TRI-PARTY AGREEMENT

Change Notice Number TPA-CN- 1130	**TPA CHANGE NOTICE FORM**	**Date:** February 12, 2024
Document Number, Title, and Revision: RPP-PLAN-64889, 241-A-101 Tank Waste Retrieval Work Plan, Rev. 1		**Date Document Last Issued:** April 17, 2023
Approved Change Notices Against this Document: None		
Originator: Bryan Trimberger		**Phone:** 509-372-2674

Description of Change:

RPP-PLAN-64889, "241-A-101 Tank Waste Retrieval Work Plan" needs to be revised to incorporate and respond to Ecology comments, update select citations and references, and make some minor, general editorial changes, and clarifications.

P.A. Schroder (**DOE**) and J.J. Lyon (**Lead Regulatory Agency**) agree that the proposed change modifies an approved workplan/document and will be processed in accordance with the Tri-Party Agreement Action Plan, Section 9.0, *Documentation and Records,* and not Chapter 12.0, *Changes to the Agreement*.

The following changes have been made:

Multiple changes were made throughout the document. Please see the attached redlines and the justification of change section below, that explicitly identify what changes will be made, why, and where in the document.

Additions are shown using <u>double underline</u>. Deletions are shown using ~~strikeout~~.

Justification and Impacts of Change:

Provided below are the page numbers and basis for each proposed redline change. The redline changes are attached. These changes are required to incorporate Ecology comments, update select citations and references, and to complete minor editorial changes and clarifications.

Page i: Updated Consent Decree reference to included changes made during COVID.
Page V: Updated Consent Decree reference to included changes made during COVID.
Page 1-1: Regulation was updated, referenced the updated regulation. Also updated Consent Decree reference.
Page 2-4: Updated how Enraf level detectors are referenced based on WRPS style guide.
Page 3-3: Updated Enraf reference.
Page 3-5: Clarified operating strategy to prevent line plugging.
Page 3-6: Clarified operating strategy for water addition.
Page 4-1: Updated Enraf reference and clarified that DST annulus continuous air monitors may not be used.
Page 5-1: Regulation was updated, referenced the updated regulation.
Page 7-5: Clarifications made based on Ecology comments to the A-102 TWRWP.
Page 7-7: Clarifications made based on Ecology comments to the A-102 TWRWP.
Page 7-10: Clarifications made based on Ecology comments to the A-102 TWRWP.
Page 7-11: Clarifications made based on Ecology comments to the A-102 TWRWP.

Page 7-12: Clarifications made based on Ecology comments to the A-102 TWRWP.
Page 7-19: Clarifications made based on Ecology comments to the A-102 TWRWP.
Page 7-21: Clarifications made based on Ecology comments to the A-102 TWRWP.
Page 7-22: Clarifications made based on Ecology comments to the A-102 TWRWP.
Page 7-23: Clarifications made based on Ecology comments to the A-102 TWRWP.
Page 7-25: Clarifications made based on Ecology comments to the A-102 TWRWP.
Page 7-27: Clarifications made based on Ecology comments to the A-102 TWRWP.
Page 7-28: Clarifications made based on Ecology comments to the A-102 TWRWP.
Page 7-29: Clarifications made based on Ecology comments to the A-102 TWRWP.
Page 7-34: Clarifications made based on Ecology comments to the A-102 TWRWP.
Page 7-37: Editorial
Page 8-2: Updated Consent Decree reference to included changes made during COVID.
Page 8-4: Regulation was updated, referenced the updated regulation.
Page B-11: Clarifications made based on Ecology comments to the A-102 TWRWP.

Approvals:

Paul A. Schroder Digitally signed by Paul A. Schroder Date: 2024.02.19 15:53:42 -08'00'

DOE Project Manager — Date — [X] Approved [ ] Disapproved

EPA Project Manager — Date — [ ] Approved [ ] Disapproved

Digitally signed by Lyon, Jeffery (ECY) Date: 2024.03.05 16:17:36 -08'00'

Ecology Project Manager — Date — [x] Approved [ ] Disapproved

Tank Waste Retrieval Work Plan Format

Tank Waste Retrieval Work Plans (TWRWP) are documents that are required by both the Hanford Federal Facility Agreement and Consent Order, EPA Docket Number 1089-03-04-120; Ecology Docket Number 89-54, (HFFACO Attachment 2, Action Plan Appendix I) and Appendix C of the Consent Decree in *State of Washington v. Dept. of Energy*, Case No. 2: 08-CV-05085-FVS (E.D. WA October 25, 2010).[1] The TWRWP content required in both the HFFACO and the Consent Decree is nearly identical and is delineated in outline form with section titles such as the following:

- Operational requirements during retrieval; and
- Functions and associated requirements necessary to support design of proposed waste retrieval and leak detection monitoring and mitigation system(s);

Prior to the creation and execution of the Consent Decree in 2010, the Departments of Energy and Ecology had cooperatively developed and employed a format for TWRWPs created under the HFFACO. Once the Consent Decree and its requirement for TWRWPs came into effect, Ecology and DOE simply decided to continue to use the TWRWP format developed under the HFFACO in satisfaction of the Consent Decree TWRWP requirement, thus avoiding, among other things, a potentially lengthy development period for a document that already existed and that both parties were already accustomed to and satisfied with.

The following pages provide a crosswalk to point to the sections in the TWRWP where the required elements of the Consent Decree, Appendix C, Parts 1 and 2, may be located.

[1] The "Consent Decree" collectively refers to the Consent Decree in Case No. 2:08-cv-05085-FVS (October 25, 2010), the Amended Consent Decree, Case No. 2:08-cv-05085-RMP (March 11, 2016), and the Second Amended Consent Decree, Case No. 2:08-cv-05085-RMP (April 12, 2016) and the Third Amended Consent Decree, Case No. 2.08-cv-05085-RMP (October 12, 2018) and the Fourth Amended Consent Decree, Case No. 2.08-cv-05085-RMP (December 10, 2020) and the Fifth Amended Consent Decree, Case No. 2.08-cv-05085-RMP (July 18, 2022). The TWRWP requirements of the October 25, 2010 Consent Decree were not modified by either the Amended Consent Decree or the Second Amended Consent Decree.

Consent Decree Appendix C				TWRWP	
***Page**	**Part**	**Line Number**	**Requirement**	**Location by Section Number**	**Supplemental Notes, if Necessary**
		21	General arrangement diagrams	3.5, *Waste Retrieval System Diagram*	
		22	System description	3.1.1, *Physical Description*	
		1-2	Piping and instrumentation drawings (P&ID) for the retrieval system	3.8, *Information for New Aboveground Tank Systems*	Not required. P&ID drawings are included with the IQRPE package.
		3	Process flow diagrams	3.8, *Information for New Aboveground Tank Systems*	Not required. Process flow diagrams are included with the IQRPE package.
		4-5	Information to demonstrate compliance with WAC 173-303-640	3.8, *Information for New Aboveground Tank Systems*	Not required. Compliance information is included with the IQRPE package.
		6-7	Describe the disposition of the system at completion of the retrieval.	3.7, *Anticipated Impacts of Tank Waste Retrieval on Future Pipeline/Ancillary Equipment Retrieval* 3.9, *Disposition of Waste Retrieval System Following Waste Retrieval*	

*Neither the Amended Consent Decree (March 11, 2016), the Second Amended Consent Decree (April 12, 2016) nor the Third Amended Consent Decree nor the Fourth Amended Consent Decree (12/10/20) nor the Fifth Amended Consent Decree (7/18/2022) changed the text of Appendix C, as the Consent Decree was entered by the Court on October 25, 2010. This table refers to the page numbers and text as set forth in Appendix C as entered October 25, 2010.

1.0 INTRODUCTION

The U.S. Department of Energy (DOE) mission includes storage, retrieval, immobilization, and disposal of radioactive mixed waste presently stored in underground tanks located in the 200 East and 200 West Areas of the DOE Hanford Site. Single-shell tank 241-A-101 (A-101)[1] located in the 200 East Area (Figure 1-1), is scheduled for waste retrieval using a modified sluicing system retrieval technology. Tank A-101 is classified as "sound" as specified in HNF-EP-0182, Rev. 405, *Waste Tank Summary Report for Month Ending September 30, 2021*.

As of October 25, 2010, Consent Decree in *State of Washington v. Department of Energy*, Case No. CV-08-5085-FVS[2] has provided the regulating direction for Tank Waste Retrieval Work Plans (TWRWP) for tanks that are required to be retrieved under the Consent Decree. The purpose of this TWRWP is to provide the State of Washington, Department of Ecology (Ecology) information on the planned approach for retrieving waste from tank A-101 to allow Ecology to approve the waste retrieval action.

Where information regarding treatment, management, and disposal of the radioactive source, byproduct material, and/or special nuclear components of mixed waste (as defined by the *Atomic Energy Act of 1954*) has been incorporated into this TWRWP, it is not incorporated for the purpose of regulating the radiation hazards of such components under the authority of this tank waste retrieval work plan or *Revised Code of Washington,* Chapter ~~70.105~~ 70A.300 RCW, "Hazardous waste management."

[1] NOTE: To aid readability of the document, the official designation of "241-" in tank and tank farm names will be omitted. Unless otherwise specified, tanks and tank farms are classified with "241-".

