

Current and Projected Future Disposed Inventory Estimate for Trenches 31 and 34 for Performance Assessment and Composite Analysis

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

CH2MHILL
Plateau Remediation Company

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Current and Projected Future Disposed Inventory Estimate for Trenches 31 and 34 for Performance Assessment and Composite Analysis

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ENVIRONMENTAL CALCULATION COVER PAGE

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ENVIRONMENTAL CALCULATION COVER PAGE (Continued)

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Terms

CA	composite analysis
ECF	environmental calculation file
PA	performance assessment
RCRA	Resource Conservation and Recovery Act of 1976
SWITS	Solid Waste Information Tracking System
TC&WM EIS	Tank Closure and Waste Management Environmental Impact Statement

1 Purpose

The purpose of this environmental calculation file (ECF) is to document and project future disposed radionuclide inventory estimates for the two currently active trenches in burial ground 218-W-5, which are designated as Trenches 31 and 34. This ECF also documents the current disposed radionuclide inventory estimate for the balance of the trenches in burial ground 218-W-5, which consist of 11 inactive trenches. All inventories were derived from disposal records maintained in the Solid Waste Information Tracking System (SWITS) database and are decayed corrected to a common date of January 1, 2070 to facilitate summation. This ECF supports modeling for performance assessment (PA) and composite analysis (CA) of waste facilities on the Hanford Site Central Plateau.

2 Background

Burial ground 218-W-5 contains 13 trenches, including two that are currently active. The active trenches (Trenches 31 and 34) are lined, *Resource Conservation and Recovery Act of 1976* (RCRA) compliant trenches and are used for disposal of low-level waste and mixed low-level waste. Both trenches are assumed for purposes of this ECF to remain operational until filled. Waste disposed in the 11 unlined, inactive trenches was largely untreated prior to disposal, whereas waste disposed in Trenches 31 and 34 must meet RCRA Land Disposal Restrictions. This waste is commonly treated (e.g., by macroencapsulation) prior to disposal. To address waste form differences, the forthcoming update to the Hanford Site CA is expected to address active and inactive trenches separately. Accordingly, this ECF develops three separate sets of radionuclide inventories for burial ground 218-W-5, consisting of trench-specific inventories for Trenches 31 and 34 and a combined inventory for the remaining 11 inactive trenches.

Consideration was given to obtaining the needed inventories from information presented in the Tank Closure and Waste Management Environmental Impact Statement (TC&WM EIS) (DOE/EIS-0391, *Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*). A review of the TC&WM EIS indicated that total radionuclide inventories for burial ground 218-W-5 are available in DOE/EIS-0391, Appendix S, "Waste Inventories for Cumulative Impact Analyses." However, the information presented in Appendix S was found to lack sufficient detail to allow break out of the necessary trench-specific inventories. Inventories for 218-W-5 were therefore developed from waste disposal records obtained from the SWITS database. Inventories were developed for the 14 primary radionuclides identified for groundwater pathway dose calculations in the forthcoming update of the Hanford Site CA (CP-60649, *Summary Analysis: Hanford Site Composite Analysis Update*) and to support potential updates to the 200 West low-level burial ground PA (WHC-EP-0645, *Performance Assessment for the Disposal of Low Level Waste in the 200 West Area Burial Grounds*). Inventories were not developed for two CA groundwater pathway radionuclides that will be tracked during modeling only as decay chain products (Th-230 and Ra-226). To support ingrowth calculations during long-term fate and transport modeling, inventories were also developed for four precursor isotopes, which are isotopes with a primary radionuclide daughter that have a potential to produce non-negligible increases in primary radionuclide activities over a 1,000-yr assessment period. For purposes of the update to the Hanford Site CA, Hanford Site closure is assumed to occur in 2070 for analysis purposes, and inventories for solid waste forms are needed decay-corrected to that year.

3 Methodology

The methodology used to develop the burial ground 218-W-5 inventory data sets involved the following general steps:

- Obtaining and preparing the SWITS data.
- Generating total inventories for Trenches 31 and 34 by summing current and projected future disposed inventories for each trench. Projected inventories (C_i) were estimated as the product of the average radionuclide-specific disposal concentrations (C_i/m^3) derived from recent SWITS disposal records and the remaining disposal capacity (m^3) in each trench. A 10-year averaging period was chosen to compute the radionuclide concentrations used in the inventory projections.
- Generating a combined inventory for the 11 inactive trenches (Trenches 03, 08, 09, 13, 14, 21, 22, 24, 27, 29, and 33) by summing the current disposed inventories reported in SWITS for the 11 trenches. The inventories reported in SWITS for these trenches are decayed to 2070 before being combined and reported in the tables in this document.

Additional methodology implementation detail for each of these general steps is provided in the following subsections.

