Contract No:

This document was prepared in conjunction with work accomplished under Contract No. DE-AC09-08SR22470 with the U.S. Department of Energy (DOE) Office of Environmental Management (EM).

We put science to work.™

Savannah River National Laboratory™

OPERATED BY SAVANNAH RIVER NUCLEAR SOLUTIONS

A U.S. DEPARTMENT OF ENERGY NATIONAL LABORATORY • SAVANNAH RIVER SITE • AIKEN, SC

Special Analysis: Impact of Updated GSA Flow Model on E-Area Low-Level Waste Facility Groundwater Performance

L. L. Hamm, S. E. Aleman, T. L. Danielson, B. T. Butcher

December 2018

SRNL-STI-2018-00624, Revision 0

SRNL.DOE.GOV

DISCLAIMER

Printed in the United States of America

Prepared for
U.S. Department of Energy

Keywords: *ELLWF, Aquifer, Stochastic, SA, Disposal Unit, Dose, SOF*

Retention: *Permanent*

Special Analysis:
Impact of Updated GSA Flow Model on E-Area Low-Level Waste Facility Groundwater Performance

L. L. Hamm
S. E. Aleman
T. L. Danielson
B. T. Butcher

December 2018

Prepared for the U.S. Department of Energy under contract number DE-AC09-08SR22470.

Savannah River National Laboratory™

OPERATED BY SAVANNAH RIVER NUCLEAR SOLUTIONS

REVIEWS AND APPROVALS

____

L. L. Hamm, Author, Threat Assessments - National Security Date

____

S. E. Aleman, Author, Threat Assessments - National Security Date

____

T. L. Danielson, Author / Reviewer*, Environmental Modeling Date

____

B. T. Butcher, Author, Environmental Modeling Date

____

W. P. Kubilius, Reviewer, Immobilization Technology Date

____

T. Hang, Reviewer, Environmental Modeling Date

____

J. L. Wohlwend, Reviewer, Environmental Modeling Date

____

D. A. Crowley, Manager, Environmental Modeling Date

____

L. T. Reid, Director, Environmental Restoration Technologies Date

____

K. C. Crawford, Solid Waste Programs Date

____

P. B. Andrews, Solid Waste & F Area Engineering Date

____

J. L. Mooneyhan, Solid Waste Facility Manager Date

*Review performed by author was of work performed independently by the other authors.

PREFACE OR ACKNOWLEDGEMENTS

The authors gratefully acknowledge J. A. Dyer, G. P. Flach, N. S. Roddy, J. O. Simmons, I. J. Stewart and K. L. Tempel, for their contributions of key inputs to this report.

EXECUTIVE SUMMARY

In March 2018, the Savannah River National Laboratory (SRNL) notified Solid Waste Management (SWM) of new information that could potentially impact groundwater (GW) disposal limits and possibly require temporary protective measures (Crowley 2018). GW flow directions in the E-Area Low-Level Waste Facility (LLWF) Slit Trenches (STs), Engineered Trenches (ETs), and the Low Activity Waste Vault (LAWV) have notably changed in the new 2018 General Separations Area (GSA) flow model (Flach 2018a). The 2018 GSA flow model had been updated using 20 years of new hydrologic field data and model calibration methods that employed mathematical optimization software. It was later determined that the primary reason for the change in GW flow directions was due to the influence of low permeability caps that had been placed over the Old Burial Grounds and the Low Level Radioactive Waste Disposal Facility (LLRWDF). Updated flow directions in the model produce a higher degree of plume overlap for disposal units (DU's) in the southeastern portion of E-Area than had been predicted in the 2008 E-Area LLWF Performance Assessment (PA). SWM and SRNL outlined the scope for this Special Analysis (SA) and proposed a set of interim measures (IM's) to protect trench operations from exceeding Performance Objectives (PO's) during the preparation of this SA, both of which were approved by the SWM Performance Assessment Review Committee (PARC) (Mooneyhan 2018).

The approach taken in this analysis was to assess unquantified conservatism in DU inventory limits by accounting for plume interaction based on projected radionuclide closure inventories (source term) and a predetermined sequencing of trench operations (timing). The DU's included in this SA are ST05-ST07, ST14-ST21, ET01 and ET02, and the LAWV. Non-GW pathways (i.e., Air, Radon, Intruder) are not impacted by this new information and therefore are not evaluated in this SA. Performing the analysis required SWM to prescribe likely trench usage patterns based on projected trench waste receipts and current operational plans. This information was used to develop a numerical model of an operational scenario described as Case 1 in this report (Butcher 2018b). Case 1 included a new lower limit on non-crushable containers in the trenches of interest and projected sequencing of future trench operations south of ST14 as agreed upon with SWM staff.

The following new models and updated key PA datasets were employed in this SA:

- updated GSA flow model (Flach 2018),
- new conceptual closure cap design (SRNS 2016a and 2016b),
- updated infiltration estimates (Dyer and Flach 2018),
- new trench model (Danielson 2018, Dyer 2017),
- latest geochemical parameters (Kaplan 2016a and 2016b, SRNL 2018a),
- updated hydraulic parameters (SRNL 2018c), and
- new dose model based on updated radionuclide-dose parameters and dose methodology (Smith et al. 2015 and Smith 2015, SRNL 2018b).

The SA approach relies on the expectation that the final DU inventory compositions will not be significantly different than historical ST and ET inventory compositions. To limit the size of the outputs and number of runs, nine key parent radionuclides were selected for this analysis that collectively account for >99% of the current maximum Sum-of-Fractions (SOF) for each of the affected DU's. The term "maximum SOF" refers to the most limiting SOF for the GW and intruder pathways. This maximum SOF includes limits based on the groundwater protection (GWP) requirement (i.e., Environmental Protection Agency (EPA) drinking water standards), the All-

Pathways (AP) PO (i.e., dose impacts from considering all uses of GW leading to human dose uptake), and the intruder resident and post-drilling pathways.

Both stochastic and deterministic methods were used in this SA. A stochastic method of sampling historical trench inventories for the nine key parent radionuclides was implemented in a "Monte-Carlo" analysis producing a large number of realizations (e.g., 5,000 and 10,000 runs). Each realization produced hypothetical future inventory compositions for each operating DU which, combined with existing inventory, were adjusted to a SOF of 1 based on each unit's most restrictive Waste Information and Tracking System (WITS) inventory limits. Closed DU's (ST05 and ET01) were run using their final closure inventories. Finally, these adjusted compositions were run through SRNL's new limits and doses and E-Area LLWF dose investigation tools to locate the maximum dose impact along the 100-meter (m) GW Point of Assessment (POA) and to determine the most probable maximum-SOF. In the deterministic part of the analysis, described in Section 9.1 of this report, filling each DU to a SOF of 1.0 based on the currently approved inventory limits resulted in a "true" SOF of 0.563 (i.e., "true" meaning the SOF calculated using the most up to date PA models and input) assuming the average radionuclide composition for each trench derived from Sink and Roddy's historical trench inventories (Sink 2012, Roddy 2018a and b). However, the final inventory composition for any DU will not be the historical average, but rather some unknown distribution of radionuclides. To help quantify this uncertainty, 5,000 and 10,000 randomly sampled distributions were obtained using the methods described in Section 9.2 of this report. None of the 10,000 realizations exceeded a SOF of 0.78 demonstrating there is less than 0.01% chance of ending up with a final inventory composition that exceeds a SOF of 1.0. The conditional probability curve, as shown by a frequency plot for maximum SOF's is provided in Figure ES-1. Based on deterministic and stochastic analyses, SRNL results from the SA show that the likelihood of exceeding an absolute SOF greater than one, while operating E-Area under its current WITS inventory limits, is exceedingly small.

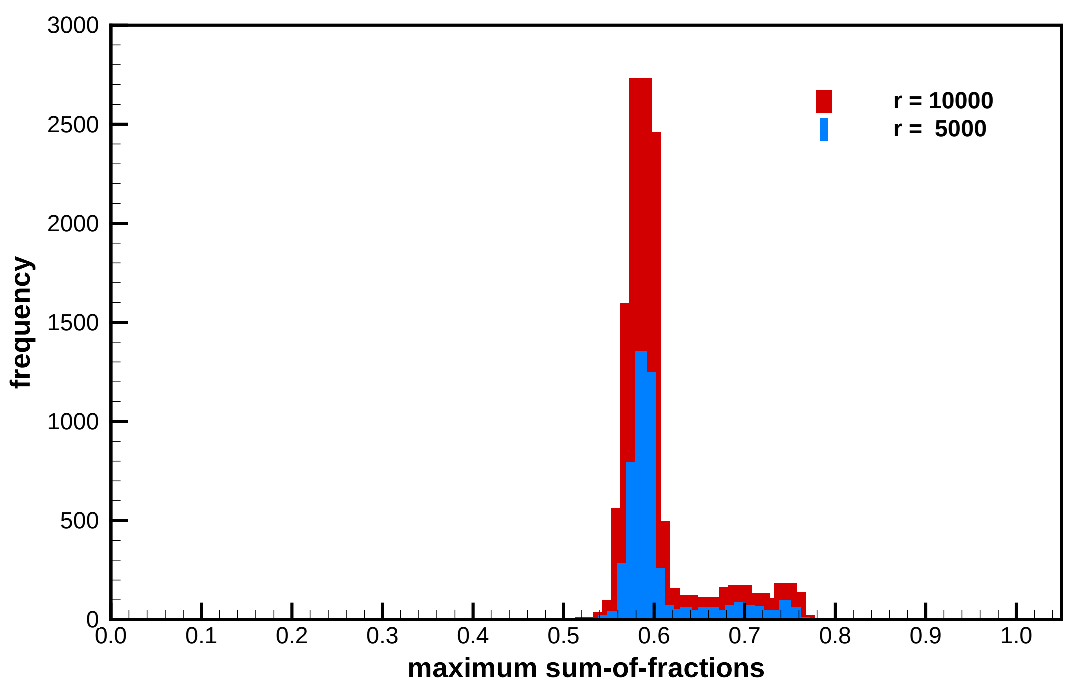


Figure ES-1. Stochastic Simulation of E-Area LLWF POA Maximum SOF.

Three IM's were imposed on trench operations in ET02 and ST14 during the preparation of this SA. To be consistent with the assumptions of Case 1 and based on the results of the analysis, the following modifications to those IM's are required:

- The SOF administrative limits applied as an IM to ET02 (maximum SOF of 75%) and ST14 (maximum SOF of 65%) can be removed. SWM can return to a SOF = 1.0.
- As prescribed in Case 1, a new lower limit of 2% of the trench area on non-crushable containers is imposed on ET02 and ST14 through ST21. No additional non-crushable containers should be disposed in ST06 or ST07 which currently contain 2.87% and 0.67% non-crushable containers, respectively. Although outside the study area, the following is restated for clarity: The current prohibition on non-crushable containers in ST09, ET03 and ET04 (future) remains in place until it is evaluated in the next PA revision. The general 10% non-crushable limit is still applicable to the remaining operating and future trenches in E-Area.
- As prescribed in Case 1, the IM prohibiting opening of any new trenches south of ST14 (i.e., ST15 through ST21) remains in effect until it can be evaluated in the next PA revision and the new PA baseline is approved or before 2037, whichever comes first. ST06 and ST07 should not be reactivated to receive additional waste prior to completion and approval of the next PA revision or before 2028, whichever comes first.

The results of this SA included the most up-to-date models and databases. Based on the new operational constraints above and the amount of margin observed in the deterministic and stochastic analyses, SRNL has determined that SWM can continue to use the current WITS inventory limits for the DU's that were the subject of this analysis and be confident that the DOE O 435.1 GWP requirement and GW PO's will not be exceeded. The results of this SA also provide increased confidence that the planned PA revision will produce acceptable GW limits.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS & ABBREVIATIONS

BE	Best Estimate
BG	Beta-Gamma pathway
CA	Composite Analysis
Case01	Intact Cap Infiltration Case
Case11a	Cap-Averaged Subsided Infiltration Case
Case11b	Back-Calculated Discrete-Hole Infiltration Case
cdf	Cumulative Density (Distribution) Function
CDP	Cellulose Degradation Products
CIG	Component in Grout
DC	Dynamic Compaction
DOE	Department of Energy
DOE O	Department of Energy Order
DU	Disposal Unit
EIC	End of Institutional Controls
EPA	Environmental Protection Agency
ET	Engineered Trench
GCL	Geosynthetic Clay Liner
GSA	General Separations Area
GW	Groundwater
GWP	Ground Water Protection
HDPE	High Density Polyethylene
HWCTR	Heavy Water Component Test Reactor
I&A	Inputs and Assumptions
IC-1	Interim Cover Stage-1 (installed in 2040)
IC-2	Interim Cover Stage-2 (installed in 2065)
ILV	Intermediate Level Vault
IM	Interim Measures
Kd	Sorption Coefficient
LAWV	Low Activity Waste Vault
LB	Lower Bound
LLRWDF	Low-Level Waste Radioactive Waste Disposal Facility
LLW	Low Level Waste
LLWF	Low Level Waste Facility
MPAD	Most Probable and Defensible

MS	Microsoft
MWMF	Mixed Waste Management Facility
NDC	Non-Dynamically Compacted
OC	Operational Cover (installed after 4 years of DU closure)
PA	Performance Assessment
PARC	Performance Assessment Review Committee
pdf	Probability Density (Distribution) Function
PI	Plume Interaction
PIF	Plume Interaction Factor
PO	Performance Objective
POA	Point of Assessment
POP	Period of Performance
R&D	Research & Development
SA	Special Analyses
SIC	Start of Institutional Controls
SLITc	ST's in the center section of E-Area (ST01-ST07)
SLITe	ST's in the eastern section of E-Area (ST14-ST21)
SLITw	ST's in the western section of E-Area (ST08-ST13)
SOF	Sum-of-Fractions
SRNL	Savannah River National Laboratory
SRS	Savannah River Site
ST	Slit Trench
SWIFT	Solid Waste Integrated Forecast Tool
SWM	Solid Waste Management
SWMF	Solid Waste Management Facility
2D	Two Dimensional
3D	Three Dimensional
UB	Upper Bound
UDQ	Unreviewed Disposal Question
UDQE	Unreviewed Disposal Question Evaluation
VZ	Vadose Zone
WITS	Waste Information Tracking System

Units

Ci	Curies
ft^3	Cubic Feet

gmole	Gram-Mole
L	Liter
m	Meter
pCi	Picocuries

1.0 Introduction

The E-Area LLWF PA baseline includes the currently approved PA (WSRC 2008) plus all subsequently approved Special Analyses (SA's) and UDQE's which can be found on the SWM homepage (SWM 2018a). The products of these PA baseline analyses are radionuclide inventory limits for each DU and operational constraints imposed by key PA model inputs and assumptions (I&A's). Inventory limits are placed on parent radionuclides being buried within a DU where the composite doses associated with potential progeny are implicitly accounted for within the analyses. The terms "E-Area" and "E-Area LLWF" are used interchangeably throughout this report and refer collectively to all the DU's in the current 100-acre Solid Waste Management Facility (SWMF).

Separate inventory limits are established for the GW, Air, Radon, and Intruder pathways to ensure DOE O 435.1 PO's and GWP requirement are protected. The approved set of radionuclide inventory limits are maintained in the PA limits database (Butcher 2018a) on the SWM homepage. Key I&A, when applicable, are protected in operational procedures and on-site drawings. A database listing the key I&A's and associated SWM controls and/or implementing documents is maintained by SWM on the site computer network (SWM 2018b). As required by DOE O 435.1, SWM and SRNL annually conduct a review of waste receipts, monitoring, research & development (R&D) work, and other evaluations and investigations performed in the preceding year to ensure that these changes do not alter the conclusions of the E-Area LLWF PA (most recent review in Hang et al. 2018).

The GW flow field as modeled in the 2008 E-Area LLWF PA (herein referred to as the 2008 PA) has been recently updated based on more recent field data and automated calibration methods. SRNL discovered that model estimations of GW flow direction have changed significantly near the east set of Slit Trenches versus those evaluated in the 2008 PA. The primary reason for this change in GW flow directions is the influence of low permeability caps that had been placed over the Old Burial Grounds and LLRWDF. This influence of caps on groundwater flow was not accounted for in previous PA modeling (e.g., 2008 PA) is now better understood, and it represents a significant change in assumptions for future PA modeling. In March 2018, SRNL notified SWM of this new information (i.e., the potential implications for GW disposal limits and possible need for temporary protective measures) (Crowley 2018). Non-GW pathways are not impacted (i.e., Air, Radon, and Intruder) because GW concentrations play no role in establishing their limits. In subsequent meetings, SWM and SRNL developed a set of IM's to protect trench operations from exceeding PO's and outlined scope for a UDQE. SWM and SRNL presented a UDQ Screening (Appendix A) describing the new information, justified the need for a UDQE, and defined IM's in a meeting of the SWM PARC on July 18, 2018. The PARC approved the UDQ Screening and proposed interim measures and authorized SRNL to proceed with a UDQE (Mooneyhan, 2018). Subsequently, due to the complexity of the analysis and the need to transition from IM's to additional permanent operational constraints on the facility, the SWM Design Authority Engineer recommended to the PARC that an SA be performed, which is consistent with the SWM UDQ procedure, SW-ENG-0601 (SWM 2016).

1.1 Background

In this chapter a high-level discussion is provided elaborating on the reasons for this SA as well as justifying the choice of a stochastic versus deterministic approach. The main driver for the SA was the adverse GW flow field results from the recently updated GSA aquifer flow model.

Considered by itself, this new “best estimate” flow field would reduce allowable E-Area LLWF DU inventory capacities unless plume interaction could be accounted for in a less conservative way and/or other recent offsetting model improvements were brought into the analysis.

In the original development efforts for the 2008 PA, an overall conservative approach was adopted to streamline the analysis and provide operational flexibility. The main building blocks were:

- Most disposed radionuclides were assumed to be uniformly distributed within each DU at the beginning of E-Area LLWF operations in 1995 (exceptions included: Component-in-Grout (CIG) trenches, LAWV, and disposal of some special waste forms).
- Plume interaction among DU’s was addressed in a steady-state manner.

Based on information available prior to 2008, these two building blocks provided acceptable DU inventory limits and minimized the number and degree of operational constraints imposed on E-Area LLW disposal operations. For example, deterministic inventory limits were provided on a DU or DU group (e.g., East, West and Center ST groups) basis that were:

- Independent of inventory within neighboring DU’s or DU groups and
- Independent of radionuclide composition within each DU.

This operational flexibility came along with a reduced overall inventory capacity (i.e., lower inventory limits). The actual amount of conservatism (i.e., operating margins as measured by the SOF’s for each DU) resulting from this approach had not been quantified up to this time.

The objective of this SA is to demonstrate that the current WITS inventory limits are acceptable given the recently updated GSA flow field (2018) and other model improvements since the 2008 PA. The approach chosen to meet this objective is based on an earlier successful effort for demonstrating the existing ST12 DU inventory limits were adequate surrogates for use in operating ET03 in the ST12 footprint (Hamm et al. 2013). This same approach was later applied to ET04 and ST13 (Butcher et.al. 2017). The approach was stochastic in nature and provided a high degree of confidence that performance measures would not be exceeded. This stochastic technique does not generate specific inventory limits (i.e., which are deterministic by nature) but provides a means of obtaining/assessing the level of risk associated with operating trenches (and the LAWV) in the region of concern under the current WITS limits when faced with new, and potentially, adverse information.

One key operational constraint from the 2008 PA that was readdressed in this evaluation is the general allowance of up to 10% non-crushable containers on a trench area basis. Failure of non-crushable containers leads to areas of localized subsidence in the final closure cap installed at the end of institutional controls (EIC). This localized subsidence can produce high infiltration through the closure cap and waste zone which can have strong negative impacts on inventory limits (e.g., Sr-90 being perhaps the most susceptible to subsidence).

Prior to the discovery of this new information (see UDQ screening provided in Appendix A), SRNL was completing activities in preparation for revising the 2008 PA. One of these activities was performing an assessment of the recently completed conceptual closure cap design by SRNS Design Engineering (SRNS 2016a and 2016b). A plan view of this closure cap design is shown in Figure 1-1. The southeastern section of E-Area identified by the black dashed box is the area most impacted by this change in GW flow direction. The surface of the closure cap is contoured with a relatively elaborate set of slopes with varying directions, grades and slope lengths (e.g., some up to 600 ft) which is significantly different than the closure concept employed in the 2008

PA and subsequent SA's. Chapter 4 includes a discussion of the constraints that were imposed on the new design. From a subsidence perspective, this new cap design required SRNL to consider reformulating the various Vadose Zone (VZ) PORFLOW models that were originally developed for the 2008 PA. The result was a new conceptual model for trenches and recalculated infiltration estimates under both intact and subsided conditions (Dyer and Flach 2018). This new VZ model is discussed in Chapter 5.

A typical section of the closure cap (section E-E in Figure 1-1) was selected as bounding the infiltration performance (i.e., higher intact infiltration rate) on the southeastern end of E-Area based on a comparison of slope length / percent slope combinations across the cap (Dyer, 2017). A new trench model based on a two-dimensional (2D) vertical cross-section oriented longitudinally down the long axis of the DU footprint was chosen to better approximate the actual three-dimensional (3D) geometry of a trench unit with respect to surface infiltration. This contrasts with the 2D trench model in the 2008 PA which was a vertical trench cross-section oriented perpendicular to the long axis of the trench unit.

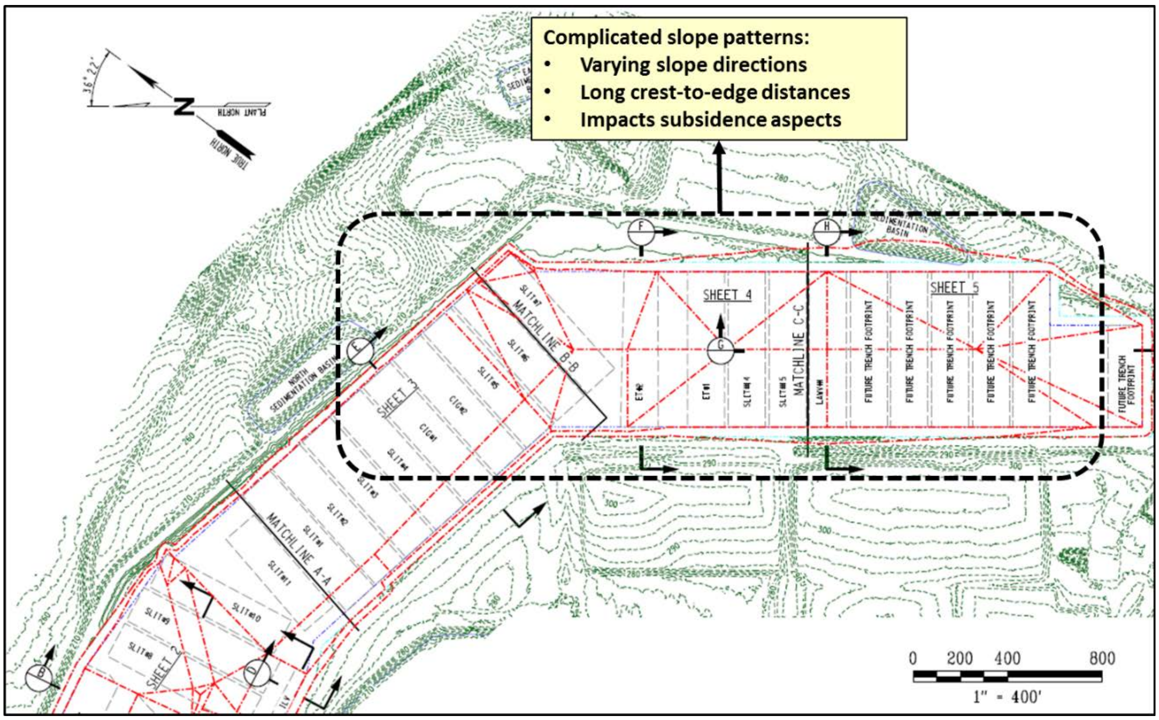


Figure 1-1. Aerial layout of proposed E-Area (ELLWF) conceptual closure cap design for PA purposes.

In addition to updating the VZ PORFLOW models and infiltration estimates for trench units to address this new closure cap design, several other activities were underway simultaneously:

- Updating dose models
- Updating radiological database
- Updating hydraulic property database
- Updating chemical property database
- Updating GSA flow model

Many of these activities were focused on updating our existing 2008 PA methodology to be current with all available pertinent information within the Department of Energy (DOE) complex, as well as capturing modeling improvements since the 2008 PA. In parallel with the closure cap assessment, an updated GSA GW flow field was created. This new flow field raised potential concerns regarding existing inventory limits for E-Area trench and LAWV operations. Section 1.2, describes how the new GSA flow field could potentially impact E-Area inventory limits.

1.2 Problem Description

In the current PA methodology, aquifer transport analyses are performed using steady-state flow field(s) created from GSA PORFLOW-based flow model(s). Each steady-state flow field for use in E-Area transport simulations is generated by cutting out a region of the GSA flow model that adequately surrounds the region of interest within E-Area. In Figure 1-2 two GSA flow fields are provided. GW streamline paths are shown emanating out from the centroid of each DU. The image on the left in Figure 1-2 was developed in 2004 (Flach 2004) (referred to as the 2004 GSA flow model) and was employed in the 2008 PA (WSRC 2008) and all subsequent approved SA's and UDQE's thus defining the current E-Area PA baseline. The image on the right in Figure 1-2 corresponds to the update to the GSA PORFLOW flow model (Flach 2018a) (referred to as the 2018 GSA flow model) that is being evaluated in this SA. This update is based on more recent field data and the use of automated calibration methods. The plan is to employ this latest model in the upcoming PA revision.

Both images shown in Figure 1-2 correspond to conditions where no E-Area closure cap is present. A comparison of the two images clearly shows that the 2018 GSA flow model represents a significant change in GW flow directions near the east set of slit trenches (i.e., see highlighted region inside the dashed red box). This area represents a "region of concern" and is the primary focus of this SA effort.

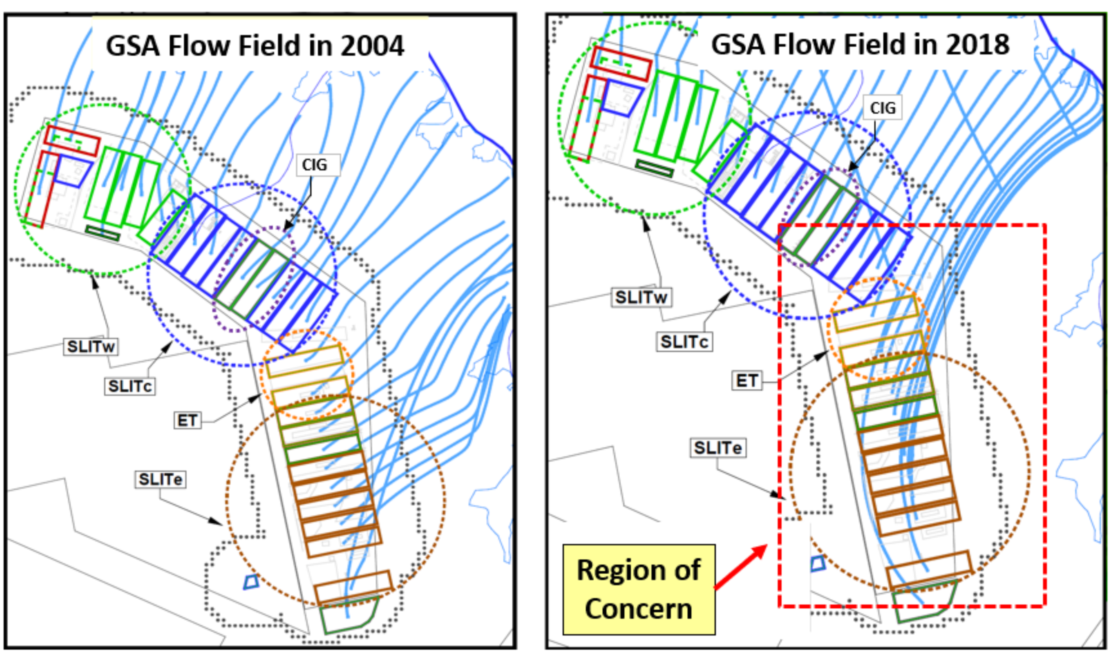


Figure 1-2. E-Area DU's showing basic streamline paths from the centroid of each unit based on the GSA PORFLOW flow model developed in 2004 (left image) and in 2018 (right image).

Plume interaction among DU's has an adverse impact on a given DU's allowable GW inventory limits. In the 2008 PA, a Plume Interaction Factor (PIF) was computed for each DU to quantify the reduction in inventory necessary to meet GW PO's and GWP requirements. These PIF's are computed from aquifer transport runs where a steady-state source of tracer is deposited into an individual DU footprint or into a group of DU footprints and then compared to the case where all DUs have tracer sources deposited into them.

To illustrate how a steady-state tracer would migrate and disperse within the aquifer, aerial views of concentration plumes for three key DU's are shown in Figure 1-3, Figure 1-4, and Figure 1-5 (i.e., ST06, ST14, and ST18, respectively). The images on the left provide the estimated steady-state plumes emanating from a specific DU based on the 2004 GSA flow model, while the corresponding images on the right are based on the 2018 GSA flow model. The orange and red contour regions represent significant concentration levels and help to illustrate how one specific DU's contaminant can cross-over into its neighbor's downstream plume. This comingling of plumes is referred to as "plume interaction" and its impact on a given DU's allowed inventory, as defined by inventory limits, is accounted for by a computed plume interaction factor (PIF):

$$C_{i,j}^{Limit} = \left[PIF_j \right] \cdot C_{i,j}^{PF} \quad (1\text{-}1)$$

where PIF_j - j^{th} DU specific plume interaction factor

$C_{i,j}^{Limit}$ - combined concentration at 100-m well for i^{th} parent nuclide in j^{th} DU

$C_{i,j}^{PF}$ - PORFLOW calculated concentration at 100-m well for i^{th} parent nuclide in j^{th} DU

The simple expression given by Eq. (**1-1**) is a direct result of the linearity of the governing transport equations. The combined concentration from multiple GW plumes at any point within the computational domain can be obtained by employing the super-positioning principle. The linearity of the transport equations results from the use of a linear isotherm which applies under sufficiently dilute conditions. For current and expected operations, inventory limits will remain within the linear isotherm range and as such, significant computational advantages can be employed throughout the entire limits analyses.

From Eq. (**1-1**) we also see a similarly simple relationship for DU inventory limits:

$$I_{i,j}^{Limit} = \frac{I_{i,j}^{preliminary}}{\left[PIF_j \right]} \quad (1\text{-}2)$$

where $I_{i,j}^{Limit}$ - final inventory limit for i^{th} parent nuclide in j^{th} DU

$I_{i,j}^{preliminary}$ - preliminary inventory limit for i^{th} parent nuclide in j^{th} DU

The preliminary limits are obtained for DUs in isolation and the final inventory limits are obtained by application of the PIF as given in Eq. (**1-2**). As one can see, increased plume interaction directly reduces a DU's allowable inventory for every species within that unit contributing to the GW pathway.

The specified PIF value for a given DU represents the impact on that DU from all other DU plume contributions within the E-Area LLWF. For example, in a DU with a PIF value of 2.0 each parent nuclide within that DU contributes 50% of the dose at the 100-m POA while the remaining 50% is being contributed by all other interacting DU's within E-Area. The use of a steady-state tracer in computing a PIF is inherently conservative as sources (i.e., DU inventories) eventually become depleted through leaching and decay (radionuclide contaminants). Thus, assuming steady-state (non-depleting) sources in surrounding DU's sets up a worst-case plume interaction condition producing the highest PIFs and most restrictive inventory limits. This approach takes the timing aspects out of consideration, completely separates the limit analyses for each DU from its neighbors, and allows for maximum operational flexibility (albeit, at the cost of more restrictive inventory limits). The resulting 2008 PA inventory limits were determined by SWM to be acceptable and so this conservative PIF approach was adopted.

In the 2008 PA, PIF values were computed based on DU groupings that were later broken out into individual DU values for subsequent SA's (Swingle 2012). As shown in Figure 1-2, the following grouping of units were considered in the 2008 PA:

- SLITc – all STs within the center section of E-Area (i.e., ST01 thru ST07)
- SLITw – all STs within the western section of E-Area (i.e., ST08 thru ST13)
- SLITe – all STs within the eastern section of E-Area (i.e., ST14 thru ST21)
- ET – all ETs in 2008 (i.e., ET1 and ET2)
- CIG – all CIG trenches in 2008 (i.e., CIG1 and CIG2)

Table 1-1 lists the computed PIF values based on the 2004 GSA flow model that were used in the 2008 PA and subsequent SA's. PIF values for ST's and ET's within the center and eastern portions of E-Area had values ranging from about 1.17 to 1.25 (i.e., comingling on the order of 20%).

Table 1-1. PA2008 Plume Interaction Factors.

Disposal Unit	PA2008 PIF (-)
SLITc	1.17
SLITw	1.90
SLITe	1.25
ET	1.24
CIG	1.53
ILV	1.94
LAW	2.14

The PIF values selected for E-Area DU's are not unique solutions, because an infinite combination of PIF values would yield a maximum SOF of one. Tradeoffs can be made among interacting DU's (i.e., based on the constraint that the maximum SOF remain under one) where more inventory is allowed in one DU at the expense of others. For example, as shown in Table 1-1 increased inventory limits were provided in the center set of ST's (PIF=1.17) at the expense of reducing allowable limits in the LAWV (PIF=2.14).

As Figure 1-2 indicates, the flow directions (and potentially PIF values) for those DU's within the "Region of Concern" have been altered based on the new 2018 GSA flow model. Updated steady-state tracer transport runs were made using this new 2018 GSA flow model. A comparison of the resulting tracer plumes (i.e., based on the 2004 versus 2018 GSA flow models) is provided for ST06, ST14, and ST18 in Figure 1-3, Figure 1-4, and Figure 1-5, respectively. In each figure, contour intervals have been colored based on:

- Red – region of maximum contaminant levels just beneath the DU where the tracer source was buried.
- Orange – region of contaminant migration where significant contaminant exists. All tracer sources shown in these figures were scaled to yield the same concentration level at the 100-m curtain.
- Green – region of contaminant migration where minor contaminant exists.
- None – region outside the plume where negligible contaminant exists.

In the follow-on aquifer transport runs, the actual meshes employed are also shown in these figures where:

- 66.7 ft by 66.7 ft (cutout from 2004 GSA flow model)
- 25.0 ft by 25.0 ft (cutout from 2018 GSA flow model)

A two-parameter dispersion model was employed in the 2008 PA transport runs while an improved four-parameter dispersion model was employed in the SA (Aleman and Flach 2010). The impact of employing a more refined mesh and improved dispersion model yields better defined transport plumes that are effectively less dispersive overall. This effect can clearly be seen when comparing the left versus right images shown in Figure 1-3.

As the two images in Figure 1-2 indicate, the flow direction beneath ST06 is closely aligned with the longitudinal layout of its footprint for both flow models. And as expected, the resulting tracer plumes emanating out from ST06, as seen in the images of Figure 1-3, only marginally impact its nearest neighbors and PIF values in the range of 20% remains valid.

On the other hand, given the lack of alignment in flow direction beneath most of the DU's in the eastern portion of E-Area, much greater plume interactions exist with the new model. As the left image in Figure 1-4 shows, ST14 significantly impacted only ET01 operations in the 2008 PA where in the new analyses it has a much more pronounced impact on both ET01 and ET02. As Figure 1-5 indicates, for ST18 the 2004 GSA flow model shows significant impact on ST17 with partial impact on ST16, while the results of the 2018 GSA flow model show a significant impact to the LAWV, ST15, ST16, and ST17 operations.

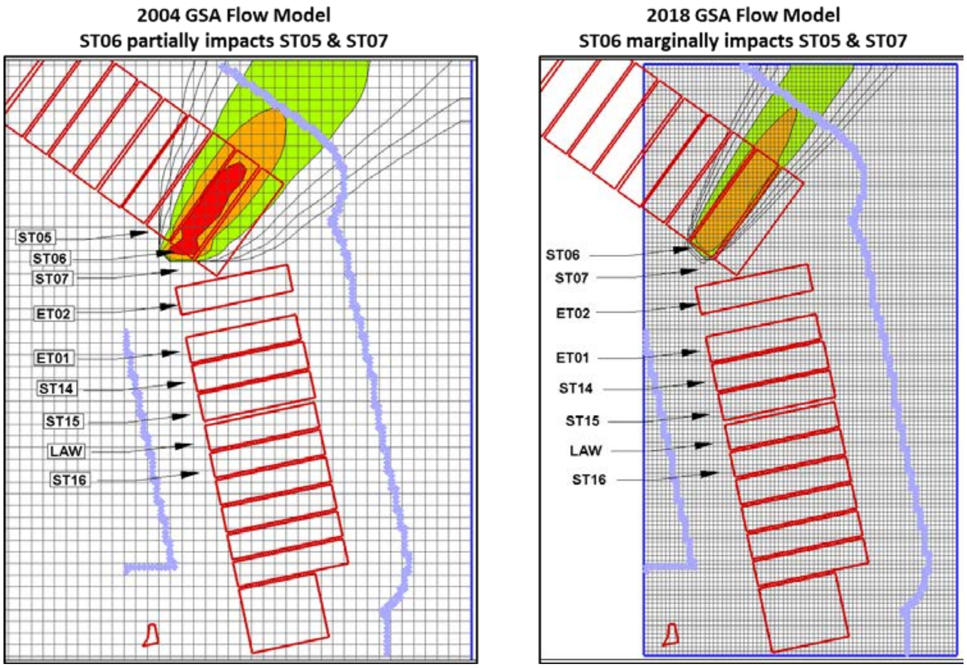


Figure 1-3. Steady-state tracer concentration profiles within eastern sector of E-Area highlighting plume interaction impacts from ST06 based on the 2004 (left image) and 2018 (right image) GSA flow models.

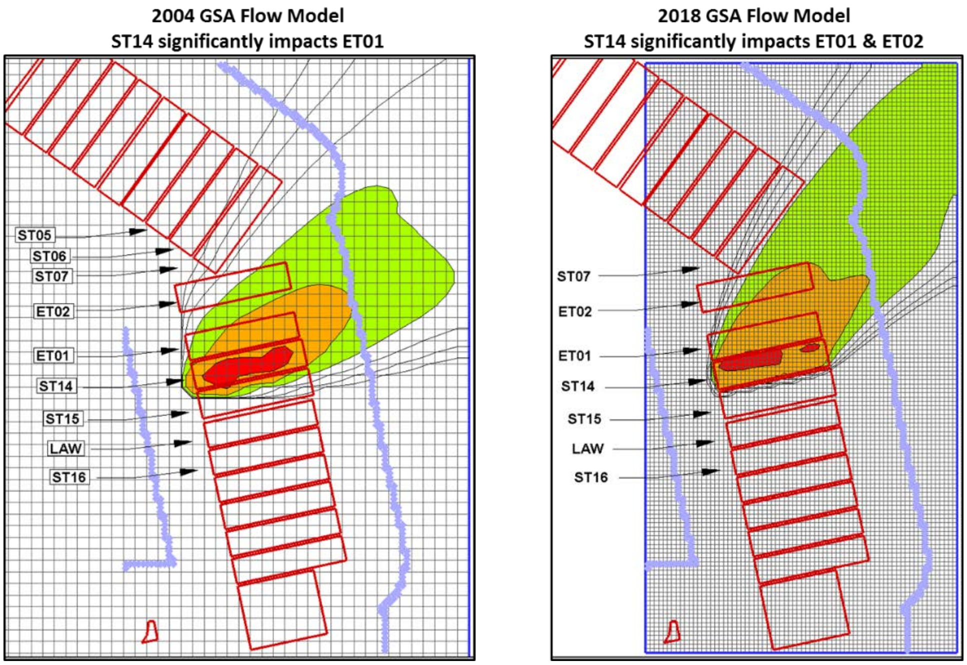


Figure 1-4. Steady-state tracer concentration profiles within eastern sector of E-Area highlighting plume interaction impacts from ST14 based on the 2004 (left image) and 2018 (right image) GSA flow models.

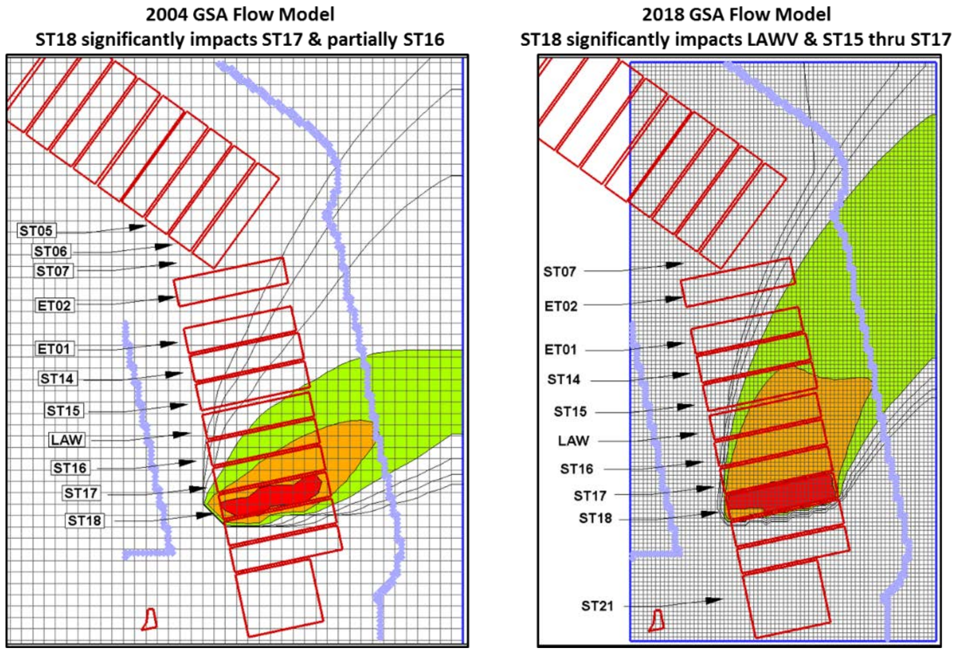


Figure 1-5. Steady-state tracer concentration profiles within eastern sector of E-Area highlighting plume interaction impacts from ST18 based on the 2004 (left image) and 2018 (right image) GSA flow models.

The 2004 GSA flow field was developed without consideration of a closure cap being present. In the 2008 PA and subsequent SA's, the 2004 GSA flow field was employed throughout the entire performance period. For the upcoming PA revision and within this SA, two new 2018 GSA flow fields will be employed: (1) the uncovered flow field shown within the right side image of Figure 1-3, and (2) an updated flow field based on the presence of an entire closure cap over E-Area (i.e., here the 2018 GSA flow model has been re-run with this cap in place). Results presented in the PORFLOW Aquifer Analysis (Chapter 6) provide details on this aspect.

1.3 Scope of Analyses

SWM WITS parent nuclide inventory limits are specified for the following pathways:

- GW pathways (i.e., beta-gamma, gross-alpha, all-pathways, radium, and uranium)
- Intruder pathways (i.e., resident and post-drilling)
- Air pathway
- Radon pathway

Parent nuclides are those radionuclides reported in the inventory by waste generators for waste receipts disposed in the E-Area LLWF. Parent nuclide inventory limits are calculated based on the most limiting result when considering all progeny that build in during decay and transport to the 100-m POA. In this way, parent radionuclide limits account for all subsequent daughter ingrowth.

For trenches, multiple (two to three) time windows were created for the GW pathways to take advantage of plume separation and thus increase the allowable inventory. For the LAWV, only one-time window was necessary for each GW pathway. Within the existing PA methodology, one can increase allowable inventory limits by just increasing the number of time windows for every pathway to take advantage of GW peak separation in time (e.g., a radionuclide with a higher K_d such as U-238 would move slower in GW than a mobile radionuclide like I-129). In theory, employing many time windows (i.e., an upper bound of one-year intervals) would eliminate one of the embedded conservatisms within the current PA methodology; however, it would produce an impractical number of limits for implementation in WITS.

This SA addresses the potential impact of the new 2018 GSA flow model on current WITS GW inventory limits – it does not produce new limits. Because inventory limits for the various GW pathways are impacted by GW concentrations at the 100-m boundary, this SA is focused on the impact to the GW pathways listed above. Note that all other pathways are independent of GW concentrations and only play a factor in constraining the acceptable compositions within each DU.

DOE O 435.1 defaults to a point of compliance/assessment corresponding to the "point of highest projected dose or concentration at or beyond a 100-m buffer zone surrounding the disposed waste" (larger or smaller buffer zones are allowed with justification) (DOE 1999a). For the E-Area LLWF this is interpreted as a flexible boundary extending laterally 100 meters beyond the outer edge of the collective E-Area DU footprint (i.e., actual waste buried may be slightly further away). In Figure 1-2 this boundary is shown by the line of dots encircling the E-Area DU's. Each dot represents a single node within the flow model that is located approximately 100 meters from a line inscribing the outer edges of all the DU's in a "shrink wrap" fashion. This buffer extends vertically into the VZ and underlying aquifers to capture contaminant plumes as they travel from DU's. This buffer or POA is sometimes referred to as a "curtain" in various places in this report.

As discussed in the Problem Description section (Section 1.2), the new 2018 GSA flow model significantly altered the previously understood aquifer GW flow directions. The significant flow direction change appears to be primarily within the southeastern sector of E-Area. The region of concern has been isolated to those DU's with footprints within the red dashed box highlighted in the right image of Figure 1-2.

The DU's of concern within this SA are shown in Figure 1-6. The range of DU's included was based on the following logic:

- The upper end of DU's was set at ST05. ST05 is a closed unit that is at a SOF of one. This DU had only a minor flow direction change with the new flow field but was added to the list due to its existing SOF value being at the performance measure limit.
- The lower end of DU's was set to ST20. ST20 is a future unit. ST21 was not included in the detailed evaluation because it was screened out due to timeline considerations discussed in Section 2.1.
- All DU's between ST05 and ST20 were included in the detailed evaluation were added in for continuity as well as other reasons.

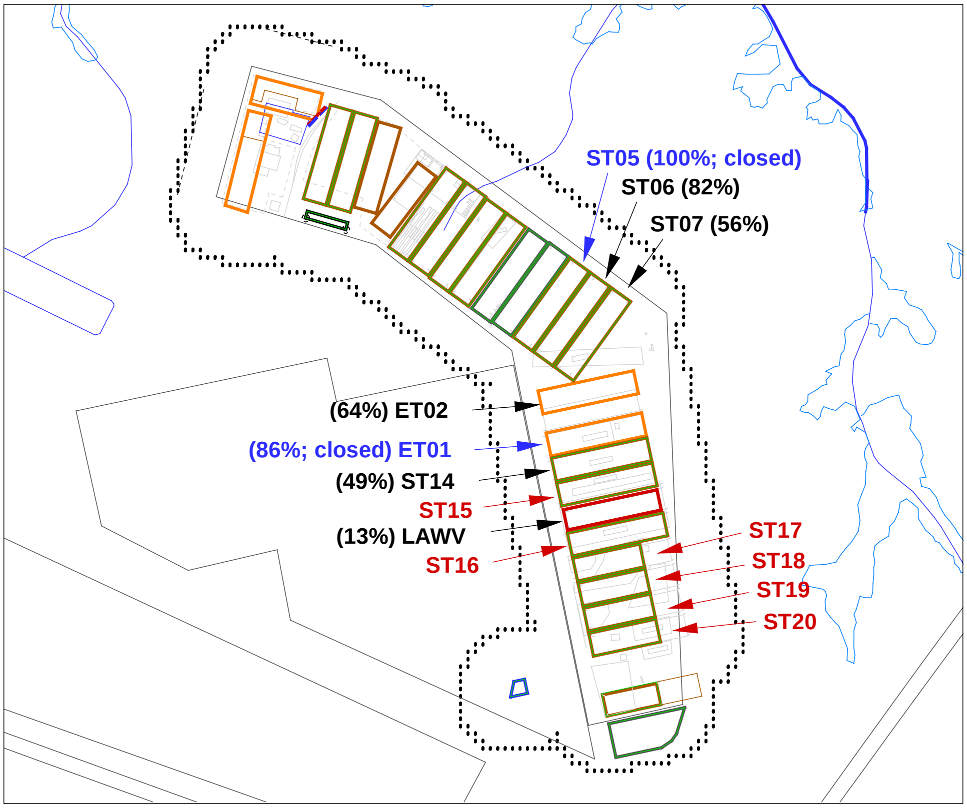


Figure 1-6. Overview of E-Area highlighting those DUs of primary interest in this SA that include closed, open, and future DU's.

Figure 1-6 shows the 13 DU's considered in this analysis effort. The operational status for each of these 13 DU's is provided in Table 1-2.

Table 1-2. Listing of DU's included in this analysis effort.

Disposal Unit	Status[a,b,c]	Existing SOF[d]
ST05	Closed	100%
ST06	Open	82%
ST07	Open	56%
ET02	Open	64%
ET01	Closed	86%
ST14	Open	49%
ST15	Future	0%
LAWV	Open	13%
ST16	Future	0%
ST17	Future	0%
ST18	Future	0%
ST19	Future	0%
ST20	Future	0%

a – Closed DU's have fixed existing inventories throughout the analysis periods.
b – Open DU's have both fixed existing and projected future inventories throughout the analysis periods.
c – Future DU's have only projected future inventories throughout the analysis periods.
d – Based on existing WITS inventories as of 9/2018 and provided to SRNL by SWM (Roddy 2018a and 2018b).

1.4 General Modeling Approach

Early scoping analyses leading to a UDQ Screening (Appendix A) indicated that the new 2018 GSA flow model would result in significantly increased PIF values for several of the key DU's of interest. Using these updated PIF values and the current WITS-based inventory data, the scoping analyses indicated that the current WITS inventory limits would not provide adequate assurance that a SOF less than one could be maintained. However, it was well known that the current 2008 PA approach has embedded conservatism in allowable inventory limits associated with the steady-state tracer-based PIF approach. Unfortunately, no deterministic method existed prior to this report that could explicitly demonstrate that the current WITS inventory limits were sufficiently conservative to accommodate these potentially much larger PIF values.

This led SRNL to investigate (and subsequently develop) a new method for addressing plume interaction that would not have these unquantified conservatisms directly embedded within it. The stochastic approach developed in an earlier UDQE for ET03 operations, based on prior ST12 limits (Hamm et al. 2013), provided SRNL with the insight into how to approach this SA.

The earlier stochastic approach employed for the ET03 assessment computationally addressed only a single DU (i.e., ET03), but did consider all 74 parent nuclides and all pathways. That stochastic approach did not attempt to address plume interaction issues or waste burial timeline changes and was a significantly less computationally demanding analysis effort than the current SA. However, the basic stochastic concept employed in the ET03 assessment was adopted in this effort.

The other key aspect to this SA was the incorporation of improved modeling techniques and datasets, developed or updated since the 2008 PA, into a new E-Area trench model and SRNL dose toolkit. As will be seen later, these modeling improvements play a significant role in compensating for the negative aspects of increased plume interaction.

1.5 DOE Order Requirement

Department of Energy Order (DOE O) 435.1 Manual (DOE 1999) states:

> Low-level waste disposal facilities shall be sited, designed, operated, maintained and closed so that a *reasonable expectation* exists that… performance objectives will be met for waste disposed of after September 26, 1988 (emphasis added)

Further the DOE O 435.1 Guide (DOE 1999) states:

> Impacts of low-level waste disposal on the public or the environment may not be realized until hundreds or thousands of years after the disposal facility has been closed. Due to the lengthy time-frame under consideration and the reliance on modeling of complicated natural processes, it is difficult to reliably predict impacts on the public or the environment. Therefore, it is not possible to provide absolute proof of a disposal facility's performance at some future time. Rather than proof, the requirement is stated in terms of a reasonable expectation.

Finally, this "reasonable expectation" concept is carried forward into the recently issued DOE Tech Standard (DOE 2017). This SA clearly demonstrates the extremely small probability of exceeding a SOF of one using the current set of WITS inventory limits when accounting for uncertainty in future inventories and employing the latest PA models and datasets. Thus, SRNL deems this requirement to be satisfied.

1.6 Quality Assurance

Requirements for performing reviews of technical reports and the extent of review are established in manual E7 2.60 (SRNS 2016) as implemented by the SRNL Technical Report Design Checklist (SRNL 2004).

2.0 Key Inputs and Assumptions

The following key inputs and assumptions apply for this SA and supplement all other key inputs and assumptions presented in the 2008 PA (WSRC 2008), subsequent SA's, and E-Area Closure Plan (Phifer et al. 2009).

2.1 Timelines

As described in Section 1.1, GW flow directions in the lower half of the E-Area LLWF notably changed in the 2018 GSA flow model (Flach 2018a) which employed significantly more hydrologic field data with 20 years of new data since the last model (Flach 2004) and new model calibration methods using mathematical optimization software. Updated flow directions in the model produce a higher degree of plume overlap for the East ST Group (ST14-ST21), Engineered Trenches (ET01, ET02), and the LAWV versus the 2008 PA. Based on a preliminary assessment of this change (see Appendix A), it was determined that a limit-setting strategy based on a time-independent plume interaction calculation could potentially challenge the acceptability of current inventory limits in these DU's. The approach in this SA is to assess any unquantified conservatism in DU inventory limits by accounting for plume interaction based on estimated radionuclide closure inventories (source term) and a predetermined sequencing of trench operations (timing).

A preliminary trench unit sequencing strategy was proposed to SWM and the final scheme incorporated SWM's current thinking and trench usage plans (Butcher, 2018b). The final trench sequencing scheme was used in the PORFLOW modeling timelines to determine whether current trench limits in WITS for DU's located in the lower portion of E-Area were still acceptable. This scheme represents a single disposal strategy scenario in which trench sequencing is fixed – variability in timing (trench opening and closure) is obtained by incorporating uncertainty in annual average volumes. The DU's being evaluated included the previously mentioned set of DU's plus ST05, ST06, and ST07 to ensure that the entire affected area had been captured. Modeling employed the most up-to-date information available including:

- new trench model configuration,
- 2016 closure cap design and resulting infiltration estimates,
- updated hydraulic parameters,
- sorption coefficients (K_d's) and radionuclide & dose parameters, and
- new E-Area flow model cutout of the 2018 GSA aquifer model.

For the operating and future units, estimates of projected closure inventories were employed to establish final dose impacts.

Appendix B contains the trench sequencing scheme and Case 1 timeline along with a description of the timeline logic. The product of this spreadsheet calculation is the timeline of DU lifecycle events shown in Table 2-1 below. The events of interest for each DU are dates for the first and last waste package, operational closure, and interim closure. Interim closure is assumed to occur in two stages, 2040 and 2065. Based on remaining trench capacity, SWM has projected closure of the first 100-acres of the E-Area LLWF in 2040 (Sink 2016). However, Case 1 upper-bound annual average volume estimates show trench capacity (and E-Area vault and naval reactor pad capacity) extending beyond 2040. The 2015 update of the Savannah River Site (SRS) ten-year plan (SRNS 2015) estimates that the SRS Environmental Management cleanup mission will continue for another 50 years – to the year 2065. Therefore, for the purpose of the Case 1 timeline, we have assumed that all trenches (ST's and ET's) filled prior to 2040 will receive a low permeability cover in 2040 as the first stage of interim closure. Interim closure for ST's and ET's open beyond 2040 will be in 2065. Final closure with a multi-layer soil-geomembrane cover is assumed to occur 100 years following this last stage of interim closure (i.e., in the year 2165).

Table 2-1. Case 1 timeline details.

Disposal Unit	First Waste Package	Last Waste Package	Operational Runoff Cover	Interim Closure
ST05	5/27/2004	10/16/2006	12/21/2010	9/30/2040
ST06	4/29/2006	11/8/2029	4/7/2036	9/30/2040
ST07	6/26/2006	4/7/2032	4/7/2036	9/30/2040
ST14	3/29/2011	3/16/2021	3/16/2025	9/30/2040
ST15 (ET06)	3/29/2060	9/4/2066	NA	9/30/2065
ST16	6/23/2037	7/12/2043	7/12/2047	9/30/2065
ST17	7/12/2043	7/31/2049	7/31/2053	9/30/2065
ST18	7/31/2049	8/20/2055	8/20/2059	9/30/2065
ST19	8/20/2055	9/8/2061	NA	9/30/2065
ST20	9/8/2061	9/28/2067	NA	9/30/2065
ST21	9/28/2067	9/28/2067	NA	NA
ET01	2/13/2001	3/30/2017	NA	9/30/2040
ET02	6/3/2004	1/24/2028	NA	9/30/2040
LAWV	9/28/1994	10/15/2056	NA	9/30/2065

Red – Estimated timing of future events

Interim Closure: 2040 | 2065 | Not used

Under the Case 1 scenario, the first ST unit south of the LAWV is not needed until 2037. The southernmost slit trench footprint, ST21, is not projected to be needed before the final stage of interim closure in 2065, and therefore it was eliminated from further consideration.

2.2 Operational Constraints

Three interim measures were imposed on trench operations in ET02 and ST14 during the preparation of this SA (Mooneyhan 2018). Based on the results of this evaluation the following modifications to those Interim Measures are required to be consistent with the assumptions of this analysis.

SOF Administrative Limit

The restricted SOF administrative limits applied as an interim measure to ET02 and ST14 can be removed (i.e., max SOF values of 75% and 65%, respectively). SWM can return to a SOF = 1.0 to protect those DU's from exceeding PO's.

Non-Crushable Container Limits

The general non-crushable container limit for trenches established in the 2008 PA has been 10% of trench (ET & ST) surface area. A lower permanent limit of 2% is now imposed on ET02 and ST14 through ST21. No additional non-crushable containers should be disposed in ST06 or ST07 which currently contain 2.87% and 0.67% non-crushable containers, respectively. Though outside the study area, the following is restated for clarity: The current prohibition on non-crushable containers in ST09, ET03 and (future) ET04 remains in place until this restriction is evaluated in the next PA revision. The general 10% non-crushable limit is still applicable to the remaining operating and future trenches in E-Area. To summarize:

- ET02, ST14 through ST21 – New permanent lower limit of 2%
- ST06, ST07 – No additional non-crushable containers
- ET03, ET04, ST09 – No non-crushable containers allowed pending re-evaluation and approval of a new baseline in the next PA revision
- ST08, ST10, ST11 – General 10% non-crushable limit still applies

Moratorium on Opening or Restarting Selected Trenches

The interim measure prohibiting opening of any new trenches south of ST14 (i.e., ST15 through ST21) remains in effect until this restriction is evaluated in the next PA revision and the new PA baseline is approved or before 2037, whichever comes first. ST06 and ST07 should not be reactivated to receive additional waste prior to completion and approval of the next PA revision or before 2028, whichever comes first.

All the above operational constraints have been discussed with and are acceptable to SWM Engineering (Tempel 2018).

3.0 Impacted Disposal Units

Table 1-2 lists the 13 DU's being addressed by this SA report. Ten of these DU's are highly impacted by the changes in GW flow direction based on the 2018 GSA flow model (Flach 2018a) including ET01, ET02, ST14 through ST20, and the LAWV. ST21 was eliminated from the list by the timeline analysis (Section 2.1 and Appendix B). ST05 through ST07 are on the downgradient edge of the affected zone but were added to ensure all potentially impacted units were included. GW flow directions in the upper half of E-Area have not changed enough to justify their inclusion in this analysis (see Figure 1-2). The main impact resulting from the GW change is a significant increase in the plume interaction among DU's in the lower portion of E-Area. The approach in this SA was to assess any unquantified conservatism in DU inventory limits by accounting for plume interaction directly based on existing inventories and projected radionuclide closure inventories (source term) along with a predetermined sequencing of trench operations (timing). This chapter describes the steps taken to reduce the computational demands and create parent inventory distributions necessary to performing stochastic analyses.

3.1 Current WITS Limits

SWM maintains WITS while SRNL provides SWM inventory limits for every DU either by way of the 2008 PA or a subsequent SA. The current WITS limits are intended to be consistent with those generated by SRNL and to confirm this, SRNL took the existing inventories from SWM and the most up to date SRNL inventory limits and computed SOF values as of September 2018. In certain cases, the original SRNL derived limit was updated by a conservatively imposed SWM administrative limit (e.g., for ET02 the beta-gamma 2 [i.e., 12-100 year time window] limit for the H-3 radionuclide was 13.0 Ci but the current limit was reduced by SWM to 2.0 Ci as a precaution).

Appendix C contains the current WITS inventory limits, along with details demonstrating that SRNL's calculated SOF values are consistent with those provided by SWM. These verified WITS limits are employed during every stochastic realization to constrain each DU's projected future inventory to be consistent with an overall total maximum SOF of one.

3.2 Current Existing Inventories

SWM uses WITS to maintain records of parent nuclide inventories provided by generators for all waste receipts. These records have been kept since the start of the E-Area facility in the late 1994 timeframe. To perform the stochastic analyses, existing inventories are required in order to generate parent nuclide historically-based distributions for generating future inventory compositions. The approach relied on the expectation that the final DU inventory compositions will not be significantly different from historical ST and ET inventory compositions based on 23 years of trench operations. A September 2018 cutoff was selected to distinguish between existing and future waste.

Of the thirteen DU's being considered in this SA, seven contain existing waste (i.e., LAWV, ET01, ET02, ST05, ST06, ST07, and ST14), and the remaining six are future units (i.e., ST15, ST16, ST17, ST18, ST19, and ST20). All of the existing ST and ET inventory data available through September 2018 were employed to improve the statistics associated with creating probabilistic distribution functions (pdf) for each parent nuclide of interest and in each DU of concern. This included existing waste in five additional DU's (i.e., ET03, ST01, ST02, ST03, and ST04).

SWM provided SRNL with existing inventory information from WITS (Sink 2012, Roddy 2018a and b). These inventories in curies (Ci) are reported by DU in Table C-3 where all 38 GW pathway parent nuclides are shown (i.e., only 35 GW pathway nuclides exist for the LAWV). Note that the inventory composition varies among the DU's and most are missing one or more of the parent nuclides from their inventory (blank cells). Special waste forms were also considered for this analysis but excluded because they represent a small fraction of trench inventory and many are either one-time disposal events (e.g., Heavy Water Component Test Reactor [HWCTR]) or waste streams that are no longer generated (e.g., waste from F & H Area GW Treatment Units).

3.3 Parent Nuclides Considered

A rank ordering process was deemed necessary to reduce the overall cost associated with performing the SA. A review of existing disposals over the last 24 years of E-Area operation has shown that only a small number of parent nuclides dominate the total SOF for a given DU. For the deterministic and stochastic analyses performed in this SA, only those parent nuclides whose SOF contributions exceeded 0.1% of the total SOF for each DU were considered. Historically, 1% has been chosen as the cutoff, but with projected PIF factors as high as 5 to 10, due to the new

GSA flow field, small SOF contributors could become significant (i.e., SOF contributions here were based on preliminary values prior to application of a PIF).

The 38 parent nuclides listed in Table C-1 were rank-ordered based on their existing SOF contributions to each DU. Two benchmarks were considered in this rank-ordering process:

- SOF contributions computed using the current WITS inventory limits information and
- SOF contributions computed using the new PORFLOW transport and dose models to generate new "preliminary" limits.

The two benchmarks capture the important parent nuclide SOF contributors under the old and new PA modeling schemes. Appendix C provides details on the current WITS inventory limits as well as the new "preliminary" limits. In performing analyses using the WITS inventory limits the 2018 interim measures (i.e., the restricted SOF's for ET02 and ST14) were not included. The WITS-limits based rank-ordering scheme was performed for all DU's with existing inventories as listed in Table C-2. (i.e., 14 DU's have existing inventories). An example of this rank ordering process using WITS inventories is shown in Table 3-1 for ST14. The cyan highlighted cells represent those radionuclides contributing 0.1% or more to the SOF for ST14.

Table 3-1. Results of the WITS-Based rank ordering for ST14.

ST14					
	BG		ALPHA		AP
Nuc	(%SOF)	Nuc	(%SOF)	Nuc	(%SOF)
H3	1.22%	NP237	7.48%	NP237	0.90%
TC99	0.66%	AM241	0.05%	TC99	0.07%
SR90	0.53%	U235	0.02%	C14	0.02%
I129	0.46%	PU241	0.01%	U235	0.01%
NP237	0.37%	RA226	0.00%	SR90	0.01%
C14	0.15%	U234	0.00%	AM241	0.01%
NI59	0.03%	PU239	0.00%	I129	0.00%
AM241	0.00%	PU238	0.00%	PU241	0.00%
PU241	0.00%	TH230	0.00%	RA226	0.00%
U235	0.00%	CM245	0.00%	NI59	0.00%
K40	0.00%	U238	0.00%	K40	0.00%
RA226	0.00%	AM243	0.00%	U234	0.00%
CL36	0.00%	CF249	0.00%	CL36	0.00%
U234	0.00%	PU242	0.00%	PU239	0.00%
PU239	0.00%	CF251	0.00%	H3	0.00%
PU238	0.00%	CM246	0.00%	PU238	0.00%
CM245	0.00%	CM247	0.00%	TH230	0.00%
TH230	0.00%			CM245	0.00%
PD107	0.00%			U238	0.00%
U238	0.00%			AM243	0.00%
AM243	0.00%			PD107	0.00%
CF249	0.00%			CF249	0.00%
PU242	0.00%			PU242	0.00%
CF251	0.00%			CF251	0.00%
CM247	0.00%			CM247	0.00%

Similar analyses were performed for all 13 DU's of concern and the union of all 13 sets of key contributing parent nuclides result in the short list of 8 parent nuclides listed in the "WITS-Based" column in Table 3-2.

A ranking using the second benchmark, new preliminary inventory limits, was then performed. Preliminary limits were obtained by running the new PORFLOW transport and dose models assuming no plume overlap resulting in preliminary limits (see equation (1-2)). This second approach evaluated the impact of all the recent modeling improvements previously described.

With these updated models and results, preliminary inventory limits were created using the current 2008 PA deterministic methodology for setting limits resulting in several differences with the first key contributors list. The original short list of parent nuclides (WITS-limits based) versus the updated list (Preliminary-limits based) are shown in Table 3-2. Appendix C provides details on the rank-ordering process and selection of the parent nuclide shortlist.

The majority of parent nuclides in both lists shown in Table 3-2 have been previously identified as major contributors. The updated models and datasets have not significantly altered the dominant list of contributors. The nine parent nuclides listed under the New "Preliminary" Limits column are used for all of the follow on analyses presented in this report.

Table 3-2. Short parent nuclide list used in the deterministic and stochastic analyses.

Parent Nuclide	WITS-Based	New "Preliminary" Limits
Am-241		X
C-14	X	X
H-3	X	X
I-129	X	X
Nb-94	X	
Ni-59		X
Np-237	X	X
Sr-90	X	X
Tc-99	X	X
U-235		X
U-238	X	

A confirmation process was employed to verify that the WITS inventories and exiting DU inventories yielded total SOF values consistent with the values supplied by SWM (i.e., discrepancies were less than 1.3%). Details of this confirmation process are also provided in Appendix C.

3.4 Parent Nuclide Distributions

To perform stochastic calculations, pdf's for the nine short-list parent nuclides listed in Table 3-2 are required for all DU's that have potential future waste burials (i.e., 11 DU's in this SA and listed in Table 1-2).

Consistent with the stochastic approach presented in Butcher et al. (2017) a "Monte-Carlo" like process will be employed where compositions within each DU of concern will be randomly generated based on log-normal cumulative density functions (cdf's) (i.e., the integrals of the pdf's). Specifically, the mean value and standard deviation calculated for each of the nine parent radionuclides across all trenches are scaled to the current inventory of each parent in a particular DU or directly applied to future trenches. These statistical values (mean value, standard deviation) are then fitted to a log-normal pdf. This pdf is integrated to obtain the cdf used in the sampling process for randomly generated trench inventory compositions. The log-normal pdf was chosen because it addresses the two end conditions in a natural way:

- The lower bound is at zero inventory which is consistent with the physical constraint of only non-negative values.

- The upper bound is infinity which yields a pure component condition that is a correct physical bound and its likelihood is extremely low based on historical burial practices. This upper bound also allows for deterministic cases to be possible.

Details on the creation of the log-normal distributions for the nine parent nuclides in each of the 11 DU's is provided in Appendix C. As an illustrative example, the pdf, cdf, and average existing inventory value for H-3 within ST14 is shown in Figure 3-1. Statistics for H-3 within ST14 produced a mean value is 0.1082 Ci with a one-standard deviation of 0.1945 Ci. As such, a wide range of potential H-3 projected future inventories are expected to be addressed during the stochastic process.

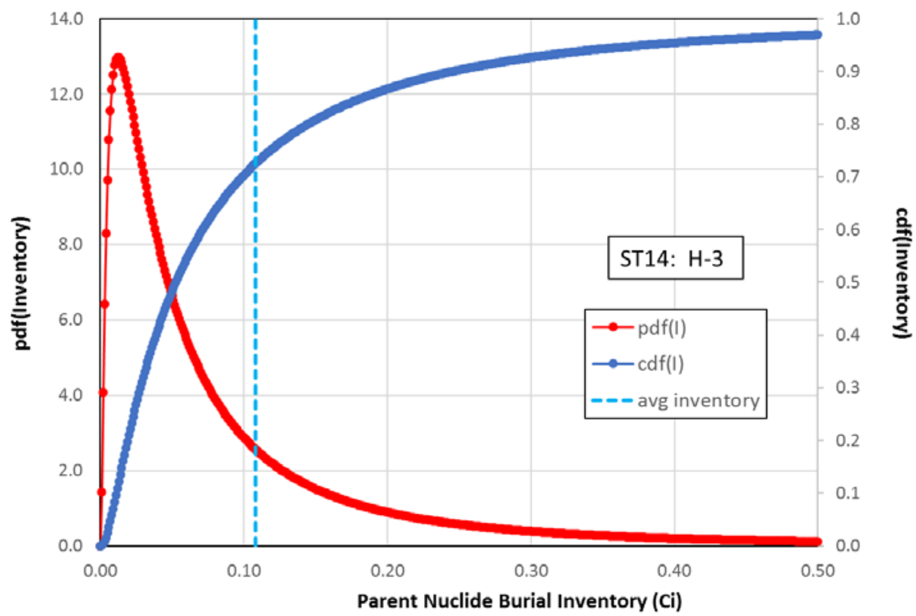


Figure 3-1. Log-Normal distributions of future waste disposals for H-3 within ST14.

4.0 New Engineered Cap

The 2016 conceptual closure cap design produced by Design Engineering (SRNS 2016a and 2016b) is a substantial change from the design evaluated in the 2008 PA. In the 2008 PA, the crest of the closure cap was centered longitudinally over each DU footprint (Phifer et al. 2009) giving the appearance of a series of parallel ridgelines along the 100-acre E-Area LLWF site. In the current design, the crest of the cap extends in a general north-south direction down the length of the 100-acre E-Area site perpendicular to the prior design, resulting in much longer slope lengths. The other major change in the cap is the addition of a 60-mil high density polyethylene (HDPE) geomembrane directly above the geosynthetic clay liner (GCL). Design guidance was provided to limit the top slopes to between 2% and 5% to minimize erosion from a probable maximum precipitation event, and to limit the maximum top slope length to 585 feet or less to justify using F Tank Farm closure cap infiltration data where possible (Phifer et al. 2007). The average closure cap thickness was kept to nine feet or less over the LAWV and eight feet or less over the Intermediate Level Vault (ILV) so that the existing analyses predicting structural performance considering differential settlement and seismic loads remain valid (Carey 2006 and Peregoy 2006, respectively). The cap was designed to not interfere with the adjacent Mixed Waste Management

Facility (MWMF) and LLRWDF caps and included drainage ditches sized to carry all runoff from the cap to nearby sediment basins so as not to impact infiltration through the DU's. Figure 4-1 shows a plan view of the 2016 conceptual closure cap design evaluated by this SA.

4.1 Infiltration Rates

A bounding conceptual infiltration model representing the proposed E-Area LLWF final closure cap design was identified by Dyer (2017) as having a 585-foot-long 3% slope and a 150-foot-long 2% slope. The section of the proposed cap design that fits this model is outlined in the blue dashed box in Figure 4-1. This infiltration model is expected to bound cap performance (i.e., result in higher intact infiltration rates) in the region of interest on the southeastern end of E-Area (outlined in the black dashed box) based on a comparison of slope length / percent slope combinations across the cap (Dyer 2017). Time dependent infiltration degradation curves for the conceptual infiltration model were calculated using a combined deterministic/probabilistic (HELP/Monte-Carlo) approach (Dyer and Flach 2018). Along with time dependent cap infiltration rates, the approach provided spatial insights leading to development of a reasonable basis for representing closure cap subsidence from collapse of non-crushable containers and identification of the most probable subsidence scenarios, collectively forming a conceptual framework of infiltration boundary condition inputs for VZ modeling.

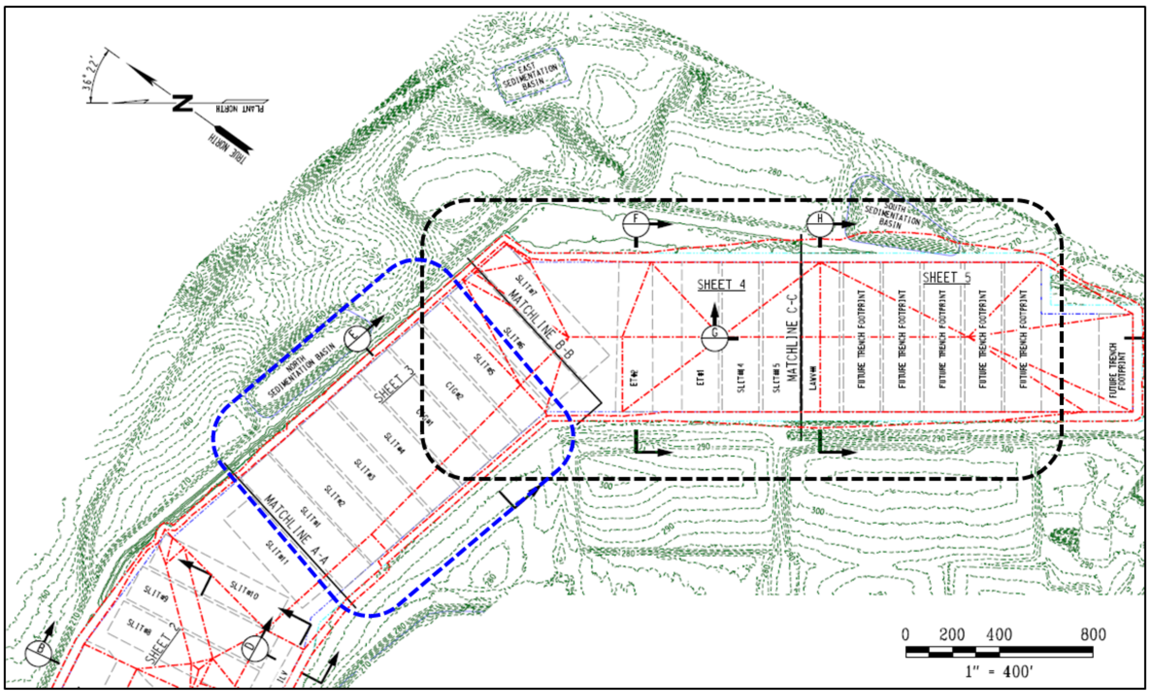


Figure 4-1. The proposed E-Area LLWF final closure cap design.

4.1.1 Intact conditions

Time dependent infiltration rates for the intact final closure cap have been calculated directly using the HELP model (Dyer, 2017) and are shown in Table 4-1 using a generic timeline (further discussion of DU-specific timelines is presented in Section 5.1.3). The infiltration rate for the operational period represents uncovered conditions, the length of which may vary depending on the date of first waste buried in a given DU relative to installation of an operational or interim cover. The institutional control (IC) period lasts for a minimum of 100 years with an assumed non-degrading interim cover (the same infiltration rate is used for operational covers, if present). The final cover, a soil-geomembrane multilayer closure cap, is applied at the end of the 100-year IC period.

Table 4-1. HELP model intact infiltration rates for proposed final closure cap.

Year	Infiltration Rate (in/yr)
Operational	15.78
0-100	0.1
100	0.00088
180	0.0079
290	0.19
300	0.20
340	0.32
380	0.41
480	1.46
660	3.23
1100	7.01
1900	10.65
2723	11.47
3300	11.53
5700	11.63
10100	11.67

Figure 4-2 shows a comparison of the infiltration degradation curve for the proposed final closure cap and the corresponding intact cap infiltration degradation model of the 2008 PA. Figure 4-2 and Table 4-1 show the infiltration rates under intact conditions for the time periods where explicit HELP modeling was performed to account for cap degradation. For VZ flow modeling purposes a much finer resolution of the time-dependent filtration rate is required, and interpolation of these time periods were performed as discussed in Chapter 5.0.

Notably, the current conceptual model has lower infiltration rates for all time periods and is up to two orders of magnitude lower in the early time periods. The improvement seen in the intact cap performance is largely the result of a new conceptual closure cap configuration which adds a 60-mil HDPE geomembrane directly above the GCL.