[2] The "Consent Decree" collectively refers to the Consent Decree in Case No. 2:08-cv-05085-FVS (October 25, 2010), the Amended Consent Decree, Case No. 2:08-cv-05085-RMP (March 11, 2016), and the Second Amended Consent Decree, Case No. 2:08-cv-05085-RMP (April 12, 2016) and the Third Amended Consent Decree, Case No. 2.08-cv-05085-RMP (October 12, 2018) and the Fourth Amended Consent Decree, Case No. 2.08-cv-05085-RMP (December 10, 2020) and the Fifth Amended Consent Decree, Case No. 2.08-cv-05085-RMP (July 18, 2022).. The TWRWP requirements of the October 25, 2010 Consent Decree were not modified by either the Amended Consent Decree or the Second Amended Consent Decree.

Table 2-2. Tank A-101 Riser Configuration[a]

Component Identification Number	Diameter (in.)	Use Descriptions and Comments
		Tank A-101
R-3	8	Dry Well
R-4	12	Spare
R-5	4	Spare
R-6	4	~~ENRAF[b]~~Enraf[b]
R-7	4	Crust Breaker
R-8	4	Floor Drain 01H Pit
R-9	20	Vapor Riser
R-10	6	Thermocouple
R-11	4	Process Waste
R-12	4	Spare
R-13	42	Spare
R-14	8	Instrument Lines
R-15	4	Spare
R-16	12	Exhauster Plenum
R17	18	Heating Coil
R-18	18	Heating Coil
R-19	4	Failed LOW
R-20	4	Sludge Measurement Port/ Spare
R-21	12	Pump Pit
R-22	12	Ventilation Exhaust
R-23	4	Drain from transfer box 241-A-153
R-24	4	Spare
N1	6	Overflow – outlet
N2	4	Spare Inlet Nozzle
N3	3	Line V039 (spare), sealed in diversion box
N4	3	Line V038 (fill)
N5	3	Line V063 (fill)

[a] H-2-73388, *Piping Waste Tank Isolation TK 241-A-101*

[b] Enraf—refers to the Enraf®; Enraf is a trademark of Honeywell International, Inc.~~Enraf is the supplier of the identified level gauges; Enraf is a trademark of Honeywell International, Inc., Morristown, New Jersey~~.

Table 3-1. Planned Riser Use for Tank A-101 Waste Retrieval System.

Riser Number	Tank A-101
002	Air Inlet/Vacuum Breaker/Camera/Lights
004	ERSS
005	Sample Sleeve/Chemical Addition Port
006	~~ENRAF~~Enraf
012	Camera/Lights
013	Slurry Pump
015	Camera/Lights
016	ERSS
022	Exhauster Port/Camera/Lights
0024	Camera/Lights

Source: RPP-RPT-57252, *241-A Farm Riser Utilization*

The new slurry pump will be installed in a riser located in the center pit. The slurry pump design for tank A-101 will allow the pump installation height to be adjusted to facilitate maximum waste removal. The slurry pump can be lowered to an elevation that allows liquid to be pumped to less than 1 inch of the bottom. In tank AX-102 the tank bottom was uneven, and the slurry pump was above a ripple. The tank A-101 pump will be installed to avoid ripples as much as possible. Riser 013 is 42 inches in diameter allowing some flexibility to move the slurry pump away from a ripple. The pump will be installed in the retracted position using a crane. The pump will be lowered into added liquid during retrieval startup. The pump will be lowered to the bottom of the tank as waste retrieval progresses. Other designs or arrangements may be used to optimize the pump installation or operation.

A mass flowmeter will be installed on the slurry pump discharge line in the center pit. The mass flowmeter will be able to measure flowrate, density, and temperature. A sample sleeve will be installed in riser 005 so that liquid/slurry waste samples can be collected from ERSS recirculation if needed.

Camera(s) will be installed in tank A-101 to provide the capability to visually monitor and aid in control of waste retrieval operations. Instrumentation will also be provided to monitor process control data (e.g., pressures and flow rates). Flowrates will be used to support material balance calculations. The existing ~~ENRAF~~Enraf[1] level gauge in tank A-101 will be retracted during waste retrieval operations and will be used periodically to monitor waste levels.

During waste retrieval operations, tank A-101 will be actively ventilated. The ventilation system will consist of skid-mounted high-efficiency particulate air filtered portable exhauster(s). Two portable exhausters POR518 and POR519 were installed in A Farm. Condensate drainage from the exhauster(s) from A Farm tanks will be routed back to an SST being retrieved or an

~~[1] ENRAF Enraf is a trademark of Honeywell International, Inc., Morristown, New Jersey.~~

compositions and to assess those compositions against specified decision rules that are provided in HNF-SD-WM-OCD-015.

Waste compatibility assessments require evaluations to determine whether or not controls are necessary to prevent the formation of gels and line plugging. The identified control requirements are called out in the process control plan.

Formal issuance of the compatibility assessment will not be completed until just before waste retrieval operations begin to ensure that current conditions are captured in the assessment.

Meeting the informational requirements for waste transfers meets the requirements of *Washington Administrative Code* (WAC) 173-303-300, "General Waste Analysis." Compliance with the following documents is required before initiating a waste transfer:

- RPP-29002, *Double-Shell Tank System Waste Analysis Plan*. SST transfers into the DSTs for any reason must meet the waste acceptance criteria presented in this plan. This plan is written pursuant to WAC 173-303-300(5) and the Environmental Protection Agency (EPA) guidance document OSWER 9938.4-03, *Waste Analysis at Facilities that Generate, Treat, Store, and Dispose of Hazardous Waste*.
- Waste Stream Profile Sheet (RPP-29002). The sheet addresses the applicable sections of WAC 173-303-300; Title 40, *Code of Federal Regulations*, Part 761, "Polychlorinated Biphenyls (PCB) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions" (40 CFR 761); 40 CFR 268, "Land Disposal Restrictions"; and WAC 173-303-140, "Land Disposal Restrictions," and also requires a waste compatibility assessment pursuant to HNF-SD-WM-DQO-001, *Data Quality Objectives for Tank Farms Waste Compatibility Program*, to meet WAC 173-303-395(1), "Precautions for ignitable, reactive, or incompatible waste."

During normal routine operations, waste retrieval will be initiated by adding water, if necessary, backflowing water through the pump and adding water through in-line water nozzles near the pump screen to create an operating well for the pump. Water may also be added through a drop leg. Tanks with saltcake often form structured columns in the waste that can fill with silt. The silt can plug the pump so adding water clears the silt and may dissolve the saltcake, which opens an operating cavity for the pump. While the pump is starting, water will be added, if needed, through the ERSS sluice or high-pressure nozzles. The specific gravity of the waste will be monitored as described in the process control plan and in-line dilution will be used to minimize the risk of plugging waste retrieval system hoses and transfer lines and to minimize impacts to DST space.

Initial sluicing will be focused on the center portion of the tank to establish a pump well that will allow liquids and solids to collect into a pool. To maximize the saturation of added water, unsaturated water will be sprayed towards the outer edge of the tanks so that contact time between the salts and water can be maximized. The in-tank camera will be used to provide visual input for directing the sluice nozzles. Typically, one sluicer motion control will be operated at a time at a flow rate of approximately 60 to 120 gal/min; however, when water is

added for dissolution it may be added through ~~more than one~~a sluicer ~~simultaneously~~ or through a drop leg.
If the pump suction is too shallow when waste retrieval is started, the sluice nozzle discharges can be aimed at the pump inlet to enable the pump to be inserted a little deeper. The flow rate through the sluice nozzles will be adjusted based on the pump-out rate so that when additional water is being added to the tank, the rate of water introduction will approximately equal the rate of solution removal whether this operation is in a batch or continuous fashion. The waste removed will consist of the mobilized solids, dissolved solids, and added water. Maintaining a balanced pumping rate into and out of the tank is integral to minimizing the liquid volume in tank A-101 and reducing the potential for leakage.

An additional technology provided by the ERSS is the capability to add high pressure water to break up particles that resist breakup or mobilization with the lower pressure recycled liquor stream. High pressure water could be used at any time during the retrieval process, but it is not envisioned that much will be needed until towards the end of retrieval.

If initial sluicing efforts show the tank A-101 salt and sludge is not readily mobilized, it may be necessary to add sufficient liquid to the tank to cover the waste and allow it to sit for a period of time to soften the solid waste before sluicing is resumed. Liquid can break down bonds in dried waste or dissolve salt crystals holding the waste together if they are present. The water used will not be saturated and thus will be expected to dissolve such salts or break the crystal structure down sufficiently to permit retrieval. The volume of free liquid added to soften any waste would be minimized by keeping the free liquid height above the waste to as small as practical.
The time needed to soften the waste is unknown but would likely not be more than a few days.

The retrieval process will be monitored using closed-circuit television to facilitate waste retrieval and aid in efficiently retrieving the tanks. Raw water will be used for waste mobilization and conveyance, transfer line flushing, equipment flushing, heel flushing, or as required for miscellaneous use. The liquid in the tank A-101 will be recirculated and used to sluice waste reducing the amount of water needed for retrieval. Sluicing with supernate will also minimize the amount of waste added to the DSTs. Supernate sluicing will be used as needed particularly when data shows that salt dissolution has slowed. During all retrieval activities the tank liquid level will be maintained below the maximum waste level designated in the process control plan.

During all field activities, standard operating procedures and safety precautions will be implemented to protect worker health and safety, the public, and the environment. In accordance with standard operating procedures, health physics and industrial health technicians will monitor conditions within the tank farm in accordance with approved monitoring plans.