3.1 Solid Waste Information Tracking System Data

1. Obtain a spreadsheet from the SWITS database administrator containing a complete set of disposal records for all trenches in burial ground 218-W-5.
2. Remove disposal records for radionuclides other than the 14 primary radionuclides for the Hanford Site CA groundwater pathway dose calculations (carbon-14, chlorine-36, hydrogen-3 [tritium], iodine-129, neptunium-237, rhenium-187, strontium-90, technetium-99, uranium-232, uranium-233, uranium-234, uranium-235, uranium-236, and uranium-238) and the four important precursor isotopes (americium-241, plutonium-238, plutonium-240, and plutonium-241) whose long-term decay has the potential to produce non-negligible increases in primary radionuclide inventories.
3. For disposal records with the radionuclide quantity reported with a value of zero for activity (C_i) but a nonzero value for mass (g), convert the mass to activity by multiplying the mass by the specific activity (C_i/g) for that radionuclide.
4. Correct all radionuclide activities (piso_ci_qty) to reflect decay from the reported acceptance date (CON_TSD_ACCEPT_DT) to a date of January 1, 2070.

3.2 Trench-Specific Inventories for Trenches 31 and 34

1. Estimate the current disposed inventory (C_i) for each of the 14 primary radionuclides and four precursors (ISO_NAME) in Trench 31 (CON_LOCN_UNIT) by summing each radionuclide's decayed activity values (piso_ci_qty) across all SWITS disposal records for Trench 31. Repeat this process for Trench 34.
2. Evaluate choices for an appropriate averaging period to use in estimating projected inventories for Trenches 31 and 34:
 - a. Estimate the average annual disposal concentration for Tc-99 and U-238 (representative radionuclides) in Trench 31 (representative trench) for each of the past 10 years (2008 – 2018):
 - i. Sum the decayed activity values (piso_ci_qty) for all disposal records with a location name (CON_LOCN_UNIT) of T31, an isotope name (ISO_NAME) of Tc-99, and a disposal date (CON_DISPOSAL_DT) of 2008. Repeat for years 2009 through 2018.

- ii. Sum the decayed activity values (piso_ci_qty) for all disposal records with a location name (CON_LOCN_UNIT) of Trench 31, an isotope name (ISO_NAME) of U-238, and a disposal date (CON_DISPOSAL_DT) of 2008. Repeat for years 2009 through 2018.
 - iii. Sum the waste package volumes (CON_CNTR_VOL) for each unique package ID (CON_PKG_ID) (remove duplicates) in Trench 31 with a disposal date (CON_DISPOSAL_DT) of 2008. Repeat for years 2009 through 2018.
 - iv. Divide each annual inventory value (Ci) by its corresponding annual volume (m³) to obtain the average annual Tc-99 and U-238 disposal concentrations (Ci/m³) in Trench 31 for each of the past ten years (2008 -2018).
- b. In a similar manner to step 2.a, determine 5-year (2013 – 2018) and 10-year (2008 -2018) average disposal concentrations for Tc-99 and U-238 in Trench 31.
 - c. Generate separate concentration vs. time plots for Tc-99 and U-238 in Trench 31 displaying the data developed for each radionuclide in steps 2.a and 2.b.
3. Based on results from step 2, use a 10-year averaging period (2008 – 2018) to calculate trench-specific radionuclide disposal concentration for each of the 14 primary radionuclides and four precursors in Trenches 31 and 34.
 4. Estimate the remaining unused disposal capacity (m³) in Trenches 31 and 34:
 - a. Sum the waste package volumes (CON_CNTR_VOL) for each unique package number (CON_PKG_ID) (remove duplicates) in Trench 31 across all disposal records to obtain the current total disposed waste volume for that trench. Repeat for Trench 34.
 - b. Subtract the current total disposed waste volume for Trenches 31 and 34 from the total disposal capacity of each trench (21,408 m³) to obtain the remaining available (unfilled) disposal capacity of each trench.
 5. Estimate a projected future disposed inventory (Ci) for each of the 14 primary radionuclides and four precursors in Trenches 31 and 34 by multiplying each radionuclide's trench-specific 10-year average disposal concentration (Ci/m³) by the remaining disposal capacity (m³) of that trench.
 6. Estimate the total disposed inventory (Ci) of each of the 14 primary radionuclides and four precursors in Trenches 31 and 34 at closure by summing each radionuclide's trench-specific current and projected future disposed inventories.

3.3 Combined Inventory for the Balance of 218-W-5 Trenches

1. Estimate the combined current disposed inventory (Ci) of each of the 14 primary radionuclides and four precursors in the 11 inactive trenches (all except Trenches 31 and 34) by summing each radionuclide's decayed activity values (piso_ci_qty) across all SWITS disposal records with location names (CON_LOCN_UNIT) of T03, T08, T09, T13, T14, T21, T22, T24, T27, T29, and T33.

4 Assumptions and Inputs

The assumptions and inputs used in developing the inventory data sets for burial ground 218-W-5 are as follows.

