FTF-WDIP-004
Revision 0

RADIONUCLIDE CONCENTRATIONS OF STABILIZED RESIDUALS, TANKS AND ANCILLARY STRUCTURES INPUT PACKAGE

for the

Section 3116 Draft Basis Document for F-Tank Farm at the Savannah River Site

June 2010

"PREDECISIONAL DELIBERATIVE DOCUMENT REQUESTED BY DOE (Releasable under FOIA only with DOE Approval)"

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ACRONYMS / ABBREVIATIONS

CFR	Code of Federal Regulations
Ci	curies
cm	Centimeter
DOE	United States Department of Energy
ft	Foot
FTF	F-Tank Farm
g	Grams
lb	Pound
LLW	Low-Level Waste
MSL	Mean Sea Level
NA	Non Applicable
NDAA	Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005
NRC	United States Nuclear Regulatory Commission
PA	Performance Assessment

1.0 INPUT PACKAGE DESCRIPTION

Input package FTF-WDIP-004 provides information anticipated to be used in Section 6.0, *Radionuclide Concentrations of Stabilized Residuals, Tanks and Ancillary Structures*, of the Draft F-Tank Farm (FTF) 3116 Basis Document. Development of FTF-WDIP-004 allows for early review of this information before the Draft FTF 3116 Basis Document is submitted to the Nuclear Regulatory Commission (NRC) for further consultation, and issued for public comment. This input package provides the anticipated approach for demonstrating that the stabilized residuals, tanks and ancillary structures will not exceed the concentration limits for Class C low-level waste (LLW) as set out in Title 10 of the Code of Federal Regulations (CFR) 61.55 pursuant to 3116(a)(3)(A) of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 (NDAA). Although the Draft FTF 3116 Basis Document will demonstrate that the waste is not anticipated to exceed Class C concentration limits, DOE is also consulting with the NRC pursuant to the consultation process in Section 3116(a)(3)(B)(iii), to take full advantage of the consultation established by NDAA Section 3116. This input package also includes wording representative of the information anticipated to be included in the Draft FTF 3116 Basis Document[1].

2.0 DRAFT FTF 3116 BASIS DOCUMENT APPROACH

The following describes the approach the Department of Energy (DOE) is considering for demonstrating that the concentration limits for Class C LLW as set out in 10 CFR 61.55, will not be exceeded in the stabilized residuals within the waste tanks and ancillary structures, the waste tanks, and the ancillary structures (including integral equipment) in FTF.

- NUREG-1854 has been reviewed and considered to ensure consistency, as applicable, with NRC staff guidance concerning NRC consultation activities related to waste determinations.
- The approach being presented is similar to that contained in the *Basis for Section 3116 Determination for the Idaho Nuclear Technology and Engineering Center Tank Farm Facility* (DOE/NE-ID-11226), including Appendix D.
- The following documents were reviewed and considered to ensure any comments received from the NRC during prior consultations have been appropriately considered:
  - CBU-PIT-2005-00131, *Response to Request for Additional Information on the Draft Section 3116 Determination for Salt Waste Disposal at the Savannah River Site, associated with the approved Basis for Section 3116 Determination for Salt Waste Disposal at the Savannah River Site* (DOE-WD-2005-001);
  - ICP/EXT-06-01204, *Response to Request for Additional Information on the Draft Section 3116 Determination, Idaho Nuclear Technology and Engineering Center Tank Farm Facility* associated with *Basis for Section 3116 Determination for the*

[1] The purpose of developing this input package and utilizing the scoping process parallel to development of the Draft FTF 3116 Basis Document is to expedite the identification of issues and assess the reasonability of DOE's approach in addressing the NDAA Section 3116 criteria, thereby allowing for more informed and efficient consultation with the NRC and a more informed draft for public comment. Changes in the described approaches and information presented in this input package may occur based on discussions during the scoping process.

  Idaho Nuclear Technology and Engineering Center Tank Farm Facility (DOE/NE-ID-11226); and
  - CBU-PIT-2006-00065, *Response to Request for Additional Information on the Draft 3116 Determination for Closure of Tank 19 and Tank 18 at the Savannah River Site* and LWO-PIT-2007-00025, *Response to the NRC's Request for Additional Information Comment #15* associated with the *Draft Section 3116 Determination for Closure of Tank 19 and Tank 18 at the Savannah River Site* (DOE-WD-2005-002).
- To be consistent with DOE and NRC general technical discussion, October 2007, that the limiting scenario should be identified: [DOE_10-03-2007]
  - The intruder-construction scenario is not considered plausible for the limiting scenario because the residual wastes will be below an engineered barrier and at depths greater than 16 feet.
  - The intruder-driller scenario as defined in NUREG-1854 is the limiting scenario used as the basis for the sum of fraction calculation.
- Using the intruder-drilling scenario, the NUREG-1854 Category 3 site-specific averaging approach is used. This is considered to be the most appropriate scenario for comparison against the Class C concentration limits.
- For the purpose of this scenario, the intruder-driller is assumed to drill a 150 foot deep borehole through a representative tank or ancillary structure. The closed tank structure (concrete floor and roof, steel liner(s), reducing grout, basemats, and soil overlying and underlying the tank) can be considered as layers.
- This concentration evaluation approach utilizes the following inputs:
  - The tanks will be filled with reducing grout.
  - The inventory at closure will represent all the residual material in the tank, present on the floor, visible on the wall, and coatings on tank walls or cooling coils. The inventory is not decayed to the concentrations that might be present at the end of the 100 year institutional control period.
  - Any residual material on walls or cooling coils is assumed to be included as a uniform thickness on the tank floor.
  - The actual thickness of the residuals will be small enough to be approximated as part of the reducing grout layer for the sum of the fractions calculation.
  - FTF waste tanks have four basic designs so the layers penetrated by the driller can be standardized in terms of masses and volumes for the sum of the fractions calculation.
  - The radionuclide content of the drill cuttings can be determined using the ratio of the borehole area to the tank floor area.
  - The ratio approach is valid for both mass- and volume-based sum of fraction calculations.
- The final waste concentration will be determined by comparing the sum of fractions calculated for radionuclide concentrations in exhumed drill cuttings for a boring through a waste tank or ancillary structure to the appropriate Class C table values.
- The majority of the waste removal activities will take place following the Secretary of Energy's determination, should the Secretary so decide, that, based on consultation with the NRC and for the reasons set forth in the final FTF 3116 Basis Document, the stabilized residuals, tanks and ancillary structures that would remain in the FTF meet the applicable criteria in section 3116(a) of the NDAA, and thus are not high-level waste.

