1.0E-03

NE – Not Estimated

Table 9.0-1: FTF Radionuclide Inventories (Ci) (Continued)

	33	34	44	45	46	47
Ac-227	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Al-26	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Am-241	6.3E+01	1.6E+03	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Am-242m	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Am-243	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Ba-137m	9.0E+02	3.7E+03	4.9E+03	4.9E+03	4.9E+03	4.9E+03
C-14	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Cf-249	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Cl-36	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Cm-243	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Cm-244	1.0E+00	1.0E+00	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Cm-245	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Cm-247	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Cm-248	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Co-60	1.7E+01	4.7E+01	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Cs-135	1.0E+00	1.0E+00	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Cs-137	9.5E+02	3.9E+03	5.2E+03	5.2E+03	5.2E+03	5.2E+03
Eu-152	3.5E+00	1.3E+01	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Eu-154	4.3E+01	1.4E+02	2.9E+00	2.9E+00	2.9E+00	2.9E+00
H-3	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
I-129	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
K-40	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Nb-93m	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Nb-94	1.0E+00	1.0E+00	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Ni-59	1.0E+00	1.8E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Ni-63	3.8E+01	1.6E+02	2.4E+01	2.4E+01	2.4E+01	2.4E+01
Np-237	2.5E-02	6.8E-02	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Pa-231	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Pd-107	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Pt-193	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Pu-238	3.6E+01	1.0E+00	1.2E+02	1.2E+02	1.2E+02	1.2E+02
Pu-239	2.2E+01	1.4E+01	2.2E+01	2.2E+01	2.2E+01	2.2E+01
Pu-240	3.9E+00	3.2E+00	4.8E+00	4.8E+00	4.8E+00	4.8E+00
Pu-241	5.5E+01	3.1E+01	5.4E+01	5.4E+01	5.4E+01	5.4E+01
Pu-242	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Pu-244	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Ra-226	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Sb-126	7.7E-02	3.4E-01	5.9E-04	5.9E-04	5.9E-04	5.9E-04
Sb-126m	5.5E-01	2.4E+00	4.2E-03	4.2E-03	4.2E-03	4.2E-03
Se-79	1.0E+00	1.3E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Sm-151	9.3E+02	4.0E+03	7.1E+01	7.1E+01	7.1E+01	7.1E+01
Sn-126	5.5E-01	2.4E+00	4.2E-03	4.2E-03	4.2E-03	4.2E-03
Sr-90	1.4E+04	5.5E+04	1.0E+03	1.0E+03	1.0E+03	1.0E+03
Tc-99	5.1E+00	2.2E+01	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Th-229	2.6E-02	7.1E-02	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Th-230	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
U-232	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
U-233	2.5E-02	6.8E-02	1.0E-03	1.0E-03	1.0E-03	1.0E-03
U-234	7.9E-02	8.8E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02
U-235	1.0E-03	1.2E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
U-236	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
U-238	7.9E-02	8.8E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02
Y-90	1.4E+04	5.5E+04	1.0E+03	1.0E+03	1.0E+03	1.0E+03
Zr-93	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03

Table 9.0-2: FTF Chemical Inventories (Kg)