1. The SWITS database query used in this ECF was run by the SWITS database administrator on May 7, 2018 and query results were provided in the form of an electronic spreadsheet. Each record (spreadsheet row) produced by the query is unique and contains data for one radionuclide in one disposal package in one trench.
2. The SWITS query results were provided with radionuclide quantities rounded to 15 decimal digits. Even at 15 digits, a small number of radionuclide quantities were reported with a rounded value of zero for both mass (g) and activity (Ci). These quantities were left unchanged and were assumed to be effectively zero.
3. The radionuclide inventories reported in the SWITS database are considered conservative in that they commonly reflect estimates made by waste generators based on considering the highest sampled concentration and then applying that concentration to an entire waste volume.
4. Adjustment of radionuclide activities to January 1, 2070 was performed as a first-order decay calculation using the GoldSim Decay Utility Calculation Software (RPP-PLAN-61415, *Software Management Plan for Grade D Utility Calculation Software GoldSim Decay Spreadsheet*). The SWITS query results were provided with two date fields, CON_TSD_ACCEPT_DT and CON_DISPOSAL_DT. Decay calculations for this ECF were performed assuming the date reported in the CON_TSD_ACCEPT_DT field was the date of determination of the radionuclide activities reported in the pisco_ci_qty field.
5. Decay chains for primary radionuclides and important precursors were evaluated to check the suitability of using first-order decay calculations for the year 2070 inventories and to assess the potential for significant ingrowth over a 1,000-yr assessment period (i.e., by year 3070). Results of this effort are summarized as follows. Additional detail is provided in Appendix A.
 - a. U-238 decay to U-234 at year 2070 is insignificant (less than 1% relative difference) so the first-order decay calculation for U-234 is considered suitable.
 - b. Pu-238 decay to U-234 at year 2070 is insignificant (less than 1% relative difference) so the first-order decay calculation for U-234 is considered suitable. At year 3070, the ingrowth has the potential to produce a maximum relative difference of 1.3%. Although it would be reasonable to neglect Pu-238 as a precursor in the CA/PA modeling, Pu-238 inventories are nevertheless developed in this ECF to facilitate long-term U-234 ingrowth calculations should that be of interest.
 - c. Pu-241 and Am-241 decay to Np-237 at year 2070 is insignificant (less than 1% relative difference) so the first-order decay calculation for Np-237 is considered suitable. At year 3070, the ingrowth has the potential to produce a relative difference of up to 8.1%; therefore, Pu-241 and Am-241 inventories are developed in this ECF to facilitate long-term Np-237 ingrowth calculations during PA/CA modeling.
 - d. Np-237 decay to U-233 at year 2070 is insignificant (less than 1% relative difference) so the first-order decay calculation for U-233 is considered suitable. Inventories developed in this ECF for Np-237 (as a primary radionuclide) will facilitate long-term U-233 ingrowth calculations during PA/CA modeling.
 - e. Pu-239 decay to U-235 at years 2070 and 3070 is insignificant (less than 1% relative difference) so the first-order decay calculation for U-235 is considered suitable and it is not considered necessary to develop Pu-239 inventories in this ECF.

- f. Pu-240 decay to U-236 is insignificant (less than 1% relative difference) at year 2070 in the active trenches so the first-order decay calculation for U-236 is considered suitable for trenches 31 and 34. For the 11 inactive trenches, the contribution of Pu-240 to U-236 at 2070 is 15%, but considering the very low total activity of U-236 in the inactive trenches (four orders of magnitude lower than in Trench 34), using the first-order decay to calculate U-236 activities at year 2070 is considered appropriate. At year 3070, the ingrowth has the potential to produce relative differences of about 12% in Trench 31 and 70% in the inactive trenches; therefore, Pu-240 inventories are developed in this ECF to facilitate long-term ingrowth calculations during PA/CA modeling.
- g. Using the first-order decay to calculate Am-241 activity at year 2070 neglects an amount of Am-241 activity due to ingrowth from Pu-241 that ranges from 37% to 49%. With the Pu-241 inventories developed in this ECF included as a precursor in the PA/CA modeling, the difference between Am-241 activities with and without the ingrowth would be expected to disappear within 100 years after closure due to the short half-life of Pu-241 (14 years). Therefore, the first-order decay calculation for Am-241 is considered appropriate.
- h. Long-term ingrowth calculations are assumed to be handled intrinsically within the PA and CA modeling software and are not explicitly addressed in this ECF.
6. Specific activities used in converting from mass to activity for SWITS disposal records with the radionuclide quantity reported with a value of zero for activity but a nonzero value for mass are listed in Table 4-1. These specific activity values are consistent with the decay rates used in the GoldSim Decay Utility Calculation Software (RPP-PLAN-61415).
7. A total disposal capacity of 21,408 m³ was assumed for each of the active trenches (trenches 31 and 34) based on information in the RCRA permit (Permit WA7890008967, Part III, Operating Unit Group 17, Low-Level Burial Grounds Trenches 31 & 34 Fact Sheet).
8. Inventories for Trenches 31 and 34 were estimated as the sum of the current and projected future disposed inventories. Projected inventories are estimates of the inventories associated with the waste that will fill the currently unused disposal capacity in each trench. Projected inventories were calculated as the product of the average radionuclide-specific disposal concentrations (Ci/m³) derived from recent SWITS disposal records and the remaining disposal capacity (m³) in each trench. Use of this approach assumes that each trench will eventually be filled, and waste disposal concentrations in the future will be the same, on average, as in the recent past.
9. The averaging period chosen to compute the radionuclide concentrations used in the inventory projections was 10 years (2008–2018). The nature of the waste disposed in Trenches 31 and 34 has changed over time as the Hanford Site cleanup mission has progressed and the waste disposed during earlier operating years was considered less likely to be representative of future waste receipts. Both 5- and 10-year averaging periods were evaluated and the outcome indicated a 10-year period was the most appropriate.