The rate of waste removal will be tracked throughout the retrieval. The project will determine when a tank retrieval is complete by following the Consent Decree requirements stating “that the recovery rate of that retrieval technology for that tank is, or has become, limited to such an extent that it extends the retrieval duration to the point at which continued operation of the retrieval technology is not practicable, with the consideration of practicability to include matters such as risk reduction, facilitating tank closures, cost, the potential for exacerbating leaks, worker safety and the overall impact on the tank waste retrieval and treatment mission.”

4.0 DESCRIPTION OF PLANNED LEAK DETECTION AND MONITORING TECHNOLOGIES

Leak detection monitoring and mitigation plan, including technology description, rationale for selection, configuration, inspection and monitoring requirements, mitigation response, and anticipated performance goals.

4.1 EXISTING TANK LEAK MONITORING

This section describes tank leak monitoring activities that have been historically performed or are currently being performed.

Prior to beginning retrieval operations, SSTs are in waste storage mode. The requirements for leak detection while in waste storage mode are provided in OSD-T-151-00031, *Operating Specifications for Tank Farm Leak Detection and Single-Shell Tank Intrusion Detection.* When retrieval operations are ready to commence for tank A-101 the tank enters retrieval mode as described in 4.2.

4.1.1 Drywell Monitoring

Seven drywells that are in the vicinity of tank A-101 will be used for leak detection monitoring. The monitoring drywells are between about 4 and 7 and a half feet from the edge of the tank footer (Figure 4.1). The seven drywells are 10-01-01, 10-01-03, 10-01-04, 10-01-06, 10-01-08, 10-01-10, and 10-01-11. The drywells are from approximately 75 ft to 125 ft deep (GJ-HAN-106).

For tanks in waste storage mode no routine drywell logging is performed.

4.1.2 Existing Tank Level Monitoring Equipment and Activities

An in-tank A-101 drywell is used for intrusion/leak detection monitoring. The receiver DST annulus has three leak detection devices installed such as ~~ENRAF~~ Enraf level gauges or similar instruments ~~and continuous air monitors for detection of leaks from the tank primary tank liner~~.

The waste level in tank A-101, while in storage mode, is monitored for intrusion only on a quarterly basis (OSD-T-151-00031). The basis for in-tank leak detection and intrusion monitoring while in storage mode is provided in RPP-9937, *Single-Shell Tank System Leak Detection and Monitoring Functions and Requirements Document*.

The primary level monitoring in the receiver DST is performed as described in OSD-T-151-00031, Section 2.0. The three annulus leak detector instruments provide indication of tank leaks as described in OSD-T-151-00031, Section 2.0.

5.0 REGULATORY REQUIREMENTS IN SUPPORT OF RETRIEVAL OPERATIONS

Functions and associated requirements necessary to support design of proposed waste retrieval and leak detection monitoring and mitigation system(s).

Retrieval of waste from the SSTs will be performed under the requirements of the Consent Decree, the *Atomic Energy Act of 1954*, and RCRA, RCW ~~70.105~~70A.300 and their implementing regulations. The SSTs do not provide secondary containment and are not compliant with RCRA, RCW 70~~.105~~A.300 and some interim facility standards of Subpart J of 40 CFR 265. The SSTs are currently authorized to continue operations under the interim status standards pending closure in accordance with WAC 173-303-610, "Closure and Post-Closure," under the authority of HFFACO Action Plan Section 5.3, and Milestones series M-45-00. Interim status standards are authorized pursuant to the Hanford Facility RCRA Permit, Condition I.A. In addition to the regulatory requirements for interim status, the Hanford Facility RCRA Permit also imposes requirements on interim status Treatment, Storage, and/or Disposal Units based on those requirements identified in the Permit Applicability Matrix (Hanford Facility RCRA Permit Attachment 9). DOE conducts day-to-day operations of the SSTs in accordance with the interim status standards established in WAC-173-303-400(3), "*Interim Status Facility Standards,*" to the extent practicable as documented in various compliance agreements. Additionally, the SSTs are governed by federal regulations promulgated under the authority of the *Atomic Energy Act of 1954* and various DOE directives incorporated into the contract between ORP and the Tank Farm Contractor (DE-AC27-08RV14800). These requirements are implemented through operating plans and procedures by the Tank Farm Contractor.

Interim status facility standards in WAC 173-303-400(3)(a) incorporate by reference the interim status standards set forth by EPA in 40 CFR 265 Subpart J for tank systems. Elements of the interim status standards relevant to the WRS along with the WRS features and/or operating plans and procedures are summarized in Table 5-1.

The ventilation system(s) used during waste retrieval operations are designed to pass air through the tank, thereby reducing condensation and fog within the tank. The ventilation systems required by the Washington State Department of Health and Washington Department of Ecology include a heater, demister, two high-efficiency particulate air filters and test sections, exhaust fan, and stack. Details of the ventilation systems are provided in 00-05-006, "Hanford Site Air Operating Permit," as amended and succeeded.

chromium may only constitute about 30% of the total chromium in residual waste (RPP-RPT-64002, *Chromium Species in Residual Waste in Retrieved Single-Shell Tanks*). By conducting bounding analyses, the speciation uncertainty is addressed.

7.1.1 Retrieval Leak Evaluation Methodology

This analysis developed the retrieval leak graphs using the following methodology:

- Focus on potential long-term groundwater pathway human health risk at the downgradient tank farm fenceline
- Use radiological and non-radiological ILCR and noncarcinogenic chemical HI as the primary human health impact metrics
- Use EPA's Tap Water exposure scenario to calculate radiological and non-radiological human health impacts
- Identify the significant contributors (95% of total) for each health impact metric and generate a separate graph for each significant contributor (note that in risk terminology, the HI for all chemicals is the sum of the hazard quotient, or HQ, for each chemical)
- Derive effects of contaminant release and transport from previous studies
- Use the best available published data and information to the maximum extent possible.

The human health impact values used to generate the retrieval leak impact graphs are estimates based on Equation (7-1).

$$R_i = I_i \times C_i \times H_i \quad (7\text{-}1)$$

Where:

i = indicator contaminant
R_i = risk metric (non-radiological/radiological ILCR or chemical HQ)
I_i = inventory (Ci or kg released into the environment [e.g., retrieval leakage])
C_i = unit groundwater concentration factor (pCi/L per Ci, or mg/L per kg)
H_i = health effects conversion factor (ILCR per pCi/L, ICLR per mg/L, or HQ per mg/L).

Equation (7-1) is a summary equation containing toxicity and exposure parameters that may vary by contaminant and exposure scenario. Additionally, there are methodology differences between radiological and non-radiological calculations. Sections 7.1.3.1 through 7.1.3.4 discuss the individual terms in Equation (7-1), including identifying indicator contaminants, developing contaminant inventories, simulating contaminant transport, and identifying exposure scenarios and health effects conversion factors.

assumption for all relevant source terms is non-trivial, and because nitrite has higher toxicity than nitrate, source terms were recalculated to include the impacts from both nitrite and nitrate.

Table 7-1 summarizes the contaminant contributions by source term for each of the human health impact metrics using results from the present modeling as described briefly in Sections 7.1.3.3 and 7.1.3.4. Details of the methodology, resulting modeling and subsequent risk, dose, and hazard impact calculations are more fully described in RPP-CALC-64793, *Estimated Groundwater Impacts from Past Leaks and Potential Waste Losses during Retrieval at WMA-A-AX*. Table 7-1 shows the peak impacts from the following WMA A-AX source terms: 1) past leaks and other waste loss events involving tanks A-104 and A-105; 2) a potential retrieval leak from A-101; 3) potential retrieval leaks from all A-100-series tanks; 4) potential retrieval leaks from all AX-100-series tanks; and 5) tank residual waste; ~~and 6)~~ which includes the impacts from ~~residual~~ waste sources left in ancillary equipment at closure. Retrieval leak volumes are discussed in Section 7.1.1.2. Peak impacts from sources in the A Farm occur at locations along the fenceline that are distant from peak impacts from sources in the AX Farm. Table 7-1 reports the maximum impacts between the two tank farms for each significant contaminant from each source except retrieval leaks, with total ILCR or HI for all indicator contaminants assumed to be additive (i.e., only one tank farm contributes to the value reported for each contaminant, but differences in location along the fenceline and in timing are ignored in the totals for all indicator contaminants). Peak impacts from potential retrieval leaks from each of the A and AX-100 series tanks are updated using the current PA modeling tools over what was reported in separate TWRWP documents that were developed previous to this document.

Results from the TC&WM EIS, the DMT, and preliminary runs of the present TWRWP model indicate that the only contributors to total WMA A-AX radiological ILCR at the fenceline at the time of peak concentration would be the long-lived and highly mobile radionuclides, technetium-99 and iodine-129, with technetium-99 being the major contributor. Technetium-99 is predicted to contribute greater than 90% of the total radiological ILCR for every source term and receptor scenario, and technetium-99 and iodine-129 combined contribute greater than 98%. Highly mobile contaminants are those with distribution coefficient (K_d) values of 0 mL/g in the vadose zone and saturated zone sediments, as assumed in the TC&WM EIS. The contribution from iodine-129 and absence of carbon-14 at the time of peak are likely to be a consequence of the updated K_d values assumed in the TC&WM EIS (0 and 4.0 mL/g, respectively) versus the older values in the DMT (0.2 and 0 mL/g, respectively). Even with the treatment of carbon-14 as both non-reactive (except for radioactive decay) and non-sorbing in the DMT, it contributes less than 2% for every source term and receptor scenario. Tritium is too short-lived to contribute at the time of peak impact. Technetium-99 and iodine-129 were therefore selected as the radiological ILCR indicator contaminants for this evaluation.