	1	2	3	4	5	6	7	8	17	18	19
Ag	5.9E+00	5.9E+00	5.9E+00	5.9E+00	5.9E+00	5.9E+00	5.9E+00	5.9E+00	6.6E+00	3.2E+00	1.2E+00
As	4.5E-02	4.5E-02	4.5E-02	4.5E-02	4.5E-02	4.5E-02	4.5E-02	4.5E-02	NE	8.2E-01	9.7E-01
Ba	1.3E+01	1.3E+01	1.3E+01	1.3E+01	1.3E+01	1.3E+01	1.3E+01	1.3E+01	3.9E+00	3.8E+00	9.9E+00
Cd	4.7E+00	4.7E+00	4.7E+00	4.7E+00	4.7E+00	4.7E+00	4.7E+00	4.7E+00	1.8E+01	1.2E+02	1.1E+00
Cr	9.7E+00	9.7E+00	9.7E+00	9.7E+00	9.7E+00	9.7E+00	9.7E+00	9.7E+00	4.7E+00	1.1E+01	4.2E+00
Cu	3.9E+00	3.9E+00	3.9E+00	3.9E+00	3.9E+00	3.9E+00	3.9E+00	3.9E+00	3.3E+00	5.1E+00	5.1E-01
F	2.9E+00	2.9E+00	2.9E+00	2.9E+00	2.9E+00	2.9E+00	2.9E+00	2.9E+00	3.5E+00	7.2E-01	1.8E+01
Fe	8.1E+02	8.1E+02	8.1E+02	8.1E+02	8.1E+02	8.1E+02	8.1E+02	8.1E+02	5.4E+02	1.7E+03	2.1E+02
Hg	6.3E+00	6.3E+00	6.3E+00	6.3E+00	6.3E+00	6.3E+00	6.3E+00	6.3E+00	1.4E+00	2.0E+01	2.0E+00
Mn	5.7E+02	5.7E+02	5.7E+02	5.7E+02	5.7E+02	5.7E+02	5.7E+02	5.7E+02	4.8E+01	2.1E+02	1.5E+01
Ni	3.1E+02	3.1E+02	3.1E+02	3.1E+02	3.1E+02	3.1E+02	3.1E+02	3.1E+02	8.3E-01	1.9E+01	1.6E+00
NO_2	4.3E+01	4.3E+01	4.3E+01	4.3E+01	4.3E+01	4.3E+01	4.3E+01	4.3E+01	NE	7.8E+00	5.5E+02
NO_3	9.0E+02	9.0E+02	9.0E+02	9.0E+02	9.0E+02	9.0E+02	9.0E+02	9.0E+02	NE	4.6E+00	3.8E+02
Pb	1.3E+01	1.3E+01	1.3E+01	1.3E+01	1.3E+01	1.3E+01	1.3E+01	1.3E+01	5.5E+00	4.0E+01	5.3E+00
Sb	1.9E+00	1.9E+00	1.9E+00	1.9E+00	1.9E+00	1.9E+00	1.9E+00	1.9E+00	NE	2.5E+01	2.2E+01
Se	3.6E-02	3.6E-02	3.6E-02	3.6E-02	3.6E-02	3.6E-02	3.6E-02	3.6E-02	NE	8.2E-01	8.8E+00
U	5.1E+02	5.1E+02	5.1E+02	5.1E+02	5.1E+02	5.1E+02	5.1E+02	5.1E+02	5.6E+01	5.4E+02	1.9E+01
Zn	7.1E+00	7.1E+00	7.1E+00	7.1E+00	7.1E+00	7.1E+00	7.1E+00	7.1E+00	6.6E+00	9.0E+00	7.1E-01
	20	**25**	**26**	**27**	**28**	**33**	**34**	**44**	**45**	**46**	**47**
Ag	3.1E+00	3.7E+00	3.7E+00	3.7E+00	3.7E+00	9.5E-01	6.0E-01	3.7E+00	3.7E+00	3.7E+00	3.7E+00
As	NE	1.5E-02	1.5E-02	1.5E-02	1.5E-02	7.4E-03	1.2E-02	1.5E-02	1.5E-02	1.5E-02	1.5E-02
Ba	1.8E+00	2.2E+00	2.2E+00	2.2E+00	2.2E+00	1.6E+00	4.5E+00	2.2E+00	2.2E+00	2.2E+00	2.2E+00
Cd	1.8E+00	1.6E+00	1.6E+00	1.6E+00	1.6E+00	7.8E-01	1.3E+00	1.6E+00	1.6E+00	1.6E+00	1.6E+00
Cr	2.5E+00	2.6E+00	2.6E+00	2.6E+00	2.6E+00	1.4E+00	3.3E+00	2.6E+00	2.6E+00	2.6E+00	2.6E+00
Cu	1.5E+00	1.8E+00	1.8E+00	1.8E+00	1.8E+00	6.4E-01	9.7E-01	1.8E+00	1.8E+00	1.8E+00	1.8E+00
F	2.4E+01	1.9E+00	1.9E+00	1.9E+00	1.9E+00	4.7E-01	1.8E-01	1.9E+00	1.9E+00	1.9E+00	1.9E+00
Fe	2.5E+02	3.0E+02	3.0E+02	3.0E+02	3.0E+02	1.2E+02	2.4E+02	3.0E+02	3.0E+02	3.0E+02	3.0E+02
Hg	6.3E-01	7.6E-01	7.6E-01	7.6E-01	7.6E-01	6.9E-01	2.2E+00	7.6E-01	7.6E-01	7.6E-01	7.6E-01
Mn	1.2E+01	5.7E+01	5.7E+01	5.7E+01	5.7E+01	1.3E+00	1.2E-01	5.7E+01	5.7E+01	5.7E+01	5.7E+01
Ni	8.0E-01	6.8E+02	6.8E+02	6.8E+02	6.8E+02	1.1E+01	6.8E+01	6.8E+02	6.8E+02	6.8E+02	6.8E+02
NO_2	1.7E+01	2.0E+01	2.0E+01	2.0E+01	2.0E+01	7.0E+00	1.1E+01	2.0E+01	2.0E+01	2.0E+01	2.0E+01
NO_3	NE	6.8E+02	6.8E+02	6.8E+02	6.8E+02	3.8E+01	6.3E+01	6.8E+02	6.8E+02	6.8E+02	6.8E+02
Pb	2.6E+00	3.9E+01	3.9E+01	3.9E+01	3.9E+01	1.7E+00	4.3E+00	3.9E+01	3.9E+01	3.9E+01	3.9E+01
Sb	NE	6.4E-01	6.4E-01	6.4E-01	6.4E-01	3.1E-01	5.1E-01	6.4E-01	6.4E-01	6.4E-01	6.4E-01
Se	NE	1.2E-02	1.2E-02	1.2E-02	1.2E-02	5.9E-03	9.6E-03	1.2E-02	1.2E-02	1.2E-02	1.2E-02
U	1.7E+01	7.7E+01	7.7E+01	7.7E+01	7.7E+01	2.3E+02	2.5E+02	7.7E+01	7.7E+01	7.7E+01	7.7E+01
Zn	3.1E+00	3.7E+00	3.7E+00	3.7E+00	3.7E+00	1.2E+00	1.5E+00	3.7E+00	3.7E+00	3.7E+00	3.7E+00