- Individual tank documentation providing concentrations will be based on actual samples collected after final waste removal operations. This documentation will either be integral to, or serve as primary reference(s) for, the Tier 2 Closure Documentation. [DOE M 435.1-1] The Tier 2 Closure Documentation will be approved by DOE-Savannah River authorizing the cessation of waste removal activities and operational closure of the waste tank or ancillary structures.
- DOE also plans to consult with NRC about DOE's disposal plans, as described in the Draft FTF 3116 Basis Document, pursuant to Section 3116 (a)(3)(B)(iii) to take full advantage of the consultation process established by Section 3116. Thus, the final FTF 3116 Basis Document will demonstrate that the criteria in Section 3116 (a)(3)(A) and (a)(3)(B) will be met for the stabilized residuals, tanks and ancillary structures.

Based on the above outlined approach, the following section provides wording similar to that anticipated to be contained in the Draft FTF 3116 Basis Document. Although the wording will be revised as DOE further develops and refines the Draft FTF 3116 Basis Document, the information provided represents the level of information and general compliance discussion anticipated to be provided in the Draft FTF 3116 Basis Document.

3.0 RADIONUCLIDE CONCENTRATIONS OF STABILIZED RESIDUALS, TANKS AND ANCILLARY STRUCTURES

Section Purpose

This section provides the methodology that will be used for comparison to Class C concentration limits found in 10 CFR Part 61, Section 61.55 to demonstrate that the stabilized residuals, tanks and ancillary structures will not exceed Class C concentration limits for the purpose of the Draft FTF 3116 Basis Document.

Section Contents

This section outlines the methodology and assumptions that DOE will use to demonstrate that the FTF stabilized residuals, tanks and ancillary structures at closure will not exceed Class C concentration limits for the purpose of the Draft FTF 3116 Basis Document.

Key Points

- The intruder-construction scenario is not applicable for the FTF waste tanks and ancillary structures after the 100 year institutional control period.
- Using a risk-informed approach accounting for depth of the stabilized residuals and the presence of a robust intruder barrier, the most appropriate scenario for calculation and comparison with the Class C concentration limits is a scenario that involves an inadvertent intruder drilling a well for groundwater.
- The approach that DOE intends to use is consistent with NRC staff guidance. [NUREG-1854] As described in NUREG-1854, the Category 3, intruder-driller scenario developed for purposes of waste tank closure is used.
- The sum of the fractions for comparison to Class C concentration limits is calculated using the radionuclide concentrations in the exhumed drill cuttings for a water well borehole drilled through a representative waste tank or ancillary structure and the NUREG-1854 Category 3 methodology.
- While DOE believes there is a reasonable basis to determine that none of the stabilized residuals, tanks or ancillary structures at FTF will exceed the Class C concentration limits in 10 CFR 61.55, DOE nevertheless is also consulting with the NRC on DOE's disposal plans pursuant to NDAA Section 3116 (a)(3)(B)(iii).

3.1 Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 (NDAA) Criteria

NDAA Section 3116(a) provides in pertinent part:

> *[T]he term "high-level radioactive waste" does not include radioactive waste resulting from the reprocessing of spent nuclear fuel that the Secretary of Energy..., in consultation with the Nuclear Regulatory Commission…, determines –*
>
> *(3) (A) does not exceed concentration limits for Class C low-level waste as set out in section 61.55 of title 10, Code of Federal Regulations, and will be disposed of—*
>
> *(i) in compliance with the performance objectives set out in subpart C of part 61 of title 10, Code of Federal Regulations; and*

(ii) pursuant to a State-approved closure plan or State-issued permit, authority for the approval or issuance of which is conferred on the State outside of this section; or

(3) (B) exceeds concentration limits for Class C low-level waste as set out in section 61.55 of title 10, Code of Federal Regulations, but will be disposed of—

(i) in compliance with the performance objectives set out in subpart C of part 61 of title 10, Code of Federal Regulations; and

(ii) pursuant to a State-approved closure plan or State-issued permit, authority for the approval or issuance of which is conferred on the State outside of this section; and

(iii)pursuant to plans developed by the Secretary in consultation with the Commission.