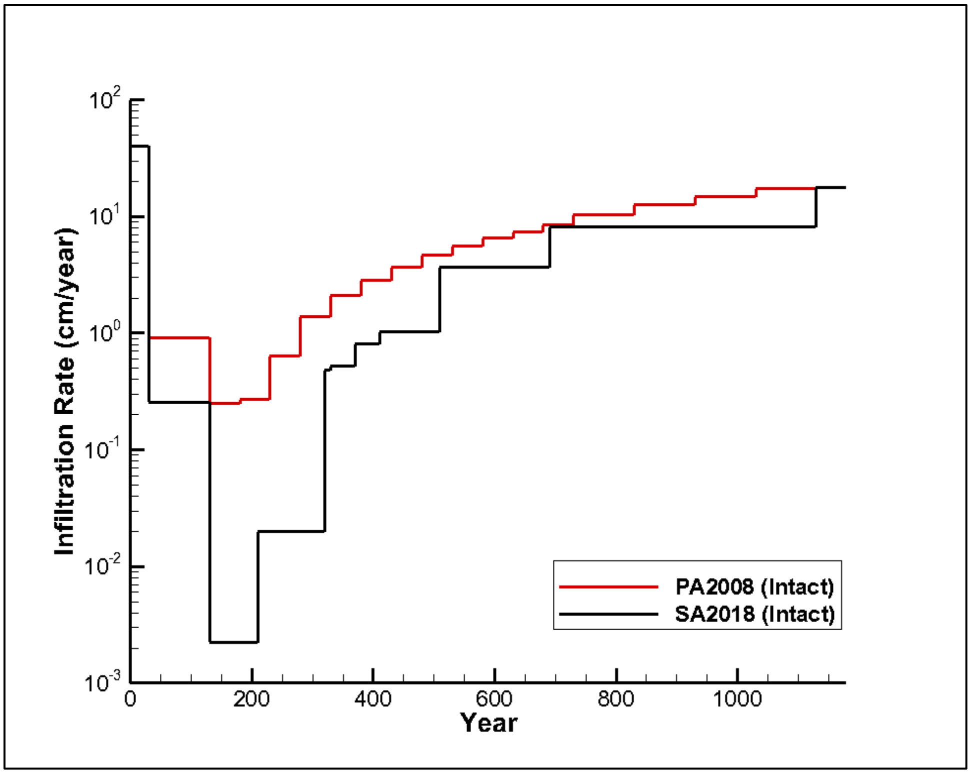


Figure 4-2. Comparison of infiltration rates used in the 2008 PA and those used in the current SA.

4.1.2 Subsided conditions

The following two distinct conceptual infiltration cases were considered representative of subsidence conditions:

- **Average Case** - A slope-length weighted cap-averaged infiltration rate directly output from the combined HELP/Monte-Carlo approach of Dyer and Flach (2018) applied along the entire length of the disposal unit.
- **Discrete Case** - A back-calculated subsided infiltration rate applied to one discrete 12-foot-long hole located at the center of the DU.

The second case utilizes two key outputs from the HELP/Monte-Carlo approach of Dyer and Flach (2018): the calculated cap-averaged infiltration rate and the probabilistically predicted hole size (i.e., 1.8% of the cap length covering the DU, or ~12 feet). The back-calculated infiltration rate is calculated as:

$$I_D = \frac{I_{Av} - 0.982 I_I}{0.018} \tag{4-1}$$

where I_{Av} - slope-length-weighted, cap-averaged infiltration rate (in/yr)

I_I - intact infiltration rate (in/yr)

I_D - back-calculated infiltration rate applied to the discrete hole region (in/yr)

Four sets of infiltration rates (shown with a generic timeline in Table 4-2) have been calculated to account for the representative quantities of projected non-crushable materials in the DU's of interest. Subsidence is assumed to occur as soon as the final cover is applied at EIC.

Table 4-2. Infiltration rates for representing subsidence conditions.

Year	Intact Infiltration Rate (in/yr)	Slope-Length-Weighted, Cap-Averaged Infiltration Rate (in/yr)		Back-Calculated Subsided Region Infiltration Rate (in/yr)	
	0% Subsidence Regions	*2.0% Subsidence (ET02, ST06, ST14-20)*	*0.6% Subsidence (ST05, ST07)*	*2.0% Subsidence (ET02, ST06, ST14-20)*	*0.6% Subsidence (ST05, ST07)*
Operational	15.78	15.78	15.78	15.78	15.78
0-100	0.1	0.1	0.1	0.1	0.1
100	0.001	5.858	2.166	325.392	120.285
180	0.008	5.824	2.188	323.139	121.142
290	0.189	5.938	2.336	319.561	119.483
300	0.204	5.972	2.353	320.622	119.578
340	0.322	6.020	2.462	316.882	119.208
380	0.405	6.092	2.514	316.315	117.568
480	1.457	6.771	3.465	296.669	112.998
660	3.230	7.928	4.982	264.221	100.580
1100	7.015	10.380	8.274	193.956	76.965
1900	10.650	12.719	11.416	125.617	53.205
2723	11.472	13.255	12.129	110.506	47.970
3300	11.532	13.302	12.195	109.881	48.368
5700	11.631	13.346	12.271	106.880	47.170
10100	11.673	13.373	12.304	106.116	41.718

Figure 4-3 provides a comparison between the subsidence infiltration rates used in the 2008 PA and those used in the current SA. The cap-averaged infiltration rate curves are the most directly comparable to the conceptual model used in the 2008 PA and are substantially lower for all time periods and percent non-crushable material. This difference is a result of the assumptions that led to decreased percentages of non-crushable materials from 10% in the 2008 PA to the present 2% or 0.6% values. Infiltration rates corresponding to the discrete hole case represent the flow rate into the subsided region only, not the average across the entire cap.

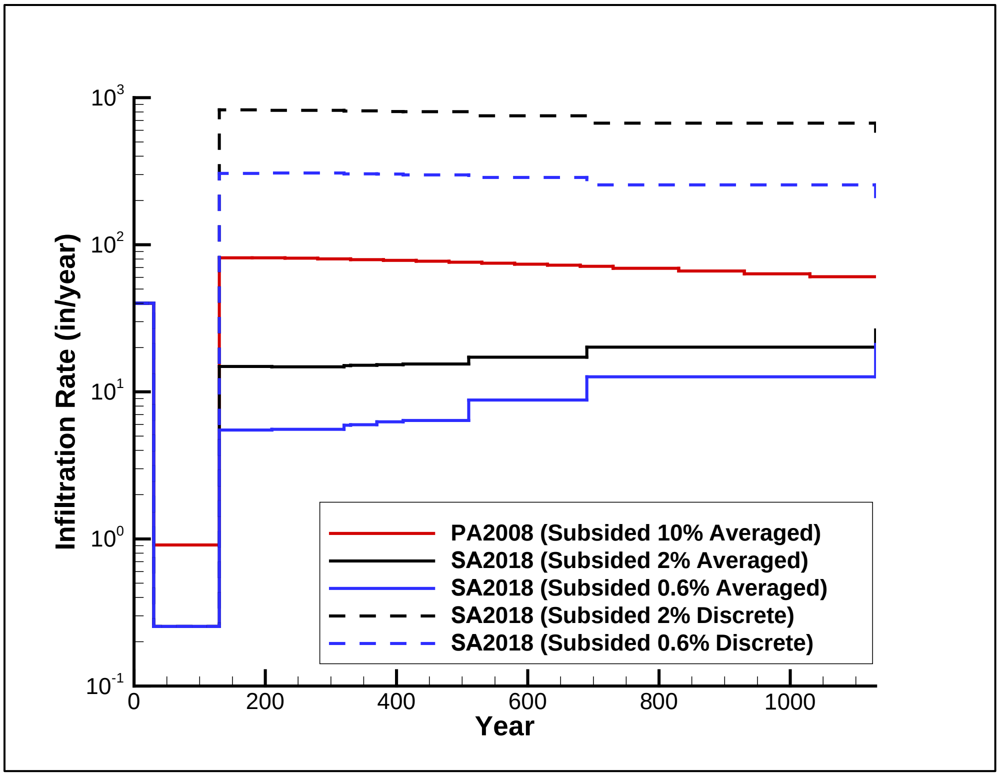


Figure 4-3. Comparison of infiltration rates used in the 2008 PA versus the current SA.

5.0 Vadose Zone Analysis

VZ transport of nine (parent) radionuclide species, from 13 DU waste zones (see Figure 1-6 and Table 1-2), to the water table has been simulated through a sequence of 2D steady-state flow and transient transport simulations as implemented in version 6.42.9 of the PORFLOW software (ACRi, 2010). The calculated flux to the water table for each species will serve as source term input for simulating radionuclide transport through the aquifer to the 100-m boundary. This basic VZ computational strategy (i.e., steady-state flow and transient transport on a 2D model domain) has been employed in both the 2008 PA, as well as all subsequent SA's.

In the following subsections, the VZ conceptual model is outlined, and key simulation results are presented.

5.1 Vadose Zone Conceptual Model

5.1.1 Model Geometry

Figure 4-1 outlined (in the blue dashed box) the area of the E-Area LLWF final closure cap to show the geometry corresponding to the bounding infiltration model. Given that the cap geometry in this region has two different slope lengths and angles, a model geometry corresponding to a longitudinal cross-section (i.e., cross-section parallel to the long axis of the trench unit) is most suitable. Figure 5-1 shows the slope directions (blue arrows) relative to the DU layout and the location along the cap used for the conceptual model.

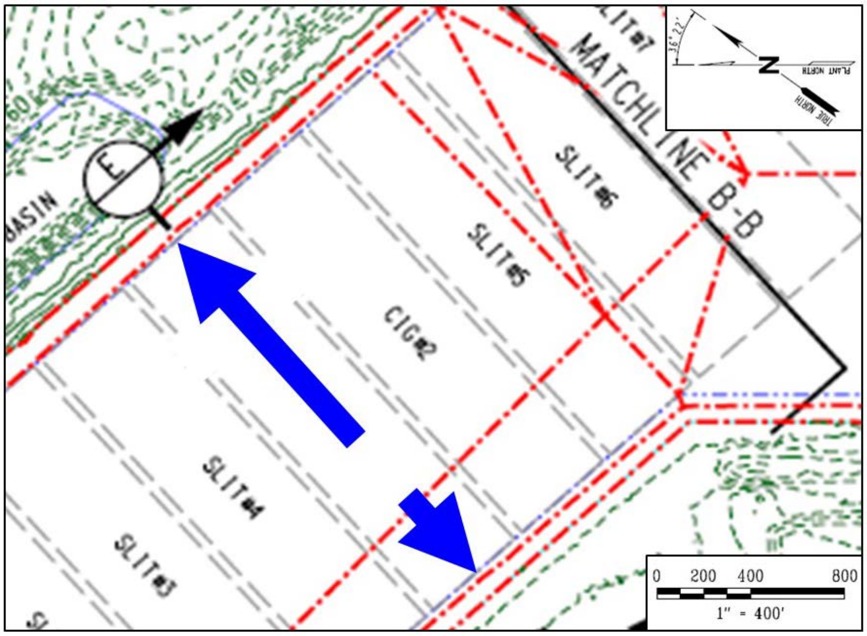


Figure 5-1. Schematic of the bounding infiltration model used as a guideline for the VZ conceptual model.

In the longitudinal direction, ET's and ST's can be represented by the same 2D model (neglecting side slopes) and therefore, only one model geometry is necessary. Figure 5-2 shows the model geometry and the corresponding material zones used for VZ PORFLOW simulations (i.e., material zones are color-coded). The distance from the ground surface to the water table was obtained from SWM drawings and SRNL water table maps (Flach et al. 2017) and is 65 feet on the left (corresponding to the south end) and 55 feet on the right (corresponding to the north end, closest to the 100-m downgradient boundary). The overall depth of the DU is 20 feet where a backfill region extends four feet below the surface with the remaining 16 feet being considered the waste zone. B-25 containerized waste was selected as the waste form for all simulations based on the fact that it produces the most highly compacted waste zone following dynamic compaction (DC) resulting in higher radionuclide concentrations nearer the water table (Phifer 2010). Non-dynamically compacted waste (NDC) extends 16 vertical feet up from the bottom of the trench. Upon dynamic compaction (DC), the waste only extends 2.5 feet from the bottom of the trench. The operational/interim covers extend 10 feet past both ends of the DU. The final cover extends 40 feet past both ends of the DU. The model domain extends another 100 feet past the final cover to minimize edge effects and adequately allow for surface infiltration from uncovered regions to penetrate beneath the covered regions. The model geometry has been non-uniformly discretized with a spatial resolution of 208 by 104 nodes in the x and y directions, respectively.

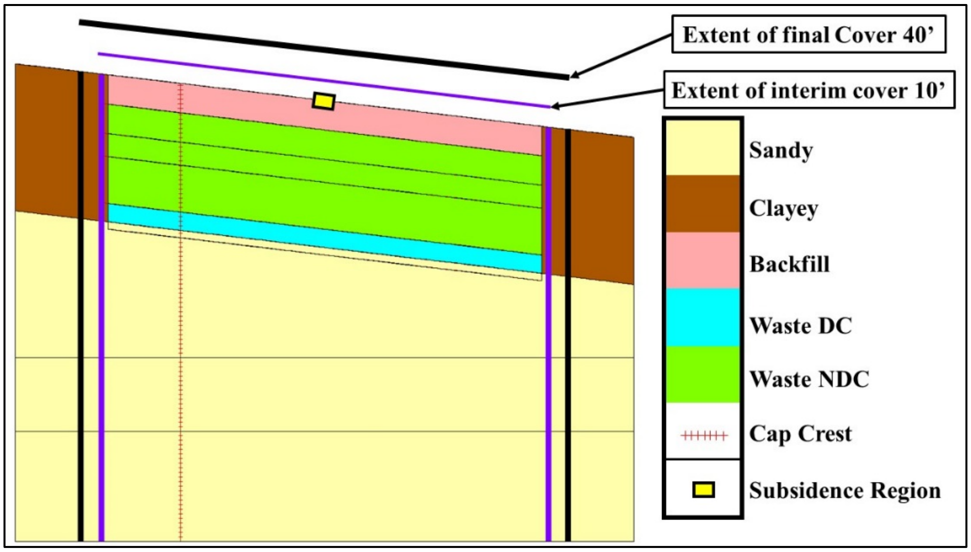


Figure 5-2. VZ geometry used for PORFLOW simulations.

Three separate infiltration models were presented in Section 4.1: intact, cap-averaged (subsided), and back-calculated (subsided-discrete hole), to be referred to from here forth as Case01, Case11a, and Case11b, respectively. In all cases, the 40-foot overhang beyond the edge of the trench is assumed to remain intact throughout the POP. In Case01, the intact infiltration rate extends the entire length of the cap. In Case11a, cap-averaged subsided infiltration rates are applied along the full 656-foot length of the DU. In Case11b, back-calculated subsided infiltration rates are only applied to the discrete 12-foot hole location marked by the yellow square in the center of the DU shown in Figure 5-2 (while the intact boundary condition is applied to the remainder of the cap length). Portions of the model that are uncovered receive a constant 15.78 in/year (40 cm/yr) infiltration as a surface boundary condition. While the cap is not directly modeled, its properties and geometry are implicitly included in the specified boundary conditions.

5.1.2 Material Properties

The material properties for each material zone in Figure 5-2 are shown in Table 5-1, consistent with WSRC (2006) (water retention curves were supplied within the same reference) as updated in (SRNL 2018c).

Table 5-1. Material properties for each material type in the VZ conceptual model.

Material Type	K_h (cm/yr)	K_v (cm/yr)	D_e (cm^2/yr)	Porosity	Particle Density (g/cm^3)
Clayey	1955.23	274.363	167.1408	0.39	2.7
Sandy	10406.90	2869.780	167.1408	0.39	2.66
Backfill NDC	3784.32	3784.320	167.1408	0.46	2.65
Backfill DC	441.504	441.504	126.1440	0.27	2.65
Waste NDC	756.864	756.864	167.1408	0.89	2.65
Waste DC	441.504	441.504	126.1440	0.32	2.65

The calculation of steady-state flow fields requires the discretization of time so that steady-state flow solutions are obtained with fine enough temporal resolution to adequately resolve the transient transport of species. In the current work, 73 unique steady-state flow fields have been computed. Each flow solution represents a specific set of material properties and boundary conditions to account for operational/interim/final cover applications and subsequent degradation. The material properties change at the EIC period (i.e., 171 years after the start of E-Area). The changes in material properties are (referencing Figure 5-2):

- Prior to the EIC: "Backfill NDC" properties applied to Backfill zone, "Waste NDC" properties applied to both "Waste NDC" and "Waste DC" zones.
- EIC: Waste is transferred from "Waste NDC" + "Waste DC" zones to only "Waste DC" zone, "Waste DC" properties applied to "Waste DC" zone, "Backfill DC" properties applied to "Backfill" and "Waste NDC" zones.

5.1.3 Disposal Unit Timeline

The DU timeline described in Section 2.1 and Appendix B provides a template for quantifying the DU-specific length of time that waste is exposed to any given infiltration boundary condition. Using the dates from Table 2-1, the relative times in years (rounded to the nearest year) from the opening of E-Area in 1994 to the date of the first waste package, the last waste package, the application of an operational cover, the start of institutional control (SIC) (i.e. interim closure), and the EIC (i.e. final closure), have been computed for each DU in Table 5-2. The same infiltration boundary condition is specified for operational runoff cover and interim cover time periods in the VZ flow simulations, as both are assumed to have the same spatial extent (10 ft overhang) and infiltration rate (0.1 in/year). Regardless of the date of the placement of the last waste package for a DU, the interim cover is installed no later than relative year 71 (i.e., the year 2065). Because ET's do not receive an operational storm water runoff cover like the ST's, each succeeding ET will be opened closer to the fixed interim closure date and have a shorter period with an operational (uncovered) infiltration rate boundary condition. The DU timelines correspond to the generic timeline boundary conditions from Table 4-1 and Table 4-2 as follows:

- From "First Waste Package" to "Operational Runoff Cover", the "operational" boundary condition is applied.
- From "Operational Runoff Cover" to "Final Closure", the "0-100" boundary condition is applied (if no operational runoff cover is applied, this period extends from "Interim Closure" to "Final Closure"). This period is loosely referred to as the IC period in this report though in some instances it encompasses part of the operational period.

- From "Final Closure" onward through time (post-closure), the time-dependent boundary conditions from "100" to "10100" are applied for the intact or subsided conditions.

Table 5-2. Relative time in years for disposal operations and closure for each DU considered. The reference date for relative times is 9/28/1994, corresponding to the first waste placement in the LAWV.

Disposal Unit	First Waste Package	Last Waste Package	Operational Runoff Cover	Interim Closure	Final Closure
ST05	10	12	16	46	171
ST06	12	35	42	46	171
ST07	12	38	42	46	171
ST14	16	26	30	46	171
ST15	66	72	-	71	171
ST16	43	49	53	71	171
ST17	49	55	59	71	171
ST18	55	61	65	71	171
ST19	61	67	-	71	171
ST20	67	73	-	71	171
ET01	6	23	-	46	171
ET02	10	33	-	46	171
LAWV	0	62	-	71	171

5.1.4 Sorption Coefficients

K_d's, for the 12 elements comprising the nine key parent radionuclides (with 5-year cutoff abbreviated chains) and their progeny being addressed within this SA are listed in Table 5-3. For comparison, the K_d values used in the 2013 ET03 UDQE (Hamm et al. 2013) and the values used in the 2008 PA (WSRC 2008) are shown. Highlighted in pink are those elements whose K_d values have been updated since the 2008 PA (Kaplan 2010 and 2016, and for C-14 specifically, Roberts and Kaplan 2013).

Table 5-3. Sorption coefficients (K_d) for the nine elements comprising the key parent radionuclides and their progeny in the 2018 GSA-M SA.[1]

Element	2018 GSA-M SA		2013 ET03 UDQE		2008 PA	
	sand	clay	sand	clay	sand	clay
Ac	1100	8500	1100	8500	1100	8500
Am	1100	8500	1100	8500	1100	8500
C	1	30	1	30	0	0
H	0	0	0	0	0	0
I	1	3	0.3	0.9	0	0.6
Ni	7	30	7	30	7	30
Np	3	9	3	9	0.6	35
Pa	3	9	3	9	0.6	35
Sr	5	17	5	17	5	17
Tc	0.6	1.8	0.6	1.8	0.1	0.2
Th	900	2000	900	2000	900	2000
U	300	400	200	300	200	300

[1] 2008 PA inventory limits were generally based on modeling with cellulose degradation product (CDP) impacted K_d values. However, the values in this table are not adjusted for CDP impacts consistent with Kaplan (2012).

5.1.5 Low Activity Waste Vault

In the current work, no new VZ model was implemented for the LAWV. Rather, the VZ flux to the water table results from the 2008 PA Case 2 (i.e., after design check, with CDP) setup was used for each of the nine parent nuclides (Smith and Hamm 2014). Cracked and uncracked fluxes to the water table were merged into a single file and read in by PORFLOW as source input from the LAWV footprint during aquifer transport.

5.2 Vadose Zone Flow Model

The steady-state flow solutions for the uncovered and IC time periods are the same regardless of DU or subsidence case. This is based on the assumption that any subsidence and damage to operational or interim covers that occurs prior to EIC will be repaired. The water saturation profile for the uncovered case is shown in Figure 5-3. Notably, the waste zone has a very low saturation profile due to the high porosity of the NDC containerized waste form. Stream traces with 5-year time markers indicate that the travel time from the ground surface to the water table is on the order of 10-15 years.

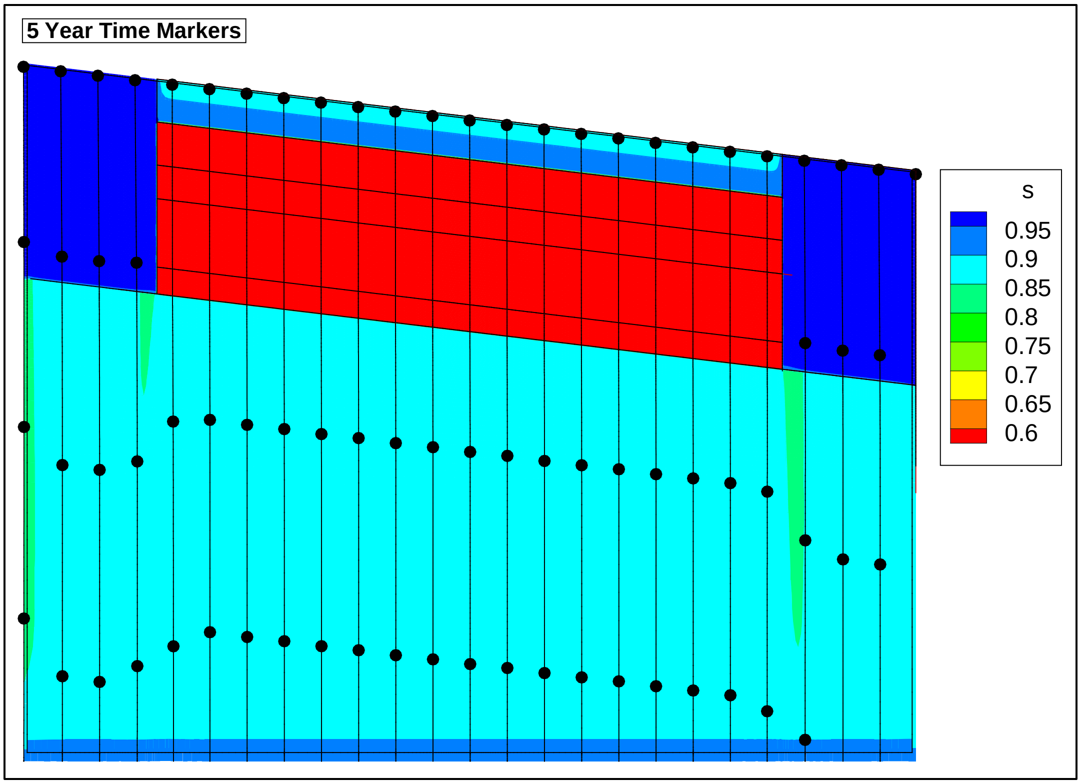


Figure 5-3. Water saturation profile for the operational period.

The water saturation profile for the IC time-period is shown in Figure 5-4. By comparison to the uncovered case, the infiltration rate over the DU is two orders of magnitude smaller and therefore, the travel time from the ground surface to the water table extends from tens of years to thousands of years.

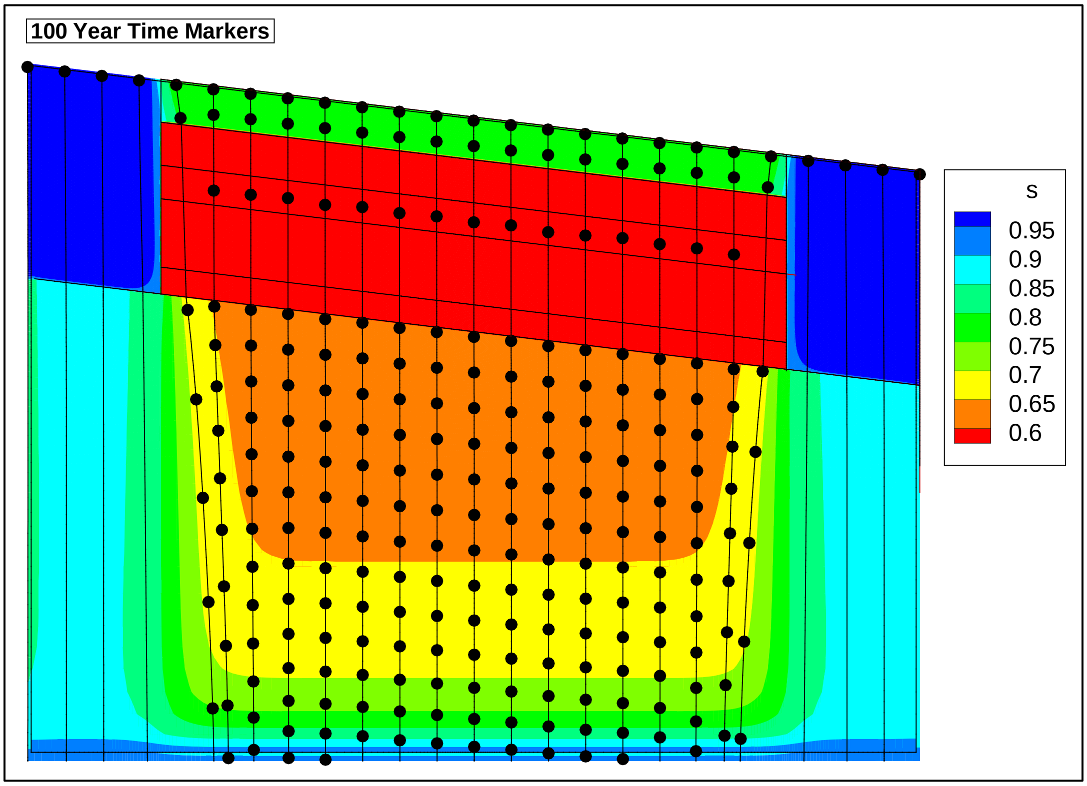


Figure 5-4. Water saturation profile for the IC period.

The water saturation profile at the EIC period differs among each of the three cases and among the DU's, depending on the subsided infiltration rate. The water saturation profile for the intact case, however, is the same across all DU's and is shown in Figure 5-5. At the EIC, dynamic compaction is performed and the final multi-layer, soil-geomembrane cover is installed. Upon compaction of the waste zone and installation of the final cover, the infiltration rate drops by another two orders of magnitude, greatly decreasing the porosity of the backfill and waste zone. Consequently, the steady-state flow solution shows a higher moisture content in the waste zone and significantly longer travel times (on the order of hundreds of thousands of years) from the ground surface to the water table. A noticeable horizontal velocity exists at the boundaries of the final cover due to the difference in the moisture content of the upper VZ and the waste zone. The water velocity at the edges of the final cover is significantly greater than in the central portions of the DU, though the travel time from ground surface to the water table is still on the order of 10,000 years.

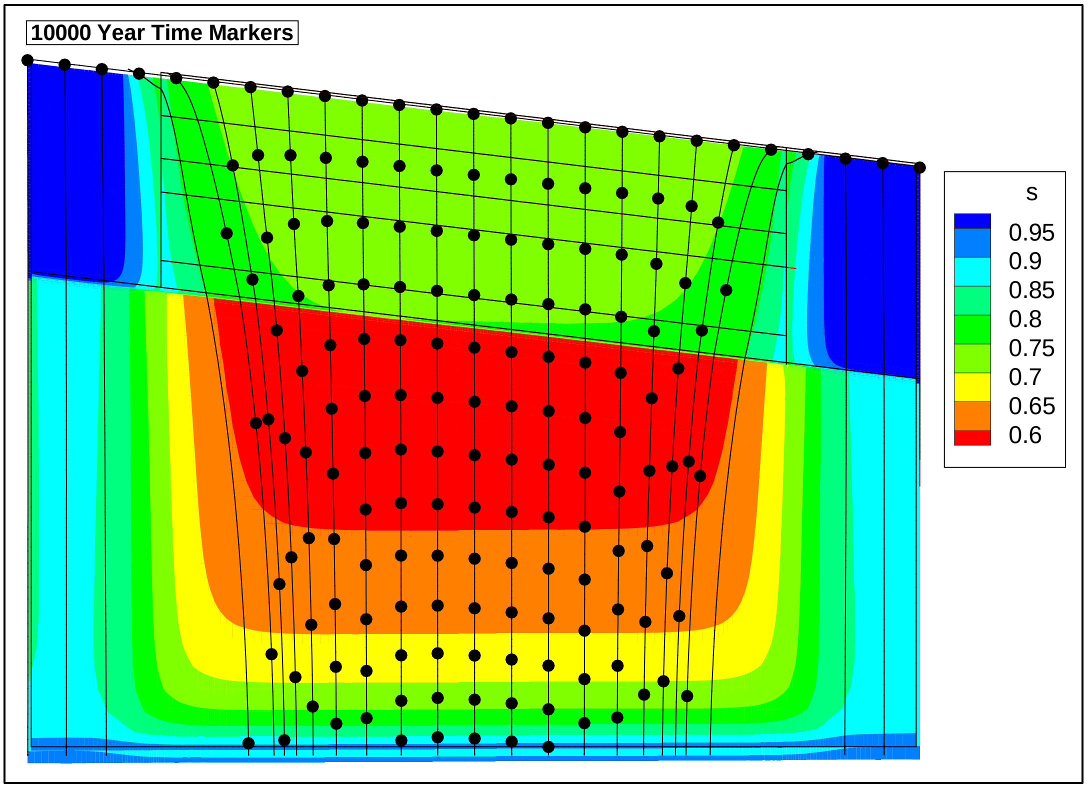


Figure 5-5. Water saturation profile for Case01 at the EIC.

While there are differences between the water saturation profiles of the subsided cases due to the difference in the infiltration rates, they are qualitatively the same. Using ET02 (i.e., at 2% subsidence) as an example, the water saturation profiles for Case11a and Case11b at the EIC are shown in Figure 5-6 and Figure 5-7, respectively. The travel time from the surface to the water table for locations over the DU is on the order of 30-40 years in Case11a. In Case11b, the travel time is significantly greater (on the order of tens of thousands of years) everywhere except the 12-foot subsided region centered over the DU where the travel time is on the order of two years. Note that as time progresses, the subsided region's infiltration rate decreases, and the intact regions' infiltration rates increase. Consequently, through time, the water saturation profiles of Case11a and Case11b become progressively more similar as the intact infiltration rate approaches that of Case11a.

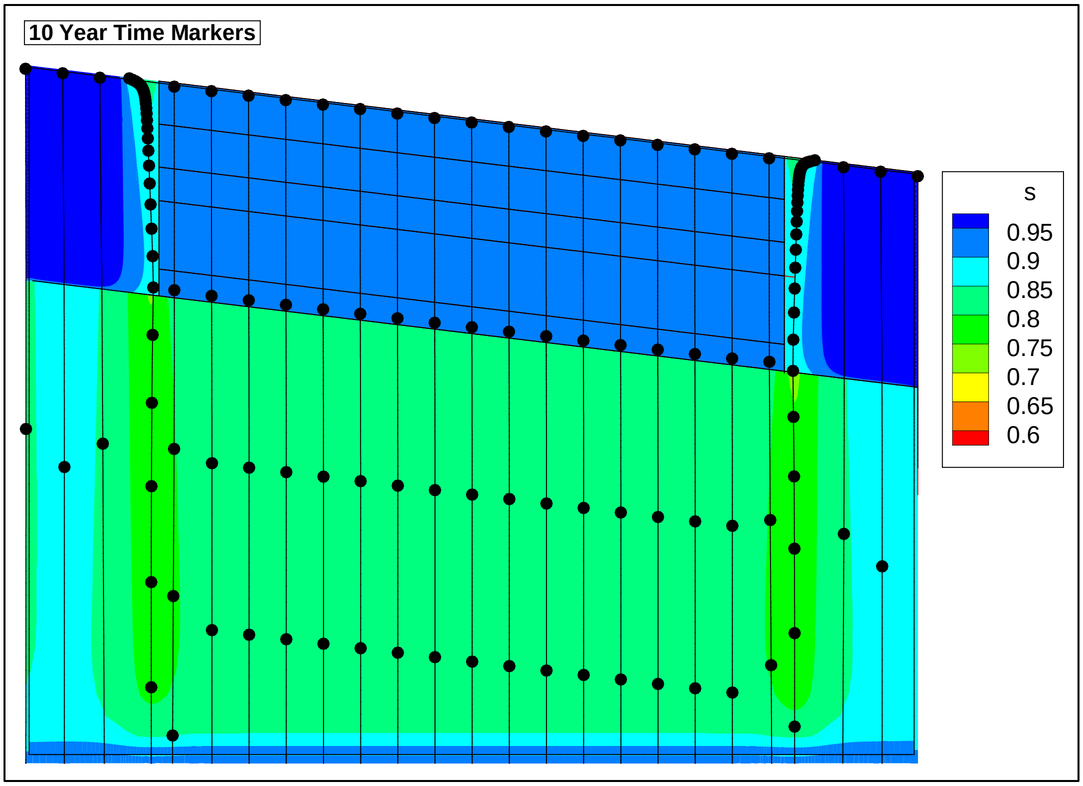


Figure 5-6. Water saturation profile for Case11a (cap-averaged subsided infiltration rate) at 2% subsidence.

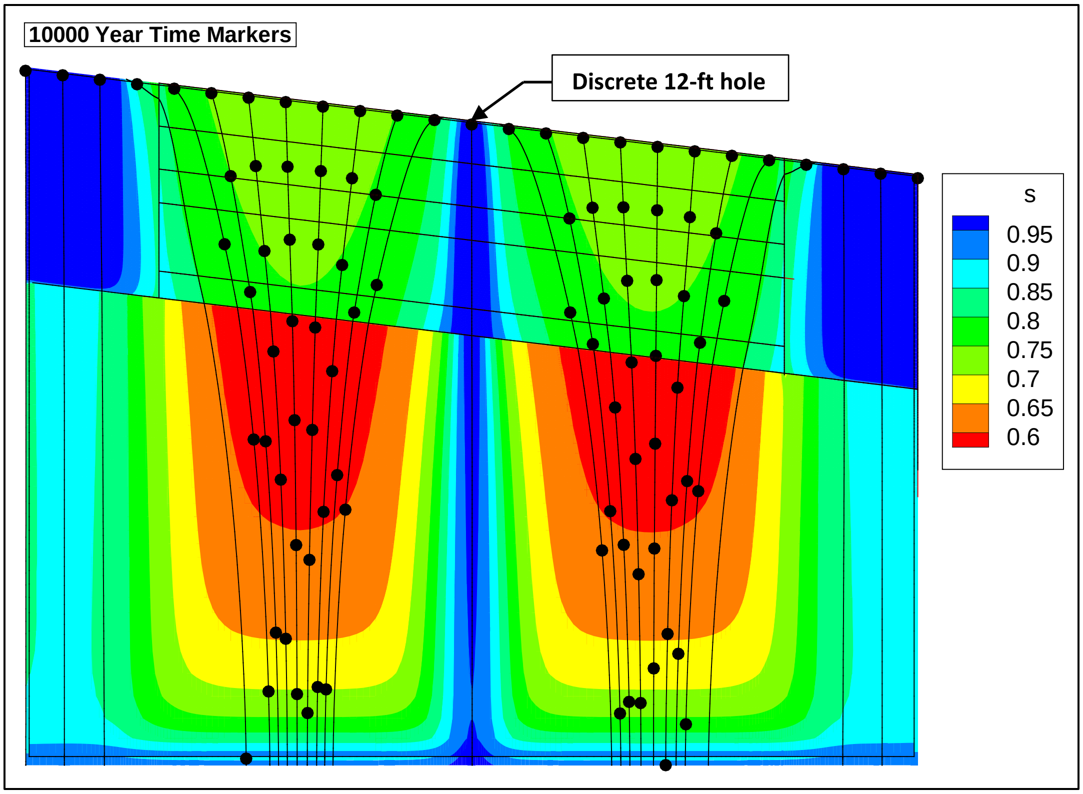


Figure 5-7. Water saturation profile for Case11b (back-calculated infiltration rate, single discrete hole) at 2% subsidence.

5.3 Vadose Zone Transport Model

2D VZ transport simulations were performed using a starting inventory equivalent to 1 curie of the parent radionuclide dispersed uniformly throughout the DU waste zone. The resulting output is the flux of the radionuclide species (parents + progeny) to the water table (in gmol/year per 1 Ci of parent buried) which was subsequently used as input for the source term in aquifer transport simulations. The 73 unique steady-state flow solutions discussed in Section 5.1 were provided as input and the transient transport equations were solved with a time discretization specified by each DU's timeline. Once again, while the DU-specific timing and boundary conditions affect the results, each DU's curve quantifying the flux to the water table for a given radionuclide species is qualitatively similar and thus, ET02 will be used as an example. All 13 DU's transport results were graphically reviewed for quality assurance purposes but are not provided within this report.

In Figure 5-8 through Figure 5-19, the flux to the water table from ET02 is shown for each of the nine parent radionuclides of interest. The first six figures shown have no progeny, while the final six figures are a mixture of parents and progeny for Am-241, Np-237, and U-235 (i.e., only the 5-year cutoff abbreviated chain progeny are shown). The flux to the water table calculated in the 2008 PA is shown for comparison and the timeline for each of the SA runs was shifted to have the same relative time zero as the 2008 PA for plotting purposes.

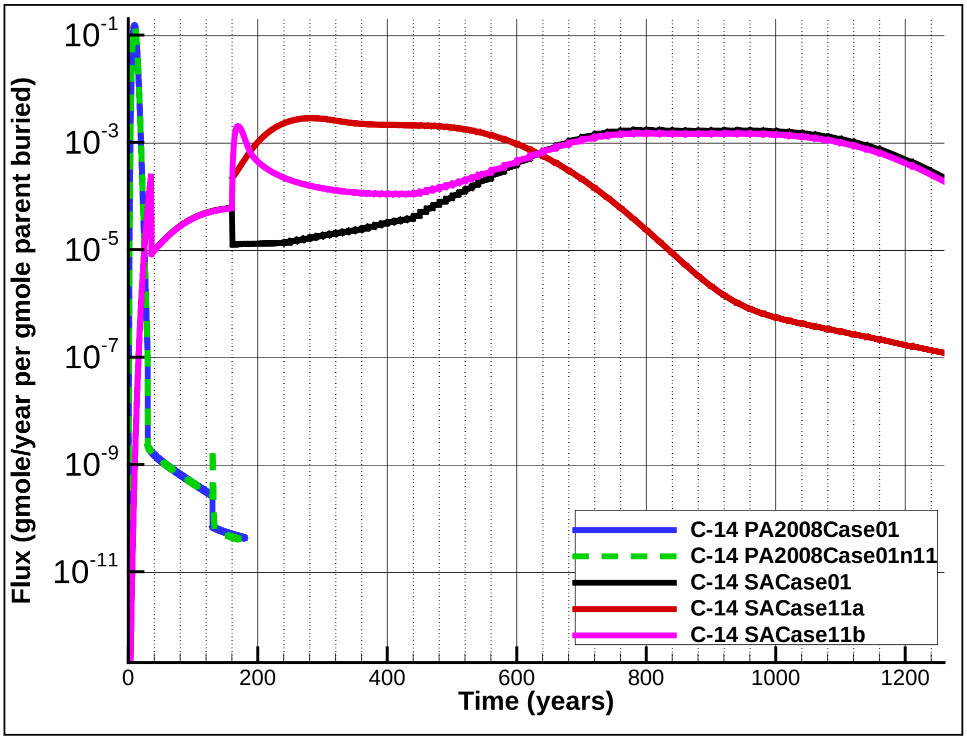


Figure 5-8. Comparison of ET02 transport results (flux to the water table) for C-14.

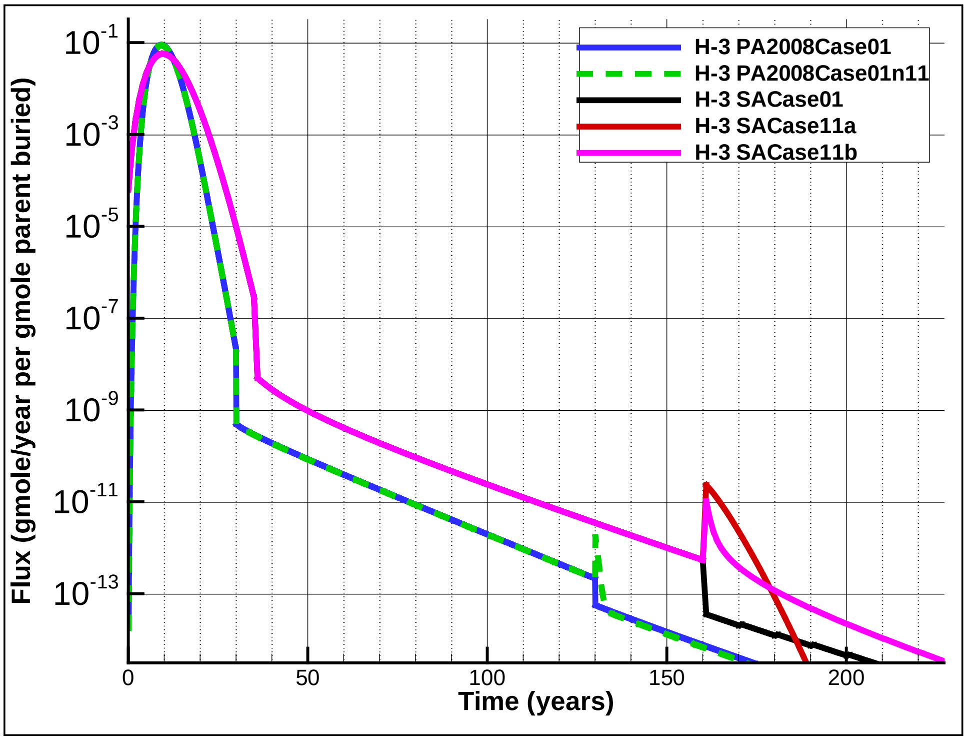


Figure 5-9. Comparison of ET02 transport results (flux to the water table) for H-3.

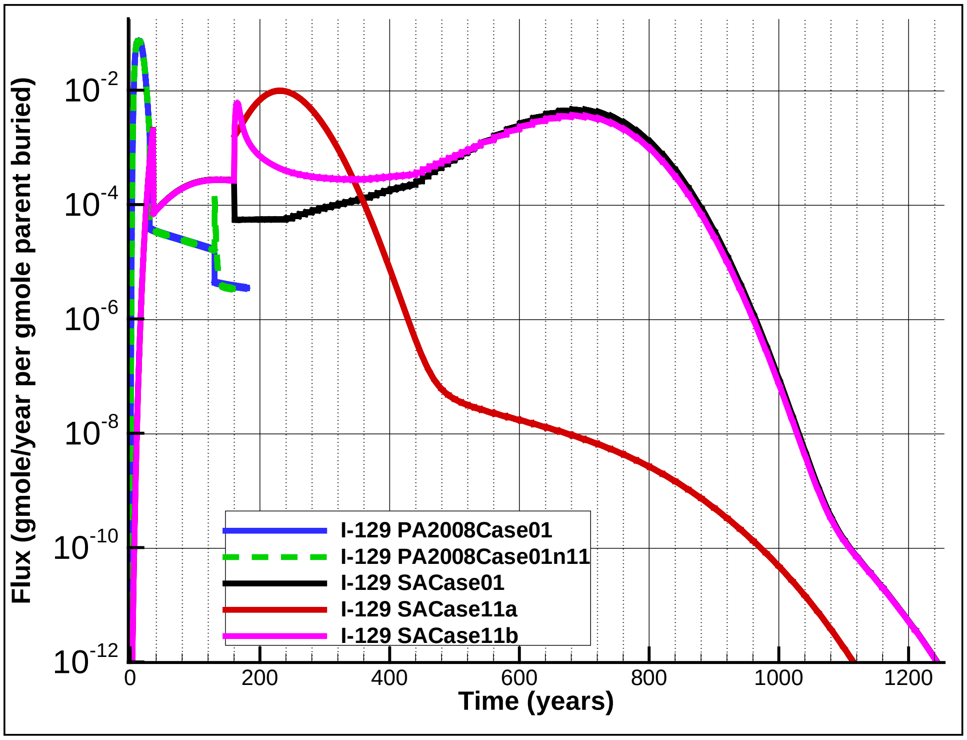


Figure 5-10. Comparison of ET02 transport results (flux to the water table) for I-129.

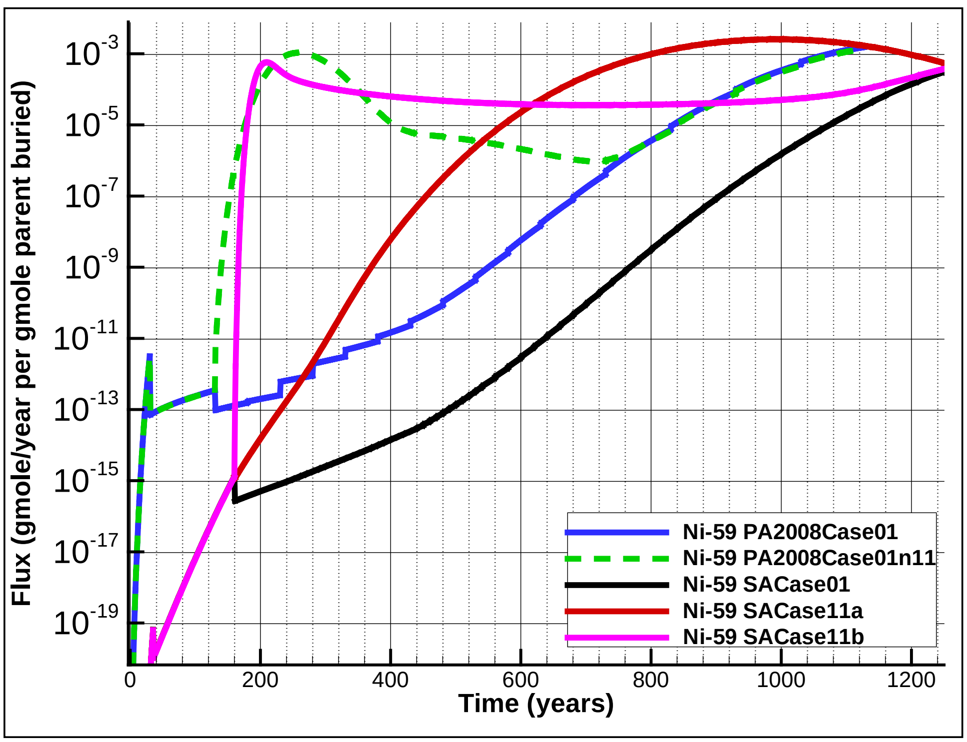


Figure 5-11. Comparison of ET02 transport results (flux to the water table) for Ni-59.

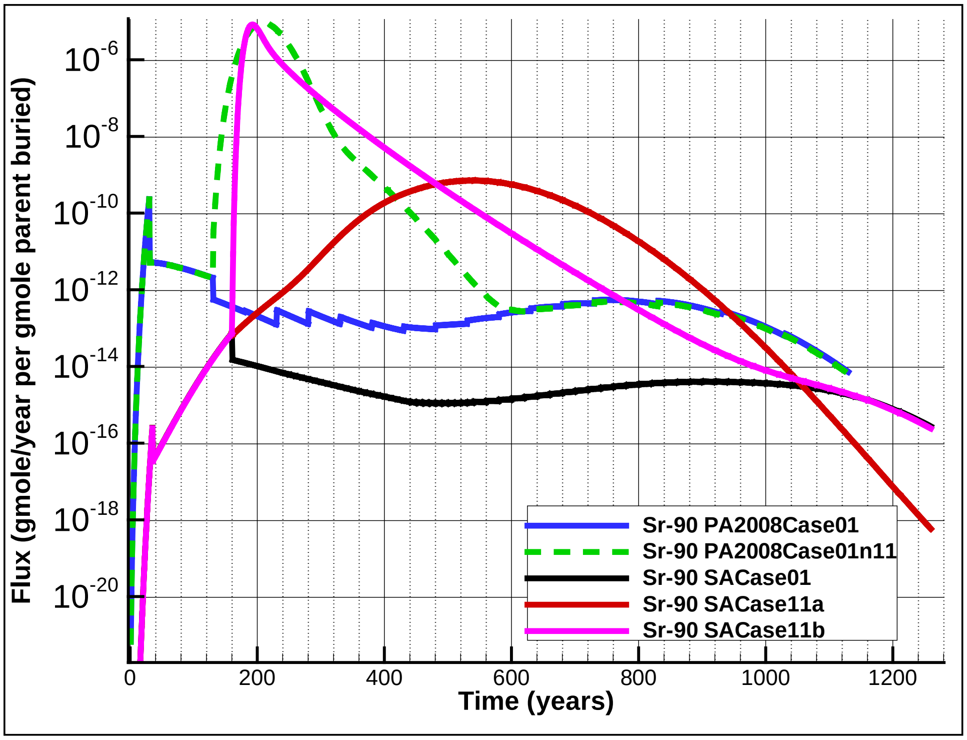


Figure 5-12. Comparison of ET02 transport results (flux to the water table) for Sr-90.

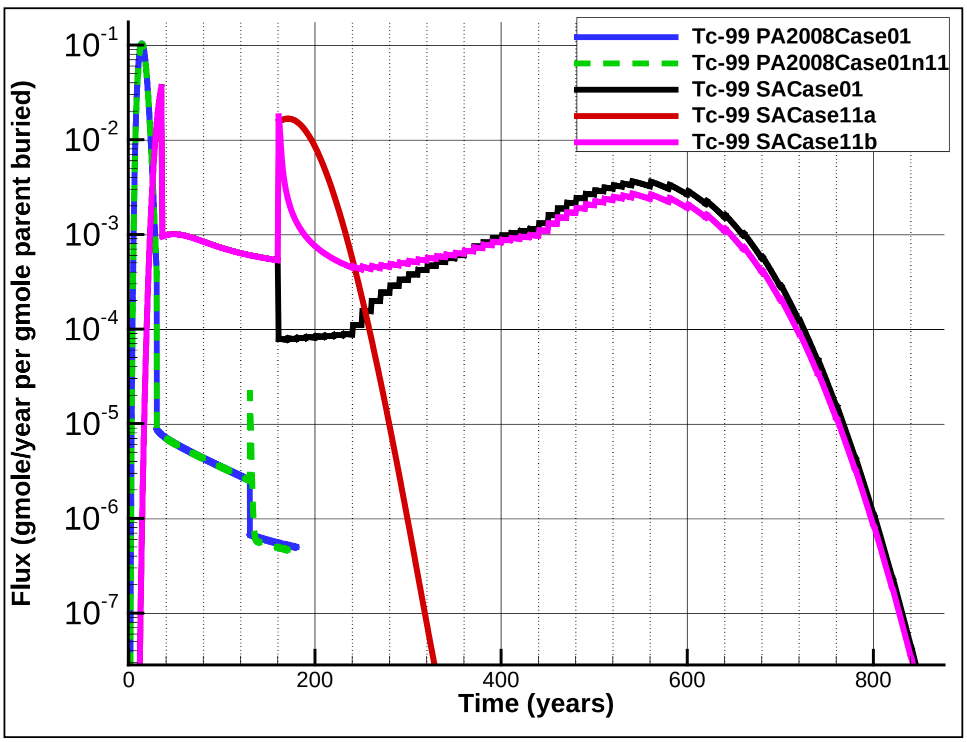


Figure 5-13. Comparison of ET02 transport results (flux to the water table) for Tc-99.

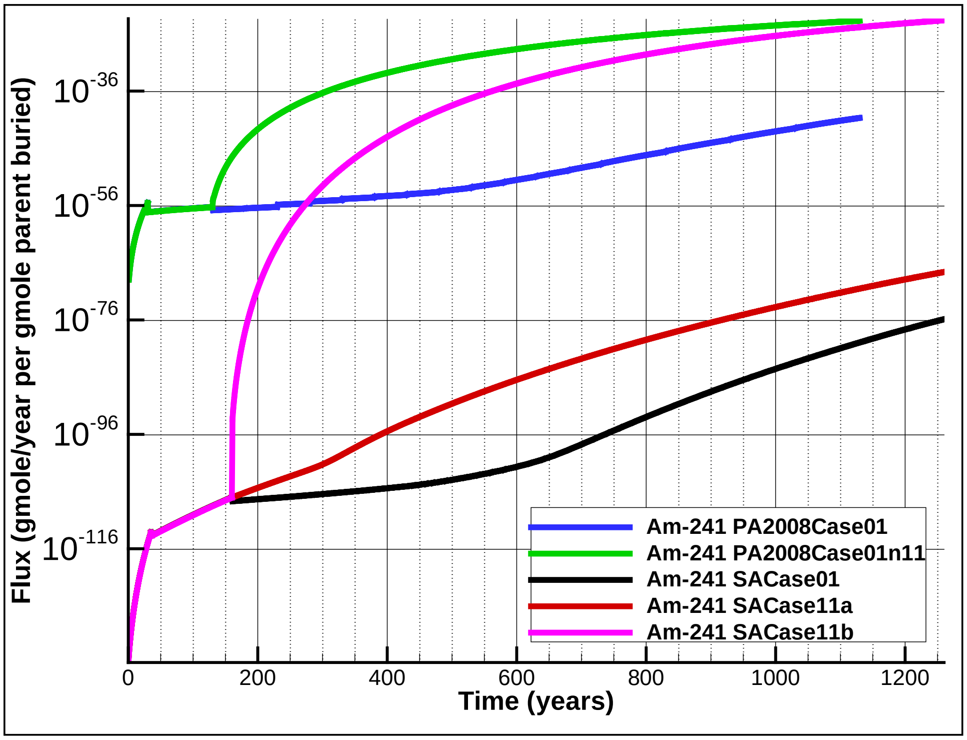


Figure 5-14. Comparison of ET02 transport results (flux to the water table) for Am-241 (parent only).

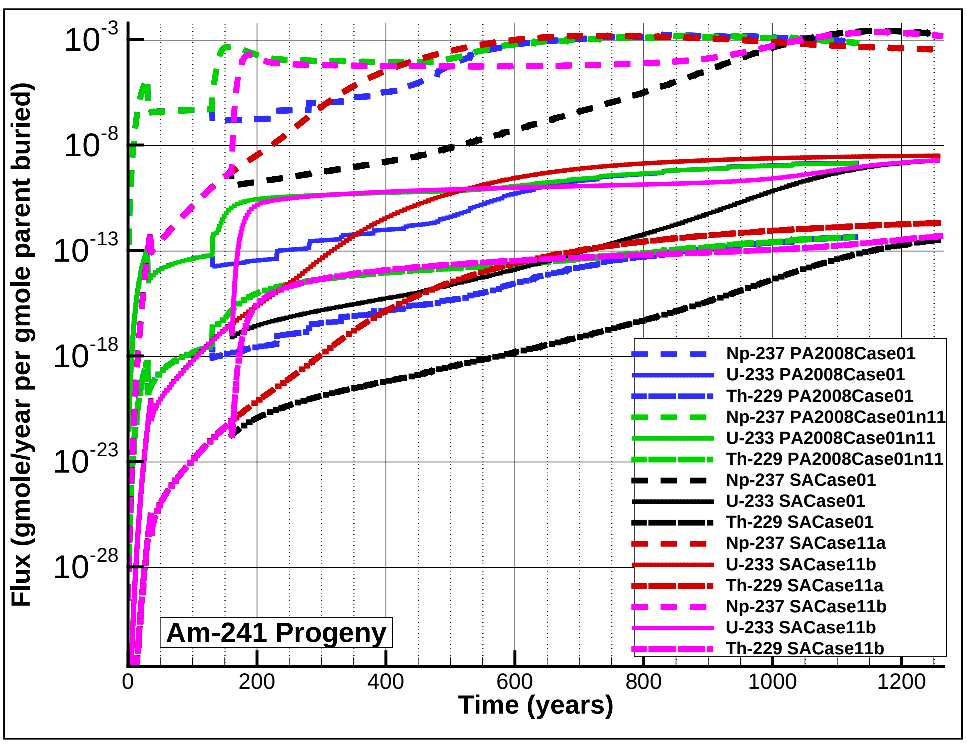


Figure 5-15. Comparison of ET02 transport results (flux to the water table) for Am-241 progeny.

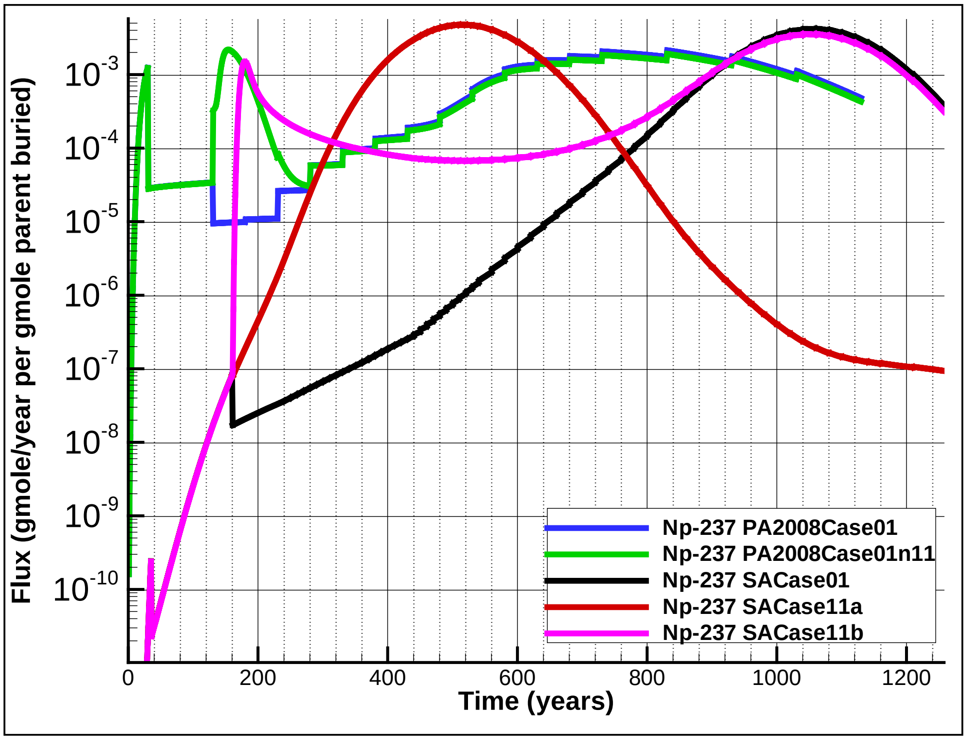


Figure 5-16. Comparison of ET02 transport results (flux to the water table) for Np-237 (parent only).

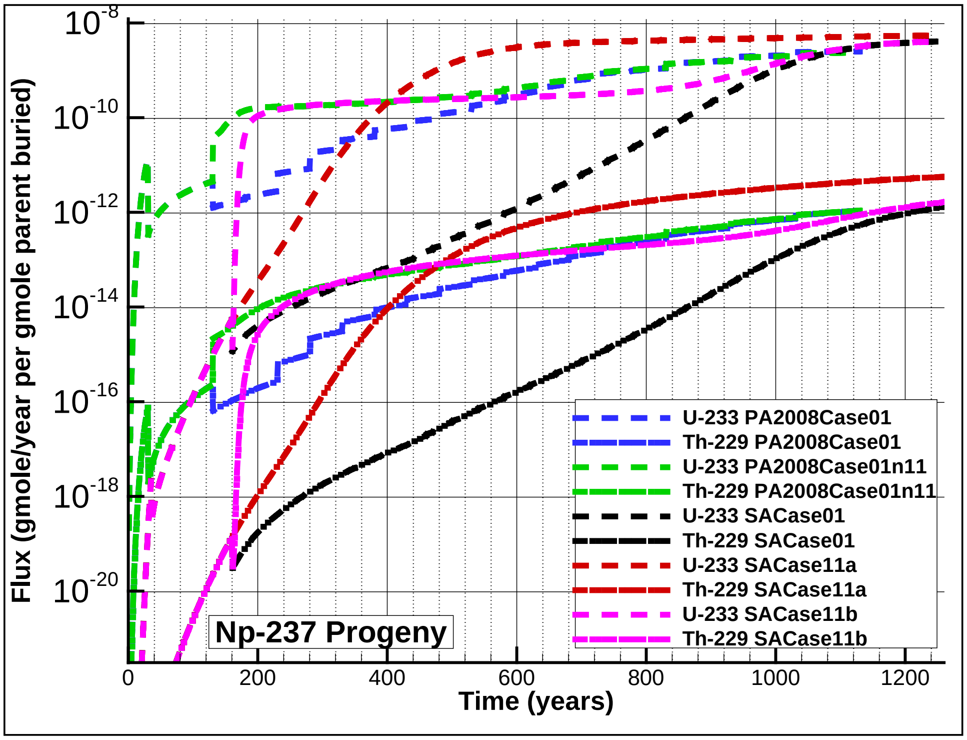


Figure 5-17. Comparison of ET02 transport results (flux to the water table) for Np-237 progeny.

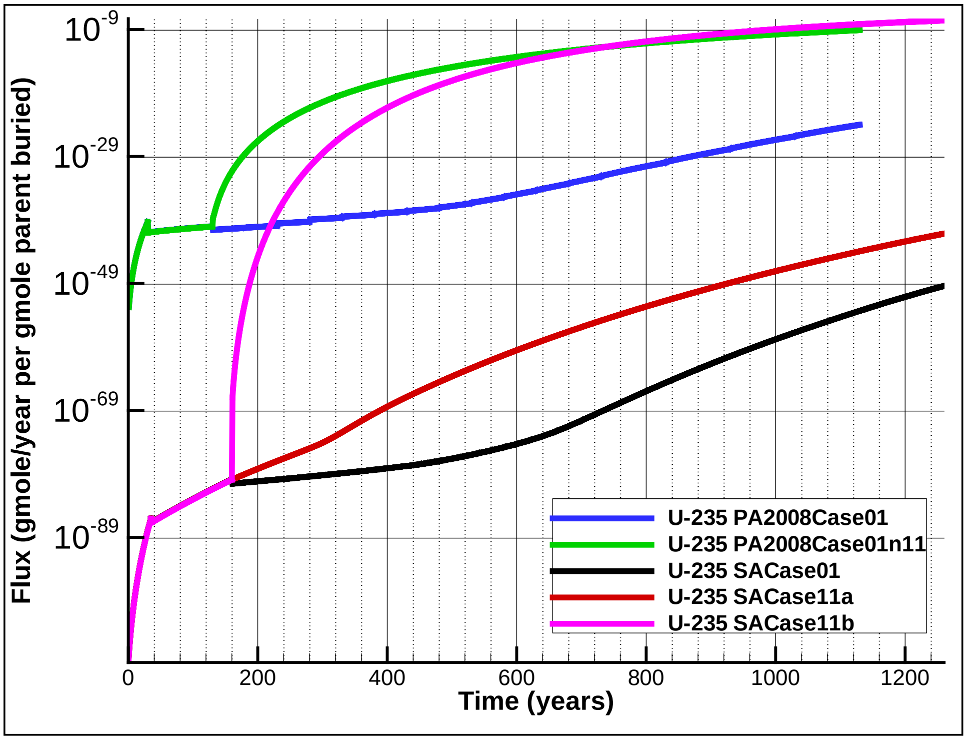


Figure 5-18. Comparison of ET02 transport results (flux to the water table) for U-235 (parent only).

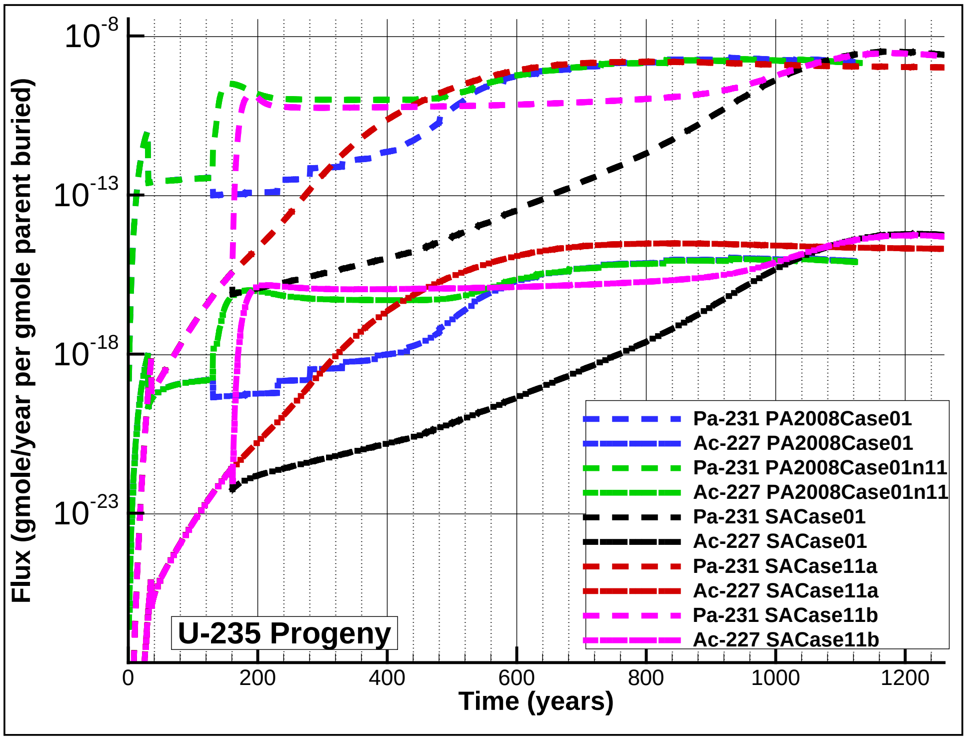


Figure 5-19. Comparison of ET02 transport results (flux to the water table) for U-235 progeny.

In the 2008 PA, the VZ transport runs for several of the mobile species (C-14, I-129, Tc-99) were truncated at around 180 years once the peak had been obtained in order to facilitate the large number of runs and limited computing power at that time. A predominant reason for the difference in shape and magnitude of flux profiles between the 2008 PA and SA is the general increase in K_d values from 2008 to the present (see Table 5-3). The jump in the flux rate for discrete hole cases at the EIC (SA Case11b and PA2008 Case01nll) shows the impact of subsidence on contaminant transport. This behavior is reflected in the subsequent sections dealing with aquifer transport.

6.0 Aquifer Analysis

Aquifer transport of the nine (parent) radionuclides from the location just beneath the source DU to the 100-m boundary has been modeled using the flux to the water table (Section 5.3) as a time-dependent source term (input as a table). Consistent with the VZ transport simulations, aquifer transport runs are made based on abbreviated chains where, for this SA a 5-year half-life cutoff was employed. Each parent's full-chain impact on dose is handled in post-processing steps where the secular equilibrium approximation is employed. All simulations were performed to 1100 years past the EIC and the time evolution of the radionuclide concentration(s) were output at all nodes along the 100-m boundary to provide inputs for the subsequent dose investigation. Two forms of output were employed in assessing the dose at the 100-m boundary (and beyond):

- **STAT.out file –** Contains at each time step the maximum concentration(s) for the parent radionuclide, and its progeny (short-chain members only), in the region at or beyond the 100-m boundary. For each time step the location of the maximum concentration for each member within the short-chain may not coincide with other chain members.
- **HIST.out file –** Contains similar concentration information as the STAT.out file but is limited to just the 100-m boundary. This 100-m boundary represents a "vertical" curtain where, at each time step the concentration profile(s) for all short-chain members are recorded. Within the PORFLOW aquifer transport model this curtain is represented by 8832 nodes (i.e., 192 by 46 mesh).

6.1 Aquifer Model Geometry

Two aquifer flow models based on the 2018 GSA flow model (Flach 2018a) were used for modeling aquifer transport of radionuclide species. Both models are represented by one cutout of the original 2018 GSA flow model. The aerial cutout chosen spans the footprints of all 13 DU's (i.e., it covers the region of concern as highlighted in Figure 1-2). Additional area is included to ensure that the outflow boundaries are appropriately handled.

The first model is the base case 2018 GSA flow model (Figure 6-1), which is used for the first 171 years of simulation time. The second model is the 2018 GSA flow model with inputs representing the E-Area LLWF with the final closure cap installed (Figure 6-2), which is applied at the EIC (i.e., year 171) in the simulation.

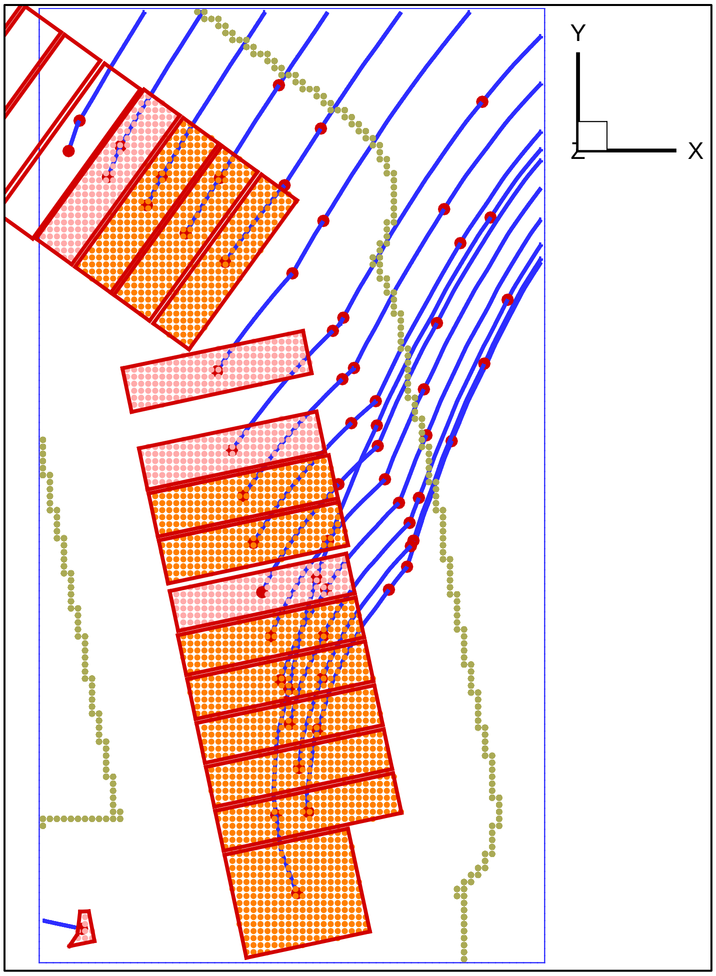


Figure 6-1. 2018 GSA flow model prior to the installation of the final cover – the model cutout is outlined in blue. Stream-traces with 5-year time markers are shown.

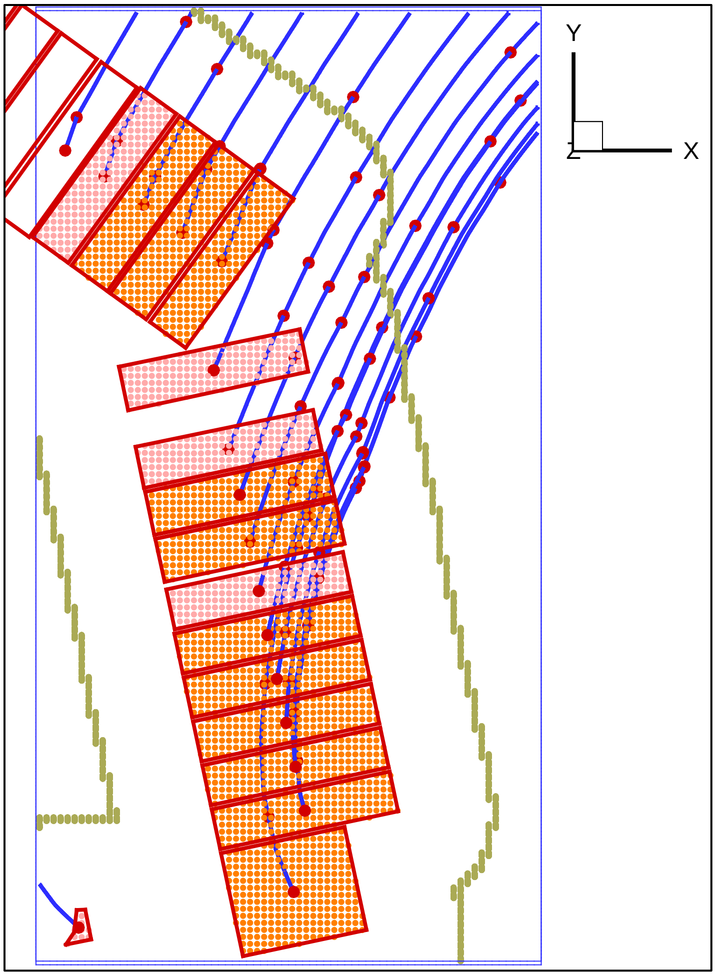


Figure 6-2. 2018 GSA flow model with the final cover installed – the model cutout is outlined in blue. Stream-traces with 5-year time markers are shown.

The section of the 2018 GSA flow model(s) containing all units of interest was cutout and spatially refined using the MESH3D program (Danielson 2017) and is shown in Figure 6-3.

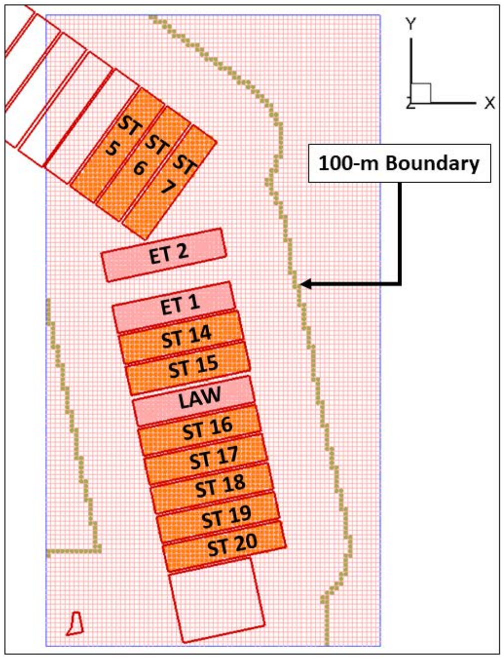


Figure 6-3. Aerial view of cutout and mesh refinement for aquifer transport modeling of ELLWF DU's of interest.

6.2 Aquifer Model Update

In the 2008 PA, a two-parameter dispersion tensor was the only option available in the PORFLOW version (5.97) used at the time. Numerical difficulties were encountered and forced the vertical velocity contribution to dispersion to be set to zero, introducing non-conservative aspects that were later quantified by Flach (2013). Subsequent investigations (e.g., Hamm et al. 2013) using updated PORFLOW versions (e.g. 6.30.2) included a four-parameter dispersion model, but numerical difficulties for some radionuclide species were again encountered that required the use of nuclide-specific correction factors. In the current investigation, using PORFLOW version 6.42.9, the four-parameter dispersion tensor option has been used, but numerical difficulties have been eliminated by using an appropriate mesh resolution and values of the dispersion tensor parameters with guidance from Flach (2018b). The following values for the four-parameter dispersion tensor have been used:

$$\begin{aligned} a_{LH} &= 32.8 \\ a_{TH} &= 3.28 \\ a_{LV} &= 3.28 \\ a_{TV} &= 0.328 \end{aligned} \qquad (6\text{-}1)$$

Material property specifications describing the aquifer zone are shown in Table 6-1. Sorption coefficients are the same as those provided in Table 5-3.

Table 6-1. Material properties used in PORFLOW aquifer simulations.

Material Type	D_a (cm^2/yr)	Porosity	Particle Density (g/cm^3)
Clayey	0.14	0.43	2.67
Sandy	0.18	0.25	1.39

6.3 Aquifer Model Results

In Figure 6-4 through Figure 6-15, the time-dependent maximum concentration at the 100-m boundary, originating from ET02, is shown for each of the nine radionuclides of interest. The first six figures shown have no progeny, while the final six figures are a mixture of parents and progeny for Am-241, Np-237, and U-235 (i.e., only the 5-year cutoff abbreviated chain progeny are shown). The maximum concentration at the 100-m boundary calculated in the 2008 PA (with no CDP) is shown for comparison and the timeline for each of the SA runs was shifted to have the same relative time zero as the 2008 PA for plotting purposes.

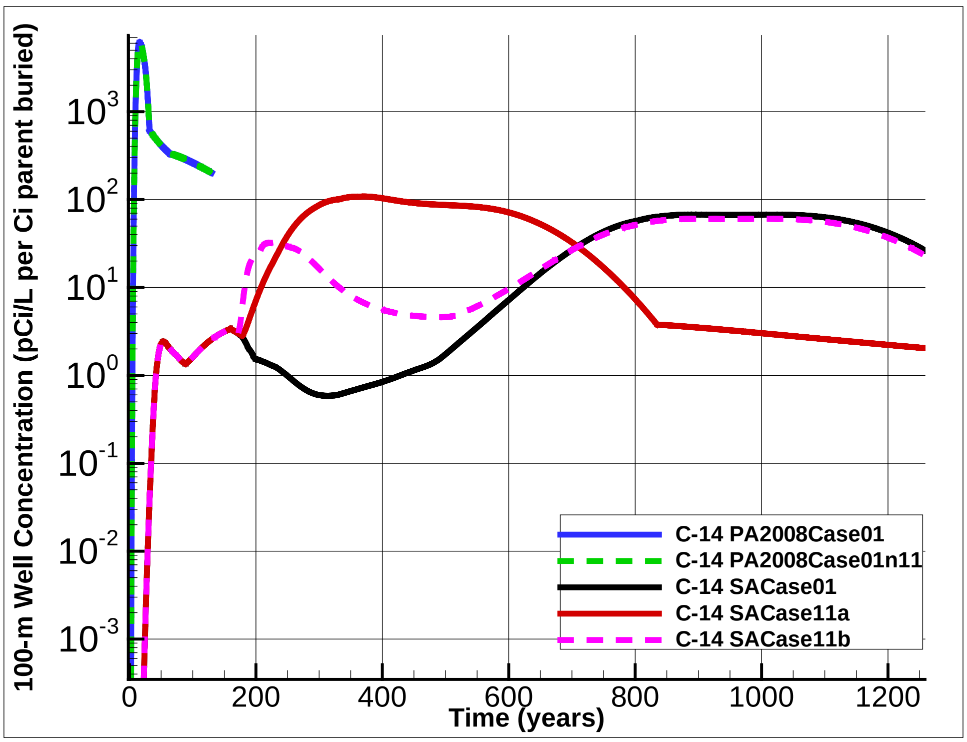


Figure 6-4. ET02 maximum concentration at the 100-m boundary for C-14.