Table 9.0-3: Tank 18 Intruder Inventory

Tank 18			
Radionuclide	**Ci**	**Chemical**	**kg**
Ac-227	6.2E-08	Ag	1.9E-04
Al-26	6.2E-05	As	5.0E-05
Am-241	5.0E-03	Ba	2.3E-04
Am-242m	6.2E-05	Cd	7.2E-03
Am-243	6.2E-08	Cr	6.9E-04
Ba-137m	5.6E-01	Cu	3.1E-04
C-14	6.2E-05	F	4.4E-05
Cf-249	6.2E-05	Fe	1.1E-01
Cl-36	6.2E-08	Hg	1.2E-03
Cm-243	6.2E-05	Mn	1.3E-02
Cm-244	6.2E-03	Ni	1.2E-03
Cm-245	6.2E-05	NO_2	4.8E-04
Cm-247	6.2E-08	NO_3	2.9E-04
Cm-248	6.2E-08	Pb	2.5E-03
Co-60	6.2E-05	Sb	1.5E-03
Cs-135	6.2E-08	Se	5.0E-05
Cs-137	5.9E-01	U	3.4E-02
Eu-152	6.2E-05	Zn	5.5E-04
Eu-154	1.9E-04		
H-3	6.2E-05		
I-129	6.2E-08		
K-40	6.2E-08		
Nb-93m	6.2E-08		
Nb-94	6.2E-08		
Ni-59	6.2E-05		
Ni-63	5.1E-03		
Np-237	7.1E-06		
Pa-231	6.2E-08		
Pd-107	6.2E-08		
Pt-193	6.2E-08		
Pu-238	4.3E-03		
Pu-239	9.6E-03		
Pu-240	3.0E-03		
Pu-241	7.8E-03		
Pu-242	6.2E-05		
Pu-244	6.2E-08		
Ra-226	1.2E-07		
Sb-126	1.4E-06		
Sb-126m	9.9E-06		
Se-79	6.2E-05		
Sm-151	2.8E-03		
Sn-126	9.9E-06		
Sr-90	6.6E-02		
Tc-99	6.2E-05		
Th-229	1.6E-07		
Th-230	1.2E-07		
U-232	6.2E-05		
U-233	6.9E-05		
U-234	2.3E-05		
U-235	5.2E-07		
U-236	6.2E-05		
U-238	1.3E-05		
Y-90	6.6E-02		
Zr-93	6.2E-08		

Table 9.0-4: FTF Radionuclide Inventory Stochastics

	Type I		Tank 18		Tank 19		Type IIIA		Tank 33		Tank 34	
Distribution	**Uniform**		**Uniform**		**Uniform**		**Uniform**		**Uniform**		**Uniform**	
Isotope	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Ac-227	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Al-26	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Am-241	0.01	10	0.5	2	0.5	2	0.01	1	0.1	10	0.1	10
Am-242m	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Am-243	0.01	10	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Ba-137m	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
C-14	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Cf-249	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Cl-36	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Cm-243	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Cm-244	0.01	10	0.5	2	0.01	1	0.01	1	0.01	1	0.01	1
Cm-245	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Cm-247	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Cm-248	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Co-60	0.01	10	0.01	1	0.01	1	0.01	10	0.1	10	0.1	10
Cs-135	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Cs-137	0.01	10	0.5	2	0.5	2	0.01	10	0.1	10	0.1	10
Eu-152	0.01	10	0.01	1	0.01	1	0.01	1	0.1	10	0.1	10
Eu-154	0.01	10	0.5	2	0.01	1	0.01	10	0.1	10	0.1	10
H-3	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
I-129	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
K-40	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Nb-93m	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Nb-94	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Ni-59	0.01	10	0.01	1	0.01	1	0.01	1	0.1	10	0.1	10
Ni-63	0.01	10	0.5	2	0.01	1	0.01	10	0.1	10	0.1	10
Np-237	0.01	10	0.5	2	0.01	1	0.01	1	0.1	10	0.1	10
Pa-231	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Pd-107	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Pt-193	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Pu-238	0.01	10	0.5	2	0.5	2	0.01	10	0.1	10	0.01	1
Pu-239	0.01	10	0.5	2	0.5	2	0.01	10	0.1	10	0.1	10
Pu-240	0.01	10	0.5	2	0.5	2	0.01	10	0.1	10	0.1	10
Pu-241	0.01	10	0.5	2	0.5	2	0.01	10	0.1	10	0.1	10
Pu-242	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Pu-244	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Ra-226	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Sb-126	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Sb-126m	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Se-79	0.01	10	0.01	1	0.01	1	0.01	1	0.01	1	0.1	10
Sm-151	0.01	10	0.5	2	0.01	1	0.01	10	0.1	10	0.1	10
Sn-126	0.01	10	0.01	1	0.01	1	0.01	1	0.01	1	0.1	10
Sr-90	0.01	10	0.5	2	0.5	2	0.01	10	0.1	10	0.1	10
Tc-99	0.01	10	0.01	1	0.5	2	0.01	1	0.1	10	0.1	10
Th-229	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Th-230	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
U-232	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
U-233	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
U-234	0.01	10	0.5	2	0.5	2	0.01	10	0.1	10	0.1	10