3.2 Waste Concentrations

The NDAA Section 3116(a)(3) provides that, regardless of whether the waste exceeds or does not exceed the concentration limits for Class C LLW as set out in 10 CFR 61.55, the Secretary of Energy must determine that the waste will be disposed of in compliance with the performance objectives of 10 CFR 61, Subpart C, and that the waste will be disposed of in accordance with State-approved closure plans. In Section 7 of this Draft FTF 3116 Basis Document, information is presented that demonstrates that the waste will be disposed of in compliance with the performance objectives of 10 CFR 61, Subpart C. In Section 8 of this Draft FTF 3116 Basis Document, information is presented that demonstrates that the waste will be disposed of in compliance with State-approved closure plans.

In situations where the waste exceeds the concentration limits for Class C LLW, NDAA Section 3116(a)(3)(B)(iii) provides for consultation with NRC about the disposal plans for the waste. [NDAA_3116]

As discussed in this section, under DOE's disposal plans, the stabilized residuals within the waste tanks and ancillary structures, the waste tanks, and the ancillary structures (including integral equipment) in the FTF are not expected to exceed Class C concentration limits for Class C LLW. Nevertheless, DOE is also consulting with the NRC pursuant to the consultation process in Section 3116(a)(3)(B)(iii) to take full advantage of the consultation process established by NDAA Section 3116. In this regard, DOE is specifically requesting in this Draft FTF 3116 Basis Document that NRC identify what changes, if any, NRC would recommend to DOE's disposal plans as described in the Draft FTF 3116 Basis Document, and DOE intends to consider the NRC recommendations, as appropriate, in the development of DOE's plans. In the following subsections, the methodology for calculating concentrations for radionuclides included in 10 CFR 61.55 is presented. The radionuclides and their associated limits are specified in two separate tables within 10 CFR 61.55 which are reproduced in Table 3.2-1 and Table 3.2-2.

Table 3.2-1: 10 CFR 61.55 Table 1 Class C Concentration Limits

Radionuclides (Long-lived)	Concentration (Ci/m^3)
C-14	8
C-14 in activated metal	80
Ni-59 in activated metal	220
Nb-94 in activated metal	0.2
Tc-99	3
I-129	0.08
Alpha Emitting Transuranic nuclides with half-life greater than five years	[1]100
Pu-241	[1]3,500
Cm-242	[1]20,000

[1] Units are in nanocuries per gram.
[10 CFR 61]

Table 3.2-2: 10 CFR 61.55 Table 2 Class C Concentration Limits

Radionuclides (Short-lived)	Concentration (Ci/m^3)		
	Column 1 [Class A]	Column 2 [Class B]	Column 3 [Class C]
Total of all nuclides with less than 5 year half-life	700	([1])	([1])
H-3	40	([1])	([1])
Co-60	700	([1])	([1])
Ni-63	3.5	70	700
Ni-63 in activated metal	35	700	7000
Sr-90	0.04	150	7000
Cs-137	1	44	4600

[1] There are no limits established for these radionuclides in Class B or C wastes. Practical considerations such as the effects of external radiation and internal heat generation on transportation, handling, and disposal will limit the concentrations for these wastes. These wastes shall be Class B unless the concentrations of other nuclides in the table determine the waste to be Class C independent of these nuclides.
[10 CFR 61]

3.2.1 Approach to Waste Concentrations for FTF Residuals

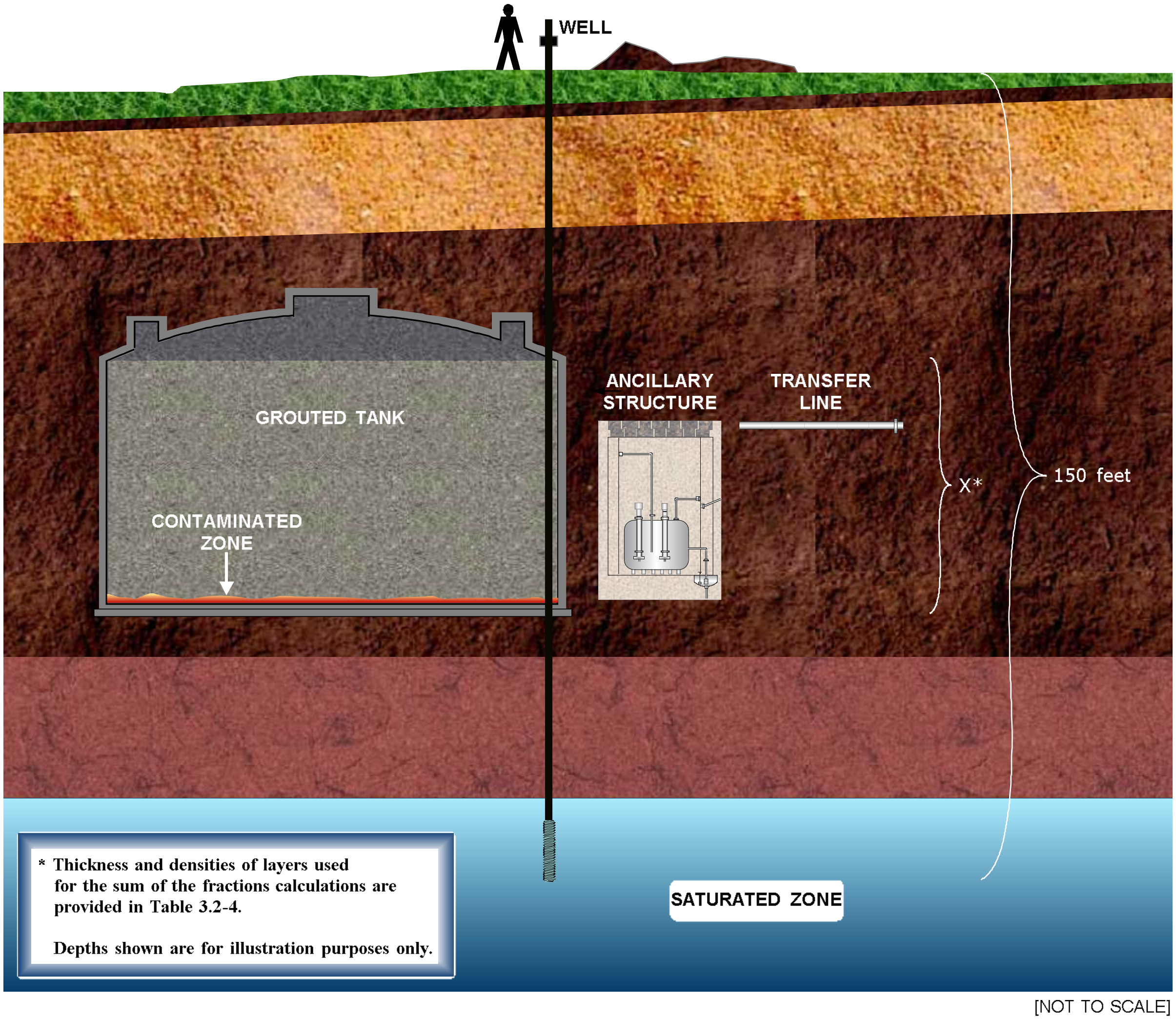
Past guidance to determine concentrations for comparison with Class C concentrations limits of 10 CFR 61.55 was based on excavation as the likely pathway to expose an inadvertent member of the public as a result of waste in a commercial burial site. This standard method is not applicable to the FTF tanks and their associated waste. The stabilized residuals will be deeper in the ground than a typical foundation, and will be protected by a surface soil barrier and a grout-filled tank structure, which makes the basement excavation scenario implausible. A more appropriate scenario for the purposes of calculation and comparison with Class C concentration limits is when the inadvertent intruder drills a groundwater well and drills through the tank.