Percentage contributions shown in Table 7-1 are based on total impacts of the indicator contaminants only, because only indicator contaminants were simulated. Impacts from other long-lived, highly mobile contaminants could be estimated by scaling impacts from one of the indicator contaminants by the ratio of the contaminant inventories. From simulations with the present TWRWP model, percentage contributions shown in Table 7-1 indicate technetium-99 accounted for 97.6 to >99% of the radiological ILCR and iodine-129 accounted for <1 to 2.4%.

Table 7-1. Contaminant Contributions to Peak Groundwater Pathway Human Health Impacts at Waste Management Area A-AX Fenceline. (3 pages)

Source Term	Contaminant	Time of Peak (Calendar year)	Radiological Incremental Lifetime Cancer Risk EPA Tap Water Scenario (Residential)	Non-radiological Incremental Lifetime Cancer Risk EPA Tap Water Scenario (Residential)	Noncarcinogenic Chemical Hazard Quotient EPA Tap Water Scenario (Residential)
	Total Nonradiological (w/Hexavalent Chromium)	**--**	**--**	**8.66E-05 (100%)**	**2.44E-01 (100%)**
Tank 241-A-101 Residual Waste[j]	Tc-99	4390	4.01E-07 (98%)	N/A	No RfD
	I-129	12050	6.54E-09 (2%)	N/A	No RfD
	Total Cr[b]	4550	N/A	No CPF	6.59E-08
	Hexavalent Chromium[c]	4550	N/A	1.37E-08 (100%)	3.33E-05 (0.5%)
	NO_2	4130	N/A	No CPF	5.95E-03 (92.4%)[d]
	NO_3	4130	N/A	No CPF	4.60E-04 (7%)[e]
	Total Radiological	**--**	**4.08E-07 (100%)**	**--**	**--**
	Total Nonradiological (w/Total Cr)	**--**	**--**	**0.00E+00**	**6.41E-03**
	Total Nonradiological (w/Hexavalent Chromium)	**--**	**--**	**1.37E-08 (100%)**	**6.44E-03 (100%)**

Note: The number of significant digits shown is not intended to imply a level of accuracy greater than the input values.

For radiological incremental lifetime cancer risk, the EPA acceptable target risk range is 10^{-6} to 10^{-4}. For nonradiological chemicals, the 13 *Revised Code of Washington* 70.105D, "Hazardous Waste Cleanup — Model Toxics Control Act." (*Washington Administrative Code (*WAC) 173-340-720 Groundwater Cleanup Standards) risk-based criteria are based on a target risk level of 10^{-5}-^{6} for carcinogens and a hazard quotient of 1 for noncarcinogens.

Note: Bold text indicates total impacts from radiological constituents and non-radiological constituents.

[a] Basis: Source-term releases of selected indicator contaminant inventories contained within WMA A-AX past waste losses associated with tanks A-103, A-104, A-105, AX-102, and AX-104

[b] Assumes all chromium is total chromium

[c] Assumes all chromium is hexavalent chromium. Hexavalent chromium is the only carcinogenic chemical in this analysis. The CLARC Washington State Model Toxics Control Act (MTCA) (Revised Code of Washington 70A.305, "Hazardous Waste Cleanup—Model Toxics Control Act") Method B (cancer) cleanup level is 4.6×10^{-2} µg/L.

[d,e] Percentage reflect percent of the HI assuming all chromium is hexavalent chromium

[f] Basis: Source-term releases of selected indicator contaminant inventories contained within an assumed 4,000-gal retrieval leak from A-Farm tank A-101, using OLI Stream Analyzer concentrations.

[g] Basis: Source-term releases of selected indicator contaminant inventories contained within retrieval leaks from A-Farm tanks (A-102, A-103, and A-106), using inventory and assumptions from the TC&WM EIS, i.e., each tank has one 4,000-gal retrieval leak simultaneously

[h] Basis: Source-term releases of selected indicator contaminant inventories contained within retrieval leaks from AX-Farm tanks (AX-101, AX-102, AX-103, and AX-104) assuming maximum impacts are additive, using OLI Stream Analyzer concentrations and assuming each tank has one 4,000-gal retrieval leak.

[i] Basis: Source-term releases of selected indicator contaminant inventories contained within WMA A-AX residual wastes, using WMA A-AX PA inventories and assumptions.

[j] Basis: Source-term releases of selected indicator contaminant inventories contained within tank 241-A-101 residual waste, using WMA A-AX PA inventories and assumptions.

CPF = Cancer Potency Factor

RFD = Reference Dose

From simulations with the present TWRWP model, percentage contributions shown in Table 7-1 (based on total impacts of the indicator contaminants only) indicate chromium as hexavalent chromium accounted for 0.5 to 86% of the HI, nitrite for about 13 to 92%, and nitrate for

<1 to 7%. Chromium and nitrite together account for the vast majority of the HI in all scenarios. However, it is safest to retain nitrate as an indicator since the percentage contributions are sensitive to assumptions about chromium and nitrogen speciation that could change given additional information. If all chromium inventory is considered hexavalent chromium, its HQ from past leaks exceeds the HQ limit.

Uranium was simulated as a moderately mobile (K_d = 0.6 mL/g) contaminant in the TC&WM EIS, and the results indicated uranium became the dominant radiological and chemical dose after calendar year 5000 but did not exceed the ILCR or HI of the mobile contaminants during the modeling period. A limited number of simulations of additional contaminants, including uranium, with the TWRWP model produced similar results. A potential retrieval leak from tank AX-102, which was estimated to have the highest uranium inventory of potential retrieval leaks from AX-100-series tanks and was nearest to the fence, produced a peak concentration of about 3×10^{-3} mg/L. Assuming essentially all of the mass was uranium-238, the resulting peak concentration would correspond to a radiological ILCR of about 2×10^{-6} less than the peak values for mobile contaminants. It would also correspond to an HQ of about ~~4.5~~0.75, which ~~exceeds~~ is below the regulatory limit of 1. Contaminants with K_d values of 2.5 mL/g and higher did not break through to the water table during the 10,000-yr modeling period. Tritium peaked early at levels well below those of the other mobile contaminants and decayed to insignificant levels at the time of peak concentration. The results confirmed the expectation based on the TC&WM EIS, and therefore most simulations included only the indicator contaminants as described.

In the TC&WM EIS, peak human health impacts from all contaminants were projected to occur in the following time ranges: 1) from before closure to within 20 years after closure for past leaks and A-100-series tank retrieval leaks, 2) within 700 years after closure for AX-100-series tank retrieval leaks, and 3) within 1,700 years after closure for residual waste in tanks and ancillary equipment. The difference in peak arrival times for retrieval leaks in the A Farm versus the AX Farm is attributed to the hydraulic properties assigned in the TC&WM EIS AX farm model for a fine layer just above the water table. Sediments at a similar depth within the A Farm model are coarser across most of the horizontal domain. The peak values in all cases were driven by contributions from the highly mobile (K_d = 0 mL/g) contaminants. Uranium and less mobile contaminants had not yet broken through to the water table at the time of peak for any source term and therefore made no contribution to the peak impacts. Tritium had decayed to insignificant levels at the time of peak impacts. Uranium exhibited increasing concentrations at the end of the 10,000-year simulation and was a primary contributor to the impacts calculated at the end of the simulation. The impacts at the end of the simulation were lower than the peak impacts by an order of magnitude or more.

The TC&WM EIS also included an assessment of nonradiological cancer risk. Cancer risks from radionuclides and carcinogenic chemicals are typically reported as separate metrics rather than being summed because of differences in how risk is estimated for these two categories of substances. Of the nonradiological indicator contaminants, only hexavalent chromium has a published cancer slope factor. In this analysis, even though only total chromium inventory is reported, ILCR is evaluated for two cases: one where all chromium is assumed to be hexavalent chromium and one where all chromium is assumed to be total chromium. The TC&WM EIS evaluated a longer list of nonradiological contaminants in the BBI or in sample results and found

chromium to be the only significant contributor to nonradiological ILCR within the A Barrier Boundary for the groundwater pathway.

The nonradiological ILCR results are shown in Table 7-1 for information purposes to provide an indication of the potential magnitude of nonradiological ILCR. The results indicate that nonradiological ILCR peaks would be on the order of 10^{-8} to 10^{-3} depending on source term and exposure scenario. All ILCR values for hexavalent chromium, except for those from residual waste in tank A-101, exceed the MTCA risk limit of 1×10^{-5}. ~~However, because it is based on only one contaminant, nonradiological ILCR was not carried forward as a separate evaluation metric (i.e., was not used to generate a separate set of retrieval leak impact graphs).~~ The degree to which the chromium ILCR provides an indication of total ILCR is uncertain because of the limited number of chemical analytes reported in the BBI. Hexavalent chromium toxicity values are applied to chromium concentration for this analysis. There is additional uncertainty regarding chromium speciation and the degree of conservatism introduced by assuming that all chromium is hexavalent chromium.

7.1.1.2 Potential Retrieval Leak Inventories

This analysis assumes a 4,000-gal. retrieval leak volume, the same volume assumed in the TC&WM EIS. This quantity is used only as a point of reference; the choice of the reference volume is arbitrary and does not affect how the risk values would be used in the event of a retrieval leak. The 4,000-gal. is a hypothetical volume that represents neither an anticipated leak volume nor a leak detection limit. Tank A-101 is classified as sound and is not anticipated to leak during waste retrieval. If a leak is detected, however, the risk graphs for tank A-101 provided in Appendix B will allow the leak impacts to be evaluated regardless of leak volume.

