SANDIA NATIONAL LABORATORIES
WASTE ISOLATION PILOT PLANT

ANALYSIS REPORT FOR RADIONUCLIDE INVENTORY SCREENING IN THE 2026 COMPLIANCE RECERTIFICATION APPLICATION PERFORMANCE ASSESSMENT: FINAL STATE REPOSITORY

REVISION 0

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ELEMENTS

Ac	actinium
Ag	silver
Am	americium
Ar	argon
At	astatine
Ba	barium
Bi	bismuth
Bk	berkelium
C	carbon
Cd	cadmium
Ce	cerium
Cf	californium
Cl	chlorine
Cm	curium
Co	cobalt
Cs	cesium
Eu	europium
Fe	iron
Fr	francium
Gd	gadolinium
H	hydrogen
Ho	holmium
I	iodine
In	indium
Ir	iridium
K	potassium
Kr	krypton
Mn	manganese
Mo	molybdenum
Na	sodium
Nb	niobium
Nd	neodymium
Ni	nickel
Np	neptunium
Os	osmium
Pa	protactinium
Pb	lead
Pd	palladium

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Pm	promethium
Po	polonium
Pr	praseodymium
Pu	plutonium
Ra	radium
Rb	rubidium
Rh	rhodium
Rn	radon
Ru	ruthenium
Sb	antimony
Se	selenium
Sm	samarium
Sn	tin
Sr	strontium
Tb	terbium
Tc	technetium
Te	tellurium
Th	thorium
Tl	thallium
Tm	thulium
U	uranium
V	vanadium
Y	yttrium
Zn	zinc
Zr	zirconium

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Executive Summary

The Waste Isolation Pilot Plant (WIPP) was initially certified as a repository consisting of 10 panels, which were excavated for the long-term storage and placement of transuranic waste (U.S. EPA 1998). However, due to operational constraints, the entire volume of the 10 panels is no longer available for waste disposal. In March 2024, the U.S. Department of Energy (DOE) submitted the Replacement Panels Planned Change Request (RPPCR) to the U.S. Environmental Protection Agency (EPA) for approval of waste emplacement in two new panels. These panels, referred to as replacement panels, are located to the west of the existing operations area. It is anticipated that the RPPCR will receive EPA approval prior to the submission of CRA-2026.

The addition of the two replacement panels is not expected to provide adequate space for the disposal of the allowable waste volume designated for WIPP under the Land Withdrawal Act (LWA); thus, the 12-panel configuration is regarded as an interim state of the repository. The DOE may pursue approval for waste disposal in seven additional panels to accommodate the full allowable volume of waste. This hypothetical 19-panel configuration is considered the anticipated final state of the repository.

The DOE demonstrates compliance with containment requirements as outlined in the Certification Criteria of Title 40 CFR Part 191.13 through performance assessment (PA). PA calculations estimate the probability and consequences of potential radionuclide releases from the repository to the accessible environment over a regulatory period of 10,000 years following facility closure. WIPP PA models are utilized to support the periodic recertification of WIPP.

The 2026 Compliance Recertification Application (CRA-2026) represents the fifth recertification application submitted to the EPA. A PA is being carried out by Sandia National Laboratories to support the DOE's submission of the CRA-2026. The results presented in the CRA-2026 PA are compared to those from the RPPCR PA, the most recent regulatory submission.

This analysis report documents the radionuclide inventory screening component of the CRA-2026 PA for the final state of the repository. This report details the effects of the changes incorporated in the CRA-2026 PA that impact the radionuclide inventories used in various codes that calculate releases via individual release mechanisms that are modeled in WIPP PA. In comparison to the RPPCR PA, the primary effects of these changes are an increase in total activity in curies.

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1.0 INTRODUCTION

The Waste Isolation Pilot Plant (WIPP), located in southeastern New Mexico, has been developed by the U.S. Department of Energy (DOE) for the geologic disposal of transuranic (TRU) waste. The containment of TRU waste at WIPP is regulated by the U.S. Environmental Protection Agency (EPA) under Title 40 of the Code of Federal Regulations (CFR), Part 191.

The DOE demonstrates compliance with the containment requirements of 40 CFR 191.13 by means of performance assessment (PA) as described in the Certification Criteria of Title 40 CFR Part 194. Sandia National Laboratories (SNL) conducts PAs at the request of the DOE. The PA calculations estimate the probability and consequences of potential radionuclide releases from the repository to the accessible environment over a regulatory period of 10,000 years following facility closure. The PA models are continuously maintained and updated with new information, which typically leads to refinements and modifications in both the models and their parameters. Additionally, planned changes to the repository and its components necessitate updates to the WIPP PA models.

All previous WIPP certifications have been based on a repository consisting of 10 panels. In March 2024, the DOE submitted the Replacement Panels Planned Change Request (RPPCR) to seek EPA approval for waste emplacement in two new panels, referred to as replacement panels, located to the west of the existing operations area (Bollinger 2024). It is anticipated that the RPPCR will receive EPA approval prior to the submission of CRA-2026.

The addition of the two replacement panels is not expected to provide sufficient space for the disposal of the allowable waste volume designated for WIPP under the Land Withdrawal Act (LWA). The 12-panel configuration is thus regarded as an interim state of the repository. The DOE may seek approval for waste disposal in up to seven additional panels to accommodate the full allowable volume of waste. This 19-panel configuration is considered the anticipated final state of the repository.

The CRA-2026 is the fifth recertification application for the WIPP submitted by the DOE for EPA approval. The PA executed by SNL in support of the CRA-2026 PA is described in AP-214 (Hansen et al. 2025). This analysis report documents the radionuclide inventory screening component of the CRA-2026 PA for the final state of the repository.

Los Alamos National Laboratory (LANL) has provided updated inventory data based on the Annual Transuranic Waste Inventory Report (ATWIR) – 2024 (U.S. DOE 2024) as documented in the Full Repository Performance Assessment Inventory Report – 2024 (FRPAIR-2024, Van Soest 2025), which contains updated estimates to the radionuclide content and waste material parameters using inventory information collected up to December 31, 2023. FRPAIR-2024 is the basis for the radionuclide inventory analysis presented in this document. The radionuclide inventory in FRPAIR-2024 contains 168 radionuclides. Many of these radionuclides have low concentrations or are short lived and would not impact releases calculated by PA simulations. Additionally, PA calculations involve a suite of computationally intensive codes, and tracking all 168 radionuclides is not practical. Therefore, the number of isotopes modeled in the PA codes is screened to reduce the number of isotopes while still capturing the dominant inventory. This

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analysis provides a list of PA inventory-related parameters that will be used in PA calculations, and it produces inventory input files for use in the PA code, EPAUNI.

1.1 Background

PA calculations were included in the 1996 Compliance Certification Application (CCA) (U.S. DOE 1996), and in a subsequent Performance Assessment Verification Test (PAVT) (MacKinnon and Freeze 1997a, 1997b and 1997c). Based in part on the CCA and PAVT PA calculations, the EPA certified that the WIPP met the regulatory containment criteria. The facility was approved for disposal of TRU waste in May 1998 (U.S. EPA 1998).

The LWA (U.S. Congress 1992) requires that the DOE apply for WIPP recertification every five years following the initial 1999 waste shipment. PA calculations were an integral part of the first WIPP recertification as documented in the 2004 Compliance Recertification Application (CRA-2004) (U.S. DOE 2004). During their review of the CRA-2004, the EPA requested an additional PA calculation, referred to as the CRA-2004 Performance Assessment Baseline Calculation (PABC) (Leigh et al. 2005), be conducted with modified assumptions and parameter values (Cotsworth 2005). Following review of the CRA-2004 and the CRA-2004 PABC, the EPA recertified the WIPP in March 2006 (U.S. EPA 2006).

PA calculations were completed for the second WIPP recertification and documented in the 2009 Compliance Recertification Application (CRA-2009). The CRA-2009 PA resulted from continued review of the CRA-2004 PABC, including several technical changes and corrections, as well as updates to parameters and improvements to the PA computer codes (Clayton et al. 2008). To incorporate additional information which was received after the CRA-2009 PA was completed, but before the submittal of the CRA-2009, the EPA has requested an additional PA calculation, referred to as the 2009 Compliance Recertification Application Performance Assessment Baseline Calculation (PABC-2009), be undertaken which included updated information (Cotsworth 2009). Following the completion and submission of the PABC-2009, the WIPP was recertified in 2010 (U.S. EPA 2010).

PA calculations were completed for the third WIPP recertification and documented in the 2014 Compliance Recertification Application (CRA-2014). Following review of the CRA-2014, the EPA recertified the WIPP in July 2017 (U.S. EPA 2017).

PA calculations were completed for the fourth WIPP recertification and documented in the 2019 Compliance Recertification Application (CRA-2019) (U.S. DOE 2019). Following review of the CRA-2019, the EPA recertified the WIPP in May 2022 (U.S. EPA 2022).

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1.2 Key Inventory Differences

The CRA26_FS inventory provided by FRPAIR-2024 (Van Soest 2025), which is based on ATWIR-2024 (U.S. DOE 2024), differs from the inventories used in CRA-2019 and in the RPPCR PA as shown in Table 1 and includes the following key changes:

- Updated inventory data based on the generator sites' estimated inventory as of December 31, 2023. The anticipated activity increase is primarily attributed to the designation of waste stream SR-KAC-PuOx-2 as WIPP-bound.
- Projections for waste generation are based on repository closure in calendar year (CY) 2083. Note that the CRA-2019 inventory is based on repository closure in CY 2033.
- The waste stream volumes of the contact-handled (CH)-TRU waste are counted based on the internal container volume for past (already-emplaced) and future (not yet emplaced) waste. The methodology for remote-handled (RH)-TRU waste volume is counted based on the internal container for past and future waste. Note that the CRA-2019 inventory counted waste stream volumes using the outermost container volume of CH-TRU waste and inner container volume for RH-TRU waste.

1.3 Scope

Background information on radionuclide containment requirements is provided in Section 2 and a history of radionuclide screening at WIPP is presented in Section 3. This calculation uses inventory input in curies from FRPAIR-2024 to determine the waste unit factor (Section 4), release limits and source term EPA units over a range of time periods (Section 5), and which radionuclides participate in radiolysis based on the relative amount of decay heats compared to the overall inventory heat production (Section 6). The computational methodology to combine radionuclide inventories into "lumped" inventories is provided in Section 7. The calculation of oxyanion moles (Section 8) and the identification of waste material parameters (Section 9) are also documented. Finally, this calculation documents the development of input files for the PA code EPAUNI based on radionuclide inventory data (Section 10).

Appendix A contains radionuclide inventories and potential releases (in EPA units) at six times. Appendix B contains a calculation of the unit of waste. An inventory assessment that determines the percentage decay heat contribution for key radionuclides is provided in Appendix C. Appendix D presents the parameter values to be included in PA calculations based on FRPAIR-2024 (Van Soest 2025). Appendix E explains how the EPAUNI input files are generated from the inventory data contained in FRPAIR-2024.

Data analysis files from the CRA26_FS radionuclide screening are available in the CVS repository at /data/cvs/CVSLIB/WIPP_EXTERNAL/ap214/Files.

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Table 1 – Comparison of the CRA-2019, RPPCR, and CRA26_FS Waste Inventories

Item	CRA-2019 (Van Soest 2018)	RPPCR PA (Van Soest 2022; U.S. DOE 2022)	CRA26_FS (Van Soest 2025; U.S. DOE 2024)
Inventory cut-off date	12/31/2017	12/31/2021	12/31/2023
Number of waste streams	510 CH waste streams 97 RH waste streams	488 CH waste streams 103 RH waste streams	485 CH waste streams 105 RH waste streams
Number of radionuclides	195	163	168
Volume of record	Use outermost container volume of CH waste and inner container volume for RH waste	Use inner container volume for both CH and RH waste	Use inner container volume for both CH and RH waste
Inventory volume [a]	CH: 168,485 m^3 RH: 7,079 m^3 Total: 175,564 m^3	CH: 168,485 m^3 RH: 7,079 m^3 Total: 175,564 m^3	CH: 168,485 m^3 RH: 7,079 m^3 Total: 175,564 m^3
Total activity at closure	CH: 5.12E+06 Ci RH: 1.01E+06 Ci Total: 6.14E+06 Ci	CH: 6.15E+06 Ci RH: 3.62E+05 Ci Total: 6.51E+06 Ci	CH: 9.32E+06 Ci RH: 3.57E+05 Ci Total: 9.68E+06 Ci
Key waste streams	Highest activity is SR-KAC-PuOx.	Highest activity is SR-KAC-PuOx. Adds waste stream SR-CH-PP, which has the second highest activity.	Adds waste stream SR-KAC-PuOx-2, which has the highest activity, followed by SR-KAC-PuOx and SR-CH-PP.
Repository closure date	2033	2083	2083

[a] PA modeling in support of WIPP explicitly assumes that the WIPP is filled to its legislated capacity at time of closure, as described in Title 40 CFR Part 194.24 (U.S. EPA 1998). The legislated capacity for WIPP is 175,564 m^3 (6,200,000 ft^3), as set by the WIPP LWA (U.S. Congress 1992), with a RH-TRU waste limit of 7,079 m^3. The CRA-2019, RPPCR, and CRA26_FS inventories were less than the legislative capacity for WIPP, therefore the CH and RH waste stream volumes (for projected waste only) were scaled up to the maximum limits.

2.0 RADIONUCLIDE CONTAINMENT REQUIREMENTS

The WIPP compliance strategy is based on the requirements of 40 CFR 191, which provides the incentive for the development of the modeling methodology and associated analysis tools devised and compiled by SNL to evaluate the long-term behavior of the WIPP disposal system. 40 CFR 191 is the basis for determining important radionuclides, as it identifies release limits for

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containment requirements. To help describe the 40 CFR 191 containment requirements, the following paragraphs were taken from *An Introduction to the Mechanics of Performance Assessment Using Examples of Calculations Done for the Waste Isolation Pilot Plant Between 1990 and 1992* (Rechard 1996, Section 6.1.2), which provides a very thorough introduction to the mechanics of the WIPP PA process:

> *Containment Requirements (40 CFR 191.13) specify general limits on the release of transuranic (TRU) waste, high-level waste, or spent nuclear fuel (SNF) from a geological repository. Environmental Protection Agency (EPA) release limits are defined as the normalizing factors for various radionuclides listed in Table 1 of Appendix A of EPA regulation 40 CFR 191 (see Table [2]). According to the Containment Requirements, there must be a reasonable expectation, based on a performance assessment that includes all significant processes and events, that the cumulative release of any one radionuclide over 10,000 years to the accessible environment shall have:*
>
> - *less than 1 chance in 10 of exceeding the promulgated EPA radionuclides limits (L_i), and*
> - *less than 1 chance in 1000 of exceeding 10 times those quantities.*
>
> *[These two points alone determine the EPA limits drawn on all WIPP Complimentary Cumulative Distribution Function codes.]*
>
> *For a mix of radionuclides, the sum of all releases, where each radionuclide is normalized with respect to its L_i, shall have:*
>
> - *Less than 1 chance in 10 of exceeding 1, and*
> - *Less than 1 chance in 1000 of exceeding 10.*
>
> *[Where the sum of all releases is expressed by:]*

$$R_j = \frac{1}{f_w}\left\{\frac{Q_{1j}}{L_1} + \frac{Q_{2j}}{L_2} + \cdots + \frac{Q_{nRj}}{L_{nR}}\right\} = \sum_{i\text{-}1}^{nR} \frac{Q_{ij}}{f_w L_i} \leq 1 (or\ 10) \quad (1)$$

where:

f_w = *waste unit factor* $= \frac{\sum W_i}{10^6\ Ci}$

W_i = *activity in Curies (Ci) for α-emitting TRU repository wastes having half-lives ($t_{½}$) greater than 20 yr*

L_i = *the EPA release limit for radionuclide i (see Table [2] for examples and units)*

nR = *number of radionuclides contributing to the release*

R_j = *total normalized release (EPA sum) for the j^{th} scenario*

Q_{ij} = *cumulative release for radionuclide q_{ij} beyond a specified boundary,* $\int_0^{10{,}000\ yr} q_{ij}\,dt$

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q_{ij} = *release rate into accessible environment at time t for radionuclide i and scenario j calculated from consequence model(s) (see Chapter 5.0, Consequence Analysis [of Rechard 1996]).*

The normalized release for TRU waste, R_j, is defined based on 40 CFR 191, which specifies release limits per "unit of waste". In accordance with 40 CFR 191, WIPP PA calculations normalize the radionuclide activity. The normalized activity of radionuclide *i* is expressed in EPA units, which is the activity of the radionuclide (in curies) divided by its release limit in curies:

$$E_i = \left(\frac{1}{f_w}\right)\left(\frac{w_i}{L_i}\right) \quad (2)$$

where f_w is the unit of waste,
w_i is the radionuclide activity in curies, and
L_i is the EPA release limit in curies per unit of waste for radionuclide *i*.

The release limits per 40 CFR 191 are provided in Table 2. These release limits are normalized to a unit of waste, f_w, which is also called a waste unit factor (WUF). For the TRU waste to be disposed of at WIPP, the WUF is "an amount of TRU wastes containing one million curies of alpha-emitting transuranic radionuclides with half-lives greater than 20 years" (40 CFR 191, Appendix A, Table 1).

Table 2 – Release Limits for Containment Requirements from 40 CFR 191 Appendix A Table 1

Radionuclides with Limits on Release	Release Limit, L_i (curies per unit of waste)
^{230}Th and ^{232}Th	10
^{241}Am, ^{243}Am, ^{14}C, ^{129}I, ^{237}Np, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{242}Pu, ^{226}Ra, ^{233}U, ^{234}U, ^{235}U, ^{236}U, ^{238}U, and any other alpha-emitting radionuclide with a half-life greater than 20 years	100
^{135}Cs, ^{137}Cs, ^{126}Sn, ^{90}Sr, and any other radionuclide with a half-life greater than 20 years that does not emit alpha particles	1,000
^{99}Tc	10,000

NOTE: For TRU waste, the unit of waste is 10^6 curies of alpha-emitting TRU radionuclides with half-lives greater than 20 years. Other units of waste are described in 40 CFR 191, Appendix A. Radionuclides with a half-life less than 20 years are not regulated and therefore do not have a release limit.

3.0 HISTORY OF RADIONUCLIDE SCREENING AT WIPP

The early screening methodology and justifications were described in an analysis of the long-term behavior of WIPP (Lappin et al. 1989, Section 4.4), which assumed that the four dominant

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radionuclides in the initial CH-TRU inventory are ^{238}Pu, ^{241}Am, ^{239}Pu, and ^{240}Pu. Simplified decay chains (e.g., radionuclides with half-lives less than a few hours were eliminated) for the four dominant radionuclides resulted in 23 radionuclides: ^{241}Am, ^{252}Cf, ^{244}Cm, ^{248}Cm, ^{237}Np, ^{231}Pa, ^{210}Pb, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu, ^{244}Pu, ^{226}Ra, ^{228}Ra, ^{229}Th, ^{230}Th, ^{232}Th, ^{233}U, ^{234}U, ^{235}U, ^{236}U, and ^{238}U.

Using this same method for screening radionuclides, the Preliminary PA (Sandia WIPP Project 1992) provided decay chains for CH radionuclides in the WIPP inventory as shown in Figure 1. The Preliminary PA also provided decay chains for RH radionuclides (Figure 2). The RH inventory decay chains include the chains in the CH inventory shown in Figure 1 plus the three chains shown in Figure 2. The RH decay chains resulted in three additional radionuclides (^{137}Cs, ^{147}Pm, and ^{90}Sr) to be included in PA calculations, bringing the total radionuclides to 26.

The inventory screening methodology and justifications were outlined in the CCA Appendix WCA (Waste Characterization Analysis), Section WCA.3, Attachment WCA.8.2, Attachment WCA.8.3, and Appendix PANEL (p. 9) (U.S. DOE 1996). The guiding principle is to include the subset of radionuclides deemed most significant to potential releases while excluding those deemed insignificant to demonstrating compliance.

Determining the importance of radionuclides is based upon several factors (U.S. DOE 1996, Appendix WCA, Attachment WCA.8.2 (memo from Sanchez to Distribution dated April 25, 1996)), including:

1) allowable release limits,
2) TRU inventory, and
3) the subsurface transportability of the radionuclides (solubility in brine, chemical sorption, etc.).

Allowable release limits are provided for regulated radionuclides identified in 40 CFR 191. Out of 140 radionuclides in the CCA inventory, 44 are regulated and have release limits (U.S. DOE 1996, Attachment WCA.8.1, Table 5). To further evaluate the CCA inventory, the CCA stipulated that if the regulated radionuclide has a total inventory greater than 0.001 EPA units during the 10,000-year compliance period, then the radionuclide should be considered for inclusion in PA calculations (U.S. DOE 1996, Appendix WCA, Figure WCA-4).

Radionuclides from the CCA inventory are rank ordered by inventory activity in EPA units (Table 3). As shown in Table 3, the CCA inventory included 25 radionuclides with activities greater than 0.001 EPA units. Twenty-two of these 25 radionuclides are included in CCA PA calculations. Justifications for exclusion are given for each of three categories of release pathways – direct releases (i.e., releases that occur directly to the surface environment) of contaminated solids (cuttings/cavings and spallings), direct releases of contaminated brine, and long-term releases of contaminated brine through the subsurface (releases to the Culebra aquifer). In general, the justifications are based on the fraction of the overall TRU inventory activity (in EPA units) represented over the time scale of interest of the release mechanism. Reasons for excluding specific radionuclides are documented in the CCA (U.S. DOE 1996, Appendix WCA, Table WCA-8).

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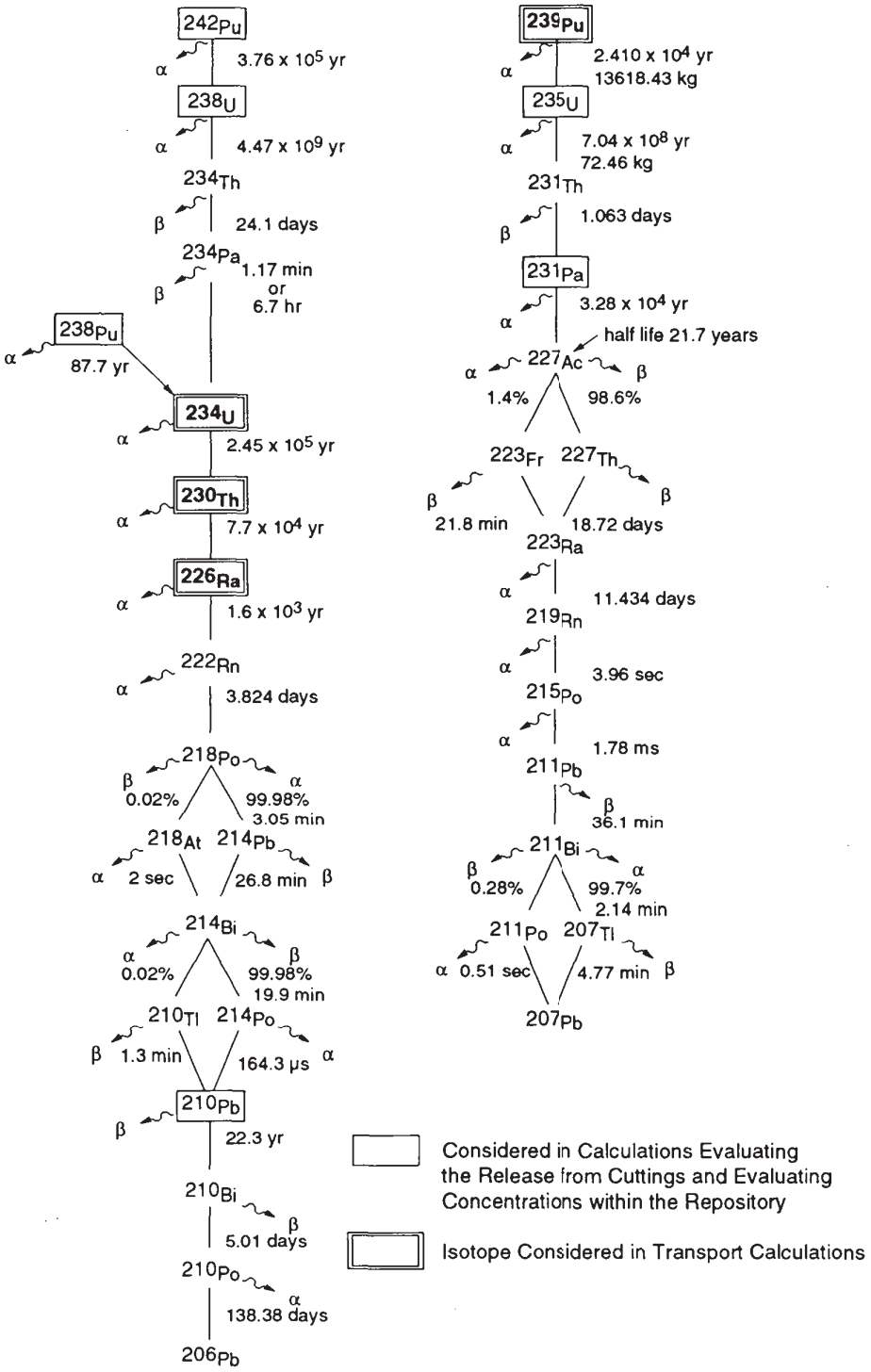


Figure 3.3-1 from Sandia WIPP Project 1992

Figure 1 – Simplified Decay Chains for Four Dominant Radionuclides (^{238}Pu, ^{239}Pu, ^{240}Pu, and ^{241}Am) in CH-TRU Waste in the Preliminary PA Inventory

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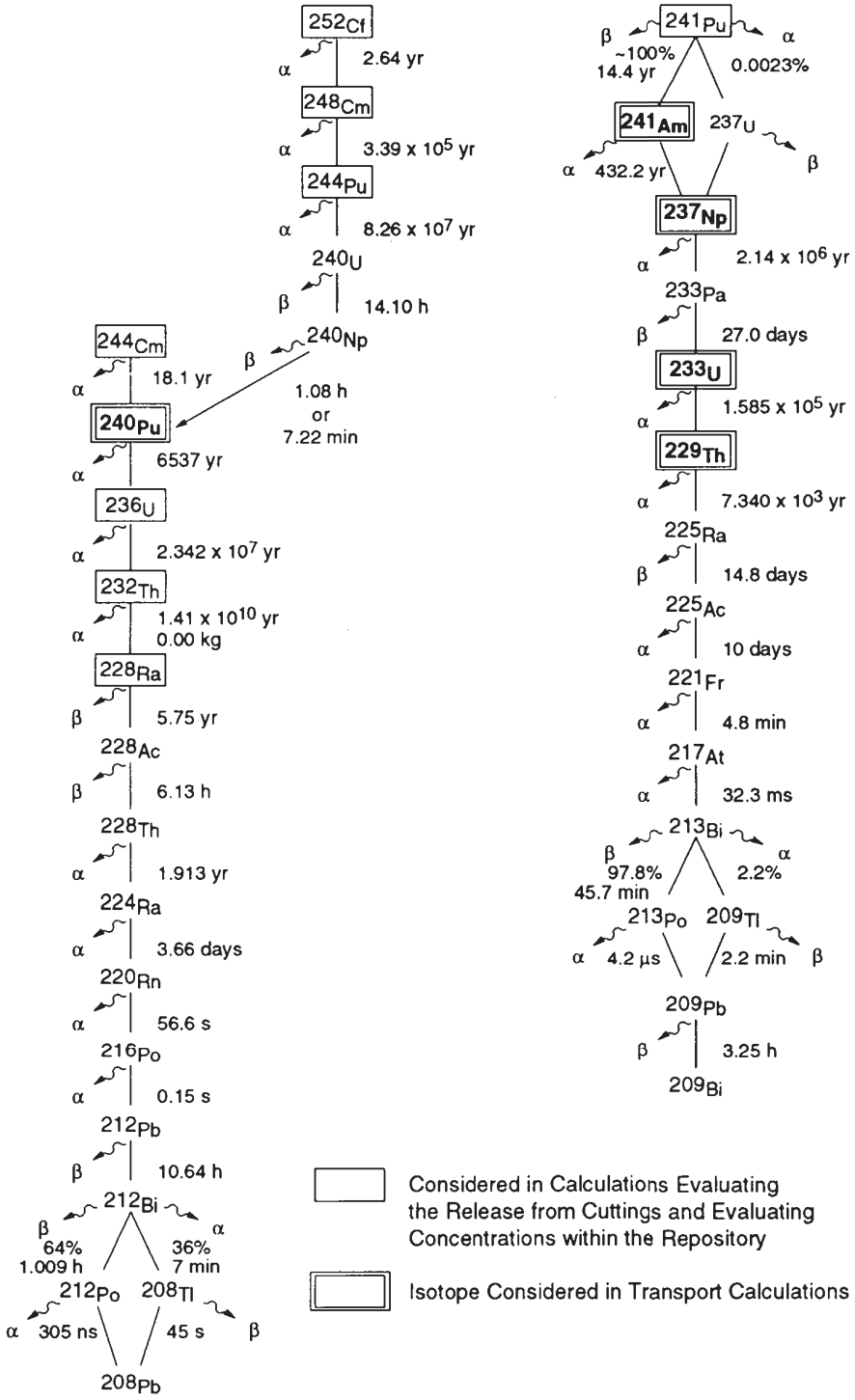


Figure 3.3-1 from Sandia WIPP Project 1992

Figure 1 – Simplified Decay Chains for Four Dominant Radionuclides (^{238}Pu, ^{239}Pu, ^{240}Pu, and ^{241}Am) in CH-TRU Waste in the Preliminary PA Inventory (Continued)

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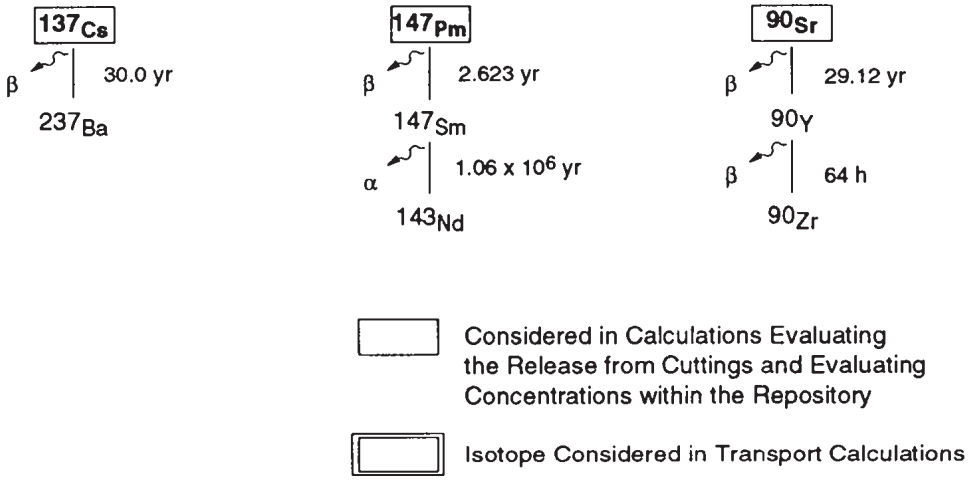


Figure 3.3-2 from Sandia WIPP Project 1992

Figure 2 – Simplified Decay Chains for Three Dominant Radionuclides (^{137}Cs, ^{147}Pm, and ^{90}Sr) in RH-TRU Waste in the Preliminary PA Inventory

Additionally, the CCA recognizes that direct release of brine to the surface and the release of brine from the repository to the Culebra carry radionuclides that are dissolved in the brine or sorbed on colloidal particles (U.S. DOE 1996, Sections WCA.3.2.2 and WCA.3.2.3), stating the following in Section WCA.3.2.2:

> *The radionuclides released in direct release of brine to the surface include several isotopes that comprise negligible fractions of the total EPA unit, but must be included in the source term because of their influence on the total quantity of dissolved radionuclides. This influence occurs because the isotopes of a radionuclide will dissolve based on mass ratio, rather than the activity ratio, in which they are present in the waste.*

The CCA included the 26 radionuclides from the seven simplified decay chains of the seven dominant radionuclides identified in the Preliminary PA (Figures 1 and 2). Consistent with the guidelines from Figure WCA-4 of the CCA (U.S. DOE 1996), three additional radionuclides with relatively large activities greater than 0.001 EPA units were also included in CCA PA calculations (^{243}Am, ^{243}Cm, and ^{245}Cm). An additional radionuclide, ^{147}Sm, was included bringing the total to 30 radionuclides treated in PA calculations (U.S. DOE 1996, Appendix PANEL, p. 9). Note that according to the RH decay chains from the Preliminary PA, ^{147}Sm should be included because it has a half-life of 1.06×10^6 years (see Figure 2). The CCA TRU waste inventory was reduced from a total of 140 radionuclides to 30 radionuclides that are of the most concern to PA (Table 3).

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Table 3 – CCA Radionuclide Inventory Rank Ordered by Maximum Potential Release (in EPA Units) During the Regulatory Period

Radionuclide [a]	Maximum EPA Unit (Rank Ordered)	Included in Preliminary PA Calculations [b]	Included in CCA PA Calculations
^{238}Pu	5.63E+03	✓	✓
^{239}Pu	2.31E+03	✓	✓
^{241}Am	1.42E+03	✓	✓
^{240}Pu	6.23E+02	✓	✓
^{137}Cs	2.71E+01	✓	✓
^{90}Sr	2.54E+01	✓	✓
^{233}U	5.67E+00	✓	✓
^{234}U	4.09E+00	✓	✓
^{230}Th	3.56E+00	✓	✓
^{242}Pu	3.40E+00	✓	✓
^{229}Th	3.40E+00	✓	✓
^{237}Np	4.82E-01	✓	✓
^{245}Cm	3.33E-01		✓
^{210}Pb	2.77E-01	✓	✓
^{226}Ra	2.77E-01	✓	✓
^{238}U	1.46E-01	✓	✓
^{236}U	1.16E-01	✓	✓
^{243}Am	9.45E-02		✓
^{235}U	7.06E-02	✓	✓
^{243}Cm	6.03E-02		✓
^{232}U	5.21E-02		
^{14}C	3.72E-02		
^{232}Th	2.92E-02	✓	✓
^{227}Ac	1.28E-02		
^{231}Pa	1.28E-02	✓	✓
^{99}Tc	7.33E-04		
^{63}Ni	4.16E-04		
^{151}Sm	3.96E-04		
^{246}Cm	2.97E-04		
^{249}Cf	1.86E-04		
^{248}Cm	1.08E-04	✓	✓
^{251}Cf	1.07E-05		
^{121m}Sn	5.70E-06		
^{59}Ni	2.18E-06		
^{93}Zr	2.02E-06		

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Radionuclide [a]	Maximum EPA Unit (Rank Ordered)	Included in Preliminary PA Calculations [b]	Included in CCA PA Calculations
^{126}Sn	3.46E-07		
^{135}Cs	1.80E-07		
^{79}Se	1.56E-07		
^{107}Pd	2.66E-08		
^{244}Pu	1.26E-08	✓	✓
^{129}I	2.05E-09		
^{247}Cm	2.77E-11		
^{147}Sm	1.32E-12		✓
^{148}Sm	2.29E-28		
^{252}Cf	—	✓	✓
^{244}Cm	—	✓	✓
^{147}Pm	—	✓	✓
^{241}Pu	—	✓	✓
^{228}Ra	—	✓	✓

[a] All regulated isotopes in the CCA inventory are included in this table.
[b] The radionuclides included in the Preliminary PA were selected from simplified decay chains (i.e., radionuclides with extremely short half-lives or low activities were eliminated) of four dominant CH-TRU radionuclides and three dominant RH-TRU radionuclides in the WIPP inventory.
SOURCES: U.S. DOE 1996, Chapter 4 (Table 4-6), Appendix WCA, Attachment WCA.8.1 (Table 5), Attachment WCA.8.2 (Table 1), Attachment WCA.8.3, and Appendix PANEL (p.9); Sandia WIPP Project 1992, Section 3.3.3 (Figures 3.3-1 and 3.3-2)

4.0 CALCULATION OF THE WASTE UNIT FACTOR

The WUF is defined in the CCA as the number of millions of curies of alpha-emitting TRU radionuclides with half-lives longer than 20 years destined for disposal in the WIPP repository (U.S. DOE 1996). Computation of a new WUF based on the updated inventory information provided by Van Soest (2025) is required for PA calculations. This computation is performed using the following equation (Sanchez et al.1997):

$$f_w = \frac{\sum W_i}{10^6 \text{ Ci}} \tag{3}$$

where f_w is the WUF, and

W_i is the WIPP-scale activity in curies (Ci) at repository closure for alpha-emitting TRU radionuclides having half-lives greater than 20 years. TRU radionuclides are those with an atomic number higher than uranium, which is 92.

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This calculation uses the WIPP inventory provided by Van Soest (2025) decayed through 2083, which is the assumed closing date of WIPP. The WUF is determined in Appendix B (Table 21) and the radionuclides that contribute to the WUF are summarized in Table 4. From these tables it can be seen that of the 168 radionuclides in the current inventory report (Van Soest 2025, Tables 5-3 and 5-4), there are reported data for the 17 TRU waste radionuclides that contribute to the WUF (i.e., that are alpha-emitting transuranic radionuclides with half-lives greater than 20 years).

The overall quantity of TRU waste radionuclides from Appendix B (Table 21) that apply to the WUF at 2083 is 8.68E+06 Ci, and the value for the WUF in accordance with Equation 3 is 8.68. The updated waste streams in the CRA26_FS waste inventory coupled with the change in waste stream volume calculation (Section 1.2) increased the WUF value compared to previous PAs (see Figure 3). The WUF parameter value is listed in Appendix D (Table 26), which provides the specific parameter data entry information required for tracking parameters in PA. The WUF value is used as input to PA calculations in the codes EPAUNI, NUTS, PANEL, and PRECCDFGF. From Table 4 it is easily identified that the plutonium and americium radionuclides dominate the unit of waste, accounting for 99.99% of the total.