Table 9.0-4: FTF Radionuclide Inventory Stochastics (Continued)

	Type I		Tank 18		Tank 19		Type IIIA		Tank 33		Tank 34	
Distribution	**Uniform**		**Uniform**		**Uniform**		**Uniform**		**Uniform**		**Uniform**	
Isotope	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
U-235	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
U-236	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
U-238	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Y-90	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1
Zr-93	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1

Tanks 17 and 20 inventory stochastics were modeled as a normal distribution with a mean of one and a standard deviation of 0.5. The distribution was not allowed to return values less than zero.

10.0 REFERENCES

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APPENDIX A: SOURCE TERM SCREENING

An initial radionuclide screening process was developed and performed to support characterization efforts and was applicable for FTF PA modeling. CBU-PIT-2005-00228 identifies how SRS performed a screening of radionuclides by initially evaluating 849 isotopes. Of the original 849 isotopes, 159 remained on the list and 690 were excluded from further consideration.

This screening process used the following information:

- physical properties of each radioisotope such as half-life and decay mechanism,
- source and handling of the waste was used in the decisions based on isotope production mechanisms and time since the isotope was produced, and
- screening factors for ground disposal of radionuclides developed in NCRP-123 which convert a quantity of each radionuclide to a dose.

The screening process performed in the initial screening was presented in CBU-PIT-2005-00228 was as follows:

Step 1. Identify isotopes that were part of any of the four decay series (Actinium, Neptunium, Thorium, or Uranium) and retained for further analysis because the FTF waste was known to contain the first member of each of the series.

Step 2. Identify isotopes for which there was high-level waste sludge characterization information and retained for further analysis since these have been determined to be likely to be present in the waste and of importance to some aspect of the program. Note that this step may identify isotopes for inclusion that could have been screened out at some later step if they had not been so designated.

Next, the remaining list of radionuclides was examined to eliminate those isotopes which can be excluded based on the criteria presented for each evaluation step. In the following steps, those that have very long half-lives (and correspondingly low specific activity) and those that have been screened out using the most up-to-date method presented in NCRP-123 were identified for exclusion.

Step 3. Identify isotopes for which there is no dose conversion information (typically very long lived and essentially stable isotopes). The two most comprehensive sources of information are the NCRP-123 and United States Environmental Protection Agency (EPA) Risk Assessment Web Site (www.epa.gov/radiation/heast), and both of these sources were consulted. Dose Conversion Factors do not exist for these isotopes because they were not considered to merit the development of factors.

Step 4. Identify isotopes that have been screened out in NCRP-123 using the screening methodology for ground disposal.

The next part of the screening process employs some general information about an assumed residual inventory of radionuclides in high-level waste sludge that is an order of magnitude or more than expected at closure.

Step 5. Assuming a large activity level (one million curies) of any isotope remaining in the residual material, and using the screening factors from NCRP-123, identify those that would

result in a hypothetical exposure to a MOP of 1 mrem/yr or less and eliminate them from the list. Note that this analysis includes the exposure due to all daughter radionuclides.

Step 6. Assuming a large mass (1,000 lbs) of any isotope remaining in the residual material, and using the screening factors from NCRP-123, identify those that would result in a hypothetical exposure to a MOP of 1 mrem/yr or less and eliminate them from the list. Note that this analysis includes the exposure due to all daughter radionuclides.

Step 7. Identify isotopes that would not be in the waste due to their physical properties (e.g., present as a gas and released in the reactor or during fuel processing).

More specific information about the waste at the SRS is used to identify those radionuclides which can be excluded based on history of the site waste.