Inventories developed from thermodynamic modeling using the OLI Systems Inc. Stream Analyzer (RPP-RPT-58867) represent the most sophisticated analysis available for the A-101 and AX Farm tank retrieval leaks. In lieu of thermodynamic modeling results, the retrieval leaks for other A Farm tanks examined in this analysis (i.e., tanks A-102, A-103, and A-106 were based on the inventory assumptions developed used in the TC&WM EIS which involve simple dilution (DOE/EIS-0391 Appendix D). The TC&WM EIS used a single source term for retrieval leaks from all six tanks in the A Farm occurring simultaneously. The specific retrieval loss inventories assigned proportionally to tanks A-102, A-103, and A-106 in the single source term were those evaluated in the retrieval losses from those tanks. The remaining A Farm tanks are expected to be retrieved in accordance with a future TWRWP(s) in which assumptions may be updated (for instance, tanks A-104 and A-105 are unlikely to be sluiced, so no specific retrieval losses were evaluated for these tanks). Pending those assessments, the TC&WM EIS assumptions for the A Farm potential retrieval leaks source term are retained as the most sophisticated analysis available for the remaining A Farm tanks at this time.

Table A-1 shows relatively high inventories of the toxic metals aluminum, lead, nickel and mercury in tank A-101. These metals are not expected to be mobile in the subsurface if leaked and were not evaluated as hazards to groundwater.

The retrieval leak impact graphs provided in the appendix were generated by applying Equation (7-1) over a range of hypothetical retrieval leak inventories for each indicator contaminant.

of retrieval and past leaks by unit ~~dose~~ health effects factors. The unit ~~dose~~ health effects factors were developed from the equations and data found in RPP-ENV-58813 by running the WMA A-AX system model using a unit groundwater concentration. Table 7-4 shows the EPA tap water scenario unit ~~dose~~ health effects factors developed for the indicator contaminants.

Table 7-4. Groundwater Unit Health Effects Factors for the Environmental Protection Agency Tap Water (Residential) Exposure Scenario.

Contaminant	Units	EPA Tap Water Scenario (Residential)[a]
Technetium-99	ILCR per pCi/L	5.26E-08
Iodine-129	ILCR per pCi/L	2.89E-06
Hexavalent Chromium	ILCR per mg/L	9.28E-03[b]
Chromium	HQ per mg/L	4.45E-02
Hexavalent Chromium	HQ per mg/L	2.25E+01
Nitrite	HQ per mg/L	1.67E-01
Nitrate	HQ per mg/L	7.05E-03

HQ = hazard quotient.

ILCR = incremental lifetime cancer risk.

[a] Calculated using equations and parameter values from RPP-ENV-58813, Appendix H, except where noted.

[b] Calculated using equations and parameter values from RPP-ENV-58813, Appendix H and CSFo from EPA (EPA Home | Risk Assessment, Queried 07/19/2021, [Regional Screening Table User's Guide (May 2021)]).

The conversion factors in Table 7-4 provide the ILCR per unit groundwater concentration for ^{99}Tc, ^{129}I, and hexavalent chromium, while for nonradiological chemicals, they provide the noncarcinogenic chemical HQ per unit groundwater concentration. The unit ~~dose~~ risk factor for cancer risk from hexavalent chromium was calculated to be 9.28×10^{-3} ILCR per mg/L, based on a screening-level oral cancer slope factor (CSFo) of 0.5 $(mg/kg\text{-}day)^{-1}$ (EPA Home Risk Assessment, Queried 07/19/2021, [Regional Screening Table User's Guide (May 2021)]). Nitrate and Nitrite have no cancer potency factors (CPF).

Groundwater concentrations at the WMA A-AX fenceline from chemicals in residual waste at WMA A-AX and related hazards were evaluated in RPP-ENV-62206. Groundwater concentrations at the WMA A-AX fenceline from radionuclides in residual wastes were evaluated in RPP-ENV-61497 and this analysis calculates the related cancer risks using the unit ~~dose~~ risk factors in Table 7-4, since RPP-ENV-61497 did not report radionuclide cancer risks. Groundwater contaminant concentrations and related cancer risks and health hazards from tank A-101 residual wastes were exported from the system models used for RPP-ENV-62206 and RPP-ENV-61497.

Uncertainty in the exposure scenarios contributes to the overall uncertainty in long-term risk predictions. To address uncertainty, exposure scenario parameters are generally biased to yield higher exposure and risk values. Inputs to the scenario unit risk factors that could contribute to exposure scenario uncertainty include the various models used (e.g., toxicokinetic model) and model parameters (e.g., exposure factors, dose factors, risk factors). There is additional uncertainty regarding chromium and nitrogen speciation. Complete descriptions of the exposure

Table 7-5. Peak Impacts at the Waste Management Area A-AX Fenceline from a Potential Retrieval Leak at Tank 241-A-101.

Contaminant	Time of Peak (Calendar Year)	Incremental Lifetime Cancer Risk	Hazard Quotient	Groundwater Concentration (pCi/L or mg/L)	CLARC[a] MTCA Method A or B (noncancer) Groundwater Cleanup Levels (mg/L)	Drinking Water Standard (MCL) (pCi/L or mg/L)
		Tap Water (Residential) Scenario	Tap Water (Residential) Scenario			

EPA = U.S. Environmental Protection Agency.

MCL = maximum contaminant level.

-- = not applicable.

No CPF = no cancer potency factor available

No Rfd = no reference dose available

Assumes one 4,000-gallon retrieval leak.

For radiological incremental lifetime cancer risk, the EPA acceptable target risk range is 10^{-6} to 10^{-4}. For nonradiological chemicals, the risk-based criteria are based on a target risk level of 10^{-5}-^{6} for carcinogens and a hazard quotient of 1 for noncarcinogens (*Washington Administrative Code (*WAC) 173-340-720 Groundwater Cleanup Standards)

Bold text indicates total impacts from radiological constituents and non-radiological constituents.

[a] Feb 2021 Cleanup Levels and Risk Calculation (CLARC) master spreadsheet was retrieved from https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Contamination-clean-up-tools/CLARC/Data-tables on May 3, 2021.

[b] MCL for total chromium. No MCL for hexavalent chromium has been published by EPA.

[c] The calculated ILCR exceeds limits, but the exceedance likely to be the result of compounded conservatisms in the assumptions regarding the concentration of Cr in the leak, and its presence as Cr+6. Hexavalent chromium is the only carcinogenic chemical in this analysis. The CLARC Washington State Model Toxics Control Act (MTCA) (Revised Code of Washington 70A.305, "Hazardous Waste Cleanup—Model Toxics Control Act") Method B (cancer) cleanup level is 4.6×10^{-2} µg/L.

[d] Concentration and MCL for nitrite reported as the ion. The MCL for nitrite reported as nitrogen is 1 mg/L.

[e] A derived limit for nitrate was calculated from the MTCA B groundwater limit for nitrate as nitrogen (NO_3^--N) using the mass fraction of nitrogen in nitrate. The mass fraction of nitrogen in nitrate = mol wt N/mol wt NO_3^- = (14 g/mol)/(62 g/mol) = 0.226. The derived limit for nitrate = (26 mg/L NO_3^--N) × (1 mg NO_3^-/0.226 mg NO_3^--N) = 115.0 mg NO_3^-/L. A similar conversion was necessary for nitrite, the tabulated values are in units of mg nitrite per liter groundwater.

[f] Concentration and MCL for nitrate reported as the ion. The MCL for nitrate reported as nitrogen is 10 mg/L.

7.1.3 Waste Management Area A-AX Risk Assessment

This section provides information to place the potential retrieval leak impacts from the individual tanks in the context of the potential impacts from WMA A-AX as a whole.

Sections 7.1.3.1 through 7.1.3.4 summarize the analysis results for past leaks, potential retrieval leaks, and residual waste remaining in tanks and ancillary equipment.

7.1.3.1 Past Leaks

WMA A-AX past leak impacts are summarized in Table 7-6~~Table 7-6~~~~Table 7-6~~. The results show the predicted peak groundwater concentration, radiological ILCR, nonradiological ILCR, and noncarcinogenic chemical HI for the indicator contaminants at the downgradient fenceline from the WMA A-AX past leak source releases.

The results indicate the peak groundwater concentrations for mobile constituent from past leaks would arrive at the WMA A-AX downgradient fenceline around calendar years 2056. Peak groundwater concentrations for the less mobile constituent ^{129}I from past leaks would arrive at the WMA A-AX downgradient fenceline around calendar year 8810. The past leaks source terms were based on past unplanned releases at tanks A-104 and A-105.

Table 7-6. Peak Impacts at the Waste Management Area A-AX Fenceline from Past Leaks.

Contaminant	Time of Peak (Calendar Year)	Incremental Lifetime Cancer Risk	Hazard Quotient	Groundwater Concentration (pCi/L or mg/L)	CLARC[a] MTCA Method A or B (noncancer) Groundwater Cleanup Levels (mg/L)	Drinking Water Standard (MCL) (pCi/L or mg/L)
		Tap Water (Residential) Scenario	Tap Water (Residential) Scenario			
Technetium-99	2056	2.53E-03	No Rfd	4.80E+04	--	900
Iodine-129	8810	1.04E-06	No Rfd	3.59E-01	--	1
Total Chromium	2056	No CPF	No Rfd	5.43E-01	5.00E-02	0.1[b]
Trivalent Chromium	2056	No CPF	2.42E-02	5.43E-01	2.40E+01	--
Hexavalent Chromium	2056	5.04E-03[c]	1.22E+01	5.43E-01	4.80E-02	--
Nitrite	2056	No CPF	2.18E+00	1.30E+01[d]	5.26E+00[e]	3.3[d]
Nitrate	2056	No CPF	1.84E-01	5.43E-01[f]	1.15E+02[e]	44[f]
Total Radiological	**--**	**2.53E-03**	**--**	**--**	**--**	**--**
Total Nonradiological (with total chromium)	**--**	**0.00E+00**	**2.39E+00**	**--**	**--**	**--**
Total Nonradiological (with hexavalent chromium)	**--**	**5.04E-03**	**1.46E+01**	**--**	**--**	**--**

EPA = U.S. Environmental Protection Agency.