Table 4 – Radionuclide Inventory Activities at 2083 that Contribute to Waste Unit Factor

Radionuclide	Activity (Ci)	Frequency
^{241}Am	1.81E+06	20.793%
^{242m}Am	2.12E+00	0.000%
^{243}Am	6.08E+02	0.007%
^{249}Cf	9.25E+01	0.001%
^{251}Cf	2.79E+01	0.000%
^{243}Cm	3.54E+01	0.000%
^{245}Cm	2.40E+01	0.000%
^{246}Cm	8.29E+02	0.010%
^{247}Cm	9.24E-01	0.000%
^{248}Cm	5.25E+00	0.000%
^{250}Cm	1.25E-07	0.000%
^{237}Np	9.15E+01	0.001%
^{238}Pu	1.60E+06	18.394%
^{239}Pu	4.17E+06	48.044%
^{240}Pu	1.11E+06	12.746%
^{242}Pu	3.10E+02	0.004%
^{244}Pu	6.96E-02	0.000%
Total	**8.68E+06**	**100.000%**

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Figure 3 shows the variation of WUF with total activity, comparing the CRA26_FS inventory based on FRPAIR-2024 (Van Soest 2025) to inventories from previous PAs, including RPPCR (Kicker 2023), CRA-2019 (Kicker 2019), CRA-2014 (Kicker and Zeitler 2013), and PABC-2009 (Fox et al. 2009). Figure 3 illustrates the following WUF relationships:

- If all radionuclides contribute to the WUF, then the WUF increases linearly with total activity (WUF = $10^{-6} \cdot W$, where W = total activity).
- The EPA release limit for all radionuclides that contribute to the WUF is L = 100 Ci/unit of waste.
- The normalized EPA release limit in curies = 100·WUF.
- The normalized potential release (E) for radionuclide i in EPA units = w_i / ($WUF \cdot L_i$) where w_i = waste stream activity in curies and L_i = EPA release limit.
- If all radionuclides contribute to the WUF, then the total normalized potential release =

$$E = \sum_i E_i = \sum_i \left(\frac{1}{\text{WUF}}\right)\left(\frac{w_i}{L_i}\right) = \left(\frac{W}{\text{WUF} \cdot 100}\right) = \left(\frac{\text{WUF} \cdot 10^6}{\text{WUF} \cdot 100}\right) = 10{,}000 \text{ EPA units.}$$

- The total normalized potential release increases above 10,000 EPA units with the addition of radionuclides that do not contribute to the WUF.

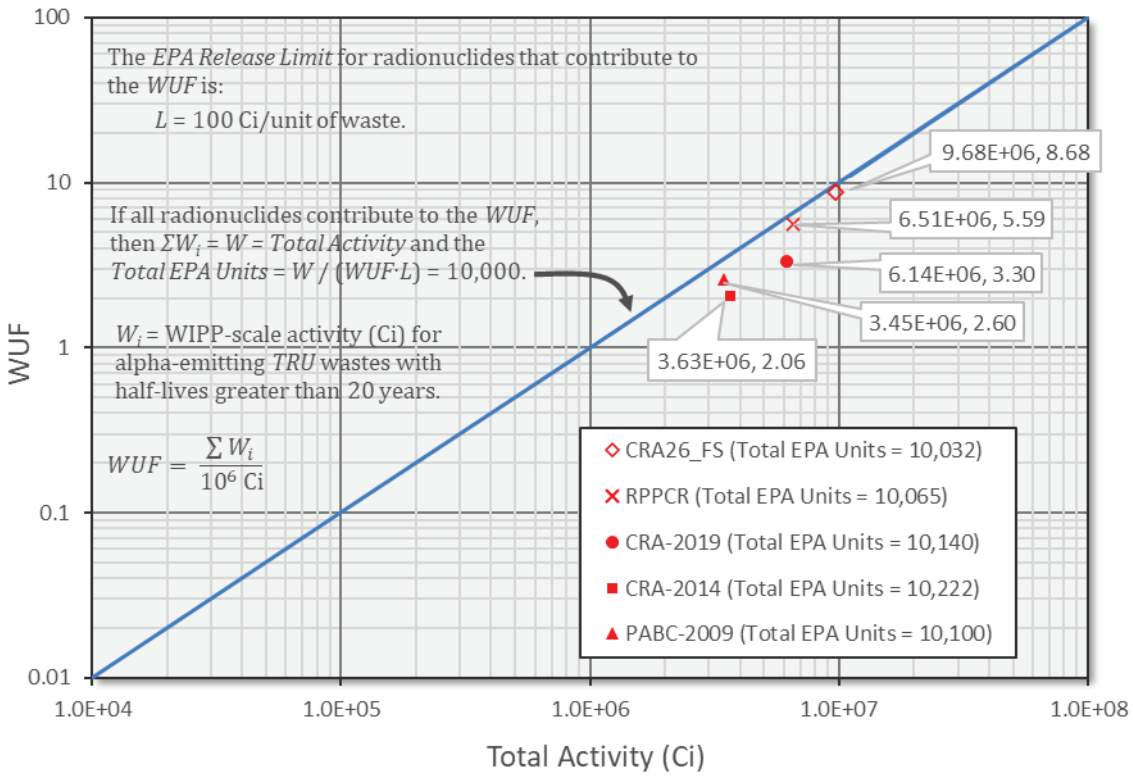


Figure 3 – The Variation of WUF with Total Activity

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5.0 RADIONUCLIDES EXPECTED TO DOMINATE POTENTIAL RELEASES

5.1 Problem Description

Each potential radionuclide release mechanism modeled in PA has as its source an inventory of radionuclides that (1) the DOE expects will be disposed in WIPP and (2) analysts believe will be prevalent in a release via the individual release mechanism. For PA calculations, the DOE through its contractor, LANL, has documented a radionuclide inventory that it expected would be disposed in the WIPP (Van Soest 2025) decayed through the following years: 2083, 2183, 2433, 3083, 7083, and 12083. These time periods are based on the assumption of a WIPP closing date of 2083. The radionuclide inventory contains 168 radionuclides. However, not all of the 168 radionuclides are important to track in a PA for the WIPP repository. Many of the isotopes have low concentrations or are short lived (short half-lives) and would not impact the releases calculated by PA simulations. In addition, tracking of all 168 radionuclides is not practical since WIPP PA involves a suite of computationally intensive codes. Therefore, the number of isotopes tracked in the WIPP PA codes is reduced.

Three of the WIPP PA codes use the radionuclide inventories directly: PANEL, NUTS, and EPAUNI. Two of these codes, PANEL and NUTS, are used in calculations of releases via individual release mechanisms that are modeled in WIPP PA. The inventory lumping used as input to PANEL and NUTS is discussed in Section 7. PANEL provides the radionuclide source for direct brine release to the surface via a borehole (a potential short-term release mechanism), the lumped radionuclide solubility limits for NUTS, and it provides the radionuclide source for releases via a borehole to the Culebra member of the Rustler formation (a potential long-term release mechanism). PANEL performs the decay and solubility limit calculations on the full set of 30 individual radionuclides (see Section 5.2) and on the lumped radionuclides (see Section 7.1). PANEL performs mass transport calculations on the lumped radionuclides. NUTS, as a simplification and for computational economy, performs decay and transport calculations using only the lumped radionuclides. NUTS calculates radionuclide releases via Salado formation to the accessible boundary (a potential long-term release mechanism). The WIPP PA code EPAUNI reports the volume and decayed activity of each waste stream through time for input into CCDFGF. CCDFGF is used to assemble results obtained from calculations performed with a number of different codes (e.g., BRAGFLO, PANEL, NUTS, SECOTP2D, CUTTINGS_S, and EPAUNI) to produce complementary cumulative distribution functions. CCDFGF uses the inventory information from EPAUNI to assign actinide concentrations to the solids volumes from CUTTINGS_S to calculate direct solid releases to the surface due to drilling activities (a potential short-term release mechanism). The criteria for selecting important radionuclides for each of these codes (and release mechanisms) vary slightly for each code.

For the CRA26_FS analysis, the radionuclides modeled in PANEL, NUTS, and CCDFGF were selected to be consistent with radionuclides modeled in the CCA and all subsequent CRAs. This analysis documents variances with the PABC-2009 selection criteria (Fox et al. 2009) and assesses the sufficiency of the modeled radionuclides based on their potential releases as determined from

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the FRPAIR-2024 radionuclide inventory of WIPP-emplaced and WIPP-bound waste streams (Van Soest 2025).

5.2 Analysis

The basis for the selection of important radionuclides for inclusion in PA calculations is described in Sections 2 and 3. Of the 168 radionuclides reported in FRPAIR-2024 (Van Soest 2025), not all are regulated by 40 CFR 191. The regulated radionuclides (i.e., those that are assigned a release limit in 40 CFR 191) are identified in Table 2. The tables in Appendix A show the projected WIPP inventory of these isotopes as potential releases in EPA units. The potential release in EPA units is defined by Equation 2 in Section 2. The repository is considered to comply with the EPA regulations if there is a less than 0.1 calculated probability (based on PA calculations) that the cumulative release to the accessible environment is greater than 1 EPA unit and a less than 0.001 probability that the cumulative release is greater than 10 EPA units.

Table 5 shows the radionuclide inventory in terms of EPA units at 0 years (2083), 100 years (2183), 350 years (2433), 1000 years (3083), 5000 years (7083), and 10,000 years (12083) for radionuclides that have an activity of at least 0.001 EPA units at some point from 2083 to 12083. Of the 168 isotopes given in FRPAIR-2024 (Van Soest 2025), only 35 have more than 0.001 EPA units of inventory at any time within the 10,000-year regulatory period. These are ^{227}Ac, ^{241}Am, ^{242m}Am, ^{243}Am, ^{14}C, ^{249}Cf, ^{251}Cf, ^{243}Cm, ^{245}Cm, ^{246}Cm, ^{247}Cm, ^{248}Cm, ^{137}Cs, ^{129}I, ^{63}Ni, ^{237}Np, ^{231}Pa, ^{210}Pb, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{242}Pu, ^{226}Ra, ^{151}Sm, ^{90}Sr, ^{99}Tc, ^{229}Th, ^{230}Th, ^{232}Th, ^{232}U, ^{233}U, ^{234}U, ^{235}U, ^{236}U, and ^{238}U. Seven additional isotopes are included in Table 5 that were modeled in the CCA and all subsequent CRA PAs, but do not satisfy the 0.001 EPA unit criterion. The basis for including these additional isotopes is described in Section 3. The additional isotopes are: ^{252}Cf, ^{244}Cm, ^{147}Pm, ^{241}Pu, ^{244}Pu, ^{228}Ra, and ^{147}Sm. Table 5 includes 35 isotopes with the highest activity together with 7 other significant isotopes, reducing the total number of isotopes from 168 to 42, thus identifying the most significant isotopes for inclusion in PA calculations. The radionuclides used in PA codes PANEL, NUTS, and CCDFGF along with the list of inventory parameters in Appendix D (Table 27) are all a subset of Table 5.

Table 5 – Radionuclide Inventory Sorted by Maximum Potential Release During the Regulatory Period

Radionuclide	Half-Life [a] (y)	Potential Release at 0 Years [b] (EPA Units)	Potential Release at 100 Years [b] (EPA Units)	Potential Release at 350 Years [b] (EPA Units)	Potential Release at 1000 Years [b] (EPA Units)	Potential Release at 5000 Years [b] (EPA Units)	Potential Release at 10000 Years [b] (EPA Units)	Maximum
^{239}Pu	2.41E+04	4.80E+03	4.79E+03	4.76E+03	4.67E+03	4.16E+03	3.60E+03	4.80E+03
^{241}Am	4.32E+02	2.08E+03	1.79E+03	1.20E+03	4.23E+02	7.19E-01	1.45E-02	2.08E+03
^{238}Pu	8.77E+01	1.84E+03	8.35E+02	1.16E+02	6.80E-01	1.26E-13	2.40E-24	1.84E+03
^{240}Pu	6.56E+03	1.27E+03	1.26E+03	1.23E+03	1.15E+03	7.52E+02	4.43E+02	1.27E+03
^{232}U	6.89E+01	1.38E+01	5.12E+00	4.28E-01	6.73E-04	3.78E-21	1.02E-42	1.38E+01
^{137}Cs	3.02E+01	9.51E+00	9.43E-01	2.92E-03	8.76E-10	0.00E+00	0.00E+00	9.51E+00
^{90}Sr	2.88E+01	7.01E+00	5.97E-01	1.27E-03	1.41E-10	0.00E+00	0.00E+00	7.01E+00

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Radionuclide	Half-Life [a] (y)	Potential Release at 0 Years [b] (EPA Units)	Potential Release at 100 Years [b] (EPA Units)	Potential Release at 350 Years [b] (EPA Units)	Potential Release at 1000 Years [b] (EPA Units)	Potential Release at 5000 Years [b] (EPA Units)	Potential Release at 10000 Years [b] (EPA Units)	Maximum
^{234}U	2.46E+05	8.70E-01	1.23E+00	1.48E+00	1.52E+00	1.51E+00	1.49E+00	1.52E+00
^{230}Th	7.54E+04	5.63E-03	1.55E-02	4.75E-02	1.38E-01	6.80E-01	1.32E+00	1.32E+00
^{246}Cm	4.76E+03	9.54E-01	9.41E-01	9.07E-01	8.24E-01	4.59E-01	2.21E-01	9.54E-01
^{243}Am	7.37E+03	7.00E-01	6.93E-01	6.77E-01	6.37E-01	4.38E-01	2.74E-01	7.00E-01
^{233}U	1.59E+05	5.54E-01	5.54E-01	5.53E-01	5.53E-01	5.52E-01	5.52E-01	5.54E-01
^{237}Np	2.14E+06	1.05E-01	1.68E-01	2.88E-01	4.45E-01	5.29E-01	5.29E-01	5.29E-01
^{242}Pu	3.75E+05	3.57E-01	3.57E-01	3.57E-01	3.58E-01	3.60E-01	3.59E-01	3.60E-01
^{229}Th	7.34E+03	8.17E-03	1.29E-02	2.47E-02	5.41E-02	2.02E-01	3.26E-01	3.26E-01
^{236}U	2.34E+07	4.41E-03	8.17E-03	1.74E-02	4.02E-02	1.51E-01	2.37E-01	2.37E-01
^{238}U	4.47E+09	1.28E-01	1.28E-01	1.28E-01	1.28E-01	1.28E-01	1.28E-01	1.28E-01
^{63}Ni	1.00E+02	1.15E-01	5.76E-02	1.02E-02	1.13E-04	1.06E-16	9.70E-32	1.15E-01
^{249}Cf	3.51E+02	1.06E-01	8.74E-02	5.33E-02	1.47E-02	5.40E-06	2.74E-10	1.06E-01
^{226}Ra	1.60E+03	1.13E-02	1.08E-02	1.00E-02	9.90E-03	4.17E-02	1.03E-01	1.03E-01
^{210}Pb	2.22E+01	1.04E-02	1.09E-02	1.00E-02	9.89E-03	4.17E-02	1.03E-01	1.03E-01
^{227}Ac	2.18E+01	9.60E-02	3.27E-02	2.99E-02	2.96E-02	2.86E-02	2.94E-02	9.60E-02
^{235}U	7.04E+08	4.36E-03	4.83E-03	6.01E-03	9.02E-03	2.64E-02	4.55E-02	4.55E-02
^{243}Cm	2.91E+01	4.07E-02	3.58E-03	8.18E-06	1.11E-12	0.00E+00	0.00E+00	4.07E-02
^{251}Cf	9.00E+02	3.21E-02	2.97E-02	2.45E-02	1.49E-02	6.77E-04	1.43E-05	3.21E-02
^{231}Pa	3.28E+04	3.00E-02	3.00E-02	2.99E-02	2.95E-02	2.86E-02	2.94E-02	3.00E-02
^{245}Cm	8.50E+03	2.77E-02	2.82E-02	2.91E-02	2.91E-02	2.15E-02	1.43E-02	2.91E-02
^{151}Sm	9.00E+01	8.97E-03	4.15E-03	6.06E-04	4.05E-06	1.69E-19	3.16E-36	8.97E-03
^{99}Tc	2.11E+05	6.76E-03	6.76E-03	6.75E-03	6.74E-03	6.65E-03	6.54E-03	6.76E-03
^{248}Cm	3.48E+05	6.04E-03	6.04E-03	6.04E-03	6.03E-03	5.98E-03	5.92E-03	6.04E-03
^{242m}Am	1.41E+02	2.44E-03	1.49E-03	4.37E-04	1.79E-05	5.16E-14	1.09E-24	2.44E-03
^{14}C	5.70E+03	1.62E-03	1.60E-03	1.55E-03	1.43E-03	8.84E-04	4.83E-04	1.62E-03
^{232}Th	1.41E+10	1.36E-03	1.36E-03	1.36E-03	1.36E-03	1.36E-03	1.36E-03	1.36E-03
^{247}Cm	1.56E+07	1.06E-03	1.06E-03	1.06E-03	1.07E-03	1.07E-03	1.07E-03	1.07E-03
^{129}I	1.57E+07	1.02E-03	1.02E-03	1.02E-03	1.02E-03	1.02E-03	1.02E-03	1.02E-03
^{244}Pu	8.00E+07	8.02E-05	8.02E-05	8.02E-05	8.02E-05	8.04E-05	8.07E-05	8.07E-05
^{147}Sm	1.06E+11	4.65E-10	4.65E-10	4.65E-10	4.65E-10	4.65E-10	4.65E-10	4.65E-10
^{252}Cf	2.65E+00	--	--	--	--	--	--	0.00E+00
^{244}Cm	1.81E+01	--	--	--	--	--	--	0.00E+00
^{147}Pm	2.62E+00	--	--	--	--	--	--	0.00E+00
^{241}Pu	1.44E+01	--	--	--	--	--	--	0.00E+00
^{228}Ra	5.75E+00	--	--	--	--	--	--	0.00E+00

[a] Half-life information taken from the International Commission on Radiological Protection (ICRP 2008, Table A.1).
[b] Potential releases taken from Appendix A (Tables 15 through 20). Note that ^{252}Cf, ^{244}Cm, ^{147}Pm, ^{241}Pu, and ^{228}Ra are not regulated isotopes and do not have release limits (see Table 2 and Appendix B, Table 21). Therefore, potential release in EPA units for these isotopes cannot be calculated.

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The contribution of each radionuclide to the overall potential release changes as the radionuclides decay or build-up over time. For example, the relatively short-lived isotope ^{238}Pu decays from a potential release of 1840 EPA units at closure to about 0.68 EPA units by 1000 years. An example of an isotope that increases in activity with time is ^{230}Th, which initially has less than 0.006 EPA units of potential release that grows to about 1.3 EPA units after 10,000 years.

Consistent with PA calculations associated with the CCA and all subsequent CRAs, 30 radionuclides are modeled in PANEL decay calculations. Those radionuclides are: ^{241}Am, ^{243}Am, ^{252}Cf, ^{243}Cm, ^{244}Cm, ^{245}Cm, ^{248}Cm, ^{137}Cs, ^{237}Np, ^{231}Pa, ^{210}Pb, ^{147}Pm, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu, ^{244}Pu, ^{226}Ra, ^{228}Ra, ^{147}Sm, ^{90}Sr, ^{229}Th, ^{230}Th, ^{232}Th, ^{233}U, ^{234}U, ^{235}U, ^{236}U and ^{238}U. These 30 radionuclides are listed as parameter values in Appendix D (Table 27), which provides the specific parameter data entry information required for tracking parameters in PA. Of these 30 radionuclides, four (^{210}Pb, ^{226}Ra, ^{228}Ra and ^{147}Sm) are only included in the decay calculations, while the remaining 26 are used in both the decay calculations and the actinide mobilization calculations. For the CRA26_FS analysis, these 30 isotopes encompass 99.85% of the total inventory in EPA units at the time of repository closure based on the FRPAIR-2024 inventory (Table 6). At the end of the regulatory period, these 30 isotopes encompass 99.99% of the total inventory in EPA units (Table 7). Radionuclides are expected to dissolve/mobilize in different proportions than they are present in the total inventory, and the impact of potentially mobilized radionuclides on releases was analyzed by Kim et al. (2024), who concluded that the current radionuclides modeled in WIPP PA are sufficient to adequately account for releases from potentially mobilized radionuclides in a typical WIPP inventory and the current approach to screen radionuclides based on total EPA units is rational.

Table 6 – Contribution to Potential Release at Closure (2083) for Isotopes Modeled in PANEL

Radionuclide [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Total Inventory	CH Potential Release [c] (EPA Units)	RH Potential Release [c] (EPA Units)	Total Potential Release (EPA Units)	Cumulative %
^{239}Pu	4.17E+06	4.53E+03	4.17E+06	4.80E+03	5.22E+00	4.80E+03	47.89%
^{241}Am	1.79E+06	1.77E+04	1.81E+06	2.06E+03	2.03E+01	2.08E+03	68.62%
^{238}Pu	1.57E+06	2.58E+04	1.60E+06	1.81E+03	2.97E+01	1.84E+03	86.95%
^{240}Pu	1.10E+06	4.55E+03	1.11E+06	1.27E+03	5.24E+00	1.27E+03	99.66%
^{137}Cs	1.05E+02	8.25E+04	8.26E+04	1.21E-02	9.49E+00	9.51E+00	99.75%
^{90}Sr	2.30E+02	6.06E+04	6.08E+04	2.65E-02	6.98E+00	7.01E+00	99.82%
^{234}U	7.36E+02	1.97E+01	7.56E+02	8.47E-01	2.26E-02	8.70E-01	99.83%
^{243}Am	3.32E+01	5.74E+02	6.08E+02	3.82E-02	6.61E-01	7.00E-01	99.84%
^{233}U	3.56E+02	1.24E+02	4.81E+02	4.10E-01	1.43E-01	5.54E-01	99.84%
^{242}Pu	2.86E+02	2.39E+01	3.10E+02	3.29E-01	2.75E-02	3.57E-01	99.85%

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Radionuclide [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Total Inventory	CH Potential Release [c] (EPA Units)	RH Potential Release [c] (EPA Units)	Total Potential Release (EPA Units)	Cumulative %
^{238}U	1.08E+02	3.50E+00	1.11E+02	1.24E-01	4.04E-03	1.28E-01	99.85%
^{237}Np	7.85E+01	1.31E+01	9.15E+01	9.04E-02	1.50E-02	1.05E-01	99.85%
^{243}Cm	3.55E+00	3.18E+01	3.54E+01	4.09E-03	3.66E-02	4.07E-02	99.85%
^{231}Pa	2.61E+01	3.25E-03	2.61E+01	3.00E-02	3.75E-06	3.00E-02	99.85%
^{245}Cm	4.46E+00	1.96E+01	2.40E+01	5.13E-03	2.25E-02	2.77E-02	99.85%
^{226}Ra	2.21E+00	7.57E+00	9.78E+00	2.55E-03	8.72E-03	1.13E-02	99.85%
^{210}Pb	1.89E+00	7.12E+00	9.01E+00	2.17E-03	8.20E-03	1.04E-02	99.85%
^{229}Th	6.42E+00	6.77E-01	7.09E+00	7.39E-03	7.79E-04	8.17E-03	99.85%
^{248}Cm	1.63E+00	3.62E+00	5.25E+00	1.88E-03	4.17E-03	6.04E-03	99.85%
^{230}Th	4.74E-01	1.49E-02	4.89E-01	5.46E-03	1.72E-04	5.63E-03	99.85%
^{236}U	3.58E+00	2.49E-01	3.83E+00	4.13E-03	2.86E-04	4.41E-03	99.85%
^{235}U	1.74E+00	2.04E+00	3.79E+00	2.01E-03	2.35E-03	4.36E-03	99.85%
^{232}Th	1.08E-01	9.77E-03	1.18E-01	1.25E-03	1.12E-04	1.36E-03	99.85%
^{244}Pu	6.96E-02	1.23E-05	6.96E-02	8.02E-05	1.42E-08	8.02E-05	99.85%
^{147}Sm	1.73E-08	3.86E-07	4.04E-07	1.99E-11	4.45E-10	4.65E-10	99.85%
^{252}Cf	1.73E-05	7.95E-05	9.68E-05	N/A [d]	N/A [d]	N/A [d]	99.85%
^{147}Pm	6.69E-05	4.52E-05	1.12E-04	N/A [d]	N/A [d]	N/A [d]	99.85%
^{244}Cm	1.85E+03	1.02E+04	1.21E+04	N/A [d]	N/A [d]	N/A [d]	99.85%
^{241}Pu	5.81E+05	8.60E+03	5.90E+05	N/A [d]	N/A [d]	N/A [d]	99.85%
^{228}Ra	1.08E-01	2.07E-02	1.29E-01	N/A [d]	N/A [d]	N/A [d]	99.85%

[a] Radionuclides are rank-ordered by total potential release in EPA units. ^{210}Pb, ^{226}Ra, ^{228}Ra, and ^{147}Sm are only included in the PANEL decay calculations. All other radionuclides are included in both PANEL decay and actinide mobilization calculations.
[b] Decayed radionuclide data taken from Van Soest 2025.
[c] CH potential release is defined as the total CH inventory in Ci divided by the release limit in Ci (see Appendix A, Table 15). Similarly, RH potential release is defined as the total RH inventory in Ci divided by the release limit in Ci. Total potential releases taken from Table 15 in Appendix A. The total potential release for all radionuclides is 10,032 EPA units at 2083.
[d] ^{252}Cf, ^{244}Cm, ^{147}Pm, ^{241}Pu, and ^{228}Ra are not regulated isotopes and do not have release limits (see Table 2 and Appendix B, Table 21). Therefore, potential release in EPA units cannot be calculated.

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Table 7 – Contribution to Potential Release at the End of the Regulatory Period (12083) for Isotopes Modeled in PANEL

Radionuclide [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Total Inventory	CH Potential Release [c] (EPA Units)	RH Potential Release [c] (EPA Units)	Total Potential Release (EPA Units)	Cumulative %
^{239}Pu	3.13E+06	3.49E+03	3.13E+06	3.60E+03	4.02E+00	3.60E+03	88.92%
^{240}Pu	3.83E+05	1.59E+03	3.85E+05	4.41E+02	1.83E+00	4.43E+02	99.86%
^{234}U	1.26E+03	2.82E+01	1.29E+03	1.46E+00	3.24E-02	1.49E+00	99.89%
^{230}Th	1.12E+02	2.51E+00	1.15E+02	1.29E+00	2.89E-02	1.32E+00	99.93%
^{233}U	3.59E+02	1.20E+02	4.79E+02	4.14E-01	1.38E-01	5.52E-01	99.94%
^{237}Np	4.42E+02	1.67E+01	4.59E+02	5.09E-01	1.92E-02	5.29E-01	99.95%
^{242}Pu	2.82E+02	3.05E+01	3.12E+02	3.24E-01	3.51E-02	3.59E-01	99.96%
^{229}Th	2.12E+02	7.16E+01	2.83E+02	2.44E-01	8.24E-02	3.26E-01	99.97%
^{243}Am	1.35E+01	2.24E+02	2.38E+02	1.56E-02	2.58E-01	2.74E-01	99.98%
^{236}U	2.05E+02	1.09E+00	2.06E+02	2.36E-01	1.25E-03	2.37E-01	99.98%
^{238}U	1.08E+02	3.50E+00	1.11E+02	1.24E-01	4.04E-03	1.28E-01	99.99%
^{226}Ra	8.76E+01	2.06E+00	8.96E+01	1.01E-01	2.37E-03	1.03E-01	99.99%
^{210}Pb	8.75E+01	2.06E+00	8.96E+01	1.01E-01	2.37E-03	1.03E-01	99.99%
^{235}U	3.74E+01	2.08E+00	3.95E+01	4.31E-02	2.40E-03	4.55E-02	99.99%
^{231}Pa	2.51E+01	3.96E-01	2.55E+01	2.89E-02	4.56E-04	2.94E-02	99.99%
^{241}Am	2.34E+00	1.03E+01	1.26E+01	2.69E-03	1.18E-02	1.45E-02	99.99%
^{245}Cm	2.13E+00	1.03E+01	1.24E+01	2.46E-03	1.18E-02	1.43E-02	99.99%
^{248}Cm	1.60E+00	3.54E+00	5.14E+00	1.84E-03	4.08E-03	5.92E-03	99.99%
^{232}Th	1.08E-01	9.77E-03	1.18E-01	1.25E-03	1.12E-04	1.36E-03	99.99%
^{244}Pu	6.97E-02	2.97E-04	7.00E-02	8.03E-05	3.42E-07	8.07E-05	99.99%
^{147}Sm	1.73E-08	3.86E-07	4.04E-07	1.99E-11	4.45E-10	4.65E-10	99.99%
^{238}Pu	2.38E-23	2.06E-21	2.08E-21	2.74E-26	2.37E-24	2.40E-24	99.99%
^{243}Cm	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	99.99%
^{137}Cs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	99.99%
^{90}Sr	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	99.99%
^{252}Cf	0.00E+00	0.00E+00	0.00E+00	N/A [d]	N/A [d]	N/A [d]	99.99%
^{147}Pm	0.00E+00	0.00E+00	0.00E+00	N/A [d]	N/A [d]	N/A [d]	99.99%
^{244}Cm	0.00E+00	0.00E+00	0.00E+00	N/A [d]	N/A [d]	N/A [d]	99.99%

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Radionuclide [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Total Inventory	CH Potential Release [c] (EPA Units)	RH Potential Release [c] (EPA Units)	Total Potential Release (EPA Units)	Cumulative %
^{241}Pu	2.14E+00	1.03E+01	1.24E+01	N/A [d]	N/A [d]	N/A [d]	99.99%
^{228}Ra	1.08E-01	9.77E-03	1.18E-01	N/A [d]	N/A [d]	N/A [d]	99.99%

[a] Radionuclides are rank-ordered by total potential release in EPA units. ^{210}Pb, ^{226}Ra, ^{228}Ra, and ^{147}Sm are only included in the PANEL decay calculations. All other radionuclides are included in both PANEL decay and actinide mobilization calculations.
[b] Decayed radionuclide data taken from Van Soest 2025.
[c] CH potential release is defined as the total CH inventory in Ci divided by the release limit in Ci (see Appendix A, Table 20). Similarly, RH potential release is defined as the total RH inventory in Ci divided by the release limit in Ci. Total potential releases taken from Table 20 in Appendix A. The total potential release for all radionuclides is 4,053 EPA units at 12083.
[d] ^{252}Cf, ^{244}Cm, ^{147}Pm, ^{241}Pu, and ^{228}Ra are not regulated isotopes and do not have release limits (see Table 2 and Appendix B, Table 21). Therefore, potential release in EPA units cannot be calculated.

Consistent with PA calculations associated with the CCA and all subsequent CRAs, the CRA26_FS NUTS calculation includes 10 isotopes: ^{241}Am, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu, ^{229}Th, ^{230}Th, ^{233}U and ^{234}U. Because NUTS is more computationally intensive compared to PANEL, the number of isotopes modeled is reduced to increase efficiency. According to Fox et al. (2009), the criterion for selecting radionuclides for the NUTS calculation was historically based on those radionuclides that had a total inventory greater than 1.0 EPA unit during the 10,000-year regulatory period. This is confirmed in Table 3, which shows that all radionuclides with a maximum inventory greater than 1.0 EPA unit (except ^{137}Cs and ^{90}Sr) are included in NUTS. For the CRA26_FS analysis, the following isotopes from the FRPAIR-2024 data satisfy the greater than 1.0 EPA unit criterion: ^{241}Am, ^{137}Cs, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{90}Sr, ^{230}Th, ^{232}U, and ^{234}U. The isotopes ^{137}Cs and ^{90}Sr were historically screened out due to their short half-life compared to the 10,000-year regulatory period over which long-term radionuclide transport to the land withdrawal boundary can occur. Similarly, ^{232}U has a relatively short half-life and can be screened out.

The radionuclides modeled in NUTS (^{241}Am, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu, ^{229}Th, ^{230}Th, ^{233}U and ^{234}U) account for 99.67% of the total inventory in EPA units at the time of repository closure in the FRPAIR-2024 inventory (see Table 8). At the end of the regulatory period, these 10 isotopes encompass 99.96% of the total inventory in EPA units (Table 9). Radionuclides are expected to dissolve/mobilize in different proportions than they are present in the total inventory, and the potential impact of this on releases was analyzed by Kim et al. (2024), who concluded that the current radionuclides modeled in WIPP PA are sufficient to adequately account for releases from potentially mobilized radionuclides in a typical WIPP inventory and the current approach to screen radionuclides based on total EPA units is rational.

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Table 8 – Contribution to Potential Release at Closure (2083) for Isotopes Modeled in NUTS

Radionuclide [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Total Inventory	CH Potential Release [c] (EPA Units)	RH Potential Release [c] (EPA Units)	Total Potential Release (EPA Units)	Cumulative %
^{239}Pu	4.17E+06	4.53E+03	4.17E+06	4.80E+03	5.22E+00	4.80E+03	47.89%
^{241}Am	1.79E+06	1.77E+04	1.81E+06	2.06E+03	2.03E+01	2.08E+03	68.62%
^{238}Pu	1.57E+06	2.58E+04	1.60E+06	1.81E+03	2.97E+01	1.84E+03	86.95%
^{240}Pu	1.10E+06	4.55E+03	1.11E+06	1.27E+03	5.24E+00	1.27E+03	99.66%
^{234}U	7.36E+02	1.97E+01	7.56E+02	8.47E-01	2.26E-02	8.70E-01	99.66%
^{233}U	3.56E+02	1.24E+02	4.81E+02	4.10E-01	1.43E-01	5.54E-01	99.67%
^{242}Pu	2.86E+02	2.39E+01	3.10E+02	3.29E-01	2.75E-02	3.57E-01	99.67%
^{229}Th	6.42E+00	6.77E-01	7.09E+00	7.39E-03	7.79E-04	8.17E-03	99.67%
^{230}Th	4.74E-01	1.49E-02	4.89E-01	5.46E-03	1.72E-04	5.63E-03	99.67%
^{241}Pu	5.81E+05	8.60E+03	5.90E+05	N/A [d]	N/A [d]	N/A [d]	99.67%

[a] Radionuclides are rank-ordered by total potential release in EPA units.
[b] Decayed radionuclide data taken from Van Soest 2025.
[c] CH potential release is defined as the total CH inventory in Ci divided by the release limit in Ci (see Appendix A, Table 15). Similarly, RH potential release is defined as the total RH inventory in Ci divided by the release limit in Ci. Total potential releases taken from Table 15 in Appendix A. The total potential release for all radionuclides is 10,032 EPA units at 2083.
[d] ^{241}Pu is not a regulated isotope and does not have a release limit (see Table 2 and Appendix B, Table 21). Therefore, potential release in EPA units cannot be calculated.

Table 9 – Contribution to Potential Release at the End of the Regulatory Period (12083) for Isotopes Modeled in NUTS

Radionuclide [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Total Inventory	CH Potential Release [c] (EPA Units)	RH Potential Release [c] (EPA Units)	Total Potential Release (EPA Units)	Cumulative %
^{239}Pu	3.13E+06	3.49E+03	3.13E+06	3.60E+03	4.02E+00	3.60E+03	88.92%
^{240}Pu	3.83E+05	1.59E+03	3.85E+05	4.41E+02	1.83E+00	4.43E+02	99.86%
^{234}U	1.26E+03	2.82E+01	1.29E+03	1.46E+00	3.24E-02	1.49E+00	99.89%
^{230}Th	1.12E+02	2.51E+00	1.15E+02	1.29E+00	2.89E-02	1.32E+00	99.93%
^{233}U	3.59E+02	1.20E+02	4.79E+02	4.14E-01	1.38E-01	5.52E-01	99.94%
^{242}Pu	2.82E+02	3.05E+01	3.12E+02	3.24E-01	3.51E-02	3.59E-01	99.95%

Information Only

Radionuclide [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Total Inventory	CH Potential Release [c] (EPA Units)	RH Potential Release [c] (EPA Units)	Total Potential Release (EPA Units)	Cumulative %
^{229}Th	2.12E+02	7.16E+01	2.83E+02	2.44E-01	8.24E-02	3.26E-01	99.96%
^{241}Am	2.34E+00	1.03E+01	1.26E+01	2.69E-03	1.18E-02	1.45E-02	99.96%
^{238}Pu	2.38E-23	2.06E-21	2.08E-21	2.74E-26	2.37E-24	2.40E-24	99.96%
^{241}Pu	2.14E+00	1.03E+01	1.24E+01	N/A [d]	N/A [d]	N/A [d]	99.96%

[a] Radionuclides are rank-ordered by total potential release in EPA units.
[b] Decayed radionuclide data taken from Van Soest 2025.
[c] CH potential release is defined as the total CH inventory in Ci divided by the release limit in Ci (see Appendix A, Table 20). Similarly, RH potential release is defined as the total RH inventory in Ci divided by the release limit in Ci. Total potential releases taken from Table 20 in Appendix A. The total potential release for all radionuclides is 4,053 EPA units at 12083.
[d] ^{241}Pu is not a regulated isotope and does not have a release limit (see Table 2 and Appendix B, Table 21). Therefore, potential release in EPA units cannot be calculated.

Consistent with PA calculations associated with the CCA and all subsequent CRAs, the CRA26_FS CCDFGF calculation includes 10 isotopes: ^{241}Am, ^{244}Cm, ^{137}Cs, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{90}Sr, ^{233}U, and ^{234}U. Fox et al. (2009) state that the radionuclides that are important for modeling the direct solid release pathway (included in CCDFGF) were historically based on those that have a potential release greater than 1.0 EPA unit during the 10,000 year regulatory period. Applying this criterion to the FRPAIR-2024 radionuclide inventory results in the following list: ^{241}Am, ^{137}Cs, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{90}Sr, ^{230}Th, ^{232}U, and ^{234}U. Not including isotopes ^{232}U and ^{230}Th has a minor impact to PA calculations because they have a low frequency of occurrence (0.14% and 0.01 %, respectively, of the total activity). In contrast to the NUTS calculation, the isotopes ^{137}Cs and ^{90}Sr are maintained for this pathway even though they have relatively short half-lives, because a human intrusion event can occur as early as 100 years after repository closure. The 10 radionuclides used to model the direct solid release pathway in the CRA26_FS CCDFGF analysis account for 99.83% of the EPA units at the time of repository closure in the FRPAIR-2024 inventory (see Table 10). At the end of the regulatory period, these 10 isotopes encompass 99.91% of the total inventory in EPA units (Table 11). Therefore, there are sufficient radionuclides modeled in the CCDFGF calculations to capture the dominant releases.

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Table 10 – Contribution to Potential Release at Closure (2083) for Isotopes Modeled in CCDFGF

Radionuclide [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Total Inventory	CH Potential Release [c] (EPA Units)	RH Potential Release [c] (EPA Units)	Total Potential Release (EPA Units)	Cumulative %
^{239}Pu	4.17E+06	4.53E+03	4.17E+06	4.80E+03	5.22E+00	4.80E+03	47.89%
^{241}Am	1.79E+06	1.77E+04	1.81E+06	2.06E+03	2.03E+01	2.08E+03	68.62%
^{238}Pu	1.57E+06	2.58E+04	1.60E+06	1.81E+03	2.97E+01	1.84E+03	86.95%
^{240}Pu	1.10E+06	4.55E+03	1.11E+06	1.27E+03	5.24E+00	1.27E+03	99.66%
^{137}Cs	1.05E+02	8.25E+04	8.26E+04	1.21E-02	9.49E+00	9.51E+00	99.75%
^{90}Sr	2.30E+02	6.06E+04	6.08E+04	2.65E-02	6.98E+00	7.01E+00	99.82%
^{234}U	7.36E+02	1.97E+01	7.56E+02	8.47E-01	2.26E-02	8.70E-01	99.83%
^{233}U	3.56E+02	1.24E+02	4.81E+02	4.10E-01	1.43E-01	5.54E-01	99.83%
^{244}Cm	1.85E+03	1.02E+04	1.21E+04	N/A [d]	N/A [d]	N/A [d]	99.83%
^{241}Pu	5.81E+05	8.60E+03	5.90E+05	N/A [d]	N/A [d]	N/A [d]	99.83%

[a] Radionuclides are rank-ordered by total potential release in EPA units.
[b] Decayed radionuclide data taken from Van Soest 2025.
[c] CH potential release is defined as the total CH inventory in Ci divided by the release limit in Ci (see Appendix A, Table 15). Similarly, RH potential release is defined as the total RH inventory in Ci divided by the release limit in Ci. Total potential releases taken from Table 15 in Appendix A. The total potential release for all radionuclides is 10,032 EPA units at 2083.
[d] ^{244}Cm and ^{241}Pu are not regulated isotopes and do not have release limits (see Table 2 and Appendix B, Table 21). Therefore, potential release in EPA units cannot be calculated.