Table 4-1. Radionuclide-Specific Activities

Radionuclide	Specific Activity (Ci/g)
C-14	4.479
Cl-36	0.03302

Table 4-1. Radionuclide-Specific Activities

Radionuclide	Specific Activity (Ci/g)
H-3	9621
I-129	0.0001766
Np-237	0.0007034
Re-187	4.64E-08
Sr-90	138.1
Tc-99	0.01712
U-232	22.36
U-233	0.009636
U-234	0.006222
U-235	0.00000216
U-236	0.00006467
U-238	3.361E-07

5 Software Applications

Software programs used for this ECF were the SWITS database and Microsoft Excel®¹. Data from SWITS were obtained through a direct request to the SWITS database administrator. A query was run for all disposal records associated with all trenches in burial ground 218-W-5 and the resulting data set was provided in an Excel spreadsheet. All supporting calculations for this ECF were then performed in Excel.

6 Calculation

All calculations for this ECF were performed on spreadsheets in Excel® using the methodology described in Section 3 and the inputs described in Section 4. Results of the calculations are summarized in Section 7. An independent review was performed to verify the spreadsheet calculation results. The ECF checker verified the accuracy of all formula-calculated values and any discrepancies identified were discussed with the preparer and resolved to the satisfaction of the checker. The radionuclide decay chain and ingrowth evaluation included in the checking process is summarized in Section 4 and further discussed in Appendix A. To maintain configuration control, the original SWITS data file, the reviewed and checked inventory calculation spreadsheet file, and the checker's calculation verification spreadsheet files will be archived in the Environmental Model Management Archive under this ECF number.

7 Results/Conclusions

- The three sets of radionuclide inventories developed for burial ground 218-W-5 for input to the Hanford Site CA models are provided in Table 7-1 for primary radionuclides and Table 7-2 for precursors. These are activities of primary radionuclides and important precursors at 1/1/2070, the assumed the closure date of 218-W-5. The tables provide inventories for the 2 active trenches (trench-specific inventories for trenches 31 and 34) and 11 inactive trenches (summed inventories from

¹ Microsoft Excel is a registered trademark of the Microsoft Corporation, Redmond, Washington.

trenches 03, 08, 09, 13, 14, 21, 22, 24, 27, 29, and 33). Inventories for the two active trenches were estimated as the sum of the current and projected inventories, as summarized in Table 7-3 for primary radionuclides and Table 7-4 for precursors. Inventories for the 11 inactive trenches were obtained by simple summation of the current inventories reported in the SWITS database for the 11 trenches. The inventories reported in SWITS for these trenches are decayed to 2070 before being combined and reported in the tables in this document.

Projected inventories for Trenches 31 and 34 were calculated as the product of the average radionuclide-specific disposal concentrations (Ci/m^3) derived from recent SWITS disposal records and the remaining disposal capacity (m^3) in each trench, as summarized in Table 7-5 for primary radionuclides and Table 7-6 for precursors. The remaining trench disposal capacities used in the inventory projections were estimated as shown in Table 7-7. Both 5- and 10-year averaging periods were evaluated for use in computing the radionuclide concentrations used in the inventory projections. The evaluation included examination of concentration trend plots for representative radionuclides, as shown in Figure 7-1. A 10-year averaging period (2008 – 2018) was selected because it better captured the fluctuations observed in the recent disposal concentrations for key groundwater pathway radionuclides.

