DOE/RL-2021-38
Revision 0

Performance Assessment Maintenance Plan for the Active Low-Level Burial Ground Trenches 31, 34, and 94 at the Hanford Site

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

U.S. DEPARTMENT OF ENERGY | Richland Operations Office

P.O. Box 550
Richland, Washington 99352

DOE/RL-2021-38
Revision 0

Performance Assessment Maintenance Plan for the Active Low-Level Burial Ground Trenches 31, 34, and 94 at the Hanford Site

R. Khaleel
INTERA, Inc.

S. Mehta
INTERA, Inc.

W. Zhou
INTERA, Inc.

Date Published
September 2023

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

U.S. DEPARTMENT OF ENERGY | Richland Operations Office
P.O. Box 550
Richland, Washington 99352

APPROVED
By Julia Raymer at 11:23 am, Oct 10, 2023

Release Approval Date

Executive Summary

This report documents the maintenance plan for the Hanford Site 200 West Area Active Low-Level Burial Ground Trenches 31 and 34 and 200 East Area Active Trench 94 performance assessment (PA). The PA maintenance plan is one of several supporting documents that are compendiums to the active trenches (Trenches 31, 34, and 94) PA as required in DOE O 435.1, *Radioactive Waste Management*[1]. The PA is documented in DOE/RL-2021-26, *Performance Assessment of Active Trenches in 200 East and West Low-Level Burial Grounds at the Hanford Site*[2]. This plan follows the requirements and outline specified in the applicable U.S. Department of Energy (DOE) standard used for developing documents supporting DOE-STD-5002-2017, *Disposal Authorization Statement and Tank Closure Documentation*[3].

This maintenance plan summarizes the following major activities DOE plans to conduct to maintain the Trenches 31, 34, and 94 PA.

- Monitoring
- Research and development
- Planned reviews and analyses
- Revisions of Trenches 31, 34, and 94 PA

The planned research and development activities relate to evaluating the key assumptions, including evaluating conceptual model assumptions and parameter value assumptions used in the PA. The planned research and development activities include those that are designed to track the release mechanisms for Category 1, Category 3, and uranium billet waste sources, as well as continued characterization and related modeling of the natural environment in the Central Plateau of the Hanford Site. In addition,

---

[1] DOE O 435.1 Chg 1 (PgChg), 2007, *Radioactive Waste Management*, U.S. Department of Energy, Washington, D.C. Available at: https://www.directives.doe.gov/directives-documents/400-series/0435.1-BOrder-chg1-PgChg.

[2] DOE/RL-2021-26, 2023, *Performance Assessment of Active Trenches in 200 East and West Low-Level Burial Grounds at the Hanford Site*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

[3] DOE-STD-5002-2017, 2017, *Radioactive Waste Management Disposal Authorization Statement Technical Basis Documentation*, U.S. Department of Energy, Washington, D.C. Available at: https://www.standards.doe.gov/standards-documents/5000/5002-astd-2017.

the planned research and development activities include focused testing and evaluation of engineered and natural materials to reduce the uncertainty in the conceptual models and parameter values used in the PA.

All key and secondary issues identified during the review of the PA by the Low-Level Waste Disposal Facility Federal Review Group have been resolved prior to finalization of the PA. There are no outstanding issues.

Contents

Figures

Tables

Terms

AEA	*Atomic Energy Act of 1954*
ASR	annual status report
CA	composite analysis
CAT1 (or WC1)	Category 1
CAT3 (or WC1)	Category 3 and Greater Than Category 3
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
DAS	disposal authorization statement
DOE	U.S. Department of Energy
DOE-HQ	U.S. Department of Energy-Headquarters
DOE-RL	U.S. Department of Energy, Richland Operations Office
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ET	evapotranspiration
FEP	feature, event, and process
HWMA	Hazardous Waste Management Act
HY-80	nickel alloy
IDF	Integrated Disposal Facility
K_d	distribution coefficient
LCRS	leachate collection and recovery system
LFRG	Low-Level Waste Disposal Facility Federal Review Group
LDR	land disposal restriction
LDS	leak detection system
LLBG	low-level burial ground
LLW	low-level waste
LLWMA	low-level waste management area
MLLW	mixed low-level waste
NEPA	*National Environmental Policy Act of 1969*

NRC	U.S. Nuclear Regulatory Commission
OU	operable unit
PA	performance assessment
PCAD	proposed corrective action decision
R&D	research and development
RCRA	*Resource Conservation and Recovery Act of 1976*
ROD	record of decision
RWMB	radioactive waste management basis
SWITS	Solid Waste Information and Tracking System
SLDS	secondary leak detection system
TC & WM EIS	Tank Closure and Waste Management Environmental Impact Statement
Tri-Party Agreement	Hanford Federal Facility Agreement and Consent Order
TSD	treatment, storage, and disposal
UDQE	unreviewed disposal question evaluation

1 Introduction

Performance assessments (PAs) for the continued disposal of low-level waste (LLW) and mixed low-level waste (MLLW) in the active trenches of the 200 West Area low-level burial grounds (LLBGs) and the continued disposal of naval reactor compartments in the 200 East Area LLBGs are required per DOE O 435.1, *Radioactive Waste Management, U.S. Department of Energy*. DOE/EIS-0391, *Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington* (TC & WM EIS) evaluates the long-term needs for continued disposal of LLW and MLLW at the Hanford Site. The record of decision (ROD) (78 FR 75913, "Record of Decision: Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington"), issued by the U.S. Department of Energy (DOE) on December 13, 2013, identifies the selection of Waste Management Alternative 2 as the preferred alternative for waste disposal. In Alternative 2, disposal of LLW and MLLW in 200 West LLBGs Trenches 31 and 34 continues until the trenches are filled.

The initial PAs of the 200 East and 200 West Area LLBGs have been maintained since 1997. Annual review reports (identified in Table 1-1) document the history of the PA maintenance associated with the continued use of the LLBGs. The following maintenance activities are associated with the LLBG PAs.

- Evaluation of waste received during each annual reporting period and the impact of the waste received and projected to be received on the relevant DOE O 435.1 performance objectives:
  - Groundwater pathway dose
  - Inadvertent intruder dose
  - Atmospheric pathway dose
  - Radon flux
- Evaluation of results of groundwater monitoring activities
- Evaluation of results of research and development activities
- Evaluation of planned or contemplated changes

As much as possible, this document follows the general outline and content guidelines that are identified in DOE-STD-5002-2017, *Radioactive Waste Management Disposal Authorization Statement Technical Basis Documentation*. This section provides a general overview of the PA process for the active trenches of the 200 West and 200 East Area LLBGs, including high-level assumptions, the relationship of this PA with previous PAs and related documents, and background information on the active trenches and associated regulatory requirements.

Table 1-1. Timeline of Major Activities Related to Permitting and Regulatory Analyses of the Active Trenches of the 200 West Area and 200 East Area Low-Level Burial Grounds

Date	Event
1944	200 West Area and 200 East Area LLBGs begin receiving waste.
1986	200 West Area LLBG 218-W-5 begins receiving waste.
1989	DOE issues the Monitoring Plan for the 200 West Area LLBGs (WHC-SD-EN-AP-015, *Revised Ground-Water Monitoring Plan for the 200 Areas Low-Level Burial Grounds*).
1994	DOE excavates and lines Trenches 31 and 34 of the 200 West Area LLBGs.
1995	DOE issues the initial PA for the 200 West Area LLBGs (WHC-EP-0645, *Performance Assessment for the Disposal of Low-Level Waste in the 200 West Area Burial Grounds*).
1995	DOE issues the disposal plan – WHC-SD-WM-ES-355, *Low-Level Burial Grounds Disposal Plan*, Rev. 0. The current version of the disposal plan is Rev. 5 (HNF-SD-WM-ES-355, *Low-Level Burial Grounds Disposal Plan*).
1996	DOE issues the initial PA for the 200 East Area LLBGs (WHC-SD-WM-Tl-730, *Performance Assessment for the Disposal of Low-Level Waste in the 200 East Area Burial Grounds*).
1996	DOE issues a memorandum stating conditional approval of the 200 West Area PA analysis. Cowan, 1996, "Conditional Acceptance of the Hanford 200 West Area Burial Ground Performance Assessment."
1996	DOE issues the addendum to the initial PA for the 200 West Area LLBGs addressing peer review comments received on the initial PA (HNF-SD-WM-TI-798, *Addendum to the Performance Assessment Analysis for Low-Level Waste Disposal in the 200 West Area Active Burial Grounds*).
1997	DOE issues a memorandum stating conditional approval of the 200 East Area PA analysis (Frei, 1997, "Conditional Acceptance of the Hanford 200 East Area Burial Ground Performance Assessment").
July 1997	DOE issues a revision to DOE/RL-88-20, *Hanford Facility Dangerous Waste Permit Application, Low-Level Burial Grounds*.
1997	DOE issues the initial maintenance plan for the 200 East Area and 200 West Area LLBGs (RFSH-9755566, *Program Plan for Maintenance of Hanford Burial Ground Performance Assessment (PA) Analyses*).
1998	DOE issues the addendum to the initial PA for the 200 East Area LLBGs addressing peer review comments received on the initial PA (HNF-2005, *Addendum to the Performance Assessment Analysis for Low-Level Waste Disposal in the 200 East Area Active Burial Grounds*).
1998	DOE issues the composite analysis for LLW disposal in the 200 Areas (PNNL-11800, *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*).
June 1998	DOE issues the waste acceptance criteria for wastes planned for disposal in Trenches 31 and 34 of the 200 West Area LLBGs based on the PA (HNF-EP-0063, *Hanford Site Solid Waste Acceptance Criteria*, Rev. 5). The current version of the waste acceptance criteria is Rev. 21.
September 1999	First waste is received in Trench 34.
October 2000	DOE issues the initial closure plan (DOE/RL-2000-70, *Closure Plan for Active Low-Level Burial Grounds*).

Table 1-1. Timeline of Major Activities Related to Permitting and Regulatory Analyses of the Active Trenches of the 200 West Area and 200 East Area Low-Level Burial Grounds

Date	Event
2000	DOE issues the initial monitoring plan (DOE/RL-2000-72, *Performance Assessment Monitoring Plan for the Hanford Site Low-Level Burial Grounds*, Rev. 0). The current version of the monitoring plan is Rev. 1.
2001	DOE issues the addendum to the composite analysis for low-level waste disposal in the Central Plateau of the Hanford Site (PNNL-11800 Addendum 1, *Addendum to Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*).
November 2001	DOE issues the disposal authorization statement for the LLBGs (Scott, 2001, "Disposal Authorization for the Hanford Site Low-Level Waste Disposal Facilities – Revision 2").
April 2002	DOE issues the draft Hanford Site solid waste EIS (DOE/EIS-0286D, *Draft Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement, Richland, Washington*).
January 2004	DOE issues the final Hanford Solid Waste EIS (DOE/EIS-0286F, *Final Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement, Richland, Washington*). This EIS evaluated alternatives to provide capabilities to treat, store, and/or dispose of existing and anticipated quantities of solid LLW, MLLW, TRU waste, and immobilized low-activity waste to support cleanup at Hanford and to assist other DOE sites in completing their cleanup programs. Ecology amended its lawsuit to challenge the adequacy of the Hanford Solid Waste EIS analysis.
June 2004	DOE issues the ROD on Hanford Solid Wastes (69 FR 39449, "Record of Decision for the Solid Waste Program, Hanford Site, Richland, WA: Storage and Treatment of Low-Level Waste and Mixed Low-Level Waste; Disposal of Low-Level Waste and Mixed Low-Level Waste, and Storage, Processing, and Certification of Transuranic Waste for Shipment to the Waste Isolation Pilot Plant"). DOE decided in the ROD to (1) limit the volumes of LLW and MLLW received at the Hanford Site from other sites for disposal; (2) dispose of LLW in lined disposal facilities; (3) construct and operate a lined, combined-use disposal facility (called the Integrated Disposal Facility) in Hanford's 200 East Area for disposal of LLW and MLLW, and further limit offsite waste receipts until the IDF is constructed; (4) treat LLW and MLLW (requiring treatment) at either offsite facilities or existing or modified facilities, as appropriate; and (5) use existing and modified onsite facilities to store, process, and certify TRU waste for subsequent shipment to DOE's Waste Isolation Pilot Plant near Carlsbad, New Mexico. Following this ROD, LLW and MLLW are only disposed in lined Trenches 31 and 34 of the 200 West Area LLBGs and naval reactor compartments are disposed in unlined Trench 94 of the 200 East Area LLBGs.
2004	DOE issues an interim status groundwater monitoring plan for LLWMA-1 to LLWMA-4, including the LLBGs near Trenches 31 and 34 and Trench 94 (PNNL-14859, *Interim Status Groundwater Monitoring Plan for Low-Level Waste Management Areas I to 4, RCRA Facilities, Hanford, Washington*).
December 2004 to June 2005	Uranium billet waste is encapsulated in grouted encasements and disposed in Trench 34. Uranium billet waste is unused uranium fuel from N Reactor and contains about 820,000 kg of uranium and 141 Ci of Tc-99, over 99% of the total uranium mass and Tc-99 activity disposed in the active trenches of the 200 West Area LLBGs.
May 2005	First waste is received in Trench 31.

Table 1-1. Timeline of Major Activities Related to Permitting and Regulatory Analyses of the Active Trenches of the 200 West Area and 200 East Area Low-Level Burial Grounds

Date	Event
October 2008	DOE issues the Part A Hanford Facility RCRA Permit (WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste*, Revision 8c).
October 2009	DOE releases the draft TC & WM EIS for review and comment.
September 2012	DOE issues the interim status groundwater monitoring plan for LLWMA-3, including LLBGs near Trenches 31 and 34 (DOE/RL-2009-68, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-3*).
November 2012	DOE releases the final TC & WM EIS (DOE/EIS-0391, *Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*).
December 2013	DOE issues the ROD for the tank closure and waste management activities at the Hanford Site (78 FR 75913, "Record of Decision: Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington"), in which DOE decides to implement Waste Management Alternative 2. In Alternative 2, disposal of LLW and MLLW in LLBGs Trenches 31 and 34 would continue until they are filled.
2015	DOE issues Hanford Facility Dangerous Waste Part B Permit Application [DOE/RL-2015-74, *Hanford Facility Dangerous Waste Part B Permit Application; Low-Level Burial Grounds Trenches 31-34-94, T Plant Complex, and Central Waste Complex-Waste Receiving and Processing Facility*].

DOE	=	U.S. Department of Energy
Ecology	=	Washington State Department of Ecology
EIS	=	environmental impact statement
IDF	=	Integrated Disposal Facility
LLBG	=	low-level burial ground
LLW	=	low-level waste
LLWMA	=	low-level waste management area
MLLW	=	mixed low-level waste
PA	=	performance assessment
RCRA	=	*Resource Conservation and Recovery Act of 1976*
ROD	=	record of decision
TC & WM EIS	=	Tank Closure and Waste Management Environmental Impact Statement
TRU	=	transuranic

1.1 General Facility Description

LLW and MLLW at the Hanford Site are currently disposed in two active, lined trenches (Trenches 31 and 34) of the 218-W-5 Burial Ground in the 200 West Area. Naval reactor compartments are disposed in the active, unlined Trench 94 of the 218-E-12B Burial Ground in the 200 East Area. Trenches 31 and 34 are intended to be used until they are filled. Trench 94 will be used and expanded as necessary to meet the needs of the U.S. Navy.

Figure 1-1 shows the location of the 200 West and 200 East Area LLBGs in relation to the Central Plateau inner and outer areas, and other facilities in the Hanford Site. As part of low-level waste management area (LLWMA)-3, four LLBGs in the 200 West Area (218-W-5, 218-W-3A, 218-W-3AE, and 218-W-4C) received LLW and MLLW after September 26, 1988. Figure 1-2 provides a location map for the facilities around the 200 West Area LLBGs. Figure 1-3 provides a site map showing the specific waste trench configuration for the 200 West Area LLBGs, including active Trenches 31 and 34. Figure 1-4 provides a site map showing the specific waste trench configuration for the 200 East Area LLBGs, including active Trench 94. The 218-E-12B Burial Ground is part of LLWMA-2 and includes several inactive trenches in addition to Trench 94. Photos of disposed wastes in Trenches 31 and 34 and Trench 94 are provided in Figure 1-5, Figure 1-6, and Figure 1-7.

The base dimensions of Trenches 31 and 34 are 76 by 31 m (250 by 100 ft) (2,325 m^2 [25,000 ft^2]), with surface grade dimensions of 91 by 137 m (300 by 450 ft) (12,500 m^2 [135,000 ft^2]) at each trench (Addendum C, Table C-4 in DOE/RL-2015, *Hanford Facility Dangerous Waste Part B Permit Application; Low-Level Burial Grounds Trenches 31-34-94, T Plant Complex, and Central Waste Complex – Waste Receiving and Processing Facility*). Each trench is designed for 21,408 m^3 (28,000 yd^3) of mixed waste. The floor of both trenches slopes slightly, providing a variable depth of 9.1 to 12.2 m (30 to 40 ft). The floor slope is a minimum of 2%, draining to a recessed area at the eastern end that houses the sump for leachate collection. The side slope ratio is 3:1 (horizontal to vertical). A ramp with an 8% slope provides access to the trench floor. Design drawings for Trenches 31 and 34 and their Waste Storage and Treatment Pads are available in Addendum C, Appendix C-B in DOE/RL-2015-74.