Table 11 – Contribution to Potential Release at the End of the Regulatory Period (12083) for Isotopes Modeled in CCDFGF

Radionuclide [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Total Inventory	CH Potential Release [c] (EPA Units)	RH Potential Release [c] (EPA Units)	Total Potential Release (EPA Units)	Cumulative %
^{239}Pu	3.13E+06	3.49E+03	3.13E+06	3.60E+03	4.02E+00	3.60E+03	88.92%
^{240}Pu	3.83E+05	1.59E+03	3.85E+05	4.41E+02	1.83E+00	4.43E+02	99.86%
^{234}U	1.26E+03	2.82E+01	1.29E+03	1.46E+00	3.24E-02	1.49E+00	99.89%
^{233}U	3.59E+02	1.20E+02	4.79E+02	4.14E-01	1.38E-01	5.52E-01	99.91%
^{241}Am	2.34E+00	1.03E+01	1.26E+01	2.69E-03	1.18E-02	1.45E-02	99.91%
^{238}Pu	2.38E-23	2.06E-21	2.08E-21	2.74E-26	2.37E-24	2.40E-24	99.91%

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Radionuclide [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Total Inventory	CH Potential Release [c] (EPA Units)	RH Potential Release [c] (EPA Units)	Total Potential Release (EPA Units)	Cumulative %
^{137}Cs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	99.91%
^{90}Sr	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	99.91%
^{244}Cm	0.00E+00	0.00E+00	0.00E+00	N/A [d]	N/A [d]	N/A [d]	99.91%
^{241}Pu	2.14E+00	1.03E+01	1.24E+01	N/A [d]	N/A [d]	N/A [d]	99.91%

[a] Radionuclides are rank-ordered by total potential release in EPA units.
[b] Decayed radionuclide data taken from Van Soest 2025.
[c] CH potential release is defined as the total CH inventory in Ci divided by the release limit in Ci (see Appendix A, Table 20). Similarly, RH potential release is defined as the total RH inventory in Ci divided by the release limit in Ci. Total potential releases taken from Table 20 in Appendix A. The total potential release for all radionuclides is 4,053 EPA units at 12083.
[d] ^{244}Cm and ^{241}Pu are not regulated isotopes and do not have release limits (see Table 2 and Appendix B, Table 21). Therefore, potential release in EPA units cannot be calculated.

6.0 RADIONUCLIDES WITH DECAY HEAT CONTRIBUTIONS TO RADIOLYSIS

Implementation of the radiolytic gas generation process model (Day 2019) requires parameterization of the decay heat associated with radionuclides in the repository. A screening analysis is performed to determine which radionuclides are the major contributors to the total decay heat and thus are necessary to include in the radiolysis calculations. The screening analysis consists of calculating the decay heat specific power generated by each of the 168 radionuclides in the inventory (as listed in FRPAIR-2024) and the fraction that each contributes to the total. Wattage is calculated based on the following equations:

$$W(t) = \sum_{i=1}^{n} W_i(t) \quad (4)$$

$$W_i(t) = I_i(t) \times DH_i / SA_i \quad (5)$$

where i = Index of radionuclides in the inventory
n = Total number of radionuclides in the inventory
$W(t)$ = Power ("wattage") in W for all radionuclides at time t
$Wi(t)$ = Power ("wattage") in W for radionuclide i at time t
$I_i(t)$ = Sum of CH and RH inventory in Ci for radionuclide i at time t
DH_i = Decay heat specific power in W/g for radionuclide i, and
SA_i = Specific activity in Ci/g for radionuclide i.

Specific activity (SA_i) is the activity per unit mass. The activity in one gram is given by

$$SA_i = \lambda N / CiBq \quad (6)$$

where λ is the radionuclide radioactive decay constant (which is a function of the radionuclide half-life in seconds, $T_{½}$):

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$$\lambda = \left(\frac{\ln(2)}{T_{1/2}}\right) \quad (7)$$

and N is the number of atoms of a radionuclide in one gram:

$$N = A_v/A_w \quad (8)$$

such that A_v is Avogadro's number, 6.022137 × 10^{23}/mol, and A_w is the atomic mass of the radionuclide in g/mol.

The becquerel (Bq) is defined as one nuclear disintegration per second, and *CiBq* is the curie to becquerel conversion. Knowing that one curie is defined as 3.7 × 10^{10} disintegrations per second (s^{-1}), then the specific activity (Ci/g) in Equation 5 is:

$$SA_i = \frac{\lambda A_v}{CiBq \cdot A_w} \quad (9)$$

where *CiBq* = 3.7 × 10^{10} s^{-1}/Ci. Knowing that one MeV per second is equal to 1.602177 × 10^{-13} W, the decay heat specific power (W/g) in Equation 5 is given by:

$$DH_i = J \cdot E_{dis,i}\lambda A_v/A_w \quad (10)$$

where J = 1.602177 × 10^{-13} W/MeV per second and $E_{dis,i}$ is the total emitted disintegration energy of radionuclide *i* (MeV).

From the screening analysis, it is determined that the decay heat from only five radionuclides is sufficient to account for about 98% to over 99% of the total decay heat at closure and beyond (Table 12). Four radionuclides (^{241}Am, ^{238}Pu, ^{239}Pu, and ^{240}Pu) account for nearly all of the total decay at a given time. ^{242}Pu is added so that all tracked Pu isotopes are included for a correct isotope fraction calculation. Note that ^{241}Pu is not included because it has a half-life less than 20 years and it is not a regulated isotope. The heat generated by the progeny of the five selected radionuclides is neglected because each decays to a long-lived radionuclide, and those daughters have much smaller molar powers.

Table 12 – Calculated Wattage Summary for Five Radionuclides

Radionuclide	Wattage Fraction in 2083 (%)	Wattage Fraction in 2183 (%)	Wattage Fraction in 12083 (%)
^{241}Am	21.41	21.59	0.00
^{238}Pu	18.79	9.98	0.00
^{239}Pu	46.02	53.72	88.88
^{240}Pu	12.24	14.17	10.95
^{242}Pu	0.00	0.00	0.01
Total	**98.47**	**99.46**	**99.84**

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NOTE: The calculation of wattage fraction is documented in Appendix C, Tables 23 through 25.

An inventory assessment that determines the percentage decay heat contribution for ^{241}Am, ^{238}Pu, ^{239}Pu, ^{240}Pu, and ^{242}Pu is provided in Appendix C. For those radionuclides, DECAYNRG parameters given in Table 13 are implemented to support the radiolysis and decay calculations (Day 2019), and the values have not changed from the CRA-2019 PA.

Table 13 – Radiolysis and Decay Parameters

Material	Property	Description	Value
^{241}Am	DECAYNRG	Radionuclide disintegration energy (MeV)	5.6379
^{238}Pu	DECAYNRG	Radionuclide disintegration energy (MeV)	5.593
^{239}Pu	DECAYNRG	Radionuclide disintegration energy (MeV)	5.2442
^{240}Pu	DECAYNRG	Radionuclide disintegration energy (MeV)	5.2559
^{242}Pu	DECAYNRG	Radionuclide disintegration energy (MeV)	4.9855

NOTE: The source for DECAYNRG values is the International Commission on Radiological Protection (ICRP 2008, Table A.1).

7.0 CALCULATION OF RADIONUCLIDE INVENTORIES FOR USE IN NUTS

7.1 Problem Description

Van Soest (2025, Tables 5-3 and 5-4) reports that the DOE waste generator sites are expected to dispose of TRU waste containing 168 different radionuclides in the WIPP. Not all of these radionuclides have significant inventories for disposal and not all of these radionuclides contribute to potential releases from the WIPP repository over the 10,000-year regulatory period. Section 5 identifies which radionuclides contribute to potential releases from the repository for the individual transport pathways modeled in performance assessment. For transport through the Salado to the accessible boundary and transport through the Salado to the Culebra which is modeled using the NUTS code in performance assessment, the important radionuclides are shown in Table 8 of Section 5.

The radionuclides in Table 8 are important contributors to potential releases and they have half-lives that are long enough to contribute to potential releases via the Salado. In addition, Section 5 identifies ^{241}Pu as being important because it is the parent isotope for ^{241}Am and it has a significant initial inventory. The inventory for ^{241}Pu at the time of repository closure (2083) is 5.81E+05 Ci in CH-TRU waste and 8.60E+03 Ci in RH-TRU waste (Table 15 in Appendix A).

Because NUTS is a computationally intensive code, minimizing the number of radionuclides that NUTS must track in a calculation is beneficial. Therefore, inventories for the uranium, plutonium,

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americium, and thorium isotopes can be combined into "lumped" inventories to facilitate the NUTS calculations for performance assessment. Technical justification for lumping is provided below (see Section 7.3 for lumped values).

7.2 Computational Methodology

7.2.1 Theory

The theory behind combining radionuclide inventories into "lumped" inventories for transport calculations is that radionuclides of the same elemental form will transport at the same rate (Leigh and Trone 2005). Therefore, the inventories for isotopes of uranium can be combined. Additionally, inventories for isotopes of plutonium can be combined, and inventories for isotopes of thorium can be combined. Using the isotopes identified in Table 8 as important: (1) the activity of ^{234}U and ^{233}U will be combined to produce values for the material U234L (the lumped uranium inventory) for the NUTS calculation, (2) the activity of ^{239}Pu, ^{240}Pu and ^{242}Pu will be combined to produce values for the material PU239L for the NUTS calculation, and (3) the activity of ^{230}Th and ^{229}Th will be combined to produce values for the material TH230L in the NUTS calculation.

In Table 8, ^{238}Pu is also listed as an important radionuclide for the NUTS calculation. The inventory of ^{238}Pu is not combined with the other plutonium isotopes because of its relatively short half-life.

Finally, the inventory of ^{241}Pu is combined with the inventory of ^{241}Am because ^{241}Pu is a parent isotope to ^{241}Am and ^{241}Pu has a relatively short half-life when compared to ^{241}Am. Combining the inventories for ^{241}Am and ^{241}Pu produces the inventory value for the material AM241L in the NUTS calculation.

The resulting decay chains for the NUTS calculations are:

$$^{238}\text{Pu} \rightarrow {}^{234}\text{U} \rightarrow {}^{230}\text{Th} \quad (11)$$

$$^{239}\text{Pu} \quad (12)$$

$$^{241}\text{Am} \quad (13)$$

7.2.2 Implementation

The computational methodology for combining radionuclide activities into lumped activity values (in curies) is shown in Equations 14 through 23 based on the approach by Leigh and Trone (2005, Section 3).

$$A_L(^{238}\text{Pu})_{CH} = A(^{238}\text{Pu})_{CH} \quad (14)$$

$$A_L(^{238}\text{Pu})_{RH} = A(^{238}\text{Pu})_{RH} \quad (15)$$

where:

$A_L(^{238}\text{Pu})_{CH}$ is the activity value for the property INVCHD (i.e., contact-handled inventory) for the material PU238L

$A(^{238}\text{Pu})_{CH}$ is the activity value for ^{238}Pu from Table 8 for CH-TRU

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$A_L(^{238}Pu)_{RH}$ is the activity value for the property INVRHD (i.e., remote-handled inventory) for the material PU238L
$A(^{238}Pu)_{RH}$ is the activity value for ^{238}Pu from Table 8 for RH-TRU.

$$A_L(^{241}Am)_{CH} = A(^{241}Am)_{CH} + A(^{241}Pu)_{CH} \times \tau_{1/2}(^{241}Pu)/\tau_{1/2}(^{241}Am) \quad (16)$$

$$A_L(^{241}Am)_{RH} = A(^{241}Am)_{RH} + A(^{241}Pu)_{RH} \times \tau_{1/2}(^{241}Pu)/\tau_{1/2}(^{241}Am) \quad (17)$$

where:
$A_L(^{241}Am)_{CH}$ is the activity value for the property INVCHD for the material AM241L
$A(^{241}Am)_{CH}$ is the activity value for ^{241}Am from Table 8 for CH-TRU
$A(^{241}Pu)_{CH}$ is the activity value for ^{241}Pu from Table 8 for CH-TRU
$A_L(^{241}Am)_{RH}$ is the activity value for the property INVRHD for the material AM241L
$A(^{241}Am)_{RH}$ is the activity value for ^{241}Am from Table 8 for RH-TRU
$A(^{241}Pu)_{RH}$ is the activity value for ^{241}Pu from Table 8 for RH-TRU
$\tau_{1/2}(^{241}Am)$ is the half-life of ^{241}Am from Table 5
$\tau_{1/2}(^{241}Pu)$ is the half-life of ^{241}Pu from Table 5.

$$A_L(^{239}Pu)_{CH} = A(^{239}Pu)_{CH} + A(^{240}Pu)_{CH} + A(^{242}Pu)_{CH} \times \tau_{1/2}(^{242}Pu)/\tau_{1/2}(^{239}Pu) \quad (18)$$

$$A_L(^{239}Pu)_{RH} = A(^{239}Pu)_{RH} + A(^{240}Pu)_{RH} + A(^{242}Pu)_{RH} \times \tau_{1/2}(^{242}Pu)/\tau_{1/2}(^{239}Pu) \quad (19)$$

where:
$A_L(^{239}Pu)_{CH}$ is the activity value for the property INVCHD for the material PU239L
$A(^{239}Pu)_{CH}$ is the activity value for ^{239}Pu from Table 8 for CH-TRU
$A(^{240}Pu)_{CH}$ is the activity value for ^{240}Pu from Table 8 for CH-TRU
$A(^{242}Pu)_{CH}$ is the activity value for ^{242}Pu from Table 8 for CH-TRU
$A_L(^{239}Pu)_{RH}$ is the activity value for the property INVRHD for the material PU239L
$A(^{239}Pu)_{RH}$ is the activity value for ^{239}Pu from Table 8 for RH-TRU
$A(^{240}Pu)_{RH}$ is the activity value for ^{240}Pu from Table 8 for RH-TRU
$A(^{242}Pu)_{RH}$ is the activity value for ^{242}Pu from Table 8 for RH-TRU
$\tau_{1/2}(^{239}Pu)$ is the half-life of ^{239}Pu from Table 5
$\tau_{1/2}(^{242}Pu)$ is the half-life of ^{242}Pu from Table 5.

$$A_L(^{234}U)_{CH} = A(^{234}U)_{CH} + A(^{233}U)_{CH} \quad (20)$$

$$A_L(^{234}U)_{RH} = A(^{234}U)_{RH} + A(^{233}U)_{RH} \quad (21)$$

where:
$A_L(^{234}U)_{CH}$ is the activity value for the property INVCHD for the material U234L
$A(^{234}U)_{CH}$ is the activity value for ^{234}U from Table 8 for CH-TRU
$A(^{233}U)_{CH}$ is the activity value for ^{233}U from Table 8 for CH-TRU
$A_L(^{234}U)_{RH}$ is the activity value for the property INVRHD for the material U234L
$A(^{234}U)_{RH}$ is the activity value for ^{234}U from Table 8 for RH-TRU
$A(^{233}U)_{RH}$ is the activity value for ^{233}U from Table 8 for RH-TRU.

$$A_L(^{230}Th)_{CH} = A(^{230}Th)_{CH} + A(^{229}Th)_{CH} \quad (22)$$

$$A_L(^{230}Th)_{RH} = A(^{230}Th)_{RH} + A(^{229}Th)_{RH} \quad (23)$$

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where:

$A_L(^{230}Th)_{CH}$ is the activity value for the property INVCHD for the material TH230L
$A(^{230}Th)_{CH}$ is the activity value for ^{230}Th from Table 8 for CH-TRU
$A(^{229}Th)_{CH}$ is the activity value for ^{229}Th from Table 8 for CH-TRU
$A_L(^{230}Th)_{RH}$ is the activity value for the property INVRHD for the material TH230L
$A(^{230}Th)_{RH}$ is the activity value for ^{230}Th from Table 8 for RH-TRU
$A(^{229}Th)_{RH}$ is the activity value for ^{229}Th from Table 8 for RH-TRU.

7.3 Results

Using the radionuclide activity values from Appendix A (Table 15) and the equations from Section 7.2 gives the values in Table 14 for the lumped radionuclide inventories at the end of 2083.

Table 14 – Lumped Radionuclide Inventory Values of 12/31/2083

Material	INVCHD (Total Ci)	INVRHD (Total Ci)
AM241L	1.81E+06	1.79E+04
PU238L	1.57E+06	2.58E+04
PU239L	5.27E+06	9.46E+03
TH230L	6.89E+00	6.91E-01
U234L	1.09E+03	1.44E+02

NOTE: INVCHD is a parameter name that refers to contact-handled inventory in curies. INVRHD is a parameter name that refers to remote-handled inventory in curies. These parameter values are listed in Appendix D (Table 28), which provides the specific parameter data entry information required for tracking parameters in PA.

7.4 Use in SECOTP2D

The PA code SECOTP2D simulates radionuclide transport through the Culebra to determine the proportion of NUTS releases to the Culebra that reach the WIPP land withdrawal boundary. To develop its convolution scaling factors, SECOTP2D simulates the release of 1.0 kg masses of the same lumped isotopes modeled by NUTS, including ^{241}Am, ^{239}Pu, ^{230}Th, and ^{234}U. Consistent with PA calculations associated with the CCA and all subsequent CRAs, the isotope ^{238}Pu is excluded from the SECOTP2D calculations because of its low half-life.

8.0 OXYANION MOLES

Oxyanions (anions containing oxygen) are important to PA because they may affect gas generation rates. Oxyanions that are important to PA include sulfates and nitrates. LANL provided masses of sulfate and nitrate in waste coming to the WIPP in FRPAIR-2024 (Van Soest 2025, Table 5-8). The values are 1.64E+06 kg of nitrate and 4.75E+05 kg of sulfate. A conversion to moles is needed

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for input to PA calculations in the code BRAGFLO, as provided by oxyanion parameters NITRATE:QINIT and SULFATE:QINIT (Appendix D, Table 30). The molecular weights for nitrate and sulfate are given in Tierney (1996). The molecular weight of nitrate used in Tierney (1996) is 6.20E-02 kg/mol. The molecular weight of sulfate used in Tierney (1996) is 9.606E-02 kg/mol. The conversion is as follows:

$$M_{waste}^{NO_3^-} = \left[\frac{1.64\text{E+}06 \text{ kg}}{6.20\text{E-}02 \text{ kg/mol}}\right] = 2.64\text{E+}07 \text{ moles } NO_3^- \quad (24)$$

$$M_{waste}^{SO_4^{-2}} = \left[\frac{4.75\text{E+}05 \text{ kg}}{9.606\text{E-}02 \text{ kg/mol}}\right] = 4.95\text{E+}06 \text{ moles } SO_4^{-2} \quad (25)$$

9.0 WASTE MATERIAL PARAMETERS

To support PA calculations in the code BRAGFLO, the total inventory of all non-radiological waste material parameters is required for both CH- and RH-TRU waste. Non-radiological waste material parameters include cellulosic, plastic, and rubber materials; iron-based metal/alloys; aluminum-based metal/alloys; other metals; solidified inorganic materials; solidified organic materials; vitrified materials; cements; soils; and other inorganic materials. These components may affect actinide solubility or gas generation rates. The waste material parameters are listed in Appendix D (Table 29), which provides the specific parameter data entry information required for tracking parameters in PA.

10.0 EPAUNI INPUT FILES

The radionuclides that are important for modeling the direct solid release pathway (via the CCDFGF code) are: ^{241}Am, ^{244}Cm, ^{137}Cs, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{90}Sr, ^{233}U, and ^{234}U. These 10 radionuclides account for 99.83% of the EPA units at the time of repository closure in the FRPAIR-2024 inventory as documented in Section 5.2 (see Table 10). These ten radionuclides are modeled in EPAUNI, which is the computational code that calculates the activities as function of time, determines the EPA units associated with the radionuclides, and generates the normalized distribution associated with the volumetric EPA units (Kicker 2024).

EPAUNI input files provide data for both CH- and RH-TRU waste and include the following files:

- *epu_CRA26_FS_ch.inp*
- *epu_CRA26_FS_ch_misc.inp*
- *epu_CRA26_FS_rh.inp*
- *epu_CRA26_FS_rh_misc.inp*

The input files *epu_CRA26_FS_ch.inp* and *epu_CRA26_FS_rh.inp* provide data for CH and RH waste, respectively, and include WIPP inventory data taken directly from FRPAIR-2024 (Van Soest 2025). These files include the scaled volume (m^3) and activity (Ci) for the 10 select radionuclides from each waste stream in the inventory. The EPAUNI input files

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epu_CRA26_FS_ch_misc.inp and *epu_CRA26_FS_rh_misc.inp* provide flags for directing code settings for reading input and producing output. The WUF value (as documented in Section 4) is manually entered into these two files. Additional details for generating EPAUNI input files are provided in Appendix E.

11.0 SUMMARY

This analysis report documents the radionuclide inventory screening component of the CRA-2026 PA for the final state of the repository. The results of the radionuclide inventory screening analysis are summarized as follows:

- Each potential radionuclide release mechanism modeled in PA has as its source an inventory of radionuclides that (1) the DOE expects will be disposed in WIPP and (2) analysts believe will be prevalent in a release via the individual release mechanism.
- In comparison to the RPPCR PA, the CRA26_FS inventory produces an increase in total activity in curies.
- The waste unit factor, or WUF, is defined as the number of millions of curies of alpha-emitting TRU radionuclides with half-lives longer than 20 years destined for disposal in the WIPP repository. For the CRA26_FS inventory, the WUF is 8.68, which increased compared to the RPPCR inventory, which had a WUF of 5.59.
- The CRA26_FS inventory contains 168 radionuclides. However, not all of the 168 radionuclides are important to track in a PA for the WIPP repository. Many of the isotopes have low concentrations or are short lived and would not impact the releases calculated by PA simulations.
- The radionuclides modeled in PA are based on simplified decay chains of key radionuclides in the WIPP inventory. Additionally, radionuclides with relatively large activities greater than 0.001 EPA units are also considered.
- The CRA26_FS inventory contains 35 isotopes with the activities greater than 0.001 EPA units. These radionuclides together with 7 other significant isotopes from the simplified decay chains of key radionuclides reduces the total number of isotopes from 168 to 42, thus identifying the most significant isotopes for consideration in PA calculations.
- Three of the WIPP PA codes use the radionuclide inventories directly: PANEL, NUTS, and EPAUNI. The WIPP PA code EPAUNI reports the volume and decayed activity of each waste stream through time for input into CCDFGF.
- For the CRA26_FS analysis, the 30 isotopes modeled in PANEL encompass 99.85% of the total inventory in EPA units at the time of repository closure. At the end of the regulatory period, these 30 isotopes encompass 99.99% of the total inventory in EPA units.
- The 10 radionuclides modeled in NUTS account for 99.67% of the total inventory in EPA units at the time of repository closure. At the end of the regulatory period, these 10 isotopes encompass 99.96% of the total inventory in EPA units.
- The 10 radionuclides used to model the direct solid release pathway in the CRA26_FS CCDFGF analysis account for 99.83% of the EPA units at the time of repository closure. At the end of the regulatory period, these 10 isotopes encompass 99.91% of the total inventory in EPA units.

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- Based on this radionuclide inventory screening analysis, there are sufficient radionuclides modeled in PA calculations to capture the dominant releases.

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13.0 APPENDIX A – RELEASE LIMITS AND SOURCE TERM EPA UNITS FOR WIPP-SCALE TRU WASTE

Table 15 – 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 2083)

Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Ac-225	A	10.0 d	6.42E+00	6.77E-01	--	--	--
Ac-227	B-A	21.772 y	8.32E+01	1.92E-01	100	868	9.60E-02
Ac-228	B-	6.15 h	1.08E-01	2.07E-02	--	--	--
Ag-108	B-ECB+	2.37 m	5.75E-04	2.21E-03	--	--	--
Ag-108m	ECIT	418 y	6.61E-03	2.54E-02	1000	8684	3.68E-06
Ag-109m	IT	39.6 s	8.56E-20	1.40E-15	--	--	--
Ag-110	B-EC	24.6 s	1.43E-29	5.01E-29	--	--	--
Ag-110m	B-IT	249.76 d	1.05E-27	3.68E-27	--	--	--
Am-241	A	432.2 y	1.79E+06	1.77E+04	100	868	2.08E+03
Am-242	B-EC	16.02 h	2.41E-02	2.09E+00	--	--	--
Am-242m	ITA	141 y	2.42E-02	2.09E+00	100	868	2.44E-03
Am-243	A	7.37E+3 y	3.32E+01	5.74E+02	100	868	7.00E-01
Am-245	B-	2.05 h	1.43E-24	1.39E-32	--	--	--
Am-246	B-	39 m	3.13E-08	0.00E+00	--	--	--
Ar-39	B-	269 y	0.00E+00	2.59E-02	1000	8684	2.98E-06
Ar-42	B-	32.9 y	0.00E+00	1.75E-02	1000	8684	2.01E-06
At-217	A	3.23E-2 s	6.42E+00	6.77E-01	--	--	--
Ba-133	EC	10.52 y	8.42E-05	8.62E-02	--	--	--
Ba-137m	IT	2.552 m	9.93E+01	7.79E+04	--	--	--
Bi-210	B-A	5.013 d	1.89E+00	7.13E+00	--	--	--
Bi-211	A B-	2.14 m	8.33E+01	1.92E-01	--	--	--
Bi-212	B-A	60.55 m	1.23E+04	3.68E+00	--	--	--
Bi-213	B-A	45.59 m	6.42E+00	6.76E-01	--	--	--
Bi-214	B-A	19.9 m	2.21E+00	7.57E+00	--	--	--
Bk-249	B-A	330 d	9.84E-20	9.59E-28	--	--	--
Bk-250	B-	3.212 h	1.75E-08	0.00E+00	--	--	--

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Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
C-14	B-	5.70E+3 y	1.52E-01	1.25E+00	100	868	1.62E-03
Cd-109	EC	461.4 d	8.56E-20	1.40E-15	--	--	--
Cd-113	B-	7.7E+15 y	1.56E-22	9.32E-18	1000	8684	1.07E-21
Cd-113m	B-IT	14.1 y	4.03E-06	1.59E-01	--	--	--
Ce-144	B-	284.91 d	1.41E-23	6.49E-22	--	--	--
Cf-249	ASF	351 y	8.50E+00	8.40E+01	100	868	1.06E-01
Cf-250	ASF	13.08 y	5.38E-01	2.65E+01	--	--	--
Cf-251	A	900 y	3.39E-01	2.76E+01	100	868	3.21E-02
Cf-252	ASF	2.645 y	1.73E-05	7.95E-05	--	--	--
Cl-36	B-ECB+	3.01E+5 y	2.08E-07	1.17E-01	1000	8684	1.35E-05
Cm-242	ASF	162.8 d	1.99E-02	1.72E+00	--	--	--
Cm-243	AEC	29.1 y	3.55E+00	3.18E+01	100	868	4.07E-02
Cm-244	ASF	18.10 y	1.85E+03	1.02E+04	--	--	--
Cm-245	ASF	8.5E+3 y	4.46E+00	1.96E+01	100	868	2.77E-02
Cm-246	ASF	4.76E+3 y	1.00E+02	7.29E+02	100	868	9.54E-01
Cm-247	A	1.56E+7 y	9.23E-01	8.64E-04	100	868	1.06E-03
Cm-248	ASF	3.48E+5 y	1.63E+00	3.62E+00	100	868	6.04E-03
Cm-250	AB-SF	8300 y	1.25E-07	0.00E+00	100	868	1.44E-10
Co-60	B-	5.2713 y	5.25E-04	7.80E-01	--	--	--
Cs-134	B-EC	2.0648 y	1.03E-09	3.47E-06	--	--	--
Cs-135	B-	2.3E+6 y	1.50E-03	5.78E-02	1000	8684	6.83E-06
Cs-137	B-	30.1671 y	1.05E+02	8.25E+04	1000	8684	9.51E+00
Eu-152	ECB+B-	13.537 y	5.42E-01	4.61E+01	--	--	--
Eu-154	B-EC	8.593 y	4.47E-02	6.20E+01	--	--	--
Eu-155	B-	4.7611 y	4.57E-04	7.41E-02	--	--	--
Fe-55	EC	2.737 y	1.02E-06	1.83E-05	--	--	--
Fr-221	A	4.9 m	6.42E+00	6.77E-01	--	--	--
Fr-223	B-A	22.00 m	1.15E+00	2.65E-03	--	--	--
Gd-152	A	1.08E+14 y	4.16E-13	3.46E-11	100	868	4.03E-14
Gd-153	EC	240.4 d	7.13E-34	2.17E-30	--	--	--
H-3	B-	12.32 y	4.46E+03	1.18E+02	--	--	--

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Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Ho-166m	B-	1.20E+3 y	3.63E-03	0.00E+00	1000	8684	4.18E-07
I-129	B-	1.57E+7 y	1.45E-03	8.82E-01	100	868	1.02E-03
In-115	B-	4.41E+14 y	0.00E+00	7.47E-17	1000	8684	8.61E-21
Ir-194	B-	19.28 h	0.00E+00	1.98E-05	--	--	--
K-40	B-ECB+	1.251E+9 y	4.84E-02	0.00E+00	1000	8684	5.57E-06
K-42	B-	12.360 h	0.00E+00	1.75E-02	--	--	--
Kr-85	B-	10.756 y	1.61E-03	1.84E+01	--	--	--
Mn-54	ECB+B-	312.12 d	5.06E-24	5.53E-21	--	--	--
Mo-93	EC	4.0E+3 y	0.00E+00	4.49E-01	1000	8684	5.17E-05
Na-22	ECB+	2.6019 y	6.34E-07	3.08E-09	--	--	--
Nb-91	ECB+	680 y	0.00E+00	3.81E-02	1000	8684	4.38E-06
Nb-93m	IT	16.13 y	1.24E-02	6.31E-01	--	--	--
Nb-94	B-	2.03E+4 y	1.61E-03	3.59E+00	1000	8684	4.14E-04
Nd-144	A	2.29E+15 y	1.36E-12	1.57E-12	100	868	3.37E-15
Ni-59	ECB+	1.01E+5 y	1.69E-07	3.94E+00	1000	8684	4.53E-04
Ni-63	B-	100.1 y	5.92E+02	4.09E+02	1000	8684	1.15E-01
Np-235	ECA	396.1 d	0.00E+00	3.62E-18	--	--	--
Np-237	A	2.144E+6 y	7.85E+01	1.31E+01	100	868	1.05E-01
Np-238	B-	2.117 d	1.09E-04	9.43E-03	--	--	--
Np-239	B-	2.3565 d	3.32E+01	5.74E+02	--	--	--
Np-240	B-	61.9 m	8.34E-05	1.47E-08	--	--	--
Np-240m	B-IT	7.22 m	6.95E-02	1.23E-05	--	--	--
Os-194	B-	6.0 y	0.00E+00	1.98E-05	--	--	--
Pa-231	A	3.276E+4 y	2.61E+01	3.25E-03	100	868	3.00E-02
Pa-233	B-	26.967 d	7.85E+01	1.31E+01	--	--	--
Pa-234	B-	6.70 h	1.40E-01	4.56E-03	--	--	--
Pa-234m	B-IT	1.17 m	1.08E+02	3.50E+00	--	--	--
Pb-209	B-	3.253 h	6.42E+00	6.76E-01	--	--	--
Pb-210	B-A	22.20 y	1.89E+00	7.12E+00	100	868	1.04E-02
Pb-211	B-	36.1 m	8.33E+01	1.92E-01	--	--	--
Pb-212	B-	10.64 h	1.23E+04	3.68E+00	--	--	--

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Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Pb-214	B-	26.8 m	2.21E+00	7.57E+00	--	--	--
Pd-107	B-	6.5E+6 y	1.50E-05	1.04E-02	1000	8684	1.20E-06
Pm-145	ECA	17.7 y	0.00E+00	1.33E-01	--	--	--
Pm-146	ECB-	5.53 y	1.20E-09	6.33E-04	--	--	--
Pm-147	B-	2.6234 y	6.69E-05	4.52E-05	--	--	--
Po-210	A	138.376 d	1.89E+00	7.13E+00	--	--	--
Po-211	A	0.516 s	2.29E-01	5.29E-04	--	--	--
Po-212	A	2.99E-7 s	7.91E+03	2.36E+00	--	--	--
Po-213	A	4.2E-6 s	6.28E+00	6.62E-01	--	--	--
Po-214	A	1.643E-4 s	2.21E+00	7.57E+00	--	--	--
Po-215	A	1.781E-3 s	8.33E+01	1.92E-01	--	--	--
Po-216	A	0.145 s	1.23E+04	3.68E+00	--	--	--
Po-218	A B-	3.10 m	2.21E+00	7.57E+00	--	--	--
Pr-144	B-	17.28 m	1.41E-23	6.49E-22	--	--	--
Pr-144m	ITB-	7.2 m	1.97E-25	9.09E-24	--	--	--
Pu-236	ASF	2.858 y	2.90E-15	2.96E-07	--	--	--
Pu-238	ASF	87.7 y	1.57E+06	2.58E+04	100	868	1.84E+03
Pu-239	A	2.411E+4 y	4.17E+06	4.53E+03	100	868	4.80E+03
Pu-240	ASF	6564 y	1.10E+06	4.55E+03	100	868	1.27E+03
Pu-241	B-A	14.35 y	5.81E+05	8.60E+03	--	--	--
Pu-242	ASF	3.75E+5 y	2.86E+02	2.39E+01	100	868	3.57E-01
Pu-243	B-	4.956 h	9.23E-01	8.64E-04	--	--	--
Pu-244	ASF	8.00E+7 y	6.96E-02	1.23E-05	100	868	8.02E-05
Pu-246	B-	10.84 d	3.13E-08	0.00E+00	--	--	--
Ra-223	A	11.43 d	8.33E+01	1.92E-01	--	--	--
Ra-224	A	3.66 d	1.23E+04	3.68E+00	--	--	--
Ra-225	B-	14.9 d	6.42E+00	6.77E-01	--	--	--
Ra-226	A	1600 y	2.21E+00	7.57E+00	100	868	1.13E-02
Ra-228	B-	5.75 y	1.08E-01	2.07E-02	--	--	--
Rb-87	B-	4.923E10 y	1.87E-10	1.57E-06	1000	8684	1.81E-10
Rh-102	ECB+B-	207 d	0.00E+00	7.23E-35	--	--	--

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Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Rh-106	B-	29.80 s	1.17E-17	1.08E-15	--	--	--
Rn-219	A	3.96 s	8.33E+01	1.92E-01	--	--	--
Rn-220	A	55.6 s	1.23E+04	3.68E+00	--	--	--
Rn-222	A	3.8235 d	2.21E+00	7.57E+00	--	--	--
Ru-106	B-	373.59 d	1.17E-17	1.08E-15	--	--	--
Sb-125	B-	2.75856 y	8.78E-08	3.74E-05	--	--	--
Sb-126	B-	12.35 d	1.21E-06	1.19E-02	--	--	--
Sb-126m	B-IT	19.15 m	1.31E-05	1.34E-01	--	--	--
Se-79	B-	2.95E+5 y	1.22E-04	1.41E-01	1000	8684	1.63E-05
Sm-145	EC	340 d	0.00E+00	8.68E-22	--	--	--
Sm-146	A	1.03E+8 y	1.81E-13	4.00E-08	100	868	4.61E-11
Sm-147	A	1.060E11 y	1.73E-08	3.86E-07	100	868	4.65E-10
Sm-148	A	7E+15 y	1.63E-15	2.83E-19	100	868	1.88E-18
Sm-151	B-	90 y	1.14E+01	6.65E+01	1000	8684	8.97E-03
Sn-119m	IT	293.1 d	0.00E+00	1.26E-24	--	--	--
Sn-121	B-	27.03 h	4.55E-05	8.15E-01	--	--	--
Sn-121m	ITB-	43.9 y	5.87E-05	1.05E+00	1000	8684	1.21E-04
Sn-126	B-	2.30E+5 y	1.31E-05	1.34E-01	1000	8684	1.54E-05
Sr-90	B-	28.79 y	2.30E+02	6.06E+04	1000	8684	7.01E+00
Tb-157	EC	71 y	0.00E+00	8.26E-02	1000	8684	9.51E-06
Tc-97	EC	2.6E+6 y	0.00E+00	3.64E-08	1000	8684	4.19E-12
Tc-99	B-	2.111E+5 y	2.18E+01	5.65E+02	10000	86840	6.76E-03
Te-123	EC	6.00E+14 y	6.98E-22	1.92E-14	1000	8684	2.21E-18
Te-125m	IT	57.40 d	2.14E-08	9.14E-06	--	--	--
Th-227	A	18.68 d	8.22E+01	1.90E-01	--	--	--
Th-228	A	1.9116 y	1.23E+04	3.68E+00	--	--	--
Th-229	A	7.34E+3 y	6.42E+00	6.77E-01	100	868	8.17E-03
Th-230	A	7.538E+4 y	4.74E-01	1.49E-02	10	87	5.63E-03
Th-231	B-	25.52 h	1.74E+00	2.04E+00	--	--	--
Th-232	A	1.405E10 y	1.08E-01	9.77E-03	10	87	1.36E-03
Th-234	B-	24.10 d	1.08E+02	3.50E+00	--	--	--

Information Only

Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Tl-204	B-EC	3.78 y	1.37E-12	0.00E+00	--	--	--
Tl-206	B-	4.200 m	2.49E-06	9.41E-06	--	--	--
Tl-207	B-	4.77 m	8.31E+01	1.92E-01	--	--	--
Tl-208	B-	3.053 m	4.44E+03	1.32E+00	--	--	--
Tl-209	B-	2.161 m	1.35E-01	1.42E-02	--	--	--
Tm-171	B-	1.92 y	0.00E+00	8.61E-11	--	--	--
U-232	A	68.9 y	1.20E+04	3.56E+00	100	868	1.38E+01
U-233	A	1.592E+5 y	3.56E+02	1.24E+02	100	868	5.54E-01
U-234	A	2.455E+5 y	7.36E+02	1.97E+01	100	868	8.70E-01
U-235	A	7.04E+8 y	1.74E+00	2.04E+00	100	868	4.36E-03
U-236	A	2.342E+7 y	3.58E+00	2.49E-01	100	868	4.41E-03
U-237	B-	6.75 d	1.39E+01	2.06E-01	--	--	--
U-238	ASF	4.468E+9 y	1.08E+02	3.50E+00	100	868	1.28E-01
U-240	B-	14.1 h	6.95E-02	1.23E-05	--	--	--
V-49	EC	330 d	0.00E+00	8.07E-21	--	--	--
Y-90	B-	64.10 h	2.30E+02	6.06E+04	--	--	--
Zn-65	ECB+	244.06 d	1.57E-29	1.73E-27	--	--	--
Zr-93	B-	1.53E+6 y	1.24E-02	1.99E-01	1000	8684	2.43E-05
Total:	**--**	**--**	**9.32E+06**	**3.57E+05**	**--**	**--**	**10032**

[a] Decay mode and half-life information taken from the International Commission on Radiological Protection (ICRP 2008, Table A.1). Note that decay modes include A = alpha, B- = beta minus, B+ = beta plus, EC = electron capture, IT = isomeric transition, and SF = spontaneous fission. Half-life units include s = second, m = minute, h = hour, d = day, and y = year.