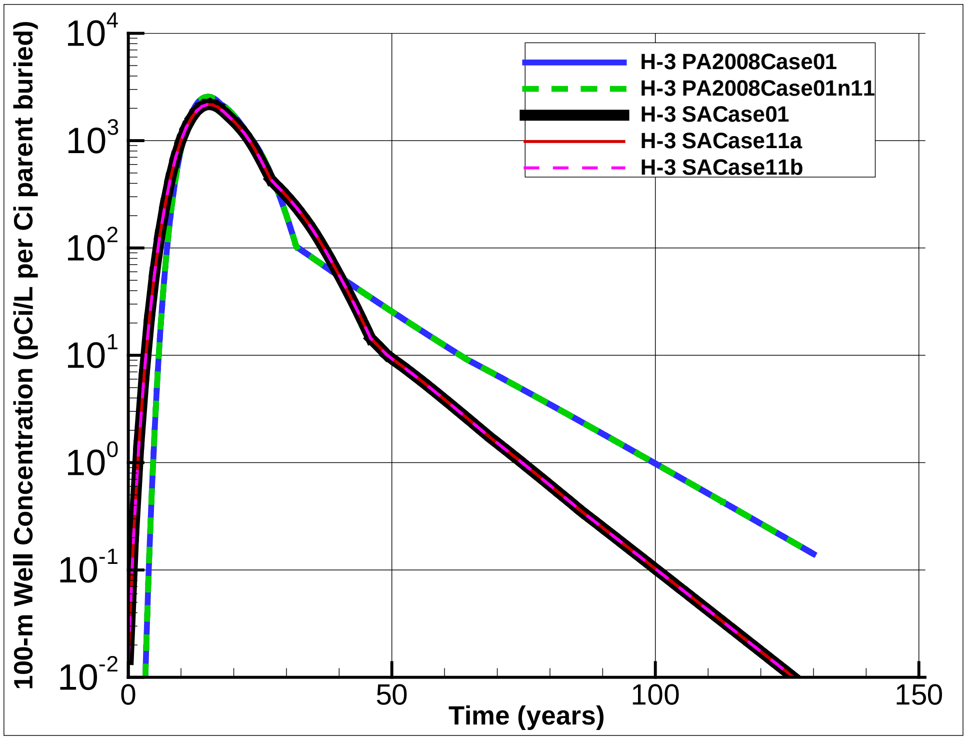


Figure 6-5. ET02 maximum concentration at the 100-m boundary for H-3.

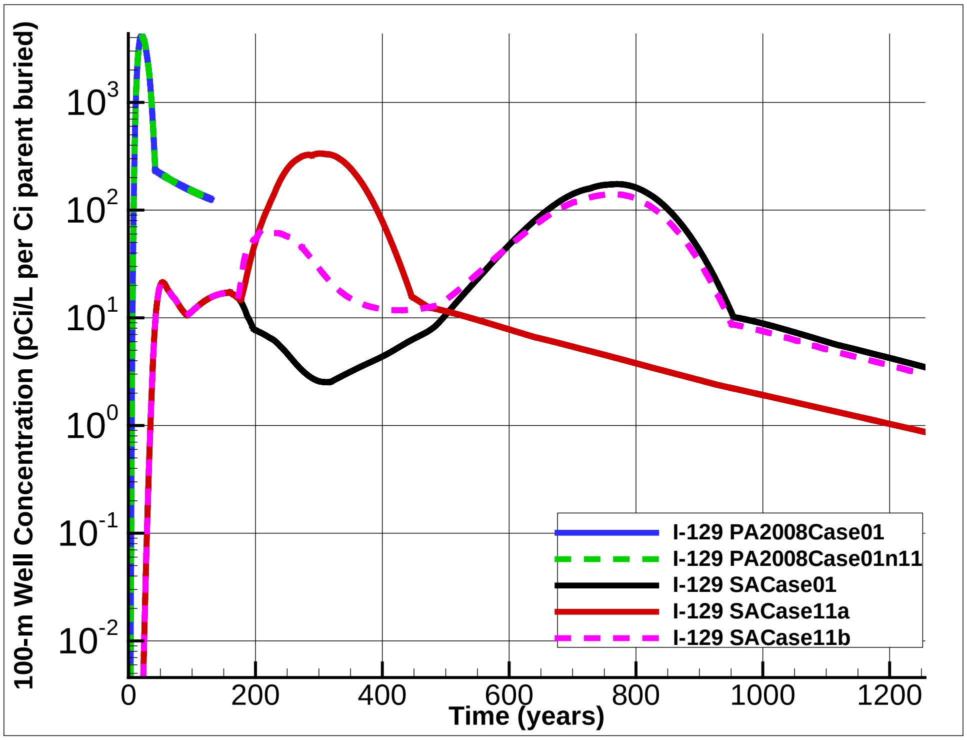


Figure 6-6. ET02 maximum concentration at the 100-m boundary for I-129.

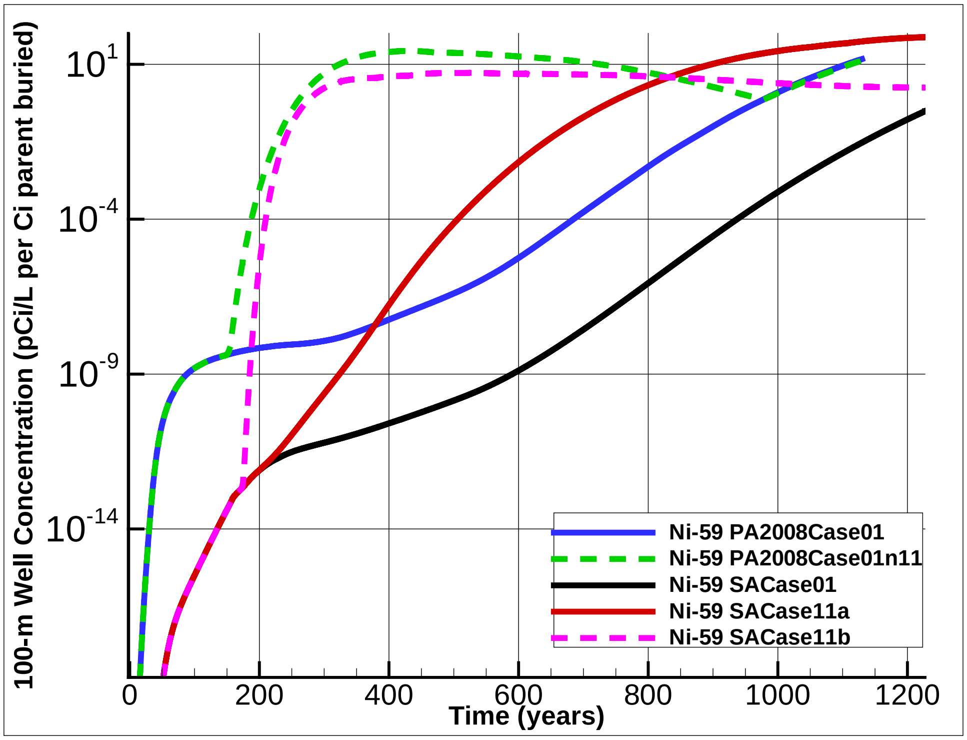


Figure 6-7. ET02 maximum concentration at the 100-m boundary for Ni-59.

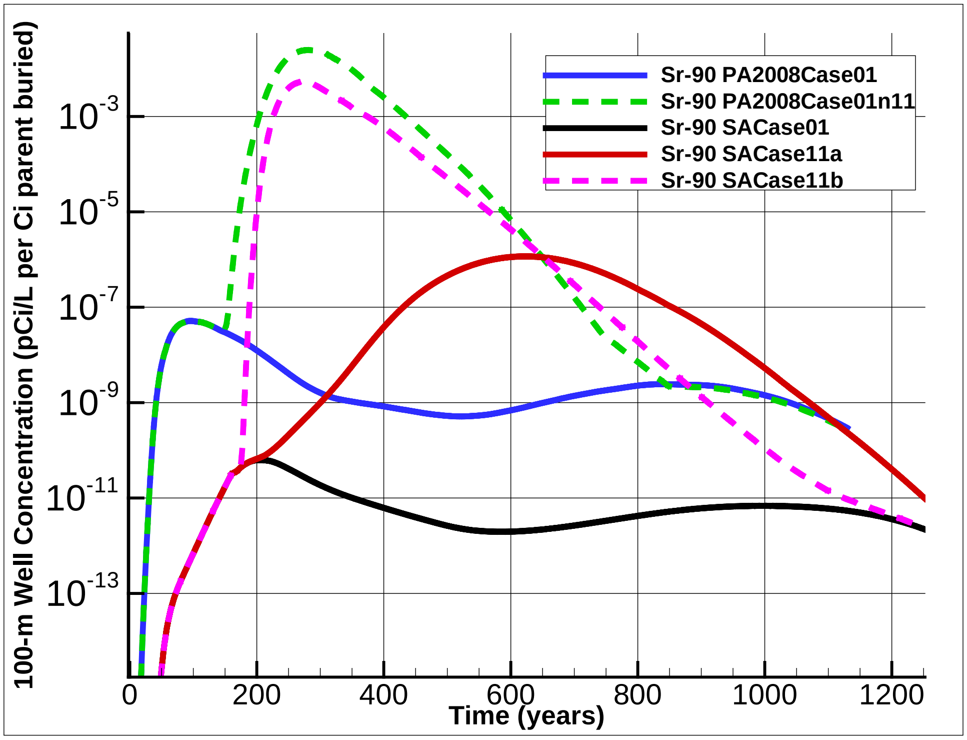


Figure 6-8. ET02 maximum concentration at the 100-m boundary for Sr-90.

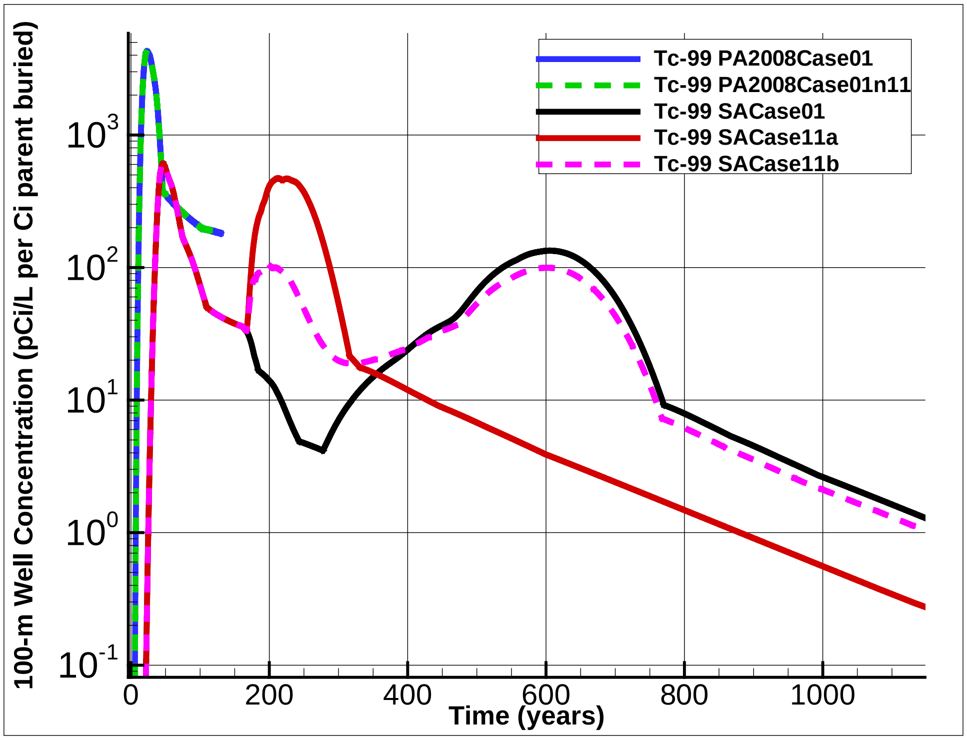


Figure 6-9. ET02 maximum concentration at the 100-m boundary for Tc-99.

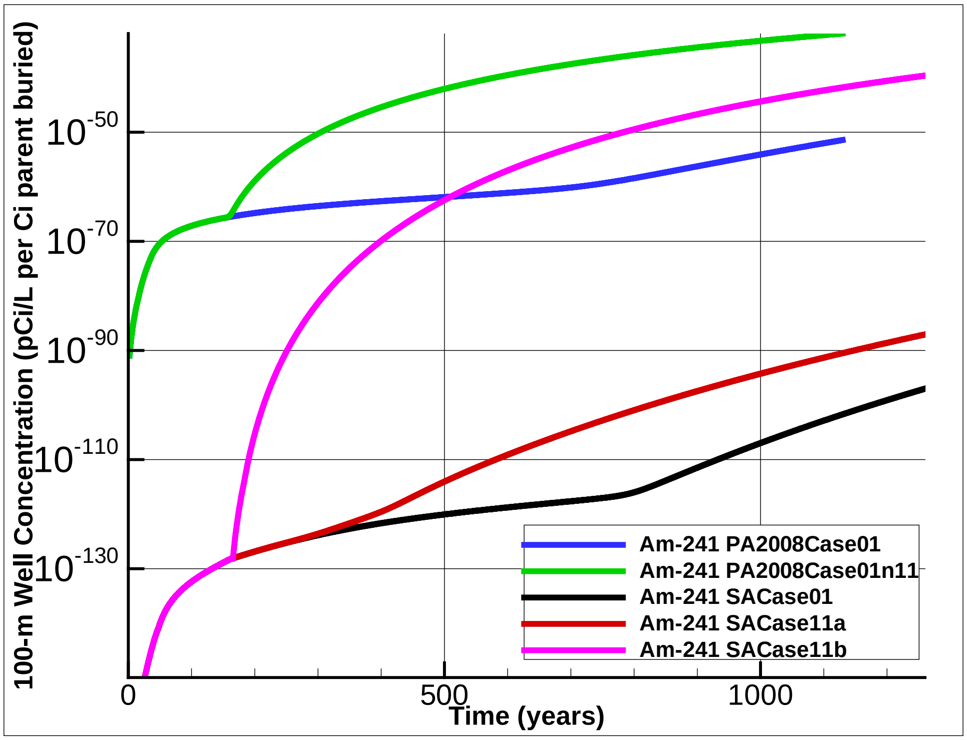


Figure 6-10. ET02 maximum concentration at the 100-m boundary for Am-241 (parent).

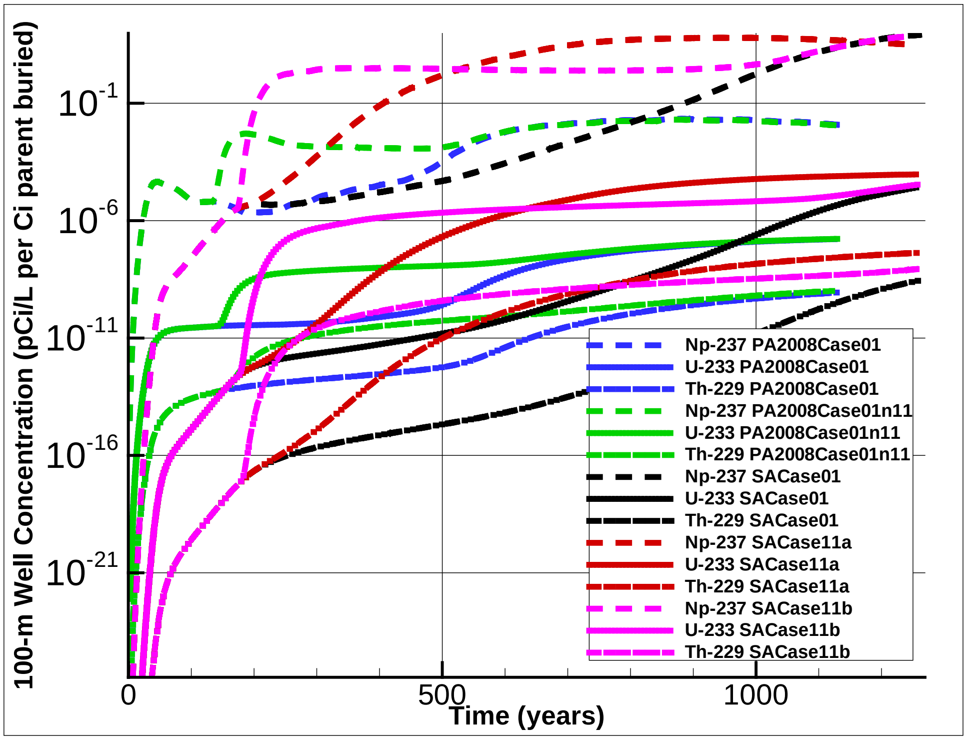


Figure 6-11. ET02 maximum concentration at the 100-m boundary for Am-241 (progeny).

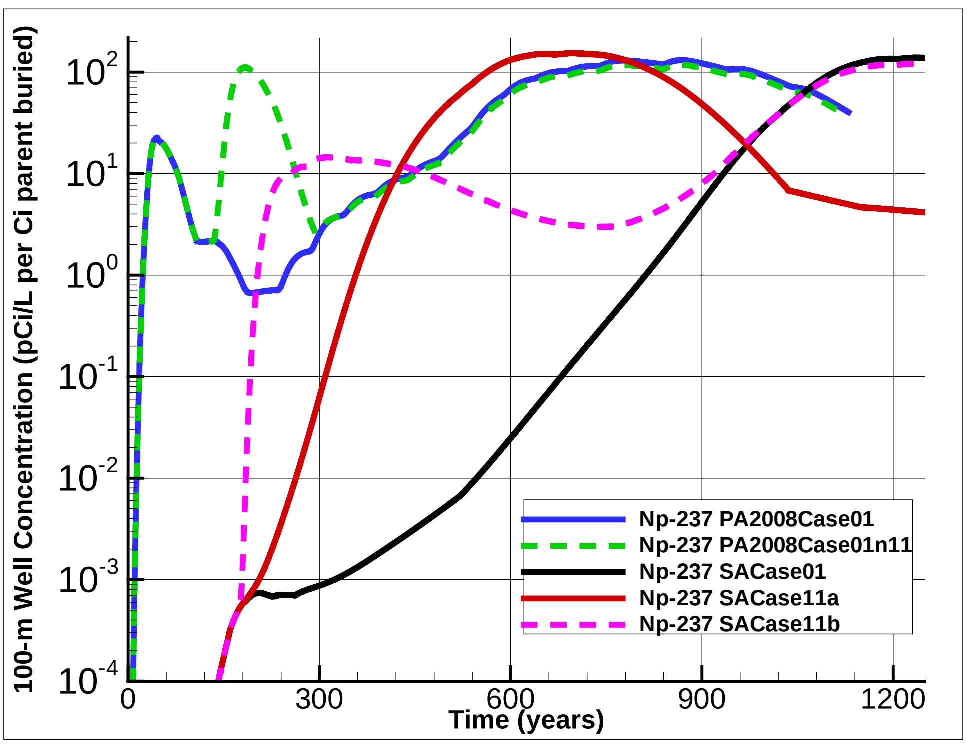


Figure 6-12. ET02 maximum concentration at the 100-m boundary for Np-237 (parent).

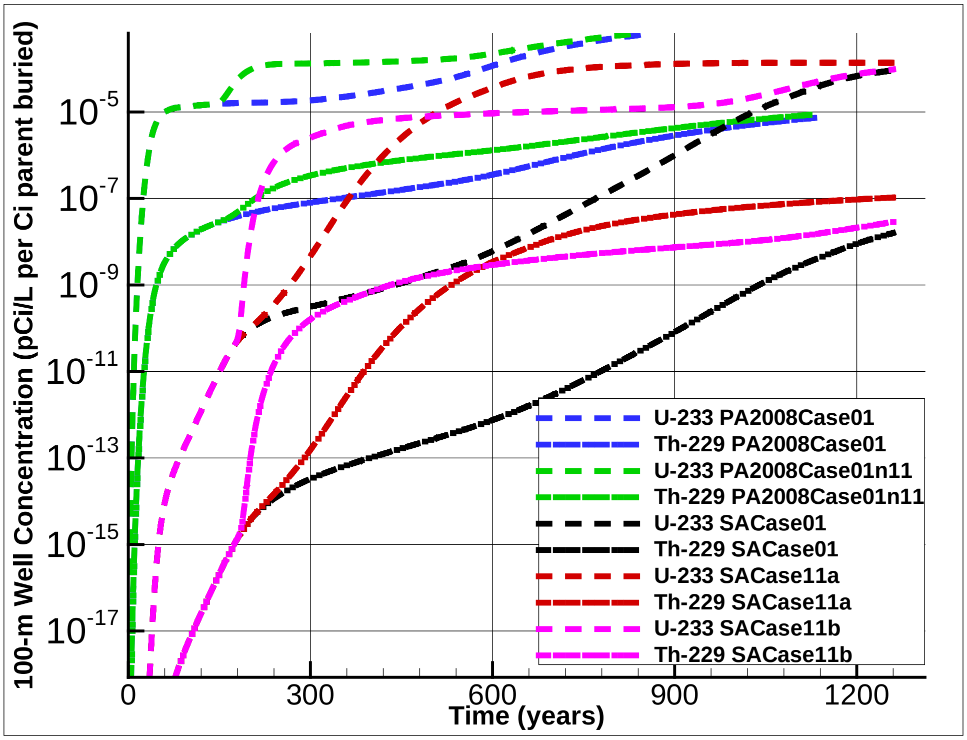


Figure 6-13. ET02 maximum concentration at the 100-m boundary for Np-237 (progeny).

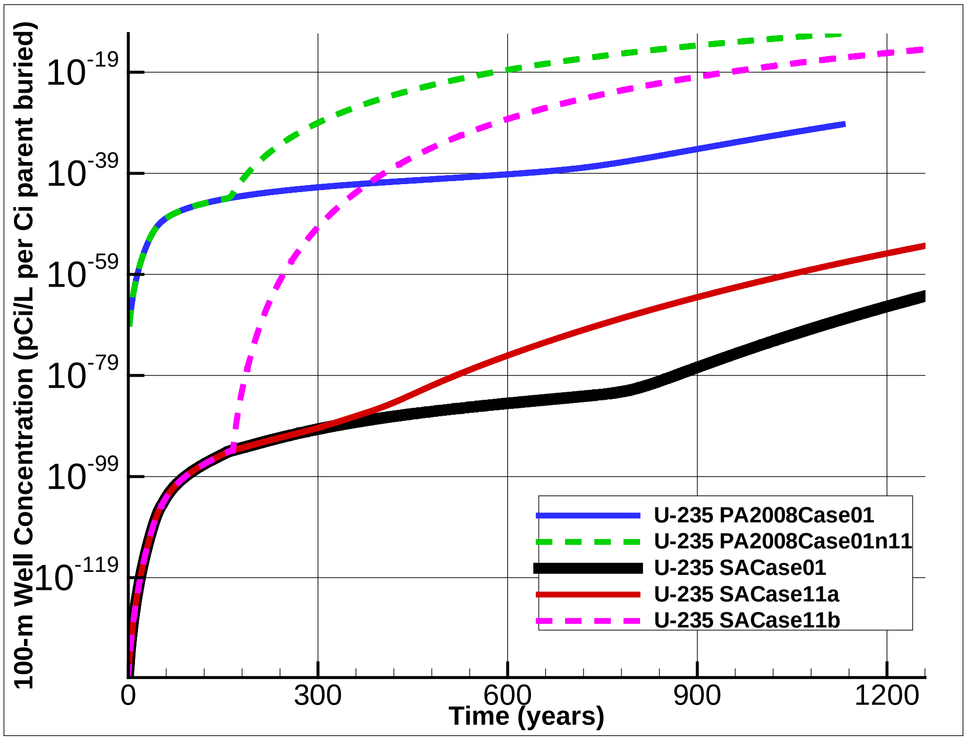


Figure 6-14. ET02 maximum concentration at the 100-m boundary for U-235 (parent).

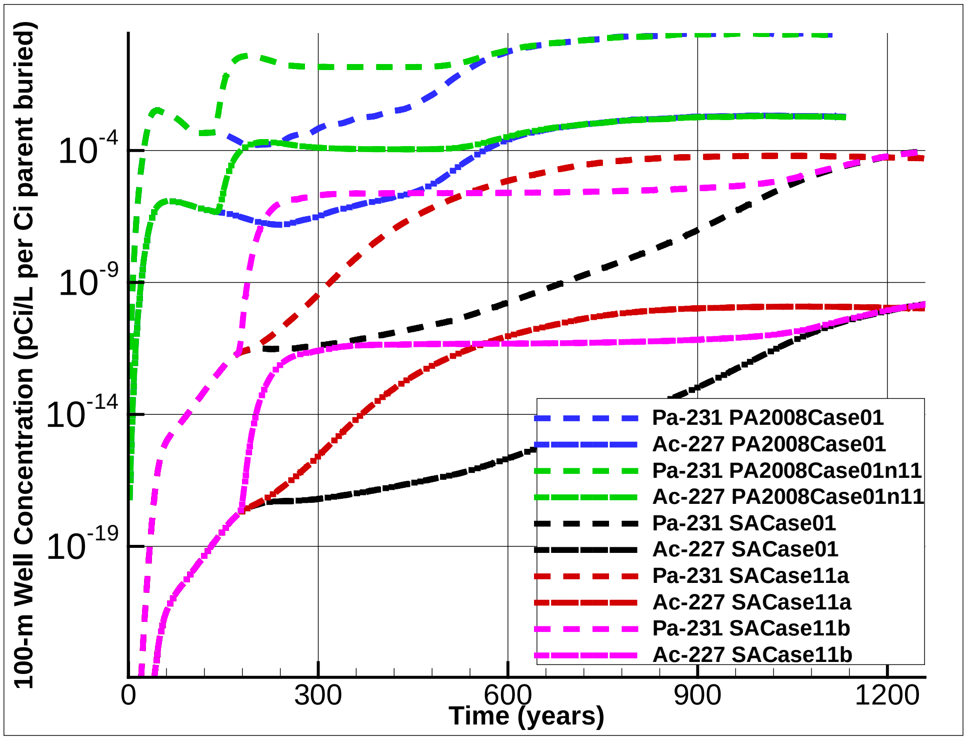


Figure 6-15**. ET02 maximum concentration at the 100-m boundary for U-235 (progeny).**

Because the VZ flux to the water table is used as a source input to the aquifer model, the time-dependent magnitude of the concentration at the 100-m boundary is directly correlated to the magnitude of the source at a given simulation time (given a transport time delay). Consequently, the significant updates to the VZ model from the 2008 PA to present result in noticeable differences in timing and magnitude of concentration for most radionuclides. H-3 does not have a significantly different 100-m boundary concentration because it travels unretarded and has a half-life of only 12.32 years (i.e. it has mostly decayed away prior to the installation of the final closure cap). These changes will be further quantified in the subsequent sections dealing with dose.

7.0 Plume Interaction

The motivation behind employing a stochastic approach to address the impacts associated with the new GSA model are discussed in this chapter. A deterministic plume interaction approach was employed in the 2008 PA and subsequent SA's to compute inventory limits on individual DU's or groups (e.g., East ST group). A stochastic approach was first employed in assessing the acceptability of ST12 inventory limits for use as limits for ET03 being opened in the ST12 footprint (Hamm et al. 2013). An updated version of this stochastic approach is being employed in this SA.

The stochastic approach being employed in this SA is not a method for creating unique inventory limits, rather, it's a tool for assessing dose impacts when provided a set of inventory limits. The deterministic plume interaction approach is discussed in the following three sections. The stochastic approach is discussed in Chapter 8.

7.1 Benefits and Limitations of 2008 PA Approach

In 2008 PA models, preliminary GW radionuclide inventory limits for each DU or group of units were adjusted for plume comingling with neighboring units to ensure the DOE O 435.1 GWP requirement and PO's were not exceeded. Plume interaction is a term employed when discussing the co-mingling of contaminant plumes from one DU with the contaminant plumes of neighboring DU's. Adjusted or final limits were obtained by dividing preliminary DU limits by a plume interaction factor (PIF) calculated in an independent analysis of GW plume comingling (see equation 1-2). The PIF analysis employed steady-state GW plumes produced by running a continuous, non-decaying tracer source first from each DU and then all DU's combined to account for spatial plume overlap. Use of steady-state GW plumes effectively removed timing aspects from plume interaction calculations.

This strategy produced acceptable inventory limits while freeing SWM to open trench units in any order that suited operational needs. This unquantified (and believed to be fairly) conservative approach provided significant operational flexibility at the cost of reduced DU inventory limits. This cost associated with reduced inventory limits was deemed acceptable by SWM. The primary benefits are:

- Inventory limits for a given DU become independent of its neighbors' GW contributions.
- All potential inventory compositions are bounded, including filling a DU with a single radionuclide component.
- A straightforward deterministic process for creating inventory limits.
- Simpler SA's by only having to focus on a single DU without considering its neighbors (e.g. HWCTR disposal in ST14 or reactor heat exchangers in ST09).

In essence, this plume interaction technique eliminated the timing aspects between DU's and allowed creation of unique inventory limit time windows independent of neighboring DU's. Time windows take advantage of peak separation throughout the performance period to increase allowable inventory. For example, the LAWV only needed a single time window spanning the entire 1000-year post-closure performance period while ST's were assigned GW limits in three time periods (or windows) to reduce their level of conservatism.

The primary limitations to this approach are the inability:

- To understand the impacts of relative timing aspects between DU's (e.g., coinciding operational periods versus being separated in time).
- To quantify the degree of conservatism within the inventory limits themselves.

7.2 Plume Interaction Concept

As described above, PIF's are computed using steady-state aquifer transport analyses for a constant source tracer. The impact of co-mingling of plumes on a given DU's allowed inventory limit is accounted for by a computed PIF that is DU specific:

$$C_{i,j}^{Limit} = \left[PIF_j \right] \cdot C_{i,j}^{PF} \tag{7-1}$$

where PIF_j - j^{th} DU specific plume interaction factor

$C_{i,j}^{Limit}$ - combined concentration at 100m well for i^{th} parent nuclide in j^{th} DU

$C_{i,j}^{PF}$ - PORFLOW calculated concentration at 100m well for i^{th} parent nuclide in j^{th} DU

This PIF accounts for the potential impact of neighboring DU's (assumed to be operating up to their inventory limits). As Eq. (7-1) indicates, increased values of PIF yield higher values for well concentrations along the 100-m boundary.

To help illustrate how a PIF is computed for a specific DU, Figure 7-1 is a cartoon representing two extreme configurations for two DU's (i.e., DU-1 and DU-2):

- DU-1 is completely isolated from its neighbor DU-2 (i.e., zero co-mingling of plumes within the 100-m boundary).
- DU-1 is completely downstream of its neighbor DU-2 (i.e., DU-1's plume is completely encompassed by the plume from DU-2).

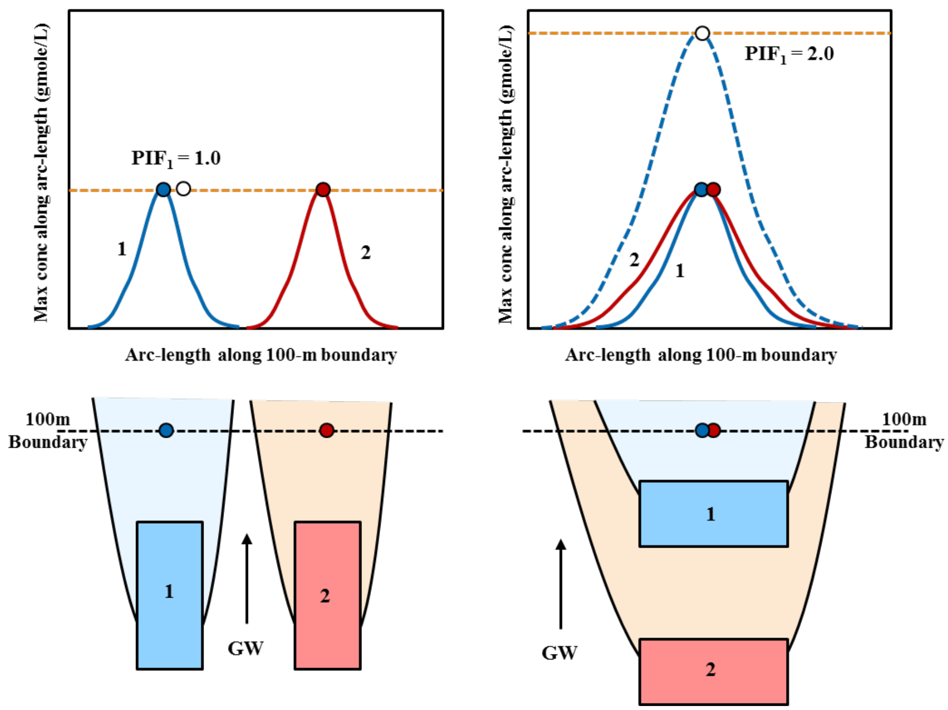


Figure 7-1. Cartoon illustrating how a PIF is computed.

These two configurations represent the two extremes when viewing the alignment between DU's relative to GW flow direction, which is a key aspect when considering plume interaction among neighboring DU's. In Figure 7-1, the configuration on the left produces a PIF of ~1.0 for DU-1, while the configuration on the right produces a PIF approaching 2.0. In computing PIF values during the 2008 PA, most of the E-Area LLWF DU's were arranged more like the configuration on the left (see Figure 1-2) with some degree of plume interaction taking place (i.e., PIF values greater than 1.0 but less than 2.0, as listed in Table 1-1). The higher PIF of 2.14 for the LAWV was imposed to help increase inventory limits within neighboring ET's and ST's. Trade-offs such as this were also considered between ET03 and ET04 in a recent UDQE (Butcher et al. 2017).

7.3 2008 PA Methodology

As discussed in Chapter 1, the ST's and ET's were grouped together and PIF values were computed for each composited group. Steady-state tracer concentrations along the 100-m boundary were computed with PORFLOW for each DU group individually and then computed with all units operating. Based on linearity (i.e., the super-positioning principle) the individual group results could be algebraically added together to yield the case where all units were operating (i.e., used as a test to verify the results). A tracer concentration of $1x10^{-8}$ gmole/L was arbitrarily chosen as the performance measure. PIF values were then determined such that the total tracer concentration at the 100-m boundary does not exceed this value when all units are operating at their individual limits. The results from this set of 2008 PA analyses are presented in Figure 7-2. In Figure 7-2, each DU group is shown as a curve of maximum tracer concentration along the 100-m boundary (i.e., this boundary is described as an arc-length).

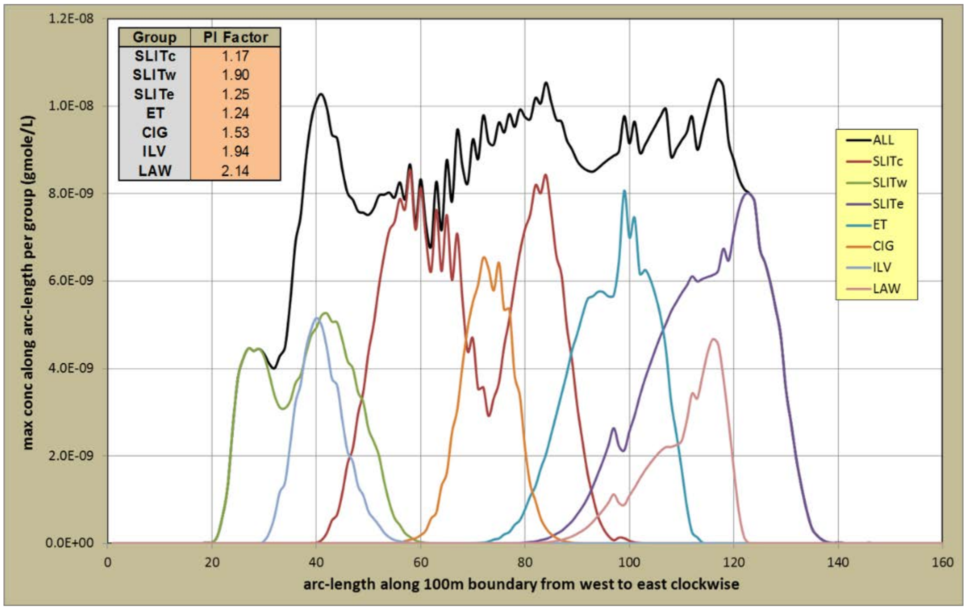


Figure 7-2. 100-m boundary maximum tracer concentration profiles based on 2008 PA PIF values and the 2004 GSA model flow field.

Each DU grouping is color-coded showing its contribution to the 100-m POA tracer concentration. For example, the ET group (i.e., consisting of ET01 and ET02) is shown in cyan where its peak concentration is about $8.06x10^{-9}$ gmole/L (i.e., a PIF = 1.24). The black curve represents the total tracer concentration along the 100-m boundary. Technically, the total tracer concentration should not exceed the limit of $1x10^{-8}$ gmole/L; however, round-off issues resulted in slight overshoots. The concentration profiles shown in Figure 7-2 are based on PORFLOW transport runs employing the 2004 GSA model flow field.

A similar set of analyses was performed in a 2013 UDQE (Hamm et al. 2013) for establishing ET03 inventory limits (and later extended to ET04). The focus of this evaluation was the western portion of E-Area where ET03, ET04, ILV and the West ST group GW plumes interact. The results of that plume analysis are shown in Figure 7-3. From Figure 7-3 one can see that both extremes portrayed in Figure 7-1 are being approached. Both the ET03/ET04 interaction and the ILV/ST8-11 group interaction have significant plume overlap. However, the overlap between these two sets of DU's is only marginal as represented by the "double hump" in the total tracer concentration curve. The concentration profiles shown in Figure 7-3 are based on PORFLOW transport runs employing the 2004 GSA model flow field.

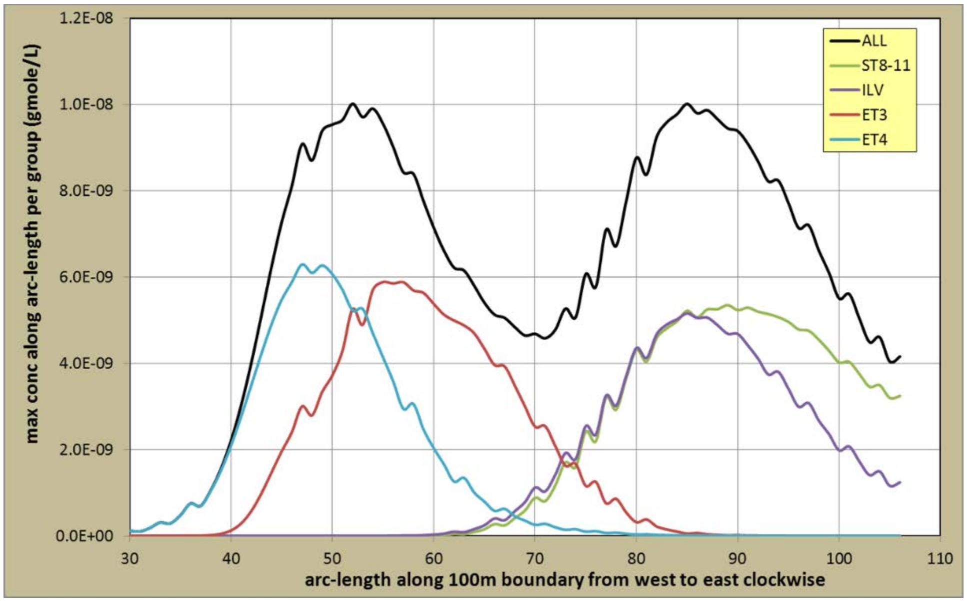


Figure 7-3. 100-m boundary maximum tracer concentration profiles based on 2004 GSA model flow field used in the ET03 and ET04 UDQE (Hamm et al. 2013).

The PIF results discussed above for the ET03/ET04 analyses can also be seen in plan view in Figure 7-4 based on 3D streamlines emanating out from each of the DU's in the western portion of E-Area. Clearly, significant plume interaction results from ET04 and ILV being directly upstream of the other DU's. Also, the composite plume resulting from ET03 and ET04 operations is fairly isolated from the composite plume resulting from all other DU's.

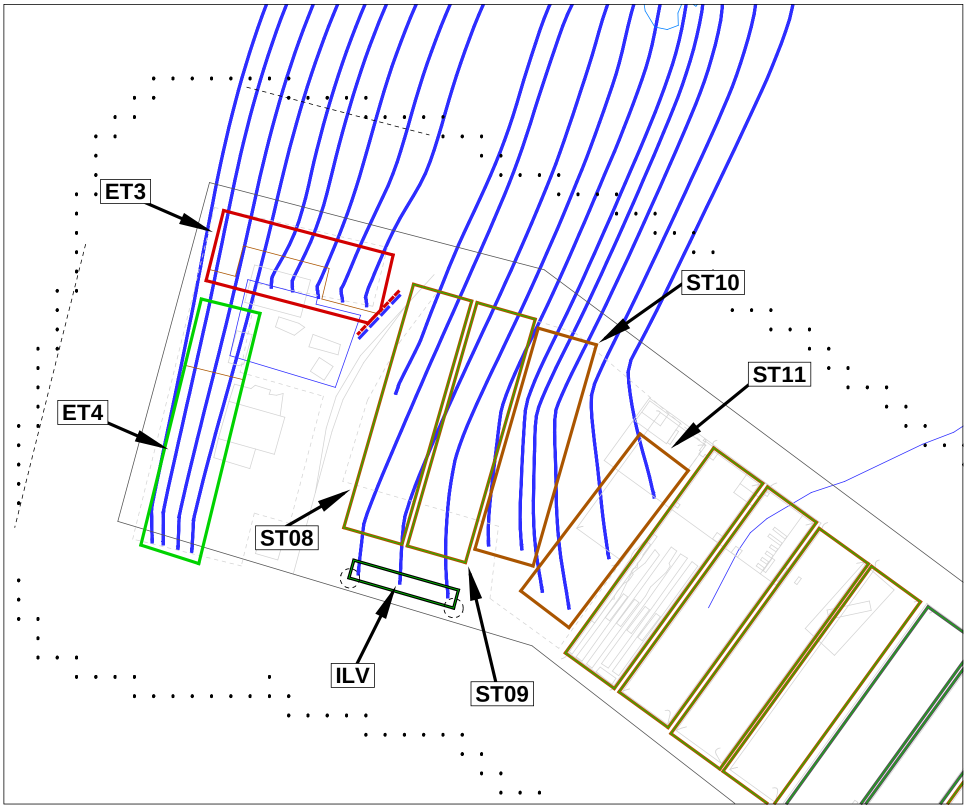


Figure 7-4. 3D streamlines based on 2004 GSA model flow field used in the ET03 and ET04 UDQE (Hamm et al. 2013).

The examples presented above clearly illustrate how PIF values are primarily dependent on the aquifer flow field; however, adjustments can be made (e.g., LAWV) to shift some of the plume interaction penalty from one DU to another DU.

As discussed in Chapter 1 the new 2018 GSA model significantly alters the flow field in the vicinity of the eastern portion of E-Area. As Figure 1-2 indicates, this new flow field rotates the streamlines that, in the prior flow model, were reasonably parallel with the long axis of each DU out to the 100-m boundary resulting in only modest amounts of local cross-flows. PIF scoping analyses were performed to assess the impact of this new 2018 GSA flow model on the DU's within the eastern portion of E-Area. The results of this scoping analysis are shown in Figure 7-5.

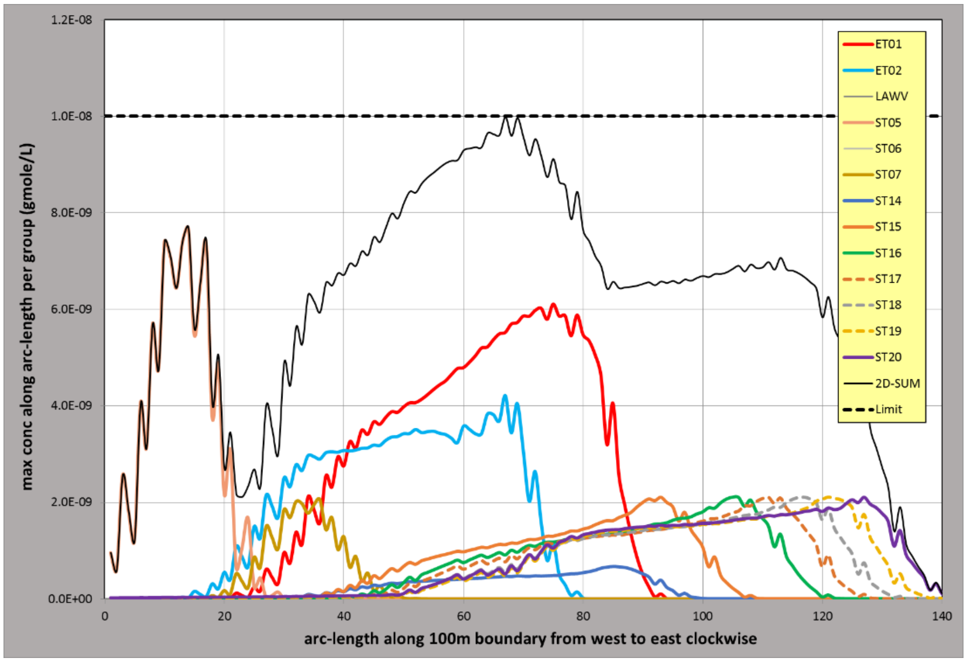


Figure 7-5. 100-m boundary maximum tracer concentration profiles based on recent PIF values and the 2018 GSA model flow field.

As expected, significant plume overlap occurs for many of the DU's shown. In order to have operating margin for the currently operating ET02 and LAWV, significant PIF values were required (i.e., PIF = 4.75) for future units, ST15 through ST20. PIF values of ~5 significantly devalue a DU's capacity (i.e., in effect dividing limits by 5). These large impacts can be reduced by incorporating timing aspects into the analyses. Unfortunately, the 2008 PA plume interaction strategy was designed specifically to eliminate timing aspects and is therefore not the right tool for this analysis.

The results of this scoping analysis were the main driver for employing a less conservative approach in assessing the potential impact of the new 2018 GSA model. Based on SRNL's prior success in employing a stochastic approach to assess ET03/ET04 operations (Butcher et al. 2017), a modified version of this approach was chosen.

8.0 Performance Evaluation

8.1 Exposure Pathways

The GW exposure pathways considered in this SA along with their respective EPA drinking water protection limits and DOE 435.1 performance measure/objective are shown in Table 8-1 below:

Table 8-1. ELLWF GW pathways analyzed.

Category	Pathway	Performance Criterion	Time Window[a]
Groundwater	Beta-Gamma	4 mrem/yr	0-1171
	Gross Alpha	15 pCi/L	0-1171
	Radium (Ra-226 + Ra-228)	5 pCi/L	0-1171
	Uranium	30 μg/L	0-1171
	All-Pathways[b]	25 mrem/yr	171-1171

a All times in years relative to the start of ELLWF operations of the LAWV in 09/28/1994.
b All-Pathways refers strictly to dose from pathways related to GW usage (i.e., excludes the air pathway dose).

The exposure pathway time windows reflect an increase in the SIC from 30 to 71 years (i.e., the 30-year period was employed in the 2008 PA). The EIC and the start of GW-AP period of performance (POP) is 171 years. The end of GWP and GW-AP POP is 1171 years.

The non-GW exposure pathways that include the PA inadvertent intruder pathway, air pathway, and radon pathway (Rn-222) were not analyzed because there are *no impacts associated with the updated GSA flow model on non-groundwater pathways*. The current WITS GW, intruder, air, and radon pathway inventory limits (see Appendix C) are included in the calculation of the maximum SOF for all existing generic and special waste forms in each disposal unit. The current WITS GW and intruder inventory limits only are used in the calculation of the maximum SOF for future stochastic inventory vectors of the nine SA parent radionuclides in each DU to ensure that the most limiting pathway group is used.

8.2 Groundwater Pathway

The 2008 PA and subsequent SA's utilized concentration time series generated by the STATistics command in a PORFLOW aquifer transport simulation (typically named "STAT.out" files). The PORFLOW STAT command generates the maximum element concentration time series for each parent and short-chain radionuclide progeny beyond the 100-m POA boundary. This approach was applied to 38 radionuclides in twelve ET/ST's and 35 radionuclides in the LAWV which contribute to the maximum GW pathways SOF using the current WITS inventories for generic and special waste forms. The PORFLOW STAT files for this list of radionuclides are then processed through the PreDose Module and then the PreDose Maximum Concentration Module to calculate preliminary DU inventory limits by the PA/CA Limits and Doses Tool. The preliminary (i.e., prior to including a PIF) DU inventory limits computed for each GW pathways were used to compute SOF using the current WITS inventories for the 38 (or 35) radionuclides in each DU. The SOF's were ranked ordered and radionuclides who contributed more than 0.1% SOF were included in the final SA list of nine radionuclides (see details in Appendix C).

A series of PORFLOW vadose and aquifer flow and transport simulations were executed for various case scenarios. In this SA the twelve ST's and ET's considered three cases in the aquifer transport calculations:

- **Case01**, the intact infiltration rate extends the entire length of the cap.
- **Case11a**, cap-averaged subsided infiltration rates are applied along the full 656-foot length of the DU.

- **Case11b**, back-calculated subsided infiltration rates are only applied to the 12-foot location marked in the center of the DU (the intact boundary condition is applied to the remainder of the cap length).

PORFLOW simulations of the LAWV were executed for four cases in the 2008 PA aquifer transport calculations:

- **Case1**, after design check and no CDP
- **Case2**, after design check and with CDP
- **Case3**, before design check and no CDP
- **Case4**, before design check and with CDP

Further investigation and discussions concluded that Case2 was the base case on which LAWV inventory limits are based (Smith and Hamm 2014) and; therefore, was the only relevant case to consider for the LAWV.

The time of parent radionuclide burial for each of the DU's is at the start of DU operation for existing inventory and 09/28/2018 for all future inventory in operating DU's. The burial time for future DU's are staggered according to the timeline in Table 8-2.

Table 8-2. ELLWF DU start of operations (burial).

Disposal Unit	Start of Operations (Year)			PORLFOW
	Calendar	Absolute	Relative[a]	Relative[a]
LAWV	09/28/1994	1994.742	0.000	0
ET01	02/13/2001	2001.117	6.375	6
ET02	06/03/2004	2004.422	9.681	10
ST05	05/27/2004	2004.406	9.664	10
ST06	04/29/2006	2006.328	11.586	12
ST07	06/26/2006	2006.486	11.744	12
ST14	03/29/2011	2011.244	16.503	17
LAWV (Future)	09/30/2018	2018.747	24.006	24
ET02 (Future)	09/30/2018	2018.747	24.006	24
ST06 (Future)	09/30/2018	2018.747	24.006	24
ST07 (Future)	09/30/2018	2018.747	24.006	24
ST14 (Future)	09/30/2018	2018.747	24.006	24
ST15 (Future)	03/29/2060	2060.244	65.503	66
ST16 (Future)	06/23/2037	2037.478	42.736	43
ST17 (Future)	07/12/2043	2043.531	48.789	49
ST18 (Future)	07/31/2049	2049.583	54.842	55
ST19 (Future)	08/20/2055	2055.636	60.894	61
ST20 (Future)	09/08/2061	2061.686	66.944	67

a All times in years relative to the start of ELLWF operations of the LAWV in 09/28/1994.

A 'curtain' of 192 by 46 elements was identified at the 100-m POA boundary that intercepts the GW flow trajectories of the twelve ET/ST's and the LAWV. The purpose of this curtain is to superpose the concentration/dose contributions from each of the SA radionuclides in the twelve ET/ST's and the LAWV. This superposition of concentrations and doses is possible due to the linearity of the advection-dispersion transport equation. The curtain is a way to rigorously account for plume interaction of the GW pathways from each DU. This method illuminates the spatial and timing dose contributions from each DU.

The nine SA parent radionuclides were then processed through PORFLOW aquifer transport simulations (separate existing and future inventory runs) for each relevant case discussed above for the twelve ET/ST's and the LAWV. The HISTory command in PORFLOW provides the option to obtain output of the time history for dependent variables at selected elements. The PORFLOW HIST command was used to generate multiple element concentration time series for each parent and short-chain radionuclide progeny at the 100-m POA boundary (curtain). The PORFLOW HIST files for this list of radionuclides are then processed through the PreDose and PreDose Maximum Concentration Modules, PA/CA Limits and Doses Tool, and finally as input to the ELLWF Dose Investigation Tool.

8.3 Dose Analysis

The "Dose Calculation Methodology and Data for Solid Waste Performance and Composite Analysis at the Savannah River Site", SRNL-STI-2015-00056, Rev. 1 is the basis for the dose analysis in this SA. The MS Excel database "SRNL Radionuclide, Element and Dose Parameter Data Package_08-30-17_version 1.2.xlsm" was used to provide the data required to perform radionuclide transport and dose calculations. The following ASCII files were exported from the database and were use as auxiliary input files to the PA_CA Limits and Doses Tool:

- Bio_Transfer_Coefficients.txt: Element-specific bio-transfer and bio-accumulation coefficients for soil-to-vegetable, feed-to-milk, feed-to-meat and water-to-fish ingestion.
- Internal_Exposure_DC.txt: Isotope-specific internal exposure dose coefficients for water ingestion and air inhalation.
- External_Exposure_DC.txt: Isotope-specific external exposure effective dose coefficients for water submersion, air submersion and ground shine.
- Soil_Contamination_DC.txt: Isotope-specific soil contamination effective dose coefficients for soil contaminated to a depth of 1 cm, 5 cm, 15 cm and infinite depth.
- PA_CA_All_Pathways_Parameters.txt: Physical parameters, key constants and human factors used in all-pathways dose calculations.
- Alpha_Decay.txt: Isotope-specific gross alpha decay fractions.
- Beta_Gamma_Decay.txt: Isotope-specific beta-gamma decay fractions and MCLs.
- Radium.txt: List of 2 radium nuclides, Ra-226 and Ra-228.
- Uranium.txt: List of uranium radionuclides and specific activities.
- Shielding_Factors.txt: Isotope-specific adjusted shielding dose conversion factors for soil shielding thickness of 0 cm, 1 cm, 5 cm, 15 cm, 30 cm, 45 cm and 100 cm.
- Species.txt: List of all 1252 ICRP radionuclides and decay constants.
- Eckerman.txt: List of all 1252 ICRP radionuclides, half-life, daughters and branching fractions.
- MasterRad.out: List of all 1252 ICRP radionuclides, half-life, AMU, Precursor, Precursor fraction and Precursor ID.

The MS Excel database "2016_GeochemDatabase_ver3.01.xlsm" was used to provide distribution coefficients required for MOP PA resident farmer dose calculations. The following ASCII file was exported from the database and its function described:

- Clayey_Sediment_Kd.txt: Element-specific distribution coefficients for 'Best Clay'.

The concentrations and doses at the 192 by 46 element curtain are computed every year from 0 to 1171 years for all the groundwater pathways using the following set of equations:

$$\text{ELLWF\%GWPW}(i,j) = \sum_{u=1}^{13} \text{DU}(u)\text{\%GWPW}(i,j) \qquad (8\text{-}1)$$

where

GWPW(i,j) .... groundwater pathway (GWPA (alpha), GWPB (beta-gamma), GWPR (radium), GWPU (uranium), or PAAP (all-pathways)) history concentrations and doses due to contributions from each disposal unit

DU(u) .... ET01, ET02, LAWV, ST05, ST06, ST07, ST14, ST15, ST16, ST17, ST18, ST19, ST20

i .... element index (1 to 8,892)

j .... time index (1 to 1,172)

u............................ disposal unit index (1 to 13)

$$\begin{aligned}&\text{DU}(u)\text{\%GWPW}(i,j)\\ &= \sum_{n=1}^{9} \text{DU}(u)\text{\%DoseNuc}(n)\text{\%GWPW}(i,j,1) \times \text{DU}(u)\text{\%DoseNuc}(n)\text{\%oldinv}\\ &+ \sum_{n=1}^{9} \text{DU}(u)\text{\%DoseNuc}(n)\text{\%GWPW}(i,j,2) \times \text{DU}(u)\text{\%DoseNuc}(n)\text{\%newinv}\end{aligned} \qquad (8\text{-}2)$$

where

DoseNuc(n) Am-241, C-14, H-3, I-129, Ni-59, Np-237, Sr-90, Tc-99, U-235

GWPW(i,j,1) .... groundwater pathway history concentrations and doses per Ci of parent from existing inventory PORFLOW run

GWPW(i,j,2) .... groundwater pathway history concentrations and doses per Ci of parent from future inventory PORFLOW run

oldinv .... existing inventory of parent radionuclide in disposal unit, Ci

newinv .... future inventory of parent radionuclide in disposal unit, Ci

n............................ nuclide index (1 to 9)

Once the concentrations and doses have been calculated using Equations (8-1) and (8-2), we can compute the proximity of the curtain concentrations and doses to their respective performance criteria by computing maximum SOF's for each groundwater pathway. The maximum SOF's at the curtain is defined and computed for each groundwater pathway as:

$$\max \text{ELLWF\%GWPA\%SOF}(i,j) = \max\left\{\text{ELLWF\%GWPA}(i,j) / 15\ \text{pCi/L}\right\} \qquad (8\text{-}3)$$

$$\max \text{ELLWF\%GWPB\%SOF}(i,j) = \max\left\{\text{ELLWF\%GWPB}(i,j) / 4\ \text{mrem/yr}\right\} \qquad (8\text{-}4)$$

$$\max \text{ELLWF\%GWPU\%SOF}(i,j) = \max\left\{\text{ELLWF\%GWPU}(i,j) / 30\ \mu\text{g/L}\right\} \qquad (8\text{-}5)$$

$$\max \text{ELLWF\%GWPR\%SOF}(i,j) = \max\left\{\text{ELLWF\%GWPR}(i,j) / 5\ \text{pCi/L}\right\} \qquad (8\text{-}6)$$

$$\max \text{ELLWF\%PAAP\%SOF}(i, j) = \max\left\{\text{ELLWF\%PAAP}(i, j)/25 \text{ mrem / yr}\right\} \quad (8\text{-}7)$$

The maximum overall SOF's at the curtain is the maximum value of Equations (8-3) through (8-7).

8.4 SRNL Dose Toolkit

The generation of GW pathway history concentrations and doses at the 100-m POA boundary (curtain) are developed through a series of calculations using five separate software codes. First, the groundwater modeling calculations are performed using the PORFLOW commercial package to establish vadose and aquifer zone flow fields. This is followed by PORFLOW contaminant transport calculations, in both the VZ (ground surface to the top of the water table) and the saturated zone (aquifer) to produce concentration history profiles for each parent and short-chain progeny radionuclide at the 100-m POA boundary (HIST.out). Next, the HIST.out files are used as input to the SRNL PreDose module. The PreDose module expands the short-chain radionuclide decay chain results in the PORLFOW HIST.out files to produce full decay chain results using the assumption of secular equilibrium. These files are written as binary files (i.e., Am-241.bin) for each existing/future inventory and PORFLOW VZ case scenario analyzed, then used as input to the SRNL PreDose Maximum Concentration module. This module generates composite 'worst case' full-chain concentration history profiles for each existing/future inventory scenario. These 'worst case' binary files are then used as input to the SRNL PA_CA Limits and Doses tool. The output of this tool is a series of binary concentration and dose files for each GW pathway where contributions from each full chain progeny have been rolled up to the parent nuclide (i.e., Am-241-GWPA.his). The *.his files are on a per Ci of parent buried basis and are used as input to the SRNL ELLWF Dose Investigation tool.

8.4.1 PreDose Module

The PreDose module post-processes simulated concentration time series for select parent nuclides with short-chain or full-chain progeny for the PA GW screening and tiered limits and doses approach. The output of this module is input to the PreDose Maximum Concentration Module or the PA/CA Limits and Doses Tool. A multi-tiered system is employed:

Tier 1 screening based on the method outlined in NCRP-123 using full chains for all 1,252 radionuclides listed in the "SRNL Radionuclide and Element Data Package" and site-specific K_d's. This new screening tool does not exist in this module. The initial list radionuclides for screening is derived from the 2008 PA or subsequent SA's.

Tier 2 is a bounding Composite Analysis (CA) approach (1D vadose and aquifer zone flow and transport) to compute concentrations at the 100-m POA boundary for each parent nuclide with short-chain progeny remaining after Tier 1 screening. This approach will be implemented in the next revision of the PA if needed to further screen out additional radionuclides before the detailed analysis (i.e., in Tier 3 and Tier 4). The current screened list of parent radionuclides is derived from the 2008 PA analysis.

Tier 3 analyzes generic waste forms (Tier 2 screened parents with no engineered barriers) modeled using PORFLOW 2D vadose and 3D aquifer flow and transport models. Each PORFLOW aquifer transport simulation computes a maximum element (STAT) or multiple element (HISTORY) concentration time series for parent radionuclides and short-chain progeny at the 100-m POA boundary. The Tier 3 modeling approach is utilized in this SA.

Tier 4 analyzes special waste forms (same parent list and calculation procedure as Tier 3, but waste release is controlled by encapsulation or special waste form properties [i.e., engineered barriers are accounted for]). Special waste forms are typically limited campaign disposals and minor contributors to dose so were not analyzed in this SA but their impact on the maximum SOF's for existing waste inventories is included.

The PORFLOW parent and short-chain progeny concentrations are typically in units of gmol/ft^3 or gmol/ft^3 per 1 gmole of parent buried for existing or future inventory, respectively. The short-chain concentrations are converted into activities, pCi/L or pCi/m^3. The short-chain activities are normalized to the equivalent activity of the parent for future inventory. The short-chain is then expanded into a full-chain to compute activities for nuclides not included in PORFLOW transport simulations. The activities are computed assuming secular equilibrium with appropriate branching fractions. Figure 8-1 shows the Am-241 full-chain concentration time series generated by PreDose for Case01 in ST15. The four short-chain radionuclides ($t_{1/2}$ > 5 years) analyzed by PORFLOW were Am-241, Np-237, U-233 and Th-229. Pa-233 is in secular equilibrium with Np-237. Ra-225 through Pb-209 are in secular equilibrium with Th-229.

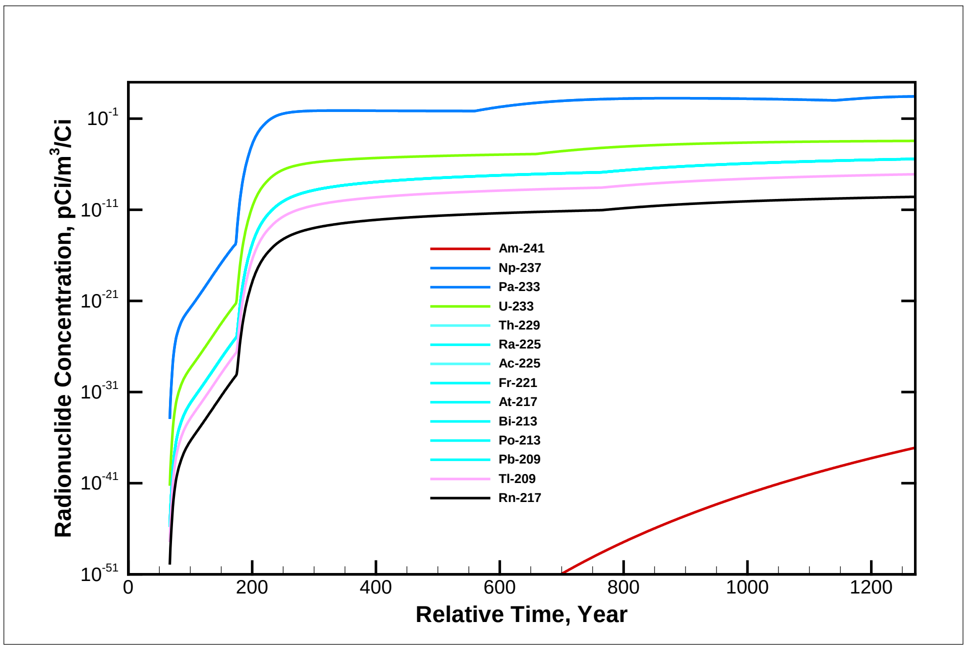


Figure 8-1. Am-241 full-chain radionuclide concentration time series for Case01 in ST15

8.4.2 PreDose Maximum Concentration Module

This module determines the maximum concentration at each point in time for each parent nuclide and its full-chain progeny in a DU from a series of PreDose files. Each series of PreDose files is derived from PORFLOW flow and transport simulations where various VZ scenarios (i.e., Case01) were analyzed and are described in Chapter 5. The PreDose files contain full-chain radionuclide time series concentrations post-processed from a single or multiple element PORFLOW concentration output. Figure 8-2 represents the Ni-59 concentration time series in ST15 derived from three PORFLOW cases analyzed and the maximum concentration values (CaseWorst curve being shown as the black dash-dotted curve) for the entire period of simulation.

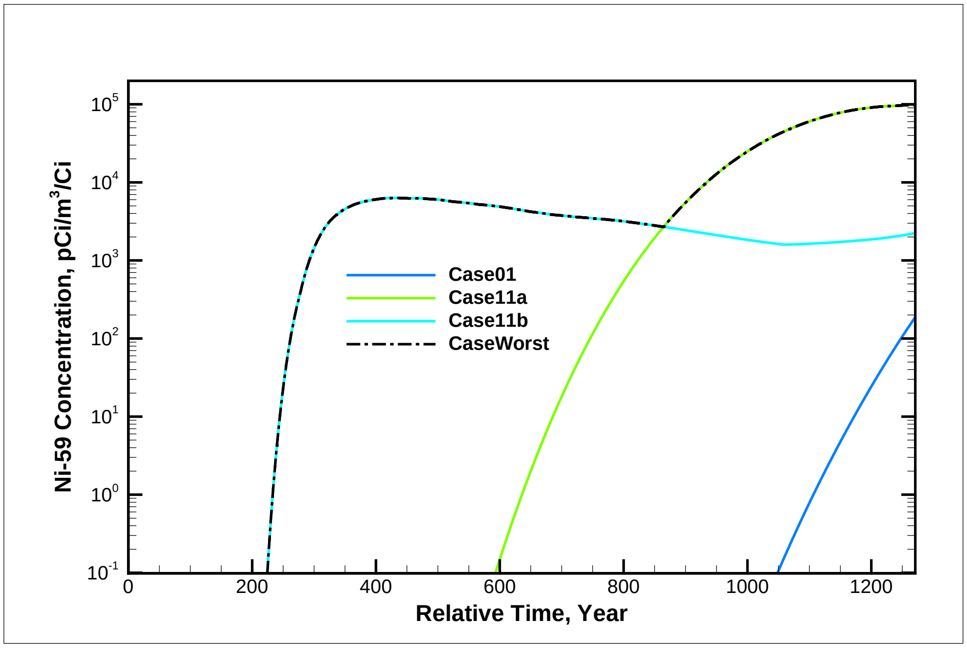


Figure 8-2. Ni-59 concentration time series in ST15 for Case01, Case11a, Case11b and CaseWorst.

The output of this module is ASCII or binary PreDose concentration time series files used as input to the PA/CA Limits and Doses Tool.

8.4.3 PA/CA Limits and Doses Tool

The Performance Assessment / Composite Analysis (PA/CA) Limits and Doses Tool was developed to implement the dose calculations and parameters described in SRNL-STI-2015-00056, Rev. 1, "Dose Calculation Methodology and Data for Solid Waste Performance and Composite Analysis at the Savannah River Site" (i.e., Smith et al. 2015 as amended by Smith 2015). The model calculates doses and disposal limits for a resident farmer (i.e., the groundwater only all-pathways receptor) and an inadvertent intruder for PA, resident and recreational doses for CA, and PA disposal limits based on EPA water protection standards.

The first set of dose scenarios assume that a member of the public establishes residence near the waste site and uses contaminated groundwater or contaminated surface water for personal consumption and to irrigate a garden and pasture where produce and farm animals are raised. Products from the garden and farm animals are used for personal consumption. This scenario applies to both E-Area PA's and SRS CA's. General dose exposure pathways for the resident farmer scenario are:

- Ingestion pathways (Drinking Water, Garden Vegetables, Meat, Milk and Garden Soil)
- Inhalation pathways (Garden Soil, Irrigation Water and Shower Water)
- External exposure pathways (Garden Soil and Shower Water)
- Recreational pathways (Dermal Adsorption of tritium, Fish ingestion, Swimming Water inhalation and external exposure, Boating Water and Shore Soil external exposure) (Composite Analysis Only)

Additional dose scenarios considered for E-Area PA assume that an inadvertent intruder encroaches on the waste disposal site after loss of IC. General dose exposure pathways considered for the inadvertent intruder are:

- Ingestion pathways
- Inhalation pathways
- External exposure pathways

Doses for all the intruder pathways are directly related to the contaminant concentration in the buried waste. Additional dose considerations related to human consumption of meat and dairy, and treatment of tritium in dose calculations are performed.

Data required to perform radionuclide dose calculations are exported as ASCII files from Microsoft (MS) Excel files generated from the "SRNL Radionuclide, Element and Dose Parameter Data Package" (SRNL 2018b) and "Geochemical Data Package for Performance Assessment Calculations Related to the Savannah River Site" (SRNL 2018a).

The output of the PA_CA Limits and Doses Tool are:

- Conc_Doses_from_STAT option: preliminary inventory limits (Appendix C.3) and concentrations/doses.
- Conc_Doses_from_HIST option: a series of binary concentration and dose files for each groundwater pathway where contributions from each full-chain progeny have been rolled up to the parent nuclide (input to ELLWF Dose Investigation Tool).

8.4.4 E-Area LLWF Dose Investigation Tool

The E-Area LLWF Dose Investigation Tool was developed to quantify the dose impact to groundwater protection and all pathways human dose receptors at the POA 100-m boundary surrounding the E-Area Low Level Waste Facility. The POA boundary comprises a 'curtain' of PORFLOW aquifer model computational cells where concentrations of select parent radionuclides and short-chain radioactive progeny are calculated and recorded at a specified time frequency. The total time history of the calculation encompasses the POP for GWP and all-pathways.

The tool is designed to compute deterministic (single realization) and stochastic (random future inventories) point-of-assessment dose impacts from select parent radionuclides within ST's, ET's, and LAWV DU's in the E-Area LLWF. The classification of the DU is either 'closed', 'opened', or 'future':

- A 'closed' DU only contains existing waste.
- An 'opened' DU contains existing waste and can receive future waste.
- A 'future' DU can receive future waste.

The stochastic dose impact arises by randomly selecting the future waste inventory based on historical DU operation and operational constraints (maximum SOF of 1 within each DU).

The tool can compute deterministic concentrations and doses at the 100-m POA boundary using existing, future or total parent nuclide inventories specified for each DU.

The stochastic module in the tool calculates the future inventory of a given DU based on the log-normal distribution of historical waste disposal in the E-Area LLWF and inventory limits for a given DU by randomly generating compositions and projecting the adjusted future inventory to yield a 100% maximum SOF for that specific DU.

9.0 Stochastic Analysis

In this chapter we demonstrate, by way of a stochastic analysis approach, that overall performance measures will not be exceeded to a high degree of confidence, by employing the current WITS GW and intruder pathways inventory limits (see Appendix C.2) for the twelve ET's/ST's and the LAWV. The stochastic dose impact arises by randomly sampling the future waste inventory based on historical DU operation and operational constraints (i.e., a maximum SOF of 1 within every DU). The probability of exceeding a maximum SOF of 1.0 was estimated to be < 0.01% based on 10,000 Monte-Carlo realizations (< 0.01% for maximum SOF > 0.77). The ELLWF GW pathway maximum SOF histograms for 5,000 and 10,000 realizations are shown in Figure 9-1. The specific details in computing these probabilities are presented in this chapter.

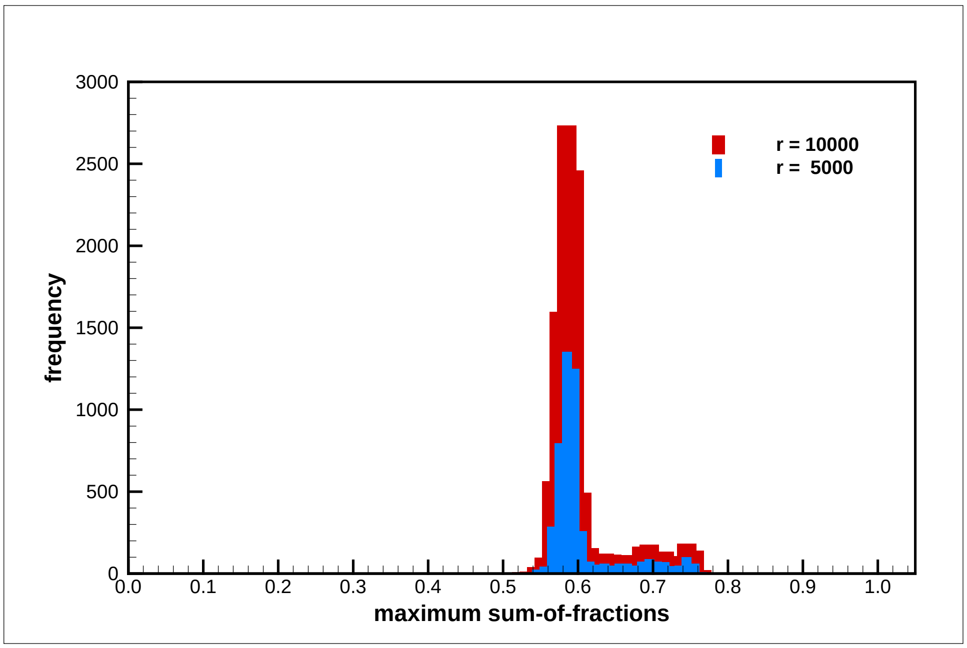


Figure 9-1. ELLWF GW pathway maximum SOF histograms at the 100-m POA.

9.1 Baseline Deterministic Simulations

A series of deterministic (single realization) simulations were performed to evaluate the concentration and dose impact of various DU future inventory scenarios to the 100-m POA performance measures. These scoping analyses were performed along the way to assess the methods being developed and to determine if margin existed to warrant continuing towards the stochastic analysis effort. The following DU future inventory scenarios were investigated (for DU's that are classified as 'opened' or 'future' units):

- **Scenario 1** - The existing inventory composition vector is scaled until the maximum SOF equals 1 in each DU. The future inventory composition vector is then the scaled vector minus the existing inventory composition vector (see Appendix C.4).
- **Scenario 2a to 2i** - The future inventory of a single SA parent radionuclide is individually scaled until the maximum SOF equals 1 in each DU (i.e., each open DU has its existing

inventory contributing to its computed SOF). Each of the remaining 8 SA radionuclides have a future inventory of 0 Ci. There are nine separate deterministic simulations (i.e., 2a through 2i).

9.1.1 Deterministic Simulation Results for Future Inventory Scenario 1

The deterministic simulation results for future inventory Scenario 1 are summarized in Table 9-1. The maximum SOF for beta-gamma, gross alpha, and all-pathways are 0.563, 0.531 and 0.073, respectively. The contribution of the uranium and radium GW pathway to the maximum SOF at the 100-m POA is insignificant during the POP.

Each figure listed in the table shows the maximum concentration or dose (black dash-dotted line) of the entire 100-m POA boundary (8,832 elements) at each point in time from the start of ELLWF operations (9/28/1994) to the end of the GWP and GW-AP POP (9/28/3165). The concentration or dose time series of each radionuclide and DU are plotted at the same element in the curtain where the maximum concentration or dose occurs. The discontinuities in the curves are due to shifts in the element where the maximum concentration or dose occurs as the plumes evolve over time.

Table 9-1. ELLWF 100-m POA maximum SOF by GW pathway for the Scenario 1 deterministic simulation.

GW Pathway	Significant NUCs	Significant DUs	Maximum SOF	Figures
gross alpha	**Np-237**	**ET02, ST07**	**0.531**	**Figure D-7 Figure D-8**
beta-gamma	**H-3, C-14, I-129**	**ET01, LAWV**	**0.563**	**Figure 9-2 Figure 9-3**
uranium	**Np-237**	**ET02, ST07**	**4.5E-10**	**Figure D-9 Figure D-10**
radium	**na**	**na**	**0.**	**na**
all-pathways	**H-3, Np-237**	**ET01, ET02**	**0.073**	**Figure D-11 Figure D-12**

For each GW pathway a pair of figures is presented. For example, Figure 9-2 and Figure 9-3 show the dose associated with beta-gamma highlighting:

- In Figure 9-2 a breakdown of the total dose at the curtain resulting from each parent radionuclide's contribution. Each parent radionuclide's contribution is its composite (rolled-up) contribution from every DU's existing plus future inventories present.
- In Figure 9-3 a breakdown of the total dose at the curtain resulting from each DU's contribution. Each DU's contribution is its composite (rolled-up) contribution from every parent radionuclide's existing plus future inventories present within that DU.

Appendix D contains the figures for the remaining GW pathways. For each GW pathway, graphically these figures quickly indicate which DU and which parent radionuclide contributes the greatest to the total dose at every point in time.

When looking at the beta-gamma GW pathway in Figure 9-3 we see that the LAWV dominants the total dose when it's at the peak value of 0.563 (i.e., at approximately the year 2530). Also, from Figure 9-2 we see that C-14 and I-129 are the main contributors to this peak SOF.