Table 7-1. 218-W-5 Burial Ground Radionuclide Inventories (curies)^a

Inventory	C-14	Cl-36	H-3	I-129	Np-237	Re-187	Sr-90	Tc-99	U-232	U-233	U-234	U-235	U-236	U-238
Total Trench 31	8.55E-01	1.97E-02	4.45E+02	4.29E-03	1.09E-01	2.26E-07	4.90E+02	2.12E+00	1.48E-01	7.84E+00	1.17E+00	5.32E-02	3.87E-03	1.57E+00
Total Trench 34	8.55E-01	3.56E-03	1.34E+03	1.23E-02	3.85E-02	0.00E+00	1.29E+04	1.43E+02	7.81E+00	9.95E+02	3.74E+02	1.84E+01	3.20E+01	3.05E+02
Total Balance of Trenches ^b	4.72E+00	1.04E-03	9.02E+02	3.27E-02	2.25E-02	3.03E-06	3.03E+02	3.04E-01	2.72E+00	1.18E-02	1.66E-01	2.94E-02	1.77E-03	5.96E-01

a. All values derived from data obtained from SWITS database and decayed to January 1, 2070.

b. Trenches 03, 08, 09, 13, 14, 21, 22, 24, 27, 29, and 33.

Table 7-2. 218-W-5 Burial Ground Precursor Inventories (curies)^a

Inventory	Am-241	Pu-238	Pu-240	Pu-241
Total Trench 31	3.29E+01	7.62E+00	1.42E+01	2.68E+01
Total Trench 34	2.82E+01	6.17E+00	2.08E+01	2.23E+01
Total Balance of Trenches ^b	2.77E+00	3.14E+00	1.36E+02	1.80E+00

a. All values derived from data obtained from SWITS database and decayed to January 1, 2070.

b. Trenches 03, 08, 09, 13, 14, 21, 22, 24, 27, 29, and 33.

Table 7-3. Trench 31 and 34 Radionuclide Inventories (curies)^a

Inventory	C-14	Cl-36	H-3	I-129	Np-237	Re-187	Sr-90	Tc-99	U-232	U-233	U-234	U-235	U-236	U-238
Trench 31														
Inventory disposed as of 5/7/2018	3.18E-01	5.26E-03	1.22E+02	1.94E-03	3.28E-02	6.04E-08	1.57E+02	6.13E-01	4.15E-02	2.33E+00	3.21E-01	1.46E-02	1.04E-03	4.24E-01
Projected inventory	5.37E-01	1.44E-02	3.23E+02	2.35E-03	7.67E-02	1.66E-07	3.32E+02	1.51E+00	1.06E-01	5.51E+00	8.48E-01	3.86E-02	2.83E-03	1.14E+00
Total	8.55E-01	1.97E-02	4.45E+02	4.29E-03	1.09E-01	2.26E-07	4.90E+02	2.12E+00	1.48E-01	7.84E+00	1.17E+00	5.32E-02	3.87E-03	1.57E+00
Trench 34														
Inventory disposed as of 5/7/2018	5.35E-01	2.44E-04	9.18E+01	4.49E-03	1.43E-02	0.00E+00	1.26E+04	1.41E+02	5.36E-01	6.83E+01	3.62E+02	1.74E+01	3.19E+01	2.76E+02
Projected inventory	3.20E-01	3.31E-03	1.25E+03	7.82E-03	2.42E-02	0.00E+00	2.98E+02	1.36E+00	7.28E+00	9.27E+02	1.17E+01	1.01E+00	4.95E-02	2.87E+01
Total	8.55E-01	3.56E-03	1.34E+03	1.23E-02	3.85E-02	0.00E+00	1.29E+04	1.43E+02	7.81E+00	9.95E+02	3.74E+02	1.84E+01	3.20E+01	3.05E+02

a. All values derived from data obtained from SWITS database and decayed to January 1, 2070.

Table 7-4. Trench 31 and 34 Precursor Inventories (curies)^a

Inventory	Am-241	Pu-238	Pu-240	Pu-241
Trench 31				
Inventory disposed as of 5/7/2018	1.02E+01	2.36E+00	4.60E+00	9.07E+00
Projected inventory	2.27E+01	5.26E+00	9.63E+00	1.77E+01
Total	3.29E+01	7.62E+00	1.42E+01	2.68E+01
Trench 34				
Inventory disposed as of 5/7/2018	2.42E+00	4.99E-01	1.67E+00	2.76E+00
Projected inventory	2.58E+01	5.68E+00	1.92E+01	1.95E+01
Total	2.82E+01	6.17E+00	2.08E+01	2.23E+01

a. All values derived from data obtained from SWITS database and decayed to January 1, 2070.