[b] Decayed radionuclide inventory information taken from Van Soest (2025).

[c] Release limits are determined in accordance with 40 CFR 191 (see Table 2 and Appendix B, Table 21). The release limit in Ci/UW corresponds to specific release limits (cumulative releases to the accessible environment for 10,000 years after disposal per "unit of waste" identified in Note 1(e) of Table 1, Appendix A, 40 CFR 191). The release limit in Ci corresponds to release limit obtained for 8.68 units of waste. The 8.68 value for the unit of waste corresponds to the units of waste present at repository closure in 2083.

[d] Potential release is defined as the total inventory (CH + RH) in Ci divided by the release limit in Ci. Those isotopes without defined release limits have no potential release.

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Table 16 – 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 2183)

Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Ac-225	A	10.0 d	9.48E+00	1.76E+00	--	--	--
Ac-227	B-A	21.772 y	2.84E+01	1.41E-02	100	868	3.27E-02
Ac-228	B-	6.15 h	1.08E-01	9.77E-03	--	--	--
Ag-108	B-ECB+	2.37 m	3.33E-04	1.28E-03	--	--	--
Ag-108m	ECIT	418 y	3.83E-03	1.47E-02	1000	8684	2.13E-06
Ag-109m	IT	39.6 s	0.00E+00	0.00E+00	--	--	--
Ag-110	B-EC	24.6 s	0.00E+00	0.00E+00	--	--	--
Ag-110m	B-IT	249.76 d	0.00E+00	0.00E+00	--	--	--
Am-241	A	432.2 y	1.54E+06	1.53E+04	100	868	1.79E+03
Am-242	B-EC	16.02 h	1.48E-02	1.28E+00	--	--	--
Am-242m	ITA	141 y	1.48E-02	1.28E+00	100	868	1.49E-03
Am-243	A	7.37E+3 y	3.29E+01	5.69E+02	100	868	6.93E-01
Am-245	B-	2.05 h	0.00E+00	0.00E+00	--	--	--
Am-246	B-	39 m	3.11E-08	0.00E+00	--	--	--
Ar-39	B-	269 y	0.00E+00	2.00E-02	1000	8684	2.30E-06
Ar-42	B-	32.9 y	0.00E+00	2.13E-03	1000	8684	2.45E-07
At-217	A	3.23E-2 s	9.48E+00	1.76E+00	--	--	--
Ba-133	EC	10.52 y	1.16E-07	1.19E-04	--	--	--
Ba-137m	IT	2.552 m	9.85E+00	7.72E+03	--	--	--
Bi-210	B-A	5.013 d	2.15E+00	7.33E+00	--	--	--
Bi-211	A B-	2.14 m	2.84E+01	1.41E-02	--	--	--
Bi-212	B-A	60.55 m	4.57E+03	1.37E+00	--	--	--
Bi-213	B-A	45.59 m	9.48E+00	1.76E+00	--	--	--
Bi-214	B-A	19.9 m	2.15E+00	7.25E+00	--	--	--
Bk-249	B-A	330 d	0.00E+00	0.00E+00	--	--	--
Bk-250	B-	3.212 h	1.74E-08	0.00E+00	--	--	--
C-14	B-	5.70E+3 y	1.50E-01	1.24E+00	100	868	1.60E-03
Cd-109	EC	461.4 d	0.00E+00	0.00E+00	--	--	--
Cd-113	B-	7.7E+15 y	1.65E-22	9.65E-18	1000	8684	1.11E-21

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Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Cd-113m	B-IT	14.1 y	2.95E-08	1.17E-03	--	--	--
Ce-144	B-	284.91 d	0.00E+00	0.00E+00	--	--	--
Cf-249	ASF	351 y	6.97E+00	6.89E+01	100	868	8.74E-02
Cf-250	ASF	13.08 y	2.69E-03	1.33E-01	--	--	--
Cf-251	A	900 y	3.14E-01	2.55E+01	100	868	2.97E-02
Cf-252	ASF	2.645 y	7.17E-17	3.30E-16	--	--	--
Cl-36	B-ECB+	3.01E+5 y	2.08E-07	1.17E-01	1000	8684	1.35E-05
Cm-242	ASF	162.8 d	1.22E-02	1.05E+00	--	--	--
Cm-243	AEC	29.1 y	3.12E-01	2.79E+00	100	868	3.58E-03
Cm-244	ASF	18.10 y	4.01E+01	2.22E+02	--	--	--
Cm-245	ASF	8.5E+3 y	4.49E+00	2.00E+01	100	868	2.82E-02
Cm-246	ASF	4.76E+3 y	9.86E+01	7.18E+02	100	868	9.41E-01
Cm-247	A	1.56E+7 y	9.23E-01	9.79E-04	100	868	1.06E-03
Cm-248	ASF	3.48E+5 y	1.63E+00	3.62E+00	100	868	6.04E-03
Cm-250	AB-SF	8300 y	1.25E-07	0.00E+00	100	868	1.43E-10
Co-60	B-	5.2713 y	1.02E-09	1.51E-06	--	--	--
Cs-134	B-EC	2.0648 y	2.59E-24	8.71E-21	--	--	--
Cs-135	B-	2.3E+6 y	1.50E-03	5.78E-02	1000	8684	6.83E-06
Cs-137	B-	30.1671 y	1.04E+01	8.18E+03	1000	8684	9.43E-01
Eu-152	ECB+B-	13.537 y	2.99E-03	2.54E-01	--	--	--
Eu-154	B-EC	8.593 y	1.40E-05	1.94E-02	--	--	--
Eu-155	B-	4.7611 y	1.69E-10	2.74E-08	--	--	--
Fe-55	EC	2.737 y	9.55E-18	1.72E-16	--	--	--
Fr-221	A	4.9 m	9.48E+00	1.76E+00	--	--	--
Fr-223	B-A	22.00 m	3.92E-01	1.94E-04	--	--	--
Gd-152	A	1.08E+14 y	4.35E-13	3.62E-11	100	868	4.22E-14
Gd-153	EC	240.4 d	0.00E+00	0.00E+00	--	--	--
H-3	B-	12.32 y	1.61E+01	4.26E-01	--	--	--
Ho-166m	B-	1.20E+3 y	3.43E-03	0.00E+00	1000	8684	3.95E-07
I-129	B-	1.57E+7 y	1.45E-03	8.82E-01	100	868	1.02E-03
In-115	B-	4.41E+14 y	0.00E+00	7.47E-17	1000	8684	8.61E-21

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Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Ir-194	B-	19.28 h	0.00E+00	1.90E-10	--	--	--
K-40	B-ECB+	1.251E+9 y	4.84E-02	0.00E+00	1000	8684	5.57E-06
K-42	B-	12.360 h	0.00E+00	2.13E-03	--	--	--
Kr-85	B-	10.756 y	2.50E-06	2.86E-02	--	--	--
Mn-54	ECB+B-	312.12 d	0.00E+00	0.00E+00	--	--	--
Mo-93	EC	4.0E+3 y	0.00E+00	4.40E-01	1000	8684	5.06E-05
Na-22	ECB+	2.6019 y	1.70E-18	8.27E-21	--	--	--
Nb-91	ECB+	680 y	0.00E+00	3.44E-02	1000	8684	3.96E-06
Nb-93m	IT	16.13 y	1.24E-02	5.62E-01	--	--	--
Nb-94	B-	2.03E+4 y	1.61E-03	3.58E+00	1000	8684	4.12E-04
Nd-144	A	2.29E+15 y	1.36E-12	1.57E-12	100	868	3.37E-15
Ni-59	ECB+	1.01E+5 y	1.69E-07	3.93E+00	1000	8684	4.53E-04
Ni-63	B-	100.1 y	2.96E+02	2.04E+02	1000	8684	5.76E-02
Np-235	ECA	396.1 d	0.00E+00	0.00E+00	--	--	--
Np-237	A	2.144E+6 y	1.32E+02	1.36E+01	100	868	1.68E-01
Np-238	B-	2.117 d	6.67E-05	5.77E-03	--	--	--
Np-239	B-	2.3565 d	3.29E+01	5.69E+02	--	--	--
Np-240	B-	61.9 m	8.34E-05	1.82E-08	--	--	--
Np-240m	B-IT	7.22 m	6.95E-02	1.52E-05	--	--	--
Os-194	B-	6.0 y	0.00E+00	1.90E-10	--	--	--
Pa-231	A	3.276E+4 y	2.60E+01	7.56E-03	100	868	3.00E-02
Pa-233	B-	26.967 d	1.32E+02	1.36E+01	--	--	--
Pa-234	B-	6.70 h	1.40E-01	4.56E-03	--	--	--
Pa-234m	B-IT	1.17 m	1.08E+02	3.50E+00	--	--	--
Pb-209	B-	3.253 h	9.48E+00	1.76E+00	--	--	--
Pb-210	B-A	22.20 y	2.15E+00	7.33E+00	100	868	1.09E-02
Pb-211	B-	36.1 m	2.84E+01	1.41E-02	--	--	--
Pb-212	B-	10.64 h	4.57E+03	1.37E+00	--	--	--
Pb-214	B-	26.8 m	2.15E+00	7.25E+00	--	--	--
Pd-107	B-	6.5E+6 y	1.50E-05	1.04E-02	1000	8684	1.20E-06
Pm-145	ECA	17.7 y	0.00E+00	2.65E-03	--	--	--

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Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Pm-146	ECB-	5.53 y	4.31E-15	2.28E-09	--	--	--
Pm-147	B-	2.6234 y	2.24E-16	1.51E-16	--	--	--
Po-210	A	138.376 d	2.15E+00	7.33E+00	--	--	--
Po-211	A	0.516 s	7.81E-02	3.88E-05	--	--	--
Po-212	A	2.99E-7 s	2.93E+03	8.75E-01	--	--	--
Po-213	A	4.2E-6 s	9.28E+00	1.72E+00	--	--	--
Po-214	A	1.643E-4 s	2.15E+00	7.25E+00	--	--	--
Po-215	A	1.781E-3 s	2.84E+01	1.41E-02	--	--	--
Po-216	A	0.145 s	4.57E+03	1.37E+00	--	--	--
Po-218	A B-	3.10 m	2.15E+00	7.25E+00	--	--	--
Pr-144	B-	17.28 m	0.00E+00	0.00E+00	--	--	--
Pr-144m	ITB-	7.2 m	0.00E+00	0.00E+00	--	--	--
Pu-236	ASF	2.858 y	1.21E-25	1.23E-17	--	--	--
Pu-238	ASF	87.7 y	7.13E+05	1.17E+04	100	868	8.35E+02
Pu-239	A	2.411E+4 y	4.16E+06	4.52E+03	100	868	4.79E+03
Pu-240	ASF	6564 y	1.09E+06	4.53E+03	100	868	1.26E+03
Pu-241	B-A	14.35 y	4.64E+03	8.84E+01	--	--	--
Pu-242	ASF	3.75E+5 y	2.86E+02	2.40E+01	100	868	3.57E-01
Pu-243	B-	4.956 h	9.23E-01	9.79E-04	--	--	--
Pu-244	ASF	8.00E+7 y	6.96E-02	1.52E-05	100	868	8.02E-05
Pu-246	B-	10.84 d	3.11E-08	0.00E+00	--	--	--
Ra-223	A	11.43 d	2.84E+01	1.41E-02	--	--	--
Ra-224	A	3.66 d	4.57E+03	1.37E+00	--	--	--
Ra-225	B-	14.9 d	9.48E+00	1.76E+00	--	--	--
Ra-226	A	1600 y	2.15E+00	7.25E+00	100	868	1.08E-02
Ra-228	B-	5.75 y	1.08E-01	9.77E-03	--	--	--
Rb-87	B-	4.923E10 y	1.87E-10	1.57E-06	1000	8684	1.81E-10
Rh-102	ECB+B-	207 d	0.00E+00	0.00E+00	--	--	--
Rh-106	B-	29.80 s	0.00E+00	0.00E+00	--	--	--
Rn-219	A	3.96 s	2.84E+01	1.41E-02	--	--	--
Rn-220	A	55.6 s	4.57E+03	1.37E+00	--	--	--

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Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Rn-222	A	3.8235 d	2.15E+00	7.25E+00	--	--	--
Ru-106	B-	373.59 d	0.00E+00	0.00E+00	--	--	--
Sb-125	B-	2.75856 y	8.24E-19	3.51E-16	--	--	--
Sb-126	B-	12.35 d	1.21E-06	1.19E-02	--	--	--
Sb-126m	B-IT	19.15 m	1.31E-05	1.34E-01	--	--	--
Se-79	B-	2.95E+5 y	1.22E-04	1.41E-01	1000	8684	1.63E-05
Sm-145	EC	340 d	0.00E+00	0.00E+00	--	--	--
Sm-146	A	1.03E+8 y	1.81E-13	4.00E-08	100	868	4.61E-11
Sm-147	A	1.060E11 y	1.73E-08	3.86E-07	100	868	4.65E-10
Sm-148	A	7E+15 y	1.63E-15	2.83E-19	100	868	1.88E-18
Sm-151	B-	90 y	5.29E+00	3.08E+01	1000	8684	4.15E-03
Sn-119m	IT	293.1 d	0.00E+00	0.00E+00	--	--	--
Sn-121	B-	27.03 h	1.29E-05	2.31E-01	--	--	--
Sn-121m	ITB-	43.9 y	1.66E-05	2.98E-01	1000	8684	3.43E-05
Sn-126	B-	2.30E+5 y	1.31E-05	1.34E-01	1000	8684	1.54E-05
Sr-90	B-	28.79 y	1.96E+01	5.16E+03	1000	8684	5.97E-01
Tb-157	EC	71 y	0.00E+00	5.20E-02	1000	8684	5.99E-06
Tc-97	EC	2.6E+6 y	0.00E+00	3.64E-08	1000	8684	4.19E-12
Tc-99	B-	2.111E+5 y	2.18E+01	5.65E+02	10000	86840	6.76E-03
Te-123	EC	6.00E+14 y	6.98E-22	1.92E-14	1000	8684	2.21E-18
Te-125m	IT	57.40 d	2.01E-19	8.57E-17	--	--	--
Th-227	A	18.68 d	2.80E+01	1.39E-02	--	--	--
Th-228	A	1.9116 y	4.57E+03	1.37E+00	--	--	--
Th-229	A	7.34E+3 y	9.48E+00	1.76E+00	100	868	1.29E-02
Th-230	A	7.538E+4 y	1.31E+00	3.56E-02	10	87	1.55E-02
Th-231	B-	25.52 h	2.15E+00	2.04E+00	--	--	--
Th-232	A	1.405E10 y	1.08E-01	9.77E-03	10	87	1.36E-03
Th-234	B-	24.10 d	1.08E+02	3.50E+00	--	--	--
Tl-204	B-EC	3.78 y	1.49E-20	0.00E+00	--	--	--
Tl-206	B-	4.200 m	2.84E-06	9.67E-06	--	--	--
Tl-207	B-	4.77 m	2.83E+01	1.41E-02	--	--	--

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Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Tl-208	B-	3.053 m	1.64E+03	4.91E-01	--	--	--
Tl-209	B-	2.161 m	1.99E-01	3.70E-02	--	--	--
Tm-171	B-	1.92 y	0.00E+00	1.81E-26	--	--	--
U-232	A	68.9 y	4.45E+03	1.32E+00	100	868	5.12E+00
U-233	A	1.592E+5 y	3.56E+02	1.24E+02	100	868	5.54E-01
U-234	A	2.455E+5 y	1.04E+03	2.47E+01	100	868	1.23E+00
U-235	A	7.04E+8 y	2.15E+00	2.04E+00	100	868	4.83E-03
U-236	A	2.342E+7 y	6.83E+00	2.62E-01	100	868	8.17E-03
U-237	B-	6.75 d	1.11E-01	2.12E-03	--	--	--
U-238	ASF	4.468E+9 y	1.08E+02	3.50E+00	100	868	1.28E-01
U-240	B-	14.1 h	6.95E-02	1.52E-05	--	--	--
V-49	EC	330 d	0.00E+00	0.00E+00	--	--	--
Y-90	B-	64.10 h	1.96E+01	5.17E+03	--	--	--
Zn-65	ECB+	244.06 d	0.00E+00	0.00E+00	--	--	--
Zr-93	B-	1.53E+6 y	1.24E-02	1.99E-01	1000	8684	2.43E-05
Total:	**--**	**--**	**7.54E+06**	**6.57E+04**	**--**	**--**	**8689**

[a] Decay mode and half-life information taken from the International Commission on Radiological Protection (ICRP 2008, Table A.1). Note that decay modes include A = alpha, B- = beta minus, B+ = beta plus, EC = electron capture, IT = isomeric transition, and SF = spontaneous fission. Half-life units include s = second, m = minute, h = hour, d = day, and y = year.
[b] Decayed radionuclide inventory information taken from Van Soest (2025).
[c] Release limits are determined in accordance with 40 CFR 191 (see Table 2 and Appendix B, Table 21). The release limit in Ci/UW corresponds to specific release limits (cumulative releases to the accessible environment for 10,000 years after disposal per "unit of waste" identified in Note 1(e) of Table 1, Appendix A, 40 CFR 191). The release limit in Ci corresponds to release limit obtained for 8.68 units of waste. The 8.68 value for the unit of waste corresponds to the units of waste present at repository closure in 2083.
[d] Potential release is defined as the total inventory (CH + RH) in Ci divided by the release limit in Ci. Those isotopes without defined release limits have no potential release.

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Table 17 – 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 2433)

Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Ac-225	A	10.0 d	1.70E+01	4.43E+00	--	--	--
Ac-227	B-A	21.772 y	2.59E+01	1.83E-02	100	868	2.99E-02
Ac-228	B-	6.15 h	1.08E-01	9.77E-03	--	--	--
Ag-108	B-ECB+	2.37 m	8.51E-05	3.27E-04	--	--	--
Ag-108m	ECIT	418 y	9.78E-04	3.76E-03	1000	8684	5.45E-07
Ag-109m	IT	39.6 s	0.00E+00	0.00E+00	--	--	--
Ag-110	B-EC	24.6 s	0.00E+00	0.00E+00	--	--	--
Ag-110m	B-IT	249.76 d	0.00E+00	0.00E+00	--	--	--
Am-241	A	432.2 y	1.03E+06	1.03E+04	100	868	1.20E+03
Am-242	B-EC	16.02 h	4.32E-03	3.73E-01	--	--	--
Am-242m	ITA	141 y	4.34E-03	3.75E-01	100	868	4.37E-04
Am-243	A	7.37E+3 y	3.21E+01	5.56E+02	100	868	6.77E-01
Am-245	B-	2.05 h	0.00E+00	0.00E+00	--	--	--
Am-246	B-	39 m	3.08E-08	0.00E+00	--	--	--
Ar-39	B-	269 y	0.00E+00	1.05E-02	1000	8684	1.21E-06
Ar-42	B-	32.9 y	0.00E+00	1.09E-05	1000	8684	1.26E-09
At-217	A	3.23E-2 s	1.70E+01	4.43E+00	--	--	--
Ba-133	EC	10.52 y	8.12E-15	8.31E-12	--	--	--
Ba-137m	IT	2.552 m	3.05E-02	2.39E+01	--	--	--
Bi-210	B-A	5.013 d	2.21E+00	6.52E+00	--	--	--
Bi-211	A B-	2.14 m	2.59E+01	1.83E-02	--	--	--
Bi-212	B-A	60.55 m	3.82E+02	1.23E-01	--	--	--
Bi-213	B-A	45.59 m	1.70E+01	4.43E+00	--	--	--
Bi-214	B-A	19.9 m	2.21E+00	6.51E+00	--	--	--
Bk-249	B-A	330 d	0.00E+00	0.00E+00	--	--	--
Bk-250	B-	3.212 h	1.73E-08	0.00E+00	--	--	--
C-14	B-	5.70E+3 y	1.46E-01	1.20E+00	100	868	1.55E-03
Cd-109	EC	461.4 d	0.00E+00	0.00E+00	--	--	--
Cd-113	B-	7.7E+15 y	1.65E-22	9.66E-18	1000	8684	1.11E-21

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Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Cd-113m	B-IT	14.1 y	1.36E-13	5.36E-09	--	--	--
Ce-144	B-	284.91 d	0.00E+00	0.00E+00	--	--	--
Cf-249	ASF	351 y	4.25E+00	4.20E+01	100	868	5.33E-02
Cf-250	ASF	13.08 y	2.20E-08	2.34E-07	--	--	--
Cf-251	A	900 y	2.59E-01	2.10E+01	100	868	2.45E-02
Cf-252	ASF	2.645 y	0.00E+00	0.00E+00	--	--	--
Cl-36	B-ECB+	3.01E+5 y	2.08E-07	1.17E-01	1000	8684	1.35E-05
Cm-242	ASF	162.8 d	3.57E-03	3.09E-01	--	--	--
Cm-243	AEC	29.1 y	7.14E-04	6.39E-03	100	868	8.18E-06
Cm-244	ASF	18.10 y	2.79E-03	1.54E-02	--	--	--
Cm-245	ASF	8.5E+3 y	4.51E+00	2.07E+01	100	868	2.91E-02
Cm-246	ASF	4.76E+3 y	9.51E+01	6.92E+02	100	868	9.07E-01
Cm-247	A	1.56E+7 y	9.23E-01	1.23E-03	100	868	1.06E-03
Cm-248	ASF	3.48E+5 y	1.63E+00	3.61E+00	100	868	6.04E-03
Cm-250	AB-SF	8300 y	1.23E-07	0.00E+00	100	868	1.42E-10
Co-60	B-	5.2713 y	5.31E-24	7.89E-21	--	--	--
Cs-134	B-EC	2.0648 y	0.00E+00	0.00E+00	--	--	--
Cs-135	B-	2.3E+6 y	1.50E-03	5.78E-02	1000	8684	6.83E-06
Cs-137	B-	30.1671 y	3.23E-02	2.53E+01	1000	8684	2.92E-03
Eu-152	ECB+B-	13.537 y	6.73E-09	5.72E-07	--	--	--
Eu-154	B-EC	8.593 y	2.43E-14	3.36E-11	--	--	--
Eu-155	B-	4.7611 y	1.40E-26	2.27E-24	--	--	--
Fe-55	EC	2.737 y	0.00E+00	0.00E+00	--	--	--
Fr-221	A	4.9 m	1.70E+01	4.43E+00	--	--	--
Fr-223	B-A	22.00 m	3.58E-01	2.53E-04	--	--	--
Gd-152	A	1.08E+14 y	4.35E-13	3.62E-11	100	868	4.22E-14
Gd-153	EC	240.4 d	0.00E+00	0.00E+00	--	--	--
H-3	B-	12.32 y	1.27E-05	3.35E-07	--	--	--
Ho-166m	B-	1.20E+3 y	2.97E-03	0.00E+00	1000	8684	3.42E-07
I-129	B-	1.57E+7 y	1.45E-03	8.82E-01	100	868	1.02E-03
In-115	B-	4.41E+14 y	0.00E+00	7.47E-17	1000	8684	8.61E-21

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Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Ir-194	B-	19.28 h	0.00E+00	5.39E-23	--	--	--
K-40	B-ECB+	1.251E+9 y	4.84E-02	0.00E+00	1000	8684	5.57E-06
K-42	B-	12.360 h	0.00E+00	1.09E-05	--	--	--
Kr-85	B-	10.756 y	2.38E-13	2.73E-09	--	--	--
Mn-54	ECB+B-	312.12 d	0.00E+00	0.00E+00	--	--	--
Mo-93	EC	4.0E+3 y	0.00E+00	4.19E-01	1000	8684	4.82E-05
Na-22	ECB+	2.6019 y	0.00E+00	0.00E+00	--	--	--
Nb-91	ECB+	680 y	0.00E+00	2.66E-02	1000	8684	3.07E-06
Nb-93m	IT	16.13 y	1.24E-02	5.44E-01	--	--	--
Nb-94	B-	2.03E+4 y	1.59E-03	3.55E+00	1000	8684	4.09E-04
Nd-144	A	2.29E+15 y	1.36E-12	1.57E-12	100	868	3.37E-15
Ni-59	ECB+	1.01E+5 y	1.68E-07	3.92E+00	1000	8684	4.52E-04
Ni-63	B-	100.1 y	5.24E+01	3.62E+01	1000	8684	1.02E-02
Np-235	ECA	396.1 d	0.00E+00	0.00E+00	--	--	--
Np-237	A	2.144E+6 y	2.35E+02	1.46E+01	100	868	2.88E-01
Np-238	B-	2.117 d	1.95E-05	1.69E-03	--	--	--
Np-239	B-	2.3565 d	3.21E+01	5.56E+02	--	--	--
Np-240	B-	61.9 m	8.34E-05	2.68E-08	--	--	--
Np-240m	B-IT	7.22 m	6.95E-02	2.23E-05	--	--	--
Os-194	B-	6.0 y	0.00E+00	5.39E-23	--	--	--
Pa-231	A	3.276E+4 y	2.59E+01	1.83E-02	100	868	2.99E-02
Pa-233	B-	26.967 d	2.35E+02	1.46E+01	--	--	--
Pa-234	B-	6.70 h	1.40E-01	4.56E-03	--	--	--
Pa-234m	B-IT	1.17 m	1.08E+02	3.50E+00	--	--	--
Pb-209	B-	3.253 h	1.70E+01	4.43E+00	--	--	--
Pb-210	B-A	22.20 y	2.21E+00	6.52E+00	100	868	1.00E-02
Pb-211	B-	36.1 m	2.59E+01	1.83E-02	--	--	--
Pb-212	B-	10.64 h	3.82E+02	1.23E-01	--	--	--
Pb-214	B-	26.8 m	2.21E+00	6.51E+00	--	--	--
Pd-107	B-	6.5E+6 y	1.50E-05	1.04E-02	1000	8684	1.20E-06
Pm-145	ECA	17.7 y	0.00E+00	1.48E-07	--	--	--

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Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Pm-146	ECB-	5.53 y	1.06E-28	5.59E-23	--	--	--
Pm-147	B-	2.6234 y	0.00E+00	0.00E+00	--	--	--
Po-210	A	138.376 d	2.21E+00	6.52E+00	--	--	--
Po-211	A	0.516 s	7.13E-02	5.04E-05	--	--	--
Po-212	A	2.99E-7 s	2.45E+02	7.89E-02	--	--	--
Po-213	A	4.2E-6 s	1.67E+01	4.33E+00	--	--	--
Po-214	A	1.643E-4 s	2.21E+00	6.51E+00	--	--	--
Po-215	A	1.781E-3 s	2.59E+01	1.83E-02	--	--	--
Po-216	A	0.145 s	3.82E+02	1.23E-01	--	--	--
Po-218	A B-	3.10 m	2.21E+00	6.51E+00	--	--	--
Pr-144	B-	17.28 m	0.00E+00	0.00E+00	--	--	--
Pr-144m	ITB-	7.2 m	0.00E+00	0.00E+00	--	--	--
Pu-236	ASF	2.858 y	0.00E+00	0.00E+00	--	--	--
Pu-238	ASF	87.7 y	9.89E+04	1.62E+03	100	868	1.16E+02
Pu-239	A	2.411E+4 y	4.13E+06	4.49E+03	100	868	4.76E+03
Pu-240	ASF	6564 y	1.06E+06	4.41E+03	100	868	1.23E+03
Pu-241	B-A	14.35 y	4.54E+00	2.08E+01	--	--	--
Pu-242	ASF	3.75E+5 y	2.86E+02	2.43E+01	100	868	3.57E-01
Pu-243	B-	4.956 h	9.23E-01	1.23E-03	--	--	--
Pu-244	ASF	8.00E+7 y	6.96E-02	2.24E-05	100	868	8.02E-05
Pu-246	B-	10.84 d	3.08E-08	0.00E+00	--	--	--
Ra-223	A	11.43 d	2.59E+01	1.83E-02	--	--	--
Ra-224	A	3.66 d	3.82E+02	1.23E-01	--	--	--
Ra-225	B-	14.9 d	1.70E+01	4.43E+00	--	--	--
Ra-226	A	1600 y	2.21E+00	6.51E+00	100	868	1.00E-02
Ra-228	B-	5.75 y	1.08E-01	9.77E-03	--	--	--
Rb-87	B-	4.923E10 y	1.87E-10	1.57E-06	1000	8684	1.81E-10
Rh-102	ECB+B-	207 d	0.00E+00	0.00E+00	--	--	--
Rh-106	B-	29.80 s	0.00E+00	0.00E+00	--	--	--
Rn-219	A	3.96 s	2.59E+01	1.83E-02	--	--	--
Rn-220	A	55.6 s	3.82E+02	1.23E-01	--	--	--

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Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Rn-222	A	3.8235 d	2.21E+00	6.51E+00	--	--	--
Ru-106	B-	373.59 d	0.00E+00	0.00E+00	--	--	--
Sb-125	B-	2.75856 y	0.00E+00	0.00E+00	--	--	--
Sb-126	B-	12.35 d	1.20E-06	1.19E-02	--	--	--
Sb-126m	B-IT	19.15 m	1.31E-05	1.33E-01	--	--	--
Se-79	B-	2.95E+5 y	1.22E-04	1.41E-01	1000	8684	1.62E-05
Sm-145	EC	340 d	0.00E+00	0.00E+00	--	--	--
Sm-146	A	1.03E+8 y	1.81E-13	4.00E-08	100	868	4.61E-11
Sm-147	A	1.060E11 y	1.73E-08	3.86E-07	100	868	4.65E-10
Sm-148	A	7E+15 y	1.63E-15	2.83E-19	100	868	1.88E-18
Sm-151	B-	90 y	7.71E-01	4.49E+00	1000	8684	6.06E-04
Sn-119m	IT	293.1 d	0.00E+00	0.00E+00	--	--	--
Sn-121	B-	27.03 h	5.53E-07	9.90E-03	--	--	--
Sn-121m	ITB-	43.9 y	7.13E-07	1.28E-02	1000	8684	1.47E-06
Sn-126	B-	2.30E+5 y	1.31E-05	1.33E-01	1000	8684	1.53E-05
Sr-90	B-	28.79 y	4.15E-02	1.09E+01	1000	8684	1.27E-03
Tb-157	EC	71 y	0.00E+00	1.64E-02	1000	8684	1.89E-06
Tc-97	EC	2.6E+6 y	0.00E+00	3.64E-08	1000	8684	4.19E-12
Tc-99	B-	2.111E+5 y	2.18E+01	5.65E+02	10000	86840	6.75E-03
Te-123	EC	6.00E+14 y	6.98E-22	1.92E-14	1000	8684	2.21E-18
Te-125m	IT	57.40 d	0.00E+00	0.00E+00	--	--	--
Th-227	A	18.68 d	2.56E+01	1.81E-02	--	--	--
Th-228	A	1.9116 y	3.82E+02	1.23E-01	--	--	--
Th-229	A	7.34E+3 y	1.70E+01	4.43E+00	100	868	2.47E-02
Th-230	A	7.538E+4 y	4.03E+00	9.76E-02	10	87	4.75E-02
Th-231	B-	25.52 h	3.17E+00	2.04E+00	--	--	--
Th-232	A	1.405E10 y	1.08E-01	9.77E-03	10	87	1.36E-03
Th-234	B-	24.10 d	1.08E+02	3.50E+00	--	--	--
Tl-204	B-EC	3.78 y	1.33E-40	0.00E+00	--	--	--
Tl-206	B-	4.200 m	2.91E-06	8.60E-06	--	--	--
Tl-207	B-	4.77 m	2.59E+01	1.83E-02	--	--	--

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Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Tl-208	B-	3.053 m	1.37E+02	4.42E-02	--	--	--
Tl-209	B-	2.161 m	3.57E-01	9.30E-02	--	--	--
Tm-171	B-	1.92 y	0.00E+00	0.00E+00	--	--	--
U-232	A	68.9 y	3.72E+02	1.10E-01	100	868	4.28E-01
U-233	A	1.592E+5 y	3.56E+02	1.24E+02	100	868	5.53E-01
U-234	A	2.455E+5 y	1.26E+03	2.83E+01	100	868	1.48E+00
U-235	A	7.04E+8 y	3.17E+00	2.04E+00	100	868	6.01E-03
U-236	A	2.342E+7 y	1.48E+01	2.95E-01	100	868	1.74E-02
U-237	B-	6.75 d	1.08E-04	4.96E-04	--	--	--
U-238	ASF	4.468E+9 y	1.08E+02	3.50E+00	100	868	1.28E-01
U-240	B-	14.1 h	6.95E-02	2.23E-05	--	--	--
V-49	EC	330 d	0.00E+00	0.00E+00	--	--	--
Y-90	B-	64.10 h	4.15E-02	1.09E+01	--	--	--
Zn-65	ECB+	244.06 d	0.00E+00	0.00E+00	--	--	--
Zr-93	B-	1.53E+6 y	1.24E-02	1.99E-01	1000	8684	2.43E-05
Total:	**--**	**--**	**6.33E+06**	**2.37E+04**	**--**	**--**	**7305**

[a] Decay mode and half-life information taken from the International Commission on Radiological Protection (ICRP 2008, Table A.1). Note that decay modes include A = alpha, B- = beta minus, B+ = beta plus, EC = electron capture, IT = isomeric transition, and SF = spontaneous fission. Half-life units include s = second, m = minute, h = hour, d = day, and y = year.
[b] Decayed radionuclide inventory information taken from Van Soest (2025).
[c] Release limits are determined in accordance with 40 CFR 191 (see Table 2 and Appendix B, Table 21). The release limit in Ci/UW corresponds to specific release limits (cumulative releases to the accessible environment for 10,000 years after disposal per "unit of waste" identified in Note 1(e) of Table 1, Appendix A, 40 CFR 191). The release limit in Ci corresponds to release limit obtained for 8.68 units of waste. The 8.68 value for the unit of waste corresponds to the units of waste present at repository closure in 2083.
[d] Potential release is defined as the total inventory (CH + RH) in Ci divided by the release limit in Ci. Those isotopes without defined release limits have no potential release.