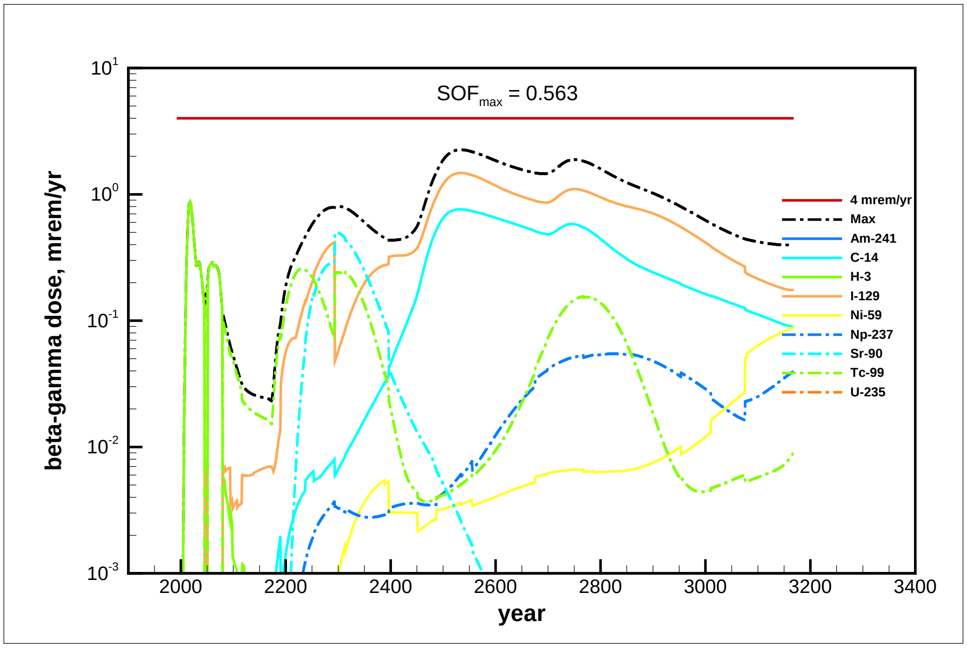


Figure 9-2. ELLWF radionuclide beta-gamma maximum dose time history at the 100-m POA (Scenario 1).

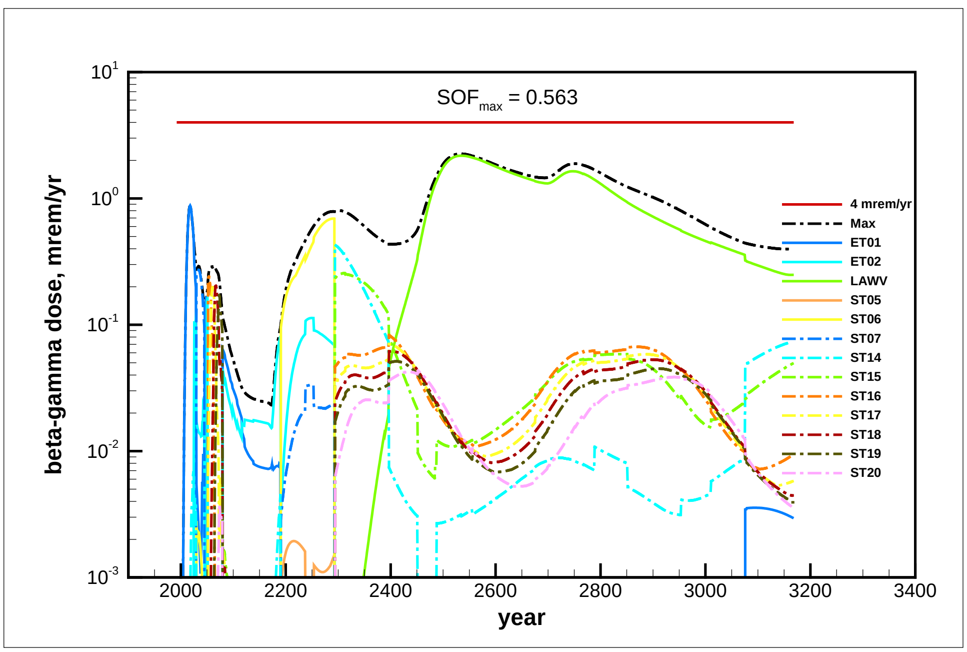


Figure 9-3. ELLWF disposal unit beta-gamma maximum dose time history at the 100-m POA (Scenario 1).

As Table 9-1 indicates, the peak value for SOF is 0.563. Given this degree of margin from one, this deterministic result strongly indicated that the stochastic analyses effort was warranted.

9.1.2 Deterministic Simulation Results for Future Inventory Scenario 2

The deterministic simulation results for Future Inventory Scenario 2 are summarized in Table 9-2. These future inventory scenarios represent an extremely unlikely mode of SWM operations where all DU's would be loaded with a future inventory of a single radionuclide to a maximum SOF of 1. These deterministic results demonstrate that the performance criteria at the 100-m POA can be challenged by such an extremely unlikely future inventory scenario.

The 2008 PA methodology establishes inventory limits without any constrain on a DU's inventory composition (i.e., the provided limits allow any composition up to a pure component to be buried within a given DU). Historically, the only DU with a nearly pure component present is the LAWV where existing inventory is ~99.9% H-3 on an activity basis.

Table 9-2. ELLWF 100-m POA radionuclide maximum SOF by GW pathway for the Scenarios 2a through 2i deterministic simulations.

Nuclide	GW Pathway	Maximum SOF[a]	Figures
Am-241	gross alpha	0.509	Figure D-13 Figure D-14
C-14	beta-gamma	0.573	Figure D-15 Figure D-16
H-3	beta-gamma	0.752	Figure D-17 Figure D-18
I-129	beta-gamma	0.581	Figure D-19 Figure D-20
Ni-59	beta-gamma	15.3	Figure 9-4 Figure 9-5
Np-237	gross alpha	0.800	Figure D-21 Figure D-22
Sr-90	beta-gamma	4.56	Figure 9-6 Figure 9-7
Tc-99	beta-gamma	1.70	Figure 9-8 Figure 9-9
U-235	gross alpha	0.173	Figure D-23 Figure D-24

a - red indicates that performance criteria have been exceeded.

Given that a SOF >1 can be realized for some set of compositions, regardless of their likelihood, the need to perform stochastic analyses based on more creditable composition scenarios is warranted.

Graphical images like the ones shown for the Scenario 1 simulations have been created and for the three cases that exceeded a SOF of 1 (i.e., Ni-59, Sr-90, and Tc-99), their results are provided below. The remaining six cases are provided in Appendix D.

As Figure 9-5, Figure 9-7, and Figure 9-9 illustrate, the dominant contributor to the exceedance of a SOF of 1 is the LAWV.

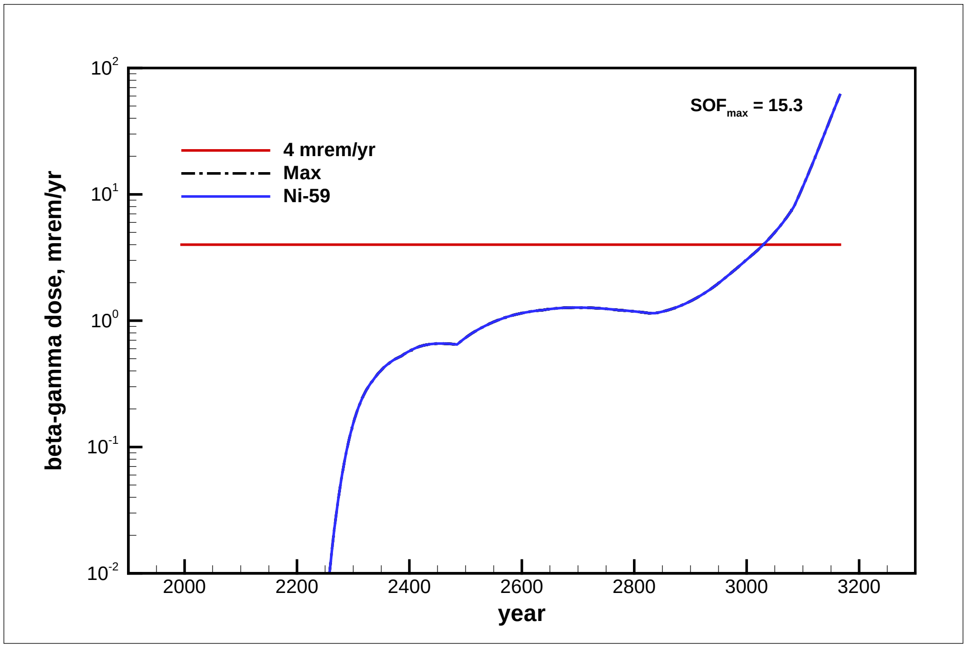


Figure 9-4. ELLWF Ni-59 beta-gamma maximum dose time history at the 100-m POA (Scenario 2e).

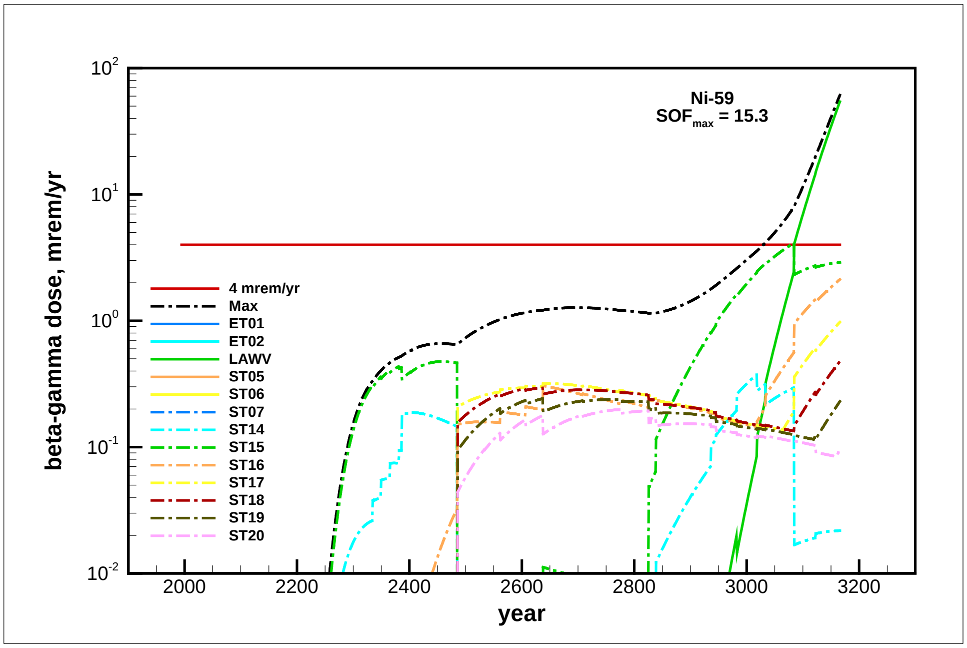


Figure 9-5. ELLWF DU beta-gamma maximum dose time history at the 100-m POA (Scenario 2e).

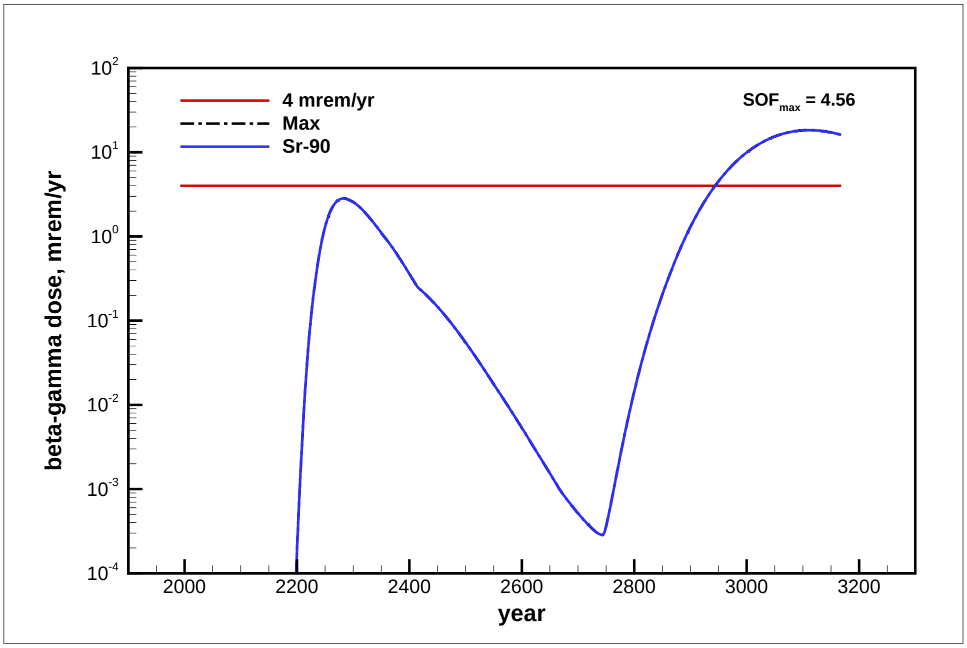


Figure 9-6. ELLWF Sr-90 beta-gamma maximum dose time history at the 100-m POA (Scenario 2g).

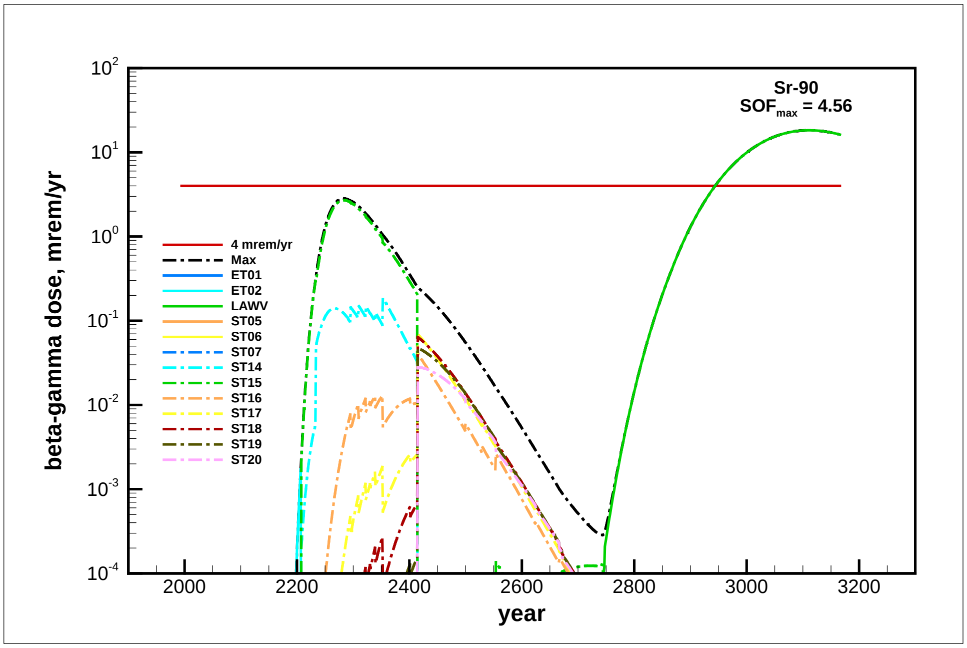


Figure 9-7. ELLWF DU beta-gamma maximum dose time history at the 100-m POA (Scenario 2g).

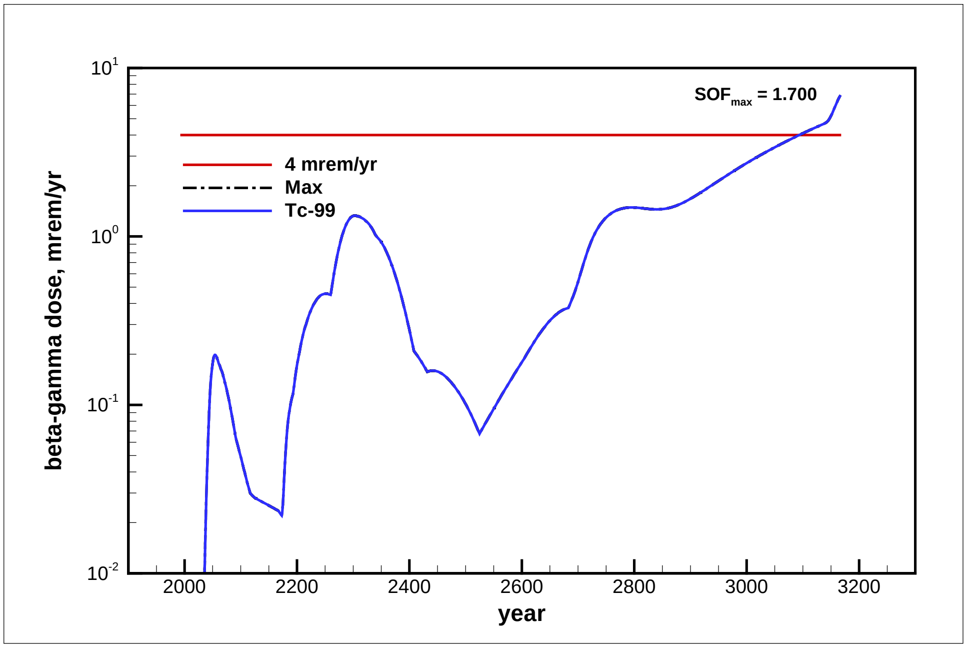


Figure 9-8. ELLWF Tc-99 beta-gamma maximum dose time history at the 100-m POA (Scenario 2h).

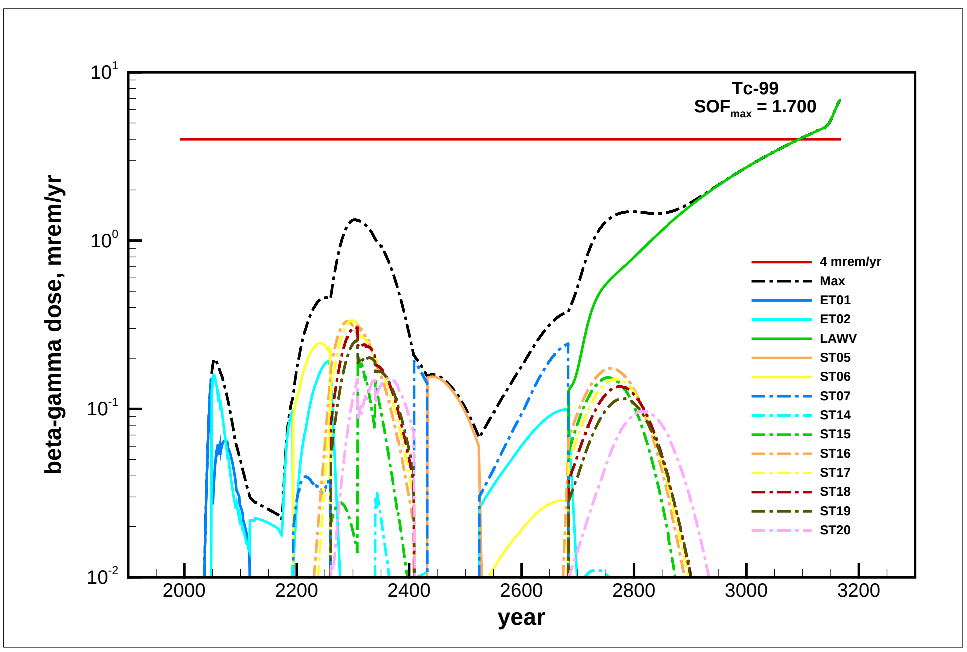


Figure 9-9. ELLWF DU beta-gamma maximum dose time history at the 100-m POA (Scenario 2h).

9.2 Stochastic Approach

The deterministic Future Inventory Scenario 1 in Chapter 9.1.1 provides a "best-estimate" of the maximum SOF of 0.531 and 0.563 for the gross alpha and beta-gamma groundwater pathways, respectively, at the 100-m POA. Existing plus projected future inventories within each DU were set to a maximum SOF of 1 based on current WITS inventory limits for GW and intruder pathways only. However, the future inventory composition vectors in each DU are unknown and are driven by SWM operations ET/ST/LAWV utilization needs and constraints. To project future inventory composition vectors, we can employ stochastic inventory sampling based on historical inventory distributions for each of the SA parent radionuclides. This stochastic approach will quantify the impact of random inventory sampling on the likelihood of exceeding overall performance measures at the 100-m POA.

The basic stochastic approach implemented in the ELLWF Dose Investigation Tool for each Monte-Carlo realization is the following:

- randomly sample (between 0 and 1) the cdf of the log- normal distribution of each SA nuclide within each DU.
- compute the random future inventory (Ci) of each nuclide using the random cdf value and the inverse of its log-normal distribution cdf.
- normalize the future inventory vector of each DU to a unit Ci composition.
- compute SOF for each WITS inventory time window using the unit composition for each DU.
- compute the maximum SOF of all the WITS inventory time windows for each DU.
- scale the unit composition vector to the future inventory vector based on the existing inventory maximum SOF and the unit composition maximum SOF.
- compute groundwater pathway history concentrations and doses at the curtain due to existing plus future inventory contributions from each DU (Equations (8-1) and (8-2)).
- compute maximum SOF for each GW pathway at the curtain (Equations (8-3) through (8-7)).
- compute the maximum overall SOF on the curtain.

The above nine-step process was applied to 10,000 realizations of a Monte-Carlo simulation. The key stochastic aspect here is the random sampling of each future inventory vector. Based on historical burial inventory distributions log-normal pdf's are used where the intrinsic random number generator in Fortran 95 is employed (i.e., in reality the inverse of the cdf is directly employed). The generated future inventory vectors are assumed to be composed of random distribution functions that are mutually independent of each other.

Figure 9-10 shows the evolution of the maximum SOF for the gross alpha and beta-gamma GW pathways during 10,000 Monte-Carlo realizations. The gross alpha GW pathway exhibits maximum SOF's that range from 0.38 to 0.77 as shown in Figure 9-11 with a peak in the histogram at 0.55/0.56. The beta-gamma GW pathway exhibits maximum SOFs that range from 0.43 to 0.74 as shown in Figure 9-12 with a narrow distribution about a peak at 0.58/0.59. The overall maximum SOF histogram ranges from 0.49 to 0.78 with a mean value at 0.605 as shown in Figure 9-13. The probability of exceeding a maximum SOF of 1.0 was estimated to be < 0.01% based on 10,000 Monte-Carlo realizations (< 0.01% for maximum SOF > 0.77).

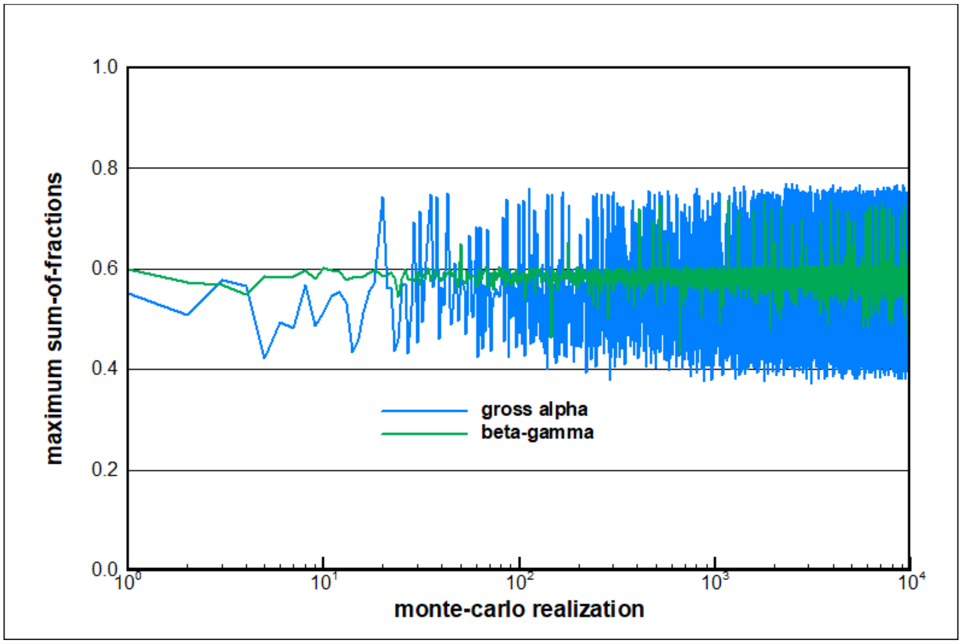


Figure 9-10. Evolution of the maximum SOF during the Monte-Carlo simulation.

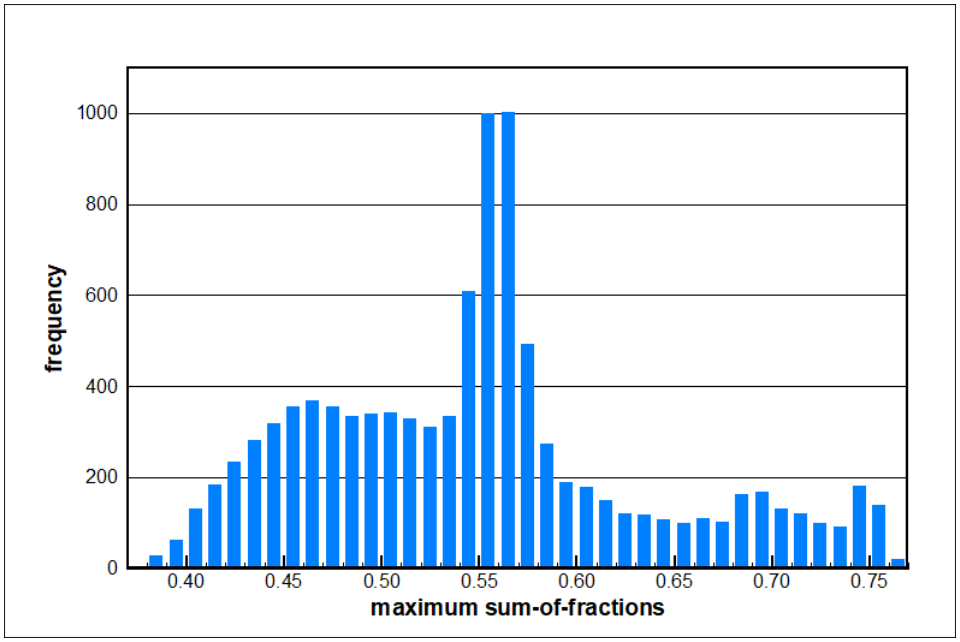


Figure 9-11. ELLWF gross alpha maximum SOF histogram.

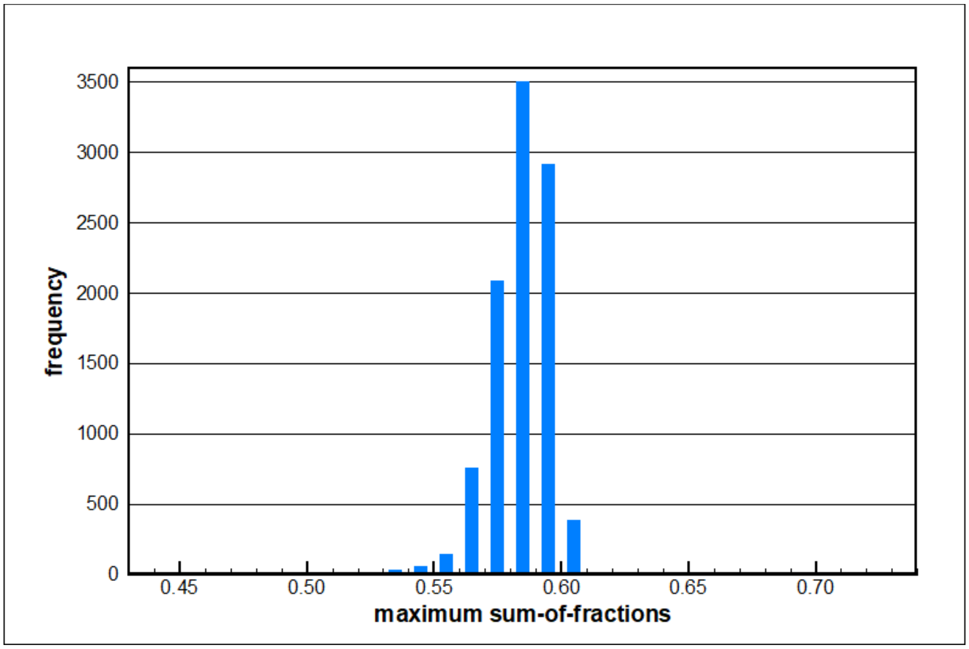


Figure 9-12. ELLWF beta-gamma maximum SOF histogram.

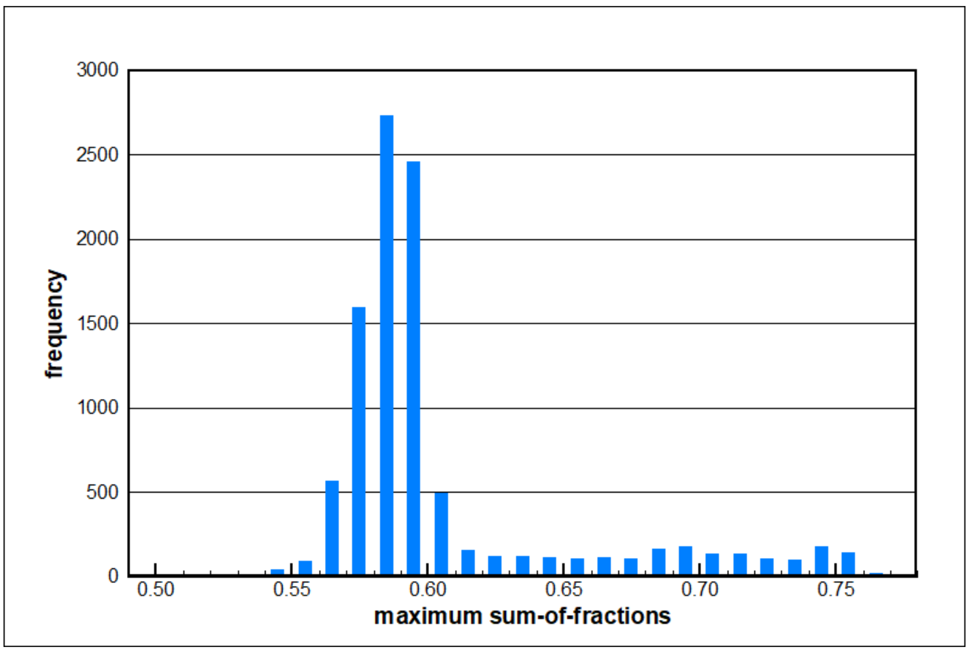


Figure 9-13. ELLWF GW pathway maximum SOF histogram.

9.3 ELLWF Dose Investigation at the 100-m POA

The E-Area LLWF Dose Investigation at the 100-m POA results are summarized in Table 9-3. The maximum SOFs for gross alpha, beta-gamma, and all-pathways are 0.770, 0.599 and 0.095, respectively, and occurred at Monte-Carlo realization 2473. The contribution of the uranium and radium GW pathway to the maximum SOF at the 100-m POA is insignificant during the POP.

Each line plot listed in the table shows the maximum concentration or dose (black dash-dotted line) of the entire 100-m POA boundary (8,832 elements) at each point in time from the start of

ELLWF operations (9/28/1994) to the end of the GWP and GW-AP POP (9/28/3165) for Monte-Carlo realization 2,473 (maximum overall SOF). The concentration or dose time series of each parent radionuclide and DU plotted are at the same element in the curtain where the maximum concentration or dose occurs. The discontinuities in the curves are due to shifts in the element where the maximum concentration or dose occurs as the plumes evolve in time.

The 2D contour plots, Figure 9-16, Figure 9-20, Figure 9-23 and Figure 9-25 are the ELLWF 100-m POA concentrations or doses at the time of maximum concentration/dose for each GW pathway.

Table 9-3. ELLWF 100-m POA maximum SOF by GW pathway.

GW Pathway	Significant NUCs	Significant DUs	Maximum SOF	Figures
gross alpha	**Np-237**	**ET02, ST07**	**0.770[a]**	**Figure 9-14- Figure 9-16**
beta-gamma	**H-3, C-14, I-129**	**ET01, ST06, LAWV**	**0.599**	**Figure 9-17- Figure 9-19**
uranium	**Np-237**	**ET02, ST07**	**6.3E-10**	**Figure 9-20- Figure 9-22**
radium	**na**	**na**	**0.**	**na**
all-pathways	**H-3, Np-237**	**ET01, ET02**	**0.095**	**Figure 9-23- Figure 9-25**

a - The overall maximum SOF of 0.770 was encountered at Monte-Carlo realization 2473.

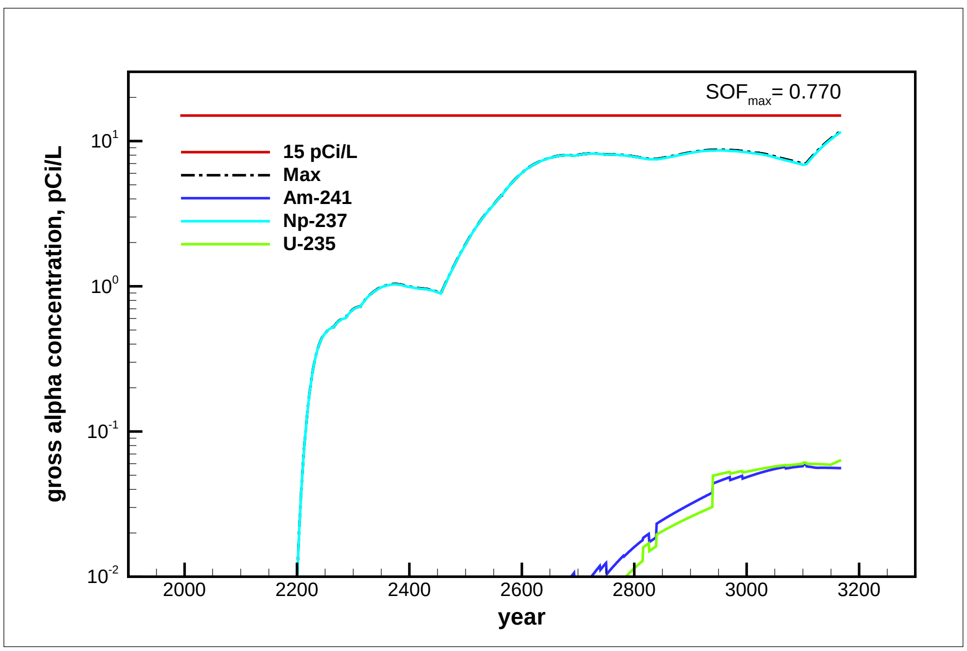


Figure 9-14. ELLWF radionuclide gross alpha maximum concentration time history at the 100-m POA (MC 2473).

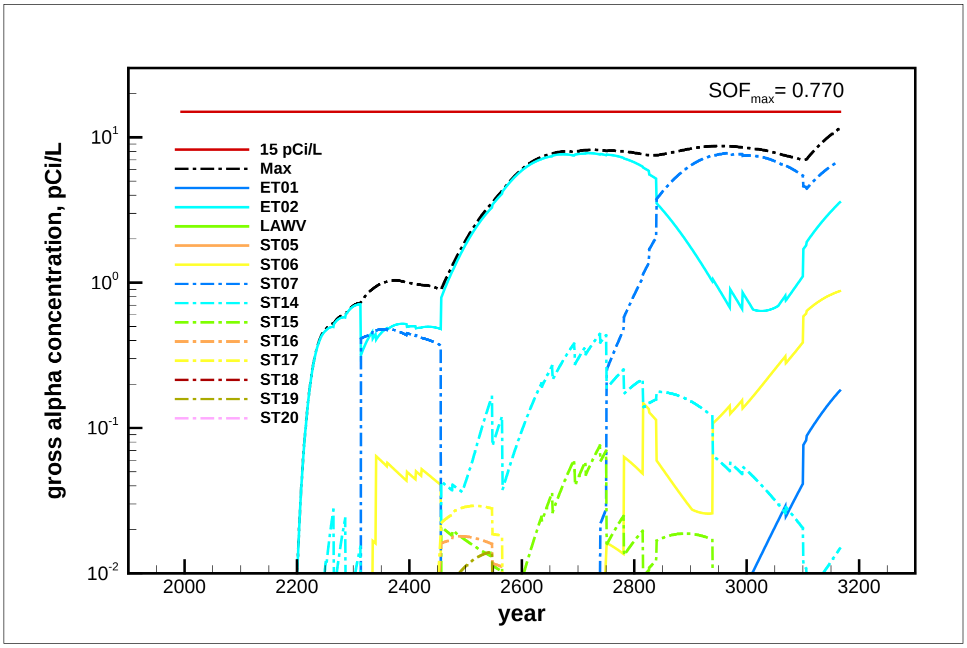


Figure 9-15. ELLWF DU gross alpha maximum concentration time history at the 100-m POA (MC 2473).

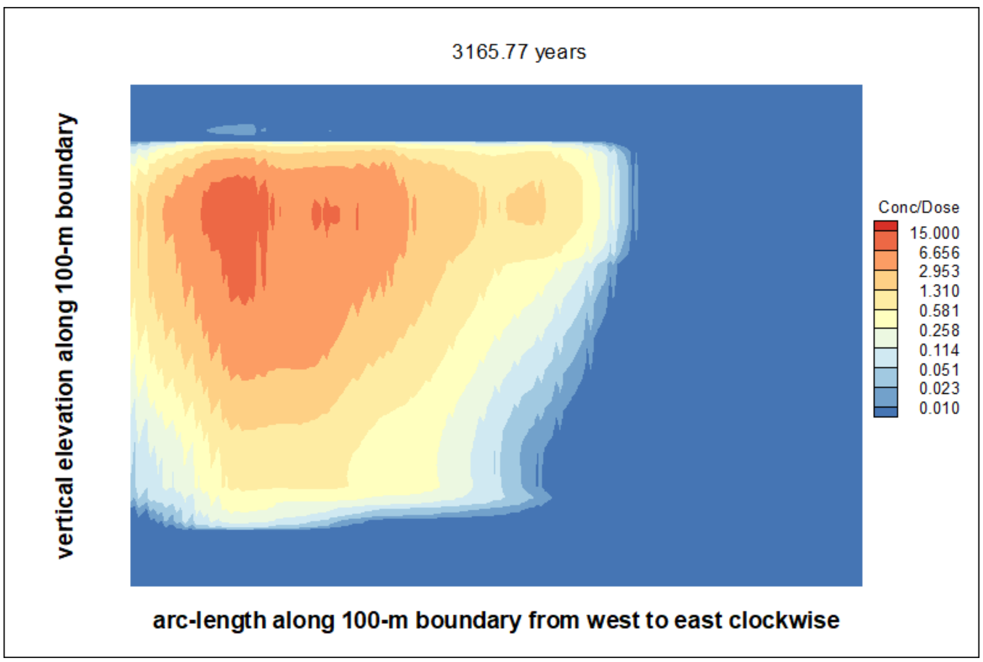


Figure 9-16. ELLWF 100-m POA gross alpha concentrations at the time of maximum concentration (MC = 2473).

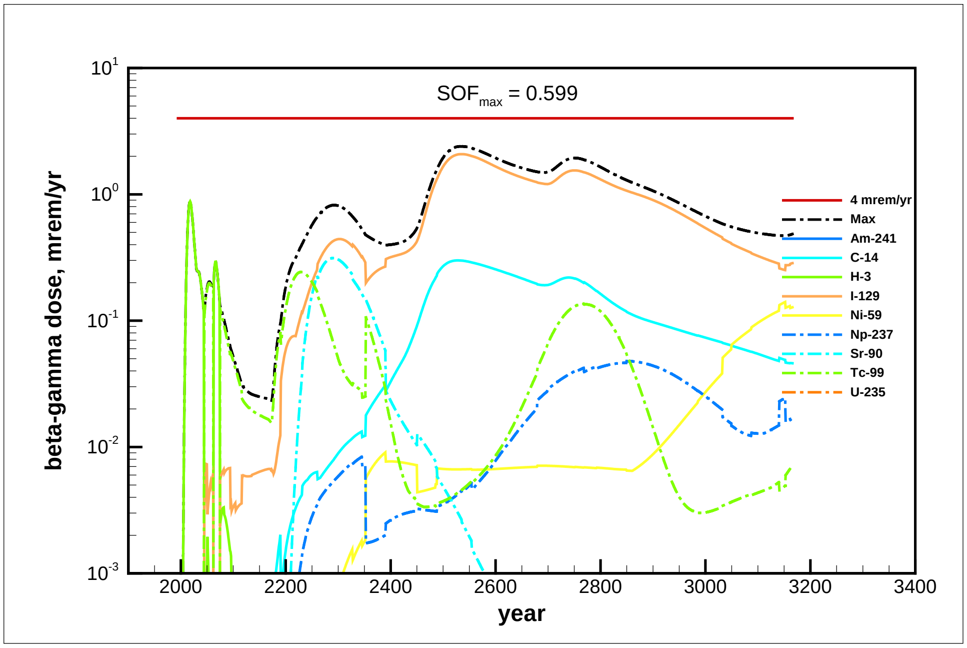


Figure 9-17. ELLWF radionuclide beta-gamma maximum dose time history at the 100-m POA (MC 2473).

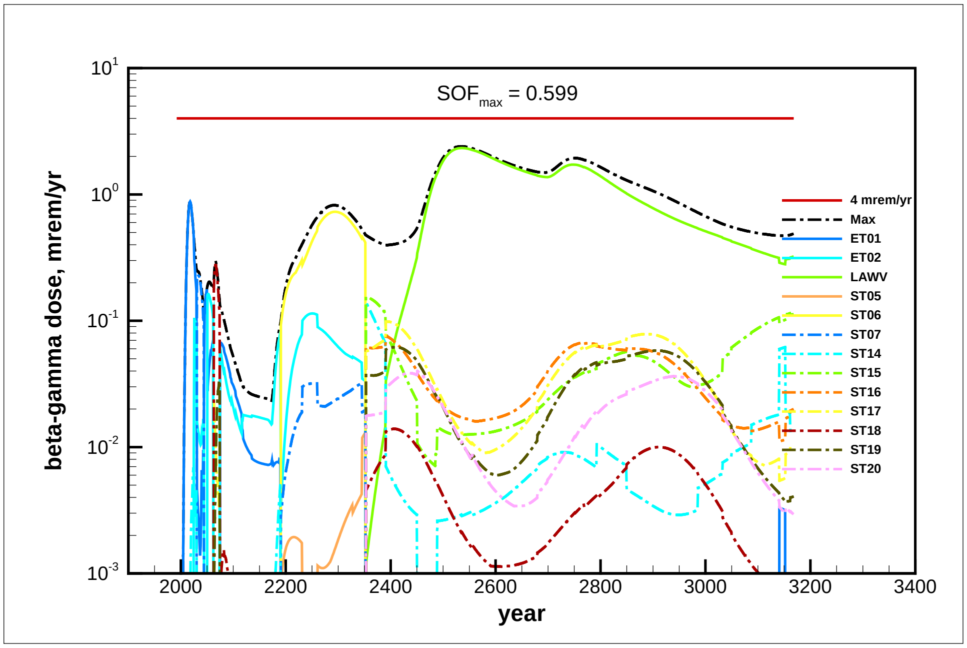


Figure 9-18. ELLWF DU beta-gamma maximum dose time history at the 100-m POA (MC 2473).

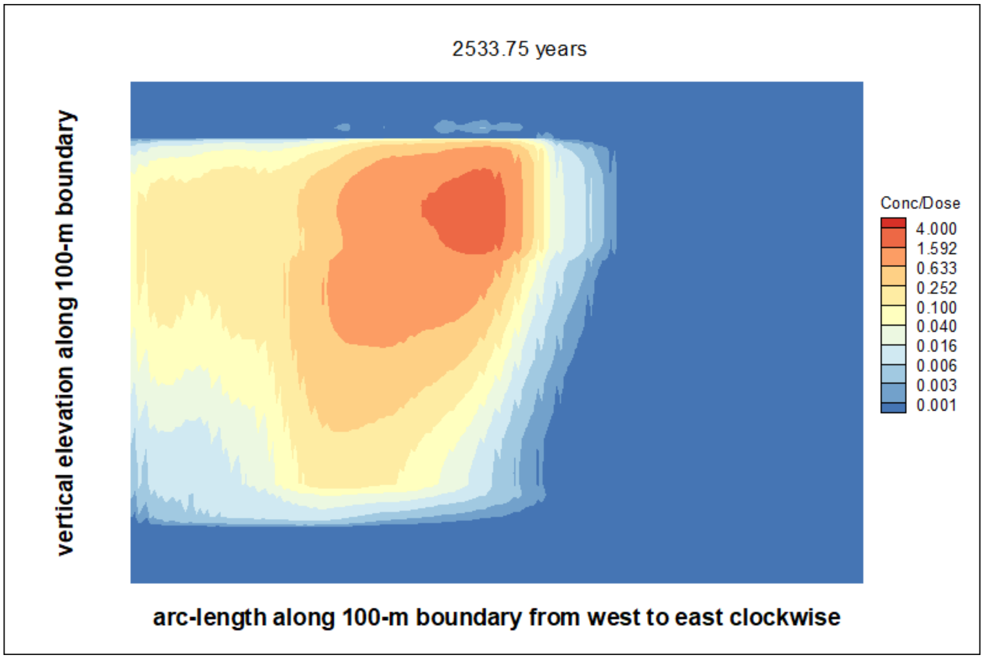


Figure 9-19. ELLWF 100-m POA beta-gamma doses at the time of maximum dose (MC 2473).

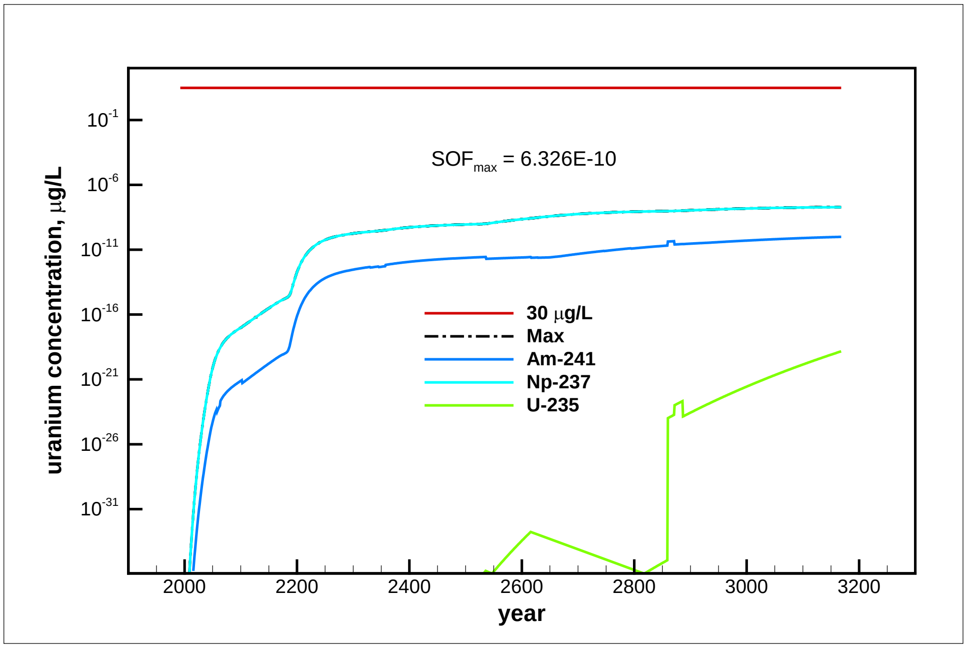


Figure 9-20. ELLWF radionuclide uranium maximum concentration time history at the 100-m POA (MC 2473).

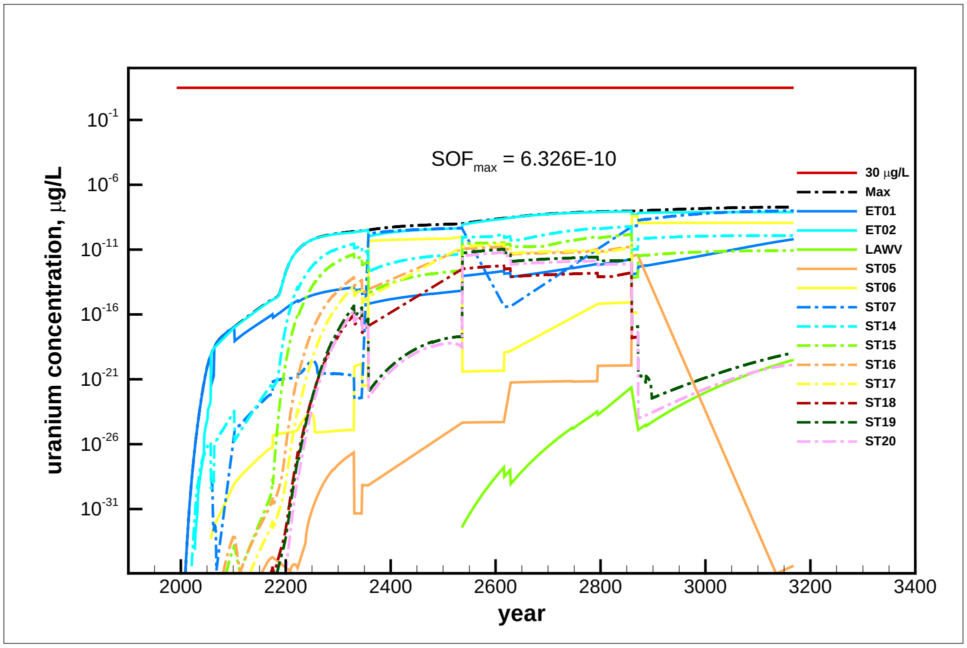


Figure 9-21. ELLWF DU uranium maximum concentration time history at the 100-m POA (MC 2473).

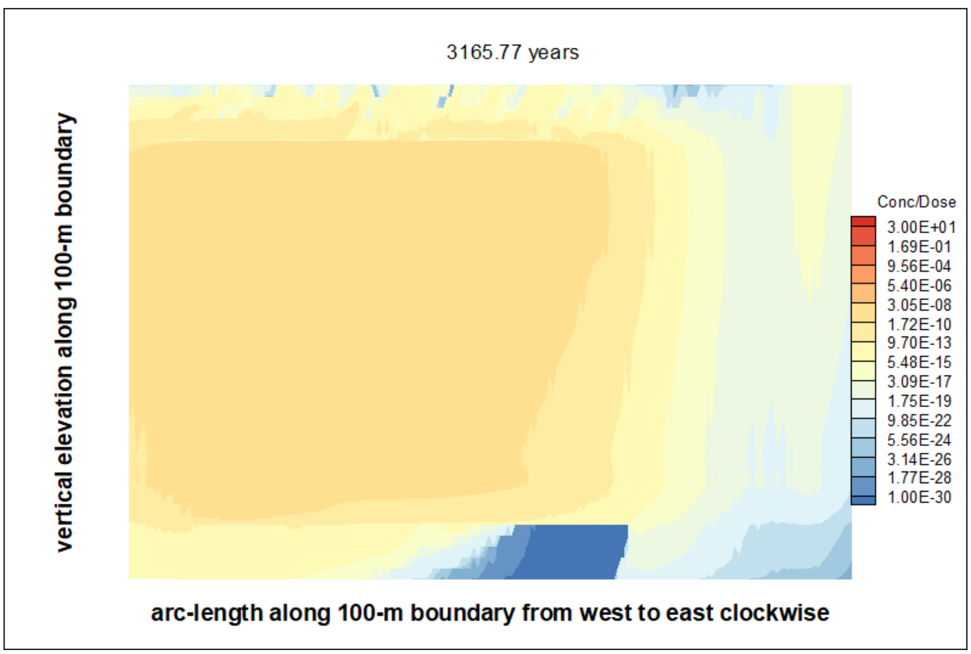


Figure 9-22. ELLWF 100-m POA uranium concentrations at the time of maximum concentration (MC 2473).

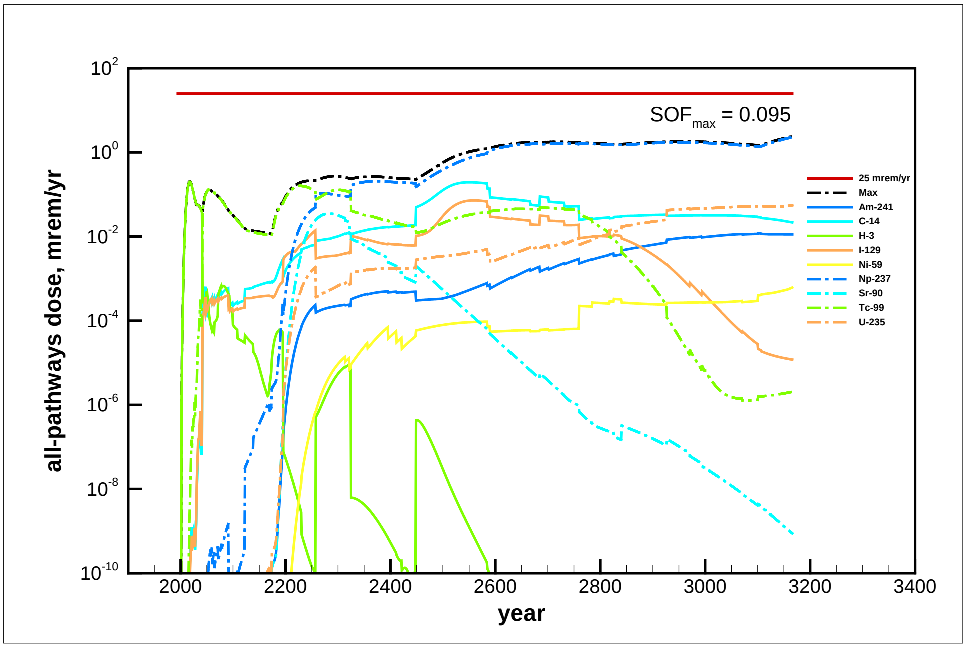


Figure 9-23. ELLWF radionuclide all-pathways maximum dose time history at the 100-m POA (MC 2473).

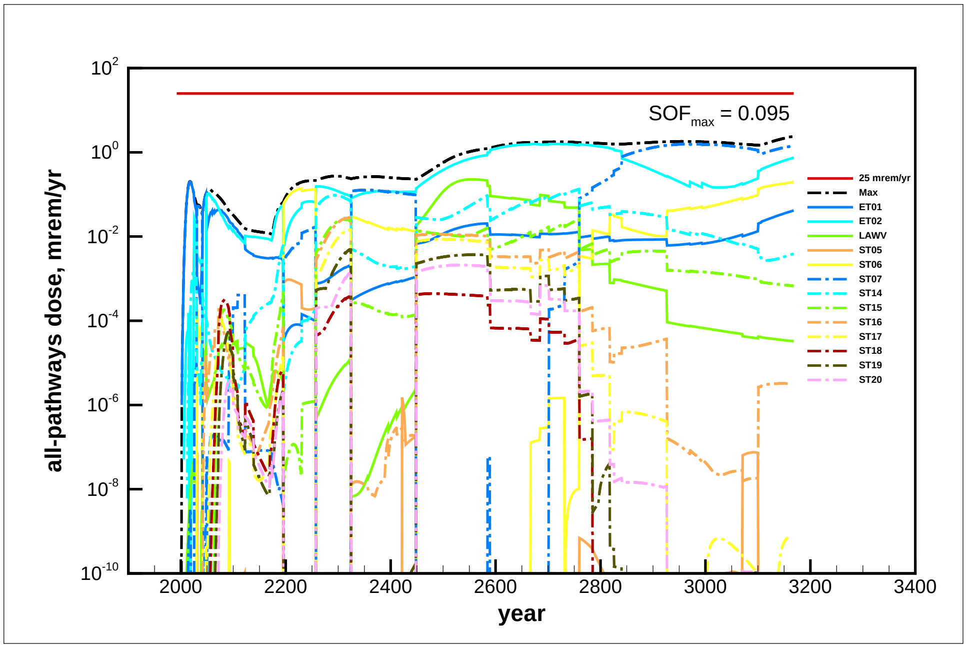


Figure 9-24. ELLWF DU all-pathways maximum dose time history at the 100-m POA MC 2473).

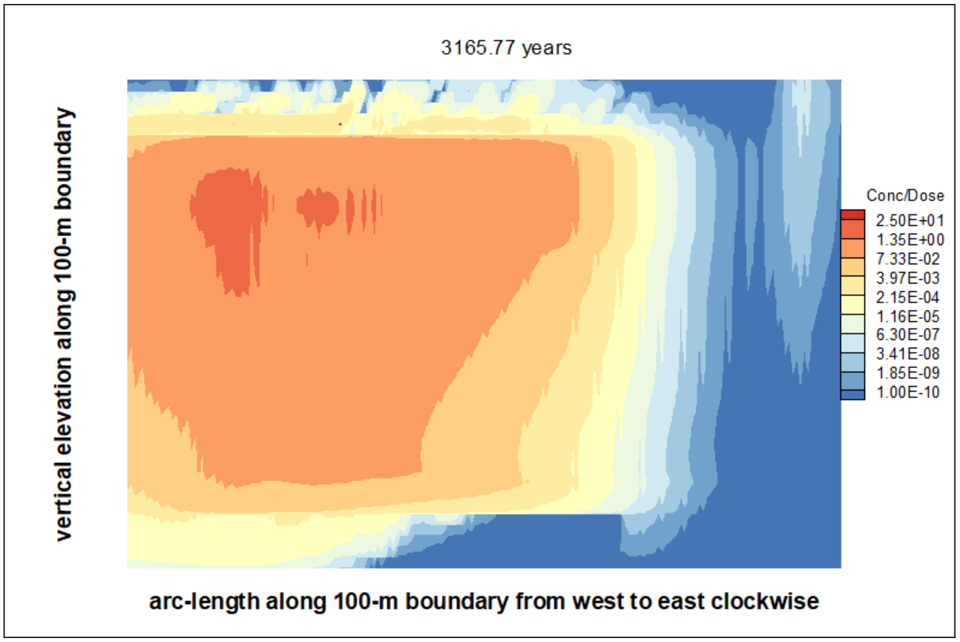


Figure 9-25. ELLWF 100-m POA all-pathways doses at the time of maximum dose (MC 2473).

10.0 Conclusions

The detrimental effects of a greater degree of plume interaction on the DU's of concern (i.e., higher dose impacts and lower limits) is more than compensated for by: (1) various new aspects of PA models and databases since the 2008 PA, (2) employing more constrained DU operating timelines, and (3) reduced allowable percentage of non-crushable containers. Under the Case 1 timeline, the likelihood of exceeding a SOF of 1.0 by continuing to use existing inventory limits is exceedingly small, less than 0.01% probability. A Case 1 deterministic run assuming average historical radionuclide compositions shows that filling all DUs to a SOF of 1.0 at their current inventory limits results in a "true" SOF of 0.563 ("true" as defined by the latest PA models). This includes filling currently operating trenches (ST06, ST07, ST14 and ET01), the LAWV and future trenches, ST15 through ST20, in accordance with the Case 1 timeline. The Case 1 timeline defines the constraints of the analysis that must be honored in operational practice. The following statements can be made about the different categories of DU's evaluated in this SA.

Operating Trenches and the LAWV

Solid Waste can continue to operate at their current limits in ET02, ST14, and the LAWV subject to the operational constraints in Section 2.2 and be confident that DOE O 435.1 PO's and GWP requirements will not be exceeded. Thus, the restricted SOF administrative limits applied as an Interim Measure to ET02 and ST14 can be removed (i.e., max SOF values of 75% and 65%, respectively). SWM can return to a SOF = 1.0 to protect DU limits.

A non-crushable container limit of 2% (as applied to trench surface area) is imposed on ET02 and ST14. Though outside the study area, the following is restated for clarity: the current prohibition on non-crushable containers in ST09 and ET03 remains in place until this restriction is evaluated in the next PA revision. The previous 10% non-crushable operational constraint is still applicable to ST08.

ST06 and ST07 should remain inactive and not receive additional waste prior to completion and approval of the next PA revision or before 2028, whichever comes first. No additional non-crushable containers should be disposed in ST06 or ST07 which currently contain 2.87% and 0.67% non-crushable containers, respectively.

Closed Trenches

Dose impacts from the final inventories in ST05 and ET01 are within DOE O 435.1 PO's and GWP requirements assuming the Case 1 timeline.

Future Trenches

ST15 through ST21 should not be opened as either ST's or ET's prior to completion and approval of the next PA revision or before 2037, whichever comes first. In the next PA revision, a new baseline for trench operations will be established.

A non-crushable container limit of 2% (as applied to trench surface area) is imposed on ST15 through ST21. Though outside the study, the following is restated for clarity: The current prohibition on non-crushable containers in the future ET04 remains in place until this restriction is evaluated in the next PA revision. The previous 10% non-crushable operational constraint is still applicable to the remaining future trenches in the western portion of E-Area (ST10 and ST11).

11.0 Recommendations, Path Forward, and/or Future Work

The following recommendations are made to implement results of this SA or for future work:

- SWM should remove interim measures imposed by the UDQ Screening (see Appendix A) and apply the new operational constraints imposed by the SA (see Section 2.2) to ensure that disposal operations are protected. SWM should also update the SWM key I&A database.
- SRNL has largely automated the evaluation performed in this SA and can likely provide relief on the newly imposed operational constraints with a quick evaluation if needed prior to completion and approval of the next PA revision. Potential relief includes accelerating when a future trench is opened and easing non-crushable container restrictions.
- This SA demonstrated a sizeable amount of operating margin with respect to performance objectives given the assumptions of Case 1. As part of the next PA revision, SRNL proposes to evaluate returning to the simpler 2008 PA approach to the PIF analysis or to consider a more flexible hybrid scheme. If the simpler approach provides acceptable inventory limits, it would allow SWM to open trench units in any order that suited operational needs.

12.0 References

ACRi 2010. ACRi, "PORFLOW Version 6.3 User's Manual," Revision 3, Analytical & Computational Research, Inc., Los Angeles, California, June 27, 2010.

Aleman 2007. S. E. Aleman, *PORFLOW Testing and Verification Document*, WSRC-STI-2007-00150, Revision 0, Savannah River National Laboratory, Savannah River Site, Aiken, SC 29808, June 2007.

Aleman and Flach 2010. S. E. Aleman and G. P. Flach, Technical Memo, "Acceptance Testing for PORFLOW version 6.30.1", SRNL-L3200-2010-00016, Savannah River National Laboratory, Savannah River Site, Aiken, SC 29808, September 1, 2010.

Butcher 2018a. B. T. Butcher to I. J. Stewart and L. C. McCollum, Memorandum, "Revision of the ELLWF Disposal Limits Database Evaluating Use of Slit Trench 13 Limits for Engineered Trench #4 (Revision 2017-1)", SRNL-L3200-2017-00154, Savannah River National Laboratory, Savannah River Site, Aiken, SC 29808, January 9, 2018.

Butcher 2018b. B. T. Butcher to P. N. Fairchild, K. L. Tempel, I. J. Stewart, J. O. Simmons, G. K. Humphries, and G. P. Flach, Email, "Summary of 8/22/18 SRNL-SW customer meeting on UDQE Trench Sequencing", Savannah River National Laboratory, Savannah River Site, Aiken, SC 29808, August 23, 2018.

Butcher et.al. 2017. B. T. Butcher, L. L. Hamm, and G. P. Flach, *Unreviewed Disposal Question Evaluation: Waste Disposal in Engineered Trenches 3 and 4*, WSRC-STI-2017-00393, Revision 1, Savannah River National Laboratory, Savannah River Site, Aiken, SC 29808, December 2013.

Butcher and Hiergesell 2012. B. T. Butcher and R. A. Hiergesell, *Performance Assessment Interim Measures for Returning E-Area Low-Level Waste Facility Trenches to Operation*, SRNL-STI-2012-00320, Revision 0, Savannah River National Laboratory, Savannah River Site, Aiken, SC 29808, May 2012.

Carey 2006. S. A. Carey, *Low Activity Waste (LAW) Vault Structural Degradation Prediction*, T-CLC-E-00018, Revision 1, Westinghouse Savannah River Company, Aiken, SC 29808, June 8, 2006.

Crowley 2018. D. A. Crowley to F. L. Fox, Email, "Interim Measures", Savannah River National Laboratory, Savannah River Site, Aiken, SC 29808, March 6, 2018.

Danielson 2018 (draft). Technical Memorandum, "Limited scope sensitivity investigation of implementation of PORFLOW subsidence boundary conditions – comparison of blending infiltration rate inputs or blending flux to the water table outputs", SRNL-STI-2018-00681, Revision 0, Savannah River National Laboratory, Savannah River Site, Aiken, SC 29808, December 5, 2018.

Danielson 2017. T. L. Danielson, *Software Quality Assurance Plan for Aquifer Model Refinement Tool (MESH3D)*, Q-SQP-G-00003, Revision 2, Savannah River National Laboratory, Savannah River Site, Aiken, SC 29808, September 2017.

DOE 2017. DOE Standard, *Disposal Authorization Statement and Tank Closure Documentation*, DOE-STD-5002-2017, U. S. Department of Energy, Washington D.C., 2017.

DOE 1999a. *Radioactive Waste Management Manual*, DOE M 435.1-1, U.S. Department of Energy Office of Environmental Management, Washington D.C., July 9, 1999.

DOE 1999b. *Implementation Guide for use with DOE M 435.1-1*, "Chapter IV Low-Level Waste Requirements", DOE G 435.1-1, U. S. Department of Energy Office of Environmental Management, Washington D.C., July 9, 1999.

Dyer 2017. J. A. Dyer, Technical Memorandum, "Conceptual Modeling Framework for E-Area PA HELP Infiltration Model Simulations", SRNL-STI-2017-00678, Revision 0, Savannah River National Laboratory, Savannah River Site, Aiken, SC 29808, November 30, 2018.

Dyer and Flach 2018. J. A. Dyer and G. P. Flach, Infiltration Time Profiles for E-Area LLWF Intact and Subsidence Scenarios, SRNL-STI-2018-00327, Revision 0, Savannah River National Laboratory, Savannah River Site, Aiken, SC 29808, July 2018.

Flach 2018a. G. P. Flach, *Updated Groundwater Flow Simulations of the Savannah River Site General Separations Area*, SRNL-STI-2018-00643, Revision A, Savannah River National Laboratory, Savannah River Site, Aiken, SC 29808, November 2018.

Flach 2018b. G. P. Flach, Technical Memorandum, "Recommended Aquifer Grid Resolution for E-Area PA Revision Transport Simulations", SRNL-STI-2018-00012, Revision 0, Savannah River National Laboratory, Savannah River Site, Aiken, SC 29808, January 3, 2018.

Flach 2013. G. P. Flach, *Unreviewed Disposal Question Evaluation: Impact of New Information since 2008 PA on Current Low-Level Solid Waste Operations*, SRNL-STI-2013-00011, Revision 0, Savannah River National Laboratory, Savannah River Site, Aiken, SC 29808, February 2013.

Flach 2004. G. P. Flach, Groundwater Flow Model of the General Separations Area Using PORFLOW (U), WSRC-TR-2004-0106, Revision 0, Savannah River National Laboratory, Savannah River Site, Aiken, SC 29808, July 2004.

Flach et al. 2017. G. P. Flach, L. A. Bagwell, and P. L. Bennett, *Groundwater Flow Simulation of the Savannah River Site General Separations Area*, SRNL-STI-2017-00008, Revision 1, Savannah River National Laboratory, Savannah River Site, Aiken, SC 29808, September 6, 2017.

Hamm et al. 2013. Unreviewed Disposal Question Evaluation: Waste Disposal in Engineered Trench #3, SRNL-STI-2013-00393, Revision 0, Savannah River National Laboratory, Savannah River Site, Aiken, SC 29808, July 2013.

Hang et al. 2018. T. Hang, N. V. Halverson, I. J. Stewart, and G. K. Humphries, *FY2017 Performance Assessment Annual Review for the E-Area Low-Level Waste Facility*, SRNL-STI-2017-00761, Revision 0, Savannah River National Laboratory, Savannah River Site, Aiken, SC 29808, March 2018.

Kaplan 2016a. D. I. Kaplan, *Geochemical Data Package for Performance Assessment Calculations Related to the Savannah River Site*, SRNL-STI-2009-00473, Revision 1, Savannah River National Laboratory, Savannah River Site, Aiken, SC 29808, July 22, 2016.

Kaplan 2016b. D. I. Kaplan, *Geochemical Data Package for Performance Assessment and Composite Analysis at the Savannah River Site – Supplemental Radionuclides*, SRNL-STI-

2016-00267, Revision 0, Savannah River National Laboratory, Savannah River Site, Aiken, SC 29808July 2016.

Kaplan 2012. D. I. Kaplan, *Revised Guidelines for using Cellulose Degradation Product-Impacted Kd Values for Performance Assessments and Composite Analyses*, SRNL-STI-2012-00138, Revision 0, Savannah River National Laboratory, Savannah River Site, Aiken, SC 29808, May 2012.

Mooneyhan 2018. J. L. Mooneyhan, "SWMF Performance Assessment Review Committee (PARC) Meeting Minutes", #PA-18-03, Savannah River Nuclear Solutions, Aiken, SC 29808, July 24, 2018.

Peregoy 2006. W. Peregoy, *Structural Evaluation of Intermediate Level Waste Disposal Vaults for Long-Term Behavior*, T-CLC-E-00024, Revision 0, Westinghouse Savannah River Company, Aiken, SC 29808, June 27, 2006.

Phifer 2010. M. A. Phifer, Technical Memorandum, "Slit Trench Waste Representation", SRNL-L6200-2010-00018, Revision 0, Savannah River National Laboratory, Savannah River Site, Aiken, SC 29808, June 15, 2010.

Phifer et al. 2009. M. A. Phifer, K. P. Crapse, M. R. Millings, M. G. Serrato, *Closure Plan for the E-Area Low-Level Waste Facility*, SRNL-RP-2009-00075, Revision 0, Savannah River National Laboratory, Savannah River Site, Aiken, SC 29808, March 16, 2009.

Phifer et al. 2007. M. A. Phifer, W. E. Jones, E. A. Nelson, M. E. Denham, M. R. Lewis, E. P. Shine, *FTF Closure Cap Concept and Infiltration Estimates*, WSRC-STI-2007-00184, Revision 2, Savannah River National Laboratory, Savannah River Site, Aiken, SC 29808, October 2007.

Roddy 2018a. N. S. Roddy, email, "RE: Need inventories from WITS (again!) for a UDQE", Savannah River Nuclear Solutions, Aiken, SC 29808, August 23, 2018.

Roddy 2018b. N. S. Roddy, email, "RE: Need inventories from WITS (again!) for a UDQE", Savannah River Nuclear Solutions, Aiken, SC 29808, September 27, 2018.

Sink 2017. D. F. Sink, *FY17 SWMF Low Level Waste Plan and Disposal Strategies*, SRNS-RP-2017-00086, DRAFT (never issued), April 2017.

Sink 2016. D. F. Sink, *FY16 Low Level Waste Plan and Disposal Strategies*, SRNS-RP-2016-00162, Revision 0, Savannah River Nuclear Solutions, Aiken, SC 29808, April 2016.

Sink 2012. D. F. Sink, SWMF Performance Assessment Limits Compared to Actual Disposed Inventory, SRNS-RP-2012-00195, Revision 1, Savannah River Nuclear Solutions, Savannah River Site, Aiken, SC 29808, July 2012.

Smith 2015. F. G. Smith, Technical Memorandum, "Revision to Vegetable Ingestion Dose Calculation", SRNL-L3200-2015-00143, Revision 0, Savannah River National Laboratory, Savannah River Site, Aiken, SC 29808, November 19, 2015.

Smith and Hamm 2014. F. G. Smith and L. L. Hamm, *Special Analysis: Revised Disposal Limits for the Low Activity Waste Vault*, SRNL-STI-2014-00289, Revision 0, Savannah River National Laboratory, Savannah River Site, Aiken, SC 29808, September 2014.

Smith et al. 2015. F. G. Smith, B. T. Butcher, M. A. Phifer, and L. L. Hamm, *Dose Calculation Methodology and Data for Solid Waste Performance Assessment and Composite Analysis at the Savannah River Site*, SRNL-STI-2015-00056, Revision 0, Savannah River National Laboratory, Savannah River Site, Aiken, SC 29808, April 2015.

SRNL 2018a. 2016_GeochemDatabase_ver3.1.xls, \\godzilla-01\hpc_project\projwork50\QA\Data\ELLWF\Rad-Dose, SRNL High Performance Computing File Server Network, Savannah River National Laboratory, Savannah River Site, Aiken, SC 29808, December 2018.

SRNL 2018b. SRNL Radionuclide, Element and Dose Parameters Data Package_12-30-15_version 1.1.xlsm, \\godzilla-01\hpc_project\projwork50\QA\Data\ELLWF\Rad-Dose, SRNL High Performance Computing File Server Network, Savannah River National Laboratory, Savannah River Site, Aiken, SC 29808, December 2018.

SRNL 2018c. 2016_HydraulicProperties_07-16-18.xls, \\godzilla-01\hpc_project\projwork50\E-Area\PA_2019\GW_Porflow\Common, SRNL High Performance Computing File Server Network, Savannah River National Laboratory, Savannah River Site, Aiken, SC 29808, December 2018.

SRNL 2004. Information Manual, *Savannah River National Laboratory Technical Report Design Check Guidelines*, WSRC-IM-2002-00011, Revision 2, Savannah River National Laboratory, Savannah River Site, Aiken, SC 29808, August 2004.

SRNS 2016a. Engineering Drawing, “E-Area Low Level Waste Facility (ELLWF) Conceptual Closure Cap – Overall Site Plan, SRS Drawing No. C-CT-E-00083, Revision A, Savannah River Nuclear Solutions, Savannah River Site, Aiken, SC 29808, July 20, 2016.

SRNS 2016b. Engineering Drawing, “E-Area Low Level Waste Facility (ELLWF) Conceptual Closure Cap – Details, SRS Drawing No. C-CT-E-00084, Revision A, Savannah River Nuclear Solutions, Savannah River Site, Aiken, SC 29808, July 20, 2016.

SRNS 2016c. Conduct of Engineering E7 Manual, *Technical Reviews*, Procedure 2.60, Revision 17, Savannah River Nuclear Solutions, Savannah River Site, Aiken, SC 29808, August 25, 2016.

SRNS 2015. Savannah River Site Ten Year Site Plan FY2016 – 2025, SRNS-RP-2015-00001, June 2015, Savannah River Nuclear Solutions, Aiken, SC 29808, April 2016.

Swingle 2012. R. F. Swingle, *Special Analysis: Revised Groundwater Protection and All-Pathways Limits for E-Area Low-Level Waste Facility Trenches*, SRNL-STI-2012-00466, Revision 0, Savannah River National Laboratory, Savannah River Site, Aiken, SC 29808, August 2012.

SWM 2018a. “Solid Waste Management Home Page”, SRNS Computer Network, http://sw.srs.gov/swhome.html, Savannah River Nuclear Solutions, Aiken, SC 29808, 2018.

SWM 2018b. “WMAP PA Inputs and Assumptions”, PA I&A Database.fmp12, SRNS Computer Network, \\Wg01\swi&a\PA I&A Databases, Savannah River Nuclear Solutions, Aiken, SC 29808, 2018.

SWM 2016. “Unreviewed Disposal Questions”, SW-ENG-0601, Revision 9, Solid Waste Administrative Procedure Manual SW18, Savannah River Nuclear Solutions, Aiken, SC 29808, September 16, 2016.

Tempel 2018. K. L. Tempel to B. T. Butcher, Email, “Re: Proposed operational constraints for UDQE – New proposed operational constraint”, Savannah River Nuclear Solutions, Aiken, SC 29808,12/4/2018.

WSRC 2008. *E-Area Low-Level Waste Facility DOE 435.1 Performance Assessment*, WSRC-STI-2007-00306, Revision 0, Washington Savannah River Company LLC, Savannah River Site, Aiken, SC 29808, July 2008.

Appendix A. UDQ Screening

This appendix contains the UDQ screening sent to the SRNL for evaluation, along with a presentation made by SRNL to SWM addressing our proposed approach to handle this UDQ and interim measures to operate under until a UQDE was issued. Subsequently, due to the complexity of the analysis and the need to transition from IM's to additional permanent operational constraints on the facility, the SWM Design Authority Engineer recommended to the PARC that an SA be performed, which is consistent with the SWM UDQ procedure, SW-ENG-0601 (SWM 2016).

SOLID WASTE OPERATING AND MAINTENANCE PROCEDURES		
UNREVIEWED DISPOSAL QUESTION SCREENING CRITERIA FORM	Manual:	SW15
	Procedure:	SW15-FRM-UDQS-01
	Revision:	0
	Effective Date:	9/16/2016
	Type-Class:	Form
	Page:	1 of 2

Proposed Activity: The groundwater flow field as modeled in the 2008 E-Area PA has been recently updated based on more recent field data and automated calibration methods. Model estimations of groundwater flow directions have changed significantly in the vicinity of the east set of Slit Trenches. See attached presentation for more description, potential impacts and proposed UDQE approach.

Review the following questions against the Proposed Activity:

1. Does the proposed disposal activity or new information involve a change to the disposal facility from what has been previously described or analyzed in the most recent Performance Assessment, Composite Analysis, approved Special Analyses, or approved UDQ Evaluations?

   Yes ☒ No ☐ N/A ☐

2. Does the proposed disposal activity or new information involve a change to the disposal process or procedures from what has been previously described or analyzed in the most recent Performance Assessment, Composite Analysis, approved Special Analyses, or approved UDQ Evaluations?

   Yes ☐ No ☒ N/A ☐

3. Does the proposed disposal activity or new information involve a change to the radionuclide disposal limits from what has been previously described or analyzed in the most recent Performance Assessment, Composite Analysis, approved Special Analyses, or approved UDQ Evaluations?