This section describes the methodology and presents the inputs that DOE will use in determining the waste classification for stabilized residuals in FTF tanks and ancillary structures at closure. Because the stabilized residuals will be more than 16 feet (5 meters) below the surface, the conceptual approach used is Category 3-Site Specific Averaging, using the intruder-drilling case as the most appropriate scenario. [NUREG-1854]

The intruder-drilling scenario used for the determination assumes an 8 inch diameter, 150 foot deep borehole drilled for a residential water supply well that penetrates a buried structure (e.g., a waste tank, transfer line, or ancillary structures) (Figure 3.2-1). The radionuclide concentrations in the exhumed drill cuttings are used for comparison to the 10 CFR 61.55 tables. For volume-based limits, the volume of material from the 8 inch well borehole is used. For mass-based limits, the mass of the structure penetrated plus the mass of the exhumed soil above and below the structure is used. Because the stabilized residuals are expected to include multiple radionuclides from both 10 CFR 61.55 Table 1 and Table 2, the sum of the fractions methodology will be applied and then compared to the Class C concentration limits.

By simplifying and standardizing a number of input parameters, the sum of fractions calculation will become a standardized methodology for each tank type and ancillary structure when it is closed. In practice, actual inventory values will be used to make the waste classification at closure. Some input parameters such as grout density may be adjusted to match the final materials, but the methodology remains constant.

Figure 3.2-1: Intruder-Driller Scenarios for Concentration Calculations



3.2.2 Methodology

The general methodology calculates the Class C ratios for the volume of an 8 inch diameter, 150 foot deep borehole and assumes densities and material layers for standard tank and ancillary structure designs that could be penetrated during the drilling. As described in the methodology inputs below, using the area ratio of the 8 inch diameter borehole to the area of the tank floor volume simplifies the estimation of the curies (Ci) contained in the borehole.

The radionuclide concentrations in a tank or ancillary structure at the time of closure are compared, using the sum of fractions methodology, to the Class C concentration limits in 10 CFR 61.55(a)(8). The radionuclide concentrations are not decayed to those that would be present after the 100 year institutional control period has ended. The residual inventory in a tank will be determined by sampling and laboratory analysis following removal of waste containing highly radioactive radionuclides to the maximum extent practical.

The following subsections describe how the sum of fractions will be calculated for the FTF tanks and structure.

3.2.2.1 Methodology Inputs

The following inputs were used to simplify and standardize the parameters for the concentration calculation. Generally, the inputs are conservative, in that they underestimate or do not take credit for certain masses or volumes that would lower the calculated radionuclide ratios.