The principal design features of Trenches 31 and 34 include provisions for liquid collection systems using geomembrane trench liners. Each trench was constructed with a double liner and a leachate collection and recovery system (LCRS). The liner systems are designed to prevent migration of leachate out of the lined trenches during their active life and comply with requirements for dangerous waste landfills in WAC 173-303-665, “Dangerous Waste Regulations,” “Landfills.” The bottom and sides of each trench are covered with a 0.9 m (3 ft) layer of soil to protect the liner system during fill operations.

The LCRS is comprised of two components, a primary LCRS and a secondary LCRS. The primary LCRS provides the preferential path along which the leachate flows into the primary LCRS sump. The secondary LCRS (also called the leak detection system) is located between the primary and secondary geomembranes and provides the preferential path along which any fluids leaking through the primary liner system flow to the secondary LCRS sump.

Trenches 31 and 34 are designed for disposal of miscellaneous dry wastes from various operations at the Hanford Site and from offsite facilities. Trenches 31 and 34 began receiving low-level mixed dry waste in 2005 and 1999, respectively. Mixed waste disposed in Trenches 31 and 34 include bulk wastes, containerized wastes, inherently stable waste, and long-length contaminated equipment. A diverse range of waste containers can be disposed at Trenches 31 and 34 including, but not limited to, containers/drums, waste boxes, and miscellaneous equipment.

Mixed waste destined for disposal in Trenches 31 and 34 must meet the land disposal restriction (LDR) requirements (WAC 173-303-140, "Land Disposal Restrictions," which includes, by reference, 40 CFR 268, "Land Disposal Restrictions") and 69 FR 39449, "Record of Decision for the Solid Waste Program, Hanford Site, Richland, WA: Storage and Treatment of Low-Level Waste and Mixed Low-Level Waste; Disposal of Low-Level Waste and Mixed Low-Level Waste, and Storage, Processing, and Certification of Transuranic Waste for Shipment to the Waste Isolation Pilot Plant." A site-specific treatability variance approved by the Washington State Department of Ecology (Ecology) must be obtained for waste not meeting these requirements.

The dangerous wastes managed at Trenches 31 and 34 are described in DOE/RL-2015-74 and managed in accordance with WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste*. Trenches 31 and 34 may manage any of the dangerous wastes identified in Table 2-2 of SGW-59564, *Engineering Evaluation Report for Low Level Burial Grounds Trenches 31 and 34 Groundwater Monitoring*.

1.2 Design Features

In general, the active trenches of the LLBGs include several engineered design features that contribute to the overall safety of the facility. These design features work in concert with the natural features of the site to limit releases of radionuclides to the natural environment and protect public health and safety.

The key engineered design features consist of the following:

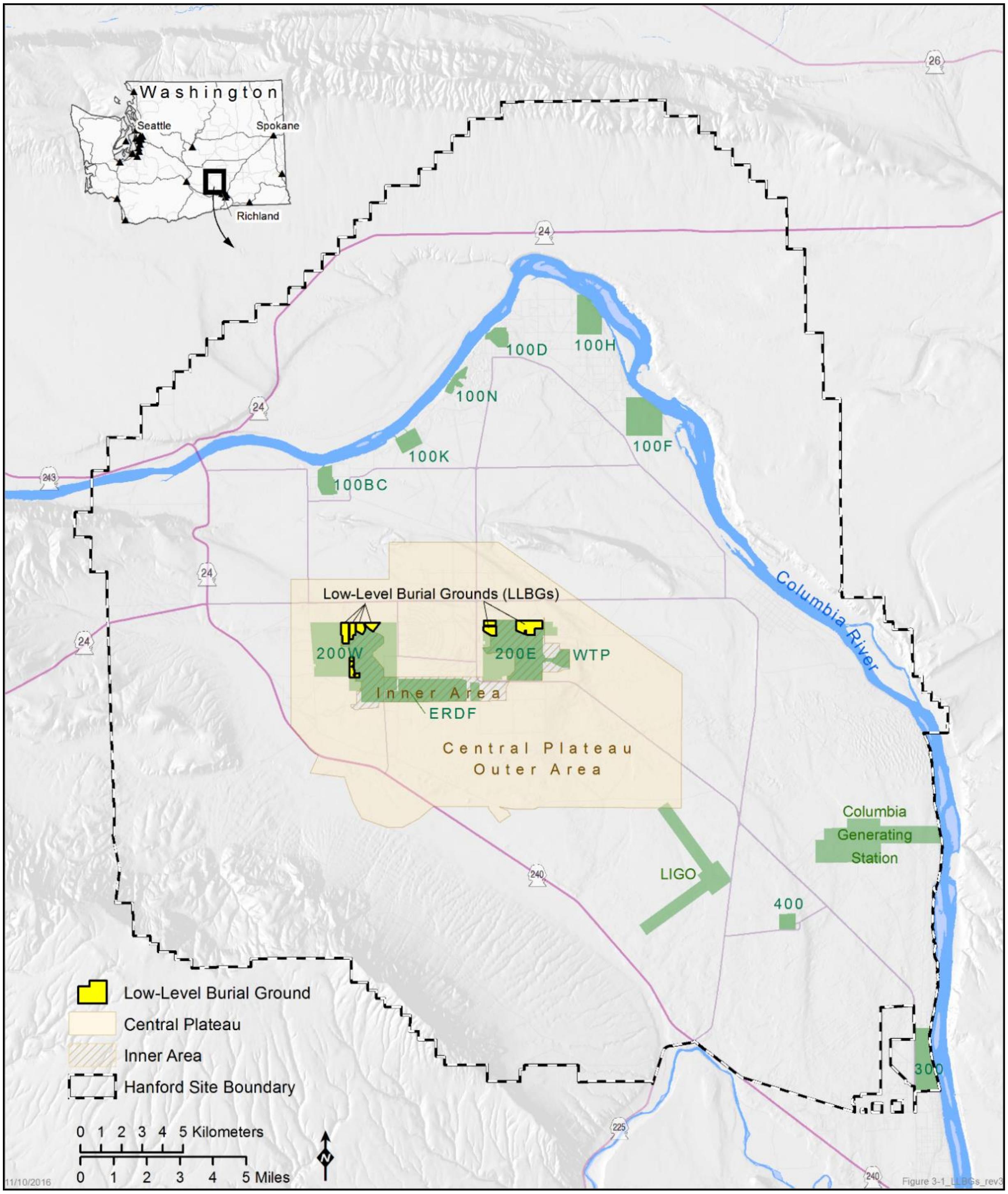
- Modified *Resource Conservation and Recovery Act of 1976* (RCRA) Subtitle C surface barrier placed above the waste to limit water from contacting the waste, minimize the potential for biointrusion into the waste, and limit the release of gaseous radionuclides, including radon, from the facility.
- Waste containers placed around the waste forms to limit water from contacting the waste during disposal operations and provide structural support for overlying waste and backfill.
- Engineered backfill placed between and above waste containers to provide structural support during operations.
- Cementitious waste forms to limit advective or diffusive release of radionuclides from the Category 3 (CAT3) waste form into water in the backfill that surrounds the waste forms and containers.
- The naval reactor compartments disposed in Trench 94 are comprised of corrosion-resistant carbon steel and highly corrosion-resistant stainless steel. The corrosion-resistant carbon steel is also used for the associated bulkheads, as well as for the reactor pressure vessel and tank structure.
- Liner to limit any water collected during operations and the institutional control period from entering the natural system beneath the facility (Trenches 31 and 34 only).

1.2.1 General Facility Description for Trenches 31 and 34

Trenches 31 and 34 were excavated in 1994. The floor of the trenches is about 76 m (249 ft) long in a west-east direction and 31 m (102 ft) wide in a north-south direction. The top of the trench liner system (i.e., where the trench side slopes intersect the land surface) is about 137 m (449 ft) long in a west-east direction and 91 m (299 ft) wide in a north-south direction. The trench floor is sloped toward the east where a sump is located to collect leachate during operations and the institutional control period. Closure of the trenches will consist of placing a modified RCRA Subtitle C surface barrier above the last waste and operations layer. Key design features of the proposed modified barrier limit net infiltration to less than 0.5 mm/yr, minimize the potential for biointrusion into the waste, and limit the release of gaseous radionuclides, including radon, from the trenches.

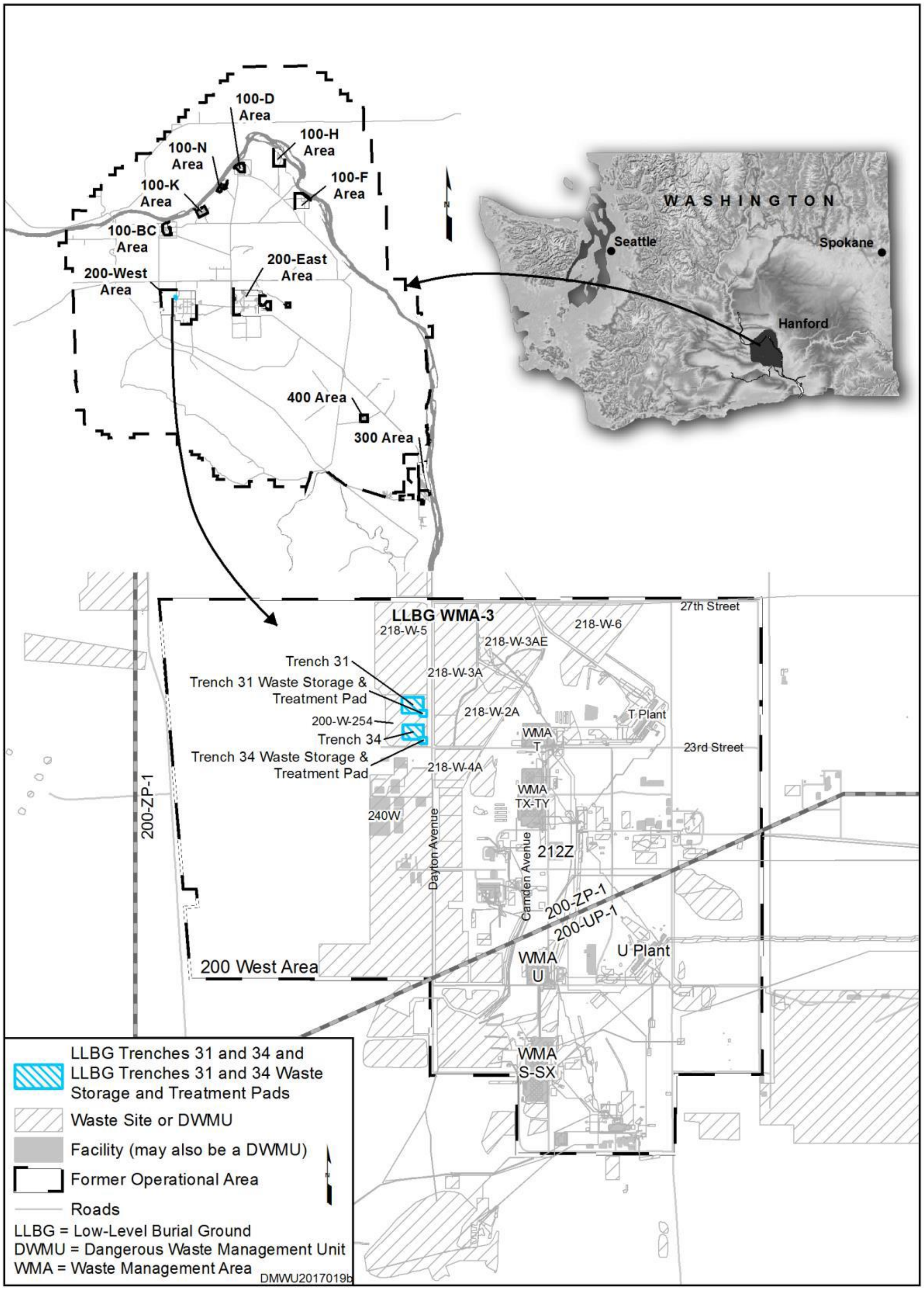
1.2.2 General Facility Description for Trench 94

The trench floor is about 120 m (394 ft) in the north-south direction and 490 m (1,608 ft) in the east-west direction. The approximate dimensions of the open excavation, excluding the access ramp in the northeast corner, are 140 m (460 ft) in the north-south direction and 540 m (1,770 ft) in the east-west direction. The depth of the excavation is approximately 14 m (45 ft). The size of Trench 94 may be expanded to meet the needs of the U.S. Navy. Trench 94 does not include a bottom liner. Naval reactor plants are the only waste disposed of in the trench. The record of decision issued in 1984 (49 FR 47649, "National Environmental Policy Act Record of Decision for Disposal of Decommissioned, Defueled Naval Submarine Reactor Plants") identified disposal of reactor plants by land burial at DOE burial sites as the preferred alternative. Trench 94 received the first reactor plant in 1986. Closure of the trench will consist of placing a modified RCRA Subtitle C surface barrier, with the same key design features indicated in Section 1.2.1, above the reactor plants and operations fill and layer.



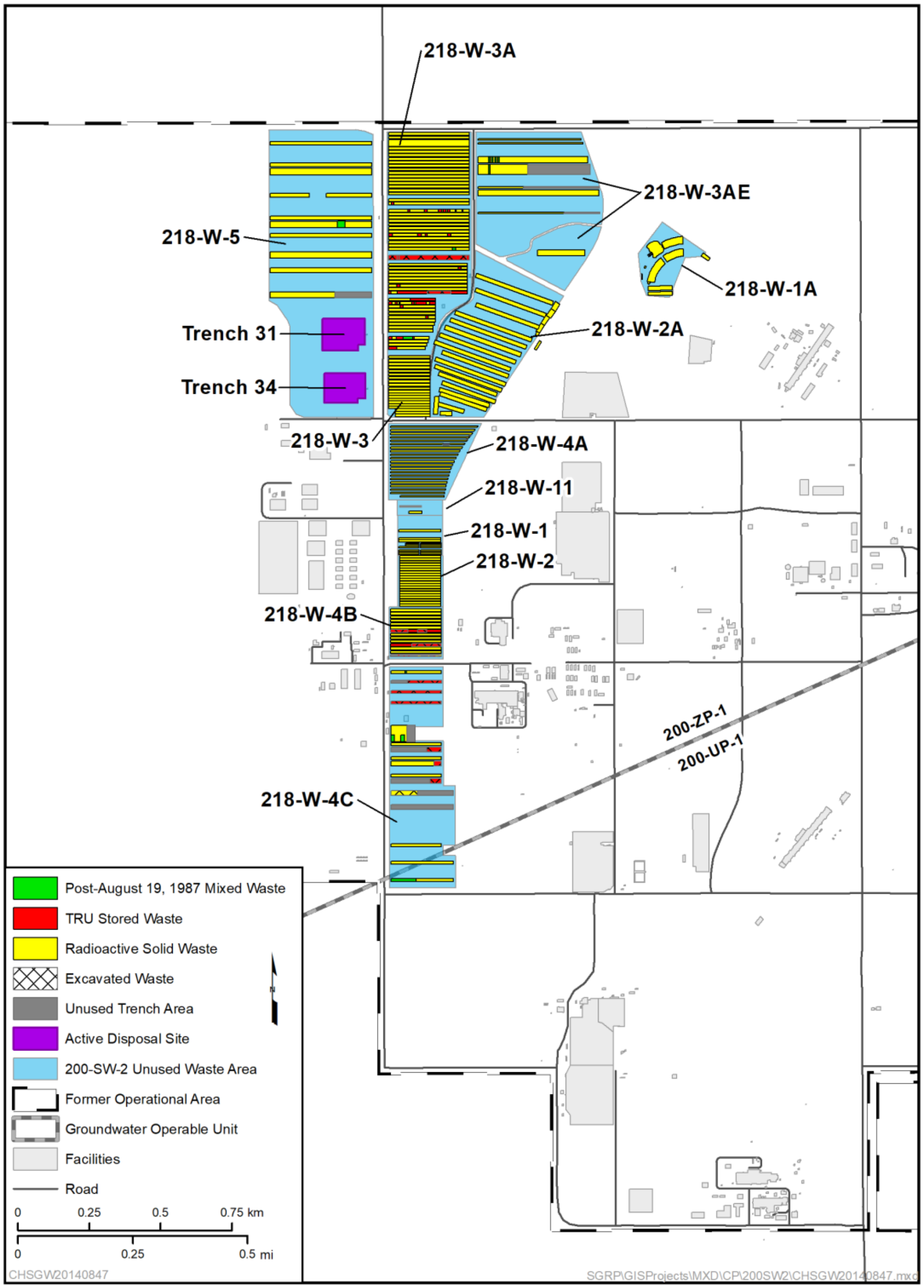
Note: The Environmental Restoration Disposal Facility is covered under a separate performance assessment (WCH-520, *Performance Assessment for the Environmental Restoration Disposal Facility, Hanford Site, Washington*).