Table 7-5. Projected Radionuclide Inventories for Trenches 31 and 34^a

Inventory	C-14	Cl-36	H-3	I-129	Np-237	Re-187	Sr-90	Tc-99	U-232	U-233	U-234	U-235	U-236	U-238
Trench 31														
10-Year Average Disposal Concentration (2008-2018) (Ci/m ³)	3.61E-05	9.69E-07	2.17E-02	1.58E-07	5.16E-06	1.11E-11	2.24E-02	1.02E-04	7.17E-06	3.71E-04	5.71E-05	2.60E-06	1.90E-07	7.68E-05
Projected Inventory (Ci) ^b	5.37E-01	1.44E-02	3.23E+02	2.35E-03	7.67E-02	1.66E-07	3.32E+02	1.51E+00	1.06E-01	5.51E+00	8.48E-01	3.86E-02	2.83E-03	1.14E+00
Trench 34														
10-Year Average Disposal Concentration (2008-2018) (Ci/m ³)	1.98E-05	2.06E-07	7.73E-02	4.85E-07	1.50E-06	0.00E+00	1.85E-02	8.45E-05	4.51E-04	5.75E-02	7.28E-04	6.26E-05	3.07E-06	1.78E-03
Projected Inventory (Ci) ^b	3.20E-01	3.31E-03	1.25E+03	7.82E-03	2.42E-02	0.00E+00	2.98E+02	1.36E+00	7.28E+00	9.27E+02	1.17E+01	1.01E+00	4.95E-02	2.87E+01

a. All values derived from data obtained from SWITS database and decayed to January 1, 2070.

b. Inventory disposed in remaining trench disposal capacity, calculated as concentration (Ci/m³) x remaining disposal capacity (m³).

Table 7-6. Projected Precursor Inventories for Trenches 31 and 34^a

Inventory	Am-241	Pu-238	Pu-240	Pu-241
Trench 31				
10-Year Average Disposal Concentration (2008-2018) (Ci/m ³)	1.53E-03	3.54E-04	6.48E-04	1.19E-03
Projected Inventory (Ci) ^b	2.27E+01	5.26E+00	9.63E+00	1.77E+01
Trench 34				
10-Year Average Disposal Concentration (2008-2018) (Ci/m ³)	1.60E-03	3.52E-04	1.19E-03	1.21E-03
Projected Inventory (Ci) ^b	2.58E+01	5.68E+00	1.92E+01	1.95E+01

- a. All values derived from data obtained from SWITS database and decayed to January 1, 2070.
- b. Inventory disposed in remaining trench disposal capacity, calculated as concentration (Ci/m³) x remaining disposal capacity (m³).

Table 7-7. Trench 31 and 34 Disposal Capacities

Capacity	Trench 31 (m ³)	Trench 34 (m ³)
Total ^a	21,408	21,408
Filled ^b	6,548	5,288
Remaining	14,860	16,120

a. RCRA Permit WA7890008967, Part III, Operating Unit Group 17, Low-Level Burial Grounds Trenches 31 & 34 Fact Sheet.

b. Total disposed volume based on waste disposal records reported in SWITS (downloaded 05/07/2018).