- The well borehole will be assumed to be 8 inches in diameter. Assuming a borehole diameter is not 8 inches would be unrealistic for a residential supply well, because most domestic wells are this size.
- The well borehole will be assumed to be 150 feet deep (total). The Gordon Aquifer is currently used for water supply in this area of South Carolina. In the area of the FTF, the elevation of the top of the Gordon Aquifer is 140 feet above mean sea level (MSL) (PIT-MISC-0124) while the average FTF tank basemat elevation is approximately 240 feet MSL. [SRS-REG-2007-00002] Therefore, at least 100 feet of drilling below the tanks would be necessary to reach the Gordon Aquifer to install a well. Adding approximately 40 feet for a representative tank thickness and 10 feet for a well screen would make 150 feet a realistic boring depth to install a well.
- The concentrations used for the Class C waste calculation are for the total inventory for the residual material on the floor, walls, piping, cooling coils, and any structure that will be abandoned in the tank at closure. For simplification, the mass of the walls, piping, etc., are not included in the mass summation for the sum of the fractions calculations. Not accounting for this mass increases the calculated radionuclide contributions to the sum of fractions and is therefore a conservative assumption.
- The residual material layer in the waste tanks and ancillary structures is assumed to be spread evenly across the base of the tank or ancillary structure. The waste thickness is also considered to be part of the reducing grout layer thickness for the sum of layers calculation.
- The ratio of the borehole area to the area of the tank floor is assumed for estimation of the curie content in the borehole cuttings. This simplifies the argument that the borehole does or does not penetrate the maximum, minimum, or unknown thickness of the waste and relies only on the curie content of the residual inventory for the concentration determination. For simplicity, the floor area occupied by any tank interior supporting columns is not subtracted from the total tank floor area calculated.
- The volume under the domed roof and above the springline for Type IV tanks is assumed to be soil for purposes of the calculation. The curved concrete dome is assumed to be 7 inches thick for mass summation purposes. This removes any uncertainty in estimating and calculating the masses of those layers for any borehole drilling scenario and increases the sum of the fractions by assuming a lower density material for this layer.
- Ancillary structure height will be considered equal to the height of any enclosing vault, and the structure may be backfilled with soil instead of grout. The soil density

assumed for the backfill, 1.62 gram (g)/cubic centimeter (cm^3), will be approximately equal to the soil density of the underlying FTF soil. No material is specified in the FTF Performance Assessment (PA) for backfilling ancillary structures. Material selection will be made at the time of operational closure based on current engineering practices and available materials. [SRS-REG-2007-00002] Backfilling of ancillary structures and tanks will only be for stability purposes.

- The 4 foot minimum thickness of the sloping Type IIIA tank roof is used in the mass of layers summation. The thicker basemat drop panel sections under the Type III and IIIA tank support columns are ignored and the average basemat thickness is used in the summation. Air circulation slot depths in the insulating concrete slab under the primary liner for Type III and IIIA tanks are subtracted from the slab thicknesses.
- The bulk density used for the reducing and strong grout is 128.9 pounds (lbs)/cubic foot (ft^3) (2.06 g/cm^3). This density is an average value taken from the study evaluating various mixes and properties. [WSRC-STI-2007-00641] The final reducing grout properties might be appropriate for its use as the strong grout layer in the Type IV tanks. This value is higher than the 1.81 g/cm^3 used in the PORFLOW modeling in the FTF PA. [SRS-REG-2007-00002]

3.2.2.2 Calculation Inputs

Because the FTF structures use a limited number of designs, the layer thicknesses, materials and densities were assigned to standardize the sum of the fractions calculations. Table 3.2-3 presents the standard waste ratios (ratio of the borehole area to tank floor area) that will be used for the FTF waste tanks. Table 3.2-4 presents the layers, volumes and masses calculated for the four tank designs used at FTF.

Table 3.2-3: FTF Waste Ratios

Tank Type	Borehole Diameter (ft)	Borehole Area (ft^2)	Tank Floor Area[a] (ft^2)	Waste Ratio
Type I	0.667	0.349	4,417.8	0.00008
Type III	0.667	0.349	5,674.5	0.00006
Type IIIA	0.667	0.349	5,674.5	0.00006
Type IV	0.667	0.349	5,674.5	0.00006

[a] The floor area calculation does not subtract the area of any interior supporting columns.

Table 3.2-4: FTF Tanks Standard Layer Thickness and Calculated Mass

Layer	Layer Thickness (ft)	Layer Density (g/cm^3)	Layer Density (lb/ft^3)	Volume of 8 inch Diameter Layer (ft^3)	Mass of Layer (lbs)
TYPE I TANK					
Concrete Roof	1.83	2.3	143.584	0.64	91.54
Primary Liner (Roof)	0.04167	7.85	490.060	0.0154	7.11
Grout (Inside Tank)	24.5	2.06	128.602	8.54	1,097.62
Primary Liner (Floor)	0.04167	7.85	490.060	0.0154	7.11
Grout	0.25	2.06	128.602	0.09	11.20
Secondary Liner	0.04167	7.85	490.060	0.0154	7.11
Grout	0.25	2.06	128.602	0.09	11.20
Basemat (Concrete)	2.5	2.3	143.584	0.87	125.05
Plaster	0.125	2.7	168.556	0.04	7.34
Working Slab (Concrete)	0.33	2.3	143.584	0.11	16.51
Layer Total (Non-soil)	29.91	NA	NA	10.42	NA
Total of soil layers above and below tank to reach 150 ft borehole depth	120.09	1.62	101.133	41.84	4,230.97
				Total Mass of Borehole (Pounds)	**5,612.8**
				Total Mass of Borehole (Grams)	**2,545,892**
TYPE III TANK					
Concrete Roof	4	2.3	143.584	1.39	200.08
Primary Liner (Roof)	0.04167	7.85	490.060	0.0154	7.11
Grout (Inside Tank)	33	2.06	128.602	11.50	1,478.42
Primary Liner (Floor)	0.04167	7.85	490.060	0.0154	7.11
Refractory Concrete ([6”-1”slots] = 5”)	0.41667	0.977	60.992	0.15	8.85
Secondary Liner	0.03125	7.85	490.060	0.011	5.34
Grout	0.0833	2.06	128.602	0.03	3.73
Basemat (Concrete)	3.5	2.3	143.584	1.22	175.07
Working Slab (Concrete)	0.333	2.3	143.584	0.12	16.66
Layer Total (Non-soil)	41.45	NA	NA	14.44	NA
Total of soil layers above and below tank to reach 150 ft borehole depth	108.55	1.62	101.133	37.82	3,824.48
				Total Mass of Borehole (Pounds)	**5,726.86**
				Total Mass of Borehole (Grams)	**2,597,646**