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Table 18 – 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 3083)

Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Ac-225	A	10.0 d	3.59E+01	1.11E+01	--	--	--
Ac-227	B-A	21.772 y	2.56E+01	4.60E-02	100	868	2.96E-02
Ac-228	B-	6.15 h	1.08E-01	9.77E-03	--	--	--
Ag-108	B-ECB+	2.37 m	2.45E-06	9.41E-06	--	--	--
Ag-108m	ECIT	418 y	2.82E-05	1.08E-04	1000	8684	1.57E-08
Ag-109m	IT	39.6 s	0.00E+00	0.00E+00	--	--	--
Ag-110	B-EC	24.6 s	0.00E+00	0.00E+00	--	--	--
Ag-110m	B-IT	249.76 d	0.00E+00	0.00E+00	--	--	--
Am-241	A	432.2 y	3.64E+05	3.63E+03	100	868	4.23E+02
Am-242	B-EC	16.02 h	1.77E-04	1.53E-02	--	--	--
Am-242m	ITA	141 y	1.78E-04	1.54E-02	100	868	1.79E-05
Am-243	A	7.37E+3 y	3.03E+01	5.23E+02	100	868	6.37E-01
Am-245	B-	2.05 h	0.00E+00	0.00E+00	--	--	--
Am-246	B-	39 m	3.01E-08	0.00E+00	--	--	--
Ar-39	B-	269 y	0.00E+00	1.97E-03	1000	8684	2.26E-07
Ar-42	B-	32.9 y	0.00E+00	1.23E-11	1000	8684	1.42E-15
At-217	A	3.23E-2 s	3.59E+01	1.11E+01	--	--	--
Ba-133	EC	10.52 y	2.04E-33	2.09E-30	--	--	--
Ba-137m	IT	2.552 m	9.16E-09	7.18E-06	--	--	--
Bi-210	B-A	5.013 d	3.63E+00	4.96E+00	--	--	--
Bi-211	A B-	2.14 m	2.56E+01	4.60E-02	--	--	--
Bi-212	B-A	60.55 m	7.09E-01	9.95E-03	--	--	--
Bi-213	B-A	45.59 m	3.59E+01	1.11E+01	--	--	--
Bi-214	B-A	19.9 m	3.63E+00	4.96E+00	--	--	--
Bk-249	B-A	330 d	0.00E+00	0.00E+00	--	--	--
Bk-250	B-	3.212 h	1.68E-08	0.00E+00	--	--	--
C-14	B-	5.70E+3 y	1.35E-01	1.11E+00	100	868	1.43E-03
Cd-109	EC	461.4 d	0.00E+00	0.00E+00	--	--	--
Cd-113	B-	7.7E+15 y	1.65E-22	9.66E-18	1000	8684	1.11E-21

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Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Cd-113m	B-IT	14.1 y	1.79E-27	7.09E-23	--	--	--
Ce-144	B-	284.91 d	0.00E+00	0.00E+00	--	--	--
Cf-249	ASF	351 y	1.18E+00	1.16E+01	100	868	1.47E-02
Cf-250	ASF	13.08 y	1.68E-08	2.56E-22	--	--	--
Cf-251	A	900 y	1.57E-01	1.27E+01	100	868	1.49E-02
Cf-252	ASF	2.645 y	0.00E+00	0.00E+00	--	--	--
Cl-36	B-ECB+	3.01E+5 y	2.08E-07	1.17E-01	1000	8684	1.35E-05
Cm-242	ASF	162.8 d	1.46E-04	1.26E-02	--	--	--
Cm-243	AEC	29.1 y	9.71E-11	8.69E-10	100	868	1.11E-12
Cm-244	ASF	18.10 y	4.31E-14	2.38E-13	--	--	--
Cm-245	ASF	8.5E+3 y	4.40E+00	2.09E+01	100	868	2.91E-02
Cm-246	ASF	4.76E+3 y	8.65E+01	6.30E+02	100	868	8.24E-01
Cm-247	A	1.56E+7 y	9.23E-01	1.70E-03	100	868	1.07E-03
Cm-248	ASF	3.48E+5 y	1.63E+00	3.61E+00	100	868	6.03E-03
Cm-250	AB-SF	8300 y	1.20E-07	0.00E+00	100	868	1.38E-10
Co-60	B-	5.2713 y	0.00E+00	0.00E+00	--	--	--
Cs-134	B-EC	2.0648 y	0.00E+00	0.00E+00	--	--	--
Cs-135	B-	2.3E+6 y	1.50E-03	5.78E-02	1000	8684	6.83E-06
Cs-137	B-	30.1671 y	9.70E-09	7.60E-06	1000	8684	8.76E-10
Eu-152	ECB+B-	13.537 y	1.40E-23	1.19E-21	--	--	--
Eu-154	B-EC	8.593 y	0.00E+00	0.00E+00	--	--	--
Eu-155	B-	4.7611 y	0.00E+00	0.00E+00	--	--	--
Fe-55	EC	2.737 y	0.00E+00	0.00E+00	--	--	--
Fr-221	A	4.9 m	3.59E+01	1.11E+01	--	--	--
Fr-223	B-A	22.00 m	3.54E-01	6.35E-04	--	--	--
Gd-152	A	1.08E+14 y	4.35E-13	3.62E-11	100	868	4.22E-14
Gd-153	EC	240.4 d	0.00E+00	0.00E+00	--	--	--
H-3	B-	12.32 y	1.71E-21	4.51E-23	--	--	--
Ho-166m	B-	1.20E+3 y	2.04E-03	0.00E+00	1000	8684	2.35E-07
I-129	B-	1.57E+7 y	1.45E-03	8.82E-01	100	868	1.02E-03
In-115	B-	4.41E+14 y	0.00E+00	7.47E-17	1000	8684	8.61E-21

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Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Ir-194	B-	19.28 h	0.00E+00	0.00E+00	--	--	--
K-40	B-ECB+	1.251E+9 y	4.84E-02	0.00E+00	1000	8684	5.57E-06
K-42	B-	12.360 h	0.00E+00	1.23E-11	--	--	--
Kr-85	B-	10.756 y	1.33E-31	1.52E-27	--	--	--
Mn-54	ECB+B-	312.12 d	0.00E+00	0.00E+00	--	--	--
Mo-93	EC	4.0E+3 y	0.00E+00	3.68E-01	1000	8684	4.24E-05
Na-22	ECB+	2.6019 y	0.00E+00	0.00E+00	--	--	--
Nb-91	ECB+	680 y	0.00E+00	1.37E-02	1000	8684	1.58E-06
Nb-93m	IT	16.13 y	1.24E-02	5.02E-01	--	--	--
Nb-94	B-	2.03E+4 y	1.56E-03	3.47E+00	1000	8684	4.00E-04
Nd-144	A	2.29E+15 y	1.36E-12	1.57E-12	100	868	3.37E-15
Ni-59	ECB+	1.01E+5 y	1.67E-07	3.90E+00	1000	8684	4.49E-04
Ni-63	B-	100.1 y	5.82E-01	4.02E-01	1000	8684	1.13E-04
Np-235	ECA	396.1 d	0.00E+00	0.00E+00	--	--	--
Np-237	A	2.144E+6 y	3.70E+02	1.59E+01	100	868	4.45E-01
Np-238	B-	2.117 d	7.99E-07	6.91E-05	--	--	--
Np-239	B-	2.3565 d	3.03E+01	5.23E+02	--	--	--
Np-240	B-	61.9 m	8.35E-05	4.92E-08	--	--	--
Np-240m	B-IT	7.22 m	6.95E-02	4.10E-05	--	--	--
Os-194	B-	6.0 y	0.00E+00	0.00E+00	--	--	--
Pa-231	A	3.276E+4 y	2.56E+01	4.60E-02	100	868	2.95E-02
Pa-233	B-	26.967 d	3.70E+02	1.59E+01	--	--	--
Pa-234	B-	6.70 h	1.40E-01	4.56E-03	--	--	--
Pa-234m	B-IT	1.17 m	1.08E+02	3.50E+00	--	--	--
Pb-209	B-	3.253 h	3.59E+01	1.11E+01	--	--	--
Pb-210	B-A	22.20 y	3.63E+00	4.96E+00	100	868	9.89E-03
Pb-211	B-	36.1 m	2.56E+01	4.60E-02	--	--	--
Pb-212	B-	10.64 h	7.09E-01	9.95E-03	--	--	--
Pb-214	B-	26.8 m	3.63E+00	4.96E+00	--	--	--
Pd-107	B-	6.5E+6 y	1.50E-05	1.04E-02	1000	8684	1.20E-06
Pm-145	ECA	17.7 y	0.00E+00	1.30E-18	--	--	--

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Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Pm-146	ECB-	5.53 y	0.00E+00	0.00E+00	--	--	--
Pm-147	B-	2.6234 y	0.00E+00	0.00E+00	--	--	--
Po-210	A	138.376 d	3.63E+00	4.96E+00	--	--	--
Po-211	A	0.516 s	7.05E-02	1.26E-04	--	--	--
Po-212	A	2.99E-7 s	4.54E-01	6.37E-03	--	--	--
Po-213	A	4.2E-6 s	3.51E+01	1.08E+01	--	--	--
Po-214	A	1.643E-4 s	3.63E+00	4.96E+00	--	--	--
Po-215	A	1.781E-3 s	2.56E+01	4.60E-02	--	--	--
Po-216	A	0.145 s	7.09E-01	9.95E-03	--	--	--
Po-218	A B-	3.10 m	3.63E+00	4.96E+00	--	--	--
Pr-144	B-	17.28 m	0.00E+00	0.00E+00	--	--	--
Pr-144m	ITB-	7.2 m	0.00E+00	0.00E+00	--	--	--
Pu-236	ASF	2.858 y	0.00E+00	0.00E+00	--	--	--
Pu-238	ASF	87.7 y	5.81E+02	9.56E+00	100	868	6.80E-01
Pu-239	A	2.411E+4 y	4.05E+06	4.42E+03	100	868	4.67E+03
Pu-240	ASF	6564 y	9.92E+05	4.12E+03	100	868	1.15E+03
Pu-241	B-A	14.35 y	4.40E+00	2.09E+01	--	--	--
Pu-242	ASF	3.75E+5 y	2.86E+02	2.51E+01	100	868	3.58E-01
Pu-243	B-	4.956 h	9.23E-01	1.70E-03	--	--	--
Pu-244	ASF	8.00E+7 y	6.96E-02	4.10E-05	100	868	8.02E-05
Pu-246	B-	10.84 d	3.01E-08	0.00E+00	--	--	--
Ra-223	A	11.43 d	2.56E+01	4.60E-02	--	--	--
Ra-224	A	3.66 d	7.09E-01	9.95E-03	--	--	--
Ra-225	B-	14.9 d	3.59E+01	1.11E+01	--	--	--
Ra-226	A	1600 y	3.63E+00	4.96E+00	100	868	9.90E-03
Ra-228	B-	5.75 y	1.08E-01	9.77E-03	--	--	--
Rb-87	B-	4.923E10 y	1.87E-10	1.57E-06	1000	8684	1.81E-10
Rh-102	ECB+B-	207 d	0.00E+00	0.00E+00	--	--	--
Rh-106	B-	29.80 s	0.00E+00	0.00E+00	--	--	--
Rn-219	A	3.96 s	2.56E+01	4.60E-02	--	--	--
Rn-220	A	55.6 s	7.09E-01	9.95E-03	--	--	--

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Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Rn-222	A	3.8235 d	3.63E+00	4.96E+00	--	--	--
Ru-106	B-	373.59 d	0.00E+00	0.00E+00	--	--	--
Sb-125	B-	2.75856 y	0.00E+00	0.00E+00	--	--	--
Sb-126	B-	12.35 d	1.20E-06	1.18E-02	--	--	--
Sb-126m	B-IT	19.15 m	1.30E-05	1.33E-01	--	--	--
Se-79	B-	2.95E+5 y	1.21E-04	1.41E-01	1000	8684	1.62E-05
Sm-145	EC	340 d	0.00E+00	0.00E+00	--	--	--
Sm-146	A	1.03E+8 y	1.81E-13	4.00E-08	100	868	4.61E-11
Sm-147	A	1.060E11 y	1.73E-08	3.86E-07	100	868	4.65E-10
Sm-148	A	7E+15 y	1.63E-15	2.83E-19	100	868	1.88E-18
Sm-151	B-	90 y	5.16E-03	3.00E-02	1000	8684	4.05E-06
Sn-119m	IT	293.1 d	0.00E+00	0.00E+00	--	--	--
Sn-121	B-	27.03 h	1.53E-10	2.74E-06	--	--	--
Sn-121m	ITB-	43.9 y	1.98E-10	3.54E-06	1000	8684	4.07E-10
Sn-126	B-	2.30E+5 y	1.30E-05	1.33E-01	1000	8684	1.53E-05
Sr-90	B-	28.79 y	4.63E-09	1.22E-06	1000	8684	1.41E-10
Tb-157	EC	71 y	0.00E+00	8.13E-04	1000	8684	9.36E-08
Tc-97	EC	2.6E+6 y	0.00E+00	3.64E-08	1000	8684	4.19E-12
Tc-99	B-	2.111E+5 y	2.17E+01	5.64E+02	10000	86840	6.74E-03
Te-123	EC	6.00E+14 y	6.98E-22	1.92E-14	1000	8684	2.21E-18
Te-125m	IT	57.40 d	0.00E+00	0.00E+00	--	--	--
Th-227	A	18.68 d	2.53E+01	4.54E-02	--	--	--
Th-228	A	1.9116 y	7.09E-01	9.95E-03	--	--	--
Th-229	A	7.34E+3 y	3.59E+01	1.11E+01	100	868	5.41E-02
Th-230	A	7.538E+4 y	1.17E+01	2.68E-01	10	87	1.38E-01
Th-231	B-	25.52 h	5.79E+00	2.05E+00	--	--	--
Th-232	A	1.405E10 y	1.08E-01	9.77E-03	10	87	1.36E-03
Th-234	B-	24.10 d	1.08E+02	3.50E+00	--	--	--
Tl-204	B-EC	3.78 y	0.00E+00	0.00E+00	--	--	--
Tl-206	B-	4.200 m	4.80E-06	6.55E-06	--	--	--
Tl-207	B-	4.77 m	2.56E+01	4.59E-02	--	--	--

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Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Tl-208	B-	3.053 m	2.55E-01	3.57E-03	--	--	--
Tl-209	B-	2.161 m	7.53E-01	2.33E-01	--	--	--
Tm-171	B-	1.92 y	0.00E+00	0.00E+00	--	--	--
U-232	A	68.9 y	5.85E-01	1.73E-04	100	868	6.73E-04
U-233	A	1.592E+5 y	3.56E+02	1.24E+02	100	868	5.53E-01
U-234	A	2.455E+5 y	1.29E+03	2.88E+01	100	868	1.52E+00
U-235	A	7.04E+8 y	5.79E+00	2.05E+00	100	868	9.02E-03
U-236	A	2.342E+7 y	3.45E+01	3.77E-01	100	868	4.02E-02
U-237	B-	6.75 d	1.05E-04	5.00E-04	--	--	--
U-238	ASF	4.468E+9 y	1.08E+02	3.50E+00	100	868	1.28E-01
U-240	B-	14.1 h	6.95E-02	4.10E-05	--	--	--
V-49	EC	330 d	0.00E+00	0.00E+00	--	--	--
Y-90	B-	64.10 h	4.64E-09	1.22E-06	--	--	--
Zn-65	ECB+	244.06 d	0.00E+00	0.00E+00	--	--	--
Zr-93	B-	1.53E+6 y	1.24E-02	1.99E-01	1000	8684	2.43E-05
Total:	**--**	**--**	**5.41E+06**	**1.49E+04**	**--**	**--**	**6244**

[a] Decay mode and half-life information taken from the International Commission on Radiological Protection (ICRP 2008, Table A.1). Note that decay modes include A = alpha, B- = beta minus, B+ = beta plus, EC = electron capture, IT = isomeric transition, and SF = spontaneous fission. Half-life units include s = second, m = minute, h = hour, d = day, and y = year.
[b] Decayed radionuclide inventory information taken from Van Soest (2025).
[c] Release limits are determined in accordance with 40 CFR 191 (see Table 2 and Appendix B, Table 21). The release limit in Ci/UW corresponds to specific release limits (cumulative releases to the accessible environment for 10,000 years after disposal per "unit of waste" identified in Note 1(e) of Table 1, Appendix A, 40 CFR 191). The release limit in Ci corresponds to release limit obtained for 8.68 units of waste. The 8.68 value for the unit of waste corresponds to the units of waste present at repository closure in 2083.
[d] Potential release is defined as the total inventory (CH + RH) in Ci divided by the release limit in Ci. Those isotopes without defined release limits have no potential release.

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Table 19 – 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 7083)

Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Ac-225	A	10.0 d	1.31E+02	4.43E+01	--	--	--
Ac-227	B-A	21.772 y	2.47E+01	2.09E-01	100	868	2.86E-02
Ac-228	B-	6.15 h	1.08E-01	9.77E-03	--	--	--
Ag-108	B-ECB+	2.37 m	8.08E-16	3.11E-15	--	--	--
Ag-108m	ECIT	418 y	9.29E-15	3.57E-14	1000	8684	5.18E-18
Ag-109m	IT	39.6 s	0.00E+00	0.00E+00	--	--	--
Ag-110	B-EC	24.6 s	0.00E+00	0.00E+00	--	--	--
Ag-110m	B-IT	249.76 d	0.00E+00	0.00E+00	--	--	--
Am-241	A	432.2 y	6.02E+02	2.21E+01	100	868	7.19E-01
Am-242	B-EC	16.02 h	5.10E-13	4.41E-11	--	--	--
Am-242m	ITA	141 y	5.12E-13	4.43E-11	100	868	5.16E-14
Am-243	A	7.37E+3 y	2.11E+01	3.59E+02	100	868	4.38E-01
Am-245	B-	2.05 h	0.00E+00	0.00E+00	--	--	--
Am-246	B-	39 m	2.56E-08	0.00E+00	--	--	--
Ar-39	B-	269 y	0.00E+00	6.56E-08	1000	8684	7.56E-12
Ar-42	B-	32.9 y	0.00E+00	0.00E+00	1000	8684	0.00E+00
At-217	A	3.23E-2 s	1.31E+02	4.43E+01	--	--	--
Ba-133	EC	10.52 y	0.00E+00	0.00E+00	--	--	--
Ba-137m	IT	2.552 m	0.00E+00	0.00E+00	--	--	--
Bi-210	B-A	5.013 d	3.46E+01	1.64E+00	--	--	--
Bi-211	A B-	2.14 m	2.47E+01	2.09E-01	--	--	--
Bi-212	B-A	60.55 m	1.08E-01	9.77E-03	--	--	--
Bi-213	B-A	45.59 m	1.31E+02	4.43E+01	--	--	--
Bi-214	B-A	19.9 m	3.46E+01	1.64E+00	--	--	--
Bk-249	B-A	330 d	0.00E+00	0.00E+00	--	--	--
Bk-250	B-	3.212 h	1.44E-08	0.00E+00	--	--	--
C-14	B-	5.70E+3 y	8.31E-02	6.85E-01	100	868	8.84E-04
Cd-109	EC	461.4 d	0.00E+00	0.00E+00	--	--	--
Cd-113	B-	7.7E+15 y	1.65E-22	9.66E-18	1000	8684	1.11E-21

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Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Cd-113m	B-IT	14.1 y	0.00E+00	0.00E+00	--	--	--
Ce-144	B-	284.91 d	0.00E+00	0.00E+00	--	--	--
Cf-249	ASF	351 y	4.31E-04	4.26E-03	100	868	5.40E-06
Cf-250	ASF	13.08 y	1.44E-08	0.00E+00	--	--	--
Cf-251	A	900 y	7.14E-03	5.81E-01	100	868	6.77E-04
Cf-252	ASF	2.645 y	0.00E+00	0.00E+00	--	--	--
Cl-36	B-ECB+	3.01E+5 y	2.06E-07	1.16E-01	1000	8684	1.34E-05
Cm-242	ASF	162.8 d	4.23E-13	3.66E-11	--	--	--
Cm-243	AEC	29.1 y	0.00E+00	0.00E+00	100	868	0.00E+00
Cm-244	ASF	18.10 y	0.00E+00	0.00E+00	--	--	--
Cm-245	ASF	8.5E+3 y	3.21E+00	1.54E+01	100	868	2.15E-02
Cm-246	ASF	4.76E+3 y	4.81E+01	3.50E+02	100	868	4.59E-01
Cm-247	A	1.56E+7 y	9.23E-01	2.38E-03	100	868	1.07E-03
Cm-248	ASF	3.48E+5 y	1.61E+00	3.58E+00	100	868	5.98E-03
Cm-250	AB-SF	8300 y	1.03E-07	0.00E+00	100	868	1.18E-10
Co-60	B-	5.2713 y	0.00E+00	0.00E+00	--	--	--
Cs-134	B-EC	2.0648 y	0.00E+00	0.00E+00	--	--	--
Cs-135	B-	2.3E+6 y	1.50E-03	5.77E-02	1000	8684	6.82E-06
Cs-137	B-	30.1671 y	0.00E+00	0.00E+00	1000	8684	0.00E+00
Eu-152	ECB+B-	13.537 y	0.00E+00	0.00E+00	--	--	--
Eu-154	B-EC	8.593 y	0.00E+00	0.00E+00	--	--	--
Eu-155	B-	4.7611 y	0.00E+00	0.00E+00	--	--	--
Fe-55	EC	2.737 y	0.00E+00	0.00E+00	--	--	--
Fr-221	A	4.9 m	1.31E+02	4.43E+01	--	--	--
Fr-223	B-A	22.00 m	3.40E-01	2.88E-03	--	--	--
Gd-152	A	1.08E+14 y	4.35E-13	3.62E-11	100	868	4.22E-14
Gd-153	EC	240.4 d	0.00E+00	0.00E+00	--	--	--
H-3	B-	12.32 y	0.00E+00	0.00E+00	--	--	--
Ho-166m	B-	1.20E+3 y	2.02E-04	0.00E+00	1000	8684	2.33E-08
I-129	B-	1.57E+7 y	1.45E-03	8.81E-01	100	868	1.02E-03
In-115	B-	4.41E+14 y	0.00E+00	7.47E-17	1000	8684	8.61E-21

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Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Ir-194	B-	19.28 h	0.00E+00	0.00E+00	--	--	--
K-40	B-ECB+	1.251E+9 y	4.84E-02	0.00E+00	1000	8684	5.57E-06
K-42	B-	12.360 h	0.00E+00	0.00E+00	--	--	--
Kr-85	B-	10.756 y	0.00E+00	0.00E+00	--	--	--
Mn-54	ECB+B-	312.12 d	0.00E+00	0.00E+00	--	--	--
Mo-93	EC	4.0E+3 y	0.00E+00	1.67E-01	1000	8684	1.92E-05
Na-22	ECB+	2.6019 y	0.00E+00	0.00E+00	--	--	--
Nb-91	ECB+	680 y	0.00E+00	2.33E-04	1000	8684	2.68E-08
Nb-93m	IT	16.13 y	1.24E-02	3.36E-01	--	--	--
Nb-94	B-	2.03E+4 y	1.36E-03	3.03E+00	1000	8684	3.49E-04
Nd-144	A	2.29E+15 y	1.36E-12	1.57E-12	100	868	3.37E-15
Ni-59	ECB+	1.01E+5 y	1.61E-07	3.76E+00	1000	8684	4.33E-04
Ni-63	B-	100.1 y	5.43E-13	3.75E-13	1000	8684	1.06E-16
Np-235	ECA	396.1 d	0.00E+00	0.00E+00	--	--	--
Np-237	A	2.144E+6 y	4.43E+02	1.67E+01	100	868	5.29E-01
Np-238	B-	2.117 d	2.31E-15	1.99E-13	--	--	--
Np-239	B-	2.3565 d	2.11E+01	3.59E+02	--	--	--
Np-240	B-	61.9 m	8.35E-05	1.86E-07	--	--	--
Np-240m	B-IT	7.22 m	6.96E-02	1.55E-04	--	--	--
Os-194	B-	6.0 y	0.00E+00	0.00E+00	--	--	--
Pa-231	A	3.276E+4 y	2.46E+01	2.09E-01	100	868	2.86E-02
Pa-233	B-	26.967 d	4.43E+02	1.67E+01	--	--	--
Pa-234	B-	6.70 h	1.40E-01	4.56E-03	--	--	--
Pa-234m	B-IT	1.17 m	1.08E+02	3.50E+00	--	--	--
Pb-209	B-	3.253 h	1.31E+02	4.43E+01	--	--	--
Pb-210	B-A	22.20 y	3.46E+01	1.64E+00	100	868	4.17E-02
Pb-211	B-	36.1 m	2.47E+01	2.09E-01	--	--	--
Pb-212	B-	10.64 h	1.08E-01	9.77E-03	--	--	--
Pb-214	B-	26.8 m	3.46E+01	1.64E+00	--	--	--
Pd-107	B-	6.5E+6 y	1.50E-05	1.04E-02	1000	8684	1.20E-06
Pm-145	ECA	17.7 y	0.00E+00	0.00E+00	--	--	--

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Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Pm-146	ECB-	5.53 y	0.00E+00	0.00E+00	--	--	--
Pm-147	B-	2.6234 y	0.00E+00	0.00E+00	--	--	--
Po-210	A	138.376 d	3.46E+01	1.64E+00	--	--	--
Po-211	A	0.516 s	6.78E-02	5.75E-04	--	--	--
Po-212	A	2.99E-7 s	6.94E-02	6.26E-03	--	--	--
Po-213	A	4.2E-6 s	1.28E+02	4.33E+01	--	--	--
Po-214	A	1.643E-4 s	3.46E+01	1.64E+00	--	--	--
Po-215	A	1.781E-3 s	2.47E+01	2.09E-01	--	--	--
Po-216	A	0.145 s	1.08E-01	9.77E-03	--	--	--
Po-218	A B-	3.10 m	3.46E+01	1.64E+00	--	--	--
Pr-144	B-	17.28 m	0.00E+00	0.00E+00	--	--	--
Pr-144m	ITB-	7.2 m	0.00E+00	0.00E+00	--	--	--
Pu-236	ASF	2.858 y	0.00E+00	0.00E+00	--	--	--
Pu-238	ASF	87.7 y	1.20E-11	9.75E-11	100	868	1.26E-13
Pu-239	A	2.411E+4 y	3.61E+06	3.99E+03	100	868	4.16E+03
Pu-240	ASF	6564 y	6.50E+05	2.70E+03	100	868	7.52E+02
Pu-241	B-A	14.35 y	3.21E+00	1.54E+01	--	--	--
Pu-242	ASF	3.75E+5 y	2.84E+02	2.84E+01	100	868	3.60E-01
Pu-243	B-	4.956 h	9.23E-01	2.38E-03	--	--	--
Pu-244	ASF	8.00E+7 y	6.97E-02	1.55E-04	100	868	8.04E-05
Pu-246	B-	10.84 d	2.56E-08	0.00E+00	--	--	--
Ra-223	A	11.43 d	2.47E+01	2.09E-01	--	--	--
Ra-224	A	3.66 d	1.08E-01	9.77E-03	--	--	--
Ra-225	B-	14.9 d	1.31E+02	4.43E+01	--	--	--
Ra-226	A	1600 y	3.46E+01	1.64E+00	100	868	4.17E-02
Ra-228	B-	5.75 y	1.08E-01	9.77E-03	--	--	--
Rb-87	B-	4.923E10 y	1.87E-10	1.57E-06	1000	8684	1.81E-10
Rh-102	ECB+B-	207 d	0.00E+00	0.00E+00	--	--	--
Rh-106	B-	29.80 s	0.00E+00	0.00E+00	--	--	--
Rn-219	A	3.96 s	2.47E+01	2.09E-01	--	--	--
Rn-220	A	55.6 s	1.08E-01	9.77E-03	--	--	--

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Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Rn-222	A	3.8235 d	3.46E+01	1.64E+00	--	--	--
Ru-106	B-	373.59 d	0.00E+00	0.00E+00	--	--	--
Sb-125	B-	2.75856 y	0.00E+00	0.00E+00	--	--	--
Sb-126	B-	12.35 d	1.17E-06	1.15E-02	--	--	--
Sb-126m	B-IT	19.15 m	1.26E-05	1.29E-01	--	--	--
Se-79	B-	2.95E+5 y	1.20E-04	1.39E-01	1000	8684	1.61E-05
Sm-145	EC	340 d	0.00E+00	0.00E+00	--	--	--
Sm-146	A	1.03E+8 y	1.81E-13	4.00E-08	100	868	4.61E-11
Sm-147	A	1.060E11 y	1.73E-08	3.86E-07	100	868	4.65E-10
Sm-148	A	7E+15 y	1.63E-15	2.83E-19	100	868	1.88E-18
Sm-151	B-	90 y	2.15E-16	1.25E-15	1000	8684	1.69E-19
Sn-119m	IT	293.1 d	0.00E+00	0.00E+00	--	--	--
Sn-121	B-	27.03 h	0.00E+00	0.00E+00	--	--	--
Sn-121m	ITB-	43.9 y	0.00E+00	0.00E+00	1000	8684	0.00E+00
Sn-126	B-	2.30E+5 y	1.26E-05	1.29E-01	1000	8684	1.49E-05
Sr-90	B-	28.79 y	0.00E+00	0.00E+00	1000	8684	0.00E+00
Tb-157	EC	71 y	0.00E+00	7.63E-12	1000	8684	8.79E-16
Tc-97	EC	2.6E+6 y	0.00E+00	3.64E-08	1000	8684	4.19E-12
Tc-99	B-	2.111E+5 y	2.14E+01	5.56E+02	10000	86840	6.65E-03
Te-123	EC	6.00E+14 y	6.98E-22	1.92E-14	1000	8684	2.21E-18
Te-125m	IT	57.40 d	0.00E+00	0.00E+00	--	--	--
Th-227	A	18.68 d	2.43E+01	2.06E-01	--	--	--
Th-228	A	1.9116 y	1.08E-01	9.77E-03	--	--	--
Th-229	A	7.34E+3 y	1.31E+02	4.43E+01	100	868	2.02E-01
Th-230	A	7.538E+4 y	5.77E+01	1.29E+00	10	87	6.80E-01
Th-231	B-	25.52 h	2.09E+01	2.06E+00	--	--	--
Th-232	A	1.405E10 y	1.08E-01	9.77E-03	10	87	1.36E-03
Th-234	B-	24.10 d	1.08E+02	3.50E+00	--	--	--
Tl-204	B-EC	3.78 y	0.00E+00	0.00E+00	--	--	--
Tl-206	B-	4.200 m	4.56E-05	2.16E-06	--	--	--
Tl-207	B-	4.77 m	2.46E+01	2.08E-01	--	--	--

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Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Tl-208	B-	3.053 m	3.89E-02	3.51E-03	--	--	--
Tl-209	B-	2.161 m	2.75E+00	9.30E-01	--	--	--
Tm-171	B-	1.92 y	0.00E+00	0.00E+00	--	--	--
U-232	A	68.9 y	3.29E-18	9.75E-22	100	868	3.78E-21
U-233	A	1.592E+5 y	3.57E+02	1.22E+02	100	868	5.52E-01
U-234	A	2.455E+5 y	1.28E+03	2.85E+01	100	868	1.51E+00
U-235	A	7.04E+8 y	2.09E+01	2.06E+00	100	868	2.64E-02
U-236	A	2.342E+7 y	1.30E+02	7.75E-01	100	868	1.51E-01
U-237	B-	6.75 d	7.68E-05	3.69E-04	--	--	--
U-238	ASF	4.468E+9 y	1.08E+02	3.50E+00	100	868	1.28E-01
U-240	B-	14.1 h	6.96E-02	1.55E-04	--	--	--
V-49	EC	330 d	0.00E+00	0.00E+00	--	--	--
Y-90	B-	64.10 h	0.00E+00	0.00E+00	--	--	--
Zn-65	ECB+	244.06 d	0.00E+00	0.00E+00	--	--	--
Zr-93	B-	1.53E+6 y	1.24E-02	1.98E-01	1000	8684	2.43E-05
Total:	**--**	**--**	**4.27E+06**	**8.98E+03**	**--**	**--**	**4919**

[a] Decay mode and half-life information taken from the International Commission on Radiological Protection (ICRP 2008, Table A.1). Note that decay modes include A = alpha, B- = beta minus, B+ = beta plus, EC = electron capture, IT = isomeric transition, and SF = spontaneous fission. Half-life units include s = second, m = minute, h = hour, d = day, and y = year.
[b] Decayed radionuclide inventory information taken from Van Soest (2025).
[c] Release limits are determined in accordance with 40 CFR 191 (see Table 2 and Appendix B, Table 21). The release limit in Ci/UW corresponds to specific release limits (cumulative releases to the accessible environment for 10,000 years after disposal per "unit of waste" identified in Note 1(e) of Table 1, Appendix A, 40 CFR 191). The release limit in Ci corresponds to release limit obtained for 8.68 units of waste. The 8.68 value for the unit of waste corresponds to the units of waste present at repository closure in 2083.
[d] Potential release is defined as the total inventory (CH + RH) in Ci divided by the release limit in Ci. Those isotopes without defined release limits have no potential release.

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Table 20 – 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 12083)

Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Ac-225	A	10.0 d	2.12E+02	7.16E+01	--	--	--
Ac-227	B-A	21.772 y	2.51E+01	3.96E-01	100	868	2.94E-02
Ac-228	B-	6.15 h	1.08E-01	9.77E-03	--	--	--
Ag-108	B-ECB+	2.37 m	1.14E-27	4.37E-27	--	--	--
Ag-108m	ECIT	418 y	1.31E-26	5.02E-26	1000	8684	7.28E-30
Ag-109m	IT	39.6 s	0.00E+00	0.00E+00	--	--	--
Ag-110	B-EC	24.6 s	0.00E+00	0.00E+00	--	--	--
Ag-110m	B-IT	249.76 d	0.00E+00	0.00E+00	--	--	--
Am-241	A	432.2 y	2.34E+00	1.03E+01	100	868	1.45E-02
Am-242	B-EC	16.02 h	1.08E-23	9.33E-22	--	--	--
Am-242m	ITA	141 y	1.08E-23	9.37E-22	100	868	1.09E-24
Am-243	A	7.37E+3 y	1.35E+01	2.24E+02	100	868	2.74E-01
Am-245	B-	2.05 h	0.00E+00	0.00E+00	--	--	--
Am-246	B-	39 m	2.10E-08	0.00E+00	--	--	--
Ar-39	B-	269 y	0.00E+00	1.66E-13	1000	8684	1.92E-17
Ar-42	B-	32.9 y	0.00E+00	0.00E+00	1000	8684	0.00E+00
At-217	A	3.23E-2 s	2.12E+02	7.16E+01	--	--	--
Ba-133	EC	10.52 y	0.00E+00	0.00E+00	--	--	--
Ba-137m	IT	2.552 m	0.00E+00	0.00E+00	--	--	--
Bi-210	B-A	5.013 d	8.75E+01	2.06E+00	--	--	--
Bi-211	A B-	2.14 m	2.51E+01	3.96E-01	--	--	--
Bi-212	B-A	60.55 m	1.08E-01	9.77E-03	--	--	--
Bi-213	B-A	45.59 m	2.12E+02	7.15E+01	--	--	--
Bi-214	B-A	19.9 m	8.76E+01	2.06E+00	--	--	--
Bk-249	B-A	330 d	0.00E+00	0.00E+00	--	--	--
Bk-250	B-	3.212 h	1.18E-08	0.00E+00	--	--	--
C-14	B-	5.70E+3 y	4.54E-02	3.74E-01	100	868	4.83E-04
Cd-109	EC	461.4 d	0.00E+00	0.00E+00	--	--	--
Cd-113	B-	7.7E+15 y	1.65E-22	9.66E-18	1000	8684	1.11E-21

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Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Cd-113m	B-IT	14.1 y	0.00E+00	0.00E+00	--	--	--
Ce-144	B-	284.91 d	0.00E+00	0.00E+00	--	--	--
Cf-249	ASF	351 y	2.18E-08	2.16E-07	100	868	2.74E-10
Cf-250	ASF	13.08 y	1.18E-08	0.00E+00	--	--	--
Cf-251	A	900 y	1.51E-04	1.22E-02	100	868	1.43E-05
Cf-252	ASF	2.645 y	0.00E+00	0.00E+00	--	--	--
Cl-36	B-ECB+	3.01E+5 y	2.03E-07	1.15E-01	1000	8684	1.32E-05
Cm-242	ASF	162.8 d	8.95E-24	7.74E-22	--	--	--
Cm-243	AEC	29.1 y	0.00E+00	0.00E+00	100	868	0.00E+00
Cm-244	ASF	18.10 y	0.00E+00	0.00E+00	--	--	--
Cm-245	ASF	8.5E+3 y	2.13E+00	1.03E+01	100	868	1.43E-02
Cm-246	ASF	4.76E+3 y	2.31E+01	1.68E+02	100	868	2.21E-01
Cm-247	A	1.56E+7 y	9.23E-01	2.41E-03	100	868	1.07E-03
Cm-248	ASF	3.48E+5 y	1.60E+00	3.54E+00	100	868	5.92E-03
Cm-250	AB-SF	8300 y	8.40E-08	0.00E+00	100	868	9.67E-11
Co-60	B-	5.2713 y	0.00E+00	0.00E+00	--	--	--
Cs-134	B-EC	2.0648 y	0.00E+00	0.00E+00	--	--	--
Cs-135	B-	2.3E+6 y	1.50E-03	5.76E-02	1000	8684	6.81E-06
Cs-137	B-	30.1671 y	0.00E+00	0.00E+00	1000	8684	0.00E+00
Eu-152	ECB+B-	13.537 y	0.00E+00	0.00E+00	--	--	--
Eu-154	B-EC	8.593 y	0.00E+00	0.00E+00	--	--	--
Eu-155	B-	4.7611 y	0.00E+00	0.00E+00	--	--	--
Fe-55	EC	2.737 y	0.00E+00	0.00E+00	--	--	--
Fr-221	A	4.9 m	2.12E+02	7.16E+01	--	--	--
Fr-223	B-A	22.00 m	3.47E-01	5.47E-03	--	--	--
Gd-152	A	1.08E+14 y	4.35E-13	3.62E-11	100	868	4.22E-14
Gd-153	EC	240.4 d	0.00E+00	0.00E+00	--	--	--
H-3	B-	12.32 y	0.00E+00	0.00E+00	--	--	--
Ho-166m	B-	1.20E+3 y	1.13E-05	0.00E+00	1000	8684	1.30E-09
I-129	B-	1.57E+7 y	1.45E-03	8.81E-01	100	868	1.02E-03
In-115	B-	4.41E+14 y	0.00E+00	7.47E-17	1000	8684	8.61E-21

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Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Ir-194	B-	19.28 h	0.00E+00	0.00E+00	--	--	--
K-40	B-ECB+	1.251E+9 y	4.84E-02	0.00E+00	1000	8684	5.57E-06
K-42	B-	12.360 h	0.00E+00	0.00E+00	--	--	--
Kr-85	B-	10.756 y	0.00E+00	0.00E+00	--	--	--
Mn-54	ECB+B-	312.12 d	0.00E+00	0.00E+00	--	--	--
Mo-93	EC	4.0E+3 y	0.00E+00	6.18E-02	1000	8684	7.12E-06
Na-22	ECB+	2.6019 y	0.00E+00	0.00E+00	--	--	--
Nb-91	ECB+	680 y	0.00E+00	1.42E-06	1000	8684	1.64E-10
Nb-93m	IT	16.13 y	1.23E-02	2.49E-01	--	--	--
Nb-94	B-	2.03E+4 y	1.15E-03	2.55E+00	1000	8684	2.94E-04
Nd-144	A	2.29E+15 y	1.36E-12	1.57E-12	100	868	3.37E-15
Ni-59	ECB+	1.01E+5 y	1.54E-07	3.59E+00	1000	8684	4.13E-04
Ni-63	B-	100.1 y	4.99E-28	3.44E-28	1000	8684	9.70E-32
Np-235	ECA	396.1 d	0.00E+00	0.00E+00	--	--	--
Np-237	A	2.144E+6 y	4.42E+02	1.67E+01	100	868	5.29E-01
Np-238	B-	2.117 d	4.88E-26	4.22E-24	--	--	--
Np-239	B-	2.3565 d	1.35E+01	2.24E+02	--	--	--
Np-240	B-	61.9 m	8.36E-05	3.56E-07	--	--	--
Np-240m	B-IT	7.22 m	6.97E-02	2.97E-04	--	--	--
Os-194	B-	6.0 y	0.00E+00	0.00E+00	--	--	--
Pa-231	A	3.276E+4 y	2.51E+01	3.96E-01	100	868	2.94E-02
Pa-233	B-	26.967 d	4.42E+02	1.67E+01	--	--	--
Pa-234	B-	6.70 h	1.40E-01	4.56E-03	--	--	--
Pa-234m	B-IT	1.17 m	1.08E+02	3.50E+00	--	--	--
Pb-209	B-	3.253 h	2.12E+02	7.15E+01	--	--	--
Pb-210	B-A	22.20 y	8.75E+01	2.06E+00	100	868	1.03E-01
Pb-211	B-	36.1 m	2.51E+01	3.96E-01	--	--	--
Pb-212	B-	10.64 h	1.08E-01	9.77E-03	--	--	--
Pb-214	B-	26.8 m	8.76E+01	2.06E+00	--	--	--
Pd-107	B-	6.5E+6 y	1.50E-05	1.04E-02	1000	8684	1.20E-06
Pm-145	ECA	17.7 y	0.00E+00	0.00E+00	--	--	--