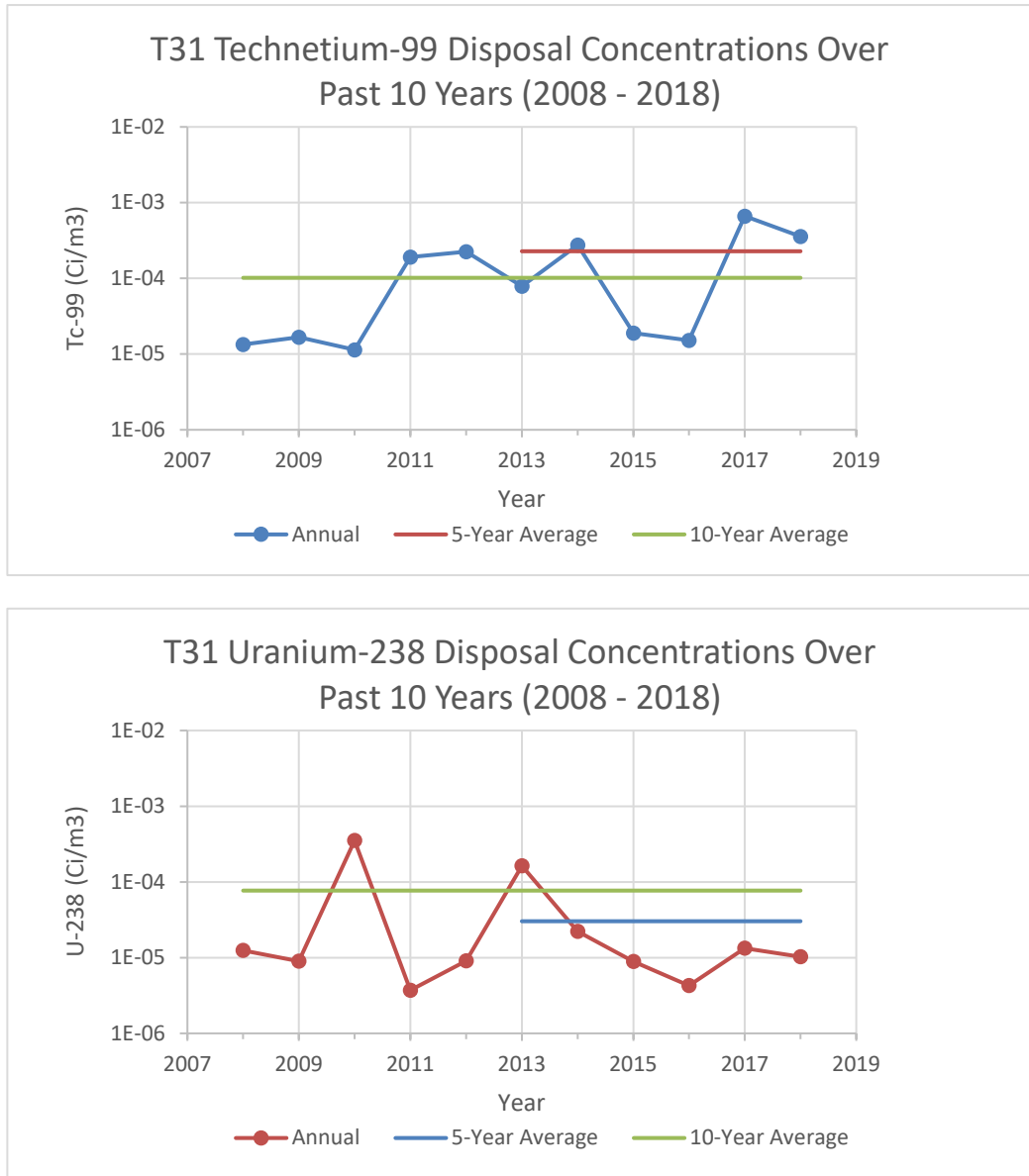


Figure 7-1. Technetium-99 and Uranium-238 Disposal Concentration Trends in Trench 31 (T31).

8 References

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Appendix A

Summary of Checking Activity Calculation Results

A1 Introduction

The data presented in Chapter 7 has been checked through calculations independent from the ECF calculation detailed in Chapters 1 - 7. The checking calculation started with the same original data file as the ECF: “Full_218W5_15Digits_2018_05_07.xlsx”

The calculation presented in this ECF adopted the first-order-decay spreadsheet calculation tool to calculate the activities of all 14 primary radionuclides at January 1, 2070. Such a calculation assumes that ingrowth to the actinide primary radionuclides can be neglected. Because the amount of data is huge (>220,000 data records and each record containing 14 properties including package ID, the disposed volume, waste type, burial ground, acceptance date, disposal date, activity and mass at the acceptance date, etc.) and the starting dates of the activities/masses of the primary radionuclides are all different, using the first-order-decay approximation to the actinide primary radionuclides is considered to be an efficient approach with little compromise to the accuracy. This is particularly practical considering the conservatism and a large uncertainty in the original database.

A2 First-Order Decay

To check that the first-order-decay calculation is appropriate, the checking calculation included the second-order-decay for the primary radionuclides whose precursors' data records are present in the original database. The same method is also used for the precursors (i.e., Am-241, Pu-238, Pu-240, and Pu-241) included in this ECF. Figure A-1 shows the primary radionuclides in the decay chains and the precursors considered in this appendix.

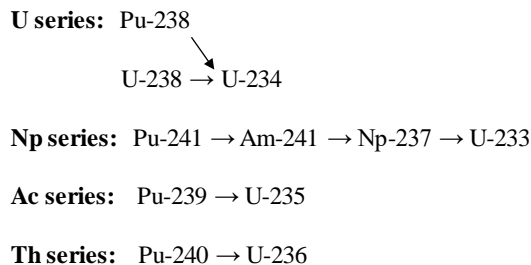


Figure A-1. Primary Radionuclides/Precursors and their Decay/Ingrowth Relationships Considered in the Checking Calculation

In Figure A-1, Pu-238, Pu-239, Pu-240, Pu-241, and Am-241 are not in the primary radionuclide list but are precursors of the primary radionuclides (Np-237, U-233, U-234, U-235, U-236, and U-238) shown in the figure. The important daughter radionuclides of the ending members of the decay chains are not shown in Figure A-1 but will be considered in the future CA/PA calculations. The activities of these daughters will be determined by the activities of their parent radionuclides in the CA/PA model. It is assumed that the precursors of the leading members in the decay chains can be neglected.

The results of total activities of the studied radionuclides at are summarized in the Table A-1 by comparing the checking results (labeled as “Checking”) with the ECF results presented in Chapter 7 (labeled as “ECF”). The relative differences are displayed in the columns labeled as “Diff [%]”. It can be seen that even with ingrowth considered in the checking calculation; the differences for most actinide primary radionuclides are less than 1% except for U-236 in the 11 inactive trenches and the precursor Am-241 in all trenches. This means that for most actinide decay chain primary radionuclides, using the first-order-decay method to calculate activities at year 2070 is appropriate.

The differences in Am-241, ranging from 37% to 49%, is caused by the ingrowth from Pu-241 considered in the checking calculation but not in the ECF calculation. With Pu-241 included as a precursor in the CA/PA model, these differences will not cause significant impacts to Np-237 and the daughters' activities because Pu-241's half-life is only 14 years and 99% of its activity will decay to Am-241 within 100 years. In other words, the activities of Np-237 and daughters calculated using the ECF and Checking activities at year 2070 will become identical at about year 2170 and beyond.