Figure 1-1. Location of the Low-Level Burial Grounds in the 200 East and 200 West Areas of the Inner Area of the Hanford Site Central Plateau



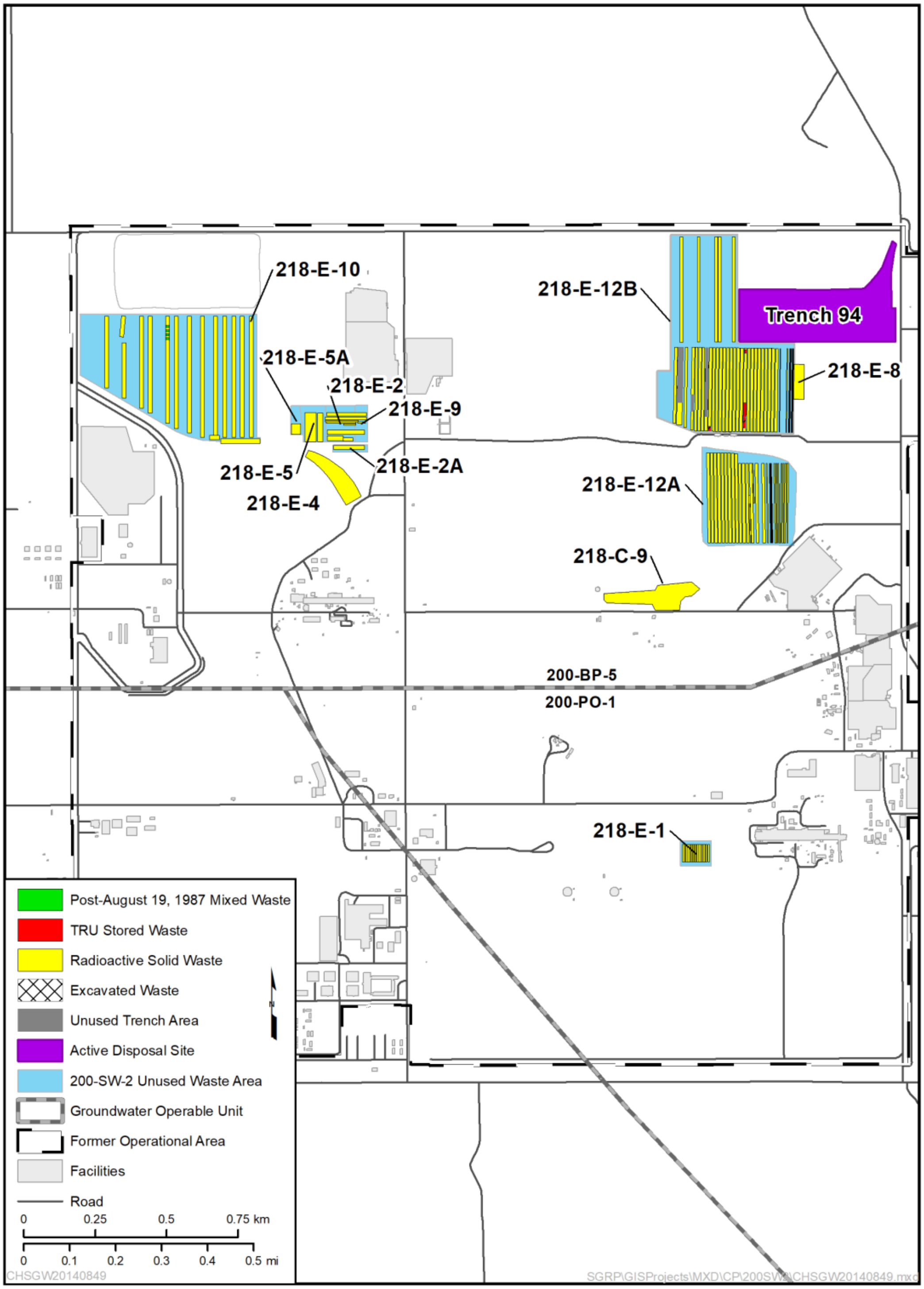
Source: Figure 1-1 in SGW-59564, *Engineering Evaluation Report for Low-Level Burial Grounds Trenches 31 and 34 Groundwater Monitoring*.

Figure 1-2. Location Map for Low-Level Burial Grounds Trenches 31 and 34 in the 200 West Area



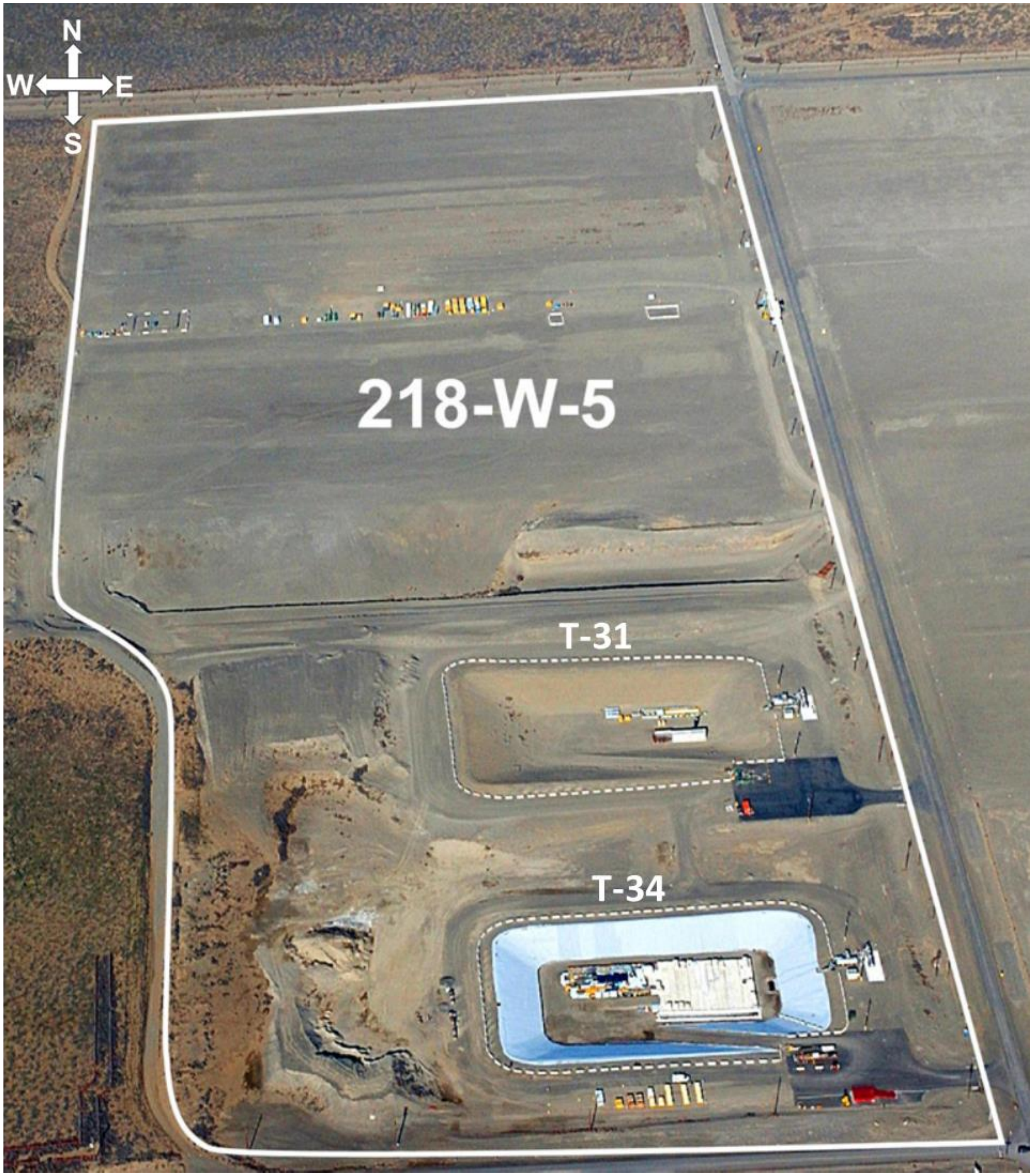
Note: Trenches 31 and 34 in the 218-W-5 Burial Ground are the only active low-level waste disposal areas within the 200 West Area LLBGs.

Figure 1-3. Location of Low-Level Waste Burial Grounds in 200 West Area



Note: Trench 94 in the 218-E-12B Burial Ground is the only active low-level waste disposal area within the 200 East LLBGs.

Figure 1-4. Location of Low-Level Waste Burial Grounds in 200 East Area



Source: DOE/RL-2004-60, *200-SW-2 Radioactive Waste Landfills Group Operable Unit RCRA FI/CMS/RI/FS Work Plan*.
Note: View to north. Photo taken around 2007. Trench 34 in foreground (south).
T-31 = Trench 31, T-34 = Trench 34.

Figure 1-5. Aerial Photograph of Trenches 31 and 34 in the 200 West Area Low-Level Burial Grounds

Source: Google® Maps.

Notes: Uranium billet monolith and other encasement cells are visible in eastern half of Trench 34. Grouted waste container encasements are located to the north and south of the uranium billet monolith.

®Google is a registered trademark of Google LLC, Mountain View, California.

Figure 1-6. 200 West Area Low-Level Burial Ground Trenches 31 and 34

Source: Figure 2-6 in DOE/EA-1889, *Final Environmental Assessment on the Disposal of Decommissioned, Defueled, Naval Reactor Plants from USS ENTERPRISE (CVN 65)*.

Note: View to west.

Figure 1-7. Naval Reactor Compartments (as of 2009) in Trench 94 in 200 East Area

1.3 Regulatory Context

This section describes site-specific regulatory context for the active trenches of the Trenches 31, 34, and 94 PA, including the performance objectives, timing and point(s) of assessment, considerations for intrusion, and the relevant agreements between the DOE, U.S. Nuclear Regulatory Commission (NRC), U.S. Environmental Protection Agency (EPA), other Federal agencies, and the State.

Following the issuance of the ROD on Hanford Solid Wastes in 2004 (69 FR 39449), the only active trenches of the LLBGs are Trenches 31 and 34 in the 200 West Area LLBGs and Trench 94 in the 200 East Area LLBGs. The inactive portions of the LLBGs, including past-practice burial grounds and trenches, are separately managed as part of the 200-SW-2 Source Operable Unit (OU).[4] Wastes were disposed into these landfills from the mid-1940s to 2004.

1.3.1 Federal and State Laws and Regulations

The regulatory context for waste disposal, including requirements for the protection of human health and the environment, is regulated by multiple agencies, DOE, Ecology, and EPA (commonly referred to as the Tri-Parties). The primary laws and regulations which govern cleanup and closure processes include the following:

- *National Environmental Policy Act of 1969* (NEPA)
- *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al., 1989)
- RCRA/Hazardous Waste Management Act (HWMA) (RCW 70.105, "Hazardous Waste Management")
- *Atomic Energy Act of 1954* (AEA)
- *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA)

In concert, these laws and regulations provide the overarching guidelines for the disposal and closure processes. NEPA provides the decision-making structure for Federal agencies. The Tri-Party Agreement describes closure activities, which are driven by the requirements of both the AEA and RCRA/HWMA. The AEA regulates the radioactive portion of mixed waste, and RCRA/HWMA, as implemented through WAC 173-303, regulates the nonradioactive dangerous portion of mixed waste. Note that the various laws and regulations for closure create redundant and possibly conflicting administrative requirements. The Tri-Party Agreement, in part, was established to address these issues. The Tri-Party Agreement also identifies analyses that will be approved by Ecology and by DOE pursuant to their authorities under RCRA and the AEA, respectively, in order to ensure that the actions taken for waste disposal are protective of human health for all contaminants of concern, both radiological and nonradiological.

[4] DOE has concluded that the inactive portions of the 200 East and 200 West Area LLBGs will continue to be maintained based on the existing PAs, awaiting CERCLA decisions about remediation efforts for past-practice burial grounds and trenches including the disposition of transuranic wastes that will be addressed as part of the 200-SW-2 disposition process.

1.3.1.1 National Environmental Policy Act of 1969

In December 2012, DOE published a NEPA environmental impact statement for the closure of Hanford Site tanks. The TC & WM EIS (DOE/EIS-0391) in part analyzes wastes planned for continued disposal in the active trenches of the LLBGs prior to the operation of the Integrated Disposal Facility (IDF). Chapter 2 of the TC & WM EIS states the following:

> Under Waste Management Alternatives 2 and 3, trenches 31 and 34 would continue to receive LLW and MLLW from onsite non-CERCLA generators through 2050. Currently, the remaining space in the two trenches totals approximately 17,215 cubic meters (22,520 cubic yards). At the projected emplacement rate, the trenches would be filled to capacity by no later than 2050.

The DOE issued the TC & WM EIS ROD in December 2013 (78 FR 75913). The ROD states the following:

> In Waste Management Alternative 2, disposal of LLW and MLLW in LLBGs Trenches 31 and 34 would continue until they are filled. DOE has decided to implement Waste Management Alternative 2.

1.3.1.2 Hanford Federal Facility Agreement and Consent Order

The Tri-Party Agreement (Ecology et al., 1989) is an agreement between the Tri-Parties concerning the cleanup of the Hanford Site.

The Tri-Party Agreement, signed by the Tri-Parties on May 15, 1989, is an enforceable agreement that requires DOE to clean up and dispose of radioactive and hazardous waste at the Hanford Site, and close facilities that have been used to treat, store, or dispose of such waste. The Tri-Party Agreement recognizes the applicability of RCRA (and its amendments) to the Hanford Site. It incorporates a regulatory strategy that specifically places waste disposal activities, including facility closure, under the HWMA. The Tri-Party Agreement contains legally-enforceable milestones, many of which cover CERCLA, RCRA corrective actions, and RCRA treatment, storage, and disposal (TSD) closure activities.

1.3.1.3 Resource Conservation and Recovery Act of 1976/Hazardous Waste Management Act

Trenches 31 and 34 in 200 West Area and Trench 94 in 200 East Area operate under interim status standards specified in applicable sections of WAC 173-303. These trenches receive low-level and mixed waste (i.e., low-level radioactive waste with a dangerous waste component regulated by WAC 173-303) and are regulated under RCRA. Acceptance of MLLW at the active trenches of the LLBGs must be in accordance with conditions in the RCRA Permit for the facility (WA7890008967). The decision under the ROD for the TC & M EIS is that the active trenches of the LLBGs will be landfill closed under the *Washington Administrative Code* regulations. Following the ROD, and in accordance with WAC 173-303-610, "Closure and Post-Closure," DOE will close the active trenches and perform closure and postclosure care in accordance with applicable landfill closure and postclosure requirements set forth in WAC 173-303-610 and WAC 173-303-665(6). Although WA7890008967 includes Trenches 31 and 34 in 218-W-5 and Trench 94 in 218-E-12B, DOE/RL-2004-60, *200-SW-2 Radioactive Waste Landfills Group Operable Unit RCRA FI/CMS/RI/FS Work Plan* considers those trenches out of scope concerning the development of a proposed plan/proposed corrective action decision (PCAD) that describes the preferred remedy for each waste site in the 200-SW-2 Source OU.

1.3.1.4 Atomic Energy Act of 1954

Under its authority of the AEA, DOE regulates the closure of its facilities containing radioactive materials. The primary mechanism for this regulation is DOE O 435.1 and the associated documents (particularly DOE M 435.1-1, *Radioactive Waste Management Manual*). Information regarding treatment, management, and disposal of the radioactive source, byproduct material, special nuclear material (as defined by the AEA) and/or the radionuclide component of mixed waste that has been incorporated into the Hanford sitewide RCRA permit (WA7890008967) is provided for informational purposes only. This information is not incorporated for the purpose of regulating the radiation hazards of such components under the authority of the permit or HWMA (RCW 70.105).

1.3.1.5 Comprehensive Environmental Response, Compensation, and Liability Act of 1980

There are no wastes generated by the remediation of Hanford CERCLA waste sites that are planned for disposal in the active trenches of the LLBGs. Instead, the bulk of such wastes are disposed at the Environmental Restoration Disposal Facility (ERDF). As noted in Section 1.6.1.5 of the PA document (DOE/RL-2021-26, *Performance Assessment of Active Trenches in 200 East and West Low-Level Burial Grounds at the Hanford Site*), DOE/RL-2004-60 considers Trenches 31, 34, and 94 out of scope concerning the development of a proposed plan/PCAD for the 200-SW-2 Source OU.

This page intentionally left blank.

2 Key Assumptions

The projected performance of the natural and engineered features of the active trenches of the LLBGs is dependent on the representativeness of the conceptual models, numerical models, and parameter values used to evaluate the release and subsequent transport of radionuclides from the waste forms and trenches. It is therefore important to identify the key assumptions associated with model and parameter uncertainties and associated data gaps. Those aspects of the system typically become the focus of the sensitivity/uncertainty analysis and future PA maintenance or facility operational controls. Although dose during the 1,000-year compliance period is principally affected by the atmospheric release pathway, the dose resulting from that pathway is very low, as noted in Chapter 8 of the PA document (DOE/RL-2021-26). Dose resulting from the groundwater exposure pathway occurs outside the 1,000-year compliance period (Chapter 8 of DOE/RL-2021-26). Therefore, the summary of key assumptions addresses those assumptions associated with both exposure pathways.

The discussion below is primarily focused on the PA maintenance for the active Trenches 31 and 34. The naval reactor compartments disposed in Trench 94 are comprised of corrosion-resistant carbon steel and highly corrosion-resistant stainless steel. The corrosion-resistant carbon steel is also used for the associated bulkheads, as well as for the reactor pressure vessel and tank structure. The robust engineering design, bounding analysis of the previous PA (WHC-SD-WM-TI-730, *Performance Assessment for the Disposal of Low-Level Waste in the 200 East Area Burial Grounds*), and the information used were reviewed and considered valid (Appendix A of DOE/RL-2021-26), thus warranting no contaminant transport analysis for Trench 94.