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Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Pm-146	ECB-	5.53 y	0.00E+00	0.00E+00	--	--	--
Pm-147	B-	2.6234 y	0.00E+00	0.00E+00	--	--	--
Po-210	A	138.376 d	8.75E+01	2.06E+00	--	--	--
Po-211	A	0.516 s	6.91E-02	1.09E-03	--	--	--
Po-212	A	2.99E-7 s	6.94E-02	6.26E-03	--	--	--
Po-213	A	4.2E-6 s	2.07E+02	7.00E+01	--	--	--
Po-214	A	1.643E-4 s	8.75E+01	2.06E+00	--	--	--
Po-215	A	1.781E-3 s	2.51E+01	3.96E-01	--	--	--
Po-216	A	0.145 s	1.08E-01	9.77E-03	--	--	--
Po-218	A B-	3.10 m	8.76E+01	2.06E+00	--	--	--
Pr-144	B-	17.28 m	0.00E+00	0.00E+00	--	--	--
Pr-144m	ITB-	7.2 m	0.00E+00	0.00E+00	--	--	--
Pu-236	ASF	2.858 y	0.00E+00	0.00E+00	--	--	--
Pu-238	ASF	87.7 y	2.38E-23	2.06E-21	100	868	2.40E-24
Pu-239	A	2.411E+4 y	3.13E+06	3.49E+03	100	868	3.60E+03
Pu-240	ASF	6564 y	3.83E+05	1.59E+03	100	868	4.43E+02
Pu-241	B-A	14.35 y	2.14E+00	1.03E+01	--	--	--
Pu-242	ASF	3.75E+5 y	2.82E+02	3.05E+01	100	868	3.59E-01
Pu-243	B-	4.956 h	9.23E-01	2.41E-03	--	--	--
Pu-244	ASF	8.00E+7 y	6.97E-02	2.97E-04	100	868	8.07E-05
Pu-246	B-	10.84 d	2.10E-08	0.00E+00	--	--	--
Ra-223	A	11.43 d	2.51E+01	3.96E-01	--	--	--
Ra-224	A	3.66 d	1.08E-01	9.77E-03	--	--	--
Ra-225	B-	14.9 d	2.12E+02	7.16E+01	--	--	--
Ra-226	A	1600 y	8.76E+01	2.06E+00	100	868	1.03E-01
Ra-228	B-	5.75 y	1.08E-01	9.77E-03	--	--	--
Rb-87	B-	4.923E10 y	1.87E-10	1.57E-06	1000	8684	1.81E-10
Rh-102	ECB+B-	207 d	0.00E+00	0.00E+00	--	--	--
Rh-106	B-	29.80 s	0.00E+00	0.00E+00	--	--	--
Rn-219	A	3.96 s	2.51E+01	3.96E-01	--	--	--
Rn-220	A	55.6 s	1.08E-01	9.77E-03	--	--	--

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Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Rn-222	A	3.8235 d	8.76E+01	2.06E+00	--	--	--
Ru-106	B-	373.59 d	0.00E+00	0.00E+00	--	--	--
Sb-125	B-	2.75856 y	0.00E+00	0.00E+00	--	--	--
Sb-126	B-	12.35 d	1.13E-06	1.11E-02	--	--	--
Sb-126m	B-IT	19.15 m	1.22E-05	1.25E-01	--	--	--
Se-79	B-	2.95E+5 y	1.19E-04	1.38E-01	1000	8684	1.59E-05
Sm-145	EC	340 d	0.00E+00	0.00E+00	--	--	--
Sm-146	A	1.03E+8 y	1.81E-13	4.00E-08	100	868	4.61E-11
Sm-147	A	1.060E11 y	1.73E-08	3.86E-07	100	868	4.65E-10
Sm-148	A	7E+15 y	1.63E-15	2.83E-19	100	868	1.88E-18
Sm-151	B-	90 y	4.03E-33	2.35E-32	1000	8684	3.16E-36
Sn-119m	IT	293.1 d	0.00E+00	0.00E+00	--	--	--
Sn-121	B-	27.03 h	0.00E+00	0.00E+00	--	--	--
Sn-121m	ITB-	43.9 y	0.00E+00	0.00E+00	1000	8684	0.00E+00
Sn-126	B-	2.30E+5 y	1.22E-05	1.25E-01	1000	8684	1.44E-05
Sr-90	B-	28.79 y	0.00E+00	0.00E+00	1000	8684	0.00E+00
Tb-157	EC	71 y	0.00E+00	7.05E-22	1000	8684	8.12E-26
Tc-97	EC	2.6E+6 y	0.00E+00	3.63E-08	1000	8684	4.18E-12
Tc-99	B-	2.111E+5 y	2.11E+01	5.47E+02	10000	86840	6.54E-03
Te-123	EC	6.00E+14 y	6.98E-22	1.92E-14	1000	8684	2.21E-18
Te-125m	IT	57.40 d	0.00E+00	0.00E+00	--	--	--
Th-227	A	18.68 d	2.48E+01	3.91E-01	--	--	--
Th-228	A	1.9116 y	1.08E-01	9.77E-03	--	--	--
Th-229	A	7.34E+3 y	2.12E+02	7.16E+01	100	868	3.26E-01
Th-230	A	7.538E+4 y	1.12E+02	2.51E+00	10	87	1.32E+00
Th-231	B-	25.52 h	3.74E+01	2.08E+00	--	--	--
Th-232	A	1.405E10 y	1.08E-01	9.77E-03	10	87	1.36E-03
Th-234	B-	24.10 d	1.08E+02	3.50E+00	--	--	--
Tl-204	B-EC	3.78 y	0.00E+00	0.00E+00	--	--	--
Tl-206	B-	4.200 m	1.16E-04	2.71E-06	--	--	--
Tl-207	B-	4.77 m	2.51E+01	3.95E-01	--	--	--

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Radionuclide ID	Decay Mode [a]	Half-Life [a]	Total CH Inventory [b] (Ci)	Total RH Inventory [b] (Ci)	Release Limit [c] (Ci/UW)	Release Limit [c] (Ci)	Potential Release [d] (EPA Units)
Tl-208	B-	3.053 m	3.90E-02	3.51E-03	--	--	--
Tl-209	B-	2.161 m	4.45E+00	1.50E+00	--	--	--
Tm-171	B-	1.92 y	0.00E+00	0.00E+00	--	--	--
U-232	A	68.9 y	8.85E-40	0.00E+00	100	868	1.02E-42
U-233	A	1.592E+5 y	3.59E+02	1.20E+02	100	868	5.52E-01
U-234	A	2.455E+5 y	1.26E+03	2.82E+01	100	868	1.49E+00
U-235	A	7.04E+8 y	3.74E+01	2.08E+00	100	868	4.55E-02
U-236	A	2.342E+7 y	2.05E+02	1.09E+00	100	868	2.37E-01
U-237	B-	6.75 d	5.11E-05	2.46E-04	--	--	--
U-238	ASF	4.468E+9 y	1.08E+02	3.50E+00	100	868	1.28E-01
U-240	B-	14.1 h	6.97E-02	2.97E-04	--	--	--
V-49	EC	330 d	0.00E+00	0.00E+00	--	--	--
Y-90	B-	64.10 h	0.00E+00	0.00E+00	--	--	--
Zn-65	ECB+	244.06 d	0.00E+00	0.00E+00	--	--	--
Zr-93	B-	1.53E+6 y	1.23E-02	1.98E-01	1000	8684	2.42E-05
Total:	**--**	**--**	**3.52E+06**	**7.12E+03**	**--**	**--**	**4053**

[a] Decay mode and half-life information taken from the International Commission on Radiological Protection (ICRP 2008, Table A.1). Note that decay modes include A = alpha, B- = beta minus, B+ = beta plus, EC = electron capture, IT = isomeric transition, and SF = spontaneous fission. Half-life units include s = second, m = minute, h = hour, d = day, and y = year.
[b] Decayed radionuclide inventory information taken from Van Soest (2025).
[c] Release limits are determined in accordance with 40 CFR 191 (see Table 2 and Appendix B, Table 21). The release limit in Ci/UW corresponds to specific release limits (cumulative releases to the accessible environment for 10,000 years after disposal per "unit of waste" identified in Note 1(e) of Table 1, Appendix A, 40 CFR 191). The release limit in Ci corresponds to release limit obtained for 8.68 units of waste. The 8.68 value for the unit of waste corresponds to the units of waste present at repository closure in 2083.
[d] Potential release is defined as the total inventory (CH + RH) in Ci divided by the release limit in Ci. Those isotopes without defined release limits have no potential release.

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14.0 APPENDIX B – 40 CFR 191 UNIT OF WASTE FOR WIPP-SCALE TRU WASTE

Table 21 – 40 CFR 191 Unit of Waste for WIPP-Scale TRU Waste

Radionuclide ID	Decay Mode [a]	Half-life [a]	Atomic Number [b]	Total Inventory at Closure [c] (Ci)	Alpha-emitting	Half-life > 20 years	Atomic Number > 92	Trans-uranic Inventory [d] (Ci)	% of Unit of Waste
Ac-225	A	10.0 d	89	7.09E+00	yes	--	--	--	--
Ac-227	B-A	21.772 y	89	8.34E+01	yes	yes	--	--	--
Ac-228	B-	6.15 h	89	1.29E-01	--	--	--	--	--
Ag-108	B-ECB+	2.37 m	47	2.78E-03	--	--	--	--	--
Ag-108m	ECIT	418 y	47	3.20E-02	--	yes	--	--	--
Ag-109m	IT	39.6 s	47	1.40E-15	--	--	--	--	--
Ag-110	B-EC	24.6 s	47	6.44E-29	--	--	--	--	--
Ag-110m	B-IT	249.76 d	47	4.73E-27	--	--	--	--	--
Am-241	**A**	**432.2 y**	**95**	**1.81E+06**	**yes**	**yes**	**yes**	**1.81E+06**	**20.793%**
Am-242	B-EC	16.02 h	95	2.11E+00	--	--	yes	--	--
Am-242m	**ITA**	**141 y**	**95**	**2.12E+00**	**yes**	**yes**	**yes**	**2.12E+00**	**0.000%**
Am-243	**A**	**7.37E+3 y**	**95**	**6.08E+02**	**yes**	**yes**	**yes**	**6.08E+02**	**0.007%**
Am-245	B-	2.05 h	95	1.43E-24	--	--	yes	--	--
Am-246	B-	39 m	95	3.13E-08	--	--	yes	--	--
Ar-39	B-	269 y	18	2.59E-02	--	yes	--	--	--
Ar-42	B-	32.9 y	18	1.75E-02	--	yes	--	--	--
At-217	A	3.23E-2 s	85	7.09E+00	yes	--	--	--	--
Ba-133	EC	10.52 y	56	8.62E-02	--	--	--	--	--
Ba-137m	IT	2.552 m	56	7.80E+04	--	--	--	--	--
Bi-210	B-A	5.013 d	83	9.01E+00	yes	--	--	--	--
Bi-211	A B-	2.14 m	83	8.35E+01	yes	--	--	--	--
Bi-212	B-A	60.55 m	83	1.23E+04	yes	--	--	--	--
Bi-213	B-A	45.59 m	83	7.09E+00	yes	--	--	--	--
Bi-214	B-A	19.9 m	83	9.78E+00	yes	--	--	--	--
Bk-249	B-A	330 d	97	9.84E-20	yes	--	yes	--	--
Bk-250	B-	3.212 h	97	1.75E-08	--	--	yes	--	--
C-14	B-	5.70E+3 y	6	1.41E+00	--	yes	--	--	--
Cd-109	EC	461.4 d	48	1.40E-15	--	--	--	--	--

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Radionuclide ID	Decay Mode [a]	Half-life [a]	Atomic Number [b]	Total Inventory at Closure [c] (Ci)	Alpha-emitting	Half-life > 20 years	Atomic Number > 92	Trans-uranic Inventory [d] (Ci)	% of Unit of Waste
Cd-113	B-	7.7E+15 y	48	9.32E-18	--	yes	--	--	--
Cd-113m	B-IT	14.1 y	48	1.59E-01	--	--	--	--	--
Ce-144	B-	284.91 d	58	6.64E-22	--	--	--	--	--
Cf-249	**ASF**	**351 y**	**98**	**9.25E+01**	**yes**	**yes**	**yes**	**9.25E+01**	**0.001%**
Cf-250	ASF	13.08 y	98	2.71E+01	yes	--	yes	--	--
Cf-251	**A**	**900 y**	**98**	**2.79E+01**	**yes**	**yes**	**yes**	**2.79E+01**	**0.000%**
Cf-252	ASF	2.645 y	98	9.68E-05	yes	--	yes	--	--
Cl-36	B-ECB+	3.01E+5 y	17	1.17E-01	--	yes	--	--	--
Cm-242	ASF	162.8 d	96	1.74E+00	yes	--	yes	--	--
Cm-243	**AEC**	**29.1 y**	**96**	**3.54E+01**	**yes**	**yes**	**yes**	**3.54E+01**	**0.000%**
Cm-244	ASF	18.10 y	96	1.21E+04	yes	--	yes	--	--
Cm-245	**ASF**	**8.5E+3 y**	**96**	**2.40E+01**	**yes**	**yes**	**yes**	**2.40E+01**	**0.000%**
Cm-246	**ASF**	**4.76E+3 y**	**96**	**8.29E+02**	**yes**	**yes**	**yes**	**8.29E+02**	**0.010%**
Cm-247	**A**	**1.56E+7 y**	**96**	**9.24E-01**	**yes**	**yes**	**yes**	**9.24E-01**	**0.000%**
Cm-248	**ASF**	**3.48E+5 y**	**96**	**5.25E+00**	**yes**	**yes**	**yes**	**5.25E+00**	**0.000%**
Cm-250	**AB-SF**	**8300 y**	**96**	**1.25E-07**	**yes**	**yes**	**yes**	**1.25E-07**	**0.000%**
Co-60	B-	5.2713 y	27	7.80E-01	--	--	--	--	--
Cs-134	B-EC	2.0648 y	55	3.47E-06	--	--	--	--	--
Cs-135	B-	2.3E+6 y	55	5.93E-02	--	yes	--	--	--
Cs-137	B-	30.1671 y	55	8.26E+04	--	yes	--	--	--
Eu-152	ECB+B-	13.537 y	63	4.66E+01	--	--	--	--	--
Eu-154	B-EC	8.593 y	63	6.20E+01	--	--	--	--	--
Eu-155	B-	4.7611 y	63	7.46E-02	--	--	--	--	--
Fe-55	EC	2.737 y	26	1.93E-05	--	--	--	--	--
Fr-221	A	4.9 m	87	7.09E+00	yes	--	--	--	--
Fr-223	B-A	22.00 m	87	1.15E+00	yes	--	--	--	--
Gd-152	A	1.08E+14 y	64	3.50E-11	yes	yes	--	--	--
Gd-153	EC	240.4 d	64	2.17E-30	--	--	--	--	--
H-3	B-	12.32 y	1	4.57E+03	--	--	--	--	--
Ho-166m	B-	1.20E+3 y	67	3.63E-03	--	yes	--	--	--
I-129	B-	1.57E+7 y	53	8.83E-01	--	yes	--	--	--

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Radionuclide ID	Decay Mode [a]	Half-life [a]	Atomic Number [b]	Total Inventory at Closure [c] (Ci)	Alpha-emitting	Half-life > 20 years	Atomic Number > 92	Trans-uranic Inventory [d] (Ci)	% of Unit of Waste
In-115	B-	4.41E+14 y	49	7.47E-17	--	yes	--	--	--
Ir-194	B-	19.28 h	77	1.98E-05	--	--	--	--	--
K-40	B-ECB+	1.251E+9 y	19	4.84E-02	--	yes	--	--	--
K-42	B-	12.360 h	19	1.75E-02	--	--	--	--	--
Kr-85	B-	10.756 y	36	1.84E+01	--	--	--	--	--
Mn-54	ECB+B-	312.12 d	25	5.54E-21	--	--	--	--	--
Mo-93	EC	4.0E+3 y	42	4.49E-01	--	yes	--	--	--
Na-22	ECB+	2.6019 y	11	6.37E-07	--	--	--	--	--
Nb-91	ECB+	680 y	41	3.81E-02	--	yes	--	--	--
Nb-93m	IT	16.13 y	41	6.44E-01	--	--	--	--	--
Nb-94	B-	2.03E+4 y	41	3.59E+00	--	yes	--	--	--
Nd-144	A	2.29E+15 y	60	2.93E-12	yes	yes	--	--	--
Ni-59	ECB+	1.01E+5 y	28	3.94E+00	--	yes	--	--	--
Ni-63	B-	100.1 y	28	1.00E+03	--	yes	--	--	--
Np-235	ECA	396.1 d	93	3.62E-18	yes	--	yes	--	--
Np-237	**A**	**2.144E+6 y**	**93**	**9.15E+01**	**yes**	**yes**	**yes**	**9.15E+01**	**0.001%**
Np-238	B-	2.117 d	93	9.54E-03	--	--	yes	--	--
Np-239	B-	2.3565 d	93	6.08E+02	--	--	yes	--	--
Np-240	B-	61.9 m	93	8.35E-05	--	--	yes	--	--
Np-240m	B-IT	7.22 m	93	6.95E-02	--	--	yes	--	--
Os-194	B-	6.0 y	76	1.98E-05	--	--	--	--	--
Pa-231	A	3.276E+4 y	91	2.61E+01	yes	yes	--	--	--
Pa-233	B-	26.967 d	91	9.15E+01	--	--	--	--	--
Pa-234	B-	6.70 h	91	1.45E-01	--	--	--	--	--
Pa-234m	B-IT	1.17 m	91	1.11E+02	--	--	--	--	--
Pb-209	B-	3.253 h	82	7.09E+00	--	--	--	--	--
Pb-210	B-A	22.20 y	82	9.01E+00	yes	yes	--	--	--
Pb-211	B-	36.1 m	82	8.35E+01	--	--	--	--	--
Pb-212	B-	10.64 h	82	1.23E+04	--	--	--	--	--
Pb-214	B-	26.8 m	82	9.78E+00	--	--	--	--	--
Pd-107	B-	6.5E+6 y	46	1.05E-02	--	yes	--	--	--

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Radionuclide ID	Decay Mode [a]	Half-life [a]	Atomic Number [b]	Total Inventory at Closure [c] (Ci)	Alpha-emitting	Half-life > 20 years	Atomic Number > 92	Trans-uranic Inventory [d] (Ci)	% of Unit of Waste
Pm-145	ECA	17.7 y	61	1.33E-01	yes	--	--	--	--
Pm-146	ECB-	5.53 y	61	6.33E-04	--	--	--	--	--
Pm-147	B-	2.6234 y	61	1.12E-04	--	--	--	--	--
Po-210	A	138.376 d	84	9.01E+00	yes	--	--	--	--
Po-211	A	0.516 s	84	2.30E-01	yes	--	--	--	--
Po-212	A	2.99E-7 s	84	7.91E+03	yes	--	--	--	--
Po-213	A	4.2E-6 s	84	6.94E+00	yes	--	--	--	--
Po-214	A	1.643E-4 s	84	9.78E+00	yes	--	--	--	--
Po-215	A	1.781E-3 s	84	8.35E+01	yes	--	--	--	--
Po-216	A	0.145 s	84	1.23E+04	yes	--	--	--	--
Po-218	A B-	3.10 m	84	9.78E+00	yes	--	--	--	--
Pr-144	B-	17.28 m	59	6.64E-22	--	--	--	--	--
Pr-144m	ITB-	7.2 m	59	9.29E-24	--	--	--	--	--
Pu-236	ASF	2.858 y	94	2.96E-07	yes	--	yes	--	--
Pu-238	**ASF**	**87.7 y**	**94**	**1.60E+06**	**yes**	**yes**	**yes**	**1.60E+06**	**18.394%**
Pu-239	**A**	**2.411E+4 y**	**94**	**4.17E+06**	**yes**	**yes**	**yes**	**4.17E+06**	**48.044%**
Pu-240	**ASF**	**6564 y**	**94**	**1.11E+06**	**yes**	**yes**	**yes**	**1.11E+06**	**12.746%**
Pu-241	B-A	14.35 y	94	5.90E+05	yes	--	yes	--	--
Pu-242	**ASF**	**3.75E+5 y**	**94**	**3.10E+02**	**yes**	**yes**	**yes**	**3.10E+02**	**0.004%**
Pu-243	B-	4.956 h	94	9.24E-01	--	--	yes	--	--
Pu-244	**ASF**	**8.00E+7 y**	**94**	**6.96E-02**	**yes**	**yes**	**yes**	**6.96E-02**	**0.000%**
Pu-246	B-	10.84 d	94	3.13E-08	--	--	yes	--	--
Ra-223	A	11.43 d	88	8.35E+01	yes	--	--	--	--
Ra-224	A	3.66 d	88	1.23E+04	yes	--	--	--	--
Ra-225	B-	14.9 d	88	7.09E+00	--	--	--	--	--
Ra-226	A	1600 y	88	9.78E+00	yes	yes	--	--	--
Ra-228	B-	5.75 y	88	1.29E-01	--	--	--	--	--
Rb-87	B-	4.923E10 y	37	1.57E-06	--	yes	--	--	--
Rh-102	ECB+B-	207 d	45	7.23E-35	--	--	--	--	--
Rh-106	B-	29.80 s	45	1.09E-15	--	--	--	--	--
Rn-219	A	3.96 s	86	8.35E+01	yes	--	--	--	--

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Radionuclide ID	Decay Mode [a]	Half-life [a]	Atomic Number [b]	Total Inventory at Closure [c] (Ci)	Alpha-emitting	Half-life > 20 years	Atomic Number > 92	Trans-uranic Inventory [d] (Ci)	% of Unit of Waste
Rn-220	A	55.6 s	86	1.23E+04	yes	--	--	--	--
Rn-222	A	3.8235 d	86	9.78E+00	yes	--	--	--	--
Ru-106	B-	373.59 d	44	1.09E-15	--	--	--	--	--
Sb-125	B-	2.75856 y	51	3.75E-05	--	--	--	--	--
Sb-126	B-	12.35 d	51	1.19E-02	--	--	--	--	--
Sb-126m	B-IT	19.15 m	51	1.34E-01	--	--	--	--	--
Se-79	B-	2.95E+5 y	34	1.41E-01	--	yes	--	--	--
Sm-145	EC	340 d	62	8.68E-22	--	--	--	--	--
Sm-146	A	1.03E+8 y	62	4.00E-08	yes	yes	--	--	--
Sm-147	A	1.060E11 y	62	4.04E-07	yes	yes	--	--	--
Sm-148	A	7E+15 y	62	1.63E-15	yes	yes	--	--	--
Sm-151	B-	90 y	62	7.79E+01	--	yes	--	--	--
Sn-119m	IT	293.1 d	50	1.26E-24	--	--	--	--	--
Sn-121	B-	27.03 h	50	8.15E-01	--	--	--	--	--
Sn-121m	ITB-	43.9 y	50	1.05E+00	--	yes	--	--	--
Sn-126	B-	2.30E+5 y	50	1.34E-01	--	yes	--	--	--
Sr-90	B-	28.79 y	38	6.08E+04	--	yes	--	--	--
Tb-157	EC	71 y	65	8.26E-02	--	yes	--	--	--
Tc-97	EC	2.6E+6 y	43	3.64E-08	--	yes	--	--	--
Tc-99	B-	2.111E+5 y	43	5.87E+02	--	yes	--	--	--
Te-123	EC	6.00E+14 y	52	1.92E-14	--	yes	--	--	--
Te-125m	IT	57.40 d	52	9.16E-06	--	--	--	--	--
Th-227	A	18.68 d	90	8.24E+01	yes	--	--	--	--
Th-228	A	1.9116 y	90	1.23E+04	yes	--	--	--	--
Th-229	A	7.34E+3 y	90	7.09E+00	yes	yes	--	--	--
Th-230	A	7.538E+4 y	90	4.89E-01	yes	yes	--	--	--
Th-231	B-	25.52 h	90	3.79E+00	--	--	--	--	--
Th-232	A	1.405E10 y	90	1.18E-01	yes	yes	--	--	--
Th-234	B-	24.10 d	90	1.11E+02	--	--	--	--	--
Tl-204	B-EC	3.78 y	81	1.37E-12	--	--	--	--	--
Tl-206	B-	4.200 m	81	1.19E-05	--	--	--	--	--

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Radionuclide ID	Decay Mode [a]	Half-life [a]	Atomic Number [b]	Total Inventory at Closure [c] (Ci)	Alpha-emitting	Half-life > 20 years	Atomic Number > 92	Trans-uranic Inventory [d] (Ci)	% of Unit of Waste
Tl-207	B-	4.77 m	81	8.33E+01	--	--	--	--	--
Tl-208	B-	3.053 m	81	4.44E+03	--	--	--	--	--
Tl-209	B-	2.161 m	81	1.49E-01	--	--	--	--	--
Tm-171	B-	1.92 y	69	8.61E-11	--	--	--	--	--
U-232	A	68.9 y	92	1.20E+04	yes	yes	--	--	--
U-233	A	1.592E+5 y	92	4.81E+02	yes	yes	--	--	--
U-234	A	2.455E+5 y	92	7.56E+02	yes	yes	--	--	--
U-235	A	7.04E+8 y	92	3.79E+00	yes	yes	--	--	--
U-236	A	2.342E+7 y	92	3.83E+00	yes	yes	--	--	--
U-237	B-	6.75 d	92	1.41E+01	--	--	--	--	--
U-238	ASF	4.468E+9 y	92	1.11E+02	yes	yes	--	--	--
U-240	B-	14.1 h	92	6.95E-02	--	--	--	--	--
V-49	EC	330 d	23	8.07E-21	--	--	--	--	--
Y-90	B-	64.10 h	39	6.08E+04	--	--	--	--	--
Zn-65	ECB+	244.06 d	30	1.74E-27	--	--	--	--	--
Zr-93	B-	1.53E+6 y	40	2.11E-01	--	yes	--	--	--
Total (Ci)	**--**	**--**	**--**	**9.68E+06**	**--**	**--**	**--**	**8.68E+06**	**100%**

From Equation 3, WUF = 8.68

[a] Decay mode and half-life information taken from the International Commission on Radiological Protection (ICRP 2008, Table A.1). Note that decay modes include A = alpha, B- = beta minus, B+ = beta plus, EC = electron capture, IT = isomeric transition, and SF = spontaneous fission. Half-life units include s = second, m = minute, h = hour, d = day, and y = year.
[b] Atomic number taken from the International Atomic Energy Agency (IAEA) (Wang et al. 2021, Table I).
[c] Decayed radionuclide inventory information taken from Van Soest (2025). The inventory information given has been decayed through 2083, which is the assumed closing date of WIPP.
[d] Transuranic inventory data correspond to the activity (Ci) data only for radionuclides that are categorized as "alpha-emitting transuranic radionuclides with half-lives greater than 20 years" per definitions in 40 CFR 191. Transuranic is defined as having an atomic number higher than uranium (92).

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15.0 APPENDIX C – DECAY HEAT CONTRIBUTIONS TO RADIOLYSIS

A screening analysis is performed to determine which radionuclides are the major contributors to the total decay heat and thus are necessary to include in the radiolysis calculations (see Section 6). Radionuclide disintegration energy, decay heat specific power, and specific activity used in the screening analysis are given in Table 22. Inventories given in FRPAIR-2024 (Van Soest 2025) and calculated wattages at calendar years 2083, 2183, and 12083 are tabulated in Table 23 through Table 25.

Table 22 – Disintegration Energy, Decay Heat Specific Power, and Specific Activity for 168 Radionuclides

Radionuclide ID	Decay Mode [a]	Half-life [a] (s)	Atomic Mass [b] (g/mol)	Disintegration Energy [a] (MeV)	Decay Heat Specific Power [c] (W/g)	Specific Activity [c] (Ci/g)
Ac-225	A	864000	225.0232286	5.9338	2.04E+03	5.80E+04
Ac-227	B-A	687057480	227.0277506	0.0853	3.66E-02	7.23E+01
Ac-228	B-	22140	228.0310197	1.3166	1.74E+04	2.23E+06
Ag-108	B-ECB+	142.2	107.9059502	0.6256	2.73E+06	7.35E+08
Ag-108m	ECIT	13190796740	107.9059502	1.6368	7.69E-02	7.93E+00
Ag-109m	IT	39.6	108.9047558	0.088	1.36E+06	2.62E+09
Ag-110	B-EC	24.6	109.9061107	1.2119	3.00E+07	4.17E+09
Ag-110m	B-IT	21579264	109.9061107	2.8363	8.00E+01	4.76E+03
Am-241	A	13638905146	241.0568273	5.6379	1.15E-01	3.43E+00
Am-242	B-EC	57672	242.0595474	0.1994	9.55E+02	8.08E+05
Am-242m	ITA	4449527130	242.0595474	0.0734	4.56E-03	1.05E+01
Am-243	A	2.32575E+11	243.0613799	5.4402	6.44E-03	2.00E-01
Am-245	B-	7380	245.0664528	0.3198	1.18E+04	6.24E+06
Am-246	B-	2340	246.069774	1.4739	1.71E+05	1.96E+07
Ar-39	B-	8488814170	38.96431304	0.2188	4.42E-02	3.41E+01
Ar-42	B-	1038222997	41.96304574	0.2325	3.57E-01	2.59E+02
At-217	A	0.0323	217.0047178	7.2011	6.87E+10	1.61E+12
Ba-133	EC	331978903.6	132.9060074	0.4583	6.95E-01	2.56E+02
Ba-137m	IT	153.12	136.9058272	0.6617	2.11E+06	5.38E+08
Bi-210	B-A	433123.2	209.9841202	0.3889	2.86E+02	1.24E+05
Bi-211	A B-	128.4	210.9872687	6.733	1.66E+07	4.16E+08
Bi-212	B-A	3633	211.991285	2.8247	2.45E+05	1.46E+07
Bi-213	B-A	2735.4	212.9943836	0.6963	7.99E+04	1.94E+07

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Radionuclide ID	Decay Mode [a]	Half-life [a] (s)	Atomic Mass [b] (g/mol)	Disintegration Energy [a] (MeV)	Decay Heat Specific Power [c] (W/g)	Specific Activity [c] (Ci/g)
Bi-214	B-A	1194	213.9987109	2.1436	5.61E+05	4.42E+07
Bk-249	B-A	28512000	249.0749831	0.0325	3.06E-01	1.59E+03
Bk-250	B-	11563.2	250.0783172	1.1932	2.76E+04	3.90E+06
C-14	B-	1.79875E+11	14.00324199	0.0495	1.31E-03	4.48E+00
Cd-109	EC	39864960	108.9049867	0.1092	1.68E+00	2.60E+03
Cd-113	B-	2.42988E+23	112.9044081	0.0926	2.26E-16	4.11E-13
Cd-113m	B-IT	444952713	112.9044081	0.1848	2.46E-01	2.25E+02
Ce-144	B-	24616224	143.9136528	0.111	2.10E+00	3.18E+03
Cf-249	ASF	11076482430	249.0748504	6.2944	1.53E-01	4.09E+00
Cf-250	ASF	412764644.4	250.0764045	6.2897	4.08E+00	1.09E+02
Cf-251	A	28401237000	251.0795872	6.1754	5.79E-02	1.58E+00
Cf-252	ASF	83468079.85	252.0816265	12.8107	4.07E+01	5.36E+02
Cl-36	B-ECB+	9.49864E+12	35.96830682	0.2733	5.35E-05	3.30E-02
Cm-242	ASF	14065920	242.0588342	6.2156	1.22E+02	3.31E+03
Cm-243	AEC	918306663	243.0613873	6.1624	1.85E+00	5.05E+01
Cm-244	ASF	571180433	244.0627506	5.9014	2.83E+00	8.09E+01
Cm-245	ASF	2.68234E+11	245.065491	5.6382	5.74E-03	1.72E-01
Cm-246	ASF	1.50211E+11	246.067222	5.5285	1.00E-02	3.05E-01
Cm-247	A	4.92288E+14	247.0703527	5.3544	2.94E-06	9.28E-05
Cm-248	ASF	1.09818E+13	248.0723491	22.5608	5.54E-04	4.14E-03
Cm-250	AB-SF	2.61923E+11	250.0783575	161.287	1.65E-01	1.72E-01
Co-60	B-	166346045.1	59.93381554	2.6007	1.74E+01	1.13E+03
Cs-134	B-EC	65158749.06	133.9067185	1.719	1.32E+01	1.29E+03
Cs-135	B-	7.25809E+13	134.9059769	0.0894	6.11E-07	1.15E-03
Cs-137	B-	951981063	136.9070893	0.1884	9.67E-02	8.66E+01
Eu-152	ECB+B-	427186161.4	151.921751	1.3045	1.34E+00	1.74E+02
Eu-154	B-EC	271168699.5	153.9229857	1.5223	2.44E+00	2.70E+02
Eu-155	B-	150245699.4	154.9228998	0.1259	3.62E-01	4.85E+02
Fe-55	EC	86371317.41	54.93829116	0.0058	8.17E-02	2.38E+03
Fr-221	A	294	221.0142537	6.4582	6.65E+06	1.74E+08
Fr-223	B-A	1320	223.0197342	0.4415	1.00E+05	3.83E+07
Gd-152	A	3.40815E+21	151.9197984	2.2046	2.85E-13	2.18E-11
Gd-153	EC	20770560	152.9217569	0.1494	3.15E+00	3.55E+03

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Radionuclide ID	Decay Mode [a]	Half-life [a] (s)	Atomic Mass [b] (g/mol)	Disintegration Energy [a] (MeV)	Decay Heat Specific Power [c] (W/g)	Specific Activity [c] (Ci/g)
H-3	B-	388781377.6	3.016049281	0.0057	3.25E-01	9.62E+03
Ho-166m	B-	37868316000	165.9322912	1.7746	1.89E-02	1.80E+00
I-129	B-	4.95444E+14	128.9049836	0.0902	9.45E-08	1.77E-04
In-115	B-	1.39166E+22	114.9038788	0.1526	6.38E-15	7.06E-12
Ir-194	B-	69408	193.9650757	0.9015	4.48E+03	8.38E+05
K-40	B-ECB+	3.94777E+16	39.96399817	0.6785	2.88E-08	7.15E-06
K-42	B-	44496	41.96240231	1.709	6.12E+04	6.04E+06
Kr-85	B-	339426339.1	84.91252726	0.2529	5.87E-01	3.91E+02
Mn-54	ECB+B-	26967168	53.94035577	0.8402	3.86E+01	7.76E+03
Mo-93	EC	1.26228E+11	92.90680877	0.0163	9.30E-05	9.62E-01
Na-22	ECB+	82107976.17	21.99443755	2.3866	8.84E+01	6.25E+03
Nb-91	ECB+	21458712400	90.90699026	0.0176	6.03E-04	5.78E+00
Nb-93m	IT	509013280.9	92.90637317	0.0314	4.44E-02	2.39E+02
Nb-94	B-	6.40606E+11	93.907279	1.7265	1.92E-03	1.88E-01
Nd-144	A	7.22654E+22	143.9100928	1.9052	1.23E-14	1.08E-12
Ni-59	ECB+	3.18725E+12	58.93434544	0.0069	2.46E-06	6.01E-02
Ni-63	B-	3158848693	62.92966902	0.0174	5.85E-03	5.68E+01
Np-235	ECA	34223040	235.0440615	0.0178	1.48E-01	1.40E+03
Np-237	A	6.76581E+13	237.0481716	4.9529	2.07E-05	7.03E-04
Np-238	B-	182908.8	238.0509446	0.8398	1.29E+03	2.59E+05
Np-239	B-	203601.6	239.0529375	0.4469	6.14E+02	2.32E+05
Np-240	B-	3714	240.0561638	1.5632	1.17E+05	1.27E+07
Np-240m	B-IT	433.2	240.0561638	1.0004	6.43E+05	1.08E+08
Os-194	B-	189341580	193.9651794	0.0498	9.07E-02	3.07E+02
Pa-231	A	1.03381E+12	231.0358825	5.158	1.44E-03	4.72E-02
Pa-233	B-	2329948.8	233.0402465	0.438	5.39E+01	2.08E+04
Pa-234	B-	24120	234.0433056	1.8755	2.22E+04	2.00E+06
Pa-234m	B-IT	70.2	234.0433056	0.8334	3.39E+06	6.87E+08
Pb-209	B-	11710.8	208.98109	0.1974	5.39E+03	4.61E+06
Pb-210	B-A	700563846	209.9841884	0.0457	2.08E-02	7.67E+01
Pb-211	B-	2166	210.9887353	0.5187	7.59E+04	2.47E+07
Pb-212	B-	38304	211.9918959	0.3217	2.65E+03	1.39E+06
Pb-214	B-	1608	213.9998035	0.5481	1.07E+05	3.28E+07

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Radionuclide ID	Decay Mode [a]	Half-life [a] (s)	Atomic Mass [b] (g/mol)	Disintegration Energy [a] (MeV)	Decay Heat Specific Power [c] (W/g)	Specific Activity [c] (Ci/g)
Pd-107	B-	2.0512E+14	106.9051281	0.0096	2.93E-08	5.14E-04
Pm-145	ECA	558557661	144.9127557	0.0441	3.64E-02	1.39E+02
Pm-146	ECB-	174509822.9	145.9147022	0.8453	2.22E+00	4.43E+02
Pm-147	B-	82786450.16	146.9151449	0.0619	3.40E-01	9.28E+02
Po-210	A	11955686.4	209.9828737	5.4075	1.44E+02	4.49E+03
Po-211	A	0.516	210.9866532	7.5944	4.67E+09	1.04E+11
Po-212	A	0.000000299	211.988868	8.9541	9.45E+15	1.78E+17
Po-213	A	0.0000042	212.9928572	8.537	6.38E+14	1.26E+16
Po-214	A	0.0001643	213.9952013	7.8335	1.49E+13	3.21E+14
Po-215	A	0.001781	214.9994184	7.5263	1.31E+12	2.95E+13
Po-216	A	0.145	216.0019134	6.9064	1.47E+10	3.60E+11
Po-218	A B-	186	218.0089712	6.1135	1.01E+07	2.78E+08
Pr-144	B-	1036.8	143.9133107	1.2373	5.55E+05	7.56E+07
Pr-144m	ITB-	432	143.9133107	0.0608	6.54E+04	1.81E+08
Pu-236	ASF	90189705.94	236.0460567	5.8674	1.84E+01	5.30E+02
Pu-238	ASF	2767542761	238.0495582	5.593	5.68E-01	1.71E+01
Pu-239	A	7.60838E+11	239.0521616	5.2442	1.93E-03	6.20E-02
Pu-240	ASF	2.0714E+11	240.0538117	5.2559	7.07E-03	2.27E-01
Pu-241	B-A	452841945.5	241.0568497	0.0054	3.31E-03	1.03E+02
Pu-242	ASF	1.18338E+13	242.058741	4.9855	1.16E-04	3.94E-03
Pu-243	B-	17841.6	243.0620021	0.1988	3.07E+03	2.60E+06
Pu-244	ASF	2.52455E+15	244.0642044	4.9094	5.33E-07	1.83E-05
Pu-246	B-	936576	246.0702042	0.259	7.52E+01	4.90E+04
Ra-223	A	987552	223.0185006	5.9895	1.82E+03	5.12E+04
Ra-224	A	316224	224.0202104	5.7893	5.47E+03	1.59E+05
Ra-225	B-	1287360	225.0236105	0.1194	2.76E+01	3.89E+04
Ra-226	A	50491088000	226.0254082	4.8716	2.85E-02	9.89E-01
Ra-228	B-	181452347.5	228.0310686	0.0163	2.63E-02	2.73E+02
Rb-87	B-	1.55355E+18	86.90918053	0.1154	5.72E-11	8.36E-08
Rh-102	ECB+B-	17884800	101.9068343	0.6777	2.49E+01	6.19E+03
Rh-106	B-	29.8	105.9072859	1.6172	3.43E+07	3.57E+09
Rn-219	A	3.96	219.0094787	6.9456	5.36E+08	1.30E+10
Rn-220	A	55.6	220.0113924	6.4047	3.50E+07	9.22E+08

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Radionuclide ID	Decay Mode [a]	Half-life [a] (s)	Atomic Mass [b] (g/mol)	Disintegration Energy [a] (MeV)	Decay Heat Specific Power [c] (W/g)	Specific Activity [c] (Ci/g)
Rn-222	A	330350.4	222.017576	5.5903	5.10E+03	1.54E+05
Ru-106	B-	32278176	105.9073282	0.01	1.96E-01	3.30E+03
Sb-125	B-	87051684.82	124.9052543	0.5383	3.31E+00	1.04E+03
Sb-126	B-	1067040	125.9072532	3.1097	1.55E+03	8.40E+04
Sb-126m	B-IT	1149	125.9072532	2.1805	1.01E+06	7.80E+07
Se-79	B-	9.30929E+12	78.91849925	0.0529	4.82E-06	1.54E-02
Sm-145	EC	29376000	144.9134172	0.095	1.49E+00	2.65E+03
Sm-146	A	3.25036E+15	145.9130468	2.529	3.57E-07	2.38E-05
Sm-147	A	3.34503E+18	146.9149044	2.3105	3.14E-10	2.30E-08
Sm-148	A	2.20899E+23	147.9148292	1.986	4.07E-15	3.45E-13
Sm-151	B-	2840123700	150.9199389	0.02	3.12E-03	2.63E+01
Sn-119m	IT	25323840	118.9033113	0.0932	2.07E+00	3.75E+03
Sn-121	B-	97308	120.9042435	0.1156	6.57E+02	9.59E+05
Sn-121m	ITB-	1385349227	120.9042435	0.0405	1.62E-02	6.74E+01
Sn-126	B-	7.25809E+12	125.907659	0.1949	1.43E-05	1.23E-02
Sr-90	B-	908524014.7	89.90772787	0.1957	1.60E-01	1.38E+02
Tb-157	EC	2240542030	156.9240319	0.0114	2.17E-03	3.21E+01
Tc-97	EC	8.2048E+13	96.90636072	0.0169	1.42E-07	1.42E-03
Tc-99	B-	6.66167E+12	98.90624968	0.1013	1.03E-05	1.71E-02
Te-123	EC	1.89342E+22	122.904271	0.0031	8.91E-17	4.85E-12
Te-125m	IT	4959360	124.9044312	0.1451	1.57E+01	1.82E+04
Th-227	A	1613952	227.0277025	6.1955	1.13E+03	3.08E+04
Th-228	A	60324227.39	228.0287397	5.5202	2.68E+01	8.20E+02
Th-229	A	2.31628E+11	229.0317614	5.1772	6.53E-03	2.13E-01
Th-230	A	2.37876E+12	230.0331323	4.7702	5.83E-04	2.06E-02
Th-231	B-	91872	231.0363028	0.1891	5.96E+02	5.32E+05
Th-232	A	4.43375E+17	232.0380536	4.0829	2.65E-09	1.10E-07
Th-234	B-	2082240	234.0435998	0.0728	9.99E+00	2.31E+04
Tl-204	B-EC	119285195.4	203.9738634	0.2385	6.56E-01	4.64E+02
Tl-206	B-	252	205.9761101	0.5399	6.96E+05	2.17E+08
Tl-207	B-	286.2	206.9774186	0.4975	5.62E+05	1.90E+08
Tl-208	B-	183.18	207.982018	3.9716	6.97E+06	2.96E+08
Tl-209	B-	129.66	208.9853517	2.8302	6.99E+06	4.16E+08

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Radionuclide ID	Decay Mode [a]	Half-life [a] (s)	Atomic Mass [b] (g/mol)	Disintegration Energy [a] (MeV)	Decay Heat Specific Power [c] (W/g)	Specific Activity [c] (Ci/g)
Tm-171	B-	60589305.6	170.9364352	0.0261	1.69E-01	1.09E+03
U-232	A	2174272477	232.0371548	5.4135	7.18E-01	2.24E+01
U-233	A	5.02386E+12	233.0396343	4.9085	2.80E-04	9.64E-03
U-234	A	7.74723E+12	234.0409503	4.8587	1.79E-04	6.22E-03
U-235	A	2.22161E+16	235.0439281	4.6891	6.01E-08	2.16E-06
U-236	A	7.39063E+14	236.0455661	4.5723	1.75E-06	6.47E-05
U-237	B-	583200	237.0487283	0.3433	1.66E+02	8.16E+04
U-238	ASF	1.40996E+17	238.0507869	4.2691	8.51E-09	3.36E-07
U-240	B-	50760	240.0565924	0.1374	7.54E+02	9.26E+05
V-49	EC	28512000	48.94851051	0.0045	2.16E-01	8.08E+03
Y-90	B-	230760	89.90714175	0.9331	3.01E+03	5.44E+05
Zn-65	ECB+	21086784	64.92924053	0.5888	2.88E+01	8.24E+03
Zr-93	B-	4.82821E+13	92.90647066	0.0194	2.89E-07	2.52E-03

[a] International Commission on Radiological Protection (ICRP 2008, Table A.1). Note that decay modes include A = alpha, B- = beta minus, B+ = beta plus, EC = electron capture, IT = isomeric transition, and SF = spontaneous fission. Half-life is converted to seconds.
[b] Atomic mass taken from IAEA (Wang et al. 2021, Table I and file *mass_1.mas20.txt*).
[c] Decay heat specific power is calculated using Equation 10 and specific activity is calculated using Equation 9.