The maximum difference in U-236 is 15% due to ingrowth from Pu-240 and occurring in the 11 inactive trenches where the U-236 activity is more than four orders of magnitude lower than Trench 34.

Table A-1. Comparison of Selected Radionuclide and Precursor Activities (Ci) at Year 2070

Primary Radionuclides & Precursors	Trench 31			Trench 34			11 inactive trenches		
	ECF	Checking	Diff [%]	ECF	Checking	Diff [%]	ECF	Checking	Diff [%]
Np-237	3.28E-02	3.30E-02	-6.47E-01	1.43E-02	1.43E-02	-3.59E-01	2.25E-02	2.26E-02	-4.76E-01
U-233	2.33E+00	2.33E+00	-3.77E-04	6.83E+01	6.83E+01	-6.35E-06	1.18E-02	1.18E-02	-6.30E-02
U-234	3.21E-01	3.21E-01	-1.90E-01	3.62E+02	3.62E+02	-1.40E-02	1.66E-01	1.68E-01	-6.37E-01
U-235	1.46E-02	1.46E-02	-3.92E-03	1.74E+01	1.74E+01	-1.94E-06	2.94E-02	2.94E-02	-1.96E-03
U-236	1.04E-03	1.05E-03	-8.12E-01	3.19E+01	3.19E+01	-9.64E-06	1.77E-03	2.09E-03	1.52E+01
U-238	4.24E-01	4.24E-01	5.24E-14	2.76E+02	2.76E+02	-1.03E-13	5.96E-01	5.96E-01	-4.13E-11
Am-241	1.02E+01	1.63E+01	3.72E+01	2.42E+00	4.78E+00	4.93E+01	2.77E+00	4.65E+00	4.04E+01
Pu-238	2.36E+00	2.36E+00	0.00E+00	4.99E-01	4.99E-01	0.00E+00	3.14E+00	3.14E+00	-1.76E-08
Pu-240	4.60E+00	4.60E+00	-3.86E-14	1.67E+00	1.67E+00	0.00E+00	1.36E+02	1.36E+02	-1.44E-08
Pu-241	9.07E+00	9.07E+00	5.87E-14	2.76E+00	2.76E+00	0.00E+00	1.80E+00	1.80E+00	-2.08E-09

A3 Long-Term Ingrowth

To investigate the long-term impact of ingrowth from the precursors not in the primary radionuclide list, in Table A-2, activities of Np-237, U-234, U-235, and U-236 at January 1, 3070 (i.e., at the end of 1,000-yr compliance period) with ingrowth ("Checking") and without ingrowth ("ECF") are compared along with the relative differences ("Diff [%]"). Referring to Figure A-1, U-233 is not in Table A-2 because its precursor is Np-237 that is already in the primary radionuclide list. U-234 has two precursors: U-238 that is in the primary radionuclide list and Pu-238 (Figure A-1). Table A-2 compares the difference with and without ingrowth from Pu-238 only.

Table A-2. Comparison of Selected Radionuclide Activities (Ci) at Year 3070

Primary Radionuclides & Precursors	Trench 31			Trench 34			11 inactive trenches		
	ECF	Checking	Diff [%]	ECF	Checking	Diff [%]	ECF	Checking	Diff [%]
Np-237	3.27E-02	3.56E-02	-8.10E+00	1.43E-02	1.51E-02	-5.52E+00	2.25E-02	2.34E-02	-3.70E+00
U-234	3.21E-01	3.22E-01	-4.50E-01	3.62E+02	3.62E+02	-1.40E-02	1.68E-01	1.70E-01	-1.29E+00
U-235	1.46E-02	1.46E-02	-6.64E-02	1.74E+01	1.74E+01	-3.27E-05	2.94E-02	2.94E-02	-2.64E-02
U-236	1.04E-03	1.18E-03	-1.17E+01	3.19E+01	3.19E+01	-1.56E-04	1.77E-03	5.90E-03	-6.99E+01

Table A-2 shows that the ingrowth from the precursors not in the primary radionuclide list is important to the long-term (1,000 yrs) activities of Np-237 (precursors Pu-241 and Am-241) in all trenches and U-236

(precursor Pu-240) in all but Trench 34. For U-234, the maximum difference is 1.3% in the 11 inactive trenches only, indicating that Pu-238 can be neglected. U-235's precursor is Pu-239 that can be neglected because the ingrowth makes a maximum difference of less 0.1%.

Overall, the result demonstrates that including Pu-241, Am-241, and Pu-240 is sufficient to account for the ingrowth of Np-237 and U-236 and their daughters. Pu-239 and Pu-238 can be neglected as the precursors to U-234 and U-235, respectively.