2.1.1 Land Use and Institutional Control

For nearer term land-use planning, the ROD (64 FR 61615) for DOE/EIS-0222-F, *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*, identifies near-term land uses for the Hanford Site. The ROD prescribes the use in the 200 Areas as exclusively industrial (primarily waste management) with much of the surrounding land having the use of preservation or conservation. Despite the Industrial Exclusive designation of the Central Plateau, including the area encompassed by the LLBGs, the assumption under issued DOE-0431, *Recommendations for Institutional Control Time Period for Conducting DOE Order 435.1 Performance Assessments at the Hanford Site*, is that control of the site and institutional records (e.g., deed restrictions) associated with its designation as Industrial Exclusive are not implemented until 243 years after assumed facility closure (calendar year 2278). These assumptions do not represent an administrative intention by DOE to release the site from its Industrial Exclusive designation but are only assumptions made as a basis for PA evaluations conducted under DOE O 435.1. For more details on future land use, see Section 2.1 of the PA document (DOE/RL-2021-26).

2.1.2 Active Trenches at Closure

The key assumptions associated with the active trenches at closure affect the both the air and groundwater pathways. The following assumptions involve the physical conditions and circumstances of the trenches, and the contaminant inventory within the trenches at closure.

- Trenches 31 and 34 are assumed to be filled to their design capacity and facility closure is assumed to occur in year 2035 for the purpose of analysis. The forecasted waste inventory at closure is estimated from the Solid Waste Information and Tracking System (SWITS). The forecast inventory involves the current waste inventory, as determined from SWITS, and assumes that the waste concentrations and container categorization disposed in the active trenches over the past 10 years, as documented in SWITS, is representative of the wastes that will be disposed in the future.

- A modified RCRA-compliant surface barrier is assumed to be constructed at closure. The design will, at a minimum, comply with applicable RCRA requirements found at 40 CFR 264, “Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities,” Subpart N, “Landfills.” The surface barrier will be designed to retain moisture and encourage evapotranspiration (ET). The upper surface of the soil cover will be composed of an admixture of silt and gravels to enhance resistance of the cover to burrowing animals and long-term wind erosion.

  The barrier is assumed to provide containment and long-term hydrologic protection for a period of at least 500 years, during which time it limits net infiltration to less than 0.5 mm/yr, and after which the recharge through the barrier becomes similar to that through the undisturbed soil. The vegetation in the surrounding area is assumed to remain shrub-steppe after closure and exert the same control on recharge as a vegetated natural soil surface.

  The surface barrier will be designed so that top of the waste is at least 5 m (16.4 ft) below the top of the surface barrier. The large thickness allows the possibility for biotic intrusion into the waste from the surface to be excluded. The design and thickness of the surface barrier minimizes the potential for biointrusion into the waste, and limits the release of gaseous radionuclides, including radon, from the trenches.

  The compaction of waste in the active trenches must be sufficient to ensure that any long-term differential settlement under the load of surface barrier is within the design criteria of the surface barrier. The waste disposed in the active trenches will be compacted to minimize settlement to meet the compaction acceptance criteria for the active trenches.

- The double-leachate liners and collection and removal system are assumed to be extant during the entire operational period and for the first 100 years postclosure, but then fail completely after 100 years. After the system fails, the inventory is assumed to become immediately available for release and transport through the composite liner material by advection and diffusion processes.

- The postclosure exposure scenarios assume that no residents live on top of the active trenches, and a resident groundwater receptor will have to be at least 100 m (328 ft) downgradient from the facility.

- A combination of land-use restrictions, institutional controls, and active and passive barriers will be placed on and around the active trenches landfill and their adjacent buffer zone to deter inadvertent intrusion for at least 243 years after closure (DOE-0431).

2.1.3 CAT1 and CAT3 Waste Release

Source-release model is an important subsystem in the active trench performance assessment. The different conceptual models were developed for the different types of the waste categories. The key assumptions related to the Category 1 (CAT1) and CAT3 waste release include the following:

- No performance credit is taken in the PA for waste containers/encasements.

- The concrete and grout properties for stabilized waste are assumed to remain constant over the simulated duration.

- The primary contaminant transport process through grout/concrete will remain diffusion dominated, while advection will likely be either negligibly small or none.

- Backfill material surrounding the concrete structure will provide a preferential pathway for any water flow due to large contrast in relative permeability.

2.1.4 Air Exposure Pathway

The key assumptions associated with the air exposure pathway include the volatile radionuclide release and receptor location as follows:

- For purposes of calculating the release of gaseous radionuclides to the surface, it has been assumed that the containers are not air-tight, and release of gaseous radionuclides can occur immediately upon closure of the facility.
- All radon produced is conservatively assumed to be available for gaseous transport (an emanation factor of unity).
- The receptor is assumed to be located at the closest offsite distance in the direction of the prevailing wind (20 km [12.4 mi]) during the institutional control period, and 100 m (328 ft) from the edge of the LLBG excavation after the institutional control period.

2.1.5 Key Assumptions Related to the Groundwater Exposure Pathway

The key assumptions associated with the groundwater exposure pathway may be broadly classified as those that affect the following:

- The estimated inventory at closure (described in first bullet in Section 2.1.2)
- Radionuclide release from the engineered waste forms and from the engineered facility (Section 2.1.3)
- Net infiltration through the engineered cover and surrounding environments
- Radionuclide transport through the vadose zone
- Radionuclide transport in the saturated zone
- Dose calculations involve 95% media intake rates:
  - Based on reasonable activities of the portion of the exposed population likely to receive the highest dose (i.e., the critical group)
  - Based on scenarios that represent reasonable actions of a typical group of individuals performing activities that are consistent with regional social customs, work, and housing practices
  - The exposed individual is assumed to use the water to drink, shower, irrigate crops, and water livestock

The mapping of key assumptions for design and operations of Trenches 31 and 34 is presented in Table 2-1. A similar mapping for Trench 94 is presented in Table 2-2. In addition to the key assumptions potentially affecting the PA, there are additional assumptions related to the conceptual models as well as the data and parameter values developed in support of the PA. These additional conceptual model assumptions and related uncertainties were presented in Section 6.1 of DOE/RL-2021-26 for Trenches 31 and 34. Table 2-3 and Table 2-4 present the summary description of conceptual model assumptions and conceptual model uncertainty, respectively, for the active Trenches 31 and 34. Similar summary description of conceptual model assumptions and uncertainty are not required for Trench 94 because no contaminant transport analysis is conducted for it in the PA.

This page intentionally left blank.

Table 2-1. Key Design and Operations Assumptions Related to Engineered System and Waste Form Performance and Potential Performance Assessment Maintenance Approaches for the Active Trenches 31 and 34

Design Feature	Design Assumption	Operations Assumption	Impact of Assumption	Potential PA Maintenance Approach
Waste types, volumes, allocation, and inventory	Waste acceptance criteria (HNF-EP-0063, Rev. 21) and SWITS (HNF-58315) constitute the basis. The database is presented in the inventory data package (ECF-HANFORD-19-0069).	Waste acceptance criteria (ECF-HANFORD-19-0069) and SWITS (HNF-58315) are the basis for estimation of the waste volumes and inventory expected at closure of the facility, the allocation between the different waste form types (CAT1 versus CAT3), and different sizes of waste containers for CAT3 waste (Section 2.3 in DOE/RL-2021-26).	Source term release rates used in the PA for different waste types	Continued use of waste acceptance criteria (HNF-EP-0063) and SWITS (HNF-58315) as the basis for estimation of the waste volumes and inventory expected at closure.
Period of operational and institutional control	A 100-year period of institutional control is assumed during which time the performance of the liner may be evaluated.	During the institutional control period, the performance of the modified RCRA Subtitle C surface barrier (closure cap) will be maintained.	The period of operational and institutional control does not directly affect the PA other than defining the time when and where the receptor may be assumed to be present.	Review Hanford operations and control documents that are expected to specify the operations and institutional control period.
Modified RCRA Subtitle C surface barrier	Design specified in preliminary closure plan and CP-ENG-0020.	Specified nominal values of hydraulic properties can be achieved during operations.	The engineered barrier material properties and the moisture storage-and-release attribute allow evapotranspiration and capillary processes to limit infiltration to about 0.5 mm/yr for the first 500 years and about 3.5 mm/yr afterwards	Modified RCRA Subtitle C surface barriers are expected to be used for other Hanford closure operations, including ERDF. Review as-constructed information from these other closed facilities.
Backfill	Backfill is used between waste lifts and above last lift to comply with design requirement for the operation of operational equipment and to provide redistribution of load of individual waste container. Backfill is used between adjacent waste containers to avoid soil arching that may create voids between adjacent containers	Emplacement of backfill meets performance specifications for even compaction at optimum moisture content allowing free drainage of water and maintaining layer stability. Backfill is comprised of natural materials. Backfill fully fills the void space between adjacent containers and allows for free drainage of water between waste containers.	Hydraulic properties allow drainage of water which infiltrates the RCRA surface barrier. Chemical properties do not impact the fate and transport of radionuclides. Moisture can potentially freely drain between the waste containers and does not focus flow or create moisture buildup.	Develop and implement methods to test trench backfill hydraulic properties during operations period.
Uranium billet monolith	The decontaminated uranium billet waste is boxed (HNF-MR-0533). The billets have been disposed in Trench 34. A single, one-time disposal only in Trench 34	The U billet waste is encapsulated in grouted encasements and disposed in Trench 34. The U billet monolith is a series of 16 encasement forms (i.e., HNF-MR-0533). Within the encasement form, three distinct sections are constructed: a concrete floor, the U billet waste packages encased in grout and the concrete roof. Compacted soil surrounds the monolith in order to stabilize waste packages between lifts within the trench. No additional U billet disposal considered and evaluated in the PA.	The U billet disposition is a one-time disposal for Trench 94 and does not impact the PA.	None. No additional U billet disposal is planned or anticipated.
Container	Containers used for the disposal of wastes in the active trenches are steel boxes or drums. CAT1 and CAT3 waste containers/encasements may be either boxes or drums.	Containers are handled during curing, cooling, transportation, storage, and disposal in such a way as to not induce degradation or cracking of the waste form other than the cooling cracks (if any) that are expected for the grouted CAT3 waste.	No performance credit is taken in the PA for waste containers/encasements.	None for Trenches 31 and 34.

Table 2-1. Key Design and Operations Assumptions Related to Engineered System and Waste Form Performance and Potential Performance Assessment Maintenance Approaches for the Active Trenches 31 and 34

Design Feature	Design Assumption	Operations Assumption	Impact of Assumption	Potential PA Maintenance Approach
CAT3 cementitious waste form	Unlike the CAT1 wastes, CAT3 wastes disposed in the active trenches are stabilized by grout either in encasements or in HICs. Cementitious grouts are used as the stabilization agent and to fill void spaces. The fill material between waste containers and encasements is assumed to be backfill soil.	Grouted monoliths are formulated, poured, and cured following established procedures.	Laboratory-derived properties are applicable in the PA calculations. The concrete and grout properties are assumed to remain constant for PA calculations. While some physical and chemical degradation of concrete and grout material can occur over time due to natural processes, limited physical damage to the grout and concrete is expected to occur since the containers and monoliths will be covered by backfill material and a surface barrier, leading to significant lithostatic (overburden) pressure. Degradation due to freezing and thawing is not likely to be significant due to emplacement of the containers below the freeze zone. Advection via any cracked concrete or grout will likely be either negligibly small or none and have no impact on PA results or conclusions (Section 3.3.3 of DOE/RL-2021-26).	Continue laboratory work on diffusion and sorption properties for cementitious grout. Develop long-term surrogates for diffusional and sorption properties based on short-term laboratory testing.
Container for CAT3 waste	An analysis of the SWITS database for the LLBG active trenches identified several container groups including encasements (ECF-HANFORD-19-0069). For each container group, a single representative container and inventory is modeled for release rate calculation. The result is then upscaled to the total volume and inventory of the container group.	Containers in each group are assumed to be the same as the representative container in terms of dimension and configuration (rectangular or cylindrical). The container/encasement group data are given in Table 2-5 of this document. The concrete layer is assumed to be 5 cm (2 in.) thick for containers (minimum) and 15 cm (6 in.) thick for encasements (the minimum thickness between two lifts within the encasement)	The inventory fractions (defined as the ratio of inventory for the given group to total CAT3 inventory for the trench) for each container/encasement group are listed in Table 2-8 of DOE/RL-2021-26. Laboratory-derived properties are applicable to as formulated and as cured conditions.	No impact.
Facility liner	Facility liner is comprised of two drainage gravel layers each above a geomembrane and low permeability admix layers.	Operations do not impact the as-emplaced properties of the liner materials. As-emplaced properties of liner materials, especially the admix layers are equivalent to the as-designed properties.	During operations and the assumed period of institutional controls, the geomembrane layer of the liner collects all precipitation that infiltrates through the operational layers and backfill. Once the geomembrane layer degrades, the drainage layer, acting as a capillary barrier, may cause infiltrating moisture to diffuse laterally and avoid moisture buildup because of low recharge and the relatively dry moisture regime in a semiarid setting (Appendix C in DOE/RL-2021-26).	Evaluate potential liner failure mechanisms.
Sumps	Sumps are designed to allow withdrawal of all infiltrating water that may collect during operational and institutional control periods (LCRS and LDS), as well as potential leakage through the primary liner (SLDS).	Sumps collect and allow removal of all water that infiltrates through backfill during operations.	No releases to vadose zone occur.	Continue monitoring sump performance as required in permit condition.

Source: Modified after information and data presented in Chapters 2 and 3 in DOE/RL-2021-26, *Performance Assessment of Active Trenches in 200 East and West Low-Level Burial Grounds at the Hanford Site*.

Note: Complete reference citations are provided in Chapter 8 of this document.

CAT1 = Category 1
CAT3 = Category 3
ERDF = Environmental Restoration Disposal Facility
HIC = high-integrity container
LCRS = leachate collection and recovery system
LDS = leak detection system
PA = performance assessment
RCRA = *Resource Conservation and Recovery Act of 1976*
SLDS = secondary leak detection system
SWITS = Solid Waste Information and Tracking System

Table 2-2. Key Design and Operations Assumptions Related to the Disposal of Naval Reactor Plants in Trench 94 and Potential Performance Assessment Maintenance Approach

Design Feature	Design Assumption	Operations Assumption	Impact of Assumption	Potential PA Maintenance Approach
Modified RCRA Subtitle C surface barrier	Design specified in preliminary closure plan and CP-ENG-0020.	Operations can achieve specified nominal values of hydraulic properties.	Hydraulic properties and geometry allow evapotranspiration and capillary processes to limit infiltration to less than 0.5 mm/yr for the first 500 years and 3.5 mm/yr afterwards	Modified RCRA Subtitle C Surface barriers are expected to be used for other Hanford closure operations, including ERDF. Review as-constructed information from these other closed facilities.
Reactor compartment disposal package – nuclear reactor plant	Nuclear reactor plant and ship support system are comprised of HY-80.	Nuclear reactor plant and ship support system are comprised of HY-80.	Corrosion of HY-80 is slow. Bounding analyses and data presented in USN/EIS-0259 indicate a delay of between 600 and 2,000 years before penetration of the reactor plant allows access to the reactor vessel.	Continue monitoring U.S. Navy, national, and international research on corrosion behavior
Reactor compartment disposal package – reactor vessel	Nuclear reactor vessel and tank structure are comprised of HY-80.	Nuclear reactor vessel and tank structure are comprised of HY-80.	Corrosion of HY-80 is slow. Bounding analyses and data presented in USN/EIS-0259 indicate a delay of between 10,000 and 30,000 years before penetration of the reactor vessel allows access to the reactor vessel internal structure.	Continue monitoring U.S. Navy, national, and international research on corrosion behavior
Reactor compartment disposal package – reactor vessel internal structure	Nuclear reactor vessel internal structure is comprised of highly corrosion-resistant nickel-iron-chromium alloy (ICONEL® alloy 600).	Nuclear reactor vessel internal structure is comprised of highly corrosion-resistant nickel-iron-chromium alloy (ICONEL alloy 600).	Corrosion of ICONEL alloy 600 is very slow, with maximum values of 0.02 mg/dm^2yr. Bounding analyses and data presented in USN/EIS-0259 indicate complete corrosion would take more than 10,000,000 years (equivalent to a fractional release rate of less than 1.0E-07 yr^{-1}).	Continue monitoring U.S. Navy, national, and international research on corrosion behavior

Source: Appendix A in DOE/RL-2021-26, *Performance Assessment of Active Trenches in 200 East and West Low-Level Burial Grounds at the Hanford Site*.

References:

CP-ENG-0020, *Functional Requirements Document and Conceptual Design for Trench 31 and 34, Modified RCRA Subtitle C, Cap Cover*.

USN/EIS-0259, *Final Environmental Impact Statement on the Disposal of Decommissioned, Defueled Cruiser, Ohio Class, and Los Angeles Class Naval Reactor Plants*.

® ICONEL is a trademark of the Special Metals Corporation Group of companies, Hartford, New York.