   Yes ☐ No ☒ N/A ☐

4. Does the proposed disposal activity or new information involve a change to the Waste Acceptance Criteria from what has been previously described or analyzed in the most recent Performance Assessment, Composite Analysis, approved Special Analyses, or approved UDQ Evaluations?

   Yes ☐ No ☒ N/A ☐

5. Does the proposed disposal activity or new information involve a change to what has been previously described or analyzed in the Performance Assessment/Composite Analysis Inputs and Assumptions (I&A) Database?

   Yes ☐ No ☒ N/A ☐

Unreviewed Disposal Question Screening Criteria Form	Manual:	SW15
	Procedure:	SW15-FRM-UDQS-01
	Revision:	0
	Page:	2 of 2

6. Does the proposed disposal activity or new information involve a change to the facility closure design or criteria from what has been previously described or analyzed in the most recent Performance Assessment, Composite Analysis, approved Special Analyses, approved UDQ Evaluations or associated Closure Plan?

   Yes ☐ No ☒ N/A ☐

7. Does the proposed disposal activity or new information involve a test or experiment not described or analyzed in the most recent Performance Assessment, Composite Analysis, approved Special Analyses, approved UDQ Evaluations or associated Closure Plan?

   Yes ☐ No ☒ N/A ☐

8. Does the proposed disposal activity or new information involve any analytical errors, omissions or deficiencies in the most recent Performance Assessment, Composite Analysis, approved Special Analyses, approved UDQ Evaluations or associated Closure Plan?

   Yes ☐ No ☒ N/A ☐

If all questions above are answered "No" or "N/A" (defined by a ✱ in the box provided), then implement Proposed Activity in Performance Assessment space. If any of the questions above answered "Yes" (defined by a ✱ in the box provided), then forward to SRNL for development of an UDQ Evaluation or Special Analysis.

Provide Explanation / Justification for all "Yes" answers:

In response to new information on the groundwater flow field beneath E-Area, perform a UDQ Evaluation to determine if current radionuclide disposal limits are still protective of performance objectives and whether operational changes or constraints are needed prior to the next PA revision. Interim measures are proposed during UDQE preparation to protect operations. See attached.

Is a UDQ Evaluation or Special Analysis required? Yes ☒ No ☐

Originator:

K. L. Tempel [signature] — Print/Sign — 4-26-18 (Date)

Reviewer:

S. J. Mentrup [signature] — Print/Sign — 4-26-18 (Date)

A slide presentation was made by SRNL to the PARC at a meeting where SWM approved the UDQ screening. This supporting slide presentation is provided below.

Savannah River National Laboratory™
OPERATED BY SAVANNAH RIVER NUCLEAR SOLUTIONS

We put science to work.™

New PA Information – Change in E-Area Groundwater Flow Field

UDQ Screening & Proposal for Interim Measures

Tom Butcher and Greg Flach
SRNL Environmental Modeling Group

Solid Waste PA Review Committee
7/18/2018

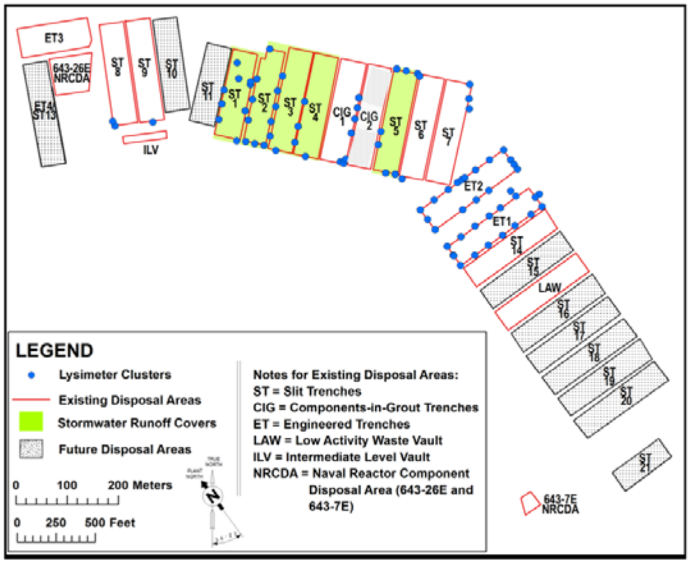
Savannah River NUCLEAR SOLUTIONS™
FLUOR • NEWPORT NEWS NUCLEAR • HONEYWELL

Acronyms

- AP – All-Pathways
- BG – Beta-Gamma
- ET – Engineered Trench
- GW – Groundwater
- LAWV – Low Activity Waste Vault
- LLRWDF – Low-Level Radioactive Waste Disposal Facility
- MWMF – Mixed Waste Management Facility
- OBG – Old Burial Ground
- PO – Performance Objective
- POA – Point of Assessment
- SOF – Sum-of-Fractions
- ST – Slit Trench
- UDQE – Unreviewed Disposal Question Evaluation

2

E-Area Disposal Unit Layout



3

Groundwater Flow Direction Change

- Change in flow direction observed in field monitoring data and model simulations
- Significant beneath southeast end of E-Area
- Primary cause is placement of OBG, MWMF and LLRWDF low-infiltration caps. Future E-Area final cover may exacerbate issue.
- Creates co-mingling / overlapping GW plumes
- Challenges ability to meet 100-meter performance objectives
- GSA_2016.LW model updated with new 2018 version. Shallower horizontal flow a potential issue.

4

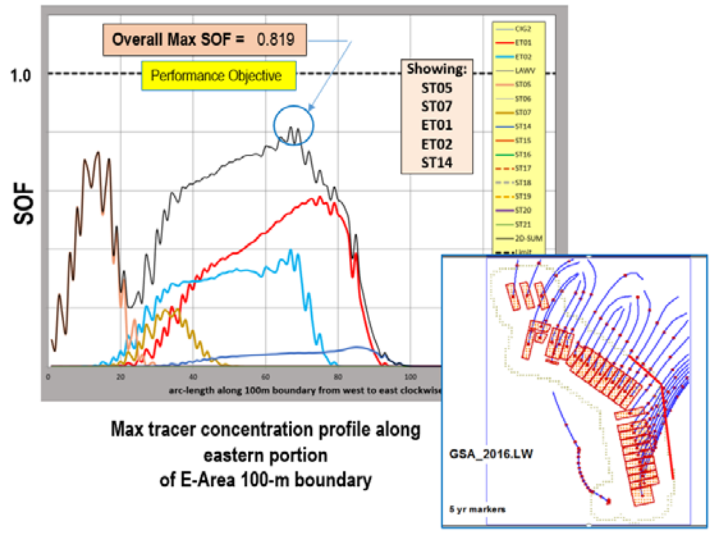
Impact of new GW Flow Field on Five Existing Trenches at Current Inventories*

Results

- **Impact of current inventories in operational trenches ~82% of the PO**
- **Small margin (~18%) available for more inventory**
- **ST05, ST06 & ST07 do not contribute to overall peak**

Key Assumptions

- Closed trenches (ET01, ST05) at their closure inventories
- Minimal non-crushable container areas in ET02 & ST14 (<1%) can be ignored
- LAWV plumes do not interact due to delayed release



Max tracer concentration profile along eastern portion of E-Area 100-m boundary

* New 2018 version of GSA flow model will be used in proposed UDQE

5

SWE/SRNL Proposed Interim Measures for ET02 and ST14

Performance Measure	ET02	ST14	Comments
Current SOF Admin Limit	95%	95%	
Limiting Pathway Groups	76.8 vol%	65.6 vol%	
1st – BG2	68%	52%	
2nd – AP2	59%	44%	
Non-Crushable Containers	0.03%	0.6%	Actuals – Limit of 10% non-crushable containers
Proposed Interim Measures			
New SOF Admin Limit (reduces available margin from 18% to 12%)	95% → 75%	95% → 65%	ET02 – Retrievable placement of future receipts Reduction applies only to BG & AP groups Other pathway groups inconsequential
New Non-Crush Container Limit	10% → 2%	10% → 0.6%	ET02 - Retrievable placement of future receipts ST14 – No additional non-crush waste receipts
Do not open any new trenches in east ST group			Applies to ST15 – ST21

6

Proposed UDQE Approach

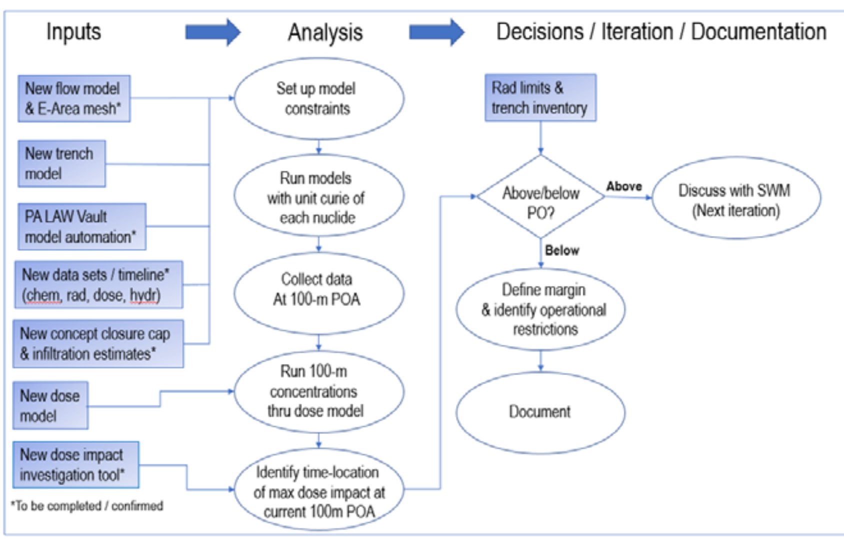
OBJECTIVE: Remove unquantified conservatism in accounting for plume overlap in limit-setting for the 2008 PA by taking into account sequencing of trench operations

STRATEGY : Determine if current radionuclide disposal limits are still protective of performance objectives and whether operational changes or constraints are needed prior to the next PA revision.

- Evaluate only groundwater performance objectives because non-GW pathways (air, radon, intruder) are not impacted
- To degree possible, preserve radionuclide disposal capacity for trench units north of LAWV (i.e., ST15, ST14, ET01, ET02) as defined by 2008 PA disposal limits
- Assign remaining margin for radionuclide disposals assigned to ST units south of the LAWV (i.e., ST16-ST21)
- Explicitly model LAWV and non-crushable containers in ET02 and ST14
- Check Center ST units adjacent to ET02 (ST05-ST07) for potential impacts
- UDQE work flow next slide

7

Proposed UDQE Workflow



8

Recommended Path Forward

- PA Review Committee approval of UDQ screening and interim measures
- Schedule
  - Finalize models, data and applications – 7 weeks
  - Set up model constraints and perform modeling – 8 weeks
  - Prepare draft UDQE report for review – 4 weeks
  - Assuming July 25th start – draft report for review 12/12/18
  - Reviews and approvals – 4 weeks
- If further analysis is needed, discuss with SWM
  - Each additional modeling case will add a month
- Cost
  - 825 hours – initial modeling case ($254K)
  - 120 hours for each additional case, if needed ($37K)

9

Appendix B. Disposal Unit Timeline Details

Below the assumptions and techniques employed to create DU timelines based on projected SWM operations is provided. This technique is employed to create the Case 1 set of DU timelines considered within the SA. Details in creating these timelines is also provided in Table B-1.

B.1 Background

A preliminary trench unit sequencing strategy was proposed to SWM with the final scheme incorporating SWM's current thinking and trench usage plans (Butcher 2018b). This trench sequencing scheme was then employed in the PORFLOW modeling timeline to determine whether current trench limits in the Waste Information Tracking System (WITS) for DU's located in the lower half of E-Area were still acceptable. This scheme represents a single disposal strategy scenario where trench sequencing is fixed – variability in timing (trench opening and closure) is obtained by incorporating uncertainty in annual average volumes. The DU's evaluated included the previously mentioned set of DU's plus ST05, ST06, and ST07 to ensure the entire affected area had been captured. Modeling employed the most up-to-date information available including; new trench model configuration, 2016 closure cap design and resulting infiltration estimates; updated hydraulic parameters, Kd's and radionuclide & dose parameters; and new E-Area flow model cutout of the GSA_2018 aquifer model, etc. For the operating and future units, estimates of projected closure inventories were employed to establish final dose impacts.

B.2 Case 1 – DU Timelines using Upper Bound Annual Average Volumes

Table B-1 contains four internal tables and two lists that are described below. The Case 1 trench sequencing scheme is laid out in the following spreadsheet. The product of this spreadsheet calculation is the timeline of DU lifecycle events shown in Table 4. The events of interest for each DU are dates for the first and last waste package, operational closure and interim closure. Final closure is assumed to occur 100 years following the last stage of interim closure. Table 1 lays out the calculation process for obtaining dates of all the projected lifecycle events for each operational and future DU. Tables 2 and 3 provide critical inputs to the calculation and Lists 1 and 2 identify the key assumptions in building the timing scheme.

Table 1

The Table 1 calculation provides the dates found in Table 4. The following discussion of the calculation logic is based on the ST example. The calculation scheme uses the remaining unfilled volume of each ST, the annual average ST volume and fraction of ST waste going to each unit to obtain the remaining years of operation for each trench. Employing the ST sequencing strategy in Table 3 and remaining years of operation, Table 1 calculates dates for the first waste package (future trenches only), last waste package, operational closure and interim closure. Operational closure with a low permeability cover is assumed to occur four years after the last waste package is placed. Interim closure is assumed to occur in two stages. Stage 1 occurs in 2040 – all ST's and ET's that are completely filled by 9/30/2040 receive a low permeability cover. Stage 2 occurs at the end of E-Area operations in 2065 for all trenches that are filled after 2040. The table uses absolute dates for the calculation which are then translated into calendar dates. The timeline was originally prepared to support the PA so includes all E-Area LLWF operating and future units. Only timeline information for those units in the area affected by the new flow model were used in the SA.

Table 2

The timing of when open and future DU's open and close relies on the estimated usage rate for each DU type (i.e., rates for ST's, ET's, and LAWV). These rates were derived from annual average volumes provided by Sink in his 2016 and 2017 Solid Waste Management Facility (SWMF) Low-Level Waste (LLW) Plan and Disposal Strategies (Sink 2016 and 2017). Sink's annual average volumes came from either a four-year average of DU waste receipts or generator supplied forecasts found in the Solid Waste Integrated Forecast Tool (SWIFT) database. Using this information, a range of rates was derived for each DU type representing the following cases: Upper Bound (UB), Most Probable and Defensible (MPAD), Best Estimate (BE) and Lower Bound (LB). UB estimates are considered more conservative than the others and therefore selected for Case 1. Higher rates result in trenches being filled more rapidly leading to plume overlap occurring in a shorter period of time.

Table 3

Future SWM trench operating strategy is uncertain. Typically, SWM operates in two (or more) ST's at any point in time. This allows for easier management of the sum-of-fractions (SOF's) for any particular trench unit and provides more flexibility in handling incoming waste receipts based on waste package inventory and non-crushable containers. The trench sequencing logic and estimated fraction of waste going to each ST unit through the end of E-Area operations for Case 1 was reviewed with SWM and adjusted to ensure it reflected current operational thinking and plans (Butcher 2018b).

List 1 and List 2

Sink's LLW Plan and Disposal Strategies (2016 and 2017) provide the basis for current ST and ET trench sequencing strategies. List 1 summarizes the key points from these two reports. Additional assumptions were needed for a complete list to support the calculation of key lifecycle dates for Case 1. The full list of assumptions used in constructing the calculation table (Table 1) is shown in List 2.

Table 4

Actual and Projected DU lifecycle event calendar dates are provided in Table 4 for Case 1. Employing the UB rates in Table 2 shows that ST's south of the LAWV will not be needed until the year 2037. One future trench unit, ST21, will not be needed before E-Area operations are projected to end in 2065 and so eliminated from further consideration. The year 2065 represents the estimated end of the environmental management mission at Savannah River Site (SRS) forecasted in the SRS Ten Year Site Plan (SRNS 2015).

Table B-1. Case 1 timelines for every DU of interest.

Case 1 - Disposal Unit Timelines using Upper Bound Annual Average Volumes

Table 4. Actual and Projected DU Lifecycle Calendar Dates

Disposal Unit	First Waste Package	Last Waste Package	Operational Runoff Cover	Interim Closure	Unused
ST01	12/21/1995	9/19/2003	12/21/2010	9/30/2040	
ST02	9/20/2001	8/31/2006	12/21/2010	9/30/2040	
ST03	10/20/2003	1/6/2010	12/21/2010	9/30/2040	
ST04	2/26/2004	8/19/2010	12/21/2010	9/30/2040	
ST05	5/27/2004	10/16/2006	12/21/2010	9/30/2040	
ST06	4/29/2006	11/8/2029	4/7/2036	9/30/2040	
ST07	6/26/2006	4/7/2032	4/7/2036	9/30/2040	
ST08*	2/6/2007	10/27/2037	1/25/2042	9/30/2040	
ST09*	3/17/2011	10/27/2037	1/25/2042	9/30/2040	
ST10*	7/1/2020	10/27/2037	1/25/2042	9/30/2040	
ST11	11/18/2028	1/25/2038	1/25/2042	9/30/2040	
ST14	3/29/2011	3/16/2021	3/16/2025	9/30/2040	
ST15 (ET06)	3/29/2060	9/4/2066	NA	9/30/2065	
ST16	6/23/2037	7/12/2043	7/12/2047	9/30/2065	
ST17	7/12/2043	7/31/2049	7/31/2053	9/30/2065	
ST18	7/31/2049	8/20/2055	8/20/2059	9/30/2065	
ST19	8/20/2055	9/8/2061	NA	9/30/2065	
ST20	9/8/2061	9/28/2067	NA	9/30/2065	
ST21	9/28/2067	9/28/2067	NA	NA	x
CIG01 (ST)	8/29/2000	6/23/2037	NA	9/30/2040	
CIG02 (ET05)	1/24/2028	3/29/2060	NA	9/30/2065	
ET01	2/13/2001	3/30/2017	NA	9/30/2040	
ET02	6/3/2004	1/24/2028	NA	9/30/2040	
ET03	9/19/2013	8/6/2020	NA	9/30/2040	
ET04	8/6/2020	1/24/2028	NA	9/30/2040	
LAWV	9/28/1994	10/15/2056	NA	9/30/2065	
ILV	9/28/1994	3/28/2033	NA	9/30/2040	
NR00	1/1/1987	5/21/2004	NA	9/30/2040	
NR01	2/6/1997	4/22/2069	NA	9/30/2065	
Plot 8	1/24/2028	12/24/2040	NA	9/30/2040	

*ST08-ST10 assumed to remain open until 2037 to receive tall boxes

Red - Estimated timing of future events

Interim Clos:	2040	2065	NA

List 1. ST order of use per Sink 2016 & 2017**

1 ST08, ST09 & ST14 in parallel
2 ST10 after ST09 filled
3 ST11 after ST10 filled
4 ST06 & ST07 after ET02 filled
5 ST15 after ST06, ST07 & ST14 filled unless CIG trench footprints converted to future ST space
6 ST16-21 after all ST space filled north of the LAWV

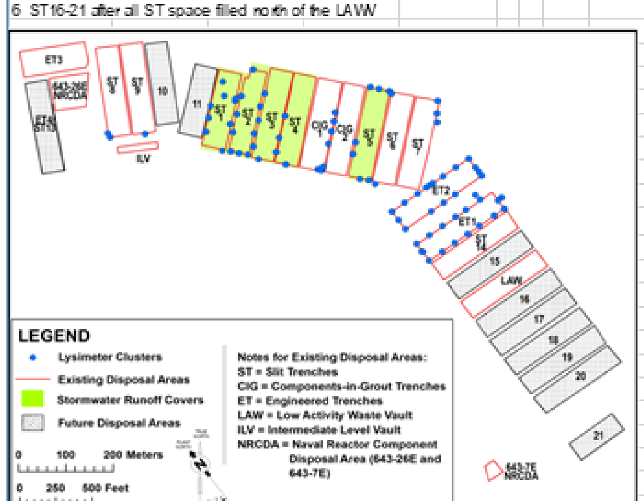


Table 1. Calculation of Projected Lifecycle DU Events

	Trench Unit	ST06	ST07	ST08	ST09	ST10	ST11	ST14	ST15 (ET06)
	Capacity* m3	23000	15900	16275	21000	16464	12842	19500	35500
	Status* m3	20848	10555	15461	18532	0	0	12927	0
	% Filled*	90.6%	66.4%	95.0%	88.2%	0.0%	0.0%	66.3%	0.0%
	Remaining vol m3	2152	5345	814	2468	16464	12842	6573	35500
UB	Avg annual Trench vol** m3	3304	3304	3304	3304	3304	3304	3304	5516
	Fraction going to Trench**	0.67	0.67	1.00	0.33	0.59	0.67	0.67	1.00
	Remaining years of operation	1.0	2.4	0.2	2.3	8.4	5.8	3.0	6.4
	Calendar date of first waste pkg*	4/29/2006	6/26/2006	2/6/2007	3/17/2011	7/1/2020	11/18/2028	3/29/2011	3/29/2060
	Absolute date of first waste pkg	2006.33	2006.48	2007.10	2011.21	2020.50	2028.88	2011.24	2060.24
	Absolute date of last waste pkg	2029.85	2032.27	2037.82	2020.50	2028.88	2038.07	2021.21	2066.68
	Calendar date of last waste pkg	11/8/2029	4/7/2032	10/27/2037	7/1/2020	11/18/2028	1/25/2038	3/16/2021	9/4/2066
	Absolute date operational cover installed	2036.27	2036.27	2042.07	2042.07	2042.07	2042.07	2025.21	NA
	Calendar date operational cover installed	4/7/2036	4/7/2036	1/25/2042	1/25/2042	1/25/2042	1/25/2042	3/16/2025	NA
	Trench Unit	ST06	ST07	ST08	ST09	ST10	ST11	ST14	ST15 (ET06)

	Trench Unit	ST16	CIG01 (ST)	CIG02 (ET05)	ET02	ET03	ET04	LAWV	ILV	NR01	Plot 8***
	Capacity* m3	20000	18166	35500	35500	27000	34560	30600	4284	6000	57000
	Status* m3	0	1834	0	27326	15019	0	9550	2469	791	0
	% Filled*	0.0%	10.1%	0.0%	77.0%	55.6%	0.0%	31.2%	57.6%	13.2%	0.0%
	Remaining vol m3	20000	16332	35500	8174	11981	34560	21050	1815	5209	57000
UB	Avg annual Trench vol** m3	3304	3304	5516	5516	5516	5516	546	121	102	5516
	Fraction going to Trench**	1.00	0.33	0.20	0.08	0.92	1	1	1	1	0.8
	Remaining years of operation	6.1	15.0	32.2	18.5	2.4	7.5	38.6	15.0	51.1	12.9
	Calendar date of first waste pkg*	6/23/2037	8/29/2000	1/24/2028	6/3/2004	9/19/2013	8/6/2020	9/28/1994	9/28/1994	2/6/1997	1/24/2028
	Absolute date of first waste pkg	2037.48	2000.66	2028.07	2004.42	2013.72	2020.60	1994.74	1994.74	1997.10	2028.07
	Absolute date of last waste pkg	2043.53	2037.48	2060.24	2028.07	2020.60	2028.07	2056.79	2033.24	2069.31	2040.98
	Calendar date of last waste pkg	7/12/2043	6/23/2037	3/29/2060	1/24/2028	8/6/2020	1/24/2028	10/15/2056	3/28/2033	4/22/2069	12/24/2040
	Absolute date operational cover installed	2047.53	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Calendar date operational cover installed	7/12/2047	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Trench Unit	ST16	CIG01 (ST)	CIG02 (ET05)	ET02	ET03	ET04	LAWV	ILV	NR01	Plot 8***

* Per Stewart 2018, "SWM Engineering LLW Review of EAV Limits - March 2018" (SRNS-N4222-2018-0004) - Volume status as of 3/28/2018

** Based on either 1) Sink 2017 (draft), "FY 17 SWMF LLW Plan and Disposal Strategies" (SRNS-RP-2017-00086) or 2) Sink 2016, "FY 16 SWMF LLW Plan and Disposal Strategies" (SRNS-RP-2016-00162)

*** Plot 8 will contain 3 open trench units each with a capacity of 19,000 m3. Plot 8 trenches will be treated as ET's and will not receive CERCLA waste - no operational runoff cover. Will operate in parallel with ET's in first 100 acres for very low activ

\# Savannah River Site Ten Year Site Plan FY2016-2025, SRNS-RP-2015-00001, June 2015

List 2. Assumptions (based on interpretation of Sink LLW Plan and discussions with SWE)

1 No waste in ST10 until ST09 is filled
2 No new waste in ST06 until BOTH ET02 filled and ST10 filled (ET02 obstructs access to ST06-07)
3 Assume ET02 closed on same day as ET04 (ET04 noncrush allowed by next PA; ET02 not needed)
4 No new waste in ST07 until ST06 filled
5 No waste in ST11 until ST07 is filled
6 CIG01 is converted to a ST and CIG02 to ET05. ET05 has same volume capacity as ET02.
7 No ST waste in CIG01 until next PA revision is approved in 2022.
8 ST15 is converted to ET06. ET06 has same volume capacity as ET02.
9 No ST waste south of the LAWV (i.e., ST16-ST21) until CIG01 is filled. Assume CIG01 ST limits will be low due to presence of existing CIG components.
10 No waste in ET04 until ET03 is filled
11 No waste in ET05 (CIG02) until ET04 is filled.
12 No waste in ET06 (ST15) until ET05 is filled and LAWV openings sealed up.
13 ET04 volume is 28% larger than ET03 volume per 2017 ET3-ET4 UDQE
14 Stormwater runoff covers installed four years following date of last waste package
15 ST06 & ST07 to be oper closed with common cover
16 ST08-ST11 group will not receive operational stormwater runoff cover because last waste pkg is so close to interim closure in 2040.
17 Final tall box disposals in ST08-ST10 assumed to occur in year ST11 filled.
18 ST14 to be oper closed with stormwater runoff cover by itself
19 Slit Trenches south of the LAWV (ST16-ST21) not needed before 2065 are not to be included in this modeling case. In this case (Case 1) ST21 is the only trench not needed before 2065.
20 Most recent estimate by K. Tempel is that ~33% of ST waste is going to ST09 and ~67% to ST14.
21 Plot #8 trenches not needed until ET06 (ST15) filled
22 Plot #8 trenches will be designed and utilized as ETs (sloped walls, drive-in trench, stacked containers) per K Tempel 8-13-18 email.
23 No operational stormwater runoff covers over Plot #8 trenches (will not receive CERCLA waste per J. Simmons 5-17-18 email.
24 Interim closure for STs/ETs is 9/30/2040 for all STs/ETs completely filled prior to 9/30/2040.
25 Interim closure for STs/ETs open beyond 9/30/2040 is 9/30/2065
26 Final closure (installation of multi-layer cap) occurs 100 years later on 9/30/2165.
27 EM operations and associated solid LLW receipts cease 9/30/2065 per site's long range planning#
28 A second IL Vault will be needed in 2033 but will not be included in the next PA revision update
29 General closure strategy as described in the table below

DU's	Operational Closure	Interim Closure	Final Closure
ET's	Minimum four-foot clean soil backfill and grading for drainage	Filling and grading for drainage, area-wide interim runoff cover	Waste stabilization (ST's and ET's only), final contour filling and grading, multi-layer closure cap and integrated drainage system
ST's, CIG's	Minimum four-foot clean soil backfill and grading for drainage; reinforced concrete slab as needed for structural stability (CIG only), runoff cover over each trench segment , trench unit or group of units		
ILV, LAWV	Sealing vault openings and sumps (LAWV); grouting head space in each cell, reinforced concrete roof slab and waterproof membrane (ILV)	No additional actions	
NRCDA's	No actions except filling around casks as needed for radiation shielding		

Table 2. Annual Average Volume (m3)**

DU	FY17 Plan	FY16 Plan	FY17 Plan	FY16 Plan	% Diff Green/Blue	UB Case	MPAD Case	BE Case	LB Case
ET	5516	5253	5038	5084	96%	5516	5253	5169	5038
ST	1314	3304	927	810	62%	3304	1314	1121	810
LAWV	546	530	96	125	18%	546	530	328	96
ILV	121	110	20	62	18%	121	110	86	20
NRCDA	83	102	75	25	30%	102	83	79	25

Used highest rate between SWIFT forecast & four-year actuals.
Blue - Represents lowest rate between the FY 16 and FY 17 Plan.

Used lowest rate between SWIFT forecast & four-year actuals.
Green - Represents lowest rate between the FY 16 and FY17 Plan.

UB-Upper Bound, LB-Lower Bound
MPAD-Most Probable & Defensible
BE-Best Estimate (Median)

Table 3. Estimated fraction of ST waste going to each trench based on dates open

Year	ST06	ST07	ST08	ST09	ST10	ST11	ST14	CIG01	ST16-20	TOTAL
2020				0.33	0.33		0.67			1.00
2021					0.33		0.67			1.00
2022					0.67			0.33		1.00
2023					0.67			0.33		1.00
2024					0.67			0.33		1.00
2025					0.67			0.33		1.00
2026					0.67			0.33		1.00
2027					0.67			0.33		1.00
2028	0.67				0.67			0.33		1.00
2029	0.67	0.67						0.33		1.00
2030		0.67						0.33		1.00
2031		0.67						0.33		1.00
2032		0.67				0.67		0.33		1.00
2033						0.67		0.33		1.00
2034						0.67		0.33		1.00
2035						0.67		0.33		1.00
2036						0.67		0.33		1.00
2037			(1)	(1)	(1)	0.67		0.33	0.67	1.00
2038-2065									1.00	1.00
Fraction	0.67	0.67	1.00	0.33	0.59	0.67	0.67	0.33		

Highlighted cells indicate one trench opened after the prior trench was filled with no overlap

Order: ST09 & ST14 > ST10 & CIG01 > ST06 & CIG01 > ST07 & CIG01 > ST11 & CIG01 > ST16 > ST17 > ST18 > ST19 > ST20

(1) Final tall box disposals in ST08-ST10 assumed to occur in year ST11 filled.

Timing of Operational Cover		Status Date* Calendar	Status Date* Absolute	Formula Check
4	Years following last waste package	3/28/2018	2018.238	3/28/2018

Appendix C. Inventory Status, Projections and Limit Details

To perform the deterministic and stochastic analyses in this SA existing inventory and current WITS inventory limits were obtained from SWM. The information provided by SWM and confirmed by SRNL is given in this appendix. This information was processed to reduce the number of parent nuclides required in the analyses and to establish historical-based parent nuclide distribution functions. For GWP purposes 38 parent nuclides were considered in the PA2008 analyses for all ST's and ET's (i.e., 35 for the LAWV). As shown in this appendix these GWP parent nuclides can be represented by the top 9 SOF contributors, based on a rank ordering process. The GWP and short list of parent nuclides considered in this report are listed in **Table C-2**. The short list of parent nuclides is shaded in cyan.

Table C-2. Comparison of GWP and short-list of parent nuclides on a DU basis.

Num	STs & Ets	LAWV	Num	STs & Ets	LAWV
1	Am-241	Am-241	20	Pu-238	Pu-238
2	Am-243	Am-243	21	Pu-239	Pu-239
3	C-14	C-14	22	Pu-240	Pu-240
4	Cf-249		23	Pu-241	Pu-241
5	Cf-251		24	Pu-242	Pu-242
6	Cl-36	Cl-36	25	Pu-244	Pu-244
7	Cm-244	Cm-244	26	Ra-226	Ra-226
8	Cm-245	Cm-245	27	Se-79	Se-79
9	Cm-246		28	Sn-126	Sn-126
10	Cm-247	Cm-247	29	Sr-90	Sr-90
11	Cm-248	Cm-248	30	Tc-99	Tc-99
12	H-3	H-3	31	Th-230	Th-230
13	I-129	I-129	32	Th-232	Th-232
14	K-40	K-40	33	U-233	U-233
15	Mo-93	Mo-93	34	U-234	U-234
16	Nb-94	Nb-94	35	U-235	U-235
17	Ni-59	Ni-59	36	U-236	U-236
18	Np-237	Np-237	37	U-238	U-238
19	Pd-107	Pd-107	38	Zr-93	Zr-93

Num	SA
1	Am-241
2	C-14
3	H-3
4	I-129
5	Ni-59
6	Np-237
7	Sr-90
8	Tc-99
9	U-235

The details associated with these various activities are also included in this appendix.

C.1 Existing Inventory Values

SWM records buried waste parent nuclide inventories over time in the WITS system. These records have been tracked since the start of the E-Area facility in the late 1994 timeframe. To perform the stochastic analyses, existing inventories are required in order to generate parent nuclide historically-based distributions. Based on the timing of these analyses efforts the following definitions were established:

- Existing waste – all waste buried in E-Area prior to September 2018.
- Future waste – all waste buried in E-Area after September 2018.

Of the 13 DU's being considered in this SA 7 have existing waste currently within them (i.e., LAWV, ET1, ET2, ST05, ST06, ST07, and ST14), the remaining 6 are future units (i.e., ST15, ST16, ST17, ST18, ST19, and ST20). To improve the statistics associated with creating probabilistic distribution functions (pdf) for each parent nuclide of interest and in each DU of concern, all of the existing inventory data available was employed. This included existing waste in 5 additional DU's (i.e., ET3, ST01, ST02, ST03, and ST04).

SWM provided SRNL all E-Area existing inventories as of September 2018. On a DU basis these inventory values on a Ci basis are listed in Table C-3. where only the 38 GWP nuclides are shown (i.e., only 35 GWP nuclides exist for the LAWV). Note that not every DU has the same list of potential parent nuclides. The list provided in Table C-3. encompasses the entire set of all parent nuclides within all of these DU's (i.e., blank cells exist where no nuclide inventory is provided). Special waste forms were not included in this analysis.

Table C-3. Existing inventories for all DU's in E-Area as of September 2018.

WITS Nuclide	LAWV Inventory (Ci)	ET1 Inventory (Ci)	ET2 Inventory (Ci)	ET3 Inventory (Ci)	ST01 Inventory (Ci)	ST02 Inventory (Ci)	ST03 Inventory (Ci)	ST04 Inventory (Ci)	ST05 Inventory (Ci)	ST06 Inventory (Ci)	ST07 Inventory (Ci)	ST08 Inventory (Ci)	ST09 Inventory (Ci)	ST14 Inventory (Ci)
AM241	4.156E-01	6.559E-1	1.487E+0	2.784E-01	3.787E-2	1.594E-1	4.039E-1	2.975E-1	6.5670E-1	6.687E-01	5.884E-01	4.818E-01	9.845E-01	3.517E-01
AM243	1.945E-03		2.867E-2		6.127E-5	1.687E-3	2.391E-3	1.581E-3	1.1642E-2	1.505E-01	1.749E-03	4.249E-02	3.680E-04	3.169E-03
C14	1.853E-01	1.309E-1	3.824E-2	7.310E-03	8.943E-3	4.574E-2	5.817E-3	3.714E-2	3.6280E-2	7.872E-03	2.304E-02	1.772E-02	7.555E-03	2.525E-02
CF249		8.120E-6	4.316E-2	2.927E-06	6.659E-6	6.232E-4	3.319E-4	1.259E-4	1.1559E-2	8.387E-02	2.874E-04	8.421E-02	2.553E-04	7.337E-11
CF251		5.739E-5	3.927E-2	3.583E-06	6.593E-5	6.683E-4	3.780E-4	1.666E-4	1.0990E-2	7.624E-02	2.379E-04	7.663E-02	7.745E-05	5.405E-08
CL36	1.840E-03	7.002E-5	1.195E-8			1.055E-5	2.100E-6		2.2640E-6	1.649E-12			2.020E-06	3.387E-07
CM244	1.959E+00	5.317E-1	3.221E+0	4.984E-01	3.842E-2	1.107E-1	3.265E-1	5.418E-1	1.4210E+0	3.177E+00	1.491E-01	3.007E+00	3.385E-01	1.596E+00
CM245	2.318E-03	2.927E-4	9.352E-4	4.412E-06	2.740E-7	2.915E-6	1.930E-4	2.399E-4	4.8717E-4	1.185E-03	1.169E-04	1.457E-03	2.426E-05	2.492E-06
CM246		4.649E-4	4.615E-4	4.777E-06	1.525E-6	2.190E-5	9.135E-5	2.234E-4	7.3303E-4	4.658E-04	1.408E-04	1.940E-05	3.256E-05	2.480E-06
CM247	8.291E-12	6.811E-11	4.250E-4	1.807E-06	1.432E-6	2.475E-9	4.971E-5	5.948E-4	1.7801E-4	1.190E-03	2.586E-04	3.184E-03	4.756E-06	1.024E-15
CM248	2.550E-12	9.437E-15	3.756E-7	3.960E-08	1.432E-6	2.579E-5	6.090E-5	1.943E-7	3.5328E-4	4.094E-04	3.262E-05	2.347E-05	1.040E-05	3.243E-15
H3	4.097E+05	2.206E+0	4.501E-1	2.190E-01	8.475E-1	1.066E+0	8.516E-1	8.548E+0	4.0233E-1	1.966E-01	4.317E-01	2.707E-01	2.102E-01	1.082E-01
I129	1.731E-04	7.199E-5	4.838E-5	3.283E-05	1.985E-5	1.969E-5	4.522E-5	3.535E-5	5.7207E-5	7.246E-05	3.046E-05	9.030E-05	2.177E-05	1.405E-05
K40	5.647E-07	1.373E-4	4.331E-5	8.504E-05	4.122E-3	3.214E-6	5.308E-6	6.553E-6	2.8856E-4	4.287E-08			1.393E-05	3.667E-06
MO93	3.129E-03	2.078E-3	1.202E-3	6.105E-09	1.145E-5	3.400E-7				1.020E-03			7.542E-03	1.520E-06
NB94	1.105E-01	3.225E-3	1.317E-3	4.135E-05	1.075E-3		6.641E-4	9.764E-4	8.6978E-4	2.070E-06	2.746E-04	3.233E-05	1.668E-04	7.217E-04
NI59	1.548E+00	1.172E-1	6.043E-2	1.043E-03	2.249E-2	3.647E-2	1.414E-2	1.926E-2	1.1257E-2	2.063E-02	1.069E-01	4.600E-02	1.586E-02	2.463E-02
NP237	4.286E-02	7.691E-3	3.130E-2	6.801E-03	1.187E-3	2.070E-3	1.871E-2	7.576E-3	5.5544E-3	3.983E-03	4.731E-03	4.373E-04	6.391E-03	5.205E-03
PD107					1.105E-7	1.832E-10				1.649E-08				1.694E-08
PU238	2.992E+00	3.334E+0	8.674E+0	2.561E+00	3.307E-1	6.506E-1	3.937E+0	3.247E+0	2.5353E+1	2.168E+01	5.403E+00	2.966E+00	8.016E+00	3.420E+00
PU239	1.180E+00	1.446E+0	6.387E+0	8.890E-01	2.568E-2	1.984E-1	9.831E-1	1.011E+0	1.7035E+0	9.875E-01	2.213E+00	1.307E+00	2.555E+00	4.721E-01
PU240	3.149E-01	3.845E-1	1.437E+0	2.960E-01	7.295E-3	7.681E-2	2.737E-1	2.645E-1	4.7580E-1	2.722E-01	5.068E-01	3.430E-01	5.876E-01	1.289E-01
PU241	1.089E+01	8.954E+0	2.263E+1	3.358E+00	2.237E-1	2.243E+0	8.854E+0	6.260E+0	8.4861E+0	5.402E+00	1.360E+01	4.275E+00	1.542E+01	3.711E+00
PU242	1.624E-03	1.189E-2	2.727E-2	7.204E-04	1.110E-4	1.033E-3	7.644E-3	1.976E-2	5.0463E-3	1.364E-02	1.966E-02	1.260E-01	6.246E-03	1.416E-03
PU244		4.692E-15	6.843E-10	5.527E-17	2.355E-15	5.101E-15	3.783E-16	1.786E-15	1.4911E-15	3.508E-20	1.129E-09	7.275E-17	7.170E-17	1.535E-15
RA226	3.950E-02	4.016E-3	8.443E-5	3.844E-05	3.181E-3	6.486E-6	2.249E-5	2.816E-5	3.5757E-4	5.616E-05	1.608E-06		5.840E-05	8.346E-05
SE79	8.385E-02	9.278E-3	8.567E-5	1.818E-10	3.210E-4	6.231E-4	6.333E-3	7.780E-4	3.9702E-4	8.594E-03	8.784E-04	1.266E-05	1.168E-05	1.613E-06
SN126	2.064E-04	6.391E-5	2.269E-5	5.448E-10	1.828E-4	2.141E-6	2.032E-4	2.661E-5	3.2406E-5	1.075E-03	8.237E-06	6.857E-07	1.014E-09	1.376E-04
SR90	2.343E+02	2.523E+1	8.340E+1	1.226E+01	3.245E+0	4.704E+0	3.144E+1	1.727E+1	4.1448E+1	2.725E+01	5.869E+00	3.676E+00	1.231E+01	3.160E+01
TC99	1.211E-01	3.930E-2	5.903E-2	1.226E-02	5.320E-3	2.024E-2	3.861E-2		4.5438E-2	2.109E-02	8.327E-03	4.892E-03	2.376E-02	1.591E-02
TH230	4.537E-05	6.751E-3	3.656E-3	1.094E-04	2.870E-4		4.096E-5	2.765E-4	3.9278E-4	2.358E-04	2.549E-05	3.084E-06	1.788E-04	3.403E-07
TH232	3.249E-04	4.521E-3	3.216E-3	1.174E-04	2.341E-3	3.527E-6	5.444E-5	2.937E-4	3.6887E-5	1.084E-02	1.317E-04	1.521E-05	1.479E-04	5.387E-07
U233	2.762E-01	2.082E+0	6.215E+0	3.245E-01	6.220E-3	2.714E-2	1.089E-1	4.465E-1	2.0319E+0	4.580E-01	9.050E-02	1.747E-01	2.179E-01	4.235E-03
U234	4.840E-01	4.329E-1	4.792E-1	3.329E-01	7.690E-2	3.589E-1	1.752E+0	4.255E+0	1.8245E+0	2.611E-01	8.318E-02	1.864E-01	1.941E-01	3.106E-02
U235	1.543E-02	1.514E-2	8.445E-3	1.439E-03	6.141E-3	3.163E-2	3.697E-2	1.185E-1	3.8885E-2	2.508E-02	3.304E-03	8.604E-03	4.712E-03	1.197E-03
U236	3.803E-02	2.612E-2	1.789E-2	1.670E-05	3.267E-3	1.150E-2	3.927E-2	2.578E-2	2.5750E-2	9.093E-03	2.496E-03	4.305E-04	2.178E-03	3.187E-04
U238	7.454E-01	4.710E+0	4.172E-1	5.983E-01	1.493E-1	1.376E+0	1.453E+0	3.751E-1	3.2819E+0	6.969E-01	5.488E-02	3.807E-01	3.779E-01	7.361E-03
ZR93	5.481E-03	2.017E-5	3.096E-5	1.889E-05		2.262E-5	2.024E-6	8.001E-6	6.6293E-6	6.895E-07	1.919E-05	3.233E-07	2.613E-05	7.861E-05
Total	4.099E+05	5.035E+01	1.352E+02	2.165E+01	5.048E+00	1.112E+01	5.056E+01	4.275E+01	8.729E+01	6.149E+01	2.916E+01	1.748E+01	4.129E+01	4.151E+01

C.2 Current WITS Limits

SWM maintains the WITS system while SRNL provides SWM inventory limits for every DU either by way of the PA2008 or some subsequent SA. The current WITS limits are intended to be consistent with those generated by SRNL and to confirm this SRNL took the existing inventories from SWM and the most up to date SRNL inventory limits (i.e., PA2008 or subsequent SA) and computed SOF values as of September 2018. In certain cases, the original SRNL derived limit was updated by an imposed SWM administrative limit (e.g., for ET2 the beta-gamma window 2 limit was 13.0 Ci but the current limit was reduced by SWM to 2.0 Ci). Limits for each DU were first set to the SRNL values and then where appropriate limits were updated to reflect SWM alterations.

Once complete these most up to date SRNL inventory limits were reasonably consistent and were then used in the deterministic and stochastic analyses in support of this SA effort. Within this report we refer to these most up to date inventory limits as the "current WITS limits." The following tables (i.e., Table C-5 through Table C-12) contain these inventory limits on a DU basis.

In each table of current WITS limits the most limiting pathway for every parent nuclide is shaded in light orange. Shading has also been included in the "WITS Nuclide" column to indicate those parent nuclides under GWP:

- Shaded in cyan – the short-list of 9 parent nuclides being employed in the SA.
- Shaded in light green – the remaining parent nuclides in the GWP list.

The existing WITS inventory values as of September 2018 are also provided. ST15 through ST20

Are future ST's and contain no existing inventory; however, when projected effects associated with those DU's were being considered the average inventory within all existing ST's was employed. These average values are listed in Table C-11.

As mentioned above these current WITS limits tables reflect the values currently being employed within WITS. Perhaps the greatest changes made, and relevant to, this SA is the SRNL H-3 inventory limit updates made by SWM. A listing of these is provided in Table C-4.

Table C-4. Current H-3 WITS limits versus PA2008 values.

Disposal Unit	Pathway (-)	PA2008 (Ci)	Current WITS (Ci)
ET1	BG2	12.0	12.0
ET2	BG2	13.0	2.0
ST05	BG2	4.8	4.8
ST06	BG2	4.8	2.0
ST07	BG2	5.3	2.0
ST14	BG2	4.2	2.0
ST15-ST20	BG2	4.6	4.6[a]
LAW	BG	4.1E+08	4.1E+08

a – In this SA the WITS value was reduced to 2.0 for these future DU's to be consistent with the other similar units.

Table C-5. Current WITS inventory limits for ET1.

WITS Nuclide	Inventory (Ci)	Most Limiting (Ci)	Groundwater Protection Limits: Beta-Gamma (Ci) 0-12 yrs	12-100 yrs	100-1130 yrs	Gross Alpha (Ci) 0-1000 yrs	1000-1120 yrs	1120-1130 yrs	Radium (Ci) 0-1000 yrs	1000-1120 yrs	1120-1130 yrs	Uranium (Ci) All Years	All-Pathways Limit (Ci) 130 - 200 yrs	200-1000 yrs	1000-1130 yrs	Intruder Limits: Resident	Post-drilling	Air Pathway Limits (Ci)	Radon Pathway Limits (Ci)
AC227		4.3E+03														2.0E+07	4.3E+03		
AG108M	1.510E-7	2.4E+01														2.4E+01	2.4E+03		
AL26	4.966E-11	2.6E+00														2.6E+00	1.7E+03		
AM241	6.559E-1	3.3E+02	1.9E+11	1.0E+07	2.1E+04	1.0E+03	1.1E+03	1.1E+03	---	---	---	2.6E+12	1.4E+03	3.3E+02	3.5E+02	4.1E+05	1.4E+03		
AM242M		1.4E+03														1.1E+05	1.4E+03		
AM243		2.6E+02	---	3.9E+17	1.7E+04	3.9E+03	9.5E+02	8.6E+02	---	---	---	7.8E+13	5.1E+10	1.5E+03	3.3E+02	2.6E+02	1.2E+03		
AR39		3.7E+07														---	3.7E+07		
BA133	5.021E-6	8.5E+06														2.8E+09	8.5E+06		
BI207	7.823E-6	2.4E+04														6.6E+04	2.4E+04		
BK249		9.4E+04														9.4E+04	5.1E+05		
C14	1.309E-1	5.0E-01	8.5E-01	5.0E-01	1.2E+01	---	---	---	---	---	---	---	1.6E+01	1.6E+01	1.6E+01	---	2.1E+03	1.9E+05	
CA41		1.2E+04														---	1.2E+04		
CD113M	9.178E-14	3.1E+04														---	3.1E+04		
CF249	8.120E-6	2.4E+02	6.8E+18	2.2E+13	5.8E+05	1.5E+04	4.8E+03	4.4E+03	---	---	---	1.7E+14	3.2E+06	4.7E+03	1.4E+03	2.4E+02	1.3E+03		
CF250	1.396E-4	2.7E+05														2.5E+13	2.7E+05		
CF251	5.739E-5	5.3E+02	---	---	5.9E+09	7.8E+03	2.1E+03	1.9E+03	---	---	---	4.8E+19	7.8E+18	2.2E+03	5.3E+02	9.0E+02	1.2E+03		
CF252	6.641E-4	5.5E+07														5.0E+11	5.5E+07		
CL36	7.002E-5	1.7E-01	3.0E-01	1.7E-01	4.0E+00	---	---	---	---	---	---	---	2.7E+00	2.7E+00	2.7E+00	---	2.6E+01	---	
CM242	5.419E-5	7.3E+05														1.8E+09	7.3E+05		
CM243	2.194E-4	2.2E+04														2.7E+07	2.2E+04		
CM244	5.317E-1	1.0E+05	---	---	4.4E+19	6.6E+13	6.3E+12	5.3E+12	7.5E+19	6.1E+19	5.9E+19	---	---	2.6E+13	2.1E+12	2.9E+11	1.0E+05		
CM245	2.927E-4	1.2E+02	9.1E+14	7.1E+09	1.5E+04	8.9E+02	3.6E+02	3.4E+02	---	---	---	3.1E+12	1.3E+04	2.9E+02	1.2E+02	1.6E+03	7.9E+02		
CM246	4.649E-4	3.4E+02	---	---	4.9E+16	4.2E+03	1.0E+03	9.1E+02	2.9E+16	1.2E+16	1.1E+16	1.2E+15	---	1.5E+03	3.4E+02	6.8E+10	1.5E+03		
CM247	6.811E-11	5.2E+01	---	---	1.3E+05	3.3E+03	7.8E+02	7.0E+02	---	---	---	8.2E+14	1.2E+13	1.3E+03	2.8E+02	5.2E+01	1.3E+03		
CM248	9.437E-15	7.8E+01	---	---	1.5E+11	3.9E+03	9.4E+02	8.5E+02	---	---	---	2.3E+19	---	3.6E+02	7.8E+01	3.6E+06	4.1E+02		
CO60	1.184E+1	8.6E+08														1.3E+09	8.6E+08		
CS134	1.036E-1	5.0E+17														9.9E+18	5.0E+17		
CS135	1.325E-11	2.5E+04														---	2.5E+04		
CS137	5.324E+1	2.5E+04														1.4E+06	2.5E+04		
EU152	1.954E-1	6.7E+05														1.5E+06	6.7E+05		
EU154	1.633E-1	1.2E+07														2.7E+07	1.2E+07		
EU155	2.390E-3	2.4E+11														2.7E+18	2.4E+11		
H3	2.206E+0	1.2E+01	1.7E+01	1.2E+01	3.1E+04	---	---	---	---	---	---	---	5.6E+06	5.6E+06	5.6E+06	---	2.1E+06	2.8E+18	
H3C		1.4E+05	---	---	1.4E+05	---	---	---	---	---	---	---	3.6E+06	1.6E+09	---	---	2.1E+06	2.8E+18	
I129	7.199E-5	3.0E-04	7.6E-04	3.0E-04	8.5E-03	---	---	---	---	---	---	---	5.8E-01	5.8E-01	5.8E-01	4.8E+09	3.9E+02	---	
I129C		4.5E-01	---	---	4.5E-01	---	---	---	---	---	---	---	5.7E+01	2.9E+01	2.7E+01	4.8E+09	3.9E+02	---	
I129I	7.437E-7	6.1E-01	5.2E+00	1.6E+00	6.1E-01	---	---	---	---	---	---	---	7.7E+01	3.9E+01	3.7E+01	4.8E+09	3.9E+02	---	
I129B		8.0E+00	6.9E+01	2.1E+01	8.0E+00	---	---	---	---	---	---	---	1.0E+03	5.2E+02	4.8E+02	4.8E+09	3.9E+02	---	
I129G	1.560E-6	8.1E-03	2.6E-02	8.1E-03	8.2E-03	---	---	---	---	---	---	---	5.0E-01	6.9E-01	1.1E+00	4.8E+09	3.9E+02	---	
I129D	1.327E-3	4.1E-01	3.5E+00	1.1E+00	4.1E-01	---	---	---	---	---	---	---	5.3E+01	2.7E+01	2.5E+01	4.8E+09	3.9E+02	---	
I129J	3.601E-5	9.0E-03	3.0E-02	9.1E-03	9.0E-03	---	---	---	---	---	---	---	5.4E-01	7.0E-01	1.1E+00	4.8E+09	3.9E+02	---	
I129A	0.000E+0	3.5E+00	3.0E+01	9.1E+00	3.5E+00	---	---	---	---	---	---	---	4.5E+02	2.3E+02	2.1E+02	4.8E+09	3.9E+02	---	
I129H	9.566E-6	3.3E-02	2.0E-01	6.0E-02	3.3E-02	---	---	---	---	---	---	---	3.0E+00	2.3E+00	2.0E+00	4.8E+09	3.9E+02	---	
I129E	9.039E-4	9.4E-01	8.1E+00	2.4E+00	9.4E-01	---	---	---	---	---	---	---	1.2E+02	6.1E+01	5.7E+01	4.8E+09	3.9E+02	---	
I129F	0.000E+0	5.6E-02	3.4E-01	1.0E-01	5.6E-02	---	---	---	---	---	---	---	5.1E+00	3.8E+00	3.4E+00	4.8E+09	3.9E+02	---	
K40	1.373E-4	2.4E-01	4.0E-01	2.4E-01	2.3E+00	---	---	---	---	---	---	---	6.0E+00	7.5E+00	1.3E+02	4.4E+01	5.3E+02		
KR85	1.296E-1	1.2E+09														6.5E+10	1.2E+09		
MO93	2.078E-3	3.3E-01	6.5E-01	3.3E-01	4.7E+00	---	---	---	---	---	---	---	2.9E+01	2.9E+01	2.9E+01	---	4.9E+05		
NA22	3.462E-7	6.2E+14														1.8E+15	6.2E+14		
NB93M	8.123E-2	1.3E+08														---	1.3E+08		
NB94	3.225E-3	1.9E-01	3.3E-01	1.9E-01	4.4E+00	---	---	---	---	---	---	---	3.2E+00	3.2E+00	3.2E+00	6.4E+00	2.8E+03		
NI59	1.172E-1	1.7E+01	---	2.9E+11	1.7E+01	---	---	---	---	---	---	---	1.2E+08	4.2E+03	7.7E+03	---	4.3E+05		
NI63	7.447E+0	3.1E+05														---	3.1E+05		
NP237	7.691E-3	5.4E-02	1.1E+05	2.0E+01	3.5E+00	1.7E-01	2.1E-01	2.5E-01	---	---	---	3.7E+08	6.4E-02	5.4E-02	6.6E-02	1.1E+02	1.1E+02		
PA231		5.4E+01														5.4E+01	1.3E+02		
PB210	3.598E-3	2.2E+03														9.3E+10	2.2E+03		
PD107		2.0E+03	---	3.6E+13	2.0E+03	---	---	---	---	---	---	---	1.9E+08	6.5E+03	1.2E+04	---	9.1E+05		
PU238	3.334E+0	3.7E+03	---	---	3.6E+07	1.2E+06	4.2E+05	3.9E+05	1.2E+06	4.3E+05	3.9E+05	---	1.4E+11	3.6E+06	1.1E+06	8.9E+06	3.7E+03		1.1E+13
PU239	1.446E+0	1.5E+03	5.2E+19	4.7E+13	2.0E+07	1.5E+07	1.3E+07	1.3E+07	---	---	---	2.7E+18	8.6E+07	1.8E+06	1.6E+06	2.5E+06	1.5E+03		
PU240	3.845E-1	1.5E+03	---	---	1.1E+17	2.6E+11	2.3E+10	1.9E+10	1.9E+17	1.6E+17	1.5E+17	2.9E+18	---	1.0E+11	7.6E+09	8.0E+08	1.5E+03		
PU241	8.954E+0	9.9E+03	7.4E+13	1.5E+09	6.4E+05	3.2E+04	3.3E+04	3.3E+04	---	---	---	8.0E+13	4.8E+04	9.9E+03	1.1E+04	1.2E+07	4.2E+04		
PU242	1.189E-2	1.6E+03	---	---	3.4E+14	2.3E+11	2.1E+10	1.7E+10	9.7E+12	4.1E+12	3.7E+12	2.5E+18	2.1E+19	9.7E+10	7.1E+09	4.6E+08	1.6E+03		
PU244	4.692E-15	2.9E+01	---	---	1.5E+12	2.1E+11	1.9E+10	1.5E+10	8.1E+18	6.2E+18	6.0E+18	2.4E+19	---	8.8E+10	6.4E+09	2.9E+01	1.3E+03		
RA226	4.016E-3	9.2E-02	---	1.5E+09	8.3E+00	2.4E-01	9.8E-02	9.2E-02	2.4E-01	9.8E-02	9.2E-02	---	2.5E+02	6.9E-01	2.7E-01	6.0E+00	7.4E+01		3.3E+04
RA228	4.310E-3	2.6E+07														8.7E+07	2.6E+07		
RB87		1.6E+04														---	1.6E+04		
S35	3.590E-21	---														---	---	---	
SB124		---																---	
SB125	1.126E-1	7.7E+14														3.3E+16	7.7E+14	---	
SC46	2.290E-21	---														---	---		
SE75	3.744E-4	---																---	
SE79	9.278E-3	2.5E+04	---	---	---	---	---	---	---	---	---	---	---	---	---	---	2.5E+04	---	
SM151	1.601E-4	6.2E+06														---	6.2E+06		
SN113	1.438E-6	---																---	
SN119M	6.338E-7	---																---	
SN121	7.186E-16	---																---	
SN121M	9.213E-16	1.7E+06														---	1.7E+06	---	
SN123		---																---	
SN126	6.391E-5	5.7E+00	---	---	---	---	---	---	---	---	---	---	---	---	---	5.7E+00	2.1E+03	---	
SR90	2.523E+1	4.3E+02	1.9E+18	2.1E+08	4.3E+02	---	---	---	---	---	---	---	3.1E+05	8.4E+03	1.4E+11	---	1.7E+03		
TC99	3.930E-2	2.7E-01	1.2E+00	2.7E-01	5.8E+00	---	---	---	---	---	---	---	1.0E+01	1.0E+01	1.0E+01	6.9E+08	2.5E+03		
TH228	3.238E-2	3.6E+18														4.4E+18	3.6E+18		
TH229	5.416E-3	6.0E+01														6.0E+01	5.2E+02		
TH230	6.751E-3	3.5E-01	---	1.2E+12	3.3E+01	1.5E+00	3.8E-01	3.5E-01	1.5E+00	3.8E-01	3.5E-01	---	8.4E+03	4.5E+00	1.0E+00	1.2E+01	2.0E+02		6.2E+05
TH232	4.521E-3	2.9E+00	---	8.8E+11	1.1E+05	1.2E+05	3.0E+05	3.9E+05	1.6E+05	3.9E+05	5.2E+05	---	1.8E+06	3.1E+05	7.8E+05	2.9E+00	1.5E+02		
U232	2.776E-2	9.7E+02														2.1E+03	9.7E+02		
U233	2.082E+0	6.2E+02	---	---	6.0E+14	1.8E+15	1.5E+14	1.3E+14	---	---	---	1.9E+16	---	5.6E+13	4.4E+12	6.2E+02	2.3E+03		
U234	4.329E-1	1.0E+02	---	4.7E+16	9.4E+03	3.4E+02	1.1E+02	1.0E+02	3.4E+02	1.1E+02	1.0E+02	6.2E+16	1.4E+07	9.9E+02	2.9E+02	2.5E+03	3.5E+03		1.1E+09
U235	1.514E-2	9.5E-01	8.7E+10	2.0E+05	1.0E+01	8.0E+00	8.2E+00	8.2E+00	---	---	---	2.2E+13	7.1E+00	9.5E-01	9.8E-01	3.3E+02	2.3E+03		
U236	2.612E-2	4.1E+03	---	---	1.1E+12	1.4E+12	1.2E+12	1.2E+12	1.9E+12	1.6E+12	1.5E+12	6.4E+14	2.8E+14	3.7E+12	2.7E+12	1.8E+07	4.1E+03		
U238	4.710E+0	6.4E+02	---	---	1.2E+07	3.6E+05	1.4E+05	1.3E+05	3.6E+05	1.4E+05	1.3E+05	3.3E+12	1.1E+11	1.1E+06	3.7E+05	6.4E+02	4.2E+03		9.1E+12
W181		---														---	---		
W185		---														---	---		
W188		---														---	---		
ZR93	2.017E-5	1.2E+00	6.2E+00	1.2E+00	1.3E+00	---	---	---	---	---	---	---	2.0E+01	8.5E+00	7.8E+00	---	9.8E+05		

Table C-6. Current WITS inventory limits for ET2.

			Groundwater Protection Limits													Intruder Limits (Ci)		Air Pathway	Radon Pathway
WITS	Inventory	Most Limiting	Beta-Gamma (Ci)			Gross Alpha (Ci)			Radium (Ci)			Uranium (Ci)	All-Pathways Limit (Ci)					Limits	Limits
Nuclide	(Ci)	(Ci)	0-12 yrs	12-100 yrs	100-1130 yrs	0-1000 yrs	1000-1120 yrs	1120-1130 yrs	0-1000 yrs	1000-1120 yrs	1120-1130 yrs	All Years	130 - 200 yrs	200-1000 yrs	1000-1130 yrs	Resident	Post-drilling	(Ci)	(Ci)
AC227	1.477E-10	4.3E+03														2.0E+07	4.3E+03		
AG108M	3.299E-8	2.4E+01														2.4E+01	2.4E+03		
AL26		2.6E+00														2.6E+00	1.7E+03		
AM241	1.487E+0	3.6E+02	2.2E+11	1.1E+07	2.3E+04	1.2E+03	1.2E+03	1.2E+03	---	---	---	2.9E+12	1.6E+03	3.6E+02	4.0E+02	4.1E+05	1.4E+03		
AM242M	2.018E-1	1.4E+03														1.1E+05	1.4E+03		
AM243	2.867E-2	2.6E+02	---	4.4E+17	1.9E+04	4.4E+03	1.1E+03	9.6E+02	---	---	---	8.7E+13	5.7E+10	1.7E+03	3.6E+02	2.6E+02	1.2E+03		
AR39		3.7E+07														---	3.7E+07		
BA133	2.328E-5	8.5E+06														2.8E+09	8.5E+06		
BI207		2.4E+04														6.6E+04	2.4E+04		
BK249		9.4E+04														9.4E+04	5.1E+05		
C14	3.824E-2	5.6E-01	9.5E-01	5.6E-01	1.3E+01	---	---	---	---	---	---	---	1.7E+01	1.7E+01	1.7E+01	---	2.1E+03	1.9E+05	
CA41		1.2E+04														---	1.2E+04		
CD113M	9.353E-12	3.1E+04														---	3.1E+04		
CF249	4.316E-2	2.4E+02	7.6E+18	2.5E+13	6.4E+05	1.7E+04	5.3E+03	4.9E+03	---	---	---	1.9E+14	3.6E+06	5.3E+03	1.5E+03	2.4E+02	1.3E+03		
CF250	3.141E-4	2.7E+05														2.5E+13	2.7E+05		
CF251	3.927E-2	5.9E+02	---	---	6.6E+09	8.7E+03	2.3E+03	2.1E+03	---	---	---	5.3E+19	8.7E+18	2.5E+03	5.9E+02	9.0E+02	1.2E+03		
CF252	7.031E-3	5.5E+07														5.0E+11	5.5E+07		
CL36	1.195E-8	1.9E-01	3.3E-01	1.9E-01	4.5E+00	---	---	---	---	---	---	---	3.1E+00	3.1E+00	3.1E+00	---	2.6E+01	---	
CM242	5.611E-6	7.3E+05														1.8E+09	7.3E+05		
CM243	6.698E-4	2.2E+04														2.7E+07	2.2E+04		
CM244	3.221E+0	1.0E+05	---	---	4.9E+19	7.4E+13	7.1E+12	5.9E+12	8.4E+19	6.9E+19	6.6E+19	---	---	2.9E+13	2.3E+12	2.9E+11	1.0E+05		
CM245	9.352E-4	1.3E+02	1.0E+15	7.9E+09	1.7E+04	9.9E+02	4.1E+02	3.8E+02	---	---	---	3.5E+12	1.5E+04	3.3E+02	1.3E+02	1.6E+03	7.9E+02		
CM246	4.615E-4	3.8E+02	---	---	5.5E+16	4.6E+03	1.1E+03	1.0E+03	3.2E+16	1.4E+16	1.2E+16	1.4E+15	---	1.7E+03	3.8E+02	6.8E+10	1.5E+03		
CM247	4.250E-4	5.2E+01	---	---	1.4E+05	3.7E+03	8.7E+02	7.8E+02	---	---	---	9.2E+14	1.4E+13	1.5E+03	3.1E+02	5.2E+01	1.3E+03		
CM248	3.756E-7	8.7E+01	---	---	1.7E+11	4.4E+03	1.0E+03	9.4E+02	---	---	---	2.5E+19	---	4.1E+02	8.7E+01	3.6E+06	4.1E+02		
CO60	6.718E-1	8.6E+08														1.3E+09	8.6E+08		
CS134	1.540E-1	5.0E+17														9.9E+18	5.0E+17		
CS135	1.091E-12	2.5E+04														---	2.5E+04		
CS137	4.800E+1	2.5E+04														1.4E+06	2.5E+04		
EU152	6.671E+0	6.7E+05														1.5E+06	6.7E+05		
EU154	2.680E+0	1.2E+07														2.7E+07	1.2E+07		
EU155	9.140E-2	2.4E+11														2.7E+18	2.4E+11		
H3	4.501E-1	2.0E+00	1.9E+01	2.0E+00	3.5E+04	---	---	---	---	---	---	---	6.3E+06	6.3E+06	6.3E+06	---	2.1E+06	2.8E+18	
H3C		1.5E+05	---	---	1.5E+05	---	---	---	---	---	---	---	4.0E+06	1.8E+09	---	---	2.1E+06	2.8E+18	
I129	4.838E-5	3.3E-04	8.5E-04	3.3E-04	9.4E-03	---	---	---	---	---	---	---	6.5E-01	6.5E-01	6.5E-01	4.8E+09	3.9E+02	---	
I129C		5.0E-01	---	---	5.0E-01	---	---	---	---	---	---	---	6.4E+01	3.3E+01	3.0E+01	4.8E+09	3.9E+02	---	
I129I		6.8E-01	5.8E+00	1.8E+00	6.8E-01	---	---	---	---	---	---	---	8.6E+01	4.4E+01	4.1E+01	4.8E+09	3.9E+02	---	
I129B		8.9E+00	7.7E+01	2.3E+01	8.9E+00	---	---	---	---	---	---	---	1.1E+03	5.8E+02	5.4E+02	4.8E+09	3.9E+02	---	
I129G		9.0E-03	2.9E-02	9.0E-03	9.2E-03	---	---	---	---	---	---	---	5.6E-01	7.7E-01	1.2E+00	4.8E+09	3.9E+02	---	
I129D		4.6E-01	4.0E+00	1.2E+00	4.6E-01	---	---	---	---	---	---	---	5.9E+01	3.0E+01	2.8E+01	4.8E+09	3.9E+02	---	
I129J		1.0E-02	3.4E-02	1.0E-02	1.0E-02	---	---	---	---	---	---	---	6.1E-01	7.8E-01	1.2E+00	4.8E+09	3.9E+02	---	
I129A		3.9E+00	3.4E+01	1.0E+01	3.9E+00	---	---	---	---	---	---	---	5.0E+02	2.5E+02	2.4E+02	4.8E+09	3.9E+02	---	
I129H		3.7E-02	2.2E-01	6.7E-02	3.7E-02	---	---	---	---	---	---	---	3.4E+00	2.6E+00	2.2E+00	4.8E+09	3.9E+02	---	
I129E		1.1E+00	9.1E+00	2.7E+00	1.1E+00	---	---	---	---	---	---	---	1.3E+02	6.8E+01	6.4E+01	4.8E+09	3.9E+02	---	
I129F		6.2E-02	3.8E-01	1.1E-01	6.2E-02	---	---	---	---	---	---	---	5.7E+00	4.3E+00	3.8E+00	4.8E+09	3.9E+02	---	
K40	4.331E-5	2.7E-01	4.5E-01	2.7E-01	2.6E+00	---	---	---	---	---	---	---	6.8E+00	8.4E+00	1.4E+02	4.4E+01	5.3E+02		
KR85	1.282E-1	1.2E+09														6.5E+10	1.2E+09		
MO93	1.202E-3	3.7E-01	7.2E-01	3.7E-01	5.2E+00	---	---	---	---	---	---	---	3.2E+01	3.2E+01	3.2E+01	---	4.9E+05		
NA22	5.750E-5	6.2E+14														1.8E+15	6.2E+14		
NB93M	1.682E-2	1.3E+08														---	1.3E+08		
NB94	1.317E-3	2.1E-01	3.6E-01	2.1E-01	4.9E+00	---	---	---	---	---	---	---	3.6E+00	3.6E+00	3.6E+00	6.4E+00	2.8E+03		
NI59	6.043E-2	1.9E+01	---	3.3E+11	1.9E+01	---	---	---	---	---	---	---	1.4E+08	4.7E+03	8.6E+03	---	4.3E+05		
NI63	9.781E-1	3.1E+05														---	3.1E+05		
NP237	3.130E-2	6.0E-02	1.3E+05	2.3E+01	3.9E+00	1.9E-01	2.4E-01	2.8E-01	---	---	---	4.1E+08	7.1E-02	6.0E-02	7.4E-02	1.1E+02	1.1E+02		
PA231	1.477E-10	5.4E+01														5.4E+01	1.3E+02		
PB210	2.234E-5	2.2E+03														9.3E+10	2.2E+03		
PD107		2.3E+03	---	4.0E+13	2.3E+03	---	---	---	---	---	---	---	2.1E+08	7.3E+03	1.3E+04	---	9.1E+05		
PU238	8.674E+0	3.7E+03	---	---	4.1E+07	1.4E+06	4.7E+05	4.3E+05	1.4E+06	4.7E+05	4.3E+05	---	1.6E+11	4.0E+06	1.3E+06	8.9E+06	3.7E+03		1.1E+13
PU239	6.387E+0	1.5E+03	5.9E+19	5.3E+13	2.2E+07	1.7E+07	1.5E+07	1.5E+07	---	---	---	3.0E+18	9.6E+07	2.0E+06	1.8E+06	2.5E+06	1.5E+03		
PU240	1.437E+0	1.5E+03	---	---	1.3E+17	2.9E+11	2.6E+10	2.2E+10	2.1E+17	1.8E+17	1.7E+17	3.2E+18	---	1.1E+11	8.5E+09	8.0E+08	1.5E+03		
PU241	2.263E+1	1.1E+04	8.3E+13	1.7E+09	7.1E+05	3.6E+04	3.7E+04	3.7E+04	---	---	---	8.9E+13	5.3E+04	1.1E+04	1.2E+04	1.2E+07	4.2E+04		
PU242	2.727E-2	1.6E+03	---	---	3.8E+14	2.6E+11	2.3E+10	1.9E+10	1.1E+13	4.5E+12	4.2E+12	2.8E+18	2.3E+19	1.1E+11	7.9E+09	4.6E+08	1.6E+03		
PU244	6.843E-10	2.9E+01	---	---	1.6E+12	2.4E+11	2.1E+10	1.7E+10	9.0E+18	7.0E+18	6.7E+18	2.7E+19	---	9.9E+10	7.2E+09	2.9E+01	1.3E+03		
RA226	8.443E-5	1.0E-01	---	1.6E+09	9.3E+00	2.6E-01	1.1E-01	1.0E-01	2.6E-01	1.1E-01	1.0E-01	---	2.8E+02	7.7E-01	3.0E-01	6.0E+00	7.4E+01		3.3E+04
RA228	3.217E-3	2.6E+07														8.7E+07	2.6E+07		
RB87		1.6E+04														---	1.6E+04		
S35		---														---	---	---	
SB124		---																---	
SB125	2.722E-3	7.7E+14														3.3E+16	7.7E+14	---	
SC46		---														---	---		
SE75	1.086E-4	---																---	
SE79	8.567E-5	2.5E+04	---	---	---	---	---	---	---	---	---	---	---	---	---	---	2.5E+04	---	
SM151	1.238E-3	6.2E+06														---	6.2E+06		
SN113	1.552E-7	---																---	
SN119M	4.628E-6	---																---	
SN121	1.486E-13	---																---	
SN121M	1.718E-6	1.7E+06														---	1.7E+06	---	
SN123		---																---	
SN126	2.269E-5	5.7E+00	---	---	---	---	---	---	---	---	---	---	---	---	---	5.7E+00	2.1E+03	---	
SR90	8.340E+1	4.9E+02	2.2E+18	2.3E+08	4.9E+02	---	---	---	---	---	---	---	3.4E+05	9.4E+03	1.6E+11	---	1.7E+03		
TC99	5.903E-2	3.0E-01	1.4E+00	3.0E-01	6.5E+00	---	---	---	---	---	---	---	1.1E+01	1.1E+01	1.1E+01	6.9E+08	2.5E+03		
TH228	8.284E-2	3.6E+18														4.4E+18	3.6E+18		
TH229	1.739E-2	6.0E+01														6.0E+01	5.2E+02		
TH230	3.656E-3	3.9E-01	---	1.3E+12	3.7E+01	1.7E+00	4.3E-01	3.9E-01	1.7E+00	4.3E-01	3.9E-01	---	9.4E+03	5.0E+00	1.1E+00	1.2E+01	2.0E+02		6.2E+05
TH232	3.216E-3	2.9E+00	---	9.8E+11	1.3E+05	1.3E+05	3.3E+05	4.4E+05	1.7E+05	4.4E+05	5.9E+05	---	2.0E+06	3.5E+05	8.8E+05	2.9E+00	1.5E+02		
U232	7.944E-2	9.7E+02														2.1E+03	9.7E+02		
U233	6.215E+0	6.2E+02	---	---	6.6E+14	2.1E+15	1.7E+14	1.4E+14	---	---	---	2.1E+16	---	6.3E+13	4.9E+12	6.2E+02	2.3E+03		
U234	4.792E-1	1.1E+02	---	5.2E+16	1.1E+04	3.8E+02	1.2E+02	1.1E+02	3.8E+02	1.2E+02	1.1E+02	6.9E+16	1.6E+07	1.1E+03	3.3E+02	2.5E+03	3.5E+03		1.1E+09
U235	8.445E-3	1.1E+00	9.7E+10	2.2E+05	1.2E+01	8.9E+00	9.1E+00	9.2E+00	---	---	---	2.4E+13	7.9E+00	1.1E+00	1.1E+00	3.3E+02	2.3E+03		
U236	1.789E-2	4.1E+03	---	---	1.3E+12	1.6E+12	1.3E+12	1.3E+12	2.1E+12	1.8E+12	1.7E+12	7.2E+14	3.1E+14	4.1E+12	3.0E+12	1.8E+07	4.1E+03		
U238	4.172E-1	6.4E+02	---	---	1.3E+07	4.0E+05	1.6E+05	1.4E+05	4.0E+05	1.6E+05	1.4E+05	3.7E+12	1.2E+11	1.2E+06	4.2E+05	6.4E+02	4.2E+03		9.1E+12
W181		---														---	---		
W185		---														---	---		
W188		---														---	---		
ZR93	3.096E-5	1.3E+00	7.0E+00	1.3E+00	1.5E+00	---	---	---	---	---	---	---	2.3E+01	9.5E+00	8.7E+00	---	9.8E+05		

Table C-7. Current WITS inventory limits for ST05.