MCL = maximum contaminant level.

-- = not applicable.

No CPF = no cancer potency factor available

No Rfd = no reference dose available

Assumes one 4,000 gallon retrieval leak.

For radiological incremental lifetime cancer risk, the EPA acceptable target risk range is 10^{-6} to 10^{-4}. For nonradiological chemicals, the risk-based criteria are based on a target risk level of 10^{-5}-^{6} for carcinogens and a hazard quotient of 1 for noncarcinogens (*Washington Administrative Code (*WAC) 173-340-720 Groundwater Cleanup Standards).

Bold text indicates total impacts from radiological constituents and non-radiological constituents.

[a] Feb 2021 Cleanup Levels and Risk Calculation (CLARC) master spreadsheet was retrieved from https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Contamination-clean-up-tools/CLARC/Data-tables on May 3, 2021.

[b] MCL for total chromium. No MCL for hexavalent chromium has been published by EPA.

[c] The calculated ILCR exceeds limits, but that exceednace is likely to be the result of compounded conservatisms in the assumptions regarding the concentration of Cr in the leak, and its presence as Cr+6. Hexavalent chromium is the only carcinogenic chemical in this analysis. The CLARC Washington State Model Toxics Control Act (MTCA) (Revised Code of Washington 70A.305, "Hazardous Waste Cleanup—Model Toxics Control Act") Method B (cancer) cleanup level is 4.6×10^{-2} µg/L.

[d] Concentration and MCL for nitrite reported as the ion. The MCL for nitrite reported as nitrogen is 1 mg/L.

[e] A derived limit for nitrate was calculated from the MTCA B groundwater limit for nitrate as nitrogen (NO_3^--N) using the mass fraction of nitrogen in nitrate. The mass fraction of nitrogen in nitrate = mol wt N/mol wt NO_3^- = (14 g/mol)/(62 g/mol) = 0.226. The derived limit for nitrate = (26 mg/L NO_3^--N) × (1 mg NO_3^-/0.226 mg NO_3^--N) = 115.0 mg NO_3^-/L. A similar conversion was necessary for nitrite, the tabulated values are in units of mg nitrite per liter groundwater.

[f] Concentration and MCL for nitrate reported as the ion. The MCL for nitrate reported as nitrogen is 10 mg/L.

Groundwater concentrations were calculated as cumulative fenceline maximum concentrations over the entire downgradient length of the WMA A-AX fenceline. The peak groundwater concentrations from past leaks were projected to overlap in time and be additive with the peak groundwater concentrations from potential retrieval leaks from the A Farm tanks but were not projected to be additive with the peaks from potential retrieval leaks from the AX Farm tanks or

from residual waste remaining in tanks and ancillary equipment. The peak from A Farm retrieval leaks was projected to arrive around calendar year 3640 compared with year 2056 for the past leaks. The differences in the peaks of the releases reflects the timing differences of the releases prior to the placement of a surface barrier over WMA A-AX at the projected closure date of calendar year 2050.

Contaminant transport from past releases was based on water flow from the original releases and natural recharge only (i.e., surface infiltration of meteoric water). The effect of artificial recharge on existing contamination, such as a retrieval leak or water line leak, was not explicitly simulated. Generally speaking, should the fluid released in a retrieval leak intercept an existing vadose zone plume in WMA A-AX, there is a potential for the contamination to be flushed more quickly to the water table. The effect of the flushing on peak groundwater concentration and arrival time would depend on a number of factors, including initial plume depth and the rate, volume, and location of the retrieval leak. If this were to occur, the WMA A-AX past leak impacts could differ from the projected impacts shown in Table 7-6, which were calculated assuming meteoric infiltration. However, until the assumed time of final closure in calendar year 2050, an enhanced average rate of infiltration is assumed based on disturbance of soil and vegetation (DOE/EIS-0391), and the enhanced meteoric infiltration rate likely exceeds any artificial recharge.

7.1.3.2 Potential Retrieval Leaks

Potential WMA A-AX retrieval leak impacts are summarized in Table 7-7. The table shows the predicted peak groundwater concentration, radiological ILCR, nonradiological ILCR, and noncarcinogenic chemical HI for the indicator contaminants at the downgradient fenceline from the A Farm retrieval leak source term as well as total impacts from all the AX-100-series tank retrieval leak source terms.

The retrieval leak source terms were based on a hypothetical 4,000-gal. retrieval leak from AX-100-series tanks (AX-101 and AX-103) and A-100-series tanks (A-101, A-102, A-103, and A-106) all occurring in calendar year 2018. The contaminant concentrations in the retrieval leaks from the AX-100-series tanks were estimated by a different method than that used for the A-100-series tanks (see Section 7.1.1.2).

The peak from A Farm retrieval leaks was projected to arrive around calendar year 3640, and the peak from AX Farm retrieval leaks was projected to arrive from calendar years ~~3630~~3770. As noted in Section 7.1.3.3, the difference is attributed primarily to the hydraulic properties of a layer of fine sediments occurring only below the AX tanks in the model. Ongoing evaluation of the hydrogeology in WMA A-AX suggests the layer may be both more widespread and less resistant to flow than the currently available analysis in the model indicates. If so, the peak concentrations from retrieval leaks in A Farm and AX Farm may arrive closer together in time, but still at different locations on the fenceline. The currently simulated peak from A Farm retrieval leaks was projected to overlap in time and be additive with the peak groundwater concentrations from past leaks. Neither peak concentrations from A Farm retrieval leaks nor those from AX Farm retrieval leaks were projected to be additive with peak concentrations from residual waste remaining in tanks and ancillary equipment. Declining concentrations from AX Farm retrieval leaks following the peak were projected to overlap increasing concentrations

Table 7-7. Peak Impacts at the Waste Management Area A-AX Fenceline from Potential Retrieval Leaks for All WMA A-AX Tanks.

Contaminant	Time of Peak (Calendar Year)	Incremental Lifetime Cancer Risk	Hazard Quotient	Groundwater Concentration (pCi/L or mg/L)	CLARC[a] MTCA Method A or B (noncancer) Groundwater Cleanup Levels (mg/L)	Drinking Water Standard (MCL) (pCi/L or mg/L)
		Tap Water (Residential) Scenario	Tap Water (Residential) Scenario			

For radiological incremental lifetime cancer risk, the EPA acceptable target risk range is 10-6 to 10-4. For nonradiological chemicals, the risk-based criteria are based on a target risk level of 10^{-5}~~$^{-6}$~~ for carcinogens and a hazard quotient of 1 for noncarcinogens (Washington Administrative Code (WAC) 173-340-720 Groundwater Cleanup Standards).

Bold text indicates total impacts from radiological constituents and non-radiological constituents.

[a] Feb 2021 Cleanup Levels and Risk Calculation (CLARC) master spreadsheet was retrieved from https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Contamination-clean-up-tools/CLARC/Data-tables on May 3, 2021.

[b] MCL for total chromium. No MCL for hexavalent chromium has been published by EPA.

[c] The calculated ILCR exceeds limits, but that ~~exceednace~~exceedance is likely to be the result of compounded conservatisms in the assumptions regarding the concentration of Cr in the leak, and its presence as Cr+6. Hexavalent chromium is the only carcinogenic chemical in this analysis. The CLARC Washington State Model Toxics Control Act (MTCA) (Revised Code of Washington 70A.305, "Hazardous Waste Cleanup—Model Toxics Control Act") Method B (cancer) cleanup level is 4.6×10^{-2} µg/L.

[d] Concentration and MCL for nitrite reported as the ion. The MCL for nitrite reported as nitrogen is 1 mg/L.

[e] A derived limit for nitrate was calculated from the MTCA B groundwater limit for nitrate as nitrogen (NO_3^--N) using the mass fraction of nitrogen in nitrate. The mass fraction of nitrogen in nitrate = mol wt N/mol wt NO_3^- = (14 g/mol)/(62 g/mol) = 0.226. The derived limit for nitrate = (26 mg/L NO_3^--N) × (1 mg NO_3^-/0.226 mg NO_3^--N) = 115.0 mg NO_3^-/L. A similar conversion was necessary for nitrite, the tabulated values are in units of mg nitrite per liter groundwater.

[f] Concentration and MCL for nitrate reported as the ion. The MCL for nitrate reported as nitrogen is 10 mg/L.

7.1.3.3 Residual Waste Remaining in WMA A-AX

Table 7-8 summarizes the potential groundwater impacts from WMA A-AX residual wastes. The table shows the predicted peak groundwater concentration, radiological ILCR, nonradiological ILCR, and noncarcinogenic chemical HQ at the fenceline for the indicator contaminants from the WMA A-AX residual waste source terms. These source terms include the tanks, ancillary equipment and pipelines as evaluated in RPP-ENV-61497 and RPP-ENV-62206.