ERDF = Environmental Restoration Disposal Facility

HY-80 = corrosion-resistant carbon steel

RCRA = *Resource Conservation and Recovery Act of 1976*

Table 2-3. Key Conceptual Model and Parameter Assumptions Related to the Natural System Performance and Potential and Potential Performance Assessment Maintenance Approaches for the Active Trenches 31 and 34

Natural System Feature	Conceptual Model Assumption	Parameter Assumption or Basis	Impact of Assumption or Basis	Potential PA Maintenance Approach
Climate/meteorology	Semi-arid conditions	Precipitation, wind, ET conditions for the active trenches are based on analogous conditions elsewhere in the Central Plateau.	Observed present-day conditions are applicable for the next 1,000 years and longer.	Review Hanford sitewide monitoring of meteorologic and atmospheric conditions.
Climate change	Anticipated changes in long-term precipitation rates and patterns are not substantially different from present-day rates and pattern	A 75,000 plus year pollen record from Carp Lake located near Goldendale, Washington (about 160 km [100 mi] southwest of the Hanford Site) provides evidence that the mean annual precipitation in the Columbia River Basin ranged between 0.5 times of modern level and 1.28 times of modern level.	Meteoric recharge estimate used in PA for the next 1,000 years and longer is appropriate.	None.
Vegetation impact	The vegetation in the LLBGs and surrounding areas is assumed to remain shrub steppe indefinitely and exert the same control on recharge that it has in the past.	For most of the pollen record (almost 65,000 years out of the 75,000 years), the climate in the Columbia Basin was drier than the present-day Hanford Site climate.	Local climate changes do not appear to be substantial enough to change the dominant shrub steppe vegetation or its characteristic ability to control meteoric recharge.	None
Natural net infiltration	Long-term average net infiltration for the natural and system in and around the active trenches are equivalent to present-day conditions.	Steady-state ambient and long-term infiltration rate is conservatively assumed to be 3.5 mm/yr, about twice the value indicated in PNNL-16688 for Rupert sand.	Net infiltration rate directly controls the time for contaminants released from the active trenches to be transported to the water table.	Estimate meteoric recharge via chloride mass balance and field measurement of matric potential and moisture content to determine in situ ambient net infiltration in Rupert sand with native vegetation. Such an investigation is part of sitewide initiative involving multiple end-users including PA, CA, CIE, 200-DV-1 Source OU, and other modeling assessments.
Episodic precipitation events	Average meteoric recharge rate in PA simulations	Any potential unfavorable impacts from above average, short term infiltration events are not sustained over an extended depth within the thick, heterogeneous vadose zone that is characteristic of the active trench sites.	Temporal variation in precipitation can effectively be ignored and an average value can be used with little loss of accuracy in PA simulations.	None.
Hydrostratigraphy	The HSU at the trench sites have variable flow and transport characteristics, which can affect the flow of moisture and transport of radionuclides.	The vadose and saturated zone hydrostratigraphy is based on observations from boreholes drilled to the water table in the vicinity of the active trenches in the 200 West Area. These observations have allowed for the development of a hydrostratigraphic framework model of both the vadose zone near the active trenches and the saturated zone beneath and downgradient of the active trenches.	The vertical and lateral distribution of HSUs at the active trenches affect the flow of moisture and radionuclides released from the active trench waste types.	Review detailed hydrostratigraphy in boreholes drilled in the future near the active Trenches 31 and 34.
Vadose zone – moisture regime	Recharge and infiltration of meteoric water are some of the key FEPs. Recharge estimates for the active trenches can vary spatially and temporally depending on surface condition.	Field measurements of moisture regime in the vicinity of the active trenches.	Vadose zone sediments below active trenches, albeit draining, are under a low moisture regime comprised mostly of the tightly bound moisture adsorbed to solid particles.	Measure moisture regime (moisture content as well as matric potential) in boreholes drilled in future near the active Trenches 31 and 34.

Table 2-3. Key Conceptual Model and Parameter Assumptions Related to the Natural System Performance and Potential and Potential Performance Assessment Maintenance Approaches for the Active Trenches 31 and 34

Natural System Feature	Conceptual Model Assumption	Parameter Assumption or Basis	Impact of Assumption or Basis	Potential PA Maintenance Approach
Vadose zone – moisture regime	Equilibration of meteoric recharge with sediment moisture profiles	Matric potentials below the shallow fluctuation zone or active root zone contribute little to the total hydraulic gradient; the steady state profiles thus approach unit gradient conditions.	In the absence of anthropogenic recharge, moisture contents correlate with sediment texture (i.e., fine textured sediments in CCUz, CCUc, and Rtf units have a higher moisture content (θ) and coarse textured sediments in HfA, HfB, HfC, HfD, and Rwie units have a lower θ). Also, in the absence of anthropogenic recharge, the field measured θs are in equilibrium with natural recharge at the active trench sites.	None.
Vadose zone – HSUs	Each heterogeneous vadose zone HSU is treated as an EHM.	Each HSU is assumed to have representative but uniform values in terms of vadose zone hydraulic properties. Each HSU, however, is treated as an anisotropic EHM having a variable moisture dependent anisotropy. Observations at the 200 East Area Sisson and Lu field injection site (Zhang and Khaleel, 2010) are analogous to those under the active trenches.	An evaluation of the Sisson and Lu field injection site moisture data demonstrate similar behavior relative to first moment (center of mass) and second moment (spread around the center of mass) of the simulated and observed moisture plumes.	Develop a Sisson and Lu type field injection site in 200 West Area, obtain data on hydraulic properties, and field measurements of moisture regime (moisture content as well as matric potential). Such an investigation is part of sitewide initiative involving multiple end-users including PA, CA, CIE, 200-DV-1 Source OU, and other modeling assessments.
Vadose zone – colloid and colloid facilitated transport	For radioactive waste disposal sites, the formation of colloids (particles whose sizes range from one nanometer to one micrometer) and the occurrence of colloid facilitated contaminant transport has often been identified as potentially an important process.	Research conducted at other radioactive sites in the Central Plateau (i.e., ERDF) is applicable to analogous low moisture regime observed at the active trench sites.	Due to the low moisture regime under unsaturated conditions in semiarid regions, and significant filtration at the air water/solid interfaces, conditions are generally not conducive to colloid formation or colloid facilitated transport.	None.
Vadose zone –Hf clastic dike	Clastic dikes have not been observed at the active trench sites, but their presence cannot be ignored since these semi vertical structures have been observed in the Hanford formation elsewhere in the Central Plateau.	Clastic dikes, if present under active trenches, are infilled with fine-textured sediments, and have hydraulic properties that are analogous to those observed elsewhere in the Central Plateau.	Under unsaturated flow in a low moisture regime, because of higher moisture holding capacity of the infilled fine sediments, the dikes may in fact represent barrier to flow rather than act as fast flow channels. Thus, clastic dike sediments, representing fine sediment properties (e.g., fine sand, silt, and clay), often are regions of higher moisture content, but not necessarily of fast transport, under conditions of unsaturated flow and low fluxes characteristic of semiarid regions.	None.

Table 2-3. Key Conceptual Model and Parameter Assumptions Related to the Natural System Performance and Potential and Potential Performance Assessment Maintenance Approaches for the Active Trenches 31 and 34

Natural System Feature	Conceptual Model Assumption	Parameter Assumption or Basis	Impact of Assumption or Basis	Potential PA Maintenance Approach
Saturated zone – Rwie	Extent and characteristics of Rwie are based on interpolating hydrostratigraphic information from boreholes near the active trenches.	Model calibrated values of hydraulic conductivity for the Rwie are derived from nearby slug and pumping test results and site-wide groundwater models.	The slug and pumping test data and sitewide groundwater models yield an average saturated hydraulic conductivity of 5 m/day for Rwie. Uncertainty in the sitewide models and the calibrated hydraulic conductivity has not been quantified. The hydraulic conductivity directly affects the dispersive dilution of species downgradient of the trenches.	Conduct hydraulic testing in boreholes located in and around the trench sites and drilled into the Rwie as part of 200-ZP-1 pump and treat investigations.

Source: Modified after information and data presented in Chapter 3 in DOE/RL-2021-26. *Performance Assessment of Active Trenches in 200 East and West Low-Level Burial Grounds at the Hanford Site*.

References:

PNNL-16688, *Recharge Data Package for Hanford Single-Shell Tank Waste Management Areas*.

Zhang and Khaleel, 2010, "Simulating Field-Scale Moisture Flow Using a Combined Power-Averaging and Tensorial Connectivity-Tortuosity Approach."

CA = composite analysis
CCUc = Cold Creek caliche unit
CCUz = Cold Creek silt unit
CIE = cumulative impact evaluation
EHM = equivalent homogeneous medium
ERDF = Environmental Restoration Disposal Facility
ET = evapotranspiration
FEP = feature, event, and process
Hf = Hanford formation
HfA = Hanford formation unit A
HfB = Hanford formation unit B
HfC = Hanford formation unit C
HfD = Hanford formation unit D
HSU = hydrostratigraphic unit
LLBG = low-level burial ground
OU = operable unit
PA = performance assessment
Rtf = Ringold Formation member of Taylor Flat
Rwie = Ringold Formation member of Wooded Island – unit E

Table 2-4. Summary of Conceptual Model Assumptions and Conceptual Model Uncertainty for the Active Trenches 31 and 34 Performance Assessment

Feature	Conceptual Model Assumption	Conceptual Model Uncertainty
Climate meteorology	Semi-arid conditions are assumed to persist throughout the 1,000-year performance period and the 10,000-year sensitivity and uncertainty analysis period.	N/A – Semi-arid conditions are expected to persist in the Pasco Basin and the Hanford Site
Modified RCRA Subtitle C surface barrier	• The modified RCRA Subtitle C surface barrier (closure cap) performs as designed for a minimum of 500 years after closure, after which it is assumed the flow rate into the active trenches equals the long-term net infiltration into the closure cap surface. • Closure occurs immediately upon emplacement of closure cap, which occurs immediately after last waste is emplaced in 2035. • Unsaturated zone flow processes limit net infiltration due to evapotranspiration from surface of the surface barrier and capillary processes due to properties of different cap layers. • Evapotranspiration is expected to be equivalent to shrub-steppe vegetation on Rupert Sand. • Lateral flow of moisture along capillary breaks of the closure cap increases recharge along cap margins. • Because background ambient infiltration rate is uncertain, net infiltration into cap and flow rate through cap is also uncertain. • The closure cap is expected to perform analogously to Hanford prototype barrier, which limited net average drainage of 0.005 mm/yr (i.e., two orders of magnitude smaller than the design goal of 0.5 mm/yr) for a 19-year nearly continuous monitoring period that included enhanced precipitation treatments (Appendix C in DOE/RL-2021-26).	• Long-term net infiltration through the closure cap is affected by vegetation type – fires and establishment of non-native vegetation (i.e., cheat grass) could increase net infiltration for some time. • Long-term net infiltration through the cap is affected by soil type – dune migration could alter net infiltration. • Recharge below the closure cap could be spatially variable; however, it is assumed to be uniform in space. • Surface depressions and other local topographic features could locally increase net infiltration; however, these features are not expected to increase the average recharge into the trenches. • Flow through the surface cap may be substantially reduced for a longer time than the assumed 500-year design life.
Container	• The emplaced unstabilized CAT1 waste containers are assumed to form a rectangular stack. The waste zone is assumed to have a height of 7 m (23 ft) (WHC-EP-0645). • The fill material between waste containers and encasements is assumed to be the backfill soil. • Containers are designed for handling and storage prior to disposal, but do not provide any impedance to water contacting the waste forms. • Containers are expected to degrade by general corrosion (mild steel) or localized corrosion (stainless steel). • Container corrosion products may be highly sorptive for some COPCs, but no credit is taken for this process in the PA. • An individual container's configuration and dimension play no discernible role in release modeling.	• Containers may provide significant delay in the time water contacts the waste form. • Containers may significantly reduce the surface area of waste exposed to water for diffusive release. • Degraded containers may result in sorption of some species.
Non-uranium billet cementitious waste form	• The non-uranium billet CAT3 wastes are stabilized by grouting either within the HICs with a prefabricated layer of minimum 5 cm (2 in.) thick concrete, or by encasement that grouts many containers in a monolith surrounded by additional layers of concrete. • Diffusion is the principal radionuclide release mechanism from CAT3 wastes. The release rate from the grouted waste form is dependent on the diffusive properties of the grout and concrete, including the effective diffusion coefficient and the thickness of the container and encapsulating concrete layers. • Release is dependent on sorption coefficient of a radionuclide in cementitious material that govern sorption process in both the grouted waste and concrete layer of the containers. • Degradation of cementitious waste forms does not significantly affect physical properties.	• Diffusive properties may vary as waste form degrades with time. • Retardation of species may vary as waste form degrades with time. • Variability in waste form properties may be expected over the duration of waste generation, treatment, and disposal.
Uranium billet cementitious waste form	• The uranium billet monolith is a series of 16 encasement forms following the configuration shown in Figure 3-8 of DOE/RL-2021-26. • Within the encasement form, three distinct sections are constructed: a concrete floor, the uranium billet waste packages encased in grout, and the concrete roof. Compacted soil surrounds the monolith in order to stabilize waste packages between lifts within the trench. • Uranium billet monolith model conceptualization for aqueous and gaseous release follows Figure 3-10 of DOE/RL-2021-26. • Three materials are represented in the uranium billet monolith source-release model: stabilization soil, grout, and encapsulated uranium billet. • Diffusion is the principal release mechanism for dissolved radionuclides in uranium billet CAT3 wastes. The moisture flow through the uranium billet monolith is governed by cementitious material properties (e.g., concrete or grout), with the uranium billet waste form behaving as an impermeable solid metal. Advective flow is considered from the side soil to the bottom. • Degradation of cementitious waste forms does not significantly affect physical properties.	• Uncertainty in the generation of U-238 and Tc-99 release rates by the coupled reactive transport model. • Uncertainty in uranium solubility since the uranium billet model uses the solubility determined by the coupled reactive transport processes.

Table 2-4. Summary of Conceptual Model Assumptions and Conceptual Model Uncertainty for the Active Trenches 31 and 34 Performance Assessment

Feature	Conceptual Model Assumption	Conceptual Model Uncertainty
Trench liner	• During operations and institutional controls (i.e., the first 100 years after closure), the geomembrane and geosynthetic clay layer and the active sumps function to eliminate moisture flow through the liner. • The assumed life of the geomembrane and geosynthetic clay layer is 100 years (i.e., 400 years less than the design life assumed for the surface barrier). • Flow through the degraded liner is independent of the physical properties of the admix layer and overlying gravel drain.	• It is assumed that the liner system remains extant for 100 years. In reality, it may last significantly longer than the assumed 100 years. • Contaminant transport through the liner delays releases to the vadose zone. • The liner materials may be heterogeneous, allowing spatially variable flow and transport through the liner after the assumed life of the liner.
Vadose zone	• Ambient recharge/net infiltration in the undisturbed areas away from the Trench 31 and 34 is controlled by soil type and vegetation (shrub-steppe) and is relatively low due to semiarid conditions. • Ambient net infiltration rates vary spatially due to different topography and different soil and vegetation; however, at depth, an average annual recharge rate is developed that averages the local variations. • Ambient net infiltration rates vary seasonally (winter is higher, summer is lower) and annually (due to annual variation in precipitation amounts and timing); however, at depth, an average annual recharge rate is developed that dampens the short-term transient events. • Recharge to the vadose along the margins of the modified RCRA Subtitle C surface barrier (closure cap) varies with time and space. • Recharge to the vadose zone through the liner system varies with time and space due to the degradation of the overlying closure cap and liner. • The predominant direction for moisture flow within the vadose zone is generally vertically downward. • The vadose zone consists of heterogeneous alluvial deposits; however, each HSU may be approximated by an EHM model. • The upscaling process for the large-scale macroscopic hydraulic properties utilizes the small-scale laboratory measurements to predict the large-scale flow behavior. • For each HSU, the PA-TCT model is a reasonable representation of moisture dependent anisotropy; the upscaled or effective properties for each HSU are derived from the van Genuchten-Mualem model-based laboratory-measured hydraulic properties. • The tests performed at the Sisson and Lu field injection site located in 200 East Area provide an analog of the expected low anisotropy in moisture flow in the 200 West Area active trench sites. • The use of an alternative heterogeneous media model for the vadose zone is expected to provide results that are comparable to those based on the EHM approximation; the first moment (center of mass) and second moment (spread around the center of mass) results for the EHM- and heterogeneous media model-based moisture plumes are expected to be similar. • Clastic dikes may exist within the vadose zone Hanford formation unit. Although the vertical extent of these dikes is not known at the active trench sites, if they extend through the H2 unit, they typically increase the transport time because the infilled material within the dikes is fine-grained and has a higher moisture content. • The base of the vadose zone (i.e., the top of the water table) has varied with time due to variations in anthropogenic recharge around the active trenches. • Some radionuclides are preferentially sorbed onto the minerals in the vadose zone alluvial materials.	• Ambient average annual net infiltration rates are uncertain. • Temporary or local variations in flow through the surface barrier and around the margins of the modified RCRA Subtitle C surface barrier (closure cap) are inconsequential to the flow and transport evaluation that extends up to and beyond 1,000 years after closure. • Fires and nonnative vegetation can result in a significant increase to net infiltration, which returns to ambient rates after native vegetation is restored. • Dune sands may slowly migrate over the active trench sites and possibly result in variable net infiltration; however, the rate of migration is very slow and not expected to affect net infiltration over the 10,000-year sensitivity analysis period. • Vadose zone hydraulic properties are uncertain, which results in uncertainty in the moisture regime and radionuclide transport time to the water table. • Vadose zone heterogeneities tend to disperse contaminants migrating through vadose zone and thus increase transport times to the water table. • Vadose zone sorption properties are variable and are also dependent on the geochemistry of the vadose zone pore water.