NA Not Applicable

Table 3.2-4: FTF Tanks Standard Layer Thickness and Calculated Mass (Continued)

Layer	Layer Thickness (ft)	Layer Density (g/cm^3)	Layer Density (lb/ft^3)	Volume of 8 inch Diameter Layer (ft^3)	Mass of Layer (lbs)
TYPE IIIA TANK					
Concrete Roof	4	2.3	143.584	1.39	200.08
Primary Liner (Roof)	0.04167	7.85	490.060	0.0154	7.11
Grout (Inside Tank)	33	2.06	128.602	11.50	1,478.42
Primary Liner (Floor)	0.04167	7.85	490.060	0.0154	7.11
Refractory Concrete ([8"-2" slots] = 6")	0.5	0.977	60.992	0.17	10.62
Secondary Liner	0.03125	7.85	490.060	0.011	5.34
Grout	0.0833	2.06	128.602	0.03	3.73
Basemat (Concrete)	3.58	2.3	143.584	1.25	179.07
Working Slab (Concrete)	0.333	2.3	143.584	0.12	16.66
Layer Total (Non-soil)	41.61	NA	NA	14.50	NA
Total of soil layers above and below tank to reach 150 ft borehole depth	108.39	1.62	101.133	37.76	3,818.73
Total Mass of Borehole (Pounds)					**5,726.88**
Total Mass of Borehole (Grams)					**2,597,655**
TYPE IV TANK					
Concrete Roof (Dome)	0.583	2.3	143.584	0.20	29.16
Area Under Dome (Maximum Height Above Springline Considered as Soil)	10.625	1.62	101.133	3.70	374.34
Grout (Inside Tank)	34.3125	2.06	128.602	11.95	1,537.22
Primary Liner (Floor)	0.03125	7.85	490.060	0.011	5.34
Cement (as Grout)	0.250	2.06	128.602	0.09	11.20
Basemat (Concrete)	0.333	2.3	143.584	0.12	16.66
Layer Total (Non-soil)	46.13	NA	NA	16.07	NA
Total of soil layers above and below tank to reach 150 ft borehole depth	103.86	1.62	101.133	36.18	3,659.34
Total Mass of Borehole (Pounds)					**5,633.26**
Total Mass of Borehole (Grams)					**2,555,190**

Total volume of 150 ft borehole (ft^3) = 52.26 ft^3 =1.48 m^3

NA Not Applicable

3.2.2.3 Waste Concentration Calculation Equations

For 10 CFR 61.55 Table 1 or Table 2 radionuclides, individual radionuclide concentrations for the sum of the fractions are determined with the following equations.

For volume-based Class C concentrations:

$$SOFi = \frac{(Ci) \times (WasteRatio)}{1.48\ m^3} x \frac{1}{Table\_Value}$$

where:

SOFi	=	Radionuclide contribution to the sum of the fractions
Ci	=	Total tank inventory for radionuclide from sampling (See Section 3.2.2.1), units in curie
Waste Ratio	=	Ratio of 8 inch borehole area to the area over which waste is present (Table 3.2-5)
Table _ Value	=	Class C limit in Ci/m^3 from 10 CFR 61.55 Table 1 or Table 2 for the radionuclide being calculated
Constant 1.48 m^3	=	Total borehole volume for 8 inch diameter by 150 foot deep well

For mass-based Class C concentrations:

$$SOFi = \frac{(Ci) \times (WasteRatio)}{M_{structure}} x \frac{1}{Table\_Value}$$

where:

SOFi	=	Radionuclide contribution to the sum of the fractions
Ci	=	Total tank inventory for radionuclides from sampling (See Section 3.2.2.1), units in nCi
Waste Ratio	=	Ratio of 8 inch borehole area to the area over which waste is present (Table 3.2-5)
$M_{structure}$	=	Mass of structure including mass of soil exhumed during drilling (Table 3.2-5), units in grams
Table _ Value	=	Class C limit in nCi/g from 10 CFR 61.55 Table 1 for the radionuclide being calculated

Table 3.2-5: Waste Ratio and $M_{structure}$ Used for the Volume- and Mass-Based Sum of the Fractions Calculations

Tank Type	Waste Ratio[a]	$M_{structure}$[b] (grams)
Type I	0.00008	2,545,892
Type III	0.00006	2,597,646
Type IIIA	0.00006	2,597,655
Type IV	0.00006	2,555,190

[a] See Table 3.2-3 for derivation of these values.
[b] See Table 3.2-4 for derivation of these values.

The calculated fractions are totaled for the applicable 10 CFR 61.55 Table 1 or Table 2 radionuclides. If the sum of the fractions is less than 1.0 for the individual tables, the waste is below the Class C limit.

3.3 Waste Concentration Calculations

In calculating the radionuclide concentrations, 10 CFR 61.55(a)(8) states that the radioactivity in the waste may be divided by the volume of the final waste form. Because the FTF tanks and ancillary structures use a limited number of designs, standard volume and mass estimates have been developed for the various tank types and equipment (Tables 3.2-3 and 3.2-4).

Standard methodology inputs (Section 3.2.2.1) were also made to simplify some of the parameters for the calculation. In most cases the assumptions are conservative in that they underestimate, or do not take credit, for certain masses that would generally lower the Class C ratios calculated.