Step 8. Employ information about the age of the FTF waste (minimum of 15 years) to identify those radionuclides that would not be expected to be in the waste at the time of closure due to their short half-lives. Restrict this analysis to those isotopes that have no on-going source and decay directly to stable products so that no isotopes with significant daughters are prematurely eliminated.

Step 9. Employ information about the age of the FTF waste (minimum of 15 years) to identify those radionuclides that would not be expected to be in the waste at the time of closure due to their short half-lives. Apply this analysis to those isotopes that have no on-going source and decay to short-lived daughters (less than 1 year) and then to stable products so that no isotopes with significant daughters are prematurely eliminated.

Next, some basic information about the duration of institutional control combined with specific isotope characteristics can be used to eliminate radionuclides that are not going to be of future concern to MOP or worker exposure.

Step 10. Employ detailed decay scheme information to identify short-lived isotopes with no ongoing sources that will decay to stable isotopes in multiple short steps. This step requires the careful review of each decay scheme individually. Although there is not a general rule of thumb, it is obvious from inspection of the decay chain that both the parent and the daughters are effectively extinct.

Step 11. Employ detailed decay scheme information to identify those short-lived isotopes with no ongoing sources that will decay to a longer lived isotope that is separately tracked. Once this decay has happened, the short-lived parent isotope is no longer of interest.

Step 12. Employ detailed decay scheme information and an assumed period of institutional control (100 years) to identify those isotopes with no ongoing sources that will decay to a stable isotope during the period of institutional control.

Step 13. Employ detailed decay scheme information and an assumed period of institutional control (100 years) to identify those isotopes with no ongoing sources that will decay to a longer lived isotope that is separately tracked during the period of institutional control. Once this decay has happened, the parent isotope is no longer of interest.

The isotopes remaining on the list which have not been identified for either inclusion or exclusion can now be examined. Many of the isotopes on the list were not created in the SRS reactors. This is because the initial list of isotopes for evaluation was pulled from a variety of

sources and includes isotopes of interest for many different reasons due to other SRS activities other than just reactor operations.

Step 14. The remaining isotopes are now identified as those isotopes which require further analysis (i.e., pathway and/or inventory specific screening).

The results of the screening process yielded 159 remaining radionuclides for evaluation presented in Table A.0-1

Table A.0-1: Radionuclides Requiring Further Evaluation

Ac-225	Bk-250	Eu-152	Nb-94	Po-213	Rh-106	Th-227
Ac-227	C-14	Eu-154	Ni-59	Po-214	Rn-219	Th-228
Ac-228	Ca-41	Eu-155	Ni-63	Po-215	Rn-220	Th-229
Ag-108m	Ce-144	Fe-60	Np-236	Po-216	Rn-222	Th-230
Al-26	Cf-249	Fr-221	Np-237	Po-218	Ru-106	Th-231
Am-241	Cf-250	Fr-223	Np-239	Pr-144	Sb-125	Th-232
Am-242	Cf-251	Gd-148	Np-240	Pt-193	Sb-126	Th-234
Am-242m	Cf-252	H-3	Pa-231	Pu-236	Sb-126m	Ti-44
Am-243	Cl-36	Hf-178m	Pa-233	Pu-238	Se-79	Tl-207
Am-246	Cm-242	Hf-182	Pa-234	Pu-239	Si-32	Tl-208
At-217	Cm-243	Hg-194	Pb-202	Pu-240	Sm-146	Tl-209
At-218	Cm-244	Ho-166m	Pb-205	Pu-241	Sm-147	Tl-210
Ba-137m	Cm-245	I-129	Pb-209	Pu-242	Sm-151	U-232
Be-10	Cm-246	Ir-192	Pb-210	Pu-243	Sn-121m	U-233
Bi-207	Cm-247	Ir-192m	Pb-211	Pu-244	Sn-126	U-234
Bi-210	Cm-248	K-40	Pb-212	Pu-246	Sr-90	U-235
Bi-210m	Cm-250	La-137	Pb-214	Ra-223	Ta-182	U-236
Bi-211	Co-60	La-138	Pd-107	Ra-224	Tb-157	U-238
Bi-212	Co-60m	Lu-176	Pm-145	Ra-225	Tb-158	U-240
Bi-213	Cs-134	Mn-53	Pm-147	Ra-226	Tc-97	Y-90
Bi-214	Cs-135	Mo-93	Po-210	Ra-228	Tc-98	Zr-93
Bk-247	Cs-137	Na-22	Po-211	Rb-87	Tc-99	
Bk-249	Eu-150	Nb-93m	Po-212	Re-186m	Te-125m	

APPENDIX B: EVALUATION OF REMANING RADIONUCLIDES

From Table A.0-1, 95 isotopes are screened out for the initial inventory for the reasons described in Table B.0-1. There are radionuclides that are removed from the initial inventory although they are known to exist due to decay behavior. Justification for removing the in-growth from the initial inventories is discussed below.