WITS Nuclide	Inventory (Ci)	Most Limiting (Ci)	Groundwater Protection Limits: Beta-Gamma (Ci) 0-12 yrs	Beta-Gamma (Ci) 12-100 yrs	Beta-Gamma (Ci) 100-1130 yrs	Gross Alpha (Ci) 0-1000 yrs	Gross Alpha (Ci) 1000-1120 yrs	Gross Alpha (Ci) 1120-1130 yrs	Radium (Ci) 0-1000 yrs	Radium (Ci) 1000-1120 yrs	Radium (Ci) 1120-1130 yrs	Uranium (Ci) All Years	All-Pathways Limit (Ci) 130 - 200 yrs	All-Pathways Limit (Ci) 200-1000 yrs	All-Pathways Limit (Ci) 1000-1130 yrs	Intruder Limits (Ci) Resident	Intruder Limits (Ci) Post-drilling	Air Pathway Limits (Ci)	Radon Pathway Limits (Ci)
AC227		4.2E+03														3.1E+07	4.2E+03		
AG108M	3.1853E-9	3.6E+01														3.6E+01	2.3E+03		
AL26		3.9E+00														3.9E+00	1.6E+03		
AM241	6.5670E-1	4.5E+01	3.9E+09	1.8E+06	1.1E+04	2.2E+02	1.3E+02	1.2E+02	---	---	---	1.6E+12	6.2E+02	7.9E+01	4.5E+01	6.2E+05	1.4E+03		
AM242M	4.8091E-2	1.4E+03														1.6E+05	1.4E+03		
AM243	1.1642E-2	9.1E+00	---	5.3E+16	4.8E+02	6.6E+01	2.6E+01	2.4E+01	---	---	---	1.2E+12	2.9E+10	2.5E+01	9.1E+00	3.9E+02	1.1E+03		
AR39		3.6E+07														---	3.6E+07		
BA133	8.3598E-7	8.2E+06														4.3E+09	8.2E+06		
BI207		2.3E+04														9.9E+04	2.3E+04		
BK249		1.4E+05														1.4E+05	4.9E+05		
C14	3.6280E-2	2.5E-01	2.5E-01	2.5E-01	3.2E+00	---	---	---	---	---	---	---	3.3E+00	9.4E+00	1.1E+01	---	2.0E+03	1.9E+05	
C-14N	5.0178E-3	2.5E+00	---	---	2.5E+00	---	---	---	---	---	---	---	3.0E+00	2.6E+00	1.0E+02	---	2.0E+03	1.9E+05	
CA41		1.2E+04														---	1.2E+04		
CD113M	7.5846E-13	3.0E+04														---	3.0E+04		
CF249	1.1559E-2	4.1E+01	1.2E+17	3.1E+12	3.2E+04	3.1E+02	1.4E+02	1.3E+02	---	---	---	9.3E+13	1.8E+06	9.7E+01	4.1E+01	3.7E+02	1.3E+03		
CF250	3.6202E-2	2.6E+05														3.8E+13	2.6E+05		
CF251	1.0990E-2	1.5E+01	---	---	1.7E+08	1.3E+02	5.5E+01	5.2E+01	---	---	---	8.1E+17	3.6E+18	3.7E+01	1.5E+01	1.4E+03	1.2E+03		
CF252	5.0644E-3	5.3E+07														7.5E+11	5.3E+07		
CL36	2.2640E-6	8.6E-02	8.6E-02	8.6E-02	1.1E+00	---	---	---	---	---	---	---	5.9E-01	1.6E+00	2.0E+00	---	2.5E+01	---	
CM242	5.2885E-5	7.0E+05														2.6E+09	7.0E+05		
CM243	2.3725E-3	2.2E+04														4.1E+07	2.2E+04		
CM244	1.4210E+0	1.0E+05	---	---	8.9E+17	7.0E+10	9.2E+09	7.9E+09	1.6E+18	1.3E+18	1.2E+18	9.8E+17	---	2.7E+10	3.1E+09	4.4E+11	1.0E+05		
CM245	4.8717E-4	4.8E+00	1.7E+13	1.1E+09	1.2E+03	3.6E+01	1.4E+01	1.3E+01	---	---	---	1.8E+12	6.6E+03	1.3E+01	4.8E+00	2.4E+03	7.7E+02		
CM246	7.3303E-4	9.4E+00	---	---	7.7E+14	7.0E+01	2.7E+01	2.5E+01	1.1E+16	3.6E+15	3.3E+15	1.9E+13	---	2.6E+01	9.4E+00	1.0E+11	1.5E+03		
CM247	1.7801E-4	7.8E+00	---	---	3.6E+03	5.5E+01	2.1E+01	2.0E+01	---	---	---	1.4E+13	6.3E+12	2.2E+01	7.8E+00	7.9E+01	1.3E+03		
CM248	3.5328E-4	2.2E+00	---	---	3.1E+09	6.6E+01	2.5E+01	2.4E+01	---	---	---	2.9E+17	2.3E+19	6.1E+00	2.2E+00	5.5E+06	3.9E+02		
CO60	1.2700E+5	8.3E+08														2.0E+09	8.3E+08		
CS134	7.7957E-2	4.8E+17														1.5E+19	4.8E+17		
CS135	8.8355E-14	2.4E+04														---	2.4E+04		
CS137	2.9365E+1	2.4E+04														2.1E+06	2.4E+04		
EU152	9.0839E-5	6.5E+05														2.3E+06	6.5E+05		
EU154	2.2412E+1	1.1E+07														4.1E+07	1.1E+07		
EU155	9.2980E-1	2.4E+11														4.0E+18	2.4E+11		
H3	4.0233E-1	4.7E+00	4.7E+00	4.8E+00	1.9E+04	---	---	---	---	---	---	---	1.5E+06	4.1E+06	4.1E+06	---	2.1E+06	2.8E+18	
H3F		1.1E+01	1.1E+01	1.1E+01	4.5E+04	---	---	---	---	---	---	---	3.4E+06	9.4E+06	9.4E+06	---	2.1E+06	2.8E+18	
H3C		5.6E+04	---	---	5.6E+04	---	---	---	---	---	---	---	1.5E+06	1.1E+09	---	---	2.1E+06	2.8E+18	
I129	5.7207E-5	1.4E-04	1.4E-04	1.4E-04	1.4E-03	---	---	---	---	---	---	---	8.6E-02	1.9E-01	4.5E-01	7.3E+09	3.8E+02	---	
I129C		1.7E-01	---	---	1.7E-01	---	---	---	---	---	---	---	2.1E+01	1.1E+01	1.0E+01	7.3E+09	3.8E+02	---	
I129I		2.3E-01	1.2E+00	5.8E-01	2.3E-01	---	---	---	---	---	---	---	2.8E+01	1.5E+01	1.4E+01	7.3E+09	3.8E+02	---	
I129B		3.0E+00	1.5E+01	7.7E+00	3.0E+00	---	---	---	---	---	---	---	3.7E+02	1.9E+02	1.8E+02	7.3E+09	3.8E+02	---	
I129G		3.0E-03	5.9E-03	3.0E-03	3.1E-03	---	---	---	---	---	---	---	1.9E-01	3.0E-01	1.0E+00	7.3E+09	3.8E+02	---	
I129D		1.6E-01	7.9E-01	4.0E-01	1.6E-01	---	---	---	---	---	---	---	1.9E+01	1.0E+01	9.6E+00	7.3E+09	3.8E+02	---	
I129J	7.6472E-7	3.3E-03	6.6E-03	3.3E-03	3.3E-03	---	---	---	---	---	---	---	2.0E-01	3.3E-01	9.8E-01	7.3E+09	3.8E+02	---	
I129A		1.3E+00	6.7E+00	3.4E+00	1.3E+00	---	---	---	---	---	---	---	1.6E+02	8.5E+01	8.0E+01	7.3E+09	3.8E+02	---	
I129H		1.4E-02	4.4E-02	2.2E-02	1.4E-02	---	---	---	---	---	---	---	1.1E+00	8.9E-01	8.4E-01	7.3E+09	3.8E+02	---	
I129E		3.5E-01	1.8E+00	9.1E-01	3.5E-01	---	---	---	---	---	---	---	4.4E+01	2.3E+01	2.1E+01	7.3E+09	3.8E+02	---	
I129F		2.2E-02	7.5E-02	3.8E-02	2.2E-02	---	---	---	---	---	---	---	1.8E+00	1.5E+00	1.3E+00	7.3E+09	3.8E+02	---	
I129R	8.1780E-6	3.7E-01	3.6E+00	1.4E+00	3.7E-01	---	---	---	---	---	---	---	5.4E+01	2.3E+01	7.6E+01	7.3E+09	3.8E+02	---	
K40	2.8856E-4	5.9E-02	6.5E-02	5.9E-02	5.0E-01	---	---	---	---	---	---	---	1.1E+00	2.1E+00	2.3E+01	6.7E+01	5.1E+02		
KR85	2.6034E-2	1.2E+09														9.9E+10	1.2E+09		
MO93		1.9E-01	1.9E-01	1.9E-01	1.3E+00	---	---	---	---	---	---	---	6.2E+00	1.7E+01	2.1E+01	---	4.7E+05		
NA22		5.9E+14														2.7E+15	5.9E+14		
NB93M	4.7651E-2	1.2E+08														---	1.2E+08		
NB94	8.6978E-4	9.4E-02	9.4E-02	9.4E-02	1.2E+00	---	---	---	---	---	---	---	6.9E-01	1.9E+00	2.3E+00	9.6E+00	2.7E+03		
NI59	1.1257E-2	4.1E+00	5.8E+19	3.4E+09	4.1E+00	---	---	---	---	---	---	---	9.8E+05	2.2E+03	1.0E+03	---	4.2E+05		
NI63	2.7157E+0	3.0E+05														---	3.0E+05		
NP237	5.5544E-3	2.4E-02	2.4E+03	3.9E+00	1.6E+00	7.9E-02	1.5E-01	3.6E-01	---	---	---	2.2E+08	2.6E-02	2.4E-02	4.8E-02	1.7E+02	1.1E+02		
PA231		8.1E+01														8.1E+01	1.2E+02		
PB210	3.5628E-4	2.2E+03														1.4E+11	2.2E+03		
PD107		4.9E+02	---	4.2E+11	4.9E+02	---	---	---	---	---	---	---	1.5E+06	3.3E+03	1.6E+03	---	8.7E+05		
PU238	2.5353E+1	3.6E+03	---	---	9.8E+06	3.7E+05	1.2E+05	1.1E+05	3.7E+05	1.2E+05	1.1E+05	1.5E+17	2.3E+09	1.1E+06	3.2E+05	1.3E+07	3.6E+03		7.7E+12
PU239	1.7035E+0	1.5E+03	9.6E+17	6.7E+12	1.1E+07	9.5E+06	6.7E+06	6.5E+06	---	---	---	3.3E+15	4.3E+07	1.2E+06	9.9E+05	3.8E+06	1.5E+03		
PU240	4.7580E-1	1.5E+03	---	---	2.3E+15	2.7E+08	3.3E+07	2.8E+07	4.1E+15	3.2E+15	3.1E+15	3.6E+15	1.3E+18	1.0E+08	1.1E+07	1.2E+09	1.5E+03		
PU241	8.4861E+0	1.3E+03	1.4E+12	2.5E+08	3.3E+05	6.6E+03	3.7E+03	3.6E+03	---	---	---	5.0E+13	2.2E+04	2.4E+03	1.3E+03	1.9E+07	4.1E+04		
PU242	5.0463E-3	1.5E+03	---	---	1.0E+14	2.4E+08	2.9E+07	2.5E+07	3.7E+12	1.2E+12	1.1E+12	3.2E+15	3.3E+17	9.9E+07	1.0E+07	6.9E+08	1.5E+03		
PU244	1.4911E-15	4.4E+01	---	---	2.1E+09	2.2E+08	2.6E+07	2.2E+07	1.7E+17	1.2E+17	1.2E+17	3.0E+16	---	9.0E+07	9.2E+06	4.4E+01	1.3E+03		
RA226	3.5757E-4	3.8E-02	2.3E+17	2.5E+07	2.9E+00	6.4E-02	3.8E-02	3.8E-02	6.4E-02	3.8E-02	3.8E-02	---	5.2E+00	1.9E-01	1.1E-01	9.1E+00	7.1E+01		2.2E+04
RA226T		2.3E-01	---	1.2E+12	1.4E+01	2.3E-01	9.8E-01	8.3E-01	2.3E-01	9.9E-01	8.3E-01	---	1.0E+04	6.6E-01	2.4E+00	9.1E+00	7.1E+01		2.2E+04
RA228	3.6887E-5	2.5E+07														1.3E+08	2.5E+07		
RB87		1.5E+04														---	1.5E+04		
S35		---														---	---	---	
SB124		---																---	
SB125	7.8713E-1	7.4E+14														5.0E+16	7.4E+14	---	
SC46		---														---	---		
SE75		---																---	
SE79	3.9702E-4	2.4E+04	---	---	3.2E+19	---	---	---	---	---	---	---	---	---	3.4E+19	---	2.4E+04	---	
SM151	1.2910E+0	5.9E+06														---	5.9E+06		
SN113		---																---	
SN119M	1.6247E-12	---																---	
SN121	3.9852E-15	---																---	
SN121M	5.1093E-15	1.6E+06														---	1.6E+06	---	
SN123		---																---	
SN126	3.2406E-5	8.7E+00	---	---	---	---	---	---	---	---	---	---	---	---	---	8.7E+00	2.1E+03	---	
SR90	4.1448E+1	7.1E+01	9.9E+14	3.4E+06	7.1E+01	---	---	---	---	---	---	---	6.0E+03	1.4E+03	2.4E+10	---	1.6E+03		
SR90R	7.4035E+0	1.6E+03	1.4E+18	3.2E+09	4.0E+04	---	---	---	---	---	---	---	3.1E+06	7.7E+05	3.3E+12	---	1.6E+03		
TC99	4.5438E-2	1.3E-01	1.6E-01	1.3E-01	1.3E+00	---	---	---	---	---	---	---	1.9E+00	3.5E+00	7.7E+00	1.0E+09	2.4E+03		
TC99R	1.7905E-3	3.3E+02	5.3E+03	1.3E+03	3.3E+02	---	---	---	---	---	---	---	1.4E+03	4.9E+02	1.7E+03	1.0E+09	2.4E+03		
TH228	1.0717E-3	3.4E+18														6.6E+18	3.4E+18		
TH229	2.2229E-4	9.0E+01														9.0E+01	5.0E+02		
TH230	3.9278E-4	1.0E-01	---	2.0E+10	8.8E+00	3.1E-01	1.1E-01	1.0E-01	3.1E-01	1.1E-01	1.0E-01	---	1.4E+02	9.2E-01	3.0E-01	1.9E+01	1.9E+02		4.2E+05
TH230T		1.7E+00	---	1.0E+15	1.1E+02	1.9E+00	1.8E+00	1.7E+00	1.9E+00	1.8E+00	1.7E+00	---	4.9E+05	5.6E+00	4.9E+00	1.9E+01	1.9E+02		4.2E+05
TH232	3.6887E-5	4.4E+00	6.0E+16	3.8E+09	2.7E+03	2.7E+03	6.3E+03	8.0E+03	3.6E+03	8.4E+03	1.1E+04	---	1.7E+04	7.2E+03	1.7E+04	4.4E+00	1.5E+02		
U232	1.0318E-3	9.4E+02														3.2E+03	9.4E+02		
U233	2.0319E+0	9.3E+02	---	---	4.7E+11	1.2E+12	1.2E+11	9.9E+10	---	---	---	1.6E+13	---	3.8E+10	3.8E+09	9.3E+02	2.2E+03		
U234	1.8245E+0	2.9E+01	---	7.5E+14	2.6E+03	9.5E+01	3.1E+01	2.9E+01	9.5E+01	3.1E+01	2.9E+01	3.8E+13	2.3E+05	2.8E+02	8.4E+01	3.8E+03	3.4E+03		7.2E+08
U234G		3.4E+03	---	1.1E+18	1.1E+06	3.6E+04	1.3E+04	1.2E+04	3.6E+04	1.3E+04	1.2E+04	2.2E+16	3.9E+08	1.1E+05	3.5E+04	3.8E+03	3.4E+03		7.2E+08
U235	3.8885E-2	5.8E-01	1.7E+09	3.0E+04	6.2E+00	4.8E+00	5.0E+00	6.0E+00	---	---	---	1.3E+10	3.2E+00	5.8E-01	6.3E-01	5.0E+02	2.2E+03		
U235G		2.4E+02	2.3E+12	1.7E+07	2.4E+03	2.1E+03	1.9E+03	1.9E+03	---	---	---	7.7E+12	7.5E+03	2.6E+02	2.4E+02	5.0E+02	2.2E+03		
U235P	3.9241E-1	5.0E+02	5.6E+13	4.1E+08	2.6E+04	2.3E+04	2.1E+04	2.1E+04	---	---	---	8.4E+13	1.0E+05	2.8E+03	2.6E+03	5.0E+02	2.2E+03		
U236	2.5750E-2	3.9E+03	---	2.3E+19	2.3E+10	3.1E+10	2.5E+10	2.4E+10	4.1E+10	3.3E+10	3.2E+10	3.9E+11	2.5E+12	5.9E+10	1.2E+10	2.8E+07	3.9E+03		
U236G		3.9E+03	---	---	1.6E+13	2.1E+13	1.7E+13	1.6E+13	2.8E+13	2.3E+13	2.2E+13	2.3E+14	3.3E+15	3.7E+13	7.4E+12	2.8E+07	3.9E+03		
U238	3.2819E+0	9.7E+02	---	---	3.3E+06	1.2E+05	3.9E+04	3.6E+04	1.3E+05	3.9E+04	3.6E+04	2.0E+09	1.8E+09	3.7E+05	1.1E+05	9.7E+02	4.0E+03		6.1E+12
U238G		9.7E+02	---	---	1.3E+09	4.7E+07	1.5E+07	1.4E+07	4.7E+07	1.5E+07	1.4E+07	1.2E+12	3.0E+12	1.4E+08	4.1E+07	9.7E+02	4.0E+03		6.1E+12
W181		---														---	---		
W185		---														---	---		
W188		---														---	---		
ZR93	6.6293E-6	6.4E-01	1.5E+00	6.4E-01	7.4E-01	---	---	---	---	---	---	---	8.9E+00	4.8E+00	4.4E+00	---	9.5E+05		

Table C-8. Current WITS inventory limits for ST06.

			Groundwater Protection Limits														Intruder Limits (Ci)		Air Pathway	Radon Pathway
WITS	Inventory	Most Limiting	Beta-Gamma (Ci)			Gross Alpha (Ci)			Radium (Ci)			Uranium (Ci)	All-Pathways Limit (Ci)						Limits	Limits
Nuclide	(Ci)	(Ci)	0-12 yrs	12-100 yrs	100-1130 yrs	0-1000 yrs	1000-1120 yrs	1120-1130 yrs	0-1000 yrs	1000-1120 yrs	1120-1130 yrs	All Years	130 - 200 yrs	200-1000 yrs	1000-1130 yrs		Resident	Post-drilling	(Ci)	(Ci)
AC227	1.71E-05	4.2E+03															3.1E+07	4.2E+03		
AG108M	5.63E-05	3.6E+01															3.6E+01	2.3E+03		
AL26		3.9E+00															3.9E+00	1.6E+03		
AM241	6.69E-01	4.5E+01	3.9E+09	1.8E+06	1.1E+04	2.2E+02	1.3E+02	1.2E+02	---	---	---	1.6E+12	6.1E+02	7.8E+01	4.5E+01		6.2E+05	1.4E+03		
AM242M	3.54E-01	1.4E+03															1.6E+05	1.4E+03		
AM243	1.51E-01	9.0E+00	---	5.2E+16	4.8E+02	6.5E+01	2.6E+01	2.4E+01	---	---	---	1.2E+12	2.9E+10	2.5E+01	9.0E+00		3.9E+02	1.1E+03		
AR39	1.07E-18	3.6E+07															---	3.6E+07		
BA133	6.81E-08	8.2E+06															4.3E+09	8.2E+06		
BI207		2.3E+04															9.9E+04	2.3E+04		
BK249		1.4E+05															1.4E+05	4.9E+05		
C14	7.87E-03	2.5E-01	2.5E-01	2.5E-01	3.2E+00	---	---	---	---	---	---	---	3.3E+00	9.3E+00	1.1E+01		---	2.0E+03	1.9E+05	
C-14N		2.5E+00	---	---	2.5E+00	---	---	---	---	---	---	---	3.0E+00	2.6E+00	9.9E+01		---	2.0E+03	1.9E+05	
CA41		1.2E+04															---	1.2E+04		
CD113M	3.60E-06	3.0E+04															---	3.0E+04		
CF249	8.39E-02	4.1E+01	1.2E+17	3.1E+12	3.2E+04	3.1E+02	1.4E+02	1.3E+02	---	---	---	9.2E+13	1.8E+06	9.6E+01	4.1E+01		3.7E+02	1.3E+03		
CF250	6.49E-02	2.6E+05															3.8E+13	2.6E+05		
CF251	7.62E-02	1.5E+01	---	---	1.7E+08	1.3E+02	5.4E+01	5.1E+01	---	---	---	8.0E+17	3.6E+18	3.7E+01	1.5E+01		1.4E+03	1.2E+03		
CF252	9.09E-03	5.3E+07															7.5E+11	5.3E+07		
CL36	1.65E-12	8.5E-02	8.5E-02	8.5E-02	1.1E+00	---	---	---	---	---	---	---	5.8E-01	1.6E+00	2.0E+00		---	2.5E+01	---	
CM242	1.39E-09	7.0E+05															2.6E+09	7.0E+05		
CM243	3.64E-03	2.2E+04															4.1E+07	2.2E+04		
CM244	3.18E+00	1.0E+05	---	---	8.8E+17	6.9E+10	9.1E+09	7.8E+09	1.6E+18	1.3E+18	1.2E+18	9.7E+17	---	2.7E+10	3.1E+09		4.4E+11	1.0E+05		
CM245	1.18E-03	4.8E+00	1.7E+13	1.1E+09	1.2E+03	3.6E+01	1.4E+01	1.3E+01	---	---	---	1.8E+12	6.5E+03	1.3E+01	4.8E+00		2.4E+03	7.7E+02		
CM246	4.66E-04	9.3E+00	---	---	7.6E+14	6.9E+01	2.7E+01	2.5E+01	1.1E+16	3.6E+15	3.3E+15	1.9E+13	---	2.6E+01	9.3E+00		1.0E+11	1.5E+03		
CM247	1.19E-03	7.7E+00	---	---	3.6E+03	5.4E+01	2.1E+01	2.0E+01	---	---	---	1.4E+13	6.2E+12	2.2E+01	7.7E+00		7.9E+01	1.3E+03		
CM248	4.09E-04	2.2E+00	---	---	3.1E+09	6.5E+01	2.5E+01	2.4E+01	---	---	---	2.9E+17	2.3E+19	6.0E+00	2.2E+00		5.5E+06	3.9E+02		
CO60	1.69E-01	8.3E+08															2.0E+09	8.3E+08		
CS134	1.36E-04	4.8E+17															1.5E+19	4.8E+17		
CS135	5.92E-08	2.4E+04															---	2.4E+04		
CS137	2.69E+01	2.4E+04															2.1E+06	2.4E+04		
EU152	2.23E-03	6.5E+05															2.3E+06	6.5E+05		
EU154	6.64E+00	1.1E+07															4.1E+07	1.1E+07		
EU155	1.65E+00	2.4E+11															4.0E+18	2.4E+11		
H3	1.97E-01	2.0E+00	4.7E+00	2.0E+00	1.9E+04	---	---	---	---	---	---	---	1.5E+06	4.1E+06	4.1E+06		---	2.1E+06	2.8E+18	
H3C		5.5E+04	---	---	5.5E+04	---	---	---	---	---	---	---	1.5E+06	1.1E+09	---		---	2.1E+06	2.8E+18	
I129	7.25E-05	1.4E-04	1.4E-04	1.4E-04	1.4E-03	---	---	---	---	---	---	---	8.5E-02	1.9E-01	4.5E-01		7.3E+09	3.8E+02	---	
I129C		1.7E-01	---	---	1.7E-01	---	---	---	---	---	---	---	2.1E+01	1.1E+01	9.9E+00		7.3E+09	3.8E+02	---	
I129I		2.3E-01	1.2E+00	5.7E-01	2.3E-01	---	---	---	---	---	---	---	2.8E+01	1.5E+01	1.4E+01		7.3E+09	3.8E+02	---	
I129B		3.0E+00	1.5E+01	7.6E+00	3.0E+00	---	---	---	---	---	---	---	3.7E+02	1.9E+02	1.8E+02		7.3E+09	3.8E+02	---	
I129G		3.0E-03	5.8E-03	3.0E-03	3.1E-03	---	---	---	---	---	---	---	1.9E-01	3.0E-01	9.9E-01		7.3E+09	3.8E+02	---	
I129D		1.6E-01	7.8E-01	4.0E-01	1.6E-01	---	---	---	---	---	---	---	1.9E+01	9.9E+00	9.5E+00		7.3E+09	3.8E+02	---	
I129J		3.3E-03	6.5E-03	3.3E-03	3.3E-03	---	---	---	---	---	---	---	2.0E-01	3.3E-01	9.7E-01		7.3E+09	3.8E+02	---	
I129A		1.3E+00	6.6E+00	3.4E+00	1.3E+00	---	---	---	---	---	---	---	1.6E+02	8.4E+01	7.9E+01		7.3E+09	3.8E+02	---	
I129H		1.4E-02	4.4E-02	2.2E-02	1.4E-02	---	---	---	---	---	---	---	1.1E+00	8.8E-01	8.3E-01		7.3E+09	3.8E+02	---	
I129E		3.5E-01	1.8E+00	9.0E-01	3.5E-01	---	---	---	---	---	---	---	4.4E+01	2.3E+01	2.1E+01		7.3E+09	3.8E+02	---	
I129F		2.2E-02	7.4E-02	3.8E-02	2.2E-02	---	---	---	---	---	---	---	1.8E+00	1.5E+00	1.3E+00		7.3E+09	3.8E+02	---	
I129R		3.7E-01	3.6E+00	1.4E+00	3.7E-01	---	---	---	---	---	---	---	5.3E+01	2.3E+01	7.5E+01		7.3E+09	3.8E+02	---	
K40	4.29E-08	5.8E-02	6.4E-02	5.8E-02	5.0E-01	---	---	---	---	---	---	---	1.1E+00	2.1E+00	2.3E+01		6.7E+01	5.1E+02		
KR85	7.54E-04	1.2E+09															9.9E+10	1.2E+09		
MO93	1.02E-03	1.9E-01	1.9E-01	1.9E-01	1.3E+00	---	---	---	---	---	---	---	6.1E+00	1.7E+01	2.1E+01		---	4.7E+05		
NA22		5.9E+14															2.7E+15	5.9E+14		
NB93M	2.82E-05	1.2E+08															---	1.2E+08		
NB94	2.07E-06	9.3E-02	9.3E-02	9.3E-02	1.2E+00	---	---	---	---	---	---	---	6.8E-01	1.9E+00	2.3E+00		9.6E+00	2.7E+03		
NI59	2.06E-02	4.1E+00	5.7E+19	3.4E+09	4.1E+00	---	---	---	---	---	---	---	9.7E+05	2.2E+03	9.9E+02		---	4.2E+05		
NI63	5.83E-02	3.0E+05															---	3.0E+05		
NP237	3.98E-03	2.4E-02	2.4E+03	3.9E+00	1.6E+00	7.8E-02	1.5E-01	3.6E-01	---	---	---	2.2E+08	2.6E-02	2.4E-02	4.8E-02		1.7E+02	1.1E+02		
PA231	2.82E-10	8.1E+01															8.1E+01	1.2E+02		
PB210	3.99E-02	2.2E+03															1.4E+11	2.2E+03		
PD107	1.65E-08	4.9E+02	---	4.2E+11	4.9E+02	---	---	---	---	---	---	---	1.5E+06	3.3E+03	1.6E+03		---	8.7E+05		
PU238	2.17E+01	3.6E+03	---	---	9.7E+06	3.7E+05	1.2E+05	1.1E+05	3.7E+05	1.2E+05	1.1E+05	1.5E+17	2.3E+09	1.1E+06	3.2E+05		1.3E+07	3.6E+03		7.7E+12
PU239	9.88E-01	1.5E+03	9.5E+17	6.6E+12	1.1E+07	9.4E+06	6.6E+06	6.4E+06	---	---	---	3.3E+15	4.3E+07	1.2E+06	9.8E+05		3.8E+06	1.5E+03		
PU240	2.72E-01	1.5E+03	---	---	2.3E+15	2.7E+08	3.3E+07	2.8E+07	4.1E+15	3.2E+15	3.1E+15	3.6E+15	1.3E+18	9.9E+07	1.1E+07		1.2E+09	1.5E+03		
PU241	5.40E+00	1.3E+03	1.4E+12	2.5E+08	3.3E+05	6.5E+03	3.7E+03	3.6E+03	---	---	---	5.0E+13	2.2E+04	2.4E+03	1.3E+03		1.9E+07	4.1E+04		
PU242	1.36E-02	1.5E+03	---	---	9.9E+13	2.4E+08	2.9E+07	2.5E+07	3.7E+12	1.2E+12	1.1E+12	3.2E+15	3.3E+17	9.8E+07	9.9E+06		6.9E+08	1.5E+03		
PU244	3.51E-20	4.4E+01	---	---	2.1E+09	2.2E+08	2.6E+07	2.2E+07	1.7E+17	1.2E+17	1.2E+17	3.0E+16	---	8.9E+07	9.1E+06		4.4E+01	1.3E+03		
RA226	5.62E-05	3.8E-02	2.3E+17	2.5E+07	2.9E+00	6.3E-02	3.8E-02	3.8E-02	6.3E-02	3.8E-02	3.8E-02	---	5.1E+00	1.9E-01	1.1E-01		9.1E+00	7.1E+01		2.2E+04
RA226T	3.99E-02	2.3E-01	---	1.2E+12	1.4E+01	2.3E-01	9.7E-01	8.2E-01	2.3E-01	9.8E-01	8.2E-01	---	9.9E+03	6.5E-01	2.4E+00		9.1E+00	7.1E+01		2.2E+04
RA228	1.08E-02	2.5E+07															1.3E+08	2.5E+07		
RB87	1.26E-11	1.5E+04															---	1.5E+04		
S35		---															---	---	---	
SB124	6.00E-10	---																	---	
SB125	1.62E-06	7.4E+14															5.0E+16	7.4E+14	---	
SC46		---															---	---		
SE75		---																	---	
SE79	8.59E-03	2.4E+04	---	---	3.2E+19	---	---	---	---	---	---	---	---	---	3.4E+19		---	2.4E+04	---	
SM151	1.06E+00	5.9E+06															---	5.9E+06		
SN113	1.58E-09	---																	---	
SN119M	2.43E-20	---																	---	
SN121	3.21E-07	---																	---	
SN121M	4.27E-07	1.6E+06															---	1.6E+06	---	
SN123		---																	---	
SN126	1.07E-03	8.7E+00	---	---	---	---	---	---	---	---	---	---	---	---	---		8.7E+00	2.1E+03	---	
SR90	2.73E+01	7.0E+01	9.8E+14	3.4E+06	7.0E+01	---	---	---	---	---	---	---	5.9E+03	1.4E+03	2.4E+10		---	1.6E+03		
SR90R		1.6E+03	1.4E+18	3.2E+09	4.0E+04	---	---	---	---	---	---	---	3.1E+06	7.6E+05	3.3E+12		---	1.6E+03		
TC99	2.11E-02	1.3E-01	1.6E-01	1.3E-01	1.3E+00	---	---	---	---	---	---	---	1.9E+00	3.5E+00	7.6E+00		1.0E+09	2.4E+03		
TC99R		3.3E+02	5.2E+03	1.3E+03	3.3E+02	---	---	---	---	---	---	---	1.4E+03	4.9E+02	1.7E+03		1.0E+09	2.4E+03		
TH228	1.71E-02	3.4E+18															6.6E+18	3.4E+18		
TH229	1.23E-03	9.0E+01															9.0E+01	5.0E+02		
TH230	2.36E-04	9.9E-02	---	2.0E+10	8.7E+00	3.1E-01	1.1E-01	9.9E-02	3.1E-01	1.1E-01	9.9E-02	---	1.4E+02	9.1E-01	3.0E-01		1.9E+01	1.9E+02		4.2E+05
TH230T	3.99E-02	1.7E+00	---	9.9E+14	1.1E+02	1.9E+00	1.8E+00	1.7E+00	1.9E+00	1.8E+00	1.7E+00	---	4.9E+05	5.5E+00	4.9E+00		1.9E+01	1.9E+02		4.2E+05
TH232	1.08E-02	4.4E+00	5.9E+16	3.8E+09	2.7E+03	2.7E+03	6.2E+03	7.9E+03	3.6E+03	8.3E+03	1.1E+04	---	1.7E+04	7.1E+03	1.7E+04		4.4E+00	1.5E+02		
U232	6.49E-03	9.4E+02															3.2E+03	9.4E+02		
U233	4.58E-01	9.3E+02	---	---	4.7E+11	1.2E+12	1.2E+11	9.8E+10	---	---	---	1.6E+13	---	3.8E+10	3.8E+09		9.3E+02	2.2E+03		
U234	2.61E-01	2.9E+01	---	7.4E+14	2.6E+03	9.4E+01	3.1E+01	2.9E+01	9.4E+01	3.1E+01	2.9E+01	3.8E+13	2.3E+05	2.8E+02	8.3E+01		3.8E+03	3.4E+03		7.2E+08
U234G		3.4E+03	---	1.1E+18	1.1E+06	3.6E+04	1.3E+04	1.2E+04	3.6E+04	1.3E+04	1.2E+04	2.2E+16	3.9E+08	1.1E+05	3.5E+04		3.8E+03	3.4E+03		7.2E+08
U235	2.51E-02	5.7E-01	1.7E+09	3.0E+04	6.1E+00	4.8E+00	5.0E+00	5.9E+00	---	---	---	1.3E+10	3.2E+00	5.7E-01	6.2E-01		5.0E+02	2.2E+03		
U235G		2.4E+02	2.3E+12	1.7E+07	2.4E+03	2.1E+03	1.9E+03	1.9E+03	---	---	---	7.6E+12	7.4E+03	2.6E+02	2.4E+02		5.0E+02	2.2E+03		
U235P		5.0E+02	5.5E+13	4.1E+08	2.6E+04	2.3E+04	2.1E+04	2.1E+04	---	---	---	8.3E+13	9.9E+04	2.8E+03	2.6E+03		5.0E+02	2.2E+03		
U236	9.09E-03	3.9E+03	---	2.3E+19	2.3E+10	3.1E+10	2.5E+10	2.4E+10	4.1E+10	3.3E+10	3.2E+10	3.9E+11	2.5E+12	5.8E+10	1.2E+10		2.8E+07	3.9E+03		
U236G		3.9E+03	---	---	1.6E+13	2.1E+13	1.7E+13	1.6E+13	2.8E+13	2.3E+13	2.2E+13	2.3E+14	3.3E+15	3.7E+13	7.3E+12		2.8E+07	3.9E+03		
U238	6.97E-01	9.7E+02	---	---	3.3E+06	1.2E+05	3.9E+04	3.6E+04	1.3E+05	3.9E+04	3.6E+04	2.0E+09	1.8E+09	3.7E+05	1.1E+05		9.7E+02	4.0E+03		6.1E+12
U238G		9.7E+02	---	---	1.3E+09	4.7E+07	1.5E+07	1.4E+07	4.7E+07	1.5E+07	1.4E+07	1.2E+12	3.0E+12	1.4E+08	4.1E+07		9.7E+02	4.0E+03		6.1E+12
W181		---															---	---		
W185		---															---	---		
W188		---															---	---		
ZR93	6.90E-07	6.3E-01	1.5E+00	6.3E-01	7.3E-01	---	---	---	---	---	---	---	8.8E+00	4.8E+00	4.4E+00		---	9.5E+05		

Table C-9. Current WITS inventory limits for ST07.

WITS	Inventory	Most Limiting	Groundwater Protection Limits													Intruder Limits (Ci)		Air Pathway	Radon Pathway
			Beta-Gamma (Ci)			Gross Alpha (Ci)			Radium (Ci)			Uranium (Ci)	All-Pathways Limit (Ci)					Limits	Limits
Nuclide	(Ci)	(Ci)	0-12 yrs	12-100 yrs	100-1130 yrs	0-1000 yrs	1000-1120 yrs	1120-1130 yrs	0-1000 yrs	1000-1120 yrs	1120-1130 yrs	All Years	130 - 200 yrs	200-1000 yrs	1000-1130 yrs	Resident	Post-drilling	(Ci)	(Ci)
AC227	2.340E-04	4.2E+03														3.1E+07	4.2E+03		
AG108M		3.6E+01														3.6E+01	2.3E+03		
AL26		3.9E+00														3.9E+00	1.6E+03		
AM241	5.884E-01	5.0E+01	4.3E+09	2.0E+06	1.2E+04	2.4E+02	1.4E+02	1.3E+02	---	---	---	1.8E+12	6.9E+02	8.8E+01	5.0E+01	6.2E+05	1.4E+03		
AM242M	2.446E-04	1.4E+03														1.6E+05	1.4E+03		
AM243	1.749E-03	1.0E+01	---	5.9E+16	5.3E+02	7.3E+01	2.9E+01	2.7E+01	---	---	---	1.3E+12	3.2E+10	2.8E+01	1.0E+01	3.9E+02	1.1E+03		
AR39		3.6E+07														---	3.6E+07		
BA133	1.371E-05	8.2E+06														4.3E+09	8.2E+06		
BI207		2.3E+04														9.9E+04	2.3E+04		
BK249		1.4E+05														1.4E+05	4.9E+05		
C14	2.304E-02	2.8E-01	2.8E-01	2.8E-01	3.6E+00	---	---	---	---	---	---	---	3.7E+00	1.0E+01	1.2E+01	---	2.0E+03	1.9E+05	
C-14N	1.198E-02	2.8E+00	---	---	2.8E+00	---	---	---	---	---	---	---	3.3E+00	2.9E+00	1.1E+02	---	2.0E+03	1.9E+05	
CA41		1.2E+04														---	1.2E+04		
CD113M		3.0E+04														---	3.0E+04		
CF249	2.874E-04	4.6E+01	1.3E+17	3.4E+12	3.6E+04	3.4E+02	1.6E+02	1.4E+02	---	---	---	1.0E+14	2.0E+06	1.1E+02	4.6E+01	3.7E+02	1.3E+03		
CF250		2.6E+05														3.8E+13	2.6E+05		
CF251	2.379E-04	1.7E+01	---	---	1.9E+08	1.4E+02	6.1E+01	5.8E+01	---	---	---	9.0E+17	4.0E+18	4.1E+01	1.7E+01	1.4E+03	1.2E+03		
CF252	1.766E-03	5.3E+07														7.5E+11	5.3E+07		
CL36		9.5E-02	9.5E-02	9.5E-02	1.2E+00	---	---	---	---	---	---	---	6.5E-01	1.8E+00	2.2E+00	---	2.5E+01	---	
CM242	4.995E-05	7.0E+05														2.6E+09	7.0E+05		
CM243	2.417E-04	2.2E+04														4.1E+07	2.2E+04		
CM244	1.491E-01	1.0E+05	---	---	9.9E+17	7.8E+10	1.0E+10	8.8E+09	1.8E+18	1.4E+18	1.3E+18	1.1E+18	---	3.0E+10	3.4E+09	4.4E+11	1.0E+05		
CM245	1.169E-04	5.3E+00	1.9E+13	1.2E+09	1.3E+03	4.0E+01	1.6E+01	1.4E+01	---	---	---	2.0E+12	7.3E+03	1.4E+01	5.3E+00	2.4E+03	7.7E+02		
CM246	1.408E-04	1.0E+01	---	---	8.5E+14	7.8E+01	3.0E+01	2.8E+01	1.2E+16	4.0E+15	3.7E+15	2.1E+13	---	2.9E+01	1.0E+01	1.0E+11	1.5E+03		
CM247	2.586E-04	8.7E+00	---	---	4.0E+03	6.1E+01	2.3E+01	2.2E+01	---	---	---	1.6E+13	7.0E+12	2.4E+01	8.7E+00	7.9E+01	1.3E+03		
CM248	3.262E-05	2.4E+00	---	---	3.4E+09	7.3E+01	2.8E+01	2.7E+01	---	---	---	3.2E+17	2.6E+19	6.8E+00	2.4E+00	5.5E+06	3.9E+02		
CO60	1.322E+00	8.3E+08														2.0E+09	8.3E+08		
CS134	2.132E-03	4.8E+17														1.5E+19	4.8E+17		
CS135		2.4E+04														---	2.4E+04		
CS137	2.744E+01	2.4E+04														2.1E+06	2.4E+04		
EU152	9.929E-02	6.5E+05														2.3E+06	6.5E+05		
EU154	4.969E-02	1.1E+07														4.1E+07	1.1E+07		
EU155	3.214E-01	2.4E+11														4.0E+18	2.4E+11		
H3	4.317E-01	2.0E+00	5.2E+00	2.0E+00	2.1E+04	---	---	---	---	---	---	---	1.7E+06	4.6E+06	4.6E+06	---	2.1E+06	2.8E+18	
H3C	6.990E-02	6.2E+04	---	---	6.2E+04	---	---	---	---	---	---	---	1.7E+06	1.2E+09	---	---	2.1E+06	2.8E+18	
I129	3.046E-05	1.6E-04	1.6E-04	1.6E-04	1.6E-03	---	---	---	---	---	---	---	9.5E-02	2.1E-01	5.0E-01	7.3E+09	3.8E+02	---	
I129C	3.750E-03	1.9E-01	---	---	1.9E-01	---	---	---	---	---	---	---	2.3E+01	1.2E+01	1.1E+01	7.3E+09	3.8E+02	---	
I129I		2.6E-01	1.3E+00	6.4E-01	2.6E-01	---	---	---	---	---	---	---	3.1E+01	1.7E+01	1.6E+01	7.3E+09	3.8E+02	---	
I129B		3.3E+00	1.7E+01	8.5E+00	3.3E+00	---	---	---	---	---	---	---	4.1E+02	2.1E+02	2.0E+02	7.3E+09	3.8E+02	---	
I129G		3.3E-03	6.5E-03	3.3E-03	3.4E-03	---	---	---	---	---	---	---	2.1E-01	3.3E-01	1.1E+00	7.3E+09	3.8E+02	---	
I129D		1.8E-01	8.8E-01	4.4E-01	1.8E-01	---	---	---	---	---	---	---	2.1E+01	1.1E+01	1.1E+01	7.3E+09	3.8E+02	---	
I129J	7.810E-07	3.7E-03	7.3E-03	3.7E-03	3.7E-03	---	---	---	---	---	---	---	2.2E-01	3.7E-01	1.1E+00	7.3E+09	3.8E+02	---	
I129A		1.4E+00	7.4E+00	3.8E+00	1.4E+00	---	---	---	---	---	---	---	1.8E+02	9.4E+01	8.9E+01	7.3E+09	3.8E+02	---	
I129H		1.6E-02	4.9E-02	2.4E-02	1.6E-02	---	---	---	---	---	---	---	1.2E+00	9.9E-01	9.3E-01	7.3E+09	3.8E+02	---	
I129E		3.9E-01	2.0E+00	1.0E+00	3.9E-01	---	---	---	---	---	---	---	4.9E+01	2.6E+01	2.3E+01	7.3E+09	3.8E+02	---	
I129F		2.4E-02	8.3E-02	4.2E-02	2.4E-02	---	---	---	---	---	---	---	2.0E+00	1.7E+00	1.4E+00	7.3E+09	3.8E+02	---	
I129R		4.1E-01	4.0E+00	1.6E+00	4.1E-01	---	---	---	---	---	---	---	6.0E+01	2.6E+01	8.4E+01	7.3E+09	3.8E+02	---	
K40		6.5E-02	7.2E-02	6.5E-02	5.6E-01	---	---	---	---	---	---	---	1.2E+00	2.3E+00	2.6E+01	6.7E+01	5.1E+02		
KR85	5.371E-02	1.2E+09														9.9E+10	1.2E+09		
MO93		2.1E-01	2.1E-01	2.1E-01	1.4E+00	---	---	---	---	---	---	---	6.9E+00	1.9E+01	2.3E+01	---	4.7E+05		
NA22	1.670E-11	5.9E+14														2.7E+15	5.9E+14		
NB93M	1.982E-02	1.2E+08														---	1.2E+08		
NB94	2.746E-04	1.0E-01	1.0E-01	1.0E-01	1.3E+00	---	---	---	---	---	---	---	7.7E-01	2.1E+00	2.6E+00	9.6E+00	2.7E+03		
NI59	1.069E-01	4.6E+00	6.4E+19	3.8E+09	4.6E+00	---	---	---	---	---	---	---	1.1E+06	2.4E+03	1.1E+03	---	4.2E+05		
NI63	5.046E-01	3.0E+05														---	3.0E+05		
NP237	4.731E-03	2.7E-02	2.7E+03	4.3E+00	1.8E+00	8.8E-02	1.7E-01	4.0E-01	---	---	---	2.4E+08	2.9E-02	2.7E-02	5.3E-02	1.7E+02	1.1E+02		
PA231		8.1E+01														8.1E+01	1.2E+02		
PB210	1.603E-06	2.2E+03														1.4E+11	2.2E+03		
PD107		5.4E+02	---	4.7E+11	5.4E+02	---	---	---	---	---	---	---	1.7E+06	3.7E+03	1.8E+03	---	8.7E+05		
PU238	5.403E+00	3.6E+03	---	---	1.1E+07	4.1E+05	1.3E+05	1.2E+05	4.1E+05	1.3E+05	1.2E+05	1.7E+17	2.6E+09	1.2E+06	3.6E+05	1.3E+07	3.6E+03		7.7E+12
PU239	2.213E+00	1.5E+03	1.1E+18	7.4E+12	1.2E+07	1.1E+07	7.4E+06	7.2E+06	---	---	---	3.7E+15	4.8E+07	1.3E+06	1.1E+06	3.8E+06	1.5E+03		
PU240	5.068E-01	1.5E+03	---	---	2.6E+15	3.0E+08	3.7E+07	3.1E+07	4.6E+15	3.6E+15	3.4E+15	4.0E+15	1.4E+18	1.1E+08	1.2E+07	1.2E+09	1.5E+03		
PU241	1.360E+01	1.4E+03	1.6E+12	2.8E+08	3.7E+05	7.3E+03	4.1E+03	4.0E+03	---	---	---	5.6E+13	2.4E+04	2.7E+03	1.4E+03	1.9E+07	4.1E+04		
PU242	1.966E-02	1.5E+03	---	---	1.1E+14	2.7E+08	3.2E+07	2.8E+07	4.1E+12	1.3E+12	1.2E+12	3.6E+15	3.7E+17	1.1E+08	1.1E+07	6.9E+08	1.5E+03		
PU244	1.129E-09	4.4E+01	---	---	2.3E+09	2.4E+08	2.9E+07	2.4E+07	1.9E+17	1.3E+17	1.3E+17	3.3E+16	---	1.0E+08	1.0E+07	4.4E+01	1.3E+03		
RA226	1.608E-06	4.2E-02	2.6E+17	2.8E+07	3.2E+00	7.1E-02	4.2E-02	4.2E-02	7.1E-02	4.2E-02	4.2E-02	---	5.8E+00	2.1E-01	1.2E-01	9.1E+00	7.1E+01		2.2E+04
RA226T		2.6E-01	---	1.3E+12	1.6E+01	2.6E-01	1.1E+00	9.2E-01	2.6E-01	1.1E+00	9.2E-01	---	1.1E+04	7.3E-01	2.7E+00	9.1E+00	7.1E+01		2.2E+04
RA228	2.575E-05	2.5E+07														1.3E+08	2.5E+07		
RB87		1.5E+04														---	1.5E+04		
S35		---														---	---	---	
SB124		---																---	
SB125	1.281E-02	7.4E+14														5.0E+16	7.4E+14	---	
SC46		---														---	---		
SE75		---																---	
SE79	8.784E-04	2.4E+04	---	---	3.6E+19	---	---	---	---	---	---	---	---	---	3.8E+19	---	2.4E+04	---	
SM151	1.708E-02	5.9E+06														---	5.9E+06		
SN113	6.495E-06	---																---	
SN119M		---																---	
SN121		---																---	
SN121M		1.6E+06														---	1.6E+06	---	
SN123		---																---	
SN126	8.237E-06	8.7E+00	---	---	---	---	---	---	---	---	---	---	---	---	---	8.7E+00	2.1E+03	---	
SR90	5.869E+00	7.9E+01	1.1E+15	3.8E+06	7.9E+01	---	---	---	---	---	---	---	6.7E+03	1.6E+03	2.7E+10	---	1.6E+03		
SR90R		1.6E+03	1.6E+18	3.6E+09	4.4E+04	---	---	---	---	---	---	---	3.4E+06	8.5E+05	3.7E+12	---	1.6E+03		
TC99	8.327E-03	1.4E-01	1.8E-01	1.4E-01	1.4E+00	---	---	---	---	---	---	---	2.1E+00	3.9E+00	8.5E+00	1.0E+09	2.4E+03		
TC99R		3.7E+02	5.9E+03	1.4E+03	3.7E+02	---	---	---	---	---	---	---	1.6E+03	5.4E+02	1.9E+03	1.0E+09	2.4E+03		
TH228	1.052E-03	3.4E+18														6.6E+18	3.4E+18		
TH229	1.942E-04	9.0E+01														9.0E+01	5.0E+02		
TH230	2.549E-05	1.1E-01	---	2.2E+10	9.8E+00	3.4E-01	1.2E-01	1.1E-01	3.4E-01	1.2E-01	1.1E-01	---	1.6E+02	1.0E+00	3.3E-01	1.9E+01	1.9E+02		4.2E+05
TH230T		1.9E+00	---	1.1E+15	1.2E+02	2.1E+00	2.0E+00	1.9E+00	2.1E+00	2.0E+00	1.9E+00	---	5.4E+05	6.2E+00	5.4E+00	1.9E+01	1.9E+02		4.2E+05
TH232	1.317E-04	4.4E+00	6.7E+16	4.2E+09	3.0E+03	3.0E+03	7.0E+03	8.9E+03	4.0E+03	9.3E+03	1.2E+04	---	1.9E+04	8.0E+03	1.9E+04	4.4E+00	1.5E+02		
U232	1.037E-03	9.4E+02														3.2E+03	9.4E+02		
U233	9.050E-02	9.3E+02	---	---	5.2E+11	1.3E+12	1.3E+11	1.1E+11	---	---	---	1.8E+13	---	4.2E+10	4.2E+09	9.3E+02	2.2E+03		
U234	8.318E-02	3.2E+01	---	8.3E+14	2.9E+03	1.1E+02	3.4E+01	3.2E+01	1.1E+02	3.4E+01	3.2E+01	4.2E+13	2.6E+05	3.1E+02	9.3E+01	3.8E+03	3.4E+03		7.2E+08
U234G		3.4E+03	---	1.2E+18	1.2E+06	4.0E+04	1.4E+04	1.3E+04	4.0E+04	1.4E+04	1.3E+04	2.4E+16	4.3E+08	1.2E+05	3.9E+04	3.8E+03	3.4E+03		7.2E+08
U235	3.304E-03	6.4E-01	1.9E+09	3.3E+04	6.9E+00	5.3E+00	5.6E+00	6.7E+00	---	---	---	1.4E+10	3.6E+00	6.4E-01	7.0E-01	5.0E+02	2.2E+03		
U235G		2.7E+02	2.6E+12	1.9E+07	2.7E+03	2.3E+03	2.1E+03	2.1E+03	---	---	---	8.5E+12	8.3E+03	2.9E+02	2.7E+02	5.0E+02	2.2E+03		
U235P		5.0E+02	6.2E+13	4.6E+08	2.9E+04	2.6E+04	2.3E+04	2.3E+04	---	---	---	9.3E+13	1.1E+05	3.1E+03	2.9E+03	5.0E+02	2.2E+03		
U236	2.496E-03	3.9E+03	---	2.6E+19	2.6E+10	3.4E+10	2.8E+10	2.7E+10	4.6E+10	3.7E+10	3.6E+10	4.3E+11	2.8E+12	6.5E+10	1.3E+10	2.8E+07	3.9E+03		
U236G		3.9E+03	---	---	1.8E+13	2.3E+13	1.9E+13	1.8E+13	3.1E+13	2.6E+13	2.4E+13	2.6E+14	3.7E+15	4.1E+13	8.2E+12	2.8E+07	3.9E+03		
U238	5.488E-02	9.7E+02	---	---	3.7E+06	1.3E+05	4.3E+04	4.0E+04	1.4E+05	4.3E+04	4.0E+04	2.2E+09	2.0E+09	4.1E+05	1.2E+05	9.7E+02	4.0E+03		6.1E+12
U238G		9.7E+02	---	---	1.4E+09	5.2E+07	1.7E+07	1.6E+07	5.2E+07	1.7E+07	1.6E+07	1.3E+12	3.3E+12	1.6E+08	4.6E+07	9.7E+02	4.0E+03		6.1E+12
W181		---														---	---		
W185		---														---	---		
W188		---														---	---		
ZR93	1.919E-05	7.1E-01	1.7E+00	7.1E-01	8.2E-01	---	---	---	---	---	---	---	9.9E+00	5.3E+00	4.9E+00	---	9.5E+05		

Table C-10. Current WITS inventory limits for ST14.

			Groundwater Protection Limits													Intruder Limits		Air Pathway	Radon Pathway
WITS	Inventory	Most Limiting	Beta-Gamma (Ci) *			Gross Alpha (Ci)			Radium (Ci)			Uranium (Ci)	All-Pathways Limits (Ci) *					Limits	Limits
Nuclide	(Ci)	(Ci)	0-12 yrs	12-100 yrs	100-1130 yrs	0-1000 yrs	1000-1120 yrs	1120-1130 yrs	0-1000 yrs	1000-1120 yrs	1120-1130 yrs	All Years	130 - 200 yrs	200-1000 yrs	1000-1130 yrs	Resident	Post-drilling	(Ci)	(Ci)
AC227	1.430E-10	4.2E+03														3.1E+07	4.2E+03		
AG108M	3.290E+00	3.6E+01														3.6E+01	2.3E+03		
AL26		3.9E+00														3.9E+00	1.6E+03		
AM241	3.517E-01	8.9E+01	1.7E+10	1.6E+06	5.8E+03	2.9E+02	3.4E+02	3.3E+02	---	---	---	8.5E+11	4.4E+02	8.9E+01	1.1E+02	6.2E+05	1.4E+03		
AM242M	7.889E-05	1.4E+03														1.6E+05	1.4E+03		
AM243	3.169E-03	4.1E+01	---	3.5E+16	2.1E+03	4.0E+02	1.2E+02	1.1E+02	---	---	---	7.9E+12	1.7E+10	1.6E+02	4.1E+01	3.9E+02	1.1E+03		
AR39	5.776E-14	3.6E+07														---	3.6E+07		
BA133	1.770E-04	8.2E+06														4.3E+09	8.2E+06		
BI207		2.3E+04														9.9E+04	2.3E+04		
BK249		1.4E+05														1.4E+05	4.9E+05		
C14	2.525E-02	1.9E-01	2.3E-01	1.9E-01	4.4E+00	---	---	---	---	---	---	---	5.6E+00	5.6E+00	5.6E+00	---	2.0E+03	1.9E+05	
C14N	2.095E-02	1.3E+00	---	---	1.3E+00	---	---	---	---	---	---	---	2.3E+00	1.4E+00	4.0E+02	---	2.0E+03	1.9E+05	
C14H	5.181E+00	2.0E+03	---	---	---								---	---	---	---	2.0E+03	1.9E+05	
CA41		1.2E+04														---	1.2E+04		
CD113M	1.596E-01	3.0E+04														---	3.0E+04		
CF249	7.337E-11	1.8E+02	5.6E+17	2.9E+12	1.0E+05	1.7E+03	6.2E+02	5.7E+02	---	---	---	4.8E+13	1.0E+06	5.4E+02	1.8E+02	3.7E+02	1.3E+03		
CF250		2.6E+05														3.8E+13	2.6E+05		
CF251	5.405E-08	6.6E+01	---	---	7.5E+08	8.0E+02	2.6E+02	2.3E+02	---	---	---	5.0E+18	2.4E+18	2.3E+02	6.6E+01	1.4E+03	1.2E+03		
CF252		5.3E+07														7.5E+11	5.3E+07		
CL36	3.387E-07	6.8E-02	7.9E-02	6.8E-02	1.6E+00	---	---	---	---	---	---	---	1.0E+00	1.0E+00	1.0E+00	---	2.5E+01	---	
CM242	5.264E-05	7.0E+05														2.6E+09	7.0E+05		
CM243	2.699E-06	2.2E+04														4.1E+07	2.2E+04		
CM244	1.596E+00	1.0E+05	---	---	5.7E+18	2.1E+12	2.4E+11	2.0E+11	1.0E+19	8.0E+18	7.7E+18	2.7E+19	---	8.4E+11	7.8E+10	4.4E+11	1.0E+05		
CM245	2.492E-06	1.8E+01	7.5E+13	9.2E+08	3.2E+03	1.4E+02	5.5E+01	5.1E+01	---	---	---	8.9E+11	4.3E+03	4.9E+01	1.8E+01	2.4E+03	7.7E+02		
CM246	2.480E-06	4.2E+01	---	---	5.1E+15	4.2E+02	1.3E+02	1.1E+02	1.0E+16	3.5E+15	3.1E+15	1.3E+14	---	1.6E+02	4.2E+01	1.0E+11	1.5E+03		
CM247	1.024E-15	3.5E+01	---	---	1.7E+04	3.4E+02	9.2E+01	8.8E+01	---	---	---	8.6E+13	3.8E+12	1.4E+02	3.5E+01	7.9E+01	1.3E+03		
CM248	3.243E-15	1.0E+01	---	---	1.7E+10	4.0E+02	1.2E+02	1.1E+02	---	---	---	2.1E+18	---	3.8E+01	1.0E+01	5.5E+06	3.9E+02		
CO60	2.032E+02	8.3E+08														2.0E+09	8.3E+08		
CS134	1.123E-01	4.8E+17														1.5E+19	4.8E+17		
CS135	6.091E-08	2.4E+04														---	2.4E+04		
CS137	8.346E+01	2.4E+04														2.1E+06	2.4E+04		
EU152	6.244E-04	6.5E+05														2.3E+06	6.5E+05		
EU154	2.660E-05	1.1E+07														4.1E+07	1.1E+07		
EU155	9.907E-05	2.4E+11														4.0E+18	2.4E+11		
H3	1.082E-01	2.0E+00	4.5E+00	2.0E+00	1.2E+04	---	---	---	---	---	---	---	2.0E+06	2.0E+06	2.0E+06	---	2.1E+06	2.8E+18	
H3C		5.0E+04	---	---	5.0E+04	---	---	---	---	---	---	---	1.3E+06	6.3E+08	---	---	2.1E+06	2.8E+18	
I129	1.405E-05	1.0E-04	1.6E-04	1.0E-04	3.1E-03	---	---	---	---	---	---	---	2.3E-01	2.3E-01	2.3E-01	7.3E+09	3.8E+02	---	
I129C		8.6E-02	---	---	8.6E-02	---	---	---	---	---	---	---	1.0E+01	5.4E+00	5.2E+00	7.3E+09	3.8E+02	---	
I129I		1.2E-01	1.2E+00	3.1E-01	1.2E-01	---	---	---	---	---	---	---	1.5E+01	7.5E+00	7.2E+00	7.3E+09	3.8E+02	---	
I129B		1.6E+00	1.6E+01	4.1E+00	1.6E+00	---	---	---	---	---	---	---	1.9E+02	1.0E+02	9.2E+01	7.3E+09	3.8E+02	---	
I129G		1.6E-03	6.0E-03	1.6E-03	2.1E-03	---	---	---	---	---	---	---	1.3E-01	1.8E-01	6.4E-01	7.3E+09	3.8E+02	---	
I129D		8.2E-02	8.0E-01	2.1E-01	8.2E-02	---	---	---	---	---	---	---	1.0E+01	5.2E+00	5.0E+00	7.3E+09	3.8E+02	---	
I129J		1.7E-03	6.7E-03	1.7E-03	2.3E-03	---	---	---	---	---	---	---	1.4E-01	1.9E-01	6.2E-01	7.3E+09	3.8E+02	---	
I129A		6.8E-01	6.8E+00	1.8E+00	6.8E-01	---	---	---	---	---	---	---	8.4E+01	4.4E+01	4.1E+01	7.3E+09	3.8E+02	---	
I129H		7.4E-03	4.5E-02	1.2E-02	7.4E-03	---	---	---	---	---	---	---	5.7E-01	4.7E-01	4.4E-01	7.3E+09	3.8E+02	---	
I129E		1.8E-01	1.8E+00	4.9E-01	1.8E-01	---	---	---	---	---	---	---	2.2E+01	1.2E+01	1.1E+01	7.3E+09	3.8E+02	---	
I129F		1.1E-02	7.6E-02	2.0E-02	1.1E-02	---	---	---	---	---	---	---	9.2E-01	7.6E-01	6.8E-01	7.3E+09	3.8E+02	---	
K40	3.667E-06	8.0E-02	1.2E-01	8.0E-02	8.3E-01	---	---	---	---	---	---	---	2.2E+00	2.9E+00	4.3E+01	6.7E+01	5.1E+02		
KR85	5.671E-04	1.2E+09														9.9E+10	1.2E+09		
M093	1.520E-06	1.4E-01	1.7E-01	1.4E-01	1.7E+00	---	---	---	---	---	---	---	1.0E+01	1.0E+01	1.0E+01	---	4.7E+05		
MO93H	1.694E-02	2.5E+01	2.3E+11	1.7E+10	2.5E+01								3.0E+13	4.1E+03	1.5E+02	---	4.7E+05		
NA22	2.415E-07	5.9E+14														2.7E+15	5.9E+14		
NB93M	5.161E-02	1.2E+08														---	1.2E+08		
NB93MH	1.197E-02	1.2E+08	1.0E+10	1.9E+09	1.0E+09								1.2E+13	5.9E+09	6.0E+10	---	1.2E+08		
NB94	7.217E-04	7.5E-02	8.6E-02	7.5E-02	1.7E+00	---	---	---	---	---	---	---	1.2E+00	1.2E+00	1.2E+00	9.6E+00	2.7E+03		
NB94H	1.096E-01	9.6E+00	1.7E+10	2.8E+09	1.1E+05								3.4E+10	6.0E+04	7.7E+04	9.6E+00	2.7E+03		
NI59	2.463E-02	5.2E+00	---	8.0E+09	5.2E+00	---	---	---	---	---	---	---	1.0E+07	1.9E+03	1.3E+03	---	4.2E+05		
NI59H	3.675E+01	4.2E+05	---	---	1.5E+17								---	---	3.9E+19	---	4.2E+05		
NI63	1.083E+00	3.0E+05														---	3.0E+05		
NI63H	3.252E+03	3.0E+05	---	---	8.9E+19								---	---	---	---	3.0E+05		
NP237	5.205E-03	1.4E-02	1.0E+04	3.3E+00	9.0E-01	4.5E-02	7.5E-02	1.6E-01	---	---	---	1.3E+08	1.9E-02	1.4E-02	2.3E-02	1.7E+02	1.1E+02		
PA231	2.924E-10	8.1E+01														8.1E+01	1.2E+02		
PB210	3.207E-07	2.2E+03														1.4E+11	2.2E+03		
PD107	1.694E-08	6.3E+02	---	1.0E+12	6.3E+02	---	---	---	---	---	---	---	1.6E+07	3.0E+03	2.0E+03	---	8.7E+05		
PU238	3.420E+00	3.6E+03	---	---	9.2E+06	3.4E+05	1.1E+05	1.0E+05	3.4E+05	1.1E+05	1.0E+05	6.1E+18	1.7E+10	1.0E+06	2.9E+05	1.3E+07	3.6E+03		7.7E+12
PU239	4.721E-01	1.5E+03	4.3E+18	4.6E+12	5.4E+06	4.9E+06	4.2E+06	4.2E+06	---	---	---	9.2E+16	2.9E+07	5.8E+05	5.3E+05	3.8E+06	1.5E+03		
PU240	1.289E-01	1.5E+03	---	---	1.5E+16	8.5E+09	8.7E+08	7.4E+08	2.6E+16	2.0E+16	2.0E+16	1.0E+17	1.3E+19	3.3E+09	2.9E+08	1.2E+09	1.5E+03		
PU241	3.711E+00	2.8E+03	6.7E+12	2.2E+08	1.7E+05	8.8E+03	1.0E+04	1.0E+04	---	---	---	2.6E+13	1.6E+04	2.8E+03	3.3E+03	1.9E+07	4.1E+04		
PU242	1.416E-03	1.5E+03	---	---	9.2E+13	7.6E+09	7.7E+08	6.5E+08	3.2E+12	1.1E+12	1.0E+12	9.0E+16	2.4E+18	3.1E+09	2.7E+08	6.9E+08	1.5E+03		
PU244	1.535E-15	4.4E+01	---	---	5.5E+10	6.9E+09	6.9E+08	5.8E+08	1.1E+18	8.0E+17	7.6E+17	8.5E+17	---	2.9E+09	2.4E+08	4.4E+01	1.3E+03		
RA226	8.346E-05	2.8E-02	4.7E+18	4.8E+07	2.3E+00	6.8E-02	2.8E-02	2.8E-02	6.8E-02	2.9E-02	2.8E-02	---	2.9E+01	2.0E-01	7.9E-02	9.1E+00	7.1E+01		2.2E+04
RA228	3.859E-07	2.5E+07														1.3E+08	2.5E+07		
RB87	1.295E-11	1.5E+04														---	1.5E+04		
S35		0.0E+00														---	---	---	
SB124		0.0E+00																---	
SB125	3.160E-02	7.4E+14														5.0E+16	7.4E+14	---	
SC46		0.0E+00														---	---		
SE75		0.0E+00																---	
SE79	1.613E-06	2.4E+04	---	---	---	---	---	---	---	---	---	---	---	---	---	---	2.4E+04	---	
SM151	4.869E-04	5.9E+06														---	5.9E+06		
SN113	1.850E-09	0.0E+00																---	
SN119M	8.296E-16	0.0E+00																---	
SN121	5.076E-03	0.0E+00																---	
SN121M	6.581E-03	1.6E+06														---	1.6E+06	---	
SN123		0.0E+00																---	
SN126	1.376E-04	8.7E+00	---	---	---	---	---	---	---	---	---	---	---	---	---	8.7E+00	2.1E+03	---	
SR90	3.160E+01	1.3E+02	2.0E+16	6.6E+06	1.3E+02	---	---	---	---	---	---	---	3.6E+04	2.5E+03	2.7E+10	---	1.6E+03		
TC99	1.591E-02	1.0E-01	2.3E-01	1.0E-01	2.3E+00	---	---	---	---	---	---	---	4.0E+00	4.0E+00	4.0E+00	1.0E+09	2.4E+03		
TC99H	3.192E-03	9.9E+00	---	6.1E+16	9.9E+00								1.7E+13	1.5E+01	6.7E+01	1.0E+09	2.4E+03		
TH228	3.863E-07	3.4E+18														6.6E+18	3.4E+18		
TH229	4.015E-11	9.0E+01														9.0E+01	5.0E+02		
TH230	3.403E-07	9.1E-02	---	3.8E+10	8.4E+00	3.4E-01	1.0E-01	9.1E-02	3.4E-01	1.0E-01	9.1E-02	---	1.0E+03	1.0E+00	2.7E-01	1.9E+01	1.9E+02		4.2E+05
TH232	5.387E-07	4.4E+00	1.3E+18	2.9E+10	1.7E+04	1.7E+04	3.9E+04	4.9E+04	2.2E+04	5.1E+04	6.5E+04	---	1.7E+05	4.4E+04	1.0E+05	4.4E+00	1.5E+02		
U232	1.767E-05	9.4E+02														3.2E+03	9.4E+02		
U233	4.235E-03	9.3E+02	---	---	1.6E+13	4.1E+13	4.0E+12	3.3E+12	---	---	---	5.1E+14	---	1.3E+12	1.2E+11	9.3E+02	2.2E+03		
U234	3.106E-02	2.6E+01	---	1.5E+15	2.4E+03	9.0E+01	2.9E+01	2.6E+01	9.0E+01	2.9E+01	2.6E+01	1.6E+15	1.7E+06	2.7E+02	7.6E+01	3.8E+03	3.4E+03		7.2E+08
U235	1.197E-03	3.0E-01	7.8E+09	2.0E+04	3.2E+00	2.6E+00	2.6E+00	2.9E+00	---	---	---	8.1E+11	2.3E+00	3.0E-01	3.2E-01	5.0E+02	2.2E+03		
U236	3.187E-04	3.9E+03	---	---	1.5E+11	1.9E+11	1.6E+11	1.6E+11	2.6E+11	2.1E+11	2.0E+11	1.6E+13	2.6E+13	4.9E+11	2.5E+11	2.8E+07	3.9E+03		
U238	7.361E-03	9.7E+02	---	---	3.1E+06	1.1E+05	3.7E+04	3.4E+04	1.1E+05	3.7E+04	3.4E+04	8.3E+10	1.3E+10	3.2E+05	1.0E+05	9.7E+02	4.0E+03		6.1E+12
W181		0.0E+00														---	---		
W185		0.0E+00														---	---		
W188		0.0E+00														---	---		
ZR93	7.861E-05	4.0E-01	1.7E+00	4.0E-01	4.6E-01	---	---	---	---	---	---	---	7.4E+00	2.9E+00	2.8E+00	---	9.5E+05		

Table C-11. Current WITS inventory limits for ST15 though ST20.

			Groundwater Protection Limits													Intruder Limits		Air Pathway	Radon Pathway
WITS	Inventory	Most Limiting	Beta-Gamma (Ci)			Gross Alpha (Ci)			Radium (Ci)			Uranium (Ci)	All-Pathways Limits (Ci)					Limits	Limits
Nuclide	(Ci)	(Ci)	0-12 yrs	12-100 yrs	100-1130 yrs	0-1000 yrs	1000-1120 yrs	1120-1130 yrs	0-1000 yrs	1000-1120 yrs	1120-1130 yrs	All Years	130 - 200 yrs	200-1000 yrs	1000-1130 yrs	Resident	Post-drilling	(Ci)	(Ci)
AC227		4.2E+03														3.1E+07	4.2E+03		
AG108M		3.6E+01														3.6E+01	2.3E+03		
AL26		3.9E+00														3.9E+00	1.6E+03		
AM241	4.630E-01	9.7E+01	1.9E+10	1.7E+06	6.3E+03	3.1E+02	3.7E+02	3.6E+02	---	---	---	9.2E+11	4.8E+02	9.7E+01	1.2E+02	6.2E+05	1.4E+03		
AM242M		1.4E+03														1.6E+05	1.4E+03		
AM243	2.157E-02	4.5E+01	---	3.8E+16	2.3E+03	4.4E+02	1.3E+02	1.2E+02	---	---	---	8.6E+12	1.8E+10	1.7E+02	4.5E+01	3.9E+02	1.1E+03		
AR39		3.6E+07														---	3.6E+07		
BA133		8.2E+06														4.3E+09	8.2E+06		
BI207		2.3E+04														9.9E+04	2.3E+04		
BK249		1.4E+05														1.4E+05	4.9E+05		
C14	2.153E-02	2.1E-01	2.5E-01	2.1E-01	4.8E+00	---	---	---	---	---	---	---	6.1E+00	6.1E+00	6.1E+00	---	2.0E+03	1.9E+05	
C14N		1.4E+00	---	---	1.4E+00	---	---	---	---	---	---	---	2.5E+00	1.5E+00	4.3E+02	---	2.0E+03	1.9E+05	
CA41		1.2E+04														---	1.2E+04		
CD113M		3.0E+04														---	3.0E+04		
CF249	1.813E-02	2.0E+02	6.1E+17	3.1E+12	1.1E+05	1.9E+03	6.7E+02	6.2E+02	---	---	---	5.2E+13	1.1E+06	5.9E+02	2.0E+02	3.7E+02	1.3E+03		
CF250		2.6E+05														3.8E+13	2.6E+05		
CF251	1.655E-02	7.2E+01	---	---	8.1E+08	8.7E+02	2.8E+02	2.5E+02	---	---	---	5.4E+18	2.6E+18	2.5E+02	7.2E+01	1.4E+03	1.2E+03		
CF252		5.3E+07														7.5E+11	5.3E+07		
CL36	2.879E-06	7.4E-02	8.6E-02	7.4E-02	1.7E+00	---	---	---	---	---	---	---	1.1E+00	1.1E+00	1.1E+00	---	2.5E+01	---	
CM242		7.0E+05														2.6E+09	7.0E+05		
CM243		2.2E+04														4.1E+07	2.2E+04		
CM244	1.071E+00	1.0E+05	---	---	6.2E+18	2.3E+12	2.6E+11	2.2E+11	1.1E+19	8.7E+18	8.4E+18	2.9E+19	---	9.1E+11	8.5E+10	4.4E+11	1.0E+05		
CM245	3.709E-04	2.0E+01	8.2E+13	1.0E+09	3.5E+03	1.5E+02	6.0E+01	5.5E+01	---	---	---	9.7E+11	4.7E+03	5.3E+01	2.0E+01	2.4E+03	7.7E+02		
CM246	1.732E-04	4.6E+01	---	---	5.5E+15	4.6E+02	1.4E+02	1.2E+02	1.1E+16	3.8E+15	3.4E+15	1.4E+14	---	1.7E+02	4.6E+01	1.0E+11	1.5E+03		
CM247	5.461E-04	3.8E+01	---	---	1.8E+04	3.7E+02	1.0E+02	9.6E+01	---	---	---	9.3E+13	4.1E+12	1.5E+02	3.8E+01	7.9E+01	1.3E+03		
CM248	9.175E-05	1.1E+01	---	---	1.9E+10	4.4E+02	1.3E+02	1.2E+02	---	---	---	2.3E+18	---	4.1E+01	1.1E+01	5.5E+06	3.9E+02		
CO60		8.3E+08														2.0E+09	8.3E+08		
CS134		4.8E+17														1.5E+19	4.8E+17		
CS135		2.4E+04														---	2.4E+04		
CS137		2.4E+04														2.1E+06	2.4E+04		
EU152		6.5E+05														2.3E+06	6.5E+05		
EU154		1.1E+07														4.1E+07	1.1E+07		
EU155		2.4E+11														4.0E+18	2.4E+11		
H3	1.293E+00	4.6E+00	4.9E+00	4.6E+00	1.3E+04	---	---	---	---	---	---	---	2.2E+06	2.2E+06	2.2E+06	---	2.1E+06	2.8E+18	
H3C		5.4E+04	---	---	5.4E+04	---	---	---	---	---	---	---	1.4E+06	6.8E+08	---	---	2.1E+06	2.8E+18	
I129	4.064E-05	1.1E-04	1.7E-04	1.1E-04	3.4E-03	---	---	---	---	---	---	---	2.5E-01	2.5E-01	2.5E-01	7.3E+09	3.8E+02	---	
I129C		9.3E-02	---	---	9.3E-02	---	---	---	---	---	---	---	1.1E+01	5.9E+00	5.6E+00	7.3E+09	3.8E+02	---	
I129I		1.3E-01	1.3E+00	3.4E-01	1.3E-01	---	---	---	---	---	---	---	1.6E+01	8.2E+00	7.8E+00	7.3E+09	3.8E+02	---	
I129B		1.7E+00	1.7E+01	4.5E+00	1.7E+00	---	---	---	---	---	---	---	2.1E+02	1.1E+02	1.0E+02	7.3E+09	3.8E+02	---	
I129G		1.7E-03	6.5E-03	1.7E-03	2.3E-03	---	---	---	---	---	---	---	1.4E-01	2.0E-01	7.0E-01	7.3E+09	3.8E+02	---	
I129D		8.9E-02	8.7E-01	2.3E-01	8.9E-02	---	---	---	---	---	---	---	1.1E+01	5.7E+00	5.4E+00	7.3E+09	3.8E+02	---	
I129J		1.9E-03	7.3E-03	1.9E-03	2.5E-03	---	---	---	---	---	---	---	1.5E-01	2.1E-01	6.7E-01	7.3E+09	3.8E+02	---	
I129A		7.4E-01	7.4E+00	2.0E+00	7.4E-01	---	---	---	---	---	---	---	9.1E+01	4.8E+01	4.5E+01	7.3E+09	3.8E+02	---	
I129H		8.0E-03	4.9E-02	1.3E-02	8.0E-03	---	---	---	---	---	---	---	6.2E-01	5.1E-01	4.8E-01	7.3E+09	3.8E+02	---	
I129E		2.0E-01	2.0E+00	5.3E-01	2.0E-01	---	---	---	---	---	---	---	2.4E+01	1.3E+01	1.2E+01	7.3E+09	3.8E+02	---	
I129F		1.2E-02	8.3E-02	2.2E-02	1.2E-02	---	---	---	---	---	---	---	1.0E+00	8.3E-01	7.4E-01	7.3E+09	3.8E+02	---	
K40	5.554E-04	8.7E-02	1.3E-01	8.7E-02	9.0E-01	---	---	---	---	---	---	---	2.4E+00	3.1E+00	4.7E+01	6.7E+01	5.1E+02		
KR85		1.2E+09														9.9E+10	1.2E+09		
M093	1.715E-03	1.5E-01	1.9E-01	1.5E-01	1.9E+00	---	---	---	---	---	---	---	1.1E+01	1.1E+01	1.1E+01	---	4.7E+05		
NA22		5.9E+14														2.7E+15	5.9E+14		
NB93M		1.2E+08														---	1.2E+08		
NB94	5.314E-04	8.1E-02	9.4E-02	8.1E-02	1.8E+00	---	---	---	---	---	---	---	1.3E+00	1.3E+00	1.3E+00	9.6E+00	2.7E+03		
NI59	3.177E-02	5.7E+00	---	8.7E+09	5.7E+00	---	---	---	---	---	---	---	1.1E+07	2.1E+03	1.4E+03	---	4.2E+05		
NI63		3.0E+05														---	3.0E+05		
NP237	5.585E-03	1.5E-02	1.1E+04	3.6E+00	9.8E-01	4.9E-02	8.1E-02	1.7E-01	---	---	---	1.4E+08	2.1E-02	1.5E-02	2.5E-02	1.7E+02	1.1E+02		
PA231		8.1E+01														8.1E+01	1.2E+02		
PB210		2.2E+03														1.4E+11	2.2E+03		
PD107	3.602E-08	6.9E+02	---	1.1E+12	6.9E+02	---	---	---	---	---	---	---	1.7E+07	3.3E+03	2.2E+03	---	8.7E+05		
PU238	7.501E+00	3.6E+03	---	---	1.0E+07	3.7E+05	1.2E+05	1.1E+05	3.7E+05	1.2E+05	1.1E+05	6.6E+18	1.8E+10	1.1E+06	3.2E+05	1.3E+07	3.6E+03		7.7E+12
PU239	1.146E+00	1.5E+03	4.7E+18	5.0E+12	5.9E+06	5.3E+06	4.6E+06	4.6E+06	---	---	---	1.0E+17	3.1E+07	6.3E+05	5.8E+05	3.8E+06	1.5E+03		
PU240	2.937E-01	1.5E+03	---	---	1.6E+16	9.2E+09	9.5E+08	8.0E+08	2.8E+16	2.2E+16	2.2E+16	1.1E+17	1.4E+19	3.6E+09	3.1E+08	1.2E+09	1.5E+03		
PU241	6.847E+00	3.0E+03	7.3E+12	2.4E+08	1.9E+05	9.6E+03	1.1E+04	1.1E+04	---	---	---	2.8E+13	1.7E+04	3.0E+03	3.6E+03	1.9E+07	4.1E+04		
PU242	2.006E-02	1.5E+03	---	---	1.0E+14	8.3E+09	8.4E+08	7.1E+08	3.5E+12	1.2E+12	1.1E+12	9.8E+16	2.6E+18	3.4E+09	2.9E+08	6.9E+08	1.5E+03		
PU244	1.129E-10	4.4E+01	---	---	6.0E+10	7.5E+09	7.5E+08	6.3E+08	1.2E+18	8.7E+17	8.3E+17	9.2E+17	---	3.1E+09	2.6E+08	4.4E+01	1.3E+03		
RA226	4.217E-04	3.0E-02	5.1E+18	5.2E+07	2.5E+00	7.4E-02	3.0E-02	3.0E-02	7.4E-02	3.1E-02	3.0E-02	---	3.2E+01	2.2E-01	8.6E-02	9.1E+00	7.1E+01		2.2E+04
RA228		2.5E+07														1.3E+08	2.5E+07		
RB87		1.5E+04														---	1.5E+04		
S35		0.0E+00														---	---	---	
SB124		0.0E+00																---	
SB125		7.4E+14														5.0E+16	7.4E+14	---	
SC46		0.0E+00														---	---		
SE75		0.0E+00																---	
SE79	1.795E-03	2.4E+04	---	---	---	---	---	---	---	---	---	---	---	---	---	---	2.4E+04	---	
SM151		5.9E+06														---	5.9E+06		
SN113		0.0E+00																---	
SN119M		0.0E+00																---	
SN121		0.0E+00																---	
SN121M		1.6E+06														---	1.6E+06	---	
SN123		0.0E+00																---	
SN126	1.668E-04	8.7E+00	---	---	---	---	---	---	---	---	---	---	---	---	---	8.7E+00	2.1E+03	---	
SR90	1.788E+01	1.4E+02	2.2E+16	7.2E+06	1.4E+02	---	---	---	---	---	---	---	3.9E+04	2.7E+03	2.9E+10	---	1.6E+03		
TC99	2.040E-02	1.1E-01	2.5E-01	1.1E-01	2.5E+00	---	---	---	---	---	---	---	4.3E+00	4.3E+00	4.3E+00	1.0E+09	2.4E+03		
TH228		3.4E+18														6.6E+18	3.4E+18		
TH229		9.0E+01														9.0E+01	5.0E+02		
TH230	1.601E-04	9.9E-02	---	4.1E+10	9.1E+00	3.7E-01	1.1E-01	9.9E-02	3.7E-01	1.1E-01	9.9E-02	---	1.1E+03	1.1E+00	2.9E-01	1.9E+01	1.9E+02		4.2E+05
TH232	1.387E-03	4.4E+00	1.4E+18	3.1E+10	1.8E+04	1.8E+04	4.2E+04	5.3E+04	2.4E+04	5.5E+04	7.1E+04	---	1.8E+05	4.8E+04	1.1E+05	4.4E+00	1.5E+02		
U232		9.4E+02														3.2E+03	9.4E+02		
U233	3.566E-01	9.3E+02	---	---	1.7E+13	4.5E+13	4.3E+12	3.6E+12	---	---	---	5.5E+14	---	1.4E+12	1.3E+11	9.3E+02	2.2E+03		
U234	9.023E-01	2.8E+01	---	1.6E+15	2.6E+03	9.8E+01	3.1E+01	2.8E+01	9.8E+01	3.1E+01	2.8E+01	1.7E+15	1.8E+06	2.9E+02	8.3E+01	3.8E+03	3.4E+03		7.2E+08
U235	2.750E-02	3.3E-01	8.5E+09	2.2E+04	3.5E+00	2.8E+00	2.8E+00	3.2E+00	---	---	---	8.8E+11	2.5E+00	3.3E-01	3.5E-01	5.0E+02	2.2E+03		
U236	1.201E-02	3.9E+03	---	---	1.6E+11	2.1E+11	1.7E+11	1.7E+11	2.8E+11	2.3E+11	2.2E+11	1.7E+13	2.8E+13	5.3E+11	2.7E+11	2.8E+07	3.9E+03		
U238	8.153E-01	9.7E+02	---	---	3.4E+06	1.2E+05	4.0E+04	3.7E+04	1.2E+05	4.0E+04	3.7E+04	9.0E+10	1.4E+10	3.5E+05	1.1E+05	9.7E+02	4.0E+03		6.1E+12
W181		0.0E+00														---	---		
W185		0.0E+00														---	---		
W188		0.0E+00														---	---		
ZR93	1.825E-05	4.3E-01	1.8E+00	4.3E-01	5.0E-01	---	---	---	---	---	---	---	8.0E+00	3.2E+00	3.0E+00	---	9.5E+05		

Table C-12. Current WITS inventory limits for LAWV.