Table 23 – Calculated Wattage at 2083

Radionuclide ID	CH Inventory in 2083 [a] (Ci)	RH Inventory in 2083 [a] (Ci)	Total Inventory in 2083 (Ci)	Wattage [b] (W)	Wattage Fraction (selected) (%)
Ac-225	6.42E+00	6.77E-01	7.09E+00	2.49E-01	
Ac-227	8.32E+01	1.92E-01	8.34E+01	4.21E-02	
Ac-228	1.08E-01	2.07E-02	1.29E-01	1.01E-03	
Ag-108	5.75E-04	2.21E-03	2.78E-03	1.03E-05	
Ag-108m	6.61E-03	2.54E-02	3.20E-02	3.10E-04	
Ag-109m	8.56E-20	1.40E-15	1.40E-15	7.29E-19	
Ag-110	1.43E-29	5.01E-29	6.44E-29	4.62E-31	
Ag-110m	1.05E-27	3.68E-27	4.73E-27	7.96E-29	
Am-241	1.79E+06	1.77E+04	1.81E+06	6.03E+04	21.41%
Am-242	2.41E-02	2.09E+00	2.11E+00	2.49E-03	

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Radionuclide ID	CH Inventory in 2083 [a] (Ci)	RH Inventory in 2083 [a] (Ci)	Total Inventory in 2083 (Ci)	Wattage [b] (W)	Wattage Fraction (selected) (%)
Am-242m	2.42E-02	2.09E+00	2.12E+00	9.22E-04	
Am-243	3.32E+01	5.74E+02	6.08E+02	1.96E+01	
Am-245	1.43E-24	1.39E-32	1.43E-24	2.70E-27	
Am-246	3.13E-08	0.00E+00	3.13E-08	2.73E-10	
Ar-39	0.00E+00	2.59E-02	2.59E-02	3.36E-05	
Ar-42	0.00E+00	1.75E-02	1.75E-02	2.41E-05	
At-217	6.42E+00	6.77E-01	7.09E+00	3.03E-01	
Ba-133	8.42E-05	8.62E-02	8.62E-02	2.34E-04	
Ba-137m	9.93E+01	7.79E+04	7.80E+04	3.06E+02	
Bi-210	1.89E+00	7.13E+00	9.01E+00	2.08E-02	
Bi-211	8.33E+01	1.92E-01	8.35E+01	3.33E+00	
Bi-212	1.23E+04	3.68E+00	1.23E+04	2.07E+02	
Bi-213	6.42E+00	6.76E-01	7.09E+00	2.93E-02	
Bi-214	2.21E+00	7.57E+00	9.78E+00	1.24E-01	
Bk-249	9.84E-20	9.59E-28	9.84E-20	1.89E-23	
Bk-250	1.75E-08	0.00E+00	1.75E-08	1.24E-10	
C-14	1.52E-01	1.25E+00	1.41E+00	4.13E-04	
Cd-109	8.56E-20	1.40E-15	1.40E-15	9.05E-19	
Cd-113	1.56E-22	9.32E-18	9.32E-18	5.11E-21	
Cd-113m	4.03E-06	1.59E-01	1.59E-01	1.75E-04	
Ce-144	1.41E-23	6.49E-22	6.64E-22	4.37E-25	
Cf-249	8.50E+00	8.40E+01	9.25E+01	3.45E+00	
Cf-250	5.38E-01	2.65E+01	2.71E+01	1.01E+00	
Cf-251	3.39E-01	2.76E+01	2.79E+01	1.02E+00	
Cf-252	1.73E-05	7.95E-05	9.68E-05	7.35E-06	
Cl-36	2.08E-07	1.17E-01	1.17E-01	1.90E-04	
Cm-242	1.99E-02	1.72E+00	1.74E+00	6.43E-02	
Cm-243	3.55E+00	3.18E+01	3.54E+01	1.29E+00	
Cm-244	1.85E+03	1.02E+04	1.21E+04	4.22E+02	
Cm-245	4.46E+00	1.96E+01	2.40E+01	8.03E-01	
Cm-246	1.00E+02	7.29E+02	8.29E+02	2.72E+01	

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Radionuclide ID	CH Inventory in 2083 [a] (Ci)	RH Inventory in 2083 [a] (Ci)	Total Inventory in 2083 (Ci)	Wattage [b] (W)	Wattage Fraction (selected) (%)
Cm-247	9.23E-01	8.64E-04	9.24E-01	2.93E-02	
Cm-248	1.63E+00	3.62E+00	5.25E+00	7.02E-01	
Cm-250	1.25E-07	0.00E+00	1.25E-07	1.20E-07	
Co-60	5.25E-04	7.80E-01	7.80E-01	1.20E-02	
Cs-134	1.03E-09	3.47E-06	3.47E-06	3.54E-08	
Cs-135	1.50E-03	5.78E-02	5.93E-02	3.14E-05	
Cs-137	1.05E+02	8.25E+04	8.26E+04	9.22E+01	
Eu-152	5.42E-01	4.61E+01	4.66E+01	3.61E-01	
Eu-154	4.47E-02	6.20E+01	6.20E+01	5.60E-01	
Eu-155	4.57E-04	7.41E-02	7.46E-02	5.57E-05	
Fe-55	1.02E-06	1.83E-05	1.93E-05	6.64E-10	
Fr-221	6.42E+00	6.77E-01	7.09E+00	2.72E-01	
Fr-223	1.15E+00	2.65E-03	1.15E+00	3.01E-03	
Gd-152	4.16E-13	3.46E-11	3.50E-11	4.58E-13	
Gd-153	7.13E-34	2.17E-30	2.17E-30	1.93E-33	
H-3	4.46E+03	1.18E+02	4.57E+03	1.55E-01	
Ho-166m	3.63E-03	0.00E+00	3.63E-03	3.82E-05	
I-129	1.45E-03	8.82E-01	8.83E-01	4.72E-04	
In-115	0.00E+00	7.47E-17	7.47E-17	6.76E-20	
Ir-194	0.00E+00	1.98E-05	1.98E-05	1.06E-07	
K-40	4.84E-02	0.00E+00	4.84E-02	1.95E-04	
K-42	0.00E+00	1.75E-02	1.75E-02	1.77E-04	
Kr-85	1.61E-03	1.84E+01	1.84E+01	2.76E-02	
Mn-54	5.06E-24	5.53E-21	5.54E-21	2.76E-23	
Mo-93	0.00E+00	4.49E-01	4.49E-01	4.33E-05	
Na-22	6.34E-07	3.08E-09	6.37E-07	9.01E-09	
Nb-91	0.00E+00	3.81E-02	3.81E-02	3.97E-06	
Nb-93m	1.24E-02	6.31E-01	6.44E-01	1.20E-04	
Nb-94	1.61E-03	3.59E+00	3.59E+00	3.68E-02	
Nd-144	1.36E-12	1.57E-12	2.93E-12	3.31E-14	
Ni-59	1.69E-07	3.94E+00	3.94E+00	1.61E-04	

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Radionuclide ID	CH Inventory in 2083 [a] (Ci)	RH Inventory in 2083 [a] (Ci)	Total Inventory in 2083 (Ci)	Wattage [b] (W)	Wattage Fraction (selected) (%)
Ni-63	5.92E+02	4.09E+02	1.00E+03	1.03E-01	
Np-235	0.00E+00	3.62E-18	3.62E-18	3.82E-22	
Np-237	7.85E+01	1.31E+01	9.15E+01	2.69E+00	
Np-238	1.09E-04	9.43E-03	9.54E-03	4.75E-05	
Np-239	3.32E+01	5.74E+02	6.08E+02	1.61E+00	
Np-240	8.34E-05	1.47E-08	8.35E-05	7.73E-07	
Np-240m	6.95E-02	1.23E-05	6.95E-02	4.12E-04	
Os-194	0.00E+00	1.98E-05	1.98E-05	5.86E-09	
Pa-231	2.61E+01	3.25E-03	2.61E+01	7.97E-01	
Pa-233	7.85E+01	1.31E+01	9.15E+01	2.38E-01	
Pa-234	1.40E-01	4.56E-03	1.45E-01	1.61E-03	
Pa-234m	1.08E+02	3.50E+00	1.11E+02	5.51E-01	
Pb-209	6.42E+00	6.76E-01	7.09E+00	8.30E-03	
Pb-210	1.89E+00	7.12E+00	9.01E+00	2.44E-03	
Pb-211	8.33E+01	1.92E-01	8.35E+01	2.57E-01	
Pb-212	1.23E+04	3.68E+00	1.23E+04	2.35E+01	
Pb-214	2.21E+00	7.57E+00	9.78E+00	3.18E-02	
Pd-107	1.50E-05	1.04E-02	1.05E-02	5.95E-07	
Pm-145	0.00E+00	1.33E-01	1.33E-01	3.47E-05	
Pm-146	1.20E-09	6.33E-04	6.33E-04	3.17E-06	
Pm-147	6.69E-05	4.52E-05	1.12E-04	4.11E-08	
Po-210	1.89E+00	7.13E+00	9.01E+00	2.89E-01	
Po-211	2.29E-01	5.29E-04	2.30E-01	1.03E-02	
Po-212	7.91E+03	2.36E+00	7.91E+03	4.20E+02	
Po-213	6.28E+00	6.62E-01	6.94E+00	3.51E-01	
Po-214	2.21E+00	7.57E+00	9.78E+00	4.54E-01	
Po-215	8.33E+01	1.92E-01	8.35E+01	3.73E+00	
Po-216	1.23E+04	3.68E+00	1.23E+04	5.06E+02	
Po-218	2.21E+00	7.57E+00	9.78E+00	3.55E-01	
Pr-144	1.41E-23	6.49E-22	6.64E-22	4.87E-24	
Pr-144m	1.97E-25	9.09E-24	9.29E-24	3.35E-27	

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Radionuclide ID	CH Inventory in 2083 [a] (Ci)	RH Inventory in 2083 [a] (Ci)	Total Inventory in 2083 (Ci)	Wattage [b] (W)	Wattage Fraction (selected) (%)
Pu-236	2.90E-15	2.96E-07	2.96E-07	1.03E-08	
Pu-238	1.57E+06	2.58E+04	1.60E+06	5.30E+04	18.79%
Pu-239	4.17E+06	4.53E+03	4.17E+06	1.30E+05	46.02%
Pu-240	1.10E+06	4.55E+03	1.11E+06	3.45E+04	12.24%
Pu-241	5.81E+05	8.60E+03	5.90E+05	1.89E+01	
Pu-242	2.86E+02	2.39E+01	3.10E+02	9.16E+00	0.00%
Pu-243	9.23E-01	8.64E-04	9.24E-01	1.09E-03	
Pu-244	6.96E-02	1.23E-05	6.96E-02	2.03E-03	
Pu-246	3.13E-08	0.00E+00	3.13E-08	4.80E-11	
Ra-223	8.33E+01	1.92E-01	8.35E+01	2.96E+00	
Ra-224	1.23E+04	3.68E+00	1.23E+04	4.24E+02	
Ra-225	6.42E+00	6.77E-01	7.09E+00	5.02E-03	
Ra-226	2.21E+00	7.57E+00	9.78E+00	2.83E-01	
Ra-228	1.08E-01	2.07E-02	1.29E-01	1.25E-05	
Rb-87	1.87E-10	1.57E-06	1.57E-06	1.08E-09	
Rh-102	0.00E+00	7.23E-35	7.23E-35	2.91E-37	
Rh-106	1.17E-17	1.08E-15	1.09E-15	1.05E-17	
Rn-219	8.33E+01	1.92E-01	8.35E+01	3.44E+00	
Rn-220	1.23E+04	3.68E+00	1.23E+04	4.69E+02	
Rn-222	2.21E+00	7.57E+00	9.78E+00	3.24E-01	
Ru-106	1.17E-17	1.08E-15	1.09E-15	6.49E-20	
Sb-125	8.78E-08	3.74E-05	3.75E-05	1.20E-07	
Sb-126	1.21E-06	1.19E-02	1.19E-02	2.20E-04	
Sb-126m	1.31E-05	1.34E-01	1.34E-01	1.73E-03	
Se-79	1.22E-04	1.41E-01	1.41E-01	4.43E-05	
Sm-145	0.00E+00	8.68E-22	8.68E-22	4.89E-25	
Sm-146	1.81E-13	4.00E-08	4.00E-08	6.00E-10	
Sm-147	1.73E-08	3.86E-07	4.04E-07	5.53E-09	
Sm-148	1.63E-15	2.83E-19	1.63E-15	1.92E-17	
Sm-151	1.14E+01	6.65E+01	7.79E+01	9.24E-03	
Sn-119m	0.00E+00	1.26E-24	1.26E-24	6.97E-28	

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Radionuclide ID	CH Inventory in 2083 [a] (Ci)	RH Inventory in 2083 [a] (Ci)	Total Inventory in 2083 (Ci)	Wattage [b] (W)	Wattage Fraction (selected) (%)
Sn-121	4.55E-05	8.15E-01	8.15E-01	5.58E-04	
Sn-121m	5.87E-05	1.05E+00	1.05E+00	2.52E-04	
Sn-126	1.31E-05	1.34E-01	1.34E-01	1.54E-04	
Sr-90	2.30E+02	6.06E+04	6.08E+04	7.06E+01	
Tb-157	0.00E+00	8.26E-02	8.26E-02	5.58E-06	
Tc-97	0.00E+00	3.64E-08	3.64E-08	3.65E-12	
Tc-99	2.18E+01	5.65E+02	5.87E+02	3.53E-01	
Te-123	6.98E-22	1.92E-14	1.92E-14	3.52E-19	
Te-125m	2.14E-08	9.14E-06	9.16E-06	7.88E-09	
Th-227	8.22E+01	1.90E-01	8.24E+01	3.02E+00	
Th-228	1.23E+04	3.68E+00	1.23E+04	4.04E+02	
Th-229	6.42E+00	6.77E-01	7.09E+00	2.18E-01	
Th-230	4.74E-01	1.49E-02	4.89E-01	1.38E-02	
Th-231	1.74E+00	2.04E+00	3.79E+00	4.24E-03	
Th-232	1.08E-01	9.77E-03	1.18E-01	2.86E-03	
Th-234	1.08E+02	3.50E+00	1.11E+02	4.81E-02	
Tl-204	1.37E-12	0.00E+00	1.37E-12	1.94E-15	
Tl-206	2.49E-06	9.41E-06	1.19E-05	3.81E-08	
Tl-207	8.31E+01	1.92E-01	8.33E+01	2.46E-01	
Tl-208	4.44E+03	1.32E+00	4.44E+03	1.04E+02	
Tl-209	1.35E-01	1.42E-02	1.49E-01	2.50E-03	
Tm-171	0.00E+00	8.61E-11	8.61E-11	1.33E-14	
U-232	1.20E+04	3.56E+00	1.20E+04	3.85E+02	
U-233	3.56E+02	1.24E+02	4.81E+02	1.40E+01	
U-234	7.36E+02	1.97E+01	7.56E+02	2.18E+01	
U-235	1.74E+00	2.04E+00	3.79E+00	1.05E-01	
U-236	3.58E+00	2.49E-01	3.83E+00	1.04E-01	
U-237	1.39E+01	2.06E-01	1.41E+01	2.87E-02	
U-238	1.08E+02	3.50E+00	1.11E+02	2.82E+00	
U-240	6.95E-02	1.23E-05	6.95E-02	5.66E-05	
V-49	0.00E+00	8.07E-21	8.07E-21	2.15E-25	

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Radionuclide ID	CH Inventory in 2083 [a] (Ci)	RH Inventory in 2083 [a] (Ci)	Total Inventory in 2083 (Ci)	Wattage [b] (W)	Wattage Fraction (selected) (%)
Y-90	2.30E+02	6.06E+04	6.08E+04	3.37E+02	
Zn-65	1.57E-29	1.73E-27	1.74E-27	6.08E-30	
Zr-93	1.24E-02	1.99E-01	2.11E-01	2.43E-05	
Total:	**9.32E+06**	**3.57E+05**	**9.68E+06**	**2.82E+05**	**98.47%**

[a] Van Soest 2025, Tables 5-3 and 5-4.
[b] Wattage is calculated using Equation 5.

Table 24 – Calculated Wattage at 2183

Radionuclide ID	CH Inventory in 2083 [a] (Ci)	RH Inventory in 2083 [a] (Ci)	Total Inventory in 2083 (Ci)	Wattage [b] (W)	Wattage Fraction (selected) (%)
Ac-225	9.48E+00	1.76E+00	1.12E+01	3.95E-01	
Ac-227	2.84E+01	1.41E-02	2.84E+01	1.44E-02	
Ac-228	1.08E-01	9.77E-03	1.18E-01	9.22E-04	
Ag-108	3.33E-04	1.28E-03	1.61E-03	5.98E-06	
Ag-108m	3.83E-03	1.47E-02	1.85E-02	1.80E-04	
Ag-109m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Ag-110	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Ag-110m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Am-241	1.54E+06	1.53E+04	1.56E+06	5.20E+04	21.59%
Am-242	1.48E-02	1.28E+00	1.29E+00	1.53E-03	
Am-242m	1.48E-02	1.28E+00	1.30E+00	5.64E-04	
Am-243	3.29E+01	5.69E+02	6.02E+02	1.94E+01	
Am-245	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Am-246	3.11E-08	0.00E+00	3.11E-08	2.72E-10	
Ar-39	0.00E+00	2.00E-02	2.00E-02	2.59E-05	
Ar-42	0.00E+00	2.13E-03	2.13E-03	2.93E-06	
At-217	9.48E+00	1.76E+00	1.12E+01	4.80E-01	
Ba-133	1.16E-07	1.19E-04	1.19E-04	3.22E-07	
Ba-137m	9.85E+00	7.72E+03	7.73E+03	3.03E+01	
Bi-210	2.15E+00	7.33E+00	9.48E+00	2.19E-02	
Bi-211	2.84E+01	1.41E-02	2.84E+01	1.13E+00	

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Radionuclide ID	CH Inventory in 2083 [a] (Ci)	RH Inventory in 2083 [a] (Ci)	Total Inventory in 2083 (Ci)	Wattage [b] (W)	Wattage Fraction (selected) (%)
Bi-212	4.57E+03	1.37E+00	4.57E+03	7.66E+01	
Bi-213	9.48E+00	1.76E+00	1.12E+01	4.64E-02	
Bi-214	2.15E+00	7.25E+00	9.41E+00	1.20E-01	
Bk-249	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Bk-250	1.74E-08	0.00E+00	1.74E-08	1.23E-10	
C-14	1.50E-01	1.24E+00	1.39E+00	4.08E-04	
Cd-109	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Cd-113	1.65E-22	9.65E-18	9.65E-18	5.30E-21	
Cd-113m	2.95E-08	1.17E-03	1.17E-03	1.28E-06	
Ce-144	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Cf-249	6.97E+00	6.89E+01	7.59E+01	2.83E+00	
Cf-250	2.69E-03	1.33E-01	1.35E-01	5.04E-03	
Cf-251	3.14E-01	2.55E+01	2.58E+01	9.46E-01	
Cf-252	7.17E-17	3.30E-16	4.02E-16	3.05E-17	
Cl-36	2.08E-07	1.17E-01	1.17E-01	1.90E-04	
Cm-242	1.22E-02	1.05E+00	1.07E+00	3.93E-02	
Cm-243	3.12E-01	2.79E+00	3.11E+00	1.13E-01	
Cm-244	4.01E+01	2.22E+02	2.62E+02	9.17E+00	
Cm-245	4.49E+00	2.00E+01	2.45E+01	8.20E-01	
Cm-246	9.86E+01	7.18E+02	8.17E+02	2.68E+01	
Cm-247	9.23E-01	9.79E-04	9.24E-01	2.93E-02	
Cm-248	1.63E+00	3.62E+00	5.25E+00	7.02E-01	
Cm-250	1.25E-07	0.00E+00	1.25E-07	1.19E-07	
Co-60	1.02E-09	1.51E-06	1.51E-06	2.33E-08	
Cs-134	2.59E-24	8.71E-21	8.71E-21	8.88E-23	
Cs-135	1.50E-03	5.78E-02	5.93E-02	3.14E-05	
Cs-137	1.04E+01	8.18E+03	8.19E+03	9.15E+00	
Eu-152	2.99E-03	2.54E-01	2.57E-01	1.99E-03	
Eu-154	1.40E-05	1.94E-02	1.94E-02	1.75E-04	
Eu-155	1.69E-10	2.74E-08	2.76E-08	2.06E-11	
Fe-55	9.55E-18	1.72E-16	1.81E-16	6.23E-21	
Fr-221	9.48E+00	1.76E+00	1.12E+01	4.30E-01	
Fr-223	3.92E-01	1.94E-04	3.92E-01	1.03E-03	

Information Only

Radionuclide ID	CH Inventory in 2083 [a] (Ci)	RH Inventory in 2083 [a] (Ci)	Total Inventory in 2083 (Ci)	Wattage [b] (W)	Wattage Fraction (selected) (%)
Gd-152	4.35E-13	3.62E-11	3.66E-11	4.79E-13	
Gd-153	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
H-3	1.61E+01	4.26E-01	1.65E+01	5.59E-04	
Ho-166m	3.43E-03	0.00E+00	3.43E-03	3.61E-05	
I-129	1.45E-03	8.82E-01	8.83E-01	4.72E-04	
In-115	0.00E+00	7.47E-17	7.47E-17	6.76E-20	
Ir-194	0.00E+00	1.90E-10	1.90E-10	1.02E-12	
K-40	4.84E-02	0.00E+00	4.84E-02	1.95E-04	
K-42	0.00E+00	2.13E-03	2.13E-03	2.15E-05	
Kr-85	2.50E-06	2.86E-02	2.86E-02	4.29E-05	
Mn-54	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Mo-93	0.00E+00	4.40E-01	4.40E-01	4.25E-05	
Na-22	1.70E-18	8.27E-21	1.71E-18	2.42E-20	
Nb-91	0.00E+00	3.44E-02	3.44E-02	3.59E-06	
Nb-93m	1.24E-02	5.62E-01	5.74E-01	1.07E-04	
Nb-94	1.61E-03	3.58E+00	3.58E+00	3.66E-02	
Nd-144	1.36E-12	1.57E-12	2.93E-12	3.31E-14	
Ni-59	1.69E-07	3.93E+00	3.93E+00	1.61E-04	
Ni-63	2.96E+02	2.04E+02	5.01E+02	5.16E-02	
Np-235	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Np-237	1.32E+02	1.36E+01	1.46E+02	4.29E+00	
Np-238	6.67E-05	5.77E-03	5.83E-03	2.90E-05	
Np-239	3.29E+01	5.69E+02	6.02E+02	1.59E+00	
Np-240	8.34E-05	1.82E-08	8.35E-05	7.73E-07	
Np-240m	6.95E-02	1.52E-05	6.96E-02	4.12E-04	
Os-194	0.00E+00	1.90E-10	1.90E-10	5.61E-14	
Pa-231	2.60E+01	7.56E-03	2.60E+01	7.96E-01	
Pa-233	1.32E+02	1.36E+01	1.46E+02	3.79E-01	
Pa-234	1.40E-01	4.56E-03	1.45E-01	1.61E-03	
Pa-234m	1.08E+02	3.50E+00	1.11E+02	5.51E-01	
Pb-209	9.48E+00	1.76E+00	1.12E+01	1.32E-02	
Pb-210	2.15E+00	7.33E+00	9.48E+00	2.57E-03	
Pb-211	2.84E+01	1.41E-02	2.84E+01	8.74E-02	

Information Only

Radionuclide ID	CH Inventory in 2083 [a] (Ci)	RH Inventory in 2083 [a] (Ci)	Total Inventory in 2083 (Ci)	Wattage [b] (W)	Wattage Fraction (selected) (%)
Pb-212	4.57E+03	1.37E+00	4.57E+03	8.72E+00	
Pb-214	2.15E+00	7.25E+00	9.41E+00	3.06E-02	
Pd-107	1.50E-05	1.04E-02	1.05E-02	5.95E-07	
Pm-145	0.00E+00	2.65E-03	2.65E-03	6.92E-07	
Pm-146	4.31E-15	2.28E-09	2.28E-09	1.14E-11	
Pm-147	2.24E-16	1.51E-16	3.75E-16	1.38E-19	
Po-210	2.15E+00	7.33E+00	9.48E+00	3.04E-01	
Po-211	7.81E-02	3.88E-05	7.82E-02	3.52E-03	
Po-212	2.93E+03	8.75E-01	2.93E+03	1.56E+02	
Po-213	9.28E+00	1.72E+00	1.10E+01	5.57E-01	
Po-214	2.15E+00	7.25E+00	9.40E+00	4.37E-01	
Po-215	2.84E+01	1.41E-02	2.84E+01	1.27E+00	
Po-216	4.57E+03	1.37E+00	4.57E+03	1.87E+02	
Po-218	2.15E+00	7.25E+00	9.41E+00	3.41E-01	
Pr-144	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Pr-144m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Pu-236	1.21E-25	1.23E-17	1.23E-17	4.29E-19	
Pu-238	7.13E+05	1.17E+04	7.25E+05	2.40E+04	9.98%
Pu-239	4.16E+06	4.52E+03	4.16E+06	1.29E+05	53.72%
Pu-240	1.09E+06	4.53E+03	1.10E+06	3.41E+04	14.17%
Pu-241	4.64E+03	8.84E+01	4.73E+03	1.51E-01	
Pu-242	2.86E+02	2.40E+01	3.10E+02	9.16E+00	0.00%
Pu-243	9.23E-01	9.79E-04	9.24E-01	1.09E-03	
Pu-244	6.96E-02	1.52E-05	6.96E-02	2.03E-03	
Pu-246	3.11E-08	0.00E+00	3.11E-08	4.78E-11	
Ra-223	2.84E+01	1.41E-02	2.84E+01	1.01E+00	
Ra-224	4.57E+03	1.37E+00	4.57E+03	1.57E+02	
Ra-225	9.48E+00	1.76E+00	1.12E+01	7.96E-03	
Ra-226	2.15E+00	7.25E+00	9.41E+00	2.72E-01	
Ra-228	1.08E-01	9.77E-03	1.18E-01	1.14E-05	
Rb-87	1.87E-10	1.57E-06	1.57E-06	1.08E-09	
Rh-102	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Rh-106	0.00E+00	0.00E+00	0.00E+00	0.00E+00	

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Radionuclide ID	CH Inventory in 2083 [a] (Ci)	RH Inventory in 2083 [a] (Ci)	Total Inventory in 2083 (Ci)	Wattage [b] (W)	Wattage Fraction (selected) (%)
Rn-219	2.84E+01	1.41E-02	2.84E+01	1.17E+00	
Rn-220	4.57E+03	1.37E+00	4.57E+03	1.74E+02	
Rn-222	2.15E+00	7.25E+00	9.41E+00	3.12E-01	
Ru-106	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Sb-125	8.24E-19	3.51E-16	3.52E-16	1.12E-18	
Sb-126	1.21E-06	1.19E-02	1.19E-02	2.20E-04	
Sb-126m	1.31E-05	1.34E-01	1.34E-01	1.73E-03	
Se-79	1.22E-04	1.41E-01	1.41E-01	4.43E-05	
Sm-145	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Sm-146	1.81E-13	4.00E-08	4.00E-08	6.00E-10	
Sm-147	1.73E-08	3.86E-07	4.04E-07	5.53E-09	
Sm-148	1.63E-15	2.83E-19	1.63E-15	1.92E-17	
Sm-151	5.29E+00	3.08E+01	3.61E+01	4.28E-03	
Sn-119m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Sn-121	1.29E-05	2.31E-01	2.31E-01	1.58E-04	
Sn-121m	1.66E-05	2.98E-01	2.98E-01	7.15E-05	
Sn-126	1.31E-05	1.34E-01	1.34E-01	1.54E-04	
Sr-90	1.96E+01	5.16E+03	5.18E+03	6.01E+00	
Tb-157	0.00E+00	5.20E-02	5.20E-02	3.52E-06	
Tc-97	0.00E+00	3.64E-08	3.64E-08	3.65E-12	
Tc-99	2.18E+01	5.65E+02	5.87E+02	3.52E-01	
Te-123	6.98E-22	1.92E-14	1.92E-14	3.52E-19	
Te-125m	2.01E-19	8.57E-17	8.59E-17	7.39E-20	
Th-227	2.80E+01	1.39E-02	2.80E+01	1.03E+00	
Th-228	4.57E+03	1.37E+00	4.57E+03	1.50E+02	
Th-229	9.48E+00	1.76E+00	1.12E+01	3.45E-01	
Th-230	1.31E+00	3.56E-02	1.34E+00	3.80E-02	
Th-231	2.15E+00	2.04E+00	4.20E+00	4.70E-03	
Th-232	1.08E-01	9.77E-03	1.18E-01	2.86E-03	
Th-234	1.08E+02	3.50E+00	1.11E+02	4.81E-02	
Tl-204	1.49E-20	0.00E+00	1.49E-20	2.11E-23	
Tl-206	2.84E-06	9.67E-06	1.25E-05	4.01E-08	
Tl-207	2.83E+01	1.41E-02	2.84E+01	8.36E-02	

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Radionuclide ID	CH Inventory in 2083 [a] (Ci)	RH Inventory in 2083 [a] (Ci)	Total Inventory in 2083 (Ci)	Wattage [b] (W)	Wattage Fraction (selected) (%)
Tl-208	1.64E+03	4.91E-01	1.64E+03	3.87E+01	
Tl-209	1.99E-01	3.70E-02	2.36E-01	3.96E-03	
Tm-171	0.00E+00	1.81E-26	1.81E-26	2.80E-30	
U-232	4.45E+03	1.32E+00	4.45E+03	1.43E+02	
U-233	3.56E+02	1.24E+02	4.81E+02	1.40E+01	
U-234	1.04E+03	2.47E+01	1.07E+03	3.07E+01	
U-235	2.15E+00	2.04E+00	4.20E+00	1.17E-01	
U-236	6.83E+00	2.62E-01	7.09E+00	1.92E-01	
U-237	1.11E-01	2.12E-03	1.13E-01	2.30E-04	
U-238	1.08E+02	3.50E+00	1.11E+02	2.82E+00	
U-240	6.95E-02	1.52E-05	6.96E-02	5.67E-05	
V-49	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Y-90	1.96E+01	5.17E+03	5.18E+03	2.87E+01	
Zn-65	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Zr-93	1.24E-02	1.99E-01	2.11E-01	2.43E-05	
Total:	**7.54E+06**	**6.57E+04**	**7.61E+06**	**2.41E+05**	**99.46%**

[a] Van Soest 2025, Tables 5-3 and 5-4.
[b] Wattage is calculated using Equation 5.