The in-growth of radionuclides within a decay series is insignificant. For the short lived isotopes, the in-growth occurs quickly such that they are at equilibrium within the institutional control period (100 years). For the longer lived isotopes, the in-growth would be insignificant due to the length of the evaluation period (10,000 years). For example, assuming no in-growth within the initial inventory, the Th-299 in-growth from U-233 decay would be 62.2% of the initial U-233 inventory at 10,000 years. If in-growth is included, the Th-229 in-growth would be 62.5% of the U-233 initial inventory.

Although these radionuclides are not included in the initial inventories, they are included in the modeling software and are grown in as a function of their parent's inventory and time.

Table B.0-1: Continued Evaluation of Radionuclides

Isotope	Half-life*	Reason for Elimination from Initial Inventory	Decay Chain
Ac-225	10 days	Generated by Np-237 decay in modeling; short half-life	Neptunium Series
Ac-228	6.15 hours	Generated by Th-232 decay in modeling; short half-life	Thorium Series
Ag-108m	438 years	No decay source	Ag-108m → Ag-108 → Cd-108 (stable) and Pd-108 (stable)
Am-242	16 hours	Decay from Am-242m in modeling	Am-242m → Am-242 → Cm-242 → Pu-238 → U-234 (in Uranium Series)
Am-246	39 minutes	Ancestors not present, decays to U-238 series	Cm-250 → Pu-246 → Am-246 → Cm-246 → Pu-242 → U-238 (in Uranium Series)
At-217	<1 second	Generated by Np-237 decay in modeling; short half-life	Neptunium Series
At-218	1.5 seconds	Generated by U-238 decay in modeling; short half-life	Decay mode less than 1% of Po-218 decay.
Be-10	1,510,000 years	No decay source	Be-10 → Ba-10 (stable) Long-lived naturally occurring isotope
Bi-207	32.9 years	Ancestors not present	At-207 → Po-207 → Bi-207 → Pb-207 (stable)
Bi-210	5 days	Generated by U-238 decay in modeling; short half-life	Uranium Series
Bi-210m	3,040,000 years	No decay source	Bi-210m →Tl-206 → Pb-206 (stable)
Bi-211	2.14 seconds	Generated by U-235 decay in modeling; short half-life	Actinium Series
Bi-212	60.55 minutes	Generated by Th-232 decay in modeling; short half-life	Thorium Series

Table B.0-1: Continued Evaluation of Radionuclides (Continued)

Isotope	Half-life*	Reason for Elimination from Initial Inventory	Decay Chain
Bi-213	45.6 minutes	Generated by Np-237 decay in modeling; short half-life	Neptunium Series
Bi-214	20 minutes	Generated by U-238 decay in modeling; short half-life	Uranium Series
Bk-247	1,380 years	Ancestors not present, decays to U-235 series	Cf-247 → Bk-247 → Am-243 → Np-239 → Pu-239 → U-235 (in Actinium Series)
Bk-250	3.2 hours	Ancestors not present, decays to U-238 series	Md-258 → Es-254 → Bk-250 → Cf-250 → Cm-246 → Pu-242 → U-238 (in Uranium Series); Cm-250 → Bk-250 → Cf-250 → Cm-246 → Pu-242 → U-238 (in Uranium Series)
Ca-41	102,000 years	No decay source	Ca-41 → K-41 (stable)
Cl-36	301,000 years	No decay source	Cl-36 → Ar-36 (stable)
Cf-250	13.1 years	Ancestors not present, decays to U-238 series	Md-258 → Es-254 → Bk-250 → Cf-250 → Cm-246 → Pu-242 → U-238 (in Uranium Series) Cm-250 → Bk-250 → Cf-250 → Cm-246 → Pu-242 → U-238
Cm-246	4760 years	Ancestors not present, decays to U-238 series	Cf-250 → Cm-246 → Pu-242 → U-238 (in Uranium Series); Es-250m → Cf-250 and Bk-246 → Cm-246 → Pu-242 → U-238 (in Uranium Series) Cm-250 → Pu-246 → Am-246 → Cm-246 → Pu-242 → U-238 (in Uranium Series)
Cm-250	8,300 years	No decay source	Cm-250 → Pu-246 → Am-246 → Cm-246 → Pu-242 → U-238 (in Uranium Series)
Co-60m	10.5 seconds	Ancestors not present	Fe-60 → Co-60m → Co-60 → Ni-60 (stable)
Eu-150	36.9 years	No decay source	Eu-150 → Sm-150 (stable)

Table B.0-1: Continued Evaluation of Radionuclides (Continued)