Source terms for residual waste potentially remaining in tanks and ancillary equipment after closure are based on assumptions from the WMA A-AX PA (RPP-ENV-61497). Ten kiloliters (360 ft^3) of waste are assumed to remain in all tanks at closure, except for tanks A-104 and A-105, which are assumed to be unretrieved. Ten kiloliters is the threshold goal for 100-series Single-Shell Tanks (SSTs) specified in the HFFACO (Ecology et al., 1989). The Hanford Tank Waste Operations Simulator (HTWOS) model results are assumed to provide a best estimate for all of the SSTs except A-104 and A-105. Contaminant inventories for tanks A-104 and A-105 come from current BBI concentrations. The best estimate for residual waste concentrations in ancillary equipment in A Farm is assumed to be represented by the average HTWOS concentration for waste residuals in the A Farm SSTs.

In closed tanks, the residual waste is conceptualized to be distributed in a uniform layer at the base of the tank. The residual waste layer is underlain by a grout layer added during tank construction, which is itself underlain by a concrete base mat. Over the residual waste layer is stabilizing grout added during tank closure activities.

Table 7-8. Peak Impacts at the Waste Management Area A-AX Fenceline from Potential Residual Waste in A Tank Farm.

Contaminant	Time of Peak (Years Post-closure)	Incremental Lifetime Cancer Risk Tap Water (Residential) Scenario	Hazard Quotient Tap Water (Residential) Scenario	Groundwater Concentration (pCi/L or mg/L)	CLARC[a] MTCA Method A or B (noncancer) Groundwater Cleanup Levels (mg/L)	Drinking Water Standard (MCL)
Nitrite	2,120[c]	No CPF	3.23E-02[b]	1.94E-01[c]	5.26E+00[e] ~~00[e]~~	3.3[f] f
Nitrate	2,120[c]	No CPF	1.95E-03[b]	2.76E-01[c]	1.15E+02[e] ~~02[e]~~	44[g] g
Total Radiological	--	**5.88E-06**	--	--	--	--
Total Nonradiological (with total chromium)	--	**0.00E+00**	**3.47E-02**	--	--	--
Total Nonradiological (with hexavalent chromium)	--	**8.66E-05**	**2.44E-01**	--	--	--

EPA = U.S. Environmental Protection Agency.

MCL = maximum contaminant level.

-- = not applicable.

No CPF = no cancer potency factor available

No RfD = no reference dose available

For radiological incremental lifetime cancer risk, the EPA acceptable target risk range is 10^{-6} to 10^{-4}. For nonradiological chemicals, the risk-based criteria are based on a target risk level of 10^{-5}[-6] for carcinogens and a hazard quotient of 1 for noncarcinogens (*Washington Administrative Code (*WAC) 173-340-720 Groundwater Cleanup Standards).

Bold text indicates total impacts from radiological constituents and non-radiological constituents.

[a] Feb 2021 Cleanup Levels and Risk Calculation (CLARC) master spreadsheet was retrieved from https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Contamination-clean-up-tools/CLARC/Data-tables on May 3, 2021.

[b] RPP-ENV-61497, *Preliminary Performance Assessment of Waste Management Area A-AX, Hanford Site, Washington.*

[c] RPP-ENV-62206, *Analysis of Post-Closure Groundwater Impacts from Hazardous Chemicals in Residual Wastes in Tanks and Ancillary Equipment at Waste Management Area A-AX at the Hanford Site, Southeast Washington.*

[d] Hexavalent chromium is the only carcinogenic chemical in this analysis. The CLARC Washington State Model Toxics Control Act (MTCA) (Revised Code of Washington 70A.305, "Hazardous Waste Cleanup—Model Toxics Control Act") Method B (cancer) cleanup level is 4.6×10^{-2} µg/L.

~~[d] MCL for total chromium. No MCL for hexavalent chromium has been published by EPA~~

[e] [c] A derived limit for nitrate was calculated from the MTCA B groundwater limit for nitrate as nitrogen (NO_3^--N) using the mass fraction of nitrogen in nitrate. The mass fraction of nitrogen in nitrate = mol wt N/mol wt NO_3^- = (14 g/mol)/(62 g/mol) = 0.226. The derived limit for nitrate = (26 mg/L NO_3^--N) × (1 mg NO_3^-/0.226 mg NO_3^--N) = 115.0 mg NO_3^-/L. A similar conversion was necessary for nitrite, the tabulated values are in units of mg nitrite per liter groundwater.

[f] [f] Concentration and MCL for nitrite reported as the ion. The MCL for nitrite reported as nitrogen is 1 mg/L.

[g] Concentration and MCL for nitrate reported as the ion. The MCL for nitrate reported as nitrogen is 10 mg/L.

7.1.3.4 Residual Waste Remaining in Tank 241-A-101

In order to illustrate the contribution a closed tank A-101 would have on the overall groundwater impact and related health effects posed by WMA A-AX residual waste, Table 7-9 summarizes tank A-101's potential groundwater impacts. The table shows the predicted peak groundwater concentration, radiological ILCR, nonradiological ILCR, and noncarcinogenic chemical HQ at the fenceline for the indicator contaminants from tank A-101 residual waste. The results are from the system models used for RPP-ENV-61497 and RPP-ENV-62206 and include the source term assumptions described in section 7.1.3.3.

The results indicate the peak groundwater concentrations from tank A-101 residual waste would arrive at the fenceline approximately 2,080 to 2,340 years (i.e., between calendar years 4130 to 4390) after closure except for ^{129}I, whose groundwater concentration is still rising at 10,000 years post-closure. The separation in peak arrival times is caused by the same factors described in section 7.1.3.3.

Table 7-9 shows groundwater concentrations of indicator contaminants from residual waste in tank A-101 range from between about 2 to 5 orders of magnitude lower than their respective MCLs. Hazard quotients for the chemical indicator contaminants range from about two to seven orders of magnitude lower than the target hazard quotient of 1. The hazard index from the indicator chemicals is about two orders of magnitude lower than the target hazard index of 1, regardless of whether the chromium inventory is considered to be trivalent chromium or hexavalent chromium. There is negligible cancer risk from the indicator chemicals, if all the chromium in the waste is assumed to be total chromium. If all the chromium in the waste is assumed to be hexavalent chromium, the ILCR from hexavalent chromium is below the EPA acceptable target risk range of 1×10^{-6} to 1×10^{-4} as well as below the MTCA risk limit of 1×10^{-5}. Both indicator radionuclides have cancer risks that are below the EPA acceptable target risk range.

Table 7-9. Peak Impacts at the Waste Management Area A-AX Fenceline from Potential Residual Waste in Tank 241-A-101.

Contaminant	Time of peak (Years Post-Closure)	Incremental Lifetime Cancer Risk Tap water (Residential) Scenario	Hazard Quotient Tap water (Residential) Scenario	Groundwater Concentration (pCi/L or mg/L)	CLARC[a] MTCA Method A or B (noncancer) Groundwater Cleanup Levels (mg/L)	Drinking Water Standard (MCL) (pCi/L or mg/L)
Technetium-99	2,340	4.01E-07	No RfD	7.62E+00	--	900
Iodine-129	10,000	6.54E-09	No RfD	2.26E-03	--	1
Total Chromium	2,500	No CPF	No RfD	1.48E-06	5.00E-02	0.1[b]
Trivalent Chromium	2,500	No CPF	6.59E-08	1.48E-06	2.40E+01	--
Hexavalent Chromium	2,500	1.37E-08~~[c]~~	3.33E-05	1.48E-06	4.80E-02	--
Nitrite	2,080	No CPF	5.95E-03	3.56E-02[d]~~02~~	5.26E+00[e]~~00~~[e]	3.3[d]
Nitrate	2,080	No CPF	4.60E-04	6.53E-02[f]~~02~~	1.15E+02[e]~~02~~[e]	~~44~~[e]44[f]
Total radiological	--	**4.08E-07**	--	--	--	--
Total non-radiological (with total chromium)	--	**0.00E+00**	**6.41E-03**	--	--	--
Total Nonradiological (with hexavalent chromium)	--	**1.37E-08**	**6.44E-03**	--	--	--

EPA = U.S. Environmental Protection Agency.
MCL = maximum contaminant level.
-- = not applicable.

Table 7-9. Peak Impacts at the Waste Management Area A-AX Fenceline from Potential Residual Waste in Tank 241-A-101.

Contaminant	Time of peak (Years Post-Closure)	Incremental Lifetime Cancer Risk Tap water (Residential) Scenario	Hazard Quotient Tap water (Residential) Scenario	Groundwater Concentration (pCi/L or mg/L)	CLARC[a] MTCA Method A or B (noncancer) Groundwater Cleanup Levels (mg/L)	Drinking Water Standard (MCL) (pCi/L or mg/L)

No CPF = no cancer potency factor available

No RfD = no reference dose available

For radiological incremental lifetime cancer risk, the EPA acceptable target risk range is 10^{-6} to 10^{-4}. For nonradiological chemicals, the risk-based criteria are based on a target risk level of 10^{-5}-^{6} for carcinogens and a hazard quotient of 1 for noncarcinogens (*Washington Administrative Code (*WAC) 173-340-720 Groundwater Cleanup Standards).

Bold text indicates total impacts from radiological constituents and non-radiological constituents.

[a] Feb 2021 Cleanup Levels and Risk Calculation (CLARC) master spreadsheet was retrieved from https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Contamination-clean-up-tools/CLARC/Data-tables on May 3, 2021.

[b] MCL for total chromium. No MCL for hexavalent chromium has been published by EPA.