Table 25 – Calculated Wattage at 12083

Radionuclide ID	CH Inventory in 2083 [a] (Ci)	RH Inventory in 2083 [a] (Ci)	Total Inventory in 2083 (Ci)	Wattage [b] (W)	Wattage Fraction (selected) (%)
Ac-225	2.12E+02	7.16E+01	2.83E+02	9.97E+00	
Ac-227	2.51E+01	3.96E-01	2.55E+01	1.29E-02	
Ac-228	1.08E-01	9.77E-03	1.18E-01	9.22E-04	
Ag-108	1.14E-27	4.37E-27	5.50E-27	2.04E-29	
Ag-108m	1.31E-26	5.02E-26	6.33E-26	6.14E-28	
Ag-109m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Ag-110	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Ag-110m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Am-241	2.34E+00	1.03E+01	1.26E+01	4.22E-01	0.00%

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Radionuclide ID	CH Inventory in 2083 [a] (Ci)	RH Inventory in 2083 [a] (Ci)	Total Inventory in 2083 (Ci)	Wattage [b] (W)	Wattage Fraction (selected) (%)
Am-242	1.08E-23	9.33E-22	9.43E-22	1.12E-24	
Am-242m	1.08E-23	9.37E-22	9.48E-22	4.12E-25	
Am-243	1.35E+01	2.24E+02	2.38E+02	7.67E+00	
Am-245	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Am-246	2.10E-08	0.00E+00	2.10E-08	1.83E-10	
Ar-39	0.00E+00	1.66E-13	1.66E-13	2.16E-16	
Ar-42	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
At-217	2.12E+02	7.16E+01	2.83E+02	1.21E+01	
Ba-133	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Ba-137m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Bi-210	8.75E+01	2.06E+00	8.96E+01	2.07E-01	
Bi-211	2.51E+01	3.96E-01	2.55E+01	1.02E+00	
Bi-212	1.08E-01	9.77E-03	1.18E-01	1.98E-03	
Bi-213	2.12E+02	7.15E+01	2.83E+02	1.17E+00	
Bi-214	8.76E+01	2.06E+00	8.96E+01	1.14E+00	
Bk-249	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Bk-250	1.18E-08	0.00E+00	1.18E-08	8.32E-11	
C-14	4.54E-02	3.74E-01	4.19E-01	1.23E-04	
Cd-109	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Cd-113	1.65E-22	9.66E-18	9.66E-18	5.30E-21	
Cd-113m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Ce-144	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Cf-249	2.18E-08	2.16E-07	2.38E-07	8.87E-09	
Cf-250	1.18E-08	0.00E+00	1.18E-08	4.38E-10	
Cf-251	1.51E-04	1.22E-02	1.24E-02	4.54E-04	
Cf-252	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Cl-36	2.03E-07	1.15E-01	1.15E-01	1.86E-04	
Cm-242	8.95E-24	7.74E-22	7.83E-22	2.88E-23	
Cm-243	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Cm-244	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Cm-245	2.13E+00	1.03E+01	1.24E+01	4.14E-01	

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Radionuclide ID	CH Inventory in 2083 [a] (Ci)	RH Inventory in 2083 [a] (Ci)	Total Inventory in 2083 (Ci)	Wattage [b] (W)	Wattage Fraction (selected) (%)
Cm-246	2.31E+01	1.68E+02	1.92E+02	6.28E+00	
Cm-247	9.23E-01	2.41E-03	9.25E-01	2.94E-02	
Cm-248	1.60E+00	3.54E+00	5.14E+00	6.88E-01	
Cm-250	8.40E-08	0.00E+00	8.40E-08	8.03E-08	
Co-60	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Cs-134	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Cs-135	1.50E-03	5.76E-02	5.91E-02	3.13E-05	
Cs-137	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Eu-152	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Eu-154	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Eu-155	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Fe-55	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Fr-221	2.12E+02	7.16E+01	2.83E+02	1.09E+01	
Fr-223	3.47E-01	5.47E-03	3.52E-01	9.22E-04	
Gd-152	4.35E-13	3.62E-11	3.66E-11	4.79E-13	
Gd-153	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
H-3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Ho-166m	1.13E-05	0.00E+00	1.13E-05	1.18E-07	
I-129	1.45E-03	8.81E-01	8.83E-01	4.72E-04	
In-115	0.00E+00	7.47E-17	7.47E-17	6.76E-20	
Ir-194	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
K-40	4.84E-02	0.00E+00	4.84E-02	1.95E-04	
K-42	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Kr-85	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Mn-54	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Mo-93	0.00E+00	6.18E-02	6.18E-02	5.98E-06	
Na-22	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Nb-91	0.00E+00	1.42E-06	1.42E-06	1.48E-10	
Nb-93m	1.23E-02	2.49E-01	2.61E-01	4.86E-05	
Nb-94	1.15E-03	2.55E+00	2.55E+00	2.61E-02	
Nd-144	1.36E-12	1.57E-12	2.93E-12	3.31E-14	

Information Only

Radionuclide ID	CH Inventory in 2083 [a] (Ci)	RH Inventory in 2083 [a] (Ci)	Total Inventory in 2083 (Ci)	Wattage [b] (W)	Wattage Fraction (selected) (%)
Ni-59	1.54E-07	3.59E+00	3.59E+00	1.47E-04	
Ni-63	4.99E-28	3.44E-28	8.43E-28	8.69E-32	
Np-235	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Np-237	4.42E+02	1.67E+01	4.59E+02	1.35E+01	
Np-238	4.88E-26	4.22E-24	4.26E-24	2.12E-26	
Np-239	1.35E+01	2.24E+02	2.38E+02	6.30E-01	
Np-240	8.36E-05	3.56E-07	8.39E-05	7.78E-07	
Np-240m	6.97E-02	2.97E-04	7.00E-02	4.15E-04	
Os-194	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Pa-231	2.51E+01	3.96E-01	2.55E+01	7.80E-01	
Pa-233	4.42E+02	1.67E+01	4.59E+02	1.19E+00	
Pa-234	1.40E-01	4.56E-03	1.45E-01	1.61E-03	
Pa-234m	1.08E+02	3.50E+00	1.11E+02	5.51E-01	
Pb-209	2.12E+02	7.15E+01	2.83E+02	3.32E-01	
Pb-210	8.75E+01	2.06E+00	8.96E+01	2.43E-02	
Pb-211	2.51E+01	3.96E-01	2.55E+01	7.85E-02	
Pb-212	1.08E-01	9.77E-03	1.18E-01	2.25E-04	
Pb-214	8.76E+01	2.06E+00	8.96E+01	2.91E-01	
Pd-107	1.50E-05	1.04E-02	1.04E-02	5.95E-07	
Pm-145	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Pm-146	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Pm-147	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Po-210	8.75E+01	2.06E+00	8.96E+01	2.87E+00	
Po-211	6.91E-02	1.09E-03	7.02E-02	3.16E-03	
Po-212	6.94E-02	6.26E-03	7.57E-02	4.02E-03	
Po-213	2.07E+02	7.00E+01	2.77E+02	1.40E+01	
Po-214	8.75E+01	2.06E+00	8.96E+01	4.16E+00	
Po-215	2.51E+01	3.96E-01	2.55E+01	1.14E+00	
Po-216	1.08E-01	9.77E-03	1.18E-01	4.84E-03	
Po-218	8.76E+01	2.06E+00	8.96E+01	3.25E+00	
Pr-144	0.00E+00	0.00E+00	0.00E+00	0.00E+00	

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Radionuclide ID	CH Inventory in 2083 [a] (Ci)	RH Inventory in 2083 [a] (Ci)	Total Inventory in 2083 (Ci)	Wattage [b] (W)	Wattage Fraction (selected) (%)
Pr-144m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Pu-236	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Pu-238	2.38E-23	2.06E-21	2.08E-21	6.90E-23	0.00%
Pu-239	3.13E+06	3.49E+03	3.13E+06	9.73E+04	88.88%
Pu-240	3.83E+05	1.59E+03	3.85E+05	1.20E+04	10.95%
Pu-241	2.14E+00	1.03E+01	1.24E+01	3.97E-04	
Pu-242	2.82E+02	3.05E+01	3.12E+02	9.23E+00	0.01%
Pu-243	9.23E-01	2.41E-03	9.25E-01	1.09E-03	
Pu-244	6.97E-02	2.97E-04	7.00E-02	2.04E-03	
Pu-246	2.10E-08	0.00E+00	2.10E-08	3.22E-11	
Ra-223	2.51E+01	3.96E-01	2.55E+01	9.07E-01	
Ra-224	1.08E-01	9.77E-03	1.18E-01	4.06E-03	
Ra-225	2.12E+02	7.16E+01	2.83E+02	2.01E-01	
Ra-226	8.76E+01	2.06E+00	8.96E+01	2.59E+00	
Ra-228	1.08E-01	9.77E-03	1.18E-01	1.14E-05	
Rb-87	1.87E-10	1.57E-06	1.57E-06	1.08E-09	
Rh-102	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Rh-106	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Rn-219	2.51E+01	3.96E-01	2.55E+01	1.05E+00	
Rn-220	1.08E-01	9.77E-03	1.18E-01	4.49E-03	
Rn-222	8.76E+01	2.06E+00	8.96E+01	2.97E+00	
Ru-106	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Sb-125	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Sb-126	1.13E-06	1.11E-02	1.11E-02	2.05E-04	
Sb-126m	1.22E-05	1.25E-01	1.25E-01	1.61E-03	
Se-79	1.19E-04	1.38E-01	1.38E-01	4.32E-05	
Sm-145	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Sm-146	1.81E-13	4.00E-08	4.00E-08	6.00E-10	
Sm-147	1.73E-08	3.86E-07	4.04E-07	5.53E-09	
Sm-148	1.63E-15	2.83E-19	1.63E-15	1.92E-17	
Sm-151	4.03E-33	2.35E-32	2.75E-32	3.26E-36	

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Radionuclide ID	CH Inventory in 2083 [a] (Ci)	RH Inventory in 2083 [a] (Ci)	Total Inventory in 2083 (Ci)	Wattage [b] (W)	Wattage Fraction (selected) (%)
Sn-119m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Sn-121	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Sn-121m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Sn-126	1.22E-05	1.25E-01	1.25E-01	1.44E-04	
Sr-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Tb-157	0.00E+00	7.05E-22	7.05E-22	4.76E-26	
Tc-97	0.00E+00	3.63E-08	3.63E-08	3.64E-12	
Tc-99	2.11E+01	5.47E+02	5.68E+02	3.41E-01	
Te-123	6.98E-22	1.92E-14	1.92E-14	3.52E-19	
Te-125m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Th-227	2.48E+01	3.91E-01	2.52E+01	9.25E-01	
Th-228	1.08E-01	9.77E-03	1.18E-01	3.87E-03	
Th-229	2.12E+02	7.16E+01	2.83E+02	8.70E+00	
Th-230	1.12E+02	2.51E+00	1.15E+02	3.25E+00	
Th-231	3.74E+01	2.08E+00	3.95E+01	4.43E-02	
Th-232	1.08E-01	9.77E-03	1.18E-01	2.86E-03	
Th-234	1.08E+02	3.50E+00	1.11E+02	4.81E-02	
Tl-204	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Tl-206	1.16E-04	2.71E-06	1.18E-04	3.78E-07	
Tl-207	2.51E+01	3.95E-01	2.55E+01	7.51E-02	
Tl-208	3.90E-02	3.51E-03	4.25E-02	1.00E-03	
Tl-209	4.45E+00	1.50E+00	5.95E+00	9.98E-02	
Tm-171	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
U-232	8.85E-40	0.00E+00	8.85E-40	2.84E-41	
U-233	3.59E+02	1.20E+02	4.79E+02	1.39E+01	
U-234	1.26E+03	2.82E+01	1.29E+03	3.72E+01	
U-235	3.74E+01	2.08E+00	3.95E+01	1.10E+00	
U-236	2.05E+02	1.09E+00	2.06E+02	5.59E+00	
U-237	5.11E-05	2.46E-04	2.97E-04	6.04E-07	
U-238	1.08E+02	3.50E+00	1.11E+02	2.82E+00	
U-240	6.97E-02	2.97E-04	7.00E-02	5.70E-05	

Information Only

Radionuclide ID	CH Inventory in 2083 [a] (Ci)	RH Inventory in 2083 [a] (Ci)	Total Inventory in 2083 (Ci)	Wattage [b] (W)	Wattage Fraction (selected) (%)
V-49	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Y-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Zn-65	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Zr-93	1.23E-02	1.98E-01	2.10E-01	2.42E-05	
Total:	**3.52E+06**	**7.12E+03**	**3.52E+06**	**1.09E+05**	**99.84%**

[a] Van Soest 2025, Tables 5-3 and 5-4.
[b] Wattage is calculated using Equation 5.

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16.0 APPENDIX D – PARAMETER DATA ENTRY TABLES

The following tables identify parameter value changes associated with the inventory provided by FRPAIR-2024 (Van Soest 2025). The data found in Table 26 through Table 30 support Parameter Data Entry form NP 9-2-1 for changing parameters affected by this document. The data in Table 27 and Table 29 are provided directly from FRPAIR-2024 (Van Soest 2025). The data in Table 26, Table 28, and Table 30 are calculated within this report using inputs provided by FRPAIR-2024.

Table 26 – Waste Unit Factor (WUF) Parameter Change

Material	Property	Value / Median	Units	Distribution	Source
BOREHOLE	WUF	8.68	NONE	Constant	Appendix B, Table 21

NOTE: The WUF parameter is used by PA codes EPAUNI, NUTS, PANEL, and PRECCDFGF.

Table 27 – Radionuclide Parameter Changes

Material	Property	Value / Median	Units	Distribution	Source
AM241	INVCHD	1.79E+06	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-3)
AM241	INVRHD	1.77E+04	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-4)
AM243	INVCHD	3.32E+01	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-3)
AM243	INVRHD	5.74E+02	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-4)
CF252	INVCHD	1.73E-05	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-3)
CF252	INVRHD	7.95E-05	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-4)
CM243	INVCHD	3.55E+00	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-3)
CM243	INVRHD	3.18E+01	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-4)
CM244	INVCHD	1.85E+03	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-3)
CM244	INVRHD	1.02E+04	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-4)
CM245	INVCHD	4.46E+00	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-3)

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Material	Property	Value / Median	Units	Distribution	Source
CM245	INVRHD	1.96E+01	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-4)
CM248	INVCHD	1.63E+00	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-3)
CM248	INVRHD	3.62E+00	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-4)
CS137	INVCHD	1.05E+02	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-3)
CS137	INVRHD	8.25E+04	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-4)
NP237	INVCHD	7.85E+01	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-3)
NP237	INVRHD	1.31E+01	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-4)
PA231	INVCHD	2.61E+01	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-3)
PA231	INVRHD	3.25E-03	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-4)
PB210	INVCHD	1.89E+00	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-3)
PB210	INVRHD	7.12E+00	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-4)
PM147	INVCHD	6.69E-05	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-3)
PM147	INVRHD	4.52E-05	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-4)
PU238	INVCHD	1.57E+06	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-3)
PU238	INVRHD	2.58E+04	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-4)
PU239	INVCHD	4.17E+06	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-3)
PU239	INVRHD	4.53E+03	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-4)
PU240	INVCHD	1.10E+06	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-3)
PU240	INVRHD	4.55E+03	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-4)
PU241	INVCHD	5.81E+05	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-3)

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Material	Property	Value / Median	Units	Distribution	Source
PU241	INVRHD	8.60E+03	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-4)
PU242	INVCHD	2.86E+02	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-3)
PU242	INVRHD	2.39E+01	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-4)
PU244	INVCHD	6.96E-02	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-3)
PU244	INVRHD	1.23E-05	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-4)
RA226	INVCHD	2.21E+00	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-3)
RA226	INVRHD	7.57E+00	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-4)
RA228	INVCHD	1.08E-01	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-3)
RA228	INVRHD	2.07E-02	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-4)
SM147	INVCHD	1.73E-08	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-3)
SM147	INVRHD	3.86E-07	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-4)
SR90	INVCHD	2.30E+02	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-3)
SR90	INVRHD	6.06E+04	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-4)
TH229	INVCHD	6.42E+00	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-3)
TH229	INVRHD	6.77E-01	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-4)
TH230	INVCHD	4.74E-01	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-3)
TH230	INVRHD	1.49E-02	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-4)
TH232	INVCHD	1.08E-01	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-3)
TH232	INVRHD	9.77E-03	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-4)
U233	INVCHD	3.56E+02	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-3)

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Material	Property	Value / Median	Units	Distribution	Source
U233	INVRHD	1.24E+02	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-4)
U234	INVCHD	7.36E+02	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-3)
U234	INVRHD	1.97E+01	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-4)
U235	INVCHD	1.74E+00	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-3)
U235	INVRHD	2.04E+00	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-4)
U236	INVCHD	3.58E+00	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-3)
U236	INVRHD	2.49E-01	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-4)
U238	INVCHD	1.08E+02	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-3)
U238	INVRHD	3.50E+00	Ci	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-4)

NOTE: INVCHD and INVRHD refer to contact-handled waste and remote-handled waste, respectively. These inventory parameters are used by PA code PANEL.

Table 28 – Lumped Radionuclide Parameter Changes

Material	Property	Value / Median	Units	Distribution	Source
AM241L	INVCHD	1.81E+06	Ci	Constant	Section 7.3, Table 14
AM241L	INVRHD	1.79E+04	Ci	Constant	Section 7.3, Table 14
TH230L	INVCHD	6.89E+00	Ci	Constant	Section 7.3, Table 14
TH230L	INVRHD	6.91E-01	Ci	Constant	Section 7.3, Table 14
PU238L	INVCHD	1.57E+06	Ci	Constant	Section 7.3, Table 14
PU238L	INVRHD	2.58E+04	Ci	Constant	Section 7.3, Table 14
U234L	INVCHD	1.09E+03	Ci	Constant	Section 7.3, Table 14
U234L	INVRHD	1.44E+02	Ci	Constant	Section 7.3, Table 14
PU239L	INVCHD	5.27E+06	Ci	Constant	Section 7.3, Table 14
PU239L	INVRHD	9.46E+03	Ci	Constant	Section 7.3, Table 14

NOTE: INVCHD and INVRHD refer to contact-handled waste and remote-handled waste, respectively. These lumped inventory parameters are used by PA code NUTS.

Information Only

Table 29 – Waste Material Parameter Changes

Material	Property [a]	Description	Value / Median	Units	Distribution	Source
WAS_AREA	IRONCHW	Mass of iron-based material in CH waste	2.12E+07	kg	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-5)
WAS_AREA	IRONRHW	Mass of iron-based material in RH waste	9.43E+05	kg	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-5)
WAS_AREA	IRNCCHW	Mass of iron containers, CH waste	5.27E+07	kg	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-5)
WAS_AREA	IRNCRHW	Mass of iron containers, RH waste	1.39E+07	kg	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-5)
WAS_AREA	CELLCHW	Mass of cellulosics in CH waste	4.48E+06	kg	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-5)
WAS_AREA	CELLRHW	Mass of cellulosics in RH waste	1.77E+05	kg	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-5)
WAS_AREA	CELCCHW	Mass of cellulosics in CH waste container materials	6.01E+06	kg	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-5)
WAS_AREA	CELCRHW	Mass of cellulosics in RH waste container materials	0.00E+00	kg	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-5)
WAS_AREA	CELECHW	Mass of cellulosics in CH waste emplacement materials	3.02E+05	kg	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-7)
WAS_AREA	CELERHW	Mass of cellulosics in RH waste emplacement materials	0.00E+00 [a]	kg	Constant	Assumed based on FRPAIR-2024 data [b]
WAS_AREA	PLASCHW	Mass of plastics in CH waste	5.61E+06	kg	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-5)
WAS_AREA	PLASRHW	Mass of plastics in RH waste	3.05E+05	kg	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-5)
WAS_AREA	PLSCCHW	Mass of plastic liners, CH waste	4.61E+06	kg	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-5)
WAS_AREA	PLSCRHW	Mass of plastic liners, RH waste	1.09E+06	kg	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-5)

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Material	Property [a]	Description	Value / Median	Units	Distribution	Source
WAS_AREA	PLSECHW	Mass of plastic in CH waste emplacement materials	2.46E+06	kg	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-7)
WAS_AREA	PLSERHW	Mass of plastic in RH waste emplacement materials	0.00E+00 [a]	kg	Constant	Assumed based on FRPAIR-2024 data [b]
WAS_AREA	RUBBCHW	Mass of rubber in CH waste	1.13E+06	kg	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-5)
WAS_AREA	RUBBRHW	Mass of rubber in RH waste	4.71E+04	kg	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-5)
WAS_AREA	RUBCCHW	Mass of rubber in CH waste container materials	1.13E+05	kg	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-5)
WAS_AREA	RUBCRHW	Mass of rubber in RH waste container materials	4.96E+03	kg	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-5)
WAS_AREA	RUBECHW	Mass of rubber in CH waste emplacement materials	4.85E+03	kg	Constant	FRPAIR-2024 (Van Soest 2025, Table 5-7)
WAS_AREA	RUBERHW	Mass of rubber in RH waste emplacement materials	0.00E+00 [a]	kg	Constant	Assumed based on FRPAIR-2024 data [b]

[a] The waste material parameters are used by PA code BRAGFLO.
[b] The emplacement materials identified by Van Soest (2025, Table 5-7) are for CH waste only. Currently, no cellulosic, plastic, or rubber emplacement materials are used for RH waste emplacement.

Table 30 – Oxyanion Parameter Changes

Material	Property	Value / Median	Units	Distribution	Source
NITRATE	QINIT	2.64E+07	mol	Constant	Section 8
SULFATE	QINIT	4.95E+06	mol	Constant	Section 8

NOTE: The oxyanion parameters are used by PA code BRAGFLO.

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17.0 APPENDIX E – GENERATION OF EPAUNI INPUT FILES

This appendix provides information on the Microsoft® Excel® for Office 365 file used to generate EPAUNI input files. Excel file, *CRA26_FS_ScreeningAnalysisR0.xlsx*, was developed on a PC workstation running Windows 11 Enterprise and is available in the CVS repository at /data/cvs/CVSLIB/WIPP_EXTERNAL/ap214/Files. Additional details on EPAUNI input files are provided in the *Design Document and User's Manual for EPAUNI Version 1.21* (Kicker 2024, Section 9).

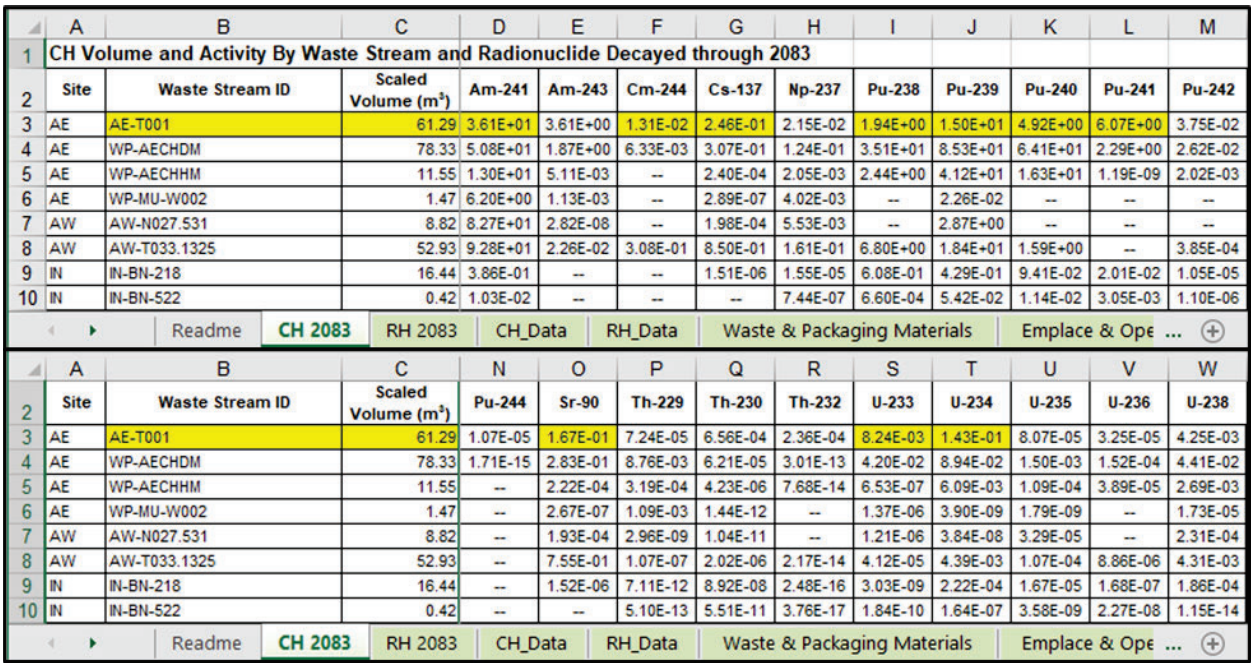
The Excel file, *CRA26_FS_ScreeningAnalysisR0.xlsx*, was created to select the radionuclides of interest from the inventory data provided by LANL. LANL provided scaled waste stream volumes (in m^3) and inventory of radionuclides on a waste stream basis for both CH- and RH-TRU waste, supplied in curies and decayed to the year 2083, for a set of radionuclides (Van Soest 2025, Tables 5-1 and 5-2). The inventory data include 485 CH waste streams and 105 RH waste streams. LANL also provided an Excel file (*FR PAIR-2024 R0 Tables.xlsx*) containing this data, which is also included in the CVS repository at /data/cvs/CVSLIB/WIPP_EXTERNAL/ap214/Files. LANL data (Van Soest 2025, Tables 5-1 and 5-2) were copied into the Excel file, *CRA26_FS_ScreeningAnalysisR0.xlsx*, worksheets "CH 2083" and "RH 2083". Worksheets "EPAUNI CH" and "EPAUNI RH" extract radionuclides of interest from worksheets "CH 2083" and "RH 2083." Also, any spaces in the waste stream names were replaced with dashes. The data in worksheets "EPAUNI CH" and "EPAUNI RH" were copied into a text editor, saved as ASCII files *epu_CRA26_FS_ch.inp* and *epu_CRA26_FS_rh.inp*, and formatted for use by EPAUNI.

The development of the EPAUNI input files was verified by comparing selected values in the data in the files to the data in the spreadsheet and verifying that the files had the same number of records as in the spreadsheet. The worksheets "CH 2083" and "RH 2083" were used for these comparisons. For example, the spreadsheet for CH waste is shown in Figure 4, showing data for the first eight CH waste streams only. The data from the CH input file (*epu_CRA26_FS_ch.inp*) that correspond to Figure 4 are listed as follows:

```
StreamRH (Really CH) Volume(m3) Am-241 Cm-244 Pu-238 Pu-239 Pu-240 Pu-241 U-234
       Cs-137 Sr-90 U-233
AE-T001 6.13E+01 3.61E+01 1.31E-02 1.94E+00 1.50E+01 4.92E+00 6.07E+00 1.43E-01
      2.46E-01 1.67E-01 8.24E-03
WP-AECHDM 7.83E+01 5.08E+01 6.33E-03 3.51E+01 8.53E+01 6.41E+01 2.29E+00 8.94E-02
      3.07E-01 2.83E-01 4.20E-02
WP-AECHHM 1.16E+01 1.30E+01 0.00E+00 2.44E+00 4.12E+01 1.63E+01 1.19E-09 6.09E-03
      2.40E-04 2.22E-04 6.53E-07
WP-MU-W002 1.47E+00 6.20E+00 0.00E+00 0.00E+00 2.26E-02 0.00E+00 0.00E+00 3.90E-09
      2.89E-07 2.67E-07 1.37E-06
AW-N027.531 8.82E+00 8.27E+01 0.00E+00 0.00E+00 2.87E+00 0.00E+00 0.00E+00 3.84E-08
      1.98E-04 1.93E-04 1.21E-06
AW-T033.1325 5.29E+01 9.28E+01 3.08E-01 6.80E+00 1.84E+01 1.59E+00 0.00E+00 4.39E-03
      8.50E-01 7.55E-01 4.12E-05
IN-BN-218 1.64E+01 3.86E-01 0.00E+00 6.08E-01 4.29E-01 9.41E-02 2.01E-02 2.22E-04
      1.51E-06 1.52E-06 3.03E-09
IN-BN-522 4.20E-01 1.03E-02 0.00E+00 6.60E-04 5.42E-02 1.14E-02 3.05E-03 1.64E-07
      0.00E+00 0.00E+00 1.84E-10
```

Note that the header specified the data as StreamRH (Really CH). The StreamRH title is used by EPAUNI to indicate that 10 radionuclides will be written into a logical record consisting of two physical records.

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CH Volume and Activity By Waste Stream and Radionuclide Decayed through 2083

Site	Waste Stream ID	Scaled Volume (m^3)	Am-241	Am-243	Cm-244	Cs-137	Np-237	Pu-238	Pu-239	Pu-240	Pu-241	Pu-242
AE	AE-T001	61.29	3.61E+01	3.61E+00	1.31E-02	2.46E-01	2.15E-02	1.94E+00	1.50E+01	4.92E+00	6.07E+00	3.75E-02
AE	WP-AECHDM	78.33	5.08E+01	1.87E+00	6.33E-03	3.07E-01	1.24E-01	3.51E+01	8.53E+01	6.41E+01	2.29E+00	2.62E-02
AE	WP-AECHHM	11.55	1.30E+01	5.11E-03	--	2.40E-04	2.05E-03	2.44E+00	4.12E+01	1.63E+01	1.19E-09	2.02E-03
AE	WP-MU-W002	1.47	6.20E+00	1.13E-03	--	2.89E-07	4.02E-03	--	2.26E-02	--	--	--
AW	AW-N027.531	8.82	8.27E+01	2.82E-08	--	1.98E-04	5.53E-03	--	2.87E+00	--	--	--
AW	AW-T033.1325	52.93	9.28E+01	2.26E-02	3.08E-01	8.50E-01	1.61E-01	6.80E+00	1.84E+01	1.59E+00	--	3.85E-04
IN	IN-BN-218	16.44	3.86E-01	--	--	1.51E-06	1.55E-05	6.08E-01	4.29E-01	9.41E-02	2.01E-02	1.05E-05
IN	IN-BN-522	0.42	1.03E-02	--	--	--	7.44E-07	6.60E-04	5.42E-02	1.14E-02	3.05E-03	1.10E-06

Readme | CH 2083 | RH 2083 | CH_Data | RH_Data | Waste & Packaging Materials | Emplace & Ope ...

Site	Waste Stream ID	Scaled Volume (m^3)	Pu-244	Sr-90	Th-229	Th-230	Th-232	U-233	U-234	U-235	U-236	U-238
AE	AE-T001	61.29	1.07E-05	1.67E-01	7.24E-05	6.56E-04	2.36E-04	8.24E-03	1.43E-01	8.07E-05	3.25E-05	4.25E-03
AE	WP-AECHDM	78.33	1.71E-15	2.83E-01	8.76E-03	6.21E-05	3.01E-13	4.20E-02	8.94E-02	1.50E-03	1.52E-04	4.41E-02
AE	WP-AECHHM	11.55	--	2.22E-04	3.19E-04	4.23E-06	7.68E-14	6.53E-07	6.09E-03	1.09E-04	3.89E-05	2.69E-03
AE	WP-MU-W002	1.47	--	2.67E-07	1.09E-03	1.44E-12	--	1.37E-06	3.90E-09	1.79E-09	--	1.73E-05
AW	AW-N027.531	8.82	--	1.93E-04	2.96E-09	1.04E-11	--	1.21E-06	3.84E-08	3.29E-05	--	2.31E-04
AW	AW-T033.1325	52.93	--	7.55E-01	1.07E-07	2.02E-06	2.17E-14	4.12E-05	4.39E-03	1.07E-04	8.86E-06	4.31E-03
IN	IN-BN-218	16.44	--	1.52E-06	7.11E-12	8.92E-08	2.48E-16	3.03E-09	2.22E-04	1.67E-05	1.68E-07	1.86E-04
IN	IN-BN-522	0.42	--	--	5.10E-13	5.51E-11	3.76E-17	1.84E-10	1.64E-07	3.58E-09	2.27E-08	1.15E-14

Readme | CH 2083 | RH 2083 | CH_Data | RH_Data | Waste & Packaging Materials | Emplace & Ope ...

Figure 4 – Example CH Waste Data from Excel Spreadsheet *CRA26_FS_ScreeningAnalysisR0.xlsx*

An example using the RH sheet is shown in Figure 5, showing data for the first eight RH waste streams only. The data from the RH input file (*epu_CRA26_FS_rh.inp*) that correspond to Figure 5 are listed as follows:

```
StreamRH Volume(m3) Am-241 Cm-244 Pu-238 Pu-239 Pu-240 Pu-241 U-234
       Cs-137 Sr-90 U-233
AE-T009 1.11E+02 3.32E+02 2.61E+01 2.39E+02 3.21E+02 1.97E+02 1.23E+02 1.43E-01
      1.13E+03 7.35E+02 1.31E-04
WP-AERHDM 7.35E+01 5.84E+02 1.30E+02 5.02E+02 1.84E+02 1.50E+02 3.86E+02 6.98E-01
      2.11E+03 1.17E+03 4.71E-02
AW-T031.1322 2.61E+02 6.61E+02 2.00E-06 1.02E+01 2.36E+02 9.20E+00 1.48E+00 5.67E-01
      2.44E+03 3.55E+03 2.86E-04
AW-W020.13 1.31E+02 3.12E+02 8.44E-01 7.97E+01 2.68E+02 5.30E+01 4.44E+01 8.66E-01
      7.35E+03 4.94E+03 1.84E-04
BT-T001 7.56E+00 3.14E-02 0.00E+00 7.48E-01 1.03E-03 0.00E+00 7.27E-03 4.69E-04
      1.19E+01 1.07E+01 9.86E-03
WP-BT-T001 3.15E+00 8.98E-02 3.30E-03 6.87E-01 1.10E-02 1.55E-02 1.19E-02 2.47E-03
      2.51E+00 3.29E+00 7.38E-03
IN-AE-AGHC-02 1.05E+02 4.90E+02 7.95E-01 5.69E+01 4.23E+02 2.27E+02 9.28E+01 1.52E+00
      4.66E+02 3.51E+02 1.21E-03
IN-AW-T031.1322 1.26E+00 1.03E+01 0.00E+00 3.64E+00 4.32E+00 2.44E+00 4.85E+00 3.16E-02
      6.03E+01 8.96E+00 2.83E-08
```

The EPAUNI input files *epu_CRA26_FS_ch_misc.inp* and *epu_CRA26_FS_rh_misc.inp* contain two lines of data and provide control flags (line 1) and the WUF value (line 2). Because the control flags and WUF are the same for both CH and RH waste, these two input files are identical. The control flags include the following values:

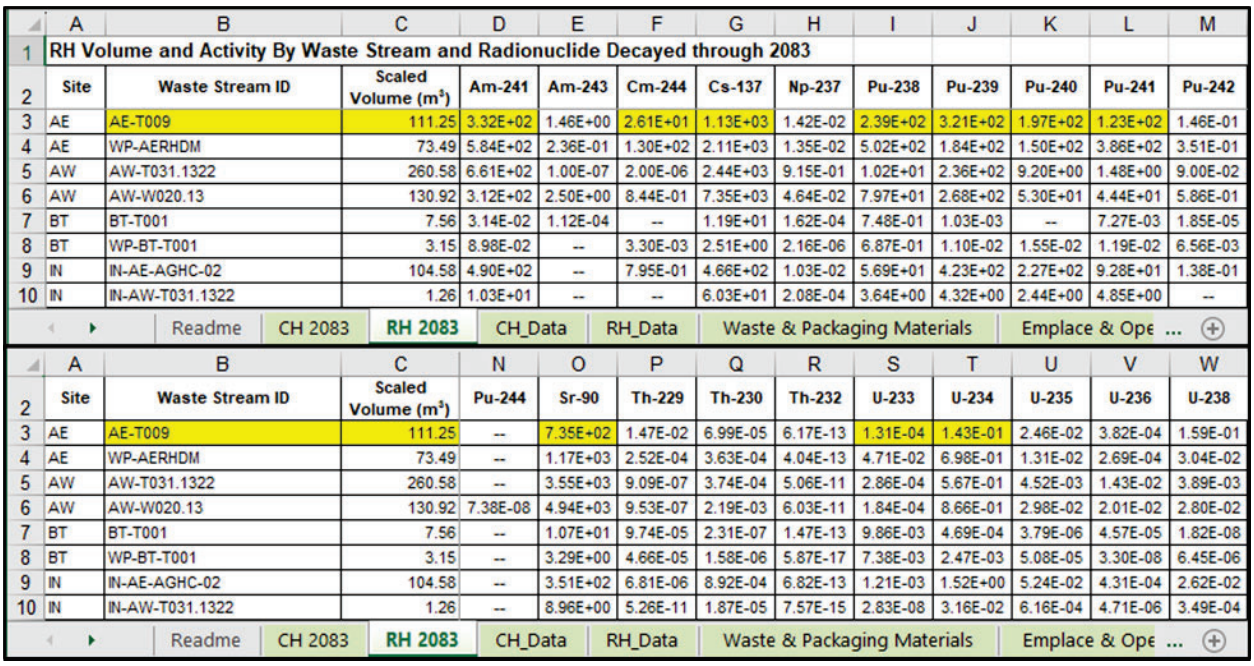
- 0 (no diagnostic print statements)

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- 2 (printout all files)
- 0 (read the input file with free format)
- 0 (data are read in as either CH or RH)
- 0 (calculations are performed assuming that start time is 0 years; i.e., the inventory year is the same as the closure year).

The WUF value in line 2 is 8.68 (as documented in Section 4).

The EPAUNI input data files were subsequently transferred to the CVS repository at /data/cvs/CVSLIB/WIPP_EXTERNAL/ap214/Files.



RH Volume and Activity By Waste Stream and Radionuclide Decayed through 2083

Site	Waste Stream ID	Scaled Volume (m^3)	Am-241	Am-243	Cm-244	Cs-137	Np-237	Pu-238	Pu-239	Pu-240	Pu-241	Pu-242
AE	AE-T009	111.25	3.32E+02	1.46E+00	2.61E+01	1.13E+03	1.42E-02	2.39E+02	3.21E+02	1.97E+02	1.23E+02	1.46E-01
AE	WP-AERHDM	73.49	5.84E+02	2.36E-01	1.30E+02	2.11E+03	1.35E-02	5.02E+02	1.84E+02	1.50E+02	3.86E+02	3.51E-01
AW	AW-T031.1322	260.58	6.61E+02	1.00E-07	2.00E-06	2.44E+03	9.15E-01	1.02E+01	2.36E+02	9.20E+00	1.48E+00	9.00E-02
AW	AW-W020.13	130.92	3.12E+02	2.50E+00	8.44E-01	7.35E+03	4.64E-02	7.97E+01	2.68E+02	5.30E+01	4.44E+01	5.86E-01
BT	BT-T001	7.56	3.14E-02	1.12E-04	--	1.19E+01	1.62E-04	7.48E-01	1.03E-03	--	7.27E-03	1.85E-05
BT	WP-BT-T001	3.15	8.98E-02	--	3.30E-03	2.51E+00	2.16E-06	6.87E-01	1.10E-02	1.55E-02	1.19E-02	6.56E-03
IN	IN-AE-AGHC-02	104.58	4.90E+02	--	7.95E-01	4.66E+02	1.03E-02	5.69E+01	4.23E+02	2.27E+02	9.28E+01	1.38E-01
IN	IN-AW-T031.1322	1.26	1.03E+01	--	--	6.03E+01	2.08E-04	3.64E+00	4.32E+00	2.44E+00	4.85E+00	--

Readme | CH 2083 | RH 2083 | CH_Data | RH_Data | Waste & Packaging Materials | Emplace & Ope ...

Site	Waste Stream ID	Scaled Volume (m^3)	Pu-244	Sr-90	Th-229	Th-230	Th-232	U-233	U-234	U-235	U-236	U-238
AE	AE-T009	111.25	--	7.35E+02	1.47E-02	6.99E-05	6.17E-13	1.31E-04	1.43E-01	2.46E-02	3.82E-04	1.59E-01
AE	WP-AERHDM	73.49	--	1.17E+03	2.52E-04	3.63E-04	4.04E-13	4.71E-02	6.98E-01	1.31E-02	2.69E-04	3.04E-02
AW	AW-T031.1322	260.58	--	3.55E+03	9.09E-07	3.74E-04	5.06E-11	2.86E-04	5.67E-01	4.52E-03	1.43E-02	3.89E-03
AW	AW-W020.13	130.92	7.38E-08	4.94E+03	9.53E-07	2.19E-03	6.03E-11	1.84E-04	8.66E-01	2.98E-02	2.01E-02	2.80E-02
BT	BT-T001	7.56	--	1.07E+01	9.74E-05	2.31E-07	1.47E-13	9.86E-03	4.69E-04	3.79E-06	4.57E-05	1.82E-08
BT	WP-BT-T001	3.15	--	3.29E+00	4.66E-05	1.58E-06	5.87E-17	7.38E-03	2.47E-03	5.08E-05	3.30E-08	6.45E-06
IN	IN-AE-AGHC-02	104.58	--	3.51E+02	6.81E-06	8.92E-04	6.82E-13	1.21E-03	1.52E+00	5.24E-02	4.31E-04	2.62E-02
IN	IN-AW-T031.1322	1.26	--	8.96E+00	5.26E-11	1.87E-05	7.57E-15	2.83E-08	3.16E-02	6.16E-04	4.71E-06	3.49E-04

Readme | CH 2083 | RH 2083 | CH_Data | RH_Data | Waste & Packaging Materials | Emplace & Ope ...

Figure 5 – Example RH Waste Data from Excel Spreadsheet *CRA26_FS_ScreeningAnalysisR0.xlsx*

Information Only