Isotope	Half-life*	Reason for Elimination from Initial Inventory	Decay Chain
Fe-60	1,500,000 years	No decay source	Fe-60 → Co-60m → Co-60 → Ni-60 (stable)
Fr-221	5 minutes	Generated by Np-237 decay in modeling; short half-life	Neptunium Series
Fr-223	22 minutes	Generated by U-235 decay in modeling; short half-life	Actinium Series
Gd-148	70.9 years	No decay source	Gd-148→ Sm-144 (stable)
Hf-178m	31 years	No decay source	Hf-178m → Hf-178 (stable)
Hf-182	8,900,000 years	Ancestors not present	Hf-182m → Hf-182 → Ta-182 → W-182 (stable)
Hg-194	444 years	Ancestors not present	[Ti-194 and Ti-194m] → Hg-194 → Au-194 → Pt-194 (stable)
Ho-166m	1200 years	No decay source	Ho-166m → Er-166 (stable)
Ir-192	74 days	Ancestors not present	Ir-192m → Ir-192 → Pt-192 (stable) or Os-192 (stable)
Ir-192m	241 years	No decay source	Ir-192m → Ir-192 → Pt-192 (stable) or Os-192 (stable)
K-40	1.25E+09 years	No decay source	K-40 → Ca-40 (stable) Long-lived naturally occurring isotope
La-137	60,000 years	Ancestors not present	Ce-137m → Ce-137 → La-137 → Ba-137 (stable); Pr-137 → Ce-137 → La-137 → Ba-137 (stable)
La-138	1.02E+11 years	No decay source	La-138→ Ce-138 (stable) Long-lived naturally occurring isotope
Lu-176	3.76E+10 years	No decay source	Lu-176 → Hf-176 (stable) Long-lived naturally occurring isotope
Mn-53	374,000 years	No decay source	Mn-53 → Cr-53 (stable)
Mo-93	4,000 years	Ancestors not present	[Mo-93m and Tc-93 and Tc-93m] → Mo-93 → Nb-93m → Nb-93 (stable)
Nb-93m	16 years	Ancestors not present	Zr-93 → Nb-93m → Nb-93 (stable)

Table B.0-1: Continued Evaluation of Radionuclides (Continued)

Isotope	Half-life*	Reason for Elimination from Initial Inventory	Decay Chain
Np-236	1,540 years	No decay source	Np-236 → U-236 → Th-232 (in Thorium Series); Np-236 → Pu-236 Np-236a → U-232 to Th-228 (in Thorium Series)
Np-239	2.4 days	Decay from Am-243 in modeling; short half-life	Cf-247 → Bk-247 → Am-243 → Np-239 → Pu-239 → U-235 (in Actinium Series); Es-255 → Bk-251 or Fm-255 → Cf-251→ Cm-247→ Pu-243 → Am-243 → Np-239 → Pu-239 → U-235 (in Actinium Series)
Np-240	62 minutes	Decay from Pu-244 in modeling; short half-life	Cf-252 → Cm-248 → Pu-244 → U-240 → Np-240 → Pu-240 → U-236 → Th-232 in Thorium Series
Pa-233	27 days	Generated by Np-237 decay in modeling; short half-life	Neptunium Series
Pa-234	6.7 hours	Generated by U-238 decay in modeling; short half-life	Uranium Series
Pb-202	52,500 years	Ancestors not present	Po-202 → Bi-202 → Pb-202 → [Tl-202 and Hg-198 (stable)]; Tl-202 → Hg-202 (stable)
Pb-205	1.73E+07 years	Ancestors not present	Po-205 → Bi-205 → Pb-205 → Tl-205 (stable)
Pb-209	3.3 hours	Generated by Np-237 decay in modeling; short half-life	Neptunium Series
Pb-210	22 years	Generated by U-238 decay in modeling	Uranium Series
Pb-211	36 minutes	Generated by U-235 decay in modeling; short half-life	Actinium Series
Pb-212	10.6 hours	Generated by Th-232 decay in modeling; short half-life	Thorium Series
Pb-214	27 minutes	Generated by U-238 decay in modeling; short half-life	Uranium Series

Table B.0-1: Continued Evaluation of Radionuclides (Continued)