Table 2-4. Summary of Conceptual Model Assumptions and Conceptual Model Uncertainty for the Active Trenches 31 and 34 Performance Assessment

Feature	Conceptual Model Assumption	Conceptual Model Uncertainty
Saturated zone	• The amount of dilution in the aquifer is a key safety function with respect to protection of offsite members of the public. The saturated hydraulic conductivity times the hydraulic gradient yields the specific discharge (Darcy Flux) which controls the amount of dilution within the saturated media. This directly impacts the contaminant concentration beneath and downgradient of the trenches. • The groundwater beneath the active trenches currently resides in the Rwie and expected to reside in Rwie for the long-term PA simulations. • Low natural recharge occurs over the Central Plateau and the 200 West Area due to semiarid conditions of low precipitation and net infiltration. • High anthropogenic recharge from Central Plateau waste disposal operations over the last 60 years has significantly affected groundwater flow in the 200 West Area. • The hydraulic gradient direction and magnitude beneath the active trenches has changed with time due to anthropogenic discharges to the groundwater during the past operations of the Hanford Site. • The appropriate gradient to use for the PA is the long-term steady-state hydraulic gradient (i.e., the gradient to which the Central Plateau and 200 West Area returns following cessation of Hanford Site operations and remediation activities, and the subsequent recovery of the system); such a gradient is directed west to east. • The best estimate of a future steady-state flow regime and the corresponding hydraulic gradient that are relevant to the period of interest for the PA simulation are based on the post operations, post remediation water levels predicted by the CPGWM. • Groundwater flow in the aquifer is generally horizontal; there is very little vertical flow. • It is assumed that very little vertical mixing occurs within the aquifer, and that lateral transport predominates over any vertical mixing. • The well screen length used for compliance purposes is assumed to be 5 m.	• The magnitude of recharge from net infiltration, and anthropogenic sources is uncertain. • It is assumed that anthropogenic recharge will cease by the time of closure or by the end of the institutional control period, and the groundwater flow will return to a steady-state condition approximating the preoperation conditions (pre-1944). • The hydraulic conductivity of the Ringold unit E is variable and is best inferred from values based on CPGWM and Plateau-to-River model and confirmed by slug and pump tests near the trenches. • The range of hydraulic gradient estimates, from about 5.0E-04 to 1.0E-03 m/m, may reflect the uncertainty in the hydraulic gradient, and corresponding uncertainty in the Darcy flux, in the vicinity of the trenches. • The radionuclide species are assumed to be well mixed within the 5-m well screen.
Atmospheric pathway	• Some radionuclides (e.g., tritium, C-14, I-129) may be transported in the gaseous phase. • The partition coefficients are based on undissociated species of I_2(aq) and CO_2(aq). • Releases from the source term are assumed to be controlled by gaseous phase diffusion. • Gaseous components may be transported vertically upward to the surface by diffusion through the unsaturated pore space in the backfill and overlying cap materials. • Gaseous components that are released at the surface are transported laterally with the prevailing wind direction and flow rate.	• It is likely that gases will dissociate to species other than the aqueous species of the gas. Assuming the undissociated species per Henry's Law constants is conservative as it maximizes the concentration of I_2 in the gas phase. • Barometric pumping may result in an advective gas phase velocity that varies with atmospheric pressure changes and diurnally; however, the gas phase velocity is small in comparison to the diffusive flux. • Variable wind directions and speeds may disperse the atmospheric transport of released gaseous species. • Backfill soil moisture content and diffusion properties can affect release of gaseous species. • Waste loading can affect gaseous release rate.

Table 2-4. Summary of Conceptual Model Assumptions and Conceptual Model Uncertainty for the Active Trenches 31 and 34 Performance Assessment

Feature	Conceptual Model Assumption	Conceptual Model Uncertainty
Exposure and dose	• Based on reasonable activities of the portion of the exposed population likely to receive the highest dose (i.e., the critical group). • Based on scenarios that represent reasonable actions of a typical group of individuals performing activities that are consistent with regional social customs, work, and housing practices, and expected regional environmental conditions at the time of the exposure scenario, and who are members of the critical group expected to receive the highest doses. • The exposed individual is assumed to use the water to drink, shower, irrigate crops, and water livestock. • Exposure occurs through the following exposure routes: – Ingestion of water – Ingestion of fruits and vegetables – Ingestion of beef raised on the farm – Ingestion of milk from cows raised on fodder grown on the farm – Ingestion of eggs from poultry fed with fodder grown on the farm – Ingestion of poultry fed with fodder grown on the farm – Incidental ingestion of contaminated soil – Inhalation of contaminated soil particulates in the air – Inhalation of water vapor – External exposure to radiation	None

Source: Modified after information and data presented in Chapters 3 and 4 of DOE/RL-2021-26, *Performance Assessment of Active Trenches in 200 East and West Low-Level Burial Grounds at the Hanford Site*.

Reference:

WHC-EP-0645, *Performance Assessment for the Disposal of Low-Level Waste in the 200 West Area Burial Grounds*.

CAT1 = Category 1
CAT3 = Category 3
COPC = contaminant of potential concern
CPGWM = Central Plateau Groundwater Model
EHM = equivalent homogeneous medium
H2 = Hanford formation unit 2
HIC = high-integrity container
HSU = hydrostratigraphic unit
N/A = not applicable
PA = performance assessment
PA-TCT = power-averaging tensorial-connectivity-tortuosity
RCRA = *Resource Conservation and Recovery Act of 1976*.
Rwie = Ringold Formation member of Wooded Island – unit E

2.2 Uncertainty and Sensitivity Analyses Used to Prioritize Significance of Key Assumptions

As summarized in Table 2-1 and Table 2-3, there are many assumptions that have the potential to affect the predicted postclosure performance of the active Trenches 31 and 34. The impact of these assumptions, and the related uncertainties in conceptual models and parameters, on the predicted performance were evaluated using uncertainty and sensitivity analyses summarized in the PA document (DOE/RL-2021-26). Uncertainty analysis results developed using the probabilistic system model are summarized in Section 6.1 of DOE/RL-2021-26. Sensitivity analysis results using the integrated system model are summarized in Section 6.2 of DOE/RL-2021-26.

The key conceptual model and parameter assumptions and related uncertainties evaluated in uncertainty analyses (Section 6.1 of DOE/RL-2021-26) include the near-field environment, cementitious waste form release, and the natural system.

- **Near-field environment** (modified RCRA Subtitle C surface barrier and backfill) uncertainty analyses include the following two parameters (Section 6.1.3.1 of DOE/RL-2021-26):
  - Long-term average net infiltration rate
  - Moisture content of backfill
- **Cementitious waste form release** uncertainty analyses include the following parameters (Section 6.1.3.2 of DOE/RL-2021-26):
  - Waste form grout volume ratio
  - Cementitious waste form and barrier sorption coefficients
  - Cementitious waste form and barrier bulk diffusivity
  - Uranium solubility
  - Uranium billet technetium-99 initial inventory
- The **natural system** parameter uncertainty analyses include the following (Section 6.1.3.3 of DOE/RL-2021-26)
  - Vadose zone Darcy flux
  - Sorption coefficients
  - Gravel contents
  - Macrodispersivities
  - Saturated zone Darcy flux

Groundwater pathway multivariate analysis results identified the correlation and importance of the uncertain parameters with respect to peak doses. Based on peak doses within 10,000 years, the four top-ranked important parameters are as follows:

- Cementitious material intrinsic diffusivity
- Saturated zone Darcy flux
- Long-term net infiltration rate
- Saturated zone longitudinal macrodispersivity

The groundwater pathway peak doses occur after the 1,000-year compliance period. Multivariate analysis results identified the correlation and importance of the uncertain parameters with respect to peak dose times. Based on peak dose times occurring within 10,000 years, the four top-ranked important parameters are as follows.

- Long-term infiltration rate
- Technetium sorption (distribution coefficient [K_d]) in sand
- Technetium sorption (K_d) in silt
- Near-field soil (backfill, CAT1 waste zone, and soil cover for air pathway) moisture content

The top three of the preceding parameters are features, events, and processes (FEPs) associated with the vadose zone safety function. The last of the preceding parameters relate to the source-release safety function.

More than 10 sensitivity analysis cases were identified and analyzed by the process and system models. The peak doses for the base and sensitivity cases conducted by the system model are listed in Table 6-28 and Table 6-30 of DOE/RL-2021-26 for the groundwater and atmospheric pathways, respectively. The results of sensitivity cases conducted by the process model for the groundwater pathway are presented in Tables 6-31 through 6-33 of DOE/RL-2021-26. The results are summarized as follows:

- Among all sensitivity analysis cases calculated using the system model, the highest impact on the groundwater and atmospheric pathway peak doses is from the case with inventory increase (doubling of base case inventory), which doubles the base case peak dose. All other cases do not have significant impact on groundwater and air pathway peak doses and peak dose times.

- Increasing the CAT3 waste concrete layer thickness by a factor of two helps reduce peak doses and delay peak dose times.

- The CAT3 waste container concrete layer early failure increases peak dose but delays peak dose times.

- A thicker CAT3 waste container backfill lowers peak doses and delays peak dose times.

- During the compliance period when the only nonzero dose is contributed by air pathway, the early liner failure decreases the peak air-pathway dose due inventory loss to release to the vadose zone. An early liner failure increases the peak doses and advances peak dose times for groundwater pathway, which occurs during the postcompliance period.

2.3 Identification of Key Assumptions to Evaluate in Maintenance Program

As described above, the PA for Trenches 31 and 34 used the uncertainty and sensitivity analyses (Chapter 6 of DOE/RL-2021-26) to identify the key assumptions that were most significant to meeting the performance objectives. From a safety function perspective of waste disposal in the active trenches, Table 2-5 is a summary table recognizing the relative significance of safety functions of key engineered and natural system and features for Trenches 31 and 34. Similar information for Trench 94 is presented in Table 2-6.

Table 2-5. Relative Significance of Safety Functions of Key Engineered and Natural System and Features of the Active Trenches 31 and 34

System – Feature	Safety Function Type	Safety Function Description	Significance
Institutional Control – Natural Environment	Institutional control	By rule, it is assumed that control of the site will be retained for a minimum of 100 years after closure. DOE-0431, *Recommendations for Institutional Control Time Period for Conducting DOE Order 435.1 Performance Assessments at the Hanford Site* extends this to 2278, or 243 years after closure. A strong potential exists that the United States government will retain control of the site for an even longer extended period of time.	Not significant.
	Societal memory	Societal memory is represented by records, deed restrictions, and other passive controls that would warn someone that additional care should be taken in the area. For a member of the public to come onsite to experience exposures to contamination from Trenches 31 and 34, records that the Hanford Site existed would need to be forgotten or ignored.	Not significant.
	Exposure point	By rule, it is assumed a postclosure well is established 100 m downgradient at the point of highest exposure. It is highly unlikely that groundwater exposure will occur at this location, and potential wells in other locations or discharges to the Columbia River would produce much lower impacts to a member of the public.	Not significant. Exposure points further downgradient would significantly reduce concentration due to increased dispersion and dilution.
	Climate – meteorology	The natural environment in the area is characterized by semi-arid conditions with low annual precipitation and high potential evapotranspiration, which limits the availability of water to infiltrate below the root zone of the native vegetation.	Highly significant. Recharge to aquifer from the vadose zone is directly dependent on the semi-arid conditions that exist at the Hanford Site.
Engineered System – Cap and Backfill	Hydraulic – flow	The final design of the cover has not yet been established but is believed to be able to produce very low initial flow rates. Over some period, this function may deteriorate. The inclined cover functions to divert infiltrating water even after the asphalt layer has degraded.	Highly significant. The net infiltration rate into the surface barrier equals the recharge rate under Trenches 31 and 34. This recharge rate affects the release rate from cementitious waste forms and controls the transport time though the vadose zone to the water table.
	Mechanical stability	The backfill representing the operational layer between different lifts is compacted to maintain mechanical integrity and prevent uneven settling of the different lifts. In addition, the operational layer will prevent freeze/thaw activities that could affect container and backfill integrity (i.e., caving of backfill, uneven compaction of operations layer).	Not significant.
	Chemical	Water infiltrating through the backfill will chemically react with the minerals present. The backfill will buffer the composition of the water to neutral-mildly alkaline conditions.	Not significant.
	Transport – sorption	The minerals present in the backfill may sorb and delay transport of certain contaminants of potential concern released from waste packages.	Not significant.
	Transport – diffusion	Low saturation in the backfill may reduce diffusive fluxes from the waste forms into the backfill.	Moderately significant. Saturation in the backfill may increase or decrease diffusive release from cementitious waste forms.
Source Term – Container	Mechanical stability	The waste containers provide a durable outer shell to enable a safe and efficient emplacement. The containers are designed to be stable and structurally sound when emplaced and surrounded by backfill.	Not significant.
	Chemical	Carbon steel boxes or drums will corrode over time, leaving behind corrosion products of (primarily) iron oxides. These corrosion products are highly sorptive toward some dissolved species. The same corrosion process and production of iron oxides can lead to reducing conditions that would limit the solubility of several key radionuclides, particularly technetium.	Not significant.
	Hydraulic	Initially, the containers will isolate the waste form from the environment. The containers are expected to degrade by corrosion (either general corrosion, localized corrosion, or stress corrosion cracking). Degraded containers could continue to attenuate flow and transport of species released from the waste forms into the backfill.	Not significant.

Table 2-5. Relative Significance of Safety Functions of Key Engineered and Natural System and Features of the Active Trenches 31 and 34

System – Feature	Safety Function Type	Safety Function Description	Significance
Source Term – Cementitious Waste Form	Hydraulic – flow	The cementitious waste form has a low permeability to limit advective flow and transport of radionuclides out of the cementitious waste form	Not significant.
	Hydraulic – capillarity	The grout with high suction creates a capillary gradient for water flow from the surrounding backfill into the waste form, delaying the release of radionuclides from the waste form.	Not significant.
	Mechanical	The composition and curing of the grout are designed to maintain mechanical integrity of the waste form for the expected loading and overburden in the active trenches.	Not significant.
	Chemical	The composition of the grout can enhance reducing conditions in the grout, as well as hydraulic characteristics (i.e., paste versus mortar, cement/water ratio). The hydrochemical conditions of the waste form may create reducing conditions, for which certain radionuclides (i.e., Tc-99) show significant sorption capacity, while others (i.e., I-129) lose sorption capacity.	Highly significant. The sorption of radionuclides on the grout impacts the radionuclides' release rate from cementitious waste forms.
	Transport – diffusion	The cementitious grouts have low effective diffusion limiting the diffusive transport of radionuclides out of the waste form.	Highly significant. The effective diffusion coefficient affects the radionuclide release rate from cementitious waste forms.
	Hydraulic – flow transport	The liner system, consisting of a capillary barrier (gravel layer) overlying the geosynthetic clay liner and geomembranes, may focus flow through the liner and may delay release of radionuclides from the base to the top of the vadose zone.	Not significant. Because of the presence of the modified RCRA Subtitle C surface barrier and the consequent storage-and-release attribute of the evapotranspiration capillary barrier, the capillary pressure driven diffusive flow is expected to dominate the gravity driven flow, thus avoiding any possible moisture buildup in the vicinity of the engineered cover-liner system.
Natural Barrier – Vadose Zone	Hydraulic – flow	The rate of water flow through the vadose zone is slow due to both low net infiltration rate and hydraulic properties of Hanford sand and gravel units, leading to long transport times in the vadose zone.	Highly significant. The flow rate through the vadose zone and the hydraulic properties of the vadose zone materials directly determines whether radionuclides released from the trenches will reach the water table (and hence compliance boundary) within 1,000 years.
	Transport – sorption	Vadose zone materials sorb some of the constituents of potential concern, delaying their arrival at the water table. However, several key contaminants are not believed to sorb significantly.	Highly significant. Sorption can significantly delay the arrival of radionuclides at the water table.
	Transport – dispersion	Dispersion results in spreading contaminants in the vadose zone, and thereby decreasing concentrations.	Not significant.
Natural Barrier – Saturated Zone	Hydraulic – flow	Advective groundwater flow in the saturated zone leads to contaminant dilution.	Highly significant. The high groundwater flow rate in the saturated Hanford formation significantly dilutes radionuclides that reach the water table.
	Transport – dispersion	Spreading of the plume in the saturated zone, adds dilution to the contaminant plume and lowers radionuclides concentrations.	Not significant.
	Hydraulic – well dilution	Dilution is caused by mixing at a groundwater well extracting groundwater where it is usable and accessible by a member of the public. This safety function is omitted from the performance assessment to make it compatible with the groundwater protection requirements.	Not significant.

Source: Chapter 6 of DOE/RL-2021-26, *Performance Assessment of Active Trenches in 200 East and West Low-Level Burial Grounds at the Hanford Site*.

The degree of significance, Low, Moderate, and High, are qualitative judgments based on results of sensitivity analyses using detailed process models described in Chapter 6 of DOE/RL-2021-26 as well as uncertainty and sensitivity analyses using the integrated system model described in Sections 6.2 and 6.3, respectively of Chapter 6 of DOE/RL-2021-26.