3.3.1 Waste Tank Concentration Example Calculation

For this example calculation, the residual estimated inventory developed for an example FTF Type IV tank is used[2]. [SRR-CWDA-2009-00045] As mentioned earlier, the Class C concentration limit comparisons are calculated using the intruder-drilling scenario.

For the intruder-drilling scenario (Figure 3.2-1), the applicable methodology inputs in Section 3.2.2.1 and material layers penetrated listed in Table 3.2-4 for a Type IV tank were used.

The contribution of each radionuclide to the sum of the fractions was calculated using the equations presented in Section 3.2.2.3 for a mass or volume basis as necessary for the Class C concentration limit comparison. For example, using the inventory values for C-14 and Np-237, the mass- and volume-based equations from Section 3.2.2.3 become:

For the volume-based C-14 fraction of Class C concentration limit:

[2] The inventory used for the example calculation contained in this input package is based on the Tank 18 closure inventory developed to support the FTF PA. [SRR-CWDA-2009-00045] For the Draft FTF 3116 Basis Document, DOE is considering using the waste tank inventory, from the FTF closure inventory developed to support the FTF PA, which results in the highest sum of fractions value. This is intended to be an example calculation and the inventory used in the example is not considered a bounding inventory. Therefore, the inventory used, and the resulting sum of fraction values calculated, should not be considered limits. DOE is considering including in the Draft FTF 3116 Basis Document, for additional information, clarification that prior to closure of a tank or ancillary structure, DOE will document based on actual residual source terms, the waste classification.

$$SOF_{[C-14]} = \frac{(1.0\ Ci) \times (0.00006)}{1.48\ m^3}\ x\ \frac{1}{8\ Ci/m^3} = 5.07\text{E-06}$$

For the mass-based Np-237 fraction of Class C concentration limit:

$$SOF_{[Np-237]} = \frac{(2.4E+08\ nCi) \times (0.00006)}{2{,}555{,}190\ g}\ x\ \frac{1}{100\ nCi/g} = 5.64\text{E-05}$$

The remainder of the Table 1 and Table 2 radionuclides are calculated similarly and the results are presented in Tables 3.3-1 and 3.3-2. [10 CFR 61.55]

The sum of the fractions from Tables 3.3-1 and 3.3-2 are 1.1.E-01 and 9.66E-05, respectively. Based on the intruder-driller scenario, the stabilized residuals do not exceed Class C concentration limits.

Table 3.3-1: Sum of the Fractions Calculation for Radionuclides in Drill Cuttings for the Intruder-Driller Scenario Using the Closure Inventory for an example Type IV Tank (10 CFR 61.55 Table 1 Radionuclides)

Table 1 Radionuclide	Tank Inventory (Ci)	Concentration in the Drill Cuttings		Class C Concentration Limit	Fraction of Class C Concentration Limit
		(nCi/g)	(Ci/m^{3})		
C-14	1.0E+00	NA	4.05E-05	8 Ci/m3	5.07E-06
Ni-59	1.0E+00	NA	4.05E-05	220 Ci/m3	1.84E-07
Nb-94	1.0E-03	NA	4.05E-08	0.2 Ci/m3	2.03E-07
Tc-99	1.0E+00	NA	4.05E-05	3 Ci/m3	1.35E-05
I-129	1.0E-03	NA	4.05E-08	0.08 Ci/m3	5.07E-07
Np-237	2.4E-01	5.64E-03	NA	100 nCi/g	5.64E-05
Pu-238	7.0E+01	1.64E+00	NA	100 nCi/g	1.64E-02
Pu-239	1.6E+02	3.76E+00	NA	100 nCi/g	3.76E-02
Pu-240	4.9E+01	1.15E+00	NA	100 nCi/g	1.15E-02
Pu-241	1.3E+02	3.05E+00	NA	3,500 nCi/g	8.72E-04
Pu-242	1.0E+00	2.35E-02	NA	100 nCi/g	2.34E-04
Pu-244	1.0E-03	2.35E-05	NA	100 nCi/g	2.35E-07
Am-241	8.2E+01	1.93E+00	NA	100 nCi/g	1.93E-02
Am-242m	1.0E+00	2.35E-02	NA	100 nCi/g	2.35E-04
Am-243	1.0E-01	2.35E-03	NA	100 nCi/g	2.35E-05
Cm-242	0.00E+00	0.00E+00	NA	20,000 nCi/g	0.00E+00
Cm-243	1.0E+00	2.35E-02	NA	100 nCi/g	2.35E-04
Cm-244	1.0E+02	2.35E+00	NA	100 nCi/g	2.35E-02
Cm-245	1.0E+00	2.35E-02	NA	100 nCi/g	2.35E-04
Cm-247	1.0E-03	2.35E-05	NA	100 nCi/g	2.35E-07
Cm-248	1.0E-03	2.35E-05	NA	100 nCi/g	2.35E-07
Cf-249	1.0E+00	2.35E-02	NA	100 nCi/g	2.35E-04
				Sum of the Fractions	**1.10E-01**

NA Not Applicable

Note: Inventory values are from SRR-CWDA-2009-00045. Only the 10 CFR 61.55 Table 1 radionuclides in the tank inventory are listed.