Isotope	Half-life*	Reason for Elimination from Initial Inventory	Decay Chain
Pd-107	650,000 years	Ancestors not present	Rh-107 → Pd-107 → Ag-107 (stable)
Pm-145	18 years	Ancestors not present	Gd-145 → Eu-145 → Sm-145 → Pm-145 → Nd-145 (stable)
Po-210	138 days	Generated by U-238 decay in modeling	Uranium Series
Po-211	<1 second	Generated by U-235 decay in modeling; short half-life	Decay mode less than 1% of Bi-211 decay.
Po-212	<1 second	Generated by Th-232 decay in modeling; short half-life	Thorium Series
Po-213	<1 second	Generated by Np-237 decay in modeling; short half-life	Neptunium Series
Po-214	<1 second	Generated by U-238 decay in modeling; short half-life	Uranium Series
Po-215	<1 second	Generated by U-235 decay in modeling; short half-life	Actinium Series
Po-216	<1 second	Generated by Th-232 decay in modeling; short half-life	Thorium Series
Po-218	3 minutes	Generated by U-238 decay in modeling; short half-life	Uranium Series
Pt-193	50 years	Ancestors not present	Hg-193m → Hg-193 → Au-193 → Pt-193 → Ir-193 (stable)
Pu-236	3 years	Ancestors not present, decays to Th-228 series	Cf-244 → Cm-240 → Pu-236 → U-232 → Th-228 (in Thorium Series)
Pu-243	5 hours	Decay from Cf-251 in modeling	Cf-251 → Cm-247→ Pu-243 → Am-243 → Np-239 → Pu-239 → U-235 (in Actinium Series)
Pu-246	11 days	Ancestors not present	Cm-250 → Pu-246 →Am-246 → Cm-245 Pu-241 (in Neptunium Series);

Table B.0-1: Continued Evaluation of Radionuclides (Continued)

Isotope	Half-life*	Reason for Elimination from Initial Inventory	Decay Chain
Ra-223	11 days	Generated by U-235 decay in modeling; short half-life	Actinium Series
Ra-224	3.6 days	Generated by Th-232 decay in modeling; short half-life	Thorium Series
Ra-225	15 days	Generated by Np-237 decay in modeling; short half-life	Neptunium Series
Rb-87	4.97E+10 years	Ancestors not present	[Kr-87 and Sr-87m] → Rb-87 → Sr-87 (stable)
Re-186m	200,000 years	No decay source	Re-186m → Re-186 → Os-186 → W-182 (stable)
Rn-219	4 seconds	Generated by U-235 decay in modeling; short half-life	Actinium Series
Rn-220	56 seconds	Generated by Th-232 decay in modeling; short half-life	Thorium Series
Rn-222	4 days	Generated by U-238 decay in modeling; short half-life	Uranium Series
Si-32	132 years	No decay source	Si-32 → P-32 → S-32 (stable)
Sm-146	1.03E+08 years	Ancestors not present	[Gd-146 and Tb-150] → Eu-146 → Sm-146 → Nd-142 (stable); Eu-150m → Gd-150 → Sm-146 → Nd-142 (stable)
Sm-147	1.06E+11 years	Decay from Pm-147 in modeling	Pr-147 → Nd-147 → Pm-147 → Sm-147 → Nd-143 (stable); Tb-147 → Gd-147 → Eu-147 → Sm-147 → Nd-143 (stable)
Sn-121m	44 years	No decay source	Sn-121m → Sn-121 → Sb-121 (stable)
Ta-182	114 days	Ancestors not present	Hf-182m → Hf-182 → Ta-182 → W-182 (stable)
Tb-157	71 years	Ancestors not present	Ho-157 → Dy-157 → Tb-157 → Gd-157 (stable)
Tb-158	180 years	No decay source	Tb-158 → Gd-158 (stable)

Table B.0-1: Continued Evaluation of Radionuclides (Continued)

Isotope	Half-life*	Reason for Elimination from Initial Inventory	Decay Chain
Tc-97	4,210,000 years	Ancestors not present	[Ru-97 and Tc-97m] → Tc-97→ Mo-97 (stable)
Tc-98	4,200,000 years	No decay source	Tc-98 → Ru-98 (stable)
Th-227	19 days	Generated by U-235 decay in modeling; short half-life	Actinium Series
Th-228	1.9 years	Generated by Th-232 decay in modeling; short half-life	Thorium Series
Th-231	25.5 hours	Generated by U-235 decay in modeling; short half-life	Actinium Series
Th-234	24 days	Generated by U-238 decay in modeling; short half-life	Uranium Series
Ti-44	60 years	No decay source	Ti-44 → Sc-44 → Ca-44 (stable)
Tl-207	5 minutes	Generated by U-235 decay in modeling; short half-life	Actinium Series
Tl-208	3 minutes	Generated by Th-232 decay in modeling; short half-life	Thorium Series
Tl-209	2.2 minutes	Generated by Np-237 decay in modeling; short half-life	Neptunium Series
Tl-210	1.3 minutes	Generated by U-238 decay in modeling; short half-life	Decay mode less than 1% of Bi-214 decay.
U-240	14 hours	Decay from Cf-252 in modeling; short half-life	Cf-252 → Cm-248 → Pu-244 → U-240 → Np-240 → Pu-240 → U-236 → Th-232 (in Thorium Series)
Zr-93	1,530,000 years	Ancestors not present	Y-93 → Zr-93 → Nb-93m → Nb-93 (stable)

*Half-life years obtained from the April 2005 Nuclear Wallet Cards. [PIT-MISC-0072]