RCRA = *Resource Conservation and Recovery Act of 1976*

Table 2-6. Safety Functions Related to the Disposal of Naval Reactor Plants in Trench 94

Barrier – Feature	Safety Function Type	Safety Function Description	Significance
Surface barrier	Hydraulic-flow	The final design cover has not yet been established but is believed to be able to produce very low initial flow rates. Over some period, this function may deteriorate. The inclined cover functions to divert infiltrating water even after the asphalt layer has degraded.	Significant
Reactor compartment package – Trench 94	Corrosion-hydraulic	Reactor compartment packages disposed in Trench 94 have exteriors made up of the nuclear reactor plant and ship support system that are comprised of a corrosion-resistant high-strength carbon steel and very high tensile strength nickel-alloyed (HY-80) steel. The outer wall (or bulkhead) of the reactor compartment package resists corrosion, thus delaying the initiation of corrosion of the reactor vessel.	Significant
	Corrosion-hydraulic	Reactor compartment packages disposed in Trench 94 have internals consisting of the reactor vessel and tank structure that are comprised of a corrosion-resistant high-strength carbon steel and very high tensile strength nickel-alloyed (HY-80) steel. The reactor vessel resists corrosion, thus delaying the initiation of corrosion of the reactor vessel internal structure and the release of radionuclides contained in the activated metal of the reactor vessel internal structure.	Significant
	Corrosion-transport	The radionuclides in the reactor compartment packages are contained in activated metal in the reactor vessel internal structure that is comprised of highly corrosion-resistant ICONEL® alloy 600. The corrosion of the reactor vessel internal structure is very slow, resulting in a very low radionuclide release rate from the activated metal of the reactor vessel internal structure and thus from the reactor compartment packages. In addition, the low corrosion rate of the nuclear reactor plant and the reactor vessel delay the initiation of radionuclides released from the reactor vessel internal structure.	Significant

Source: Appendix A of DOE/RL-2021-26, *Performance Assessment of Active Trenches in 200 East and West Low-Level Burial Grounds at the Hanford Site*.

HY-80 = corrosion-resistant carbon steel

®ICONEL is a trademark of the Special Metals Corporation Group of companies, Hartford, New York.

For Trenches 31 and 34, the significant assumptions include the following (Table 2-5):

- Climate/meteorology that control the long-term average net infiltration rate through the surface barrier and surrounding areas
- Infiltration and flow rate through the surface barrier, and surface barrier failure mechanisms and their timing

- CAT1 radionuclides' retention on substrate
- Diffusive properties of CAT3 grouted waste and container concrete barrier
- Failure mechanism and hydraulic properties of Trench 31 and 34 liner system
- Moisture flow rate and properties of the vadose zone materials
- Radionuclides' retention on vadose zone materials
- Groundwater flow rate through the saturated zone

The key conclusions of the PA for active trenches are relevant to determining the significance of the assumptions and related uncertainties to the results and conclusions. These conclusions and the associated assumptions that warrant being the focus of the PA maintenance activities are as follows:

- During the 1,000-year compliance period, the all-pathway dose performance objective is dominated by the air pathway releases and associated doses; however, the doses associated with this pathway are small (less than about 2E-03 mrem/yr for the first year after the cessation of institutional controls and decreasing after that).
- For the 1,000-year compliance period, there is a very low likelihood that CAT1 and CAT3 waste releases from the active trenches reach groundwater and affect the resulting dose for the groundwater pathway performance objective. This conclusion is the result of the long (greater than 1,000 years) transport time in the vadose zone. The most significant assumptions and related conceptual models and parameters that affect this conclusion are (1) the assumed design life of the modified RCRA Subtitle C surface barrier, (2) the assumed design life and efficacy of the liner system, (3) the long-term average net infiltration rate, (4) the moisture buildup in the vicinity of the engineered barrier cover-liner is negligible, and (5) the radionuclides retention properties of the vadose zone.
- For the post-1,000-year period, there is a very low likelihood of having a release from the active trenches that would exceed the 25-mrem/yr all pathway dose performance objective. The post-1,000-year dose is dominated by the groundwater pathway, and the estimated peak dose occurs about 2,000 to 7,000 years after closure (depending on different assumptions of source term release and fate and transport in the vadose zone). The most significant assumptions and related conceptual models and parameters that affect this conclusion are (1) the long-term average net infiltration rate, (2) the parameter values that control the diffusion and retention of radionuclides in grouted waste form and concrete barrier in the container, and (3) the groundwater flow rate in the saturated zone. The PA maintenance activities, primarily research and development activities summarized in Chapter 4 of this document, have been identified that address these assumptions.

2.4 Mapping Key Assumptions to Maintenance Activities

In general, the PA maintenance activities can be subdivided into two main categories: those maintenance activities that are evaluated using monitoring activities, as identified in the PA monitoring program and summarized in Chapter 3 of this document, and those maintenance activities that are evaluated using research and development (R&D) activities that are summarized in Chapter 4 of this document. The R&D activities fall into two groups: (1) those activities related to the review and evaluation of the evolution of scientific studies and CAT1, CAT3, and uranium billet release, and (2) those activities related to focused laboratory testing of waste form materials and site characteristics to reduce the uncertainty in parameter values used in the PA.

As noted in the PA monitoring plan (DOE/RL-2021-39, *Performance Assessment Monitoring Plan for the Active Low-Level Burial Ground Trenches 31 and 34*), performance-based monitoring relates to monitoring of waste constituents that may be present in the leachate, groundwater, or air near the active trenches. Because of the preponderance of other sources of air and groundwater contamination near the active trenches, it is very unlikely that any environmental monitoring would detect the presence of contamination that may emanate from releases from the active trenches. Therefore, traditional performance monitoring is of limited use for the active trenches.

This page intentionally left blank.

3 Monitoring

The approach to PA monitoring for Trenches 31, 34, and 94 makes use of the existing groundwater (RCRA), air, and subsidence monitoring programs. PA-related constituents of interest (uranium isotopes, technetium-99, tritium, and iodine-129) are co-sampled with the RCRA groundwater sampling schedule for the trenches. Existing programs for air sampling and analyses and subsidence monitoring appear adequate for PA monitoring at Trenches 31, 34, and 94. In addition to RCRA, results of groundwater monitoring from other programs (e.g., CERCLA, State Waste Discharge Permit) lend insight to Trenches 31, 34, and 94 performance monitoring and review. Dissemination and review of these results occurs annually (e.g., DOE/RL-2020-08, *Radionuclide Air Emissions Report for the Hanford Site, Calendar Year 2019*, and DOE/RL-2019-66, *Hanford Site Groundwater Monitoring Report for 2019*).

In solid LLW disposal facilities, release processes are likely to be slow, sporadic in time and space, or even nonexistent for long periods of time. The PA results indicate that any contaminants derived from the trenches are unlikely to appear in the aquifer for thousands of years. These predictions are fundamentally a result of site hydrogeologic and meteorological conditions. Some accelerated release may be occurring under the current operational conditions because the trenches are open at the surface, but this possibility is offset by the physical integrity of the disposed waste containers and double liner system. It is recognized in DOE M 435.1 that contemporary monitoring activities are likely to provide little indication of eventual contaminant release. Therefore, in order to satisfy the intent of the monitoring element for PA maintenance, a different approach to facility monitoring is necessary.

Effective monitoring must be done closer to or within the trenches, including the monitoring of infiltration through the waste volumes, and the monitoring of air samples collected around the facilities:

- Monitoring of leachate collected in the LCRS and leak detection system (LDS)
- Monitoring of leakage collected in the secondary leak detection system (SLDS)
- Air monitoring around the facility

Note that other monitoring that is expected to occur during operations at active Trenches 31 and 34 are not explicitly addressed in the PA monitoring plan. This includes monitoring of waste form loading, waste form characteristics, waste inventory, waste volumes, backfill properties, among others. The requirement to continue groundwater monitoring is noted as a permit condition in the permit for the active Trenches 31, 34 and 94 (WA7890008967).

Monitoring of the liquids that accumulate above the Trench 31 and 34 liner system due to infiltration of precipitation through the operational layer(s) is currently being conducted by Solid Waste Storage and Disposal personnel, who initiate and collect samples. The samples are surveyed by Radiological Control, and then prepared for transport to designated laboratories for the analysis required. This process ensures compliance with the Part III, Operating Unit 17 Unit Specific Conditions for Trenches 31 and 34, namely conditions III.17.P.2 “Leachate Collection Component Management” and III.17.P.3 “Rainwater Management and Instrumentation.”

The leachate collected from the LCRS and LDS should continue to be monitored during operations and then during the institutional control period. In addition to monitoring the leachate, the PA monitoring plan [DOE/RL-2021-39] includes the monitoring of any water or gross beta (as a possible indicator of technetium-99) that may leak through the LDS to the underlying SLDS during operations and the institutional control period.

This page intentionally left blank.

4 Research and Development

There are two broad classes of R&D activities that support the active trenches PA maintenance plan. First are those activities that relate to evaluating updated design and operations information and ongoing scientific studies to determine if the updated information is consistent with assumptions made in the PA or is reasonably bounded by the assumptions made in the PA. Second are those R&D activities that are specific to the facility and associated waste forms as modeled in the active trenches PA. The second group of R&D activities is focused on addressing specific assumptions and related uncertainties that are important to the active trenches PA results and conclusions. Except for R&D activity for Trench 94 (Section 4.4), all other R&D activities that are presented below relate to PA maintenance for the active Trenches 31 and 34.

The first group of R&D activities represent ongoing studies that are not explicitly required to support the active trenches PA. It represents information collected for other Hanford reclamation, closure and design purposes, as well related ongoing national and international R&D that may be relevant for PA models and parameters. The updated information needs to be compared to the information used as a basis for the active trenches PA. Examples of the types of studies that fall into this first group of R&D activities include:

- Evaluate the evolution of radionuclide inventory and volumes based on updates to SWITS database
- United States and international research, testing and modeling on cementitious waste forms
- Hanford and United States research, testing and modeling of surface barrier characteristics
- Hanford research, testing and modeling of vadose zone characteristics
- Hanford research, testing and modeling of saturated zone characteristics

The second group of R&D activities focuses on specific assumptions that can affect the active trenches PA results. The second group also addresses questions that have been raised by researchers studying the characteristics of the waste form planned for disposal in the active trenches. Examples of the types of studies that fall into this second group of R&D activities include:

- Evaluate transport characteristics (sorption and diffusion) of cementitious materials exposed to partially saturated conditions
- Evaluate ongoing research on transport characteristics of cementitious materials using accelerated tests to approximate the effects of aging and weathering
- Evaluate undisturbed present-day soil moisture and matric potential profiles for areas near the active trenches
- Evaluate measurements of natural infiltration

4.1 Summary of R&D Activities

This section summarizes the R&D activities that are appropriate to support Trenches 31, 34, and 94 PA maintenance to provide an overall perspective of the depth and breadth of the activities. The activities are arranged by the component models of the active trenches PA, as follows:

- Waste inventory and inventory allocation
- Near field hydrology
- Corrosion of reactor components in Trench 94

- Cementitious waste form radionuclide release
- Vadose zone and saturated zone flow and radionuclide transport

In the list below, activities are presumed to be R&D that directly address an assumption in the active trenches PA. Also included below are activities and the commitment to evaluate the consistency of the new information developed from ongoing Hanford, national, or international studies with the conceptual models and parameter assumptions used in the PA.

- Waste inventory and inventory allocation (see Section 4.2)
  - Evaluate the evolution of radionuclide inventory and volumes based on updates to SWITS database.
  - Evaluate the evolution of radionuclide inventory allocation among different waste forms based on updates to SWITS database.
  - Evaluate and update, as needed, the radionuclide screening for groundwater and atmospheric pathways.
- Near-field hydrology (see Section 4.3)
  - Evaluate ongoing studies of modified RCRA Subtitle C surface barrier (closure cap) designs and other closure cap studies in semiarid environments.
  - Evaluate ongoing studies of properties of backfill materials.
  - Evaluate liner failure mechanism and ongoing studies of properties of the different materials used in liner system.
- Corrosion of reactor components in Trench 94 (see Section 4.4)
  - Evaluate ongoing U.S. Navy, national and international research on corrosion behavior of reactor components in Trench 94.
- Cementitious waste form radionuclide release (see Section 4.5)
  - Evaluate ongoing national and international research on grout properties and release models.
  - Evaluate ongoing international research on natural analogs of cementitious materials.
  - Evaluate ongoing research on transport characteristics of cementitious materials using accelerated tests to approximate the effects of aging and weathering.
  - Evaluate transport characteristics (sorption and diffusion) of cementitious materials exposed to partially saturated conditions.
  - Evaluate potential improvement of the reactive chemistry facet of uranium billet release model.
- Vadose and saturated zone flow and radionuclide transport (see Section 4.6)
  - Evaluate vadose zone model results and parameter values used in ongoing Central Plateau remediation or related activities.
  - Evaluate undisturbed present-day soil moisture and matric potential profiles for areas near the active trenches.

   - Evaluate measurements of natural infiltration.
   - Evaluate saturated zone flow models and parameter values developed for use in other Central Plateau remediation or related activities.

- Human receptor exposure pathways and routes (see Section 4.7)
   - Evaluate ongoing national and international research and guidance on models and parameters used to evaluate human receptor exposure pathways and routes.
   - Evaluate ongoing Hanford risk and other related analyses that include models and parameters used to evaluate human receptor exposure pathways and routes.

4.2 R&D Activities Related to Waste Inventory and Inventory Allocation

Waste inventory and allocation (inventory distribution in CAT1 and CAT3 as well as among different CAT3 containers/encasements) are the key input parameters to the source term calculation for Trenches 31 and 34 and are hence the focus of the R&D activities.

1. **Evaluate the evolution of radionuclide inventory and volumes based on updates to SWITS database.**

   As described in the PA document (Section 2.3 in DOE-RL-2021-26), the radionuclide activity at closure were obtained from, and projected based on, the SWITS (HNF-58315, *Solid Waste Information and Tracking System (SWITS) User's Manual – Waste Generation*) database. While data for disposed waste are readily available from the database query, data for disposal from the query date up to the closure date (assumed to be January 1, 2035) are not available yet in the SWITS database. In addition, decay/ingrowth of activities listed in the database for different dates must be calculated to obtain the activities at the closure date. Thus, additional updates on the radionuclide inventory anticipated to be disposed in Trenches 31, 34, and 94 are possible. Any updates related to waste composition and inventory will lead to revision of the inventory data package (ECF-HANFORD-19-0069, *Inventory in the Active Trenches of the Low-Level Burial Grounds, Hanford Site, Washington*). The PA maintenance for the active trenches will include annual reviews of updates of the SWITS database to ensure the range of analyzed conditions in the PA is still valid. Any revisions to the inventory and volumes will be updated on an annual basis as part of the annual summary reports for the active trenches.

2. **Evaluate the evolution of radionuclide inventory allocation among different waste categories based on updates to SWITS database.**

   The categorization of the waste into CAT1 and CAT3 containers is based on the radiological characterization compared to the limits presented in Table A-2 of HNF-EP-0063, *Hanford Site Solid Waste Acceptance Criteria*, Rev. 21, which in turn, as a graded approach, are derived from tables in the 200 West LLBG PA (WHC-EP-0645, *Performance Assessment for the Disposal of Low-Level Waste in the 200 West Area Burial Grounds*). An important distinction between CAT1 and CAT3 wastes is that CAT1 wastes do not require stabilization prior to their disposal due to their low inventory concentration while CAT3 waste do require stabilization. Among CAT3 waste containers, radionuclide allocation in different containers will affect the release rate. Any new information on radionuclide inventory in different categories or different CAT3 containers will lead to updates to the inventory data package (ECF-HANFORD-19-0069) and breakdown on the allocation of the key radionuclides (notably iodine-129 and technetium-99). Therefore, the PA maintenance for the active trenches will include annual review of updates to ensure the range of analyzed conditions is still valid.

3. **Evaluate and update, as needed, the radionuclide screening for groundwater and atmospheric pathways.**

   As noted in the inventory data package (ECF-HANFORD-19-0069), a total of 120 radionuclides that were recorded in SWITS for LLBG active trenches and subsequently analyzed for developing forecast of future inventories (Section 2.3.2 of DOE/RL-2021-26). To perform PA calculations efficiently, the 120 radionuclides are screened to limit the PA evaluation to those that are most important. The method of radionuclide screening is to set criteria for half-life, activity at closure, consideration of parent and/or progeny, and risk-importance based on the other Hanford PA results. The screening process is described in Section 2.3.3 of DOE/RL-2021-26.

4.3 R&D Activities Related to Near-Field Hydrology

Near-field hydrology is important to contaminant release rates from the trenches and takes account of the evolution of the engineered barrier system. Three R&D activities are identified and described as follows.

1. **Evaluate ongoing studies of modified RCRA Subtitle C surface barrier (closure cap) designs and other closure cap studies in semiarid environments.**

   The modified RCRA Subtitle C surface barrier (closure cap) for the active trenches is expected to be analogous to a similar surface barrier planned for use at ERDF and may potentially be used for closure of other surface burial grounds at the Hanford Site. As the designs of these closure caps mature, it is relevant to evaluate the extent to which the modified designs impact any recharge assumptions used in the PA (e.g., net infiltration is 0.5 mm/yr for 500 years, after which it becomes similar to net infiltration through undisturbed soil). It is also relevant to compare the results of ongoing research on surface barriers being conducted in other remediation applications around the United States, especially those in semiarid conditions comparable to those existing at the Hanford Site.

2. **Evaluate ongoing studies of properties of backfill materials.**

   The backfill materials to be used as infill between adjacent waste containers and for the operations layer between different lifts of the active trenches has not been evaluated. As the trench contents evolve, the material properties can be compared to the assumed properties used in the PA.

3. **Evaluate liner failure mechanisms and as-emplaced properties of the different materials used in liner system.**

   The as-emplaced hydraulic properties of the different materials of the liner system, which include the drain gravels, geomembrane, geosynthetic clay liner, and admix layer, are assumed to be as good as the material properties defined in the design specifications. Opportunities exist to test the as-emplaced material properties and the liner failure mechanisms.