			Groundwater Pathway Limits (Ci)					Intruder	Air Pathway	Radon Pathway
WITS Nuclides	Inventory (Ci)	Most Limiting (Ci)	Beta-Gamma 0-1112.5 yrs	Gross Alpha 0-1112.5 yrs	Radium 0-1112.5 yrs	Uranium 0-1112.5 yrs	All-Pathways Limits 112.5-1112.5 yrs	Resident (Ci)	Limits (Ci)	Limits (Ci)
AC227		3.6E+04						3.6E+04		
AG108M	7.658E-05	1.5E+02						1.5E+02		
AL26		1.9E+01						1.9E+01		
AM241	4.156E-01	2.5E+07	1.2E+10	6.0E+08	---	1.1E+19	1.9E+08	2.5E+07		
AM242M	4.541E-04	5.9E+04						5.9E+04		
AM243	1.945E-03	1.3E+04	2.6E+16	1.4E+16	---	---	1.8E+15	1.3E+04		
AR39	9.820E-06	---						---		
BA133	6.549E-02	1.4E+06						1.4E+06		
BI207		4.9E+02						4.9E+02		
BK249		7.8E+05						7.8E+05		
C14	1.853E-01	4.3E+00	4.3E+00	---	---	---	4.5E+00	---	3.5E+09	
CA41	1.429E-05	---						---		
CD113M	2.733E-05	---						---		
CF249	1.814E-06	2.0E+03						2.0E+03		
CF250	6.383E-04	1.2E+13						1.2E+13		
CF2511	7.856E-06	4.1E+04						4.1E+04		
CF252	5.553E-03	5.9E+12						5.9E+12		
CL36	1.840E-03	6.3E-01	1.2E+00	---	---	---	6.3E-01	---	---	
CM242	5.936E-05	1.4E+10						1.4E+10		
CM243	1.842E-04	2.1E+05						2.1E+05		
CM244	1.959E+00	1.3E+15	---	---	---	---	---	1.3E+15		
CM245	2.318E-03	2.1E+05	8.3E+09	4.2E+08	---	8.3E+18	1.3E+08	2.1E+05		
CM246	4.091E-03	5.5E+13						5.5E+13		
CM247	8.291E-12	1.5E+03	5.3E+17	2.9E+17	---	---	3.6E+16	1.5E+03		
CM248	2.550E-12	4.3E+07	---	---	---	---	---	4.3E+07		
CO60	3.087E+01	1.4E+07						1.4E+07		
CS134	3.129E+00	3.5E+16						3.5E+16		
CS135	4.560E-10	---						---		
CS137	7.564E+01	3.3E+03						3.3E+03		
EU152	2.231E+00	1.3E+04						1.3E+04		
EU154	2.012E+00	2.2E+05						2.2E+05		
EU155	1.520E-02	3.8E+12						3.8E+12		
H3	4.097E+05	4.1E+08	4.1E+08	---	---	---	1.2E+10	---	3.8E+13	
I129	1.731E-04	2.2E-03	2.2E-03	---	---	---	1.4E-01	6.1E+18	---	
I129H		5.3E-02	5.3E-02	---	---	---	3.2E+00	6.1E+18	---	
I129J		9.5E-03	9.5E-03	---	---	---	5.8E-01	6.1E+18	---	
K40	5.647E-07	3.6E+02	---	---	---	---	---	3.6E+02		
KR85	2.556E+00	8.4E+07						8.4E+07		
MO93	3.129E-03	1.4E+00	1.4E+00	---	---	---	6.9E+00	---		
NA22	4.000E-07	1.4E+13						1.4E+13		
NB93M	2.613E+00	---						---		
NB94	1.105E-01	3.1E+01	5.6E+01	---	---	---	3.1E+01	8.6E+01		
NI59	1.548E+00	1.6E+10	1.6E+10	---	---	---	3.9E+12	---		
NI63	2.184E+02	---						---		
NP237	4.286E-02	4.1E+03	2.2E+07	1.1E+06	---	2.1E+16	3.4E+05	4.1E+03		
PA231		1.4E+03						1.4E+03		
PB210	3.130E-02	3.5E+08						3.5E+08		
PD107		1.9E+12	1.9E+12	---	---	---	6.0E+12	---		
PU238	2.992E+00	7.2E+07	8.9E+14	6.4E+12	8.5E+12	---	2.6E+13	7.2E+07		8.4E+10
PU239	1.180E+00	6.1E+08	1.2E+15	6.7E+14	---	---	8.4E+13	6.1E+08		
PU240	3.149E-01	2.1E+13	---	---	---	---	---	2.1E+13		
PU241	1.089E+01	7.7E+08	3.5E+11	1.8E+10	---	---	5.5E+09	7.7E+08		
PU242	1.624E-03	4.9E+10	---	---	---	---	---	4.9E+10		
PU244		3.4E+02	---	---	---	---	---	3.4E+02		
RA226	3.950E-02	2.4E+00	3.6E+07	2.6E+05	3.5E+05	---	1.0E+06	3.6E+01		2.4E+00
RA228	3.249E-04	2.4E+06						2.4E+06		
RB87		---						---		
S35		---						---	---	
SB124		---							---	
SB125	5.948E+00	5.2E+13						5.2E+13	---	
SC46		---						---		
SE75		---							---	
SE79	8.385E-02	---	---	---	---	---	---	---	---	
SM151	1.895E-04	---						---		
SN113	9.630E-11	---							---	
SN119M	1.603E-01	---							---	
SN121	2.361E-02	---							---	
SN121M	2.190E-02	---						---	---	
SN123		---							---	
SN126	2.064E-04	9.3E+01	---	---	---	---	---	9.3E+01	---	
SR90	2.343E+02	1.6E+15	1.6E+15	---	---	---	3.1E+16	---		
TC99	1.211E-01	6.5E+02	6.5E+02	---	---	---	9.8E+02	4.5E+11		
TH228	4.289E-03	1.4E+17						1.4E+17		
TH229	1.745E-04	7.8E+02						7.8E+02		
TH230	4.537E-05	1.0E+02	2.6E+08	1.9E+06	2.5E+06	---	7.4E+06	1.0E+02		2.2E+02
TH232	3.249E-04	2.0E+01	---	---	---	---	---	2.0E+01		
U232	3.838E-03	6.7E+01						6.7E+01		
U233	2.762E-01	8.6E+03	---	---	---	---	---	8.6E+03		
U234	4.840E-01	2.0E+04	1.7E+11	1.2E+09	1.6E+09	---	4.7E+09	2.0E+04		1.9E+06
U235	1.543E-02	2.5E+04	2.4E+08	1.3E+08	---	---	1.7E+07	2.5E+04		
U236	3.803E-02	4.1E+08	---	---	---	---	---	4.1E+08		
U238	7.454E-01	7.6E+03	4.8E+14	3.4E+12	4.5E+12	---	1.3E+13	7.6E+03		8.1E+10
W181		---						---		
W185		---						---		
W188		---						---		
ZR93	5.481E-03	2.2E+02	2.2E+02	---	---	---	1.3E+03	---		

Using the current WITS limits presented in Table C-5 through Table C-12 (as well as those not shown for ET3, ST01 through ST04, ST08 and ST09) confirmation calculations were performed. To compute absolute SOF's the use of the existing inventory limits as of September 2018 were also employed. The results of these calculations were then compared to WITS SOF values provide to SRNL by SWM. The comparisons are provided in Table C-13. Absolute SOF for all of the ST's and ET's are included in Table C-13.

There are a few items requiring some definition in Table C-13 below:

- Absolute SOF values refer to SOF values calculated directly from the current WITS limits and existing inventory for each DU.
- Note that SWM typically refers to SOF's that have been normalized by their administrative operating margin named "PA SOF Limit" (i.e., typically set to a 95% of the total SOF value). For differing reasons, the value may be different such as the 65% value for ST14. This reduced value represents a current interim measure (IM2018) in place while this current SA is being addressed. Also, a reduced value of 75% was applied to ET2 in the IM2018.
- Normalized SOF values for three months are provided as well (i.e., 7/31/2018, 8/30/2018, and 9/27/2018). Increasing values reflect ongoing disposals.
- Absolute SOF values taken from WITS data as of 9/27/2018 are listed.
- One key WITS limit having updated administrative values is for H-3 and its current numbers are provided along with the pathway that it refers to.
- Absolute SOF values computed by SRNL are provided for three groups of parent nuclides (1 - total set associated with a given DU (~75), 2 - limited to only the GWP parent nuclides with a given DU (~39), and 3 – just the short list of 9 parent nuclides (=9))
- SRNL calculated versus SWM WITS values are provided.

As the last column in Table C-13 shows, most of the percent differences between SWM WITS SOF values and those computed by SRNL are within a 1%. The LAWV 1.3% and ST02 2.9% (not a DU under consideration here) are considered acceptable but will be reviewed later.

Table C-13. SRNL computed versus WITS computed total SOF per DU as of September 2018.

EAV Facility	Facility Status	PA SOF Limit	IM2018 PA SOF Limit	Highest PA Limit Group SOF % Status (8/30/18)	Highest PA Limit Group SOF % Status (9/27/18)	Highest PA Group	Absolute SOF % Status (9/27/18)	H-3 G2 Limit (Ci)	Highest SOF Pathway	Total SOF % Calculated (9/27/18)	GWP SOF % Calculated (9/27/18)	SA (9) SOF % Calculated (9/27/18)	Total SOF (Calc/SWM)	SA SOF (9/total)	Total OF (Calc/SWM % difference)
LAWV	Open	95%	95%	13.4%	13.4%	BG	12.7%	NA	BG	12.9%	12.9%	12.5%	101.3%	96.9%	1.3%
ET1	Closed	95%	95%	91.3%	91.3%	BG2	86.7%	12.0	BG2	86.4%	85.9%	85.1%	99.6%	98.5%	-0.4%
ET2	Open	95%	75%	86.0%	86.0%	BG2	64.5%	2.0	BG2	64.4%	64.4%	64.1%	99.8%	99.5%	-0.2%
ET3	Open	95%	95%	39.7%	40.1%	BG2	38.1%	2.0	BG2	38.2%	38.2%	38.1%	100.3%	99.7%	0.3%
ST01	Closed	95%	95%	89.9%	89.9%	BG2	85.4%	4.8	BG2	85.3%	47.7%	39.5%	99.9%	46.3%	-0.1%
ST02	Closed	95%	95%	91.1%	91.1%	BG2	86.5%	4.8	BG2	84.0%	70.2%	70.2%	97.1%	83.6%	-2.9%
ST03	Closed	90%	90%	99.3%	99.3%	BG2	89.4%	4.8	AP2	89.5%	89.4%	88.3%	100.1%	98.7%	0.1%
ST04	Closed	95.0%	95.0%	99.5%	99.5%	BG2	94.5%	16.1	BG2	94.8%	94.4%	93.4%	100.3%	98.5%	0.3%
ST05	Closed	100%	100%	100.0%	100.0%	BG2	100.0%	4.8	BG2	100.3%	100.3%	98.9%	100.3%	98.6%	0.3%
ST06	Open	95%	95%	86.6%	86.6%	BG2	82.3%	2.0	BG2	82.3%	82.3%	81.8%	100.0%	99.4%	0.0%
ST07	Open	95%	95%	58.4%	58.4%	BG2	55.5%	2.0	BG2	55.7%	55.6%	55.4%	100.4%	99.5%	0.4%
ST08	Open	95%	95%	93.3%	93.3%	BG1	88.6%	2.0	BG1	88.7%	88.7%	88.6%	100.1%	99.9%	0.1%
ST09	Open	95%	95%	88.8%	88.8%	BG3	84.4%	2.0	BG3	84.4%	63.6%	57.3%	100.0%	67.9%	0.0%
ST14	Open	95%	65%	75.9%	75.9%	BG2	49.3%	2.0	BG2	49.2%	49.2%	49.2%	99.7%	100.0%	-0.3%
CIG	Open	95%	95%	46.8%	46.8%	BG2	44.5%								
ILV	Open	95%	95%	9.6%	9.6%	BG2	9.1%								
NR0	Closed	95%	95%	3.3%	3.3%	BG	3.1%								
NR1	Open	95%	95%	2.8%	2.8%	BG	2.7%								

C.3 New Preliminary Inventory Limits

To create a short list of parent nuclides a rank ordering process was employed based on preliminary inventory limits. The new PORFLOW aquifer 100m boundary concentrations were processed through the new dose related models and its supporting databases (i.e., and the inventory limits tables below are output from the "PA_CA_Limits_Doses" code discussed in Chapter 8.0).

The PORFLOW "stat.out" files were processed to compute for each of the GWP parent nuclides in each DU, new preliminary limits. SOF's were computed from these new limits and then a SOF rank ordering was performed on a DU by DU basis.

Note that "preliminary" is the terminology employed in the 2008 PA to refer to inventory limits prior to applying plume interaction. Also, inventory limits for existing versus future burials will differ since the assumed burial times differ.

The following tables (i.e., Table C-14 through Table C-31 contain these new preliminary inventory limits for every DU of interest:

- Closed units - existing limits only
- Open units – existing and future limits
- Future units – future limits only

Preliminary inventory limits that exceed a value of $1.0x10^{20}$ Ci were replaced with "---".

Table C-14. New preliminary inventory limits for existing waste in ET01.

Nuclide	Beta-Gamma (Ci)	Alpha (Ci)	Radium (Ci)	Uranium (Ci)	All-Pathways (Ci)	Acute Intruder (Ci)	Chronic Intruder (Ci)
---	0-1171 yrs	0-1171 yrs	0-1171 yrs	0-1171 yrs	171-1171 yrs	71-1171 yrs	71-1171 yrs
Am-241	2.17E+04	1.08E+03	---	7.34E+12	9.02E+03	5.04E+05	6.42E+04
Am-243	1.14E+12	7.88E+09	---	---	1.50E+10	8.38E+04	3.66E+02
C-14	2.14E+01	---	---	---	1.34E+02	9.04E+08	1.45E+06
Cf-249	4.83E+06	2.41E+05	---	2.23E+15	2.01E+06	5.19E+04	3.96E+02
Cf-251	1.89E+19	1.23E+17	---	---	2.34E+17	1.22E+05	1.22E+03
Cl-36	3.04E+00	---	---	---	2.11E+01	3.10E+07	1.81E+04
Cm-244	---	---	---	---	---	3.08E+07	2.08E+08
Cm-245	4.70E+04	2.35E+03	---	2.03E+13	1.96E+04	1.34E+05	1.26E+03
Cm-246	---	---	---	---	---	4.66E+05	3.00E+06
Cm-247	8.55E+13	5.72E+11	---	---	1.09E+12	4.26E+04	8.43E+01
Cm-248	---	---	---	---	---	9.61E+03	5.72E+04
H-3	1.00E+01	---	---	---	7.01E+08	8.29E+12	3.43E+08
I-129	4.38E-03	---	---	---	4.68E-01	3.24E+06	7.78E+04
K-40	2.84E+01	---	---	---	1.84E+02	8.40E+04	6.14E+01
Mo-93	---	---	---	---	---	9.43E+07	4.65E+05
Nb-94	---	---	---	---	---	9.33E+03	9.80E+00
Ni-59	4.70E+03	---	---	---	2.83E+06	8.72E+08	1.36E+06
Np-237	1.44E+00	7.18E-02	---	2.20E+08	5.97E-01	7.16E+04	1.81E+02
Pd-107	3.26E+05	---	---	---	2.65E+06	9.41E+09	1.84E+08
Pu-238	---	---	---	---	---	1.06E+06	1.14E+07
Pu-239	5.64E+09	4.05E+07	---	---	7.70E+07	4.43E+05	7.73E+05
Pu-240	---	---	---	---	---	4.47E+05	4.22E+06
Pu-241	2.03E+06	1.02E+05	---	6.66E+14	8.45E+05	1.48E+07	1.87E+06
Pu-242	---	---	---	---	---	4.64E+05	2.59E+06
Pu-244	---	---	---	---	---	3.86E+04	4.96E+01
Ra-226	4.47E+18	7.85E+16	7.86E+16	---	5.19E+17	8.19E+03	9.51E+00
Se-79	---	---	---	---	---	1.33E+08	1.41E+06
Sn-126	---	---	---	---	---	7.60E+03	9.26E+00
Sr-90	4.23E+10	---	---	---	2.26E+12	2.02E+07	3.12E+05
Tc-99	8.78E-01	---	---	---	5.93E+01	3.47E+08	7.73E+03
Th-230	---	1.60E+19	1.60E+19	---	---	2.04E+04	1.82E+01
Th-232	---	---	---	---	---	5.72E+03	4.68E+00
U-233	---	---	---	---	---	4.17E+05	9.40E+02
U-234	---	---	---	---	---	1.99E+06	3.29E+03
U-235	1.24E+03	9.57E+00	---	---	1.82E+01	1.01E+05	3.71E+02
U-236	---	---	---	---	---	4.70E+06	3.12E+05
U-238	---	---	---	---	---	4.68E+05	5.46E+02
Zr-93	---	---	---	---	---	3.31E+08	1.05E+08

Table C-15. New preliminary inventory limits for existing waste in ET02.

Nuclide	Beta-Gamma (Ci)	Alpha (Ci)	Radium (Ci)	Uranium (Ci)	All-Pathways (Ci)	Acute Intruder (Ci)	Chronic Intruder (Ci)
---	0-1171 yrs	0-1171 yrs	0-1171 yrs	0-1171 yrs	171-1171 yrs	71-1171 yrs	71-1171 yrs
Am-241	2.42E+04	1.21E+03	---	1.29E+12	1.01E+04	6.59E+05	8.39E+04
Am-243	2.58E+11	2.61E+09	---	---	4.97E+09	1.10E+05	4.78E+02
C-14	1.85E+01	---	---	---	1.15E+02	1.18E+09	1.90E+06
Cf-249	1.71E+06	8.53E+04	---	1.87E+14	7.09E+05	6.78E+04	5.18E+02
Cf-251	2.25E+18	2.07E+16	---	---	3.94E+16	1.59E+05	1.59E+03
Cl-36	2.38E+00	---	---	---	1.65E+01	4.05E+07	2.36E+04
Cm-244	---	---	---	---	---	4.02E+07	2.72E+08
Cm-245	2.91E+04	1.45E+03	---	2.28E+12	1.21E+04	1.76E+05	1.65E+03
Cm-246	6.87E+19	2.49E+18	2.50E+18	---	1.63E+19	6.09E+05	3.92E+06
Cm-247	1.35E+13	1.30E+11	---	---	2.47E+11	5.57E+04	1.10E+02
Cm-248	---	---	---	---	---	1.26E+04	7.48E+04
H-3	9.23E+00	---	---	---	1.07E+09	1.08E+13	4.48E+08
I-129	2.99E-03	---	---	---	3.19E-01	4.24E+06	1.02E+05
K-40	1.85E+00	---	---	---	1.20E+01	1.10E+05	8.03E+01
Mo-93	---	---	---	---	---	1.23E+08	6.08E+05
Nb-94	---	---	---	---	---	1.22E+04	1.28E+01
Ni-59	6.35E+00	---	---	---	3.82E+03	1.14E+09	1.78E+06
Np-237	1.96E+00	9.78E-02	---	1.56E+08	8.13E-01	9.37E+04	2.37E+02
Pd-107	4.42E+02	---	---	---	3.58E+03	1.23E+10	2.40E+08
Pu-238	1.28E+09	5.09E+07	5.11E+07	---	3.31E+08	1.38E+06	1.49E+07
Pu-239	2.09E+09	2.26E+07	---	---	4.31E+07	5.79E+05	1.01E+06
Pu-240	---	---	---	---	---	5.84E+05	5.52E+06
Pu-241	8.63E+05	4.32E+04	---	5.15E+13	3.59E+05	1.93E+07	2.45E+06
Pu-242	1.55E+16	5.79E+14	5.81E+14	---	3.78E+15	6.07E+05	3.39E+06
Pu-244	---	---	---	---	---	5.04E+04	6.48E+01
Ra-226	1.55E+02	6.62E+00	6.65E+00	---	4.30E+01	1.07E+04	1.24E+01
Se-79	---	---	---	---	---	1.74E+08	1.84E+06
Sn-126	---	---	---	---	---	9.94E+03	1.21E+01
Sr-90	1.33E+03	---	---	---	7.12E+04	2.64E+07	4.08E+05
Tc-99	1.49E+00	---	---	---	1.81E+01	4.54E+08	1.01E+04
Th-230	7.06E+02	3.04E+01	3.05E+01	---	1.97E+02	2.67E+04	2.38E+01
Th-232	6.41E+15	1.79E+14	2.38E+14	---	4.06E+14	7.48E+03	6.12E+00
U-233	2.12E+19	1.02E+19	---	---	1.25E+18	5.46E+05	1.23E+03
U-234	2.39E+05	9.74E+03	9.78E+03	---	6.33E+04	2.60E+06	4.30E+03
U-235	9.75E+02	1.10E+01	---	3.30E+17	2.10E+01	1.32E+05	4.85E+02
U-236	---	2.73E+19	3.63E+19	9.89E+18	1.37E+18	6.14E+06	4.08E+05
U-238	3.81E+08	1.48E+07	1.49E+07	5.14E+16	9.66E+07	6.12E+05	7.13E+02
Zr-93	---	---	---	---	---	4.32E+08	1.38E+08

Table C-16. New preliminary inventory limits for future waste in ET02.

Nuclide	Beta-Gamma (Ci)	Alpha (Ci)	Radium (Ci)	Uranium (Ci)	All-Pathways (Ci)	Acute Intruder (Ci)	Chronic Intruder (Ci)
---	0-1171 yrs	0-1171 yrs	0-1171 yrs	0-1171 yrs	171-1171 yrs	71-1171 yrs	71-1171 yrs
Am-241	2.39E+04	1.19E+03	---	1.31E+12	9.92E+03	6.59E+05	8.39E+04
Am-243	2.67E+11	2.70E+09	---	---	5.15E+09	1.10E+05	4.78E+02
C-14	1.89E+01	---	---	---	1.18E+02	1.18E+09	1.90E+06
Cf-249	1.75E+06	8.74E+04	---	1.93E+14	7.26E+05	6.78E+04	5.18E+02
Cf-251	2.38E+18	2.18E+16	---	---	4.16E+16	1.59E+05	1.59E+03
Cl-36	2.53E+00	---	---	---	1.76E+01	4.05E+07	2.36E+04
Cm-244	---	---	---	---	---	4.02E+07	2.72E+08
Cm-245	2.97E+04	1.48E+03	---	2.35E+12	1.23E+04	1.76E+05	1.65E+03
Cm-246	7.47E+19	2.70E+18	2.71E+18	---	1.76E+19	6.09E+05	3.92E+06
Cm-247	1.42E+13	1.36E+11	---	---	2.59E+11	5.57E+04	1.10E+02
Cm-248	---	---	---	---	---	1.26E+04	7.48E+04
H-3	9.23E+00	---	---	---	2.10E+08	1.08E+13	4.48E+08
I-129	2.90E-03	---	---	---	3.10E-01	4.24E+06	1.02E+05
K-40	1.79E+00	---	---	---	1.16E+01	1.10E+05	8.03E+01
Mo-93	---	---	---	---	---	1.23E+08	6.08E+05
Nb-94	---	---	---	---	---	1.22E+04	1.28E+01
Ni-59	6.84E+00	---	---	---	4.12E+03	1.14E+09	1.78E+06
Np-237	1.97E+00	9.87E-02	---	1.56E+08	8.21E-01	9.37E+04	2.37E+02
Pd-107	4.75E+02	---	---	---	3.86E+03	1.23E+10	2.40E+08
Pu-238	1.32E+09	5.26E+07	5.28E+07	---	3.42E+08	1.38E+06	1.49E+07
Pu-239	2.14E+09	2.31E+07	---	---	4.41E+07	5.79E+05	1.01E+06
Pu-240	---	---	---	---	---	5.84E+05	5.52E+06
Pu-241	8.55E+05	4.28E+04	---	5.27E+13	3.55E+05	1.93E+07	2.45E+06
Pu-242	1.65E+16	6.17E+14	6.19E+14	---	4.02E+15	6.07E+05	3.39E+06
Pu-244	---	---	---	---	---	5.04E+04	6.48E+01
Ra-226	1.55E+02	6.60E+00	6.63E+00	---	4.29E+01	1.07E+04	1.24E+01
Se-79	---	---	---	---	---	1.74E+08	1.84E+06
Sn-126	---	---	---	---	---	9.94E+03	1.21E+01
Sr-90	1.04E+03	---	---	---	5.55E+04	2.64E+07	4.08E+05
Tc-99	1.70E+00	---	---	---	1.61E+01	4.54E+08	1.01E+04
Th-230	7.18E+02	3.09E+01	3.10E+01	---	2.01E+02	2.67E+04	2.38E+01
Th-232	6.43E+15	1.79E+14	2.39E+14	---	4.07E+14	7.48E+03	6.12E+00
U-233	2.20E+19	1.06E+19	---	---	1.30E+18	5.46E+05	1.23E+03
U-234	2.47E+05	1.00E+04	1.01E+04	---	6.53E+04	2.60E+06	4.30E+03
U-235	9.75E+02	1.10E+01	---	3.42E+17	2.10E+01	1.32E+05	4.85E+02
U-236	---	2.76E+19	3.68E+19	1.02E+19	1.41E+18	6.14E+06	4.08E+05
U-238	4.01E+08	1.56E+07	1.56E+07	5.32E+16	1.01E+08	6.12E+05	7.13E+02
Zr-93	---	---	---	---	---	4.32E+08	1.38E+08

Table C-17. New preliminary inventory limits for existing waste in ST05.

Nuclide	Beta-Gamma (Ci)	Alpha (Ci)	Radium (Ci)	Uranium (Ci)	All-Pathways (Ci)	Acute Intruder (Ci)	Chronic Intruder (Ci)
---	0-1171 yrs	0-1171 yrs	0-1171 yrs	0-1171 yrs	171-1171 yrs	71-1171 yrs	71-1171 yrs
Am-241	6.53E+03	3.26E+02	---	6.85E+11	2.71E+03	3.60E+05	7.17E+04
Am-243	1.26E+11	1.15E+09	---	---	2.20E+09	5.98E+04	4.09E+02
C-14	7.54E+00	---	---	---	4.70E+01	6.45E+08	1.04E+06
Cf-249	7.24E+05	3.62E+04	---	1.48E+14	3.01E+05	3.70E+04	4.44E+02
Cf-251	1.61E+18	1.33E+16	---	---	2.53E+16	8.69E+04	1.36E+03
Cl-36	1.28E+00	---	---	---	8.89E+00	2.21E+07	1.49E+04
Cm-244	---	---	---	---	---	2.19E+07	1.49E+08
Cm-245	9.15E+03	4.58E+02	---	1.47E+12	3.80E+03	9.58E+04	1.41E+03
Cm-246	---	4.83E+19	4.84E+19	---	---	3.32E+05	2.14E+06
Cm-247	8.20E+12	7.10E+10	---	---	1.35E+11	3.04E+04	9.44E+01
Cm-248	---	---	---	---	---	6.86E+03	5.35E+04
H-3	6.11E+01	---	---	---	6.49E+06	5.92E+12	2.45E+08
I-129	1.49E-03	---	---	---	1.59E-01	2.31E+06	5.55E+04
K-40	1.35E+00	---	---	---	8.75E+00	5.99E+04	6.88E+01
Mo-93	---	---	---	---	---	6.73E+07	3.32E+05
Nb-94	---	---	---	---	---	6.66E+03	1.10E+01
Ni-59	4.11E+01	---	---	---	2.48E+04	6.23E+08	1.51E+06
Np-237	6.93E-01	3.47E-02	---	6.14E+07	2.88E-01	5.11E+04	2.03E+02
Pd-107	2.87E+03	---	---	---	2.33E+04	6.72E+09	1.31E+08
Pu-238	9.67E+09	3.44E+08	3.46E+08	---	2.25E+09	7.56E+05	1.22E+07
Pu-239	7.60E+08	7.54E+06	---	---	1.44E+07	3.16E+05	8.17E+05
Pu-240	---	---	---	---	---	3.19E+05	3.62E+06
Pu-241	3.25E+05	1.63E+04	---	4.48E+13	1.35E+05	1.05E+07	2.09E+06
Pu-242	2.14E+17	7.19E+15	7.21E+15	---	4.70E+16	3.31E+05	2.43E+06
Pu-244	---	---	---	---	---	2.75E+04	5.55E+01
Ra-226	1.36E+02	5.50E+00	5.52E+00	---	3.58E+01	5.85E+03	1.07E+01
Se-79	---	---	---	---	---	9.50E+07	1.00E+06
Sn-126	---	---	---	---	---	5.42E+03	1.04E+01
Sr-90	4.57E+03	---	---	---	2.44E+05	1.44E+07	2.23E+05
Tc-99	1.10E+00	---	---	---	1.04E+01	2.48E+08	5.52E+03
Th-230	1.53E+03	5.78E+01	5.80E+01	---	3.77E+02	1.46E+04	2.04E+01
Th-232	---	---	---	---	---	4.09E+03	5.24E+00
U-233	---	---	---	---	---	2.98E+05	1.05E+03
U-234	1.04E+06	3.76E+04	3.77E+04	---	2.45E+05	1.42E+06	3.66E+03
U-235	2.51E+02	2.71E+00	---	---	5.17E+00	7.19E+04	4.15E+02
U-236	---	---	---	---	---	3.35E+06	2.30E+05
U-238	3.04E+09	1.06E+08	1.06E+08	---	6.89E+08	3.34E+05	6.11E+02
Zr-93	---	---	---	---	---	2.36E+08	7.53E+07

Table C-18. New preliminary inventory limits for existing waste in ET06.

Nuclide	Beta-Gamma (Ci)	Alpha (Ci)	Radium (Ci)	Uranium (Ci)	All-Pathways (Ci)	Acute Intruder (Ci)	Chronic Intruder (Ci)
---	0-1171 yrs	0-1171 yrs	0-1171 yrs	0-1171 yrs	171-1171 yrs	71-1171 yrs	71-1171 yrs
Am-241	7.02E+03	3.51E+02	---	3.46E+11	2.92E+03	3.60E+05	7.17E+04
Am-243	6.47E+10	6.58E+08	---	---	1.26E+09	5.98E+04	4.09E+02
C-14	5.57E+00	---	---	---	3.47E+01	6.45E+08	1.04E+06
Cf-249	4.40E+05	2.20E+04	---	4.63E+13	1.83E+05	3.70E+04	4.44E+02
Cf-251	5.42E+17	5.01E+15	---	---	9.55E+15	8.69E+04	1.36E+03
Cl-36	6.85E-01	---	---	---	4.76E+00	2.21E+07	1.49E+04
Cm-244	---	---	---	---	---	2.19E+07	1.49E+08
Cm-245	8.16E+03	4.08E+02	---	5.76E+11	3.39E+03	9.58E+04	1.41E+03
Cm-246	2.51E+19	9.04E+17	9.07E+17	---	5.90E+18	3.32E+05	2.14E+06
Cm-247	3.32E+12	3.20E+10	---	---	6.11E+10	3.04E+04	9.44E+01
Cm-248	---	---	---	---	---	6.86E+03	5.35E+04
H-3	6.55E+00	---	---	---	3.61E+09	5.92E+12	2.45E+08
I-129	8.39E-04	---	---	---	8.96E-02	2.31E+06	5.55E+04
K-40	5.13E-01	---	---	---	3.34E+00	5.99E+04	6.88E+01
Mo-93	---	---	---	---	---	6.73E+07	3.32E+05
Nb-94	---	---	---	---	---	6.66E+03	1.10E+01
Ni-59	1.60E+00	---	---	---	9.63E+02	6.23E+08	1.51E+06
Np-237	5.55E-01	2.77E-02	---	4.71E+07	2.31E-01	5.11E+04	2.03E+02
Pd-107	1.11E+02	---	---	---	9.02E+02	6.72E+09	1.31E+08
Pu-238	4.06E+08	1.59E+07	1.59E+07	---	1.03E+08	7.56E+05	1.22E+07
Pu-239	5.51E+08	5.99E+06	---	---	1.14E+07	3.16E+05	8.17E+05
Pu-240	---	---	---	---	---	3.19E+05	3.62E+06
Pu-241	2.53E+05	1.26E+04	---	1.34E+13	1.05E+05	1.05E+07	2.09E+06
Pu-242	5.50E+15	2.04E+14	2.05E+14	---	1.33E+15	3.31E+05	2.43E+06
Pu-244	---	---	---	---	---	2.75E+04	5.55E+01
Ra-226	3.98E+01	1.76E+00	1.77E+00	---	1.14E+01	5.85E+03	1.07E+01
Se-79	---	---	---	---	---	9.50E+07	1.00E+06
Sn-126	---	---	---	---	---	5.42E+03	1.04E+01
Sr-90	4.84E+02	---	---	---	2.58E+04	1.44E+07	2.23E+05
Tc-99	4.88E-01	---	---	---	4.62E+00	2.48E+08	5.52E+03
Th-230	1.79E+02	7.53E+00	7.56E+00	---	4.89E+01	1.46E+04	2.04E+01
Th-232	1.87E+15	5.23E+13	6.97E+13	---	1.19E+14	4.09E+03	5.24E+00
U-233	5.71E+18	2.76E+18	---	---	3.36E+17	2.98E+05	1.05E+03
U-234	7.15E+04	2.86E+03	2.87E+03	---	1.86E+04	1.42E+06	3.66E+03
U-235	2.87E+02	3.24E+00	---	8.87E+16	6.18E+00	7.19E+04	4.15E+02
U-236	---	7.82E+18	1.04E+19	2.66E+18	3.68E+17	3.35E+06	2.30E+05
U-238	1.27E+08	4.86E+06	4.88E+06	1.38E+16	3.17E+07	3.34E+05	6.11E+02
Zr-93	---	---	---	---	---	2.36E+08	7.53E+07

Table C-19. New preliminary inventory limits for future waste in ET06.

Nuclide	Beta-Gamma (Ci)	Alpha (Ci)	Radium (Ci)	Uranium (Ci)	All-Pathways (Ci)	Acute Intruder (Ci)	Chronic Intruder (Ci)
---	0-1171 yrs	0-1171 yrs	0-1171 yrs	0-1171 yrs	171-1171 yrs	71-1171 yrs	71-1171 yrs
Am-241	6.96E+03	3.48E+02	---	3.49E+11	2.89E+03	3.60E+05	7.17E+04
Am-243	6.66E+10	6.78E+08	---	---	1.29E+09	5.98E+04	4.09E+02
C-14	5.48E+00	---	---	---	3.42E+01	6.45E+08	1.04E+06
Cf-249	4.49E+05	2.24E+04	---	4.76E+13	1.87E+05	3.70E+04	4.44E+02
Cf-251	5.68E+17	5.25E+15	---	---	1.00E+16	8.69E+04	1.36E+03
Cl-36	7.54E-01	---	---	---	5.24E+00	2.21E+07	1.49E+04
Cm-244	---	---	---	---	---	2.19E+07	1.49E+08
Cm-245	8.28E+03	4.14E+02	---	5.90E+11	3.44E+03	9.58E+04	1.41E+03
Cm-246	2.70E+19	9.71E+17	9.74E+17	---	6.33E+18	3.32E+05	2.14E+06
Cm-247	3.46E+12	3.33E+10	---	---	6.35E+10	3.04E+04	9.44E+01
Cm-248	---	---	---	---	---	6.86E+03	5.35E+04
H-3	6.55E+00	---	---	---	8.51E+06	5.92E+12	2.45E+08
I-129	8.16E-04	---	---	---	8.71E-02	2.31E+06	5.55E+04
K-40	4.97E-01	---	---	---	3.23E+00	5.99E+04	6.88E+01
Mo-93	---	---	---	---	---	6.73E+07	3.32E+05
Nb-94	---	---	---	---	---	6.66E+03	1.10E+01
Ni-59	1.64E+00	---	---	---	9.88E+02	6.23E+08	1.51E+06
Np-237	5.56E-01	2.78E-02	---	4.71E+07	2.31E-01	5.11E+04	2.03E+02
Pd-107	1.14E+02	---	---	---	9.26E+02	6.72E+09	1.31E+08
Pu-238	4.21E+08	1.64E+07	1.65E+07	---	1.07E+08	7.56E+05	1.22E+07
Pu-239	5.62E+08	6.10E+06	---	---	1.16E+07	3.16E+05	8.17E+05
Pu-240	---	---	---	---	---	3.19E+05	3.62E+06
Pu-241	2.51E+05	1.26E+04	---	1.37E+13	1.04E+05	1.05E+07	2.09E+06
Pu-242	5.83E+15	2.16E+14	2.17E+14	---	1.41E+15	3.31E+05	2.43E+06
Pu-244	---	---	---	---	---	2.75E+04	5.55E+01
Ra-226	3.96E+01	1.76E+00	1.76E+00	---	1.14E+01	5.85E+03	1.07E+01
Se-79	---	---	---	---	---	9.50E+07	1.00E+06
Sn-126	---	---	---	---	---	5.42E+03	1.04E+01
Sr-90	3.88E+02	---	---	---	2.07E+04	1.44E+07	2.23E+05
Tc-99	4.76E-01	---	---	---	4.51E+00	2.48E+08	5.52E+03
Th-230	1.83E+02	7.65E+00	7.68E+00	---	4.97E+01	1.46E+04	2.04E+01
Th-232	1.88E+15	5.25E+13	7.00E+13	---	1.19E+14	4.09E+03	5.24E+00
U-233	5.89E+18	2.85E+18	---	---	3.46E+17	2.98E+05	1.05E+03
U-234	7.38E+04	2.94E+03	2.96E+03	---	1.92E+04	1.42E+06	3.66E+03
U-235	2.87E+02	3.24E+00	---	9.14E+16	6.19E+00	7.19E+04	4.15E+02
U-236	---	7.91E+18	1.05E+19	2.74E+18	3.79E+17	3.35E+06	2.30E+05
U-238	1.33E+08	5.09E+06	5.11E+06	1.42E+16	3.32E+07	3.34E+05	6.11E+02
Zr-93	---	---	---	---	---	2.36E+08	7.53E+07

Table C-20. New preliminary inventory limits for existing waste in ST07.

Nuclide	Beta-Gamma (Ci)	Alpha (Ci)	Radium (Ci)	Uranium (Ci)	All-Pathways (Ci)	Acute Intruder (Ci)	Chronic Intruder (Ci)
---	0-1171 yrs	0-1171 yrs	0-1171 yrs	0-1171 yrs	171-1171 yrs	71-1171 yrs	71-1171 yrs
Am-241	5.62E+03	2.81E+02	---	5.59E+11	2.33E+03	3.60E+05	7.17E+04
Am-243	1.06E+11	9.76E+08	---	---	1.86E+09	5.98E+04	4.09E+02
C-14	8.31E+00	---	---	---	5.18E+01	6.45E+08	1.04E+06
Cf-249	6.12E+05	3.06E+04	---	1.25E+14	2.54E+05	3.70E+04	4.44E+02
Cf-251	1.38E+18	1.13E+16	---	---	2.16E+16	8.69E+04	1.36E+03
Cl-36	1.17E+00	---	---	---	8.16E+00	2.21E+07	1.49E+04
Cm-244	---	---	---	---	---	2.19E+07	1.49E+08
Cm-245	7.74E+03	3.87E+02	---	1.24E+12	3.22E+03	9.58E+04	1.41E+03
Cm-246	---	3.63E+19	3.64E+19	---	---	3.32E+05	2.14E+06
Cm-247	6.96E+12	6.00E+10	---	---	1.14E+11	3.04E+04	9.44E+01
Cm-248	---	---	---	---	---	6.86E+03	5.35E+04
H-3	6.29E+00	---	---	---	2.23E+09	5.92E+12	2.45E+08
I-129	1.55E-03	---	---	---	1.66E-01	2.31E+06	5.55E+04
K-40	8.53E-01	---	---	---	5.54E+00	5.99E+04	6.88E+01
Mo-93	---	---	---	---	---	6.73E+07	3.32E+05
Nb-94	---	---	---	---	---	6.66E+03	1.10E+01
Ni-59	2.74E+01	---	---	---	1.65E+04	6.23E+08	1.51E+06
Np-237	6.32E-01	3.16E-02	---	4.88E+07	2.63E-01	5.11E+04	2.03E+02
Pd-107	1.90E+03	---	---	---	1.55E+04	6.72E+09	1.31E+08
Pu-238	7.49E+09	2.69E+08	2.70E+08	---	1.76E+09	7.56E+05	1.22E+07
Pu-239	6.43E+08	6.39E+06	---	---	1.22E+07	3.16E+05	8.17E+05
Pu-240	---	---	---	---	---	3.19E+05	3.62E+06
Pu-241	2.76E+05	1.38E+04	---	3.66E+13	1.15E+05	1.05E+07	2.09E+06
Pu-242	1.61E+17	5.45E+15	5.46E+15	---	3.56E+16	3.31E+05	2.43E+06
Pu-244	---	---	---	---	---	2.75E+04	5.55E+01
Ra-226	1.15E+02	4.66E+00	4.68E+00	---	3.03E+01	5.85E+03	1.07E+01
Se-79	---	---	---	---	---	9.50E+07	1.00E+06
Sn-126	---	---	---	---	---	5.42E+03	1.04E+01
Sr-90	2.99E+03	---	---	---	1.60E+05	1.44E+07	2.23E+05
Tc-99	1.13E+00	---	---	---	1.07E+01	2.48E+08	5.52E+03
Th-230	1.25E+03	4.75E+01	4.77E+01	---	3.09E+02	1.46E+04	2.04E+01
Th-232	---	---	---	---	---	4.09E+03	5.24E+00
U-233	---	---	---	---	---	2.98E+05	1.05E+03
U-234	8.08E+05	2.95E+04	2.96E+04	---	1.92E+05	1.42E+06	3.66E+03
U-235	2.11E+02	2.33E+00	---	---	4.45E+00	7.19E+04	4.15E+02
U-236	---	---	---	---	---	3.35E+06	2.30E+05
U-238	2.27E+09	7.96E+07	7.99E+07	---	5.20E+08	3.34E+05	6.11E+02
Zr-93	---	---	---	---	---	2.36E+08	7.53E+07

Table C-21. New preliminary inventory limits for future waste in ST07.

Nuclide	Beta-Gamma (Ci)	Alpha (Ci)	Radium (Ci)	Uranium (Ci)	All-Pathways (Ci)	Acute Intruder (Ci)	Chronic Intruder (Ci)
---	0-1171 yrs	0-1171 yrs	0-1171 yrs	0-1171 yrs	171-1171 yrs	71-1171 yrs	71-1171 yrs
Am-241	5.58E+03	2.79E+02	---	5.71E+11	2.32E+03	3.60E+05	7.17E+04
Am-243	1.09E+11	1.00E+09	---	---	1.91E+09	5.98E+04	4.09E+02
C-14	7.21E+00	---	---	---	4.49E+01	6.45E+08	1.04E+06
Cf-249	6.21E+05	3.11E+04	---	1.27E+14	2.58E+05	3.70E+04	4.44E+02
Cf-251	1.44E+18	1.18E+16	---	---	2.25E+16	8.69E+04	1.36E+03
Cl-36	1.20E+00	---	---	---	8.31E+00	2.21E+07	1.49E+04
Cm-244	---	---	---	---	---	2.19E+07	1.49E+08
Cm-245	7.86E+03	3.93E+02	---	1.27E+12	3.27E+03	9.58E+04	1.41E+03
Cm-246	---	3.95E+19	3.96E+19	---	---	3.32E+05	2.14E+06
Cm-247	7.21E+12	6.21E+10	---	---	1.18E+11	3.04E+04	9.44E+01
Cm-248	---	---	---	---	---	6.86E+03	5.35E+04
H-3	6.29E+00	---	---	---	1.64E+07	5.92E+12	2.45E+08
I-129	1.35E-03	---	---	---	1.44E-01	2.31E+06	5.55E+04
K-40	9.92E-01	---	---	---	6.44E+00	5.99E+04	6.88E+01
Mo-93	---	---	---	---	---	6.73E+07	3.32E+05
Nb-94	---	---	---	---	---	6.66E+03	1.10E+01
Ni-59	3.46E+01	---	---	---	2.08E+04	6.23E+08	1.51E+06
Np-237	6.23E-01	3.12E-02	---	5.01E+07	2.59E-01	5.11E+04	2.03E+02
Pd-107	2.42E+03	---	---	---	1.96E+04	6.72E+09	1.31E+08
Pu-238	7.86E+09	2.82E+08	2.83E+08	---	1.84E+09	7.56E+05	1.22E+07
Pu-239	6.55E+08	6.51E+06	---	---	1.24E+07	3.16E+05	8.17E+05
Pu-240	---	---	---	---	---	3.19E+05	3.62E+06
Pu-241	2.78E+05	1.39E+04	---	3.84E+13	1.16E+05	1.05E+07	2.09E+06
Pu-242	1.72E+17	5.82E+15	5.84E+15	---	3.80E+16	3.31E+05	2.43E+06
Pu-244	---	---	---	---	---	2.75E+04	5.55E+01
Ra-226	1.15E+02	4.67E+00	4.69E+00	---	3.04E+01	5.85E+03	1.07E+01
Se-79	---	---	---	---	---	9.50E+07	1.00E+06
Sn-126	---	---	---	---	---	5.42E+03	1.04E+01
Sr-90	2.53E+03	---	---	---	1.35E+05	1.44E+07	2.23E+05
Tc-99	1.07E+00	---	---	---	1.01E+01	2.48E+08	5.52E+03
Th-230	1.27E+03	4.84E+01	4.86E+01	---	3.15E+02	1.46E+04	2.04E+01
Th-232	---	---	---	---	---	4.09E+03	5.24E+00
U-233	---	---	---	---	---	2.98E+05	1.05E+03
U-234	8.44E+05	3.07E+04	3.08E+04	---	2.00E+05	1.42E+06	3.66E+03
U-235	2.12E+02	2.35E+00	---	---	4.48E+00	7.19E+04	4.15E+02
U-236	---	---	---	---	---	3.35E+06	2.30E+05
U-238	2.41E+09	8.45E+07	8.48E+07	---	5.52E+08	3.34E+05	6.11E+02
Zr-93	---	---	---	---	---	2.36E+08	7.53E+07

Table C-22. New preliminary inventory limits for existing waste in ST14.

Nuclide	Beta-Gamma (Ci)	Alpha (Ci)	Radium (Ci)	Uranium (Ci)	All-Pathways (Ci)	Acute Intruder (Ci)	Chronic Intruder (Ci)
---	0-1171 yrs	0-1171 yrs	0-1171 yrs	0-1171 yrs	171-1171 yrs	71-1171 yrs	71-1171 yrs
Am-241	1.29E+04	6.45E+02	---	1.28E+12	5.36E+03	3.60E+05	7.17E+04
Am-243	2.39E+11	2.19E+09	---	---	4.18E+09	5.98E+04	4.09E+02
C-14	1.64E+01	---	---	---	1.02E+02	6.45E+08	1.04E+06
Cf-249	1.37E+06	6.85E+04	---	2.81E+14	5.69E+05	3.70E+04	4.44E+02
Cf-251	3.15E+18	2.58E+16	---	---	4.91E+16	8.69E+04	1.36E+03
Cl-36	2.80E+00	---	---	---	1.95E+01	2.21E+07	1.49E+04
Cm-244	---	---	---	---	---	2.19E+07	1.49E+08
Cm-245	1.74E+04	8.72E+02	---	2.79E+12	7.25E+03	9.58E+04	1.41E+03
Cm-246	---	8.45E+19	8.47E+19	---	---	3.32E+05	2.14E+06
Cm-247	1.58E+13	1.36E+11	---	---	2.58E+11	3.04E+04	9.44E+01
Cm-248	---	---	---	---	---	6.86E+03	5.35E+04
H-3	8.90E+00	---	---	---	1.50E+07	5.92E+12	2.45E+08
I-129	3.06E-03	---	---	---	3.27E-01	2.31E+06	5.55E+04
K-40	2.32E+00	---	---	---	1.51E+01	5.99E+04	6.88E+01
Mo-93	---	---	---	---	---	6.73E+07	3.32E+05
Nb-94	---	---	---	---	---	6.66E+03	1.10E+01
Ni-59	7.09E+01	---	---	---	4.27E+04	6.23E+08	1.51E+06
Np-237	1.39E+00	6.96E-02	---	1.17E+08	5.78E-01	5.11E+04	2.03E+02
Pd-107	4.96E+03	---	---	---	4.02E+04	6.72E+09	1.31E+08
Pu-238	1.57E+10	5.60E+08	5.62E+08	---	3.66E+09	7.56E+05	1.22E+07
Pu-239	1.44E+09	1.43E+07	---	---	2.73E+07	3.16E+05	8.17E+05
Pu-240	---	---	---	---	---	3.19E+05	3.62E+06
Pu-241	6.22E+05	3.11E+04	---	8.50E+13	2.58E+05	1.05E+07	2.09E+06
Pu-242	3.64E+17	1.22E+16	1.22E+16	---	7.95E+16	3.31E+05	2.43E+06
Pu-244	---	---	---	---	---	2.75E+04	5.55E+01
Ra-226	2.19E+02	8.91E+00	8.94E+00	---	5.79E+01	5.85E+03	1.07E+01
Se-79	---	---	---	---	---	9.50E+07	1.00E+06
Sn-126	---	---	---	---	---	5.42E+03	1.04E+01
Sr-90	5.92E+03	---	---	---	3.16E+05	1.44E+07	2.23E+05
Tc-99	2.39E+00	---	---	---	2.27E+01	2.48E+08	5.52E+03
Th-230	2.45E+03	9.32E+01	9.35E+01	---	6.07E+02	1.46E+04	2.04E+01
Th-232	---	---	---	---	---	4.09E+03	5.24E+00
U-233	---	---	---	---	---	2.98E+05	1.05E+03
U-234	1.67E+06	6.03E+04	6.06E+04	---	3.94E+05	1.42E+06	3.66E+03
U-235	4.86E+02	5.42E+00	---	---	1.03E+01	7.19E+04	4.15E+02
U-236	---	---	---	---	---	3.35E+06	2.30E+05
U-238	4.95E+09	1.72E+08	1.72E+08	---	1.12E+09	3.34E+05	6.11E+02
Zr-93	---	---	---	---	---	2.36E+08	7.53E+07

Table C-23. New preliminary inventory limits for future waste in ST14.

Nuclide	Beta-Gamma (Ci)	Alpha (Ci)	Radium (Ci)	Uranium (Ci)	All-Pathways (Ci)	Acute Intruder (Ci)	Chronic Intruder (Ci)
---	0-1171 yrs	0-1171 yrs	0-1171 yrs	0-1171 yrs	171-1171 yrs	71-1171 yrs	71-1171 yrs
Am-241	1.29E+04	6.45E+02	---	1.29E+12	5.36E+03	3.60E+05	7.17E+04
Am-243	2.43E+11	2.23E+09	---	---	4.25E+09	5.98E+04	4.09E+02
C-14	1.53E+01	---	---	---	9.51E+01	6.45E+08	1.04E+06
Cf-249	1.38E+06	6.91E+04	---	2.85E+14	5.75E+05	3.70E+04	4.44E+02
Cf-251	3.24E+18	2.65E+16	---	---	5.05E+16	8.69E+04	1.36E+03
Cl-36	2.57E+00	---	---	---	1.79E+01	2.21E+07	1.49E+04
Cm-244	---	---	---	---	---	2.19E+07	1.49E+08
Cm-245	1.76E+04	8.81E+02	---	2.82E+12	7.32E+03	9.58E+04	1.41E+03
Cm-246	---	8.96E+19	8.99E+19	---	---	3.32E+05	2.14E+06
Cm-247	1.61E+13	1.39E+11	---	---	2.64E+11	3.04E+04	9.44E+01
Cm-248	---	---	---	---	---	6.86E+03	5.35E+04
H-3	6.70E+01	---	---	---	6.03E+06	5.92E+12	2.45E+08
I-129	2.97E-03	---	---	---	3.17E-01	2.31E+06	5.55E+04
K-40	2.59E+00	---	---	---	1.68E+01	5.99E+04	6.88E+01
Mo-93	---	---	---	---	---	6.73E+07	3.32E+05
Nb-94	---	---	---	---	---	6.66E+03	1.10E+01
Ni-59	7.16E+01	---	---	---	4.31E+04	6.23E+08	1.51E+06
Np-237	1.34E+00	6.68E-02	---	1.19E+08	5.55E-01	5.11E+04	2.03E+02
Pd-107	5.01E+03	---	---	---	4.06E+04	6.72E+09	1.31E+08
Pu-238	1.62E+10	5.76E+08	5.78E+08	---	3.76E+09	7.56E+05	1.22E+07
Pu-239	1.46E+09	1.45E+07	---	---	2.77E+07	3.16E+05	8.17E+05
Pu-240	---	---	---	---	---	3.19E+05	3.62E+06
Pu-241	6.26E+05	3.13E+04	---	8.67E+13	2.60E+05	1.05E+07	2.09E+06
Pu-242	3.81E+17	1.27E+16	1.28E+16	---	8.31E+16	3.31E+05	2.43E+06
Pu-244	---	---	---	---	---	2.75E+04	5.55E+01
Ra-226	2.19E+02	8.92E+00	8.95E+00	---	5.80E+01	5.85E+03	1.07E+01
Se-79	---	---	---	---	---	9.50E+07	1.00E+06
Sn-126	---	---	---	---	---	5.42E+03	1.04E+01
Sr-90	5.16E+03	---	---	---	2.75E+05	1.44E+07	2.23E+05
Tc-99	2.20E+00	---	---	---	2.08E+01	2.48E+08	5.52E+03
Th-230	2.48E+03	9.43E+01	9.46E+01	---	6.14E+02	1.46E+04	2.04E+01
Th-232	---	---	---	---	---	4.09E+03	5.24E+00
U-233	---	---	---	---	---	2.98E+05	1.05E+03
U-234	1.72E+06	6.21E+04	6.23E+04	---	4.05E+05	1.42E+06	3.66E+03
U-235	4.89E+02	5.46E+00	---	---	1.04E+01	7.19E+04	4.15E+02
U-236	---	---	---	---	---	3.35E+06	2.30E+05
U-238	5.17E+09	1.79E+08	1.79E+08	---	1.17E+09	3.34E+05	6.11E+02
Zr-93	---	---	---	---	---	2.36E+08	7.53E+07

Table C-24. New preliminary inventory limits for future waste in ST15..

Nuclide	Beta-Gamma (Ci)	Alpha (Ci)	Radium (Ci)	Uranium (Ci)	All-Pathways (Ci)	Acute Intruder (Ci)	Chronic Intruder (Ci)
---	0-1171 yrs	0-1171 yrs	0-1171 yrs	0-1171 yrs	171-1171 yrs	71-1171 yrs	71-1171 yrs
Am-241	1.73E+04	8.64E+02	---	8.77E+11	7.19E+03	3.60E+05	7.17E+04
Am-243	1.77E+11	1.80E+09	---	---	3.42E+09	5.98E+04	4.09E+02
C-14	1.18E+01	---	---	---	7.34E+01	6.45E+08	1.04E+06
Cf-249	1.16E+06	5.80E+04	---	1.22E+14	4.82E+05	3.70E+04	4.44E+02
Cf-251	1.50E+18	1.39E+16	---	---	2.64E+16	8.69E+04	1.36E+03
Cl-36	1.71E+00	---	---	---	1.19E+01	2.21E+07	1.49E+04
Cm-244	---	---	---	---	---	2.19E+07	1.49E+08
Cm-245	2.14E+04	1.07E+03	---	1.54E+12	8.90E+03	9.58E+04	1.41E+03
Cm-246	5.08E+19	1.82E+18	1.82E+18	---	1.18E+19	3.32E+05	2.14E+06
Cm-247	9.17E+12	8.86E+10	---	---	1.69E+11	3.04E+04	9.44E+01
Cm-248	---	---	---	---	---	6.86E+03	5.35E+04
H-3	1.40E+02	---	---	---	2.41E+05	5.92E+12	2.45E+08
I-129	1.95E-03	---	---	---	2.08E-01	2.31E+06	5.55E+04
K-40	1.12E+00	---	---	---	7.27E+00	5.99E+04	6.88E+01
Mo-93	---	---	---	---	---	6.73E+07	3.32E+05
Nb-94	---	---	---	---	---	6.66E+03	1.10E+01
Ni-59	3.55E+00	---	---	---	2.14E+03	6.23E+08	1.51E+06
Np-237	1.25E+00	6.27E-02	---	1.16E+08	5.21E-01	5.11E+04	2.03E+02
Pd-107	2.47E+02	---	---	---	2.01E+03	6.72E+09	1.31E+08
Pu-238	7.28E+08	2.87E+07	2.88E+07	---	1.86E+08	7.56E+05	1.22E+07
Pu-239	1.47E+09	1.59E+07	---	---	3.03E+07	3.16E+05	8.17E+05
Pu-240	---	---	---	---	---	3.19E+05	3.62E+06
Pu-241	6.21E+05	3.10E+04	---	3.49E+13	2.58E+05	1.05E+07	2.09E+06
Pu-242	1.04E+16	3.86E+14	3.87E+14	---	2.52E+15	3.31E+05	2.43E+06
Pu-244	---	---	---	---	---	2.75E+04	5.55E+01
Ra-226	7.34E+01	3.25E+00	3.26E+00	---	2.11E+01	5.85E+03	1.07E+01
Se-79	---	---	---	---	---	9.50E+07	1.00E+06
Sn-126	---	---	---	---	---	5.42E+03	1.04E+01
Sr-90	2.07E+02	---	---	---	1.11E+04	1.44E+07	2.23E+05
Tc-99	1.12E+00	---	---	---	1.06E+01	2.48E+08	5.52E+03
Th-230	3.52E+02	1.50E+01	1.50E+01	---	9.73E+01	1.46E+04	2.04E+01
Th-232	8.75E+15	2.44E+14	3.26E+14	---	5.55E+14	4.09E+03	5.24E+00
U-233	3.67E+19	1.77E+19	---	---	2.11E+18	2.98E+05	1.05E+03
U-234	1.34E+05	5.42E+03	5.44E+03	---	3.52E+04	1.42E+06	3.66E+03
U-235	7.36E+02	8.33E+00	---	5.57E+17	1.59E+01	7.19E+04	4.15E+02
U-236	---	3.71E+19	4.95E+19	1.67E+19	2.29E+18	3.35E+06	2.30E+05
U-238	2.35E+08	9.08E+06	9.11E+06	8.67E+16	5.91E+07	3.34E+05	6.11E+02
Zr-93	---	---	---	---	---	2.36E+08	7.53E+07

Table C-25. New preliminary inventory limits for future waste in ST16.

Nuclide	Beta-Gamma (Ci)	Alpha (Ci)	Radium (Ci)	Uranium (Ci)	All-Pathways (Ci)	Acute Intruder (Ci)	Chronic Intruder (Ci)
---	0-1171 yrs	0-1171 yrs	0-1171 yrs	0-1171 yrs	171-1171 yrs	71-1171 yrs	71-1171 yrs
Am-241	1.78E+04	8.89E+02	---	9.62E+11	7.39E+03	3.60E+05	7.17E+04
Am-243	2.23E+11	2.23E+09	---	---	4.25E+09	5.98E+04	4.09E+02
C-14	1.25E+01	---	---	---	7.77E+01	6.45E+08	1.04E+06
Cf-249	1.39E+06	6.96E+04	---	1.68E+14	5.79E+05	3.70E+04	4.44E+02
Cf-251	2.29E+18	2.07E+16	---	---	3.95E+16	8.69E+04	1.36E+03
Cl-36	1.94E+00	---	---	---	1.35E+01	2.21E+07	1.49E+04
Cm-244	---	---	---	---	---	2.19E+07	1.49E+08
Cm-245	2.22E+04	1.11E+03	---	1.92E+12	9.23E+03	9.58E+04	1.41E+03
Cm-246	---	2.93E+19	2.93E+19	---	---	3.32E+05	2.14E+06
Cm-247	1.28E+13	1.21E+11	---	---	2.31E+11	3.04E+04	9.44E+01
Cm-248	---	---	---	---	---	6.86E+03	5.35E+04
H-3	2.21E+01	---	---	---	1.22E+06	5.92E+12	2.45E+08
I-129	2.17E-03	---	---	---	2.32E-01	2.31E+06	5.55E+04
K-40	1.33E+00	---	---	---	8.67E+00	5.99E+04	6.88E+01
Mo-93	---	---	---	---	---	6.73E+07	3.32E+05
Nb-94	---	---	---	---	---	6.66E+03	1.10E+01
Ni-59	7.86E+00	---	---	---	4.73E+03	6.23E+08	1.51E+06
Np-237	1.48E+00	7.38E-02	---	1.15E+08	6.13E-01	5.11E+04	2.03E+02
Pd-107	5.46E+02	---	---	---	4.43E+03	6.72E+09	1.31E+08
Pu-238	7.10E+09	2.61E+08	2.62E+08	---	1.70E+09	7.56E+05	1.22E+07
Pu-239	1.63E+09	1.74E+07	---	---	3.32E+07	3.16E+05	8.17E+05
Pu-240	---	---	---	---	---	3.19E+05	3.62E+06
Pu-241	6.34E+05	3.17E+04	---	4.14E+13	2.63E+05	1.05E+07	2.09E+06
Pu-242	1.47E+17	5.14E+15	5.16E+15	---	3.36E+16	3.31E+05	2.43E+06
Pu-244	---	---	---	---	---	2.75E+04	5.55E+01
Ra-226	1.95E+02	8.03E+00	8.06E+00	---	5.22E+01	5.85E+03	1.07E+01
Se-79	---	---	---	---	---	9.50E+07	1.00E+06
Sn-126	---	---	---	---	---	5.42E+03	1.04E+01
Sr-90	3.28E+03	---	---	---	1.75E+05	1.44E+07	2.23E+05
Tc-99	1.26E+00	---	---	---	1.19E+01	2.48E+08	5.52E+03
Th-230	1.69E+03	6.54E+01	6.56E+01	---	4.26E+02	1.46E+04	2.04E+01
Th-232	2.94E+19	8.19E+17	1.09E+18	---	1.86E+18	4.09E+03	5.24E+00
U-233	---	---	---	---	---	2.98E+05	1.05E+03
U-234	1.05E+06	3.91E+04	3.93E+04	---	2.55E+05	1.42E+06	3.66E+03
U-235	7.32E+02	8.28E+00	---	---	1.58E+01	7.19E+04	4.15E+02
U-236	---	---	---	---	---	3.35E+06	2.30E+05
U-238	2.60E+09	9.38E+07	9.41E+07	---	6.12E+08	3.34E+05	6.11E+02
Zr-93	---	---	---	---	---	2.36E+08	7.53E+07

Table C-26. New preliminary inventory limits for future waste in ST17.

Nuclide	Beta-Gamma (Ci)	Alpha (Ci)	Radium (Ci)	Uranium (Ci)	All-Pathways (Ci)	Acute Intruder (Ci)	Chronic Intruder (Ci)
---	0-1171 yrs	0-1171 yrs	0-1171 yrs	0-1171 yrs	171-1171 yrs	71-1171 yrs	71-1171 yrs
Am-241	1.86E+04	9.30E+02	---	1.02E+12	7.73E+03	3.60E+05	7.17E+04
Am-243	2.51E+11	2.49E+09	---	---	4.75E+09	5.98E+04	4.09E+02
C-14	1.30E+01	---	---	---	8.08E+01	6.45E+08	1.04E+06
Cf-249	1.52E+06	7.59E+04	---	1.95E+14	6.31E+05	3.70E+04	4.44E+02
Cf-251	2.76E+18	2.48E+16	---	---	4.72E+16	8.69E+04	1.36E+03
Cl-36	2.02E+00	---	---	---	1.41E+01	2.21E+07	1.49E+04
Cm-244	---	---	---	---	---	2.19E+07	1.49E+08
Cm-245	2.36E+04	1.18E+03	---	2.14E+12	9.81E+03	9.58E+04	1.41E+03
Cm-246	---	6.34E+19	6.36E+19	---	---	3.32E+05	2.14E+06
Cm-247	1.51E+13	1.42E+11	---	---	2.70E+11	3.04E+04	9.44E+01
Cm-248	---	---	---	---	---	6.86E+03	5.35E+04
H-3	2.45E+01	---	---	---	1.01E+06	5.92E+12	2.45E+08
I-129	2.28E-03	---	---	---	2.43E-01	2.31E+06	5.55E+04
K-40	1.40E+00	---	---	---	9.08E+00	5.99E+04	6.88E+01
Mo-93	---	---	---	---	---	6.73E+07	3.32E+05
Nb-94	---	---	---	---	---	6.66E+03	1.10E+01
Ni-59	1.02E+01	---	---	---	6.15E+03	6.23E+08	1.51E+06
Np-237	1.54E+00	7.72E-02	---	1.20E+08	6.42E-01	5.11E+04	2.03E+02
Pd-107	7.10E+02	---	---	---	5.76E+03	6.72E+09	1.31E+08
Pu-238	1.21E+10	4.33E+08	4.34E+08	---	2.83E+09	7.56E+05	1.22E+07
Pu-239	1.76E+09	1.87E+07	---	---	3.56E+07	3.16E+05	8.17E+05
Pu-240	---	---	---	---	---	3.19E+05	3.62E+06
Pu-241	6.62E+05	3.31E+04	---	4.49E+13	2.75E+05	1.05E+07	2.09E+06
Pu-242	2.96E+17	1.00E+16	1.01E+16	---	6.56E+16	3.31E+05	2.43E+06
Pu-244	---	---	---	---	---	2.75E+04	5.55E+01
Ra-226	2.69E+02	1.09E+01	1.10E+01	---	7.12E+01	5.85E+03	1.07E+01
Se-79	---	---	---	---	---	9.50E+07	1.00E+06
Sn-126	---	---	---	---	---	5.42E+03	1.04E+01
Sr-90	4.22E+03	---	---	---	2.25E+05	1.44E+07	2.23E+05
Tc-99	1.32E+00	---	---	---	1.25E+01	2.48E+08	5.52E+03
Th-230	2.55E+03	9.78E+01	9.81E+01	---	6.37E+02	1.46E+04	2.04E+01
Th-232	---	4.17E+18	5.56E+18	---	9.47E+18	4.09E+03	5.24E+00
U-233	---	---	---	---	---	2.98E+05	1.05E+03
U-234	1.68E+06	6.17E+04	6.19E+04	---	4.02E+05	1.42E+06	3.66E+03
U-235	7.69E+02	8.69E+00	---	---	1.66E+01	7.19E+04	4.15E+02
U-236	---	---	---	---	---	3.35E+06	2.30E+05
U-238	4.65E+09	1.63E+08	1.64E+08	---	1.07E+09	3.34E+05	6.11E+02
Zr-93	---	---	---	---	---	2.36E+08	7.53E+07

Table C-27. New preliminary inventory limits for future waste in ST18.

Nuclide	Beta-Gamma (Ci)	Alpha (Ci)	Radium (Ci)	Uranium (Ci)	All-Pathways (Ci)	Acute Intruder (Ci)	Chronic Intruder (Ci)
---	0-1171 yrs	0-1171 yrs	0-1171 yrs	0-1171 yrs	171-1171 yrs	71-1171 yrs	71-1171 yrs
Am-241	1.98E+04	9.92E+02	---	1.10E+12	8.24E+03	3.60E+05	7.17E+04
Am-243	2.73E+11	2.70E+09	---	---	5.14E+09	5.98E+04	4.09E+02
C-14	1.38E+01	---	---	---	8.57E+01	6.45E+08	1.04E+06
Cf-249	1.64E+06	8.20E+04	---	2.11E+14	6.82E+05	3.70E+04	4.44E+02
Cf-251	3.11E+18	2.78E+16	---	---	5.29E+16	8.69E+04	1.36E+03
Cl-36	2.14E+00	---	---	---	1.49E+01	2.21E+07	1.49E+04
Cm-244	---	---	---	---	---	2.19E+07	1.49E+08
Cm-245	2.55E+04	1.27E+03	---	2.31E+12	1.06E+04	9.58E+04	1.41E+03
Cm-246	---	---	---	---	---	3.32E+05	2.14E+06
Cm-247	1.66E+13	1.55E+11	---	---	2.96E+11	3.04E+04	9.44E+01
Cm-248	---	---	---	---	---	6.86E+03	5.35E+04
H-3	2.57E+01	---	---	---	7.72E+05	5.92E+12	2.45E+08
I-129	2.41E-03	---	---	---	2.57E-01	2.31E+06	5.55E+04
K-40	1.48E+00	---	---	---	9.61E+00	5.99E+04	6.88E+01
Mo-93	---	---	---	---	---	6.73E+07	3.32E+05
Nb-94	---	---	---	---	---	6.66E+03	1.10E+01
Ni-59	1.33E+01	---	---	---	8.01E+03	6.23E+08	1.51E+06
Np-237	1.64E+00	8.18E-02	---	1.27E+08	6.80E-01	5.11E+04	2.03E+02
Pd-107	9.25E+02	---	---	---	7.50E+03	6.72E+09	1.31E+08
Pu-238	1.87E+10	6.63E+08	6.65E+08	---	4.32E+09	7.56E+05	1.22E+07
Pu-239	1.91E+09	2.02E+07	---	---	3.85E+07	3.16E+05	8.17E+05
Pu-240	---	---	---	---	---	3.19E+05	3.62E+06
Pu-241	7.05E+05	3.52E+04	---	4.85E+13	2.93E+05	1.05E+07	2.09E+06
Pu-242	4.82E+17	1.62E+16	1.63E+16	---	1.06E+17	3.31E+05	2.43E+06
Pu-244	---	---	---	---	---	2.75E+04	5.55E+01
Ra-226	3.71E+02	1.49E+01	1.50E+01	---	9.72E+01	5.85E+03	1.07E+01
Se-79	---	---	---	---	---	9.50E+07	1.00E+06
Sn-126	---	---	---	---	---	5.42E+03	1.04E+01
Sr-90	5.16E+03	---	---	---	2.76E+05	1.44E+07	2.23E+05
Tc-99	1.39E+00	---	---	---	1.32E+01	2.48E+08	5.52E+03
Th-230	3.71E+03	1.41E+02	1.41E+02	---	9.18E+02	1.46E+04	2.04E+01
Th-232	---	1.89E+19	2.52E+19	---	4.30E+19	4.09E+03	5.24E+00
U-233	---	---	---	---	---	2.98E+05	1.05E+03
U-234	2.55E+06	9.25E+04	9.28E+04	---	6.03E+05	1.42E+06	3.66E+03
U-235	8.23E+02	9.31E+00	---	---	1.78E+01	7.19E+04	4.15E+02
U-236	---	---	---	---	---	3.35E+06	2.30E+05
U-238	7.30E+09	2.54E+08	2.55E+08	---	1.66E+09	3.34E+05	6.11E+02
Zr-93	---	---	---	---	---	2.36E+08	7.53E+07

Table C-28. New preliminary inventory limits for future waste in ST19.

Nuclide	Beta-Gamma (Ci)	Alpha (Ci)	Radium (Ci)	Uranium (Ci)	All-Pathways (Ci)	Acute Intruder (Ci)	Chronic Intruder (Ci)
---	0-1171 yrs	0-1171 yrs	0-1171 yrs	0-1171 yrs	171-1171 yrs	71-1171 yrs	71-1171 yrs
Am-241	2.19E+04	1.09E+03	---	1.24E+12	9.09E+03	3.60E+05	7.17E+04
Am-243	3.24E+11	3.18E+09	---	---	6.07E+09	5.98E+04	4.09E+02
C-14	1.51E+01	---	---	---	9.43E+01	6.45E+08	1.04E+06
Cf-249	1.90E+06	9.51E+04	---	2.54E+14	7.91E+05	3.70E+04	4.44E+02
Cf-251	3.74E+18	3.35E+16	---	---	6.38E+16	8.69E+04	1.36E+03
Cl-36	2.35E+00	---	---	---	1.63E+01	2.21E+07	1.49E+04
Cm-244	---	---	---	---	---	2.19E+07	1.49E+08
Cm-245	2.86E+04	1.43E+03	---	2.72E+12	1.19E+04	9.58E+04	1.41E+03
Cm-246	---	---	---	---	---	3.32E+05	2.14E+06
Cm-247	2.00E+13	1.87E+11	---	---	3.57E+11	3.04E+04	9.44E+01
Cm-248	---	---	---	---	---	6.86E+03	5.35E+04
H-3	2.89E+01	---	---	---	6.48E+05	5.92E+12	2.45E+08
I-129	2.64E-03	---	---	---	2.82E-01	2.31E+06	5.55E+04
K-40	1.62E+00	---	---	---	1.05E+01	5.99E+04	6.88E+01
Mo-93	---	---	---	---	---	6.73E+07	3.32E+05
Nb-94	---	---	---	---	---	6.66E+03	1.10E+01
Ni-59	1.46E+01	---	---	---	8.80E+03	6.23E+08	1.51E+06
Np-237	1.79E+00	8.97E-02	---	1.40E+08	7.46E-01	5.11E+04	2.03E+02
Pd-107	1.02E+03	---	---	---	8.25E+03	6.72E+09	1.31E+08
Pu-238	1.94E+10	6.98E+08	7.01E+08	---	4.56E+09	7.56E+05	1.22E+07
Pu-239	2.17E+09	2.30E+07	---	---	4.38E+07	3.16E+05	8.17E+05
Pu-240	---	---	---	---	---	3.19E+05	3.62E+06
Pu-241	7.77E+05	3.89E+04	---	5.61E+13	3.23E+05	1.05E+07	2.09E+06
Pu-242	4.74E+17	1.62E+16	1.62E+16	---	1.06E+17	3.31E+05	2.43E+06
Pu-244	---	---	---	---	---	2.75E+04	5.55E+01
Ra-226	4.22E+02	1.70E+01	1.71E+01	---	1.11E+02	5.85E+03	1.07E+01
Se-79	---	---	---	---	---	9.50E+07	1.00E+06
Sn-126	---	---	---	---	---	5.42E+03	1.04E+01
Sr-90	5.00E+03	---	---	---	2.67E+05	1.44E+07	2.23E+05
Tc-99	1.53E+00	---	---	---	1.45E+01	2.48E+08	5.52E+03
Th-230	4.13E+03	1.59E+02	1.60E+02	---	1.04E+03	1.46E+04	2.04E+01
Th-232	---	---	---	---	---	4.09E+03	5.24E+00
U-233	---	---	---	---	---	2.98E+05	1.05E+03
U-234	2.73E+06	1.01E+05	1.01E+05	---	6.56E+05	1.42E+06	3.66E+03
U-235	9.13E+02	1.03E+01	---	---	1.97E+01	7.19E+04	4.15E+02
U-236	---	---	---	---	---	3.35E+06	2.30E+05
U-238	7.48E+09	2.64E+08	2.65E+08	---	1.72E+09	3.34E+05	6.11E+02
Zr-93	---	---	---	---	---	2.36E+08	7.53E+07

Table C-29. New preliminary inventory limits for future waste in ST20.