Table 3.3-2: Sum of the Fractions Calculation for Radionuclides in Drill Cuttings for the Intruder-Driller Scenario Using the Closure Inventory for an example Type IV (10 CFR 61.55 Table 2 Radionuclides)

Table 2 Radionuclide	Tank Inventory (Ci)	Concentration in the Drill Cuttings (Ci/m^3)	Class C Concentration Limit (Ci/m^3)	Fraction of Class C Concentration Limit
H-3	1.0E+00	4.05E-05	[1]	NA
Co-60	1.0E+00	4.05E-05	[1]	NA
Ni-63	8.2E+01	3.32E-03	700	4.75E-06
Sr-90	1.1E+03	4.46E-02	7000	6.37E-06
Cs-137	9.7E+03	3.93E-01	4600	8.55E-05
			Sum of the Fractions	**9.66E-05**

[1] There are no limits established for these radionuclides in Class C waste.

NA Not Applicable

Note: Inventory values are from SRR-CWDA-2009-00045. Only the 10 CFR 61.55 Table 1 radionuclides in the tank inventory are listed.

3.3.2 Transfer Line Concentration Example Calculation

For this example calculation, the FTF PA estimated residual inventory for a 4 inch transfer line is used. [SRS-REG-2007-00002] The waste determination is also based on the Class C concentration limit comparisons using the intruder-drilling scenario.

In this example calculation, the borehole is assumed to intersect an 8 inch long section of transfer line with a waste residue on the inner surface. Because a 4 inch inner diameter line is the largest FTF line, this line size was chosen for the calculation. [SRS-REG-2007-00002] The calculation follows the methodology described in Section 3.2.2.

The sum of the fractions from Tables 3.3-3 and 3.3-4 are 3.4E-03 and 3.64E-06, respectively. Based on the intruder-driller scenario, the stabilized residuals in this example 4 inch transfer line do not exceed Class C concentration limits.

Table 3.3-3: Sum of the Fractions Calculation for Radionuclides in Drill Cuttings for the Intruder-Driller Scenario When Intersecting an example 4 inch Transfer Line (10 CFR 61.55 Table 1 Radionuclides)

Table 1 Radionuclide	4-inch Transfer Line Inventory (Ci/ft^2)	Concentration in the Drill Cuttings[a]		Class C Concentration Limit	Fraction of Class C Concentration Limit
		nCi/g	Ci/m^3		
C-14	5.53E-08	NA	2.61E-08	8 Ci/m3	3.26E-09
Ni-59	2.18E-06	NA	1.03E-06	220 Ci/m3	4.68E-09
Nb-94	4.90E-08	NA	2.31E-08	0.2 Ci/m3	1.16E-07
Tc-99	1.95E-05	NA	9.21E-06	3 Ci/m3	3.07E-06
I-129	9.23E-11	NA	4.36E-11	0.08 Ci/m3	5.45E-10
Np-237	1.03E-07	3.00E-05	NA	100 nCi/g	3.00E-07
Pu-238	2.38E-04	6.94E-02	NA	100 nCi/g	6.94E-04
Pu-239	9.36E-05	2.73E-02	NA	100 nCi/g	2.73E-04
Pu-240	3.44E-05	1.00E-02	NA	100 nCi/g	1.00E-04
Pu-241	1.62E-04	4.72E-02	NA	3500 nCi/g	1.35E-05
Pu-242	2.83E-07	8.25E-05	NA	100 nCi/g	8.25E-07
Pu-244	1.33E-10	3.88E-08	NA	100 nCi/g	3.88E-10
Am-241	7.60E-04	2.21E-01	NA	100 nCi/g	2.21E-03
Am-242m	1.09E-06	3.18E-04	NA	100 nCi/g	3.18E-06
Am-243	1.24E-07	3.61E-05	NA	100 nCi/g	3.61E-07
Cm-242	3.13E-24	9.12E-22	NA	20000 nCi/g	4.56E-26
Cm-243	1.83E-08	5.33E-06	NA	100 nCi/g	5.33E-08
Cm-244	3.51E-05	1.02E-02	NA	100 nCi/g	1.02E-04
Cm-245	4.50E-10	1.31E-07	NA	100 nCi/g	1.31E-09
Cm-247	1.68E-22	4.90E-20	NA	100 nCi/g	4.90E-22
Cm-248	3.87E-23	1.13E-20	NA	100 nCi/g	1.13E-22
Cf-249	1.05E-24	3.06E-22	NA	100 nCi/g	3.06E-24
				Sum of the Fractions	**3.4E-03**

[a] Inventory for an 8 inch long pipe section intersected by the borehole.
NA Not Applicable
Note: Inventory values are from SRS-REG-2007-00002.

Table 3.3-4: Sum of the Fractions Calculation for Radionuclides in Drill Cuttings for the Intruder-Driller Scenario When Intersecting an example 4 inch Transfer Line (10 CFR 61.55 Table 2 Radionuclides)

Table 2 Radionuclide	4 inch Transfer Line Inventory[a] (Ci/ft^2)	Concentration in the Drill Cuttings (Ci/m^3)	Class C Concentration Limit (Ci/m^3)	Fraction of Class C Concentration Limit
H-3	1.06E-06	5.00E-07	[1]	NA
Co-60	3.03E-05	1.43E-05	[1]	NA
Ni-63	1.81E-04	8.55E-05	700	1.22E-07
Sr-90	4.07E-02	1.92E-02	7000	2.75E-06
Cs-137	7.60E-03	3.59E-03	4600	7.80E-07
Sum of the Fractions				**3.64E-06**

[a] Inventory for an 8 inch long pipe section intersected by the borehole.
[1] There are no limits established for these radionuclides in Class C waste.
NA Not Applicable
Note: Inventory values are from SRS-REG-2007-00002.

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