[c] Hexavalent chromium is the only carcinogenic chemical in this analysis. The CLARC Washington State Model Toxics Control Act (MTCA) (Revised Code of Washington 70A.305, "Hazardous Waste Cleanup—Model Toxics Control Act") Method B (cancer) cleanup level is 4.6×10^{-2} µg/L.

[d] Concentration and MCL for nitrite reported as the ion. The MCL for nitrite reported as nitrogen is 1 mg/L.

[e-c] A derived limit for nitrate was calculated from the MTCA B groundwater limit for nitrate as nitrogen (NO_3^--N) using the mass fraction of nitrogen in nitrate. The mass fraction of nitrogen in nitrate = mol wt N/mol wt NO_3^- = (14 g/mol)/(62 g/mol) = 0.226. The derived limit for nitrate = (26 mg/L NO_3^--N) × (1 mg NO_3^-/0.226 mg NO_3^--N) = 115.0 mg NO_3^-/L. A similar conversion was necessary for nitrite, the tabulated values are in units of mg nitrite per liter groundwater.

~~[d] Concentration and MCL for nitrite reported as the ion. The MCL for nitrite reported as nitrogen is 1 mg/L.~~

[e-f] Concentration and MCL for nitrate reported as the ion. The MCL for nitrate reported as nitrogen is 10 mg/L.

7.2 INADVERTENT INTRUDER RISK

This section presents the analysis of the radiological doses to a hypothetical individual who inadvertently intrudes into tanks or ancillary equipment at WMA A-AX at some point in the future following closure. Inadvertent intruder dose estimates are included in this work plan to provide perspective on potential post-closure risks associated with closing tank A-101 assuming waste is retrieved to the HFFACO target volume of 10 kiloliter (360 ft^3) and the residuals are closed in place. The analyses are performed in accordance with DOE O 435.1, *Radioactive Waste Management*, and DOE M 435.1, *Radioactive Waste Management Manual* requirements and therefore only analyze exposure to residual radionuclides. Exposure scenarios are defined in RPP-ENV-58813 and the complete analysis was presented in RPP-ENV-61497.

This completed post-closure radiological impact evaluation summarized from the preliminary PA (RPP-ENV-61497) is provided to meet the Consent Decree requirements for this TWRWP for the most sophisticated analysis available of the long-term human health risk that includes the potential impacts based on an intruder scenario. Among the assumptions associated with the long-term performance assessment is the assumption that closure of the WMA will include the emplacement of a surface barrier designed to ensure that residual waste is deeper than 15 feet below ground surface in the post-closure period. The inadvertent intruder scenarios considered in the evaluation are described in the next section.

Hypothetical intruder analyses are only performed to analyze the impacts on human health from radionuclides. Due to the depth of the waste in the post-closure configuration (> 15 ft) and the

- For the acute well driller exposure scenario, the driller is assumed to drill through the residual waste and all the way to the water table.
- The acute well driller dose is calculated by assuming that the cuttings are uniformly spread across the drill pad and are not diluted by mixing with clean soil.
- For calculating dose from external exposure, the thickness and lateral extent of the contaminated layer is assumed to be infinite as a conservatism when applied to exposures from relatively small contamination sources (like a drill core).
- Chronic post-intrusion exposures are calculated for several alternative exposure scenarios. In these scenarios, waste exhumed by the intrusion event is assumed to be mixed with a surface soil layer. In each scenario, the volume of soil in this layer represents the minimum area consistent with the assumed activities of the scenario. For instance, the residential garden scenario mixes the contamination in an area of a garden sufficient to grow vegetables, whereas the rural pasture scenario mixes the contamination in an area sufficient for cattle grazing. The effect of this assumption is that different post-intrusion chronic scenarios have different soil concentrations, and the relative importance of the scenarios is strongly dependent on the assumed area of contamination.
- In the chronic scenarios (commercial farm worker, resident with a rural pasture, resident with a suburban garden), contaminated drill cuttings are assumed to be spread evenly over the receptor's land to a tillage depth of 15 cm.
- Radionuclide concentration in water for chronic inadvertent intruder dose calculations is assumed to be zero.
- The minimum depth to groundwater is approximately 87 m assuming a long-term groundwater elevation of approximately 119.5 m above mean sea level (amsl), a ground surface elevation between 202 m and 211 m amsl (RPP-RPT-58693, *Engineered System Data Package for Waste Management Area A-AX*, Section 3.1), and a minimum surface barrier depth of 5 m.

Sections 7.2.2.1 and 7.2.2.2 discuss the calculation methodology for the two primary components of the inadvertent intruder calculation, inventory, and dose. Results for all sources at WMA A-AX are provided in Section 7.2.3.

7.2.2.1 Inventory

The starting inventories for the inadvertent intruder calculation are the estimated radionuclide inventories remaining in the tanks in the WMA A-AX PA as described in Section 7.1.3.3 . Tank residual inventories in the WMA A-AX PA use BBI data, corrected for decay and ingrowth to January 1st, 2050. The nominal estimate for residual waste concentrations in pipelines is assumed to be represented by the average HTWOS concentration for waste residuals in the A Farm SSTs. The HTWOS model uses retrieval assumptions supporting preferential removal of soluble constituents to provide an estimate of tank residuals; the retrieval assumptions are similar to assumptions that would be made about flushing pipelines after they are used to transfer waste. ~~Since HTWOS is a model, its results are uncertain.~~ Retrieval data reports from C Farm retrievals compared post-retrieval waste sample results with HTWOS results for each tank. In general, HTWOS was not a good predictor for sorbing radionuclides' (e.g., ^{90}Sr, ^{137}Cs) post-

Table 7-12. Peak Effective Dose for the Inadvertent Intruder Scenarios for All Residual Waste Sources.

Source	Well Driller Acute Dose (mrem)	Commercial Farm Chronic Dose Rate (mrem/yr)	Rural Pasture Chronic Dose Rate (mrem/yr)	Suburban Garden Chronic Dose Rate (mrem/yr)
Tank 241-AX-104	1.43E+01	2.31E-02	2.15E+00	3.66E+00
241-A Farm Pipeline (HTWOS)	3.74E+00	2.83E-03	6.63E+01	3.10E+01
241-AX Farm Pipeline (HTWOS)	5.72E+00	4.67E-03	**1.16E+02***	**5.42E+01**
241-A Farm Pipeline (BBI)	4.95E+00	4.17E-03	3.28E+01	1.55E+01
241-AX Farm Pipeline (BBI)	8.57E+00	7.41E-03	7.29E+01	3.42E+01

Source: RPP-ENV-61497, *Preliminary Performance Assessment of Waste Management Area A-AX, Hanford Site, Washington,* Table 7-7.

Note: Peak dose occurs at 500 years for all sources except for pipeline, which occurs at 100 years after closure. The peak dose for each scenario is shown in **bold**.

BBI = Best-Basis Inventory HTWOS = Hanford Tank Waste Operations Simulator

* DOE-0431, *Recommendations for Institutional Control Time Period for Conducting DOE Order 435.1 Performance Assessments at the Hanford Site*, recommends that institutional controls and societal memory of the Hanford Site be assumed until at least 2278, at which time the rural pasture dose rate from 241-AX farm pipelines (HTWOS) will be 5.44 mrem/yr.

Table 7-13 presents the dose contribution of the top five dose-driving radionuclides in tank A-101 residual waste for each inadvertent intruder scenario. The total peak dose for each scenario is between three and five orders of magnitude below its respective performance measure.

Table 7-13. Peak Doses to an Inadvertent Intruder from Dose-Driving Radionuclides in Tank 241-A-101 Residual Waste.

Radionuclide	Well Driller (mrem)	Suburban Gardener (mrem/yr)	Rural Pasture (mrem/yr)	Commercial Farm (mrem/yr)
Technetium-99	8.92E-05	6.74E-02	6.97E-02	5.08E-07
Tin-126	2.64E-02	6.97E-03	1.11E-02	9.54E-05
Plutonium-239	4.45E-02	1.04E-02	4.29E-03	6.93E-05
Plutonium-240	1.02E-02	2.39E-03	9.89E-04	1.60E-05
Americium-241	7.96E-02	1.82E-02	8.64E-03	1.31E-04
Other Radionuclides	4.72E-03	1.99E-03	5.33E-03	1.48E-05
Total	**1.66E-01**	**1.07E-01**	**1.00E-01**	**3.27E-04**
Performance Measure	5.00E+02	1.00E+02	1.00E+02	1.00E+02

Note: The number of significant digits shown in Table 7-13~~Table 7-13~~~~Table 7-13~~ is not intended to imply a level of accuracy greater than the input values.

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Table B-3. Tank A-101 Inadvertent Intruder Dose at 500 Years Post Closure

Radionuclide Decay Chain	Well Driller (mrem EDE)	Suburban Garden (mrem/yr EDE)	Rural Pasture (mrem/yr EDE)	Commercial Farm (mrem/yr EDE)
Americium-241	7.96E-02	1.82E-02	8.64E-03	1.31E-04
Other radionuclides	4.72E-03	1.99E-03	5.33E-03	1.48E-05
TOTAL	**1.66E-01**	**1.07E-01**	**1.00E-01**	**3.27E-04**

Note: The number of significant digits shown in Table B-3 is not intended to imply a level of accuracy greater than the input values.
EDE = effective dose equivalent.

Table B-3 indicates that tank A-101 would not exceed the performance measures of 500 mrem~~/yr~~ effective dose equivalent for acute exposure and 100 mrem/yr effective dose equivalent for chronic exposure beginning 500 years after closure.

B4.0 REFERENCES

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