Nuclide	Beta-Gamma (Ci)	Alpha (Ci)	Radium (Ci)	Uranium (Ci)	All-Pathways (Ci)	Acute Intruder (Ci)	Chronic Intruder (Ci)
---	0-1171 yrs	0-1171 yrs	0-1171 yrs	0-1171 yrs	171-1171 yrs	71-1171 yrs	71-1171 yrs
Am-241	2.57E+04	1.28E+03	---	1.50E+12	1.07E+04	3.60E+05	7.17E+04
Am-243	3.96E+11	3.91E+09	---	---	7.46E+09	5.98E+04	4.09E+02
C-14	1.68E+01	---	---	---	1.05E+02	6.45E+08	1.04E+06
Cf-249	2.35E+06	1.17E+05	---	3.08E+14	9.76E+05	3.70E+04	4.44E+02
Cf-251	4.69E+18	4.17E+16	---	---	7.95E+16	8.69E+04	1.36E+03
Cl-36	2.59E+00	---	---	---	1.80E+01	2.21E+07	1.49E+04
Cm-244	---	---	---	---	---	2.19E+07	1.49E+08
Cm-245	3.47E+04	1.73E+03	---	3.34E+12	1.44E+04	9.58E+04	1.41E+03
Cm-246	---	---	---	---	---	3.32E+05	2.14E+06
Cm-247	2.46E+13	2.29E+11	---	---	4.37E+11	3.04E+04	9.44E+01
Cm-248	---	---	---	---	---	6.86E+03	5.35E+04
H-3	8.34E+02	---	---	---	6.09E+05	5.92E+12	2.45E+08
I-129	3.11E-03	---	---	---	3.32E-01	2.31E+06	5.55E+04
K-40	1.92E+00	---	---	---	1.25E+01	5.99E+04	6.88E+01
Mo-93	---	---	---	---	---	6.73E+07	3.32E+05
Nb-94	---	---	---	---	---	6.66E+03	1.10E+01
Ni-59	1.94E+01	---	---	---	1.17E+04	6.23E+08	1.51E+06
Np-237	2.07E+00	1.04E-01	---	1.65E+08	8.61E-01	5.11E+04	2.03E+02
Pd-107	1.35E+03	---	---	---	1.09E+04	6.72E+09	1.31E+08
Pu-238	2.79E+10	9.80E+08	9.83E+08	---	6.40E+09	7.56E+05	1.22E+07
Pu-239	2.68E+09	2.81E+07	---	---	5.37E+07	3.16E+05	8.17E+05
Pu-240	---	---	---	---	---	3.19E+05	3.62E+06
Pu-241	9.10E+05	4.55E+04	---	6.94E+13	3.78E+05	1.05E+07	2.09E+06
Pu-242	7.80E+17	2.59E+16	2.60E+16	---	1.69E+17	3.31E+05	2.43E+06
Pu-244	---	---	---	---	---	2.75E+04	5.55E+01
Ra-226	4.87E+02	1.95E+01	1.96E+01	---	1.27E+02	5.85E+03	1.07E+01
Se-79	---	---	---	---	---	9.50E+07	1.00E+06
Sn-126	---	---	---	---	---	5.42E+03	1.04E+01
Sr-90	5.24E+03	---	---	---	2.80E+05	1.44E+07	2.23E+05
Tc-99	1.84E+00	---	---	---	1.74E+01	2.48E+08	5.52E+03
Th-230	5.17E+03	1.95E+02	1.96E+02	---	1.27E+03	1.46E+04	2.04E+01
Th-232	---	---	---	---	---	4.09E+03	5.24E+00
U-233	---	---	---	---	---	2.98E+05	1.05E+03
U-234	3.72E+06	1.34E+05	1.35E+05	---	8.74E+05	1.42E+06	3.66E+03
U-235	1.07E+03	1.21E+01	---	---	2.32E+01	7.19E+04	4.15E+02
U-236	---	---	---	---	---	3.35E+06	2.30E+05
U-238	1.12E+10	3.87E+08	3.88E+08	---	2.53E+09	3.34E+05	6.11E+02
Zr-93	---	---	---	---	---	2.36E+08	7.53E+07

Table C-30. New preliminary inventory limits for existing waste in LAWV.

Nuclide	Beta-Gamma (Ci)	Alpha (Ci)	Radium (Ci)	Uranium (Ci)	All-Pathways (Ci)	Acute Intruder (Ci)	Chronic Intruder (Ci)
---	0-1171 yrs	0-1171 yrs	0-1171 yrs	0-1171 yrs	171-1171 yrs	71-1171 yrs	71-1171 yrs
Am-241	2.73E+09	1.37E+08	---	8.72E+17	1.14E+09	4.33E+05	7.07E+03
Am-243	4.49E+17	3.07E+15	---	---	5.85E+15	7.19E+04	5.96E+01
C-14	7.89E+00	---	---	---	4.91E+01	7.76E+08	1.25E+06
Cl-36	2.08E+00	---	---	---	1.45E+01	2.66E+07	8.64E+03
Cm-244	---	---	---	---	---	2.64E+07	1.79E+08
Cm-245	1.73E+09	8.66E+07	---	5.97E+17	7.20E+08	1.15E+05	1.50E+02
Cm-247	9.05E+18	6.09E+16	---	---	1.16E+17	3.66E+04	1.99E+01
Cm-248	---	---	---	---	---	8.24E+03	1.11E+03
H-3	4.76E+08	---	---	---	1.28E+12	7.12E+12	2.94E+08
I-129	3.68E-03	---	---	---	3.93E-01	2.78E+06	6.68E+04
K-40	---	---	---	---	---	7.21E+04	2.51E+01
Mo-93	4.12E+14	---	---	---	5.22E+15	8.09E+07	3.99E+05
Nb-94	4.78E+18	---	---	---	3.19E+19	8.01E+03	3.22E+00
Ni-59	5.26E+08	---	---	---	3.16E+11	7.49E+08	3.77E+05
Np-237	4.00E+06	2.00E+05	---	1.40E+15	1.66E+06	6.15E+04	3.70E+01
Pd-107	4.85E+10	---	---	---	3.94E+11	8.08E+09	1.58E+08
Pu-238	7.68E+15	1.73E+14	1.74E+14	---	1.14E+15	9.08E+05	4.28E+06
Pu-239	1.64E+16	1.15E+14	---	---	2.19E+14	3.80E+05	1.67E+05
Pu-240	---	---	---	---	---	3.84E+05	9.84E+05
Pu-241	8.00E+10	4.00E+09	---	2.55E+19	3.33E+10	1.27E+07	2.06E+05
Pu-242	---	---	---	---	---	3.98E+05	3.35E+05
Pu-244	---	---	---	---	---	3.31E+04	1.59E+01
Ra-226	3.46E+08	7.97E+06	7.98E+06	---	5.25E+07	7.03E+03	3.58E+00
Se-79	---	---	---	---	---	1.14E+08	1.21E+06
Sn-126	---	---	---	---	---	6.52E+03	2.76E+00
Sr-90	3.05E+14	---	---	---	1.63E+16	1.73E+07	2.52E+05
Tc-99	2.89E+02	---	---	---	2.74E+03	2.98E+08	6.57E+03
Th-230	2.42E+09	5.52E+07	5.53E+07	---	3.64E+08	1.75E+04	6.84E+00
Th-232	---	---	---	---	---	4.91E+03	1.84E+00
U-233	---	---	---	---	---	3.58E+05	2.51E+02
U-234	1.47E+12	3.34E+10	3.35E+10	---	2.20E+11	1.71E+06	1.24E+03
U-235	3.48E+09	2.49E+07	---	---	4.73E+07	8.65E+04	5.82E+01
U-236	---	---	---	---	---	4.03E+06	1.69E+05
U-238	4.05E+15	9.10E+13	9.12E+13	---	6.00E+14	4.01E+05	1.82E+02
Zr-93	---	---	---	---	---	2.84E+08	9.05E+07

Table C-31. New preliminary inventory limits for future waste in LAWV.

Nuclide	Beta-Gamma (Ci)	Alpha (Ci)	Radium (Ci)	Uranium (Ci)	All-Pathways (Ci)	Acute Intruder (Ci)	Chronic Intruder (Ci)
---	0-1171 yrs	0-1171 yrs	0-1171 yrs	0-1171 yrs	171-1171 yrs	71-1171 yrs	71-1171 yrs
Am-241	4.18E+09	2.09E+08	---	1.26E+18	1.74E+09	4.33E+05	7.07E+03
Am-243	7.08E+17	5.32E+15	---	---	1.01E+16	7.19E+04	5.96E+01
C-14	7.89E+00	---	---	---	4.91E+01	7.76E+08	1.25E+06
Cl-36	2.08E+00	---	---	---	1.45E+01	2.66E+07	8.64E+03
Cm-244	---	---	---	---	---	2.64E+07	1.79E+08
Cm-245	2.76E+09	1.38E+08	---	8.84E+17	1.15E+09	1.15E+05	1.50E+02
Cm-247	1.46E+19	1.08E+17	---	---	2.05E+17	3.66E+04	1.99E+01
Cm-248	---	---	---	---	---	8.24E+03	1.11E+03
H-3	4.76E+08	---	---	---	5.03E+11	7.12E+12	2.94E+08
I-129	3.68E-03	---	---	---	3.93E-01	2.78E+06	6.68E+04
K-40	---	---	---	---	---	7.21E+04	2.51E+01
Mo-93	6.20E+14	---	---	---	7.85E+15	8.09E+07	3.99E+05
Nb-94	8.00E+18	---	---	---	5.33E+19	8.01E+03	3.22E+00
Ni-59	1.03E+09	---	---	---	6.19E+11	7.49E+08	3.77E+05
Np-237	6.43E+06	3.21E+05	---	2.07E+15	2.67E+06	6.15E+04	3.70E+01
Pd-107	9.49E+10	---	---	---	7.70E+11	8.08E+09	1.58E+08
Pu-238	1.75E+16	3.81E+14	3.82E+14	---	2.51E+15	9.08E+05	4.28E+06
Pu-239	2.53E+16	1.93E+14	---	---	3.68E+14	3.80E+05	1.67E+05
Pu-240	---	---	---	---	---	3.84E+05	9.84E+05
Pu-241	1.22E+11	6.12E+09	---	3.68E+19	5.09E+10	1.27E+07	2.06E+05
Pu-242	---	---	---	---	---	3.98E+05	3.35E+05
Pu-244	---	---	---	---	---	3.31E+04	1.59E+01
Ra-226	7.61E+08	1.70E+07	1.70E+07	---	1.12E+08	7.03E+03	3.58E+00
Se-79	---	---	---	---	---	1.14E+08	1.21E+06
Sn-126	---	---	---	---	---	6.52E+03	2.76E+00
Sr-90	3.05E+14	---	---	---	1.63E+16	1.73E+07	2.52E+05
Tc-99	3.33E+02	---	---	---	3.16E+03	2.98E+08	6.57E+03
Th-230	5.38E+09	1.19E+08	1.19E+08	---	7.85E+08	1.75E+04	6.84E+00
Th-232	---	---	---	---	---	4.91E+03	1.84E+00
U-233	---	---	---	---	---	3.58E+05	2.51E+02
U-234	3.33E+12	7.30E+10	7.31E+10	---	4.81E+11	1.71E+06	1.24E+03
U-235	5.26E+09	4.07E+07	---	---	7.75E+07	8.65E+04	5.82E+01
U-236	---	---	---	---	---	4.03E+06	1.69E+05
U-238	9.27E+15	2.02E+14	2.02E+14	---	1.33E+15	4.01E+05	1.82E+02
Zr-93	---	---	---	---	---	2.84E+08	9.05E+07

C.4 Inventories for Deterministic Analysis

In the process of performing this SA, scoping analyses were performed along the way to assess the methods being developed and to determine if margin existed to warrant continuing towards the ultimate stochastic analysis effort. For example, initial DU timelines were established along with specified allowable % non-crushable containers. This set of conditions/assumptions, referred to as operational constrains, is call our "Case-1" analysis effort. As discussed in Appendix B this Case 1 represents an upper bound estimate with regards to out-year projections of waste burial within E-Area.

Prior to proceeding to the stochastic set of analyses, a single deterministic run was made to see if a SOF greater than one would be observed if all future waste was set to the same composition as a given DU's existing waste was currently at. This deterministic case was also employed to perform diagnostics, debugging, and QA activities.

In the stochastic analysis random compositions for each DU is computed from parent nuclide distribution functions. These pdf's for each parent nuclide within each DU were established where their mean values correspond to their existing values as discussed in Appendix C.5. For the future units (i.e., ST15 through ST20) the average composition was set to the average values computed for all of the ST's with existing inventory within them also discussed in Appendix C.5.

These specified DU compositions (i.e., "best estimate" compositions) were then scaled up to inventory such that a SOF of one would be achieved under the current WITS limits. The resulting computed SOF for Case-1 represents the 50-percentile value of possible SOF values. If this computed SOF value was sufficiently below a value of one, then the stochastic analyses effort would be warranted. If not, a new case would have to be reconsidered.

For each of the 13 DU's under consideration future inventories were computed and the existing, future, and total (i.e., existing plus future) inventory values are tabulated in Table C-32, Table C-33, and Table C-34.

Table C-32. Best estimate total inventories for use in a deterministic analysis for the LAWV, ET1, and ET2 DU's.

		LAWV	Open		ET1	Closed		ET2	Open
Nuclide	12.9% Existing (Ci)	Future (Ci)	7.767 Total (Ci)	86.4% Existing (Ci)	Future (Ci)	0.000 Total (Ci)	64.4% Existing (Ci)	Future (Ci)	1.553 Total (Ci)
AM241	4.156E-01	2.813E+00	3.228E+0	6.559E-1	0.000E+00	6.559E-1	1.487E+0	8.217E-01	2.308E+0
C14	1.853E-01	1.254E+00	1.439E+0	1.309E-1	0.000E+00	1.309E-1	3.824E-2	2.113E-02	5.937E-2
H3	4.097E+05	2.772E+06	3.182E+6	2.206E+0	0.000E+00	2.206E+0	4.501E-1	2.488E-01	6.989E-1
I129	1.731E-04	1.172E-03	1.345E-3	7.199E-5	0.000E+00	7.199E-5	4.838E-5	2.674E-05	7.512E-5
NI59	1.548E+00	1.048E+01	1.203E+1	1.172E-1	0.000E+00	1.172E-1	6.043E-2	3.340E-02	9.384E-2
NP237	4.286E-02	2.901E-01	3.329E-1	7.691E-3	0.000E+00	7.691E-3	3.130E-2	1.730E-02	4.860E-2
SR90	2.343E+02	1.586E+03	1.820E+3	2.523E+1	0.000E+00	2.523E+1	8.340E+1	4.610E+01	1.295E+2
TC99	1.211E-01	8.198E-01	9.409E-1	3.930E-2	0.000E+00	3.930E-2	5.903E-2	3.262E-02	9.165E-2
U235	1.543E-02	1.044E-01	1.198E-1	1.514E-2	0.000E+00	1.514E-2	8.445E-3	4.668E-03	1.311E-2

Table C-33. Best estimate total inventories for use in a deterministic analysis for the ST05, ST06, and ST07 DU's.

	ST05		Closed	ST06		Open	ST07		Open
Nuclide	100.3% Existing (Ci)	Future (Ci)	0.000 Future (Ci)	82.3% Existing (Ci)	Future (Ci)	1.215 Total (Ci)	55.7% Existing (Ci)	Future (Ci)	1.797 Total (Ci)
AM241	6.567E-1	0.000E+00	6.567E-1	6.687E-01	1.436E-01	8.122E-1	5.884E-01	4.688E-01	1.057E+0
C14	3.628E-2	0.000E+00	3.628E-2	7.872E-03	1.690E-03	9.562E-3	2.304E-02	1.836E-02	4.140E-2
H3	4.023E-1	0.000E+00	4.023E-1	1.966E-01	4.222E-02	2.389E-1	4.317E-01	3.440E-01	7.757E-1
I129	5.721E-5	0.000E+00	5.721E-5	7.246E-05	1.556E-05	8.801E-5	3.046E-05	2.427E-05	5.473E-5
NI59	1.126E-2	0.000E+00	1.126E-2	2.063E-02	4.428E-03	2.505E-2	1.069E-01	8.521E-02	1.921E-1
NP237	5.554E-3	0.000E+00	5.554E-3	3.983E-03	8.550E-04	4.838E-3	4.731E-03	3.770E-03	8.501E-3
SR90	4.145E+1	0.000E+00	4.145E+1	2.725E+01	5.850E+00	3.310E+1	5.869E+00	4.676E+00	1.055E+1
TC99	4.544E-2	0.000E+00	4.544E-2	2.109E-02	4.528E-03	2.562E-2	8.327E-03	6.635E-03	1.496E-2
U235	3.889E-2	0.000E+00	3.889E-2	2.508E-02	5.385E-03	3.047E-2	3.304E-03	2.633E-03	5.936E-3

Table C-34. Best estimate total inventories for use in a deterministic analysis for the ST14 and ST15 through ST20 DU's.

	ST14		Open	ST15-20		New
Nuclide	49.2% Existing (Ci)	Future (Ci)	2.031 Total (Ci)	0.0% Existing (Ci)	Future (Ci)	NA Total (Ci)
AM241	3.517E-01	3.627E-01	7.143E-1	0.000E+00	2.236E-02	2.236E-02
C14	2.525E-02	2.603E-02	5.128E-2	0.000E+00	2.232E-02	2.232E-02
H3	1.082E-01	1.116E-01	2.199E-1	0.000E+00	1.341E+00	1.341E+00
I129	1.405E-05	1.449E-05	2.853E-5	0.000E+00	4.213E-05	4.213E-05
NI59	2.463E-02	2.540E-02	5.003E-2	0.000E+00	3.293E-02	3.293E-02
NP237	5.205E-03	5.367E-03	1.057E-2	0.000E+00	5.790E-03	5.790E-03
SR90	3.160E+01	3.259E+01	6.419E+1	0.000E+00	1.854E+01	1.854E+01
TC99	1.591E-02	1.640E-02	3.231E-2	0.000E+00	2.115E-02	2.115E-02
U235	1.197E-03	1.234E-03	2.432E-3	0.000E+00	2.851E-02	2.851E-02

C.5 Parent Nuclide Distributions

Stochastic parameters were computed for the 11 DU's that will potentially have future waste buried within them. The log-normal distribution function requires specification of two parameter values. These parameter values are computed from the sample mean (average) and sample variance of a selected population of inventory values. Table C-1 contains the existing inventory values (as of Septemeber 2018) for the 9 parent nuclides of interest. Inventory values for a total of 14 DU's are available for estimating historical-based distributions:

- 10 DU's of ST units
- 3 DU's of ET units
- 1 DU of LAWV units

The variability in burial history for each of these 9 parent nuclides is plotted in Figure C-1 for these 14 units. For each DU the Curie fraction for each parent nuclide has been plotted. As shown in Figure C-1 the variability in Curie fraction for the various trenches (i.e., both slit and engineered trenches) is consistent. However, the composition for the LAWV is quite different than for trenches. In fact, for the LAWV the Curie fraction for H-3 dominants that unit with a Curie fraction of ~99.9%.

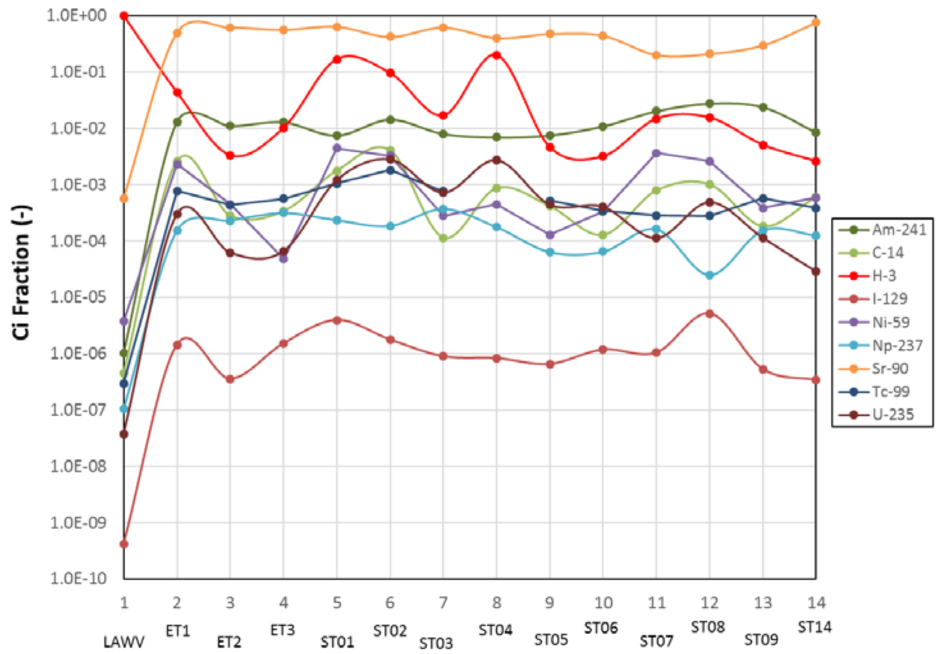


Figure C-1. Variability in inventory among the existing DU's as of September 2018.

Analyses were considered based on Curie fractions and also on gmole fractions. Similar results were being seen; thus, the approach of using Curie fractions was continued consistent with the earlier work by Butcher et al. (2017).

To create distribution functions for every parent nuclide in every DU of interest a grouping of units was required. These grouping allowed sample means and sample standard deviations to be computed for each parent nuclide. Once a grouping of DU's was chosen that group was employed for every parent nuclide within that group. Table C-35 contains the computed sample mean and standard deviations for the chosen grouping of ST's plus ET's. All trenches were included within this grouping while the LAWV was left out due to its unique difference in composition values.

Table C-35. Parent nuclide mean and standard deviations for various grouping of DU's.

WITS Nuclide	Average ET+ST Inventory (Ci)	1-Std ET+ST Inventory (Ci)	1-Std/Avg ET+ST Inventory (-)
AM241	5.424E-01	3.639E-01	6.708E-01
C14	3.014E-02	3.205E-02	1.063E+00
H3	1.216E+00	2.185E+00	1.797E+00
I129	4.304E-05	2.298E-05	5.340E-01
NI59	3.818E-02	3.487E-02	9.133E-01
NP237	7.818E-03	8.043E-03	1.029E+00
SR90	2.305E+01	2.114E+01	9.171E-01
TC99	2.451E-02	1.662E-02	6.781E-01
U235	2.308E-02	3.047E-02	1.320E+00

The last column in Table C-35 represents the variability in a given parent nuclide per Curie buried. This variable was used to scale the standard deviation of each parent nuclide of a specific DU back to this average standard deviation value:

$$S_{ij} = I_{ij}\left(\frac{\bar{S}_i}{\bar{I}_i}\right) \quad \text{(C-1)}$$

where $\bar{S}_i$ (grouping) - standard deviation of inventory for i^{th} parent nuclide among chosen DU's

S_{ij} - scale standard deviation of inventory for i^{th} parent nuclide in j^{th} DU

These scaled standard deviations were then used along with the existing value of parent nuclides within each DU to compute log-normal distributions. The relationship between these sample means and scaled sample standard deviations are expressed as:

$$\mu_{ij} = \ln\left(\bar{S}_i^2\right) - \frac{1}{2}\sigma_{ij}^2 \quad \text{(C-2)}$$

$$\sigma_{ij}^2 = \ln\left[1 + \left(\frac{I_{ij}}{S_{ij}}\right)^2\right] \quad \text{(C-3)}$$

where μ_{ij} - location parameter for a log-normal distribution for i^{th} parent nuclide in j^{th} DU

σ_{ij} - scale parameter for a log normal distribution for i^{th} parent nuclide in j^{th} DU

I_{ij} - WITS inventory value for i^{th} parent nuclide in j^{th} DU

S_{ij} - scaled standard deviation value for i^{th} parent nuclide in j^{th} DU

For the future DU's ST15 through ST20 no existing inventory values exist and the mean values computed from all ST units was chosen. These ST average inventory values are listed in Table C-36 along with the mean values for the other two types of DU being considered.

Table C-36. Parent nuclide mean values for each type of DU.

WITS Nuclide	Average LAWV Inventory (Ci)	Average ET Inventory (Ci)	Average ST Inventory (Ci)
AM241	4.156E-01	8.07E-01	4.630E-01
C14	1.853E-01	5.88E-02	2.153E-02
H3	4.097E+05	9.58E-01	1.293E+00
I129	1.731E-04	5.11E-05	4.064E-05
NI59	1.548E+00	5.96E-02	3.177E-02
NP237	4.286E-02	1.53E-02	5.585E-03
SR90	2.343E+02	4.03E+01	1.788E+01
TC99	1.211E-01	3.69E-02	2.040E-02
U235	1.543E-02	8.34E-03	2.750E-02

Based on the Existing WITS inventory values listed in Table C-3 and the scaled standard deviation values listed in Table C-35, the two log-normal parameters were computed for all future waste projections. These parameters are summarized in Table C-37 (for units LAWV, ET2, and ST06) and in Table C-38 (for units ST-7, ST14, and ST15 through ST20). Table C-37 and Table C-38 also includes the existing inventory and scale standard deviation values. For the future DU's ST15 through ST20 existing values were set to the average values taken from all of the available ST's with existing inventory.

Table C-37. Log-normal distribution parameters for LAWV, ET2, and ST06 DU's.

Stocastic Summary	LAWV Stocastic Parameters				ET2 Stocastic Parameters				ST06 Stocastic Parameters			
	Normal Values		Log-Normal Values		Normal Values		Log-Normal Values		Normal Values		Log-Normal Values	
WITS Nuclide	Existing (Ci)	1-std dev (Ci)	avg (Ci)	1-std dev (Ci)	Existing (Ci)	1-std dev (Ci)	avg (Ci)	1-std dev (Ci)	Existing (Ci)	1-std dev (Ci)	avg (Ci)	1-std dev (Ci)
AM241	4.156E-01	2.788E-01	-1.06375	0.60956	1.487E+00	9.972E-01	0.21070	0.60956	6.687E-01	4.486E-01	-0.58824	0.60956
C14	1.853E-01	1.970E-01	-2.06395	0.86971	3.824E-02	4.066E-02	-3.64218	0.86971	7.872E-03	8.370E-03	-5.22267	0.86971
H3	4.097E+05	7.361E+05	12.20225	1.20074	4.501E-01	8.087E-01	-1.51916	1.20074	1.966E-01	3.533E-01	-2.34726	1.20074
I129	1.731E-04	9.246E-05	-8.78686	0.50088	4.838E-05	2.583E-05	-10.06192	0.50088	7.246E-05	3.869E-05	-9.65795	0.50088
NI59	1.548E+00	1.414E+00	0.13382	0.77882	6.043E-02	5.519E-02	-3.10947	0.77882	2.063E-02	1.884E-02	-4.18445	0.77882
NP237	4.286E-02	4.409E-02	-3.51063	0.84960	3.130E-02	3.220E-02	-3.82508	0.84960	3.983E-03	4.097E-03	-5.88670	0.84960
SR90	2.343E+02	2.149E+02	5.15162	0.78123	8.340E+01	7.649E+01	4.11852	0.78123	2.725E+01	2.499E+01	2.99993	0.78123
TC99	1.211E-01	8.215E-02	-2.29997	0.61510	5.903E-02	4.003E-02	-3.01896	0.61510	2.109E-02	1.430E-02	-4.04815	0.61510
U235	1.543E-02	2.037E-02	-4.67618	1.00452	8.445E-03	1.115E-02	-5.27867	1.00452	2.508E-02	3.312E-02	-4.19007	1.00452

Table C-38. Log-normal distribution parameters for ST07, ST14, and ST15 through ST20 DU's.

Stocastic Summary	ST07 Stocastic Parameters				ST14 Stocastic Parameters				ST15 thru ST20 Stocastic Parameters			
	Normal Values		Log-Normal Values		Normal Values		Log-Normal Values		Normal Values		Log-Normal Values	
WITS Nuclide	Existing (Ci)	1-std dev (Ci)	avg (Ci)	1-std dev (Ci)	Existing (Ci)	1-std dev (Ci)	avg (Ci)	1-std dev (Ci)	Existing (Ci)	1-std dev (Ci)	avg (Ci)	1-std dev (Ci)
AM241	5.884E-01	3.947E-01	-0.71612	0.60956	3.517E-01	2.359E-01	-1.23077	0.60956	4.630E-01	3.106E-01	-0.95571	0.60956
C14	2.304E-02	2.450E-02	-4.14880	0.86971	2.525E-02	2.684E-02	-4.05725	0.86971	2.153E-02	2.290E-02	-4.21631	0.86971
H3	4.317E-01	7.757E-01	-1.56088	1.20074	1.082E-01	1.945E-01	-2.94424	1.20074	1.293E+00	2.324E+00	-0.46367	1.20074
I129	3.046E-05	1.626E-05	-10.52465	0.50088	1.405E-05	7.502E-06	-11.29849	0.50088	4.064E-05	2.170E-05	-10.23629	0.50088
NI59	1.069E-01	9.766E-02	-2.53880	0.77882	2.463E-02	2.249E-02	-4.00710	0.77882	3.177E-02	2.901E-02	-3.75260	0.77882
NP237	4.731E-03	4.867E-03	-5.71454	0.84960	5.205E-03	5.354E-03	-5.61900	0.84960	5.585E-03	5.745E-03	-5.54861	0.84960
SR90	5.869E+00	5.382E+00	1.46451	0.78123	3.160E+01	2.898E+01	3.14811	0.78123	1.788E+01	1.640E+01	2.57864	0.78123
TC99	8.327E-03	5.647E-03	-4.97743	0.61510	1.591E-02	1.079E-02	-4.33008	0.61510	2.040E-02	1.383E-02	-4.08142	0.61510
U235	3.304E-03	4.362E-03	-6.21721	1.00452	1.197E-03	1.581E-03	-7.23232	1.00452	2.750E-02	3.631E-02	-4.09813	1.00452

Given the log-normal distribution parameters listed in Table C-37 and Table C-38 the following figures show comparisons of these distributions for each of the 9 parent nuclides ranging over the various DU's of interest.

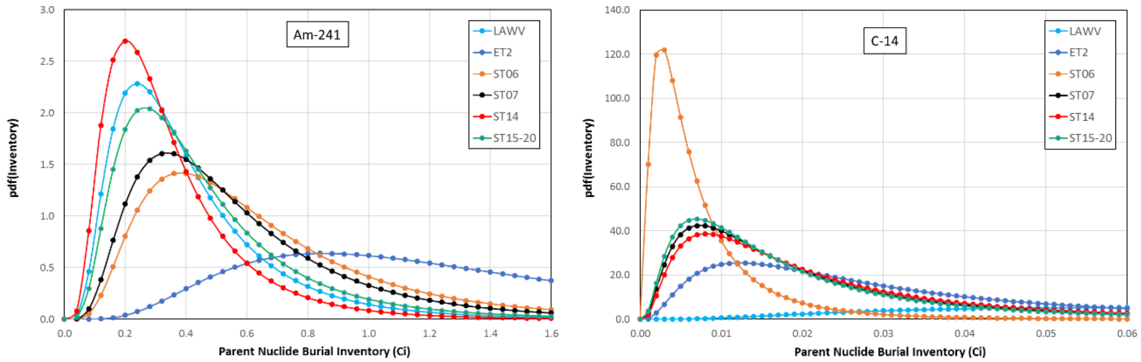


Figure C-2. Probability distributions for Am-241 and C-14 in each DU with future disposals.

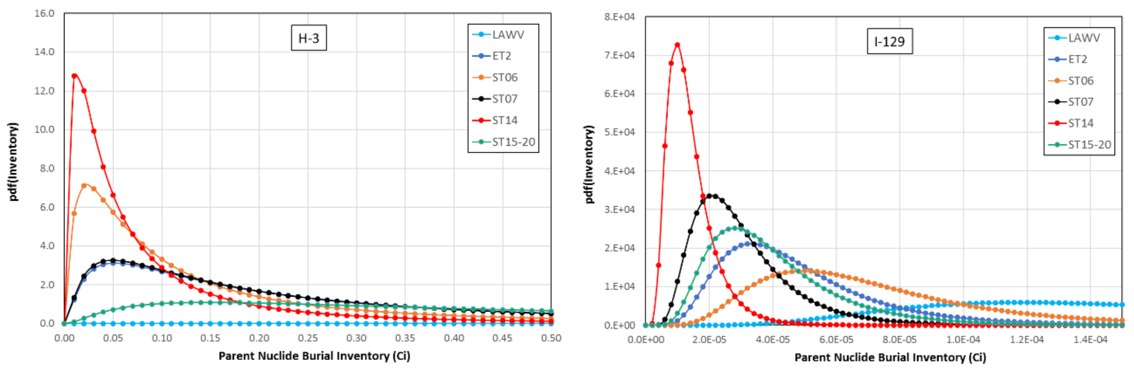


Figure C-3. Probability distributions for H-3 and I-129 in each DU with future disposals.

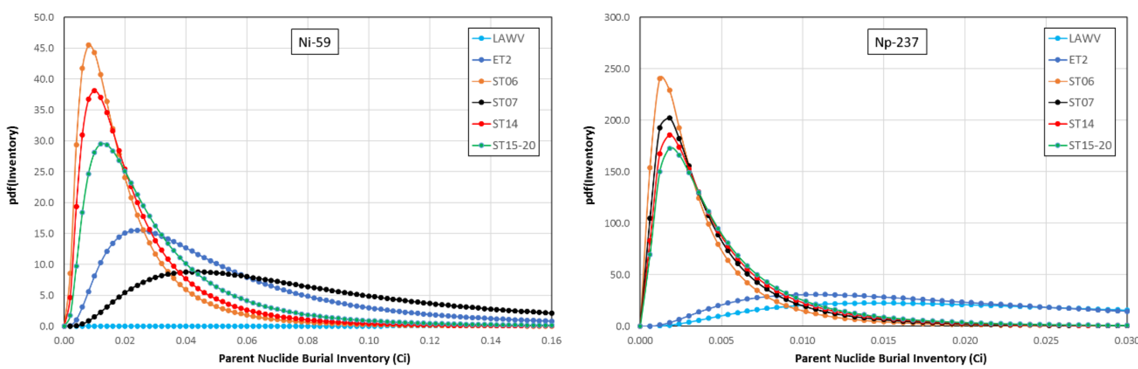


Figure C-4. Probability distributions for Ni-59 and Np-237 in each DU with future disposals.

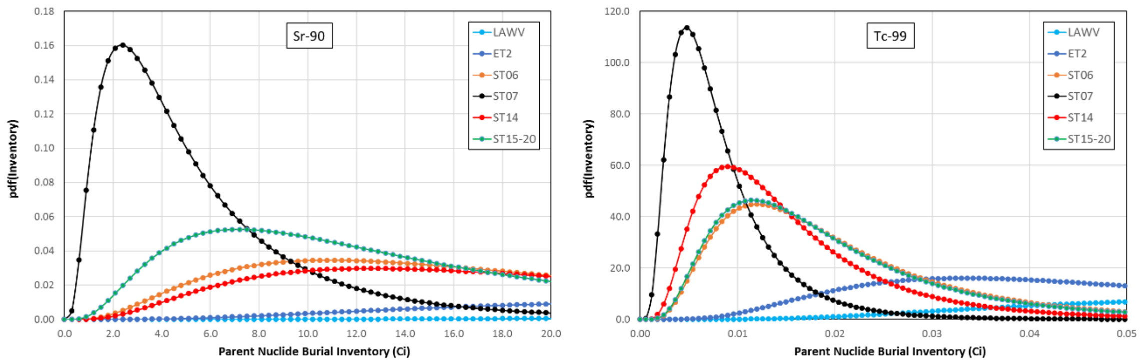


Figure C-5. Probability distributions for Sr-90 and Tc-99 in each DU with future disposals.

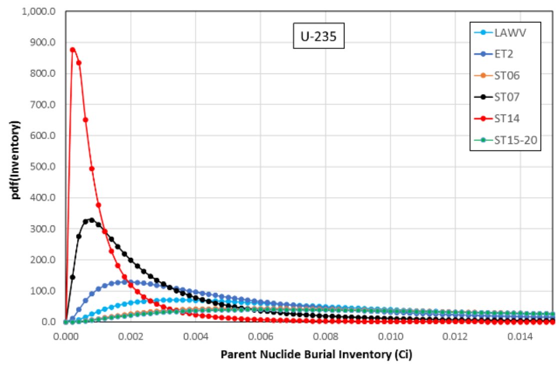


Figure C-6. Probability distribution for U-235 in each DU with future disposals.

These specific distributions were employed in the stochastic analyses presented within this report.

Appendix D. Dose Analysis Details

D.1 Deterministic Simulation Results for Future Inventory Scenario 1

In Chapter 9 results for the Scenario 1 deterministic simulations were discussed. Simulations were performed for four of the five GW pathways as presented in Table 9-1. Only the results associated with the beta-gamma pathway were graphically shown in Chapter 9. Below the graphical results for the other three pathways are provided.

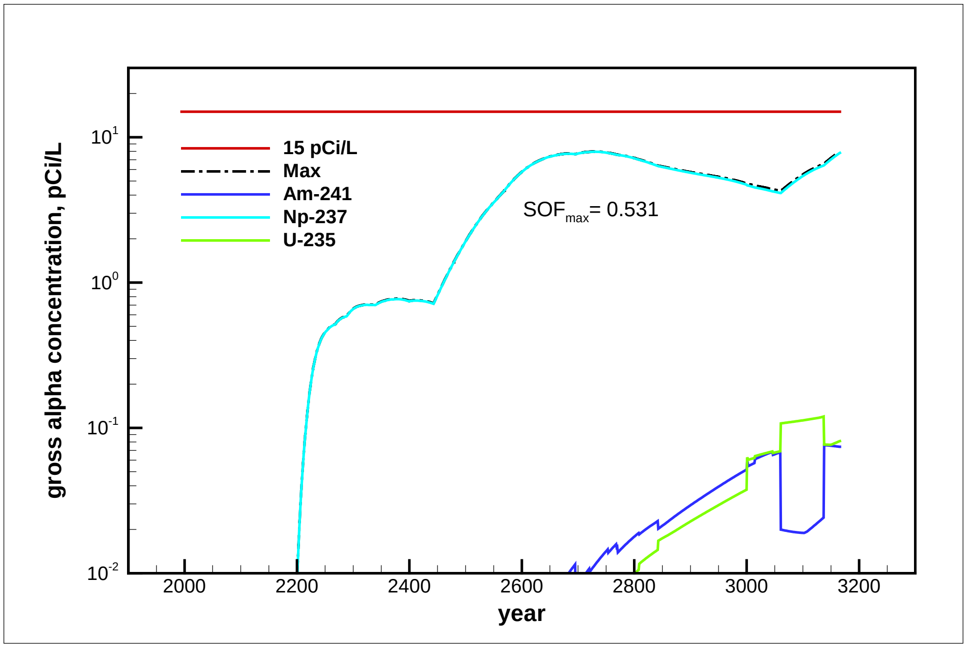


Figure D-7. ELLWF radionuclide gross alpha maximum concentration time history at the 100-m POA (Scenario 1).

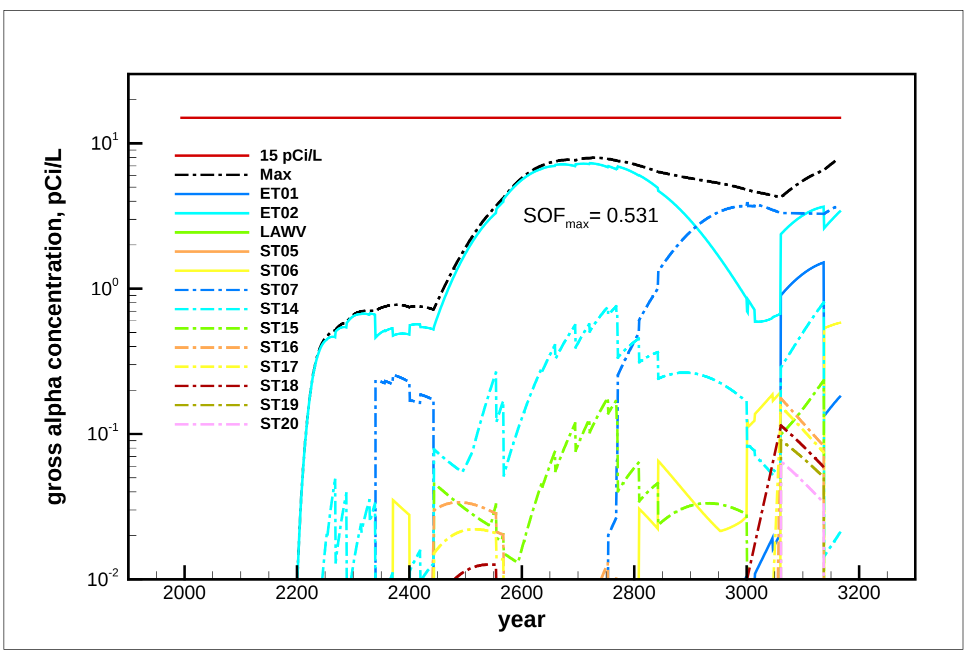


Figure D-8. ELLWF disposal unit gross alpha maximum concentration time history at the 100-m POA (Scenario 1).

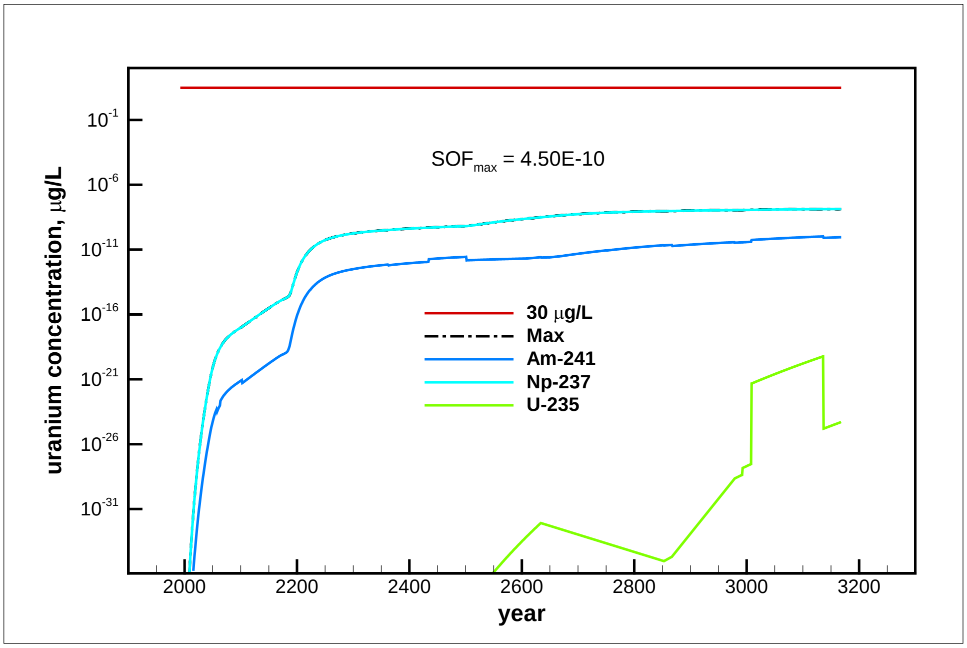


Figure D-9. ELLWF radionuclide uranium maximum concentration time history at the 100-m POA (Scenario 1).

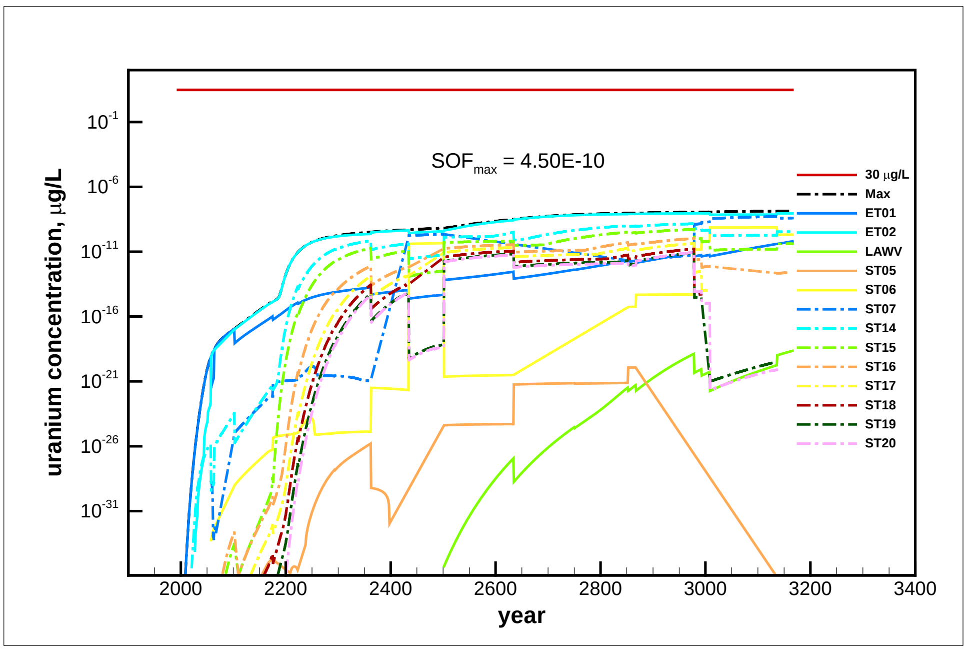


Figure D-10. ELLWF disposal unit uranium maximum concentration time history at the 100-m POA (Scenario 1).

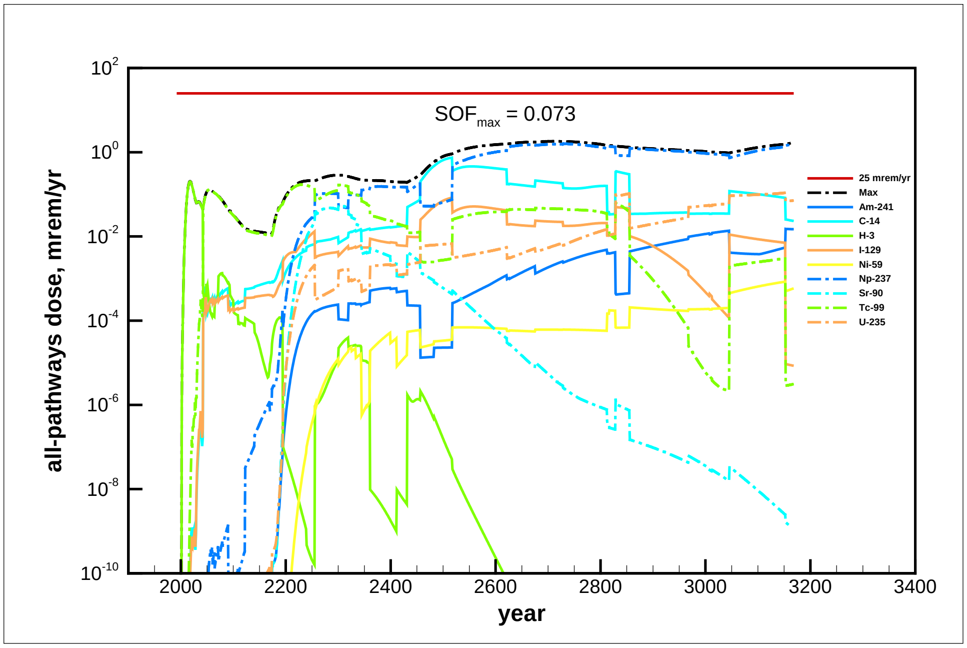


Figure D-11. ELLWF radionuclide all-pathways maximum dose time history at the 100-m POA (Scenario 1).

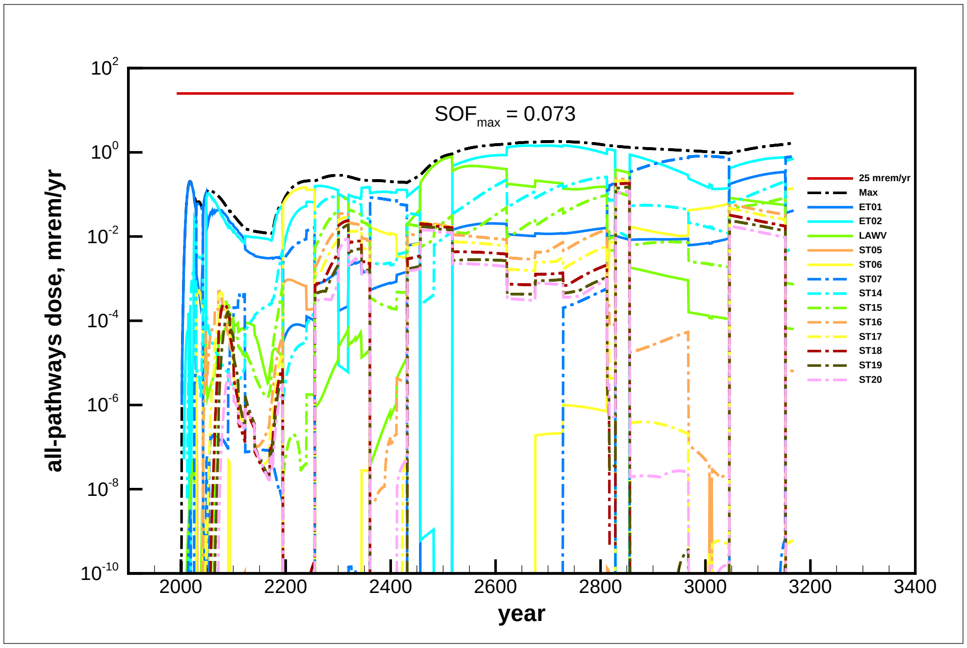


Figure D-12. ELLWF disposal unit all-pathways maximum dose time history at the 100-m POA (Scenario 1).

D.2 Deterministic Simulation Results for Future Inventory Scenario 2

In Chapter 9 results for the scenario 2 deterministic simulations were discussed. Simulations were performed for all 9 SA parent radionuclides as presented in Table 9-2. Only the results associated with the 3 SA parent radionuclides that exceed a SOF of 1 were graphically shown in Chapter 9. Below the graphical results for the other 6 SA parent radionuclides are provided.

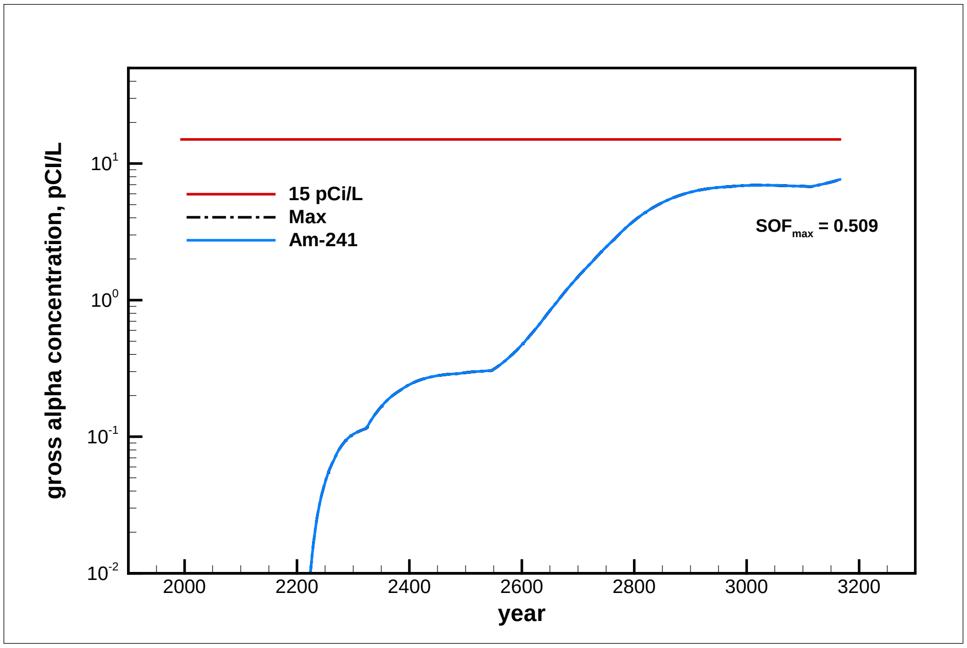


Figure D-13. ELLWF Am-241 gross alpha maximum concentration time history at the 100-m POA (Scenario 2a).

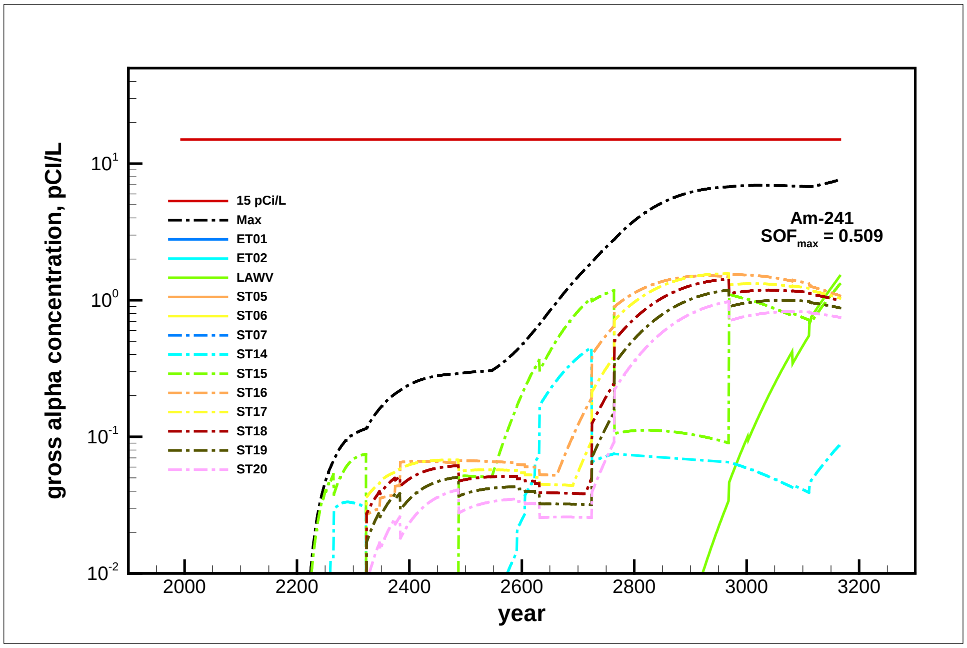


Figure D-14. ELLWF disposal unit gross alpha maximum concentration time history at the 100-m POA (Scenario 2a).

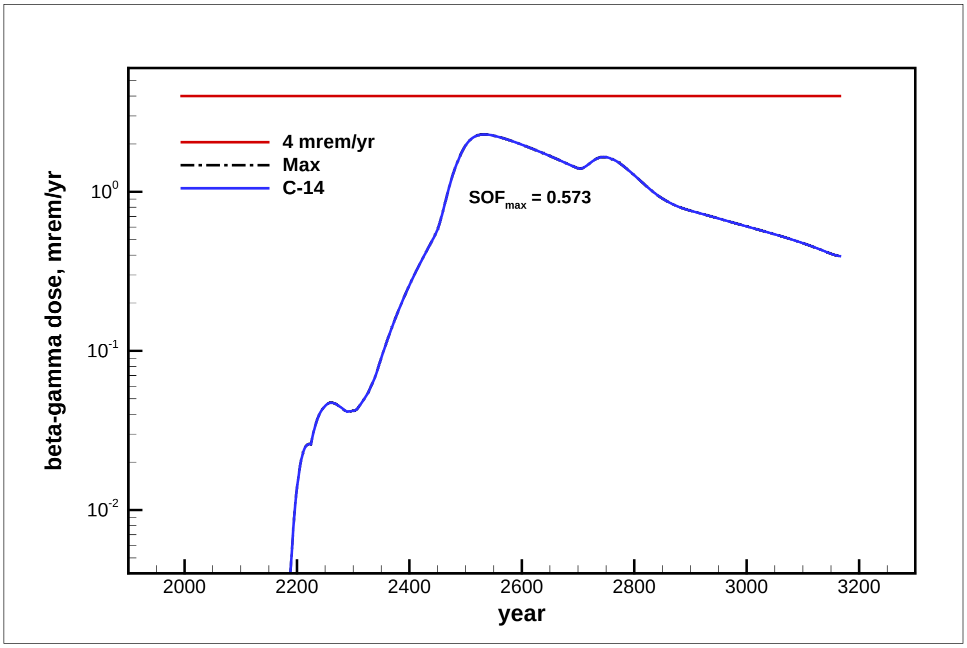


Figure D-15. ELLWF C-14 beta-gamma maximum dose time history at the 100-m POA (Scenario 2b).

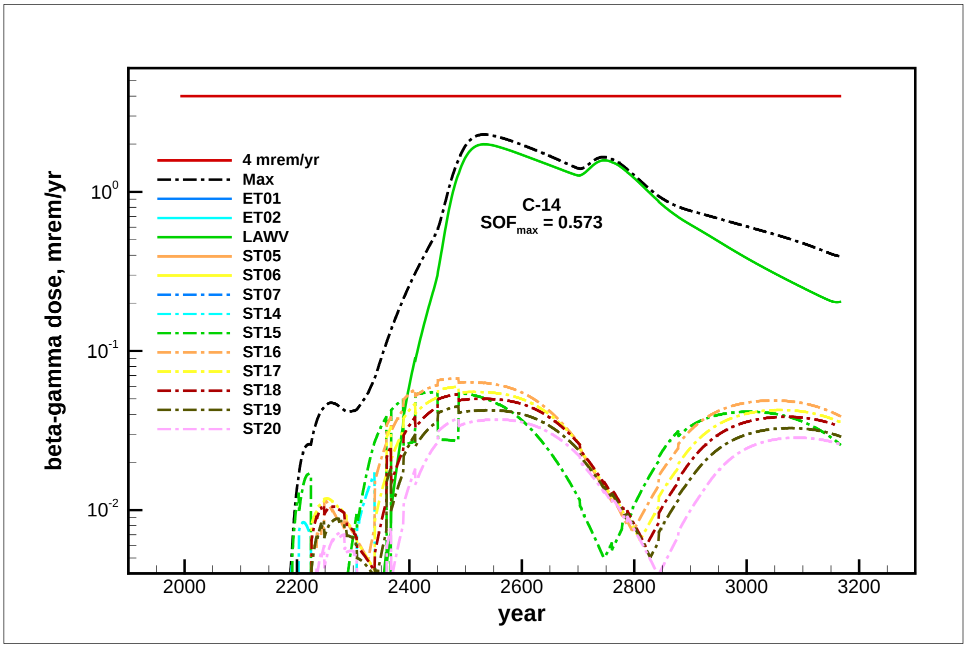


Figure D-16. ELLWF disposal unit beta-gamma maximum dose time history at the 100-m POA (Scenario 2b).

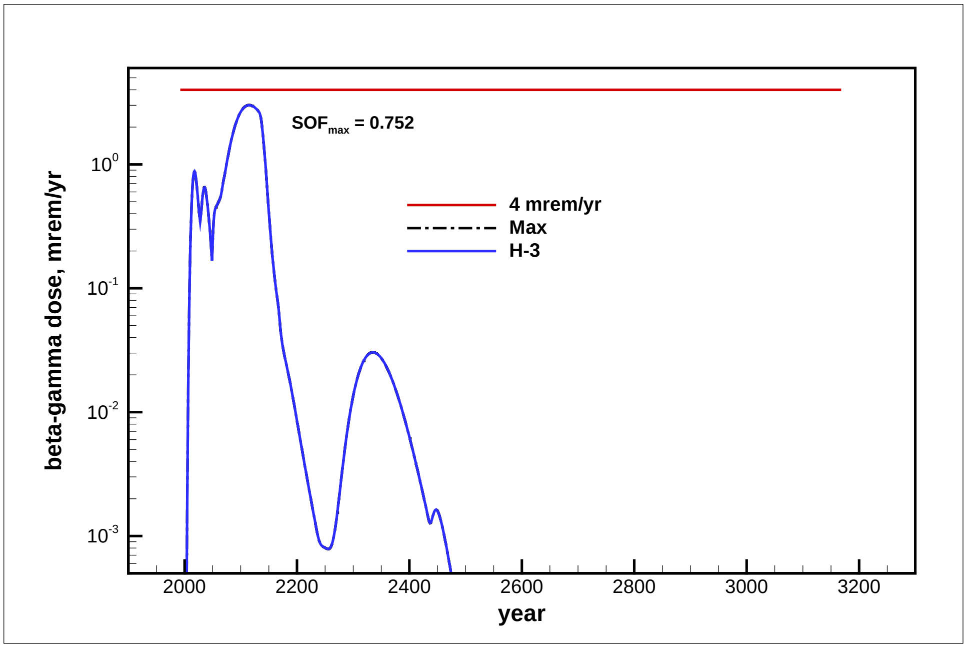


Figure D-17. ELLWF H-3 beta-gamma maximum dose time history at the 100-m POA (Scenario 2c).

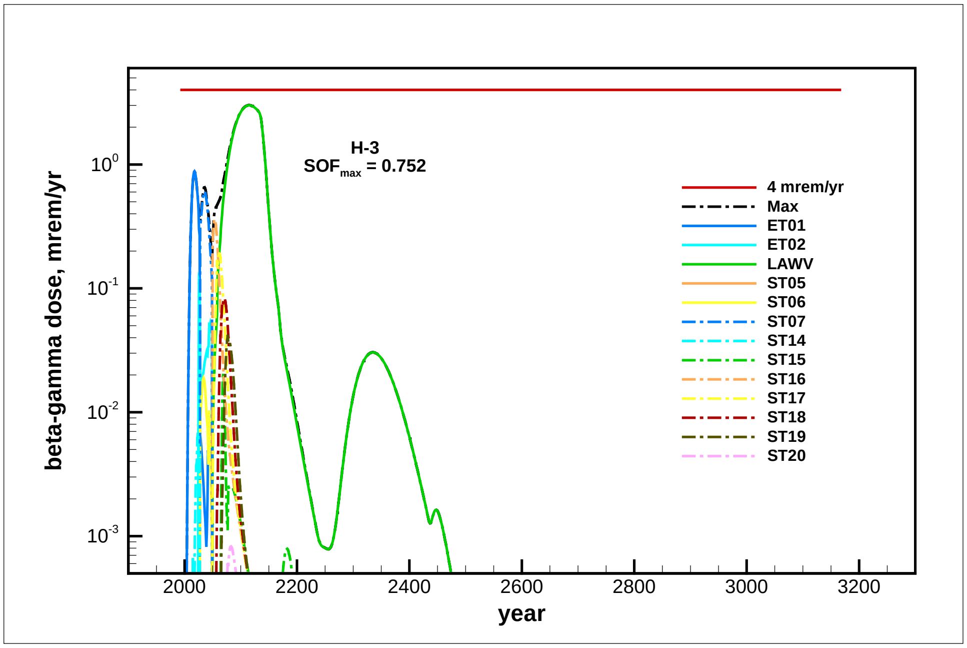


Figure D-18. ELLWF disposal unit beta-gamma maximum dose time history at the 100-m POA (Scenario 2c).

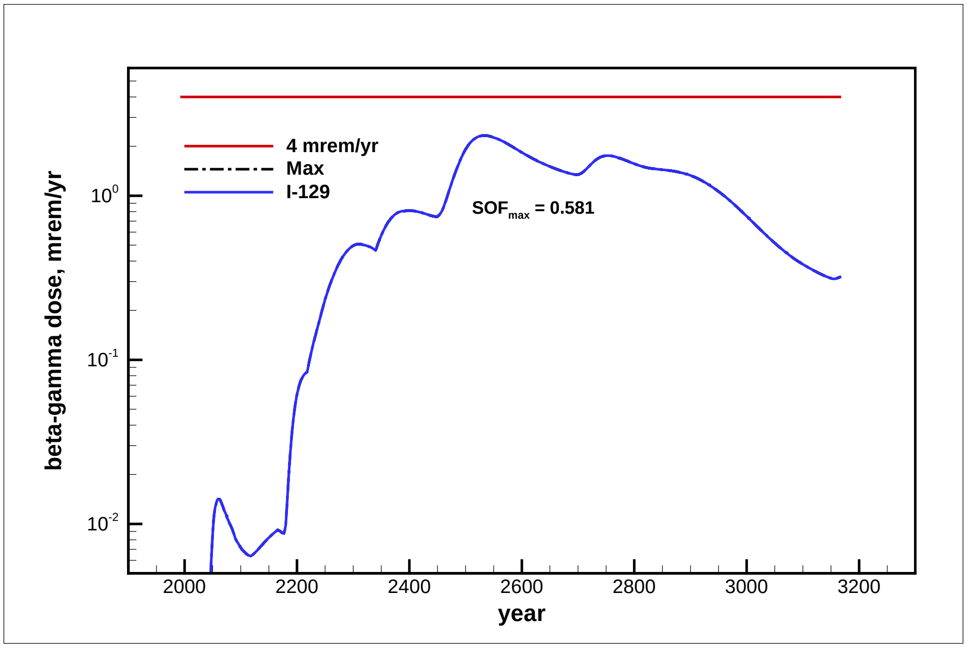


Figure D-19. ELLWF I-129 beta-gamma maximum dose time history at the 100-m POA (Scenario 2d).

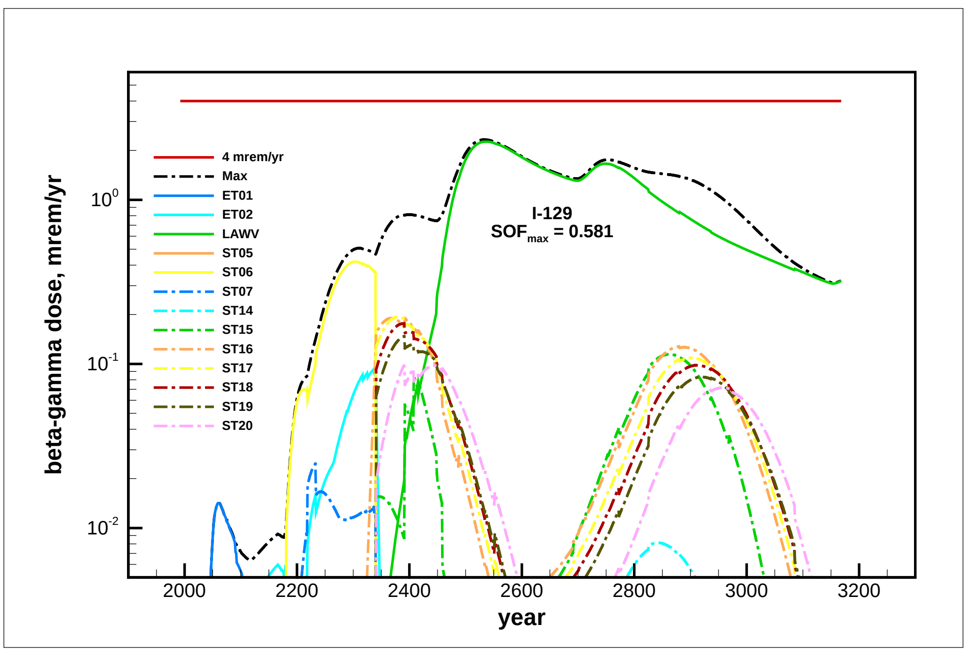


Figure D-20. ELLWF disposal unit beta-gamma maximum dose time history at the 100-m POA (Scenario 2d).

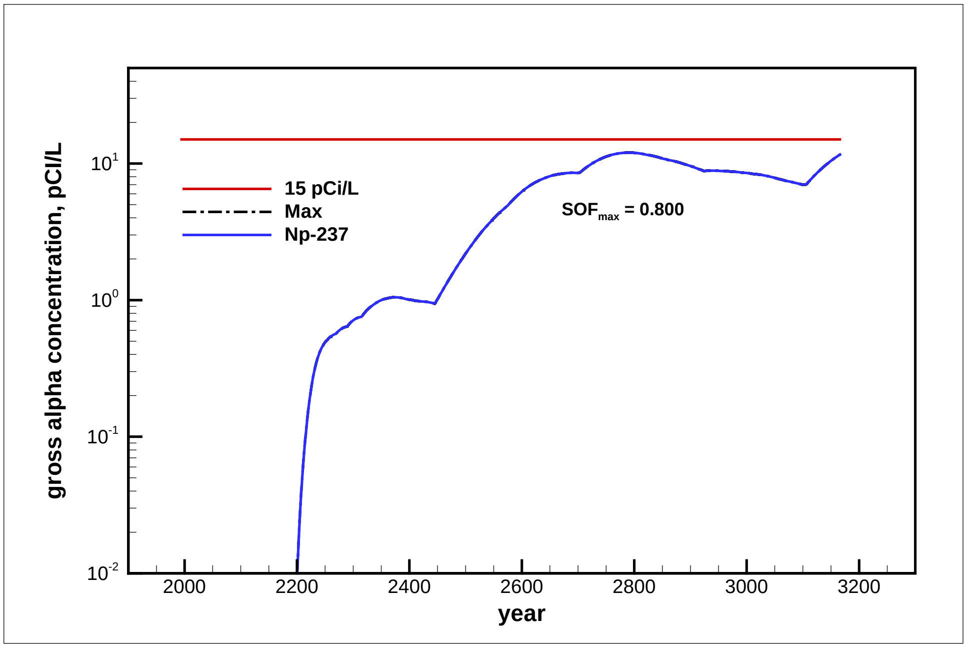


Figure D-21. ELLWF Np-237 gross alpha maximum concentration time history at the 100-m POA (Scenario 2f).

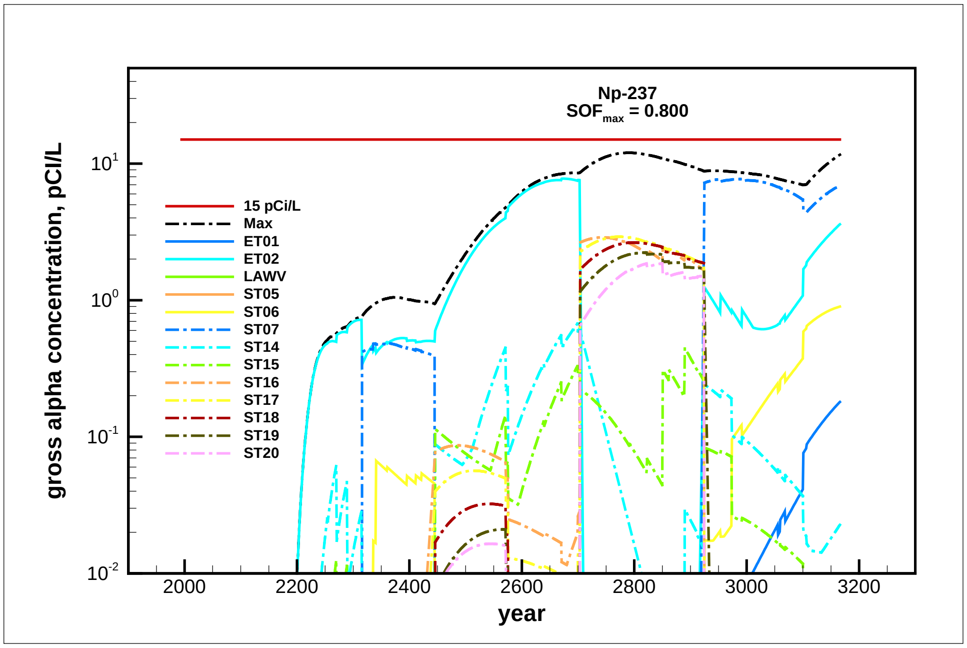


Figure D-22. ELLWF disposal unit gross alpha maximum concentration time history at the 100-m POA (Scenario 2f).

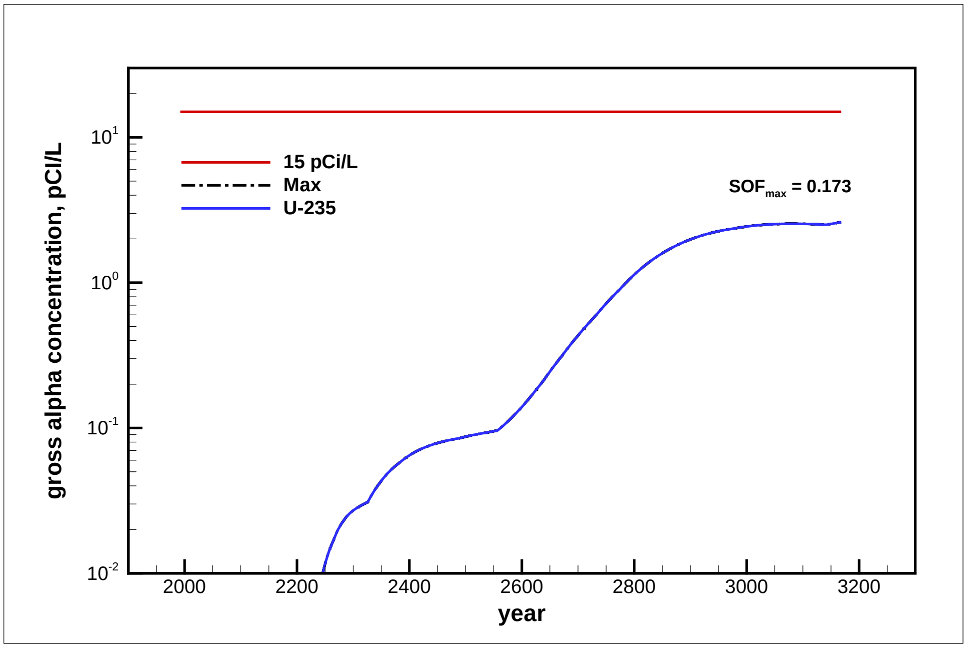


Figure D-23. ELLWF U-235 gross alpha maximum concentration time history at the 100-m POA (Scenario 2i).

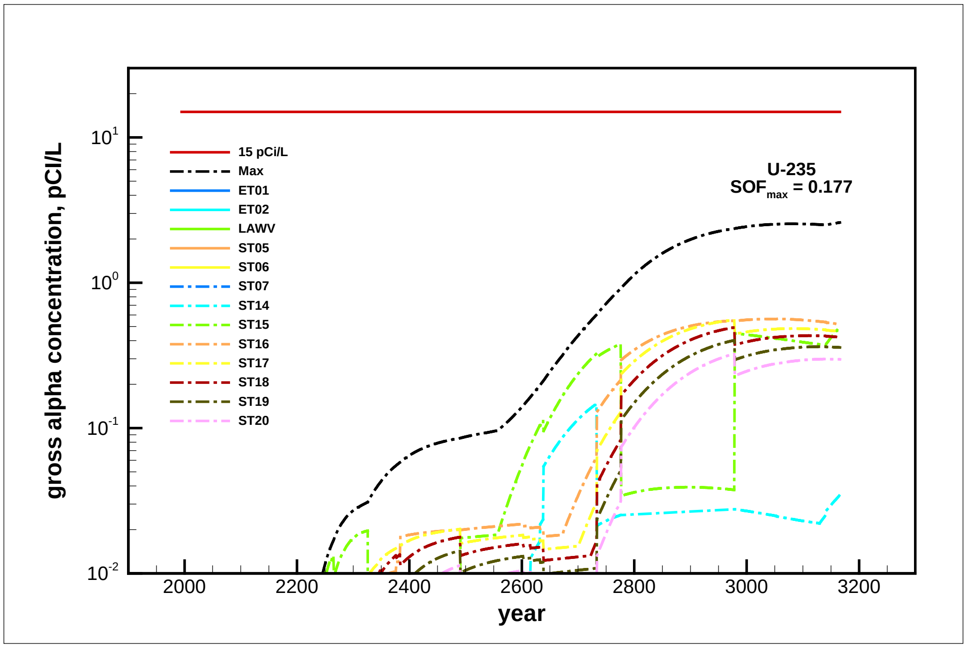


Figure D-24. ELLWF disposal unit gross alpha maximum concentration time history at the 100-m POA (Scenario 2i).

DISTRIBUTION

sebastian.aleman@srnl.doe.gov
paul.andrews@srs.gov
dan.burns@srs.gov
tom.butcher@srnl.doe.gov
kerri.crawford@srs.gov
david.crowley@srnl.doe.gov
Thomas.Danielson@srnl.doe.gov
kenneth.dixon@srnl.doe.gov
James.Dyer@srnl.doe.gov
peter.fairchild@srs.gov
gregory.flach@srnl.doe.gov
Scott.Germain@srs.gov
nancy.halverson@srnl.doe.gov
luther.hamm@srnl.doe.gov
thong.hang@srnl.doe.gov
connie.herman@srnl.doe.gov
daniel.kaplan@srnl.doe.gov
walt.kubilius@srnl.doe.gov
Dien.Li@srs.gov
john.mayer@srnl.doe.gov
steven.mentrup@srs.gov
robert.minnick@srs.gov
verne.mooneyhan@srs.gov
ralph.nichols@srnl.doe.gov
luke.reid@srnl.doe.gov
nathaniel.roddy@srs.gov
Jansen.Simmons@srs.gov
Ira.Stewart@srs.gov
kevin.tempel@srs.gov
Tad.Whiteside@srnl.doe.gov
Jennifer.Wohlwend@srnl.doe.gov
EM File (1 file copy & 1 electronic copy), 773-42A - Rm.243
Records Administration (EDWS)