4.4 R&D Activities Related to Corrosion Behavior of Reactor Components in Trench 94

Corrosion of the Navy reactor compartments disposed in Trench 94 is the key process for containing the radionuclides. The corrosion process is the only R&D activity identified for Trench 94.

1. **Evaluate ongoing U.S. Navy, national and international research on corrosion behavior of reactor components in Trench 94.**

   Reactor compartment packages disposed in Trench 94 have exteriors made up of the nuclear reactor plant and ship support system that are comprised of a corrosion-resistant high-strength carbon steel and very high tensile strength nickel-alloyed (HY-80) steel. The radionuclides in the reactor compartment packages are contained in activated metal in the reactor vessel internal structure that is comprised of highly corrosion-resistant ICONEL® alloy 600. The U.S. Navy and other national programs as well as international studies are conducting active research on the corrosion-resistant behavior of various reactor compartments. The ongoing research will be evaluated as part of maintenance activity for Trench 94 PA.

4.5 R&D Activities Related to Characteristics of Cementitious Waste Form

Cementitious barriers are required for CAT3 wastes to stabilize the waste and reinforce the containers against intrusion for at least 500 years. The barriers also play significant role in delaying the contaminant release. The transport properties of the cementitious barriers are uncertain. Several R&D activities are identified and described as follows.

1. **Evaluate ongoing national and international research on grout properties and release models.**

   A range of other national programs as well as international studies are conducting active research on the properties of cementitious materials that may be used as analogs to those being considered for use at the active trenches for CAT3 wastes. The national research includes ongoing research being performed by the Cement Barriers Partnership as well as Saltstone studies conducted at Savannah-River National Laboratory. There are useful insights to be gained by this related research that can be used to compare with conceptual and numerical model assumptions and parameter values used in the PA for the active trenches.

2. **Evaluate ongoing international research on natural analogs of cementitious materials.**

   International programs use research on natural analogs to corroborate the release models and parameters used in long-term performance projections. Although natural analogs have a disadvantage in that the details of the environmental conditions and materials are not directly analogous to the conditions at the trench sites, they have an advantage of being able to replicate the long times of concern for the performance assessment. Extrapolating short duration accelerated laboratory tests to the timeframes of interest to the PA is sometimes questionable, and natural analogs may instead offer support the assumptions made in the PA. The natural analogs may be used to evaluate aging/weathering effects of cementitious materials.

® ICONEL is a trademark of the Special Metals Corporation Group of companies, Hartford, New York.

3. **Evaluate ongoing national and international research on transport characteristics of cementitious materials using accelerated tests to approximate the effects of aging and weathering**.

   The PA assumes that as the cementitious waste forms age, the hydraulic properties will change; but for the unsaturated environment at the active trenches, these property changes do not negatively affect the diffusive or advective release characteristics. This is a significantly different assumption than used in the TC & WM EIS (DOE/EIS-0391), where it was assumed that the diffusion coefficient increased by a factor of 60 when the cementitious materials were assumed to degrade. Although sensitivity analyses results conducted in the PA indicate that this assumption does not significantly affect the results, a better understanding on the effects of aging/alteration/weathering on transport properties is desirable.

4. **Evaluate transport characteristics (sorption and diffusion) of cementitious materials exposed to partially saturated conditions.**

   The PA makes assumptions on whether the properties of cementitious materials are affected by possible changes in saturation as the materials age and interact with partially saturated backfill in the active trenches. It is assumed that there would be a marked difference in sorption characteristics for both technetium-99 and iodine-129, depending on whether conditions are oxidizing or reducing. Additional studies would be useful to confirm the actual transport characteristics, in terms of consistency, between the diffusion and sorption coefficients.

5. **Evaluate potential improvement of the reactive chemistry facet of uranium billet release model.**

   The PA makes several assumptions on the uranium billet release model. The geochemical component for the uranium billet release model is assumed to be dynamic. This allows reactive transport of contaminants and secondary mineral precipitation to govern contaminant porewater chemistry through time. A uniform waste and concrete mineral assemblage is assumed within the monolith. The chemical evolution progresses with the porewater entering the soil and equilibrating with concrete. Moisture in contact with the waste dissolves billet solids, releasing uranium and technetium. Between encasement trenches, the concrete pore water reaches equilibrium with the uranium waste, resulting in homogeneous porewater concentrations. Additional work would be helpful to evaluate the use of multiple assumptions for the release model.

4.6 R&D Activities Related to Vadose Zone and Saturated Zone Flow and Transport

R&D activities in the field of flow and transport processes are focused on data collection used to improve the model for natural system, as follows.

1. **Evaluate vadose zone models and parameter values developed for use in other Central Plateau remediation or related activities**.

   The Hanford Site is an area of ongoing characterization and modeling of shallow (less than 15 m) and deep vadose zone contamination, and evaluation of alternative remediation technologies. In addition, fate and transport modeling of vadose zone contamination associated with past waste disposal practices at the Hanford Site is actively being pursued for several Central Plateau waste locations. While there are important differences between the other Central Plateau locations and the active trench sites, these other studies (including the 2012 TC & WM EIS, the 2013 ERDF PA, and the 2016 Waste Management Area C PA) provide useful analogs for the models and parameters used in the PA for the active trenches. These reviews should be conducted annually and summarized in the annual summary of related activities.

2. **Evaluate undisturbed present-day soil moisture and matric potential profiles for areas near the active trenches**.

   There are no or limited data on the existing undisturbed matric potential and moisture content in the shallow or deep vadose zone near the active trenches. Existing waste sites and tank farms in the Central Plateau have been the focus of detailed characterization efforts of the vadose zone, in large part to evaluate the potential consequences associated with past waste disposal practices or unplanned tank leaks. However, there is limited information on the ambient moisture profile and matric potential that may be able to constrain the vadose zone hydraulic properties or flow rates beneath the trenches. Future boreholes in the Central Plateau should be measured or monitored for soil moisture and matric potential. This is especially relevant in areas underlain by the Hanford sands and gravels, and where the net infiltration rate is expected to approximate conditions that are undisturbed by Hanford operations. Such an investigation is part of sitewide initiative involving multiple end-users including PA, CA, CIE, 200-DV-1 Source OU, and other modeling assessments.

3. **Evaluate measurements of natural infiltration**.

   This may include direct measurements using field lysimeter test facilities, such as the one that used to exist at the IDF dune site. In addition, indirect measurements may be used to infer present-day infiltration rates, such as using chloride mass balance and bomb-pulse chlorine-36 measurements. Such monitoring activities were performed in the past (e.g., PNNL-19945, *Soil Water Balance and Recharge Monitoring at the Hanford Site – FY 2010 Status Report*); the observed data were used to support the development of the range of likely postclosure net infiltration rates. It is recognized that the monitoring of net infiltration will be a long process because, for many years, there may be no observed net infiltration. However, there is expected eventually to be some observable net infiltration that should be monitored to reduce the uncertainty in this key parameter value. Such an investigation is part of sitewide initiative involving multiple end-users including PA, CA, CIE, 200-DV-1 Source OU, and other modeling assessments.

4. **Evaluate saturated zone flow models and parameter values developed for use in other Central Plateau remediation or related activities**.

   There is an area of ongoing characterization and modeling of the groundwater flow domain in the Central Plateau area. These groundwater investigations and models include the 200 West Area and areas around the trench sites. These studies are expected to be of relevance to PA for the active trenches, specifically with respect to analyses of the present trends in the water table surface in the 200 West Area, as well as the hydraulic conductivity of the Ringold Formation member of Wooded Island – unit E. Although the PA groundwater flow model uses a projected groundwater flow field after the end of Hanford operations, an understanding the transient behavior of the groundwater flow system near the trenches supports the development of the groundwater flow rates used in the PA for the active trenches.

4.7 R&D Activities Related to Human Receptor Exposure Pathways and Routes

R&D activities in this category of PA aim at improving dose estimation as follows.

1. **Evaluate ongoing national and international research and guidance on models and parameters used to evaluate human receptor exposure pathways and routes.**

   The definition of the receptor and biosphere characteristics relevant for calculating the dose a receptor may receive by all relevant exposure routes has been based on guidance provided by Federal agencies. Ongoing research is underway to enhance the scientific basis of the dose models, and the guidance has changed with time to reflect the ongoing research. This ongoing research relates to the dose that may be received when the receptor inhales a certain concentration of contaminated air or ingests a certain amount of contaminated water or food grown from contaminated soil. A case in point is the estimated dose that the receptor may receive if s/he drinks a liter of water containing 1.0 pCi/L of a radionuclide, such as iodine-129. This ongoing research is vetted in the scientific community and is ultimately reflected in updated guidance provided by Federal agencies. As the guidance is developed, it is relevant to track the updates to determine their potential impact on the PA results for the active trenches.

2. **Evaluate ongoing Hanford risk and other related analyses that include models and parameters used to evaluate human receptor exposure pathways and routes.**

   Assumptions are made in the PA regarding the characteristics of the receptor for which the groundwater or air pathway dose is calculated. These characteristics include, among others, assumptions about (1) the eating and drinking habits of the individual, (2) the amount of locally grown fruits, vegetables, and animal products (meat, eggs, milk, poultry) consumed by the individual, and (3) the amount of locally grown fodder the animals eat, among other factors. Although there exists guidance on parameter values that are recommended to quantify these characteristics, alternative assumptions can be made, resulting in alternative results. Although different models and parameter assumptions have been used for Hanford assessments over the past 20 years to evaluate the dose a receptor may receive by using contaminated groundwater, the unit concentration dose factors (i.e., dose per 1.0 pCi/L of groundwater) for the key radionuclides iodine-129 and technetium-99 have remained virtually unchanged. However, it is possible that different receptor characteristics may be recommended in future. Therefore, it is relevant to continue to evaluate the evolution of the recommendations to determine what impact the different values may have on the PA results for the active trenches.

5 Planned Review and Analysis

DOE M 435.1-1 requires the ongoing maintenance of the PA to evaluate changes that could affect the performance, design, and operating bases for the facility. The maintenance includes a series of activities that are performed on an annual basis. A determination of continued adequacy of the PA (DOE/RL-2021-26) is required on an annual basis, and it includes consideration of the results of data collection and analysis from any research, field studies, and monitoring needed to address uncertainties or gaps in existing data. The results of the annual reviews are reported in annual status reports (ASRs).

5.1 Periodic Review

Periodic reviews are needed to evaluate any information that has become available and may be relevant to the PA. The review and evaluation include data and information gained from the Central Plateau site characterization and R&D activities. Periodic reviews can focus on reducing conservatisms and uncertainties in the PA results.

5.1.1 Requirements

Specifically, the objectives of annual reviews can be summarized as the following:

- Confirmation of existing controls being effective in ensuring that PA conclusions are valid.
- Consideration of expected future events in terms of their significance to facility closure and the adequacy of the PA.
- Review of new information and determining the significance of this new information to the PA conclusions through special analysis, if found necessary.
- Identification of R&D needs that have been met during the past year, new needs that have arisen because of changes in actual or expected future conditions, and revised R&D priorities.

Any data derived from monitoring, tests, or research activities during the review period must be evaluated relative to the current PA assumptions to determine if such assumptions remain credible. Finally, any other information or changes in the larger 200 West Area LLBGs closure that are relevant to Trenches 31 and 34 PA assumptions and conclusions must be reviewed to determine if the current PA still adequately describes the closure condition for the LLBGs, and PA results still predict compliance with the performance objectives. The assessment of any significant changes identified to the input parameters or conceptual model or assumptions (of the original PA) through annual monitoring, R&D, or new data or information will be conducted as part of the unreviewed disposal question evaluation (UDQE) process. The results of implementing the UDQE process will be summarized in the ASR.

5.1.2 Status

Annual reviews of the PA (DOE/RL-2021-26) will be provided to the U.S. Department of Energy, Richland Operations Office (DOE-RL) starting with fiscal year 2023. DOE-RL will evaluate the information provided in the review and make the annual determination to document the continued adequacy of the PA, or to identify those areas requiring revision(s).

5.1.3 Plans

The purpose of the PA maintenance program is to confirm the continued adequacy of the current PA, and to maintain and enhance confidence in the results of the PA. A requirement of the maintenance program is to conduct an annual review of the facility closure-related activities. The annual PA review is conducted in a systematic manner that incorporates the following considerations:

1. Changes in estimates of radionuclide inventories, waste volumes, and waste types
2. Testing and research activities performed during the year and planned for the out years
3. Results of PA monitoring conducted in accordance with the PA Monitoring Plan for Trenches 31 and 34

The above factors are reviewed annually to confirm the adequacy of the current facility PA, and to evaluate the need to conduct special analyses under the UDQE process, or to prepare a revision to that PA. The results of the review will be documented in the ASR for the Trenches 31, 34, and 94 PA.

5.2 Status of Disposal Authorization Statement Conditions/Limits

A revised operating disposal authorization statement (DAS) is expected after the review of the Trenches 31, 34, and 94 PA and supporting documents, and after any conditions associated with these or predecessor documents have been resolved. Any planned or ongoing revisions of the PA, monitoring plans, or closure plans must be described.

5.2.1 Requirements

The DOE M 435.1-1 requires that the performance assessment be revised when significant new information alters the conclusions or conceptual models of the PA. The manual specifically mentions changes in waste forms or containers, radionuclide inventories, facility design and operations, closure concepts, or improved understanding. In addition, any planned or ongoing revisions to the monitoring plan or closure plan must be described.

5.2.2 Status

The need for PA revision will be determined by DOE-RL based on the results of annual reviews and special analyses. The form of a revision will be an addendum or revised PA document. Report revisions will be submitted to U.S. Department of Energy Headquarters (DOE-HQ) for review and approval. At facility closure of the broader 200 West Area LLBGs, a final PA will be prepared and submitted to DOE-HQ for approval together with the final monitoring and closure plans.

5.2.3 Plans

The PA will be revised whenever new data or information are obtained that would change the conclusions of the PA. Similarly, the PA monitoring plan (DOE/RL-2021-39) and preliminary closure plan (DOE/RL-2021-40, *Performance Assessment Closure Plan for the Active Low-Level Burial Ground Trenches 31 and 34 at the Hanford Site*) will be updated as more information becomes available.

At this stage and prior to closure, update the closure plan (DOE/RL-2021-40) to address the closure cover design selected for construction.

5.3 LFRG Key and Secondary Issues

All key and secondary issues identified by the Low-Level Waste Disposal Facility Federal Review Group (LFRG) Review have been resolved prior to publication of the PA document. There are currently no outstanding issues.

6 Planned Maintenance Activities and Schedule

The maintenance of the Trenches 31, 34, and 94 PA is comprised of four inter-related activities: (1) monitoring, (2) research and development, (3) planned reviews and analyses, and (4) revisions to the Trenches 31, 34, and 94 PA and the related Hanford Site Composite Analysis (CA) (DOE/RL-2019-52, *Composite Analysis for Low-Level Waste Disposal in the Hanford Site Central Plateau (FY 2020)*).

The details of the planned monitoring activities are presented in DOE/RL-2021-39 and are summarized in Chapter 3 of this document.

The planned research and development activities, including both (1) activities planned to continue the evaluation of assumptions related to the design basis used for the Trenches 31, 34, and 94 PA and the related scientific studies of releases of different waste categories and site characteristics, and (2) activities planned to conduct focused testing on key assumptions related to the conceptual models and parameter values used in the forecasts of the Trenches 31, 34, and 94 performance, are summarized in Chapter 4 of this document.

The planned reviews and analyses are summarized in Chapter 5 of this document. These reviews support the integrated and iterative development of the technical basis document supporting disposal of wastes at the Trenches 31, 34, and 94.

Based on the additional information garnered from these sources, revisions to the Trenches 31, 34, and 94 PA and Hanford Site CA documents are possible.

The schedules for the above activities are presented in the following tables:

- Table 6-1 presents the schedule for monitoring activities
- Table 6-2 presents the schedule for R&D activities related to reviewing updates to the design basis and related scientific studies
- Table 6-3 presents the schedule for R&D activities related to specific testing to address conceptual model and parameter assumptions relative to Trenches 31, 34, and 94 PA
- Table 6-4 presents the schedule for planned reviews and analysis
- Table 6-5 presents the schedule for planned revisions of the Trenches 31, 34, and 94 PA and related documents

The preceding schedules are contingent on available funding. It is expected that the schedules will be revisited and updated as the ongoing operations and closure decisions are made for the 200 West and 200 East Area LLBGs (LLWMA-3 and LLWMA-2, respectively) and specifically for the active Trenches 31, 34, and 94.

Table 6-1. Schedule of Monitoring

Monitoring Activity	Frequency	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30
Meteorological monitoring[a]	Continual	X	X	X	X	X	X	X	X	X
Air concentration monitoring[b]	Annual	X	X	X	X	X	X	X	X	X
Water-level monitoring	Annual	X	X	X	X	X	X	X	X	X
Groundwater concentration[c]	As required	X	X	X	X	X	X	X	X	X
Leachate monitoring and management[d]	As required	X	X	X	X	X	X	X	X	X
Leak monitoring[d]	As required	X	X	X	X	X	X	X	X	X

a. Monitoring conducted in accordance with permitting process.

b. Air concentration monitoring will be performed annually based on DOE/RL-91-50, *Hanford Site Environmental Monitoring Plan*.

c. The final selection of sampling frequency for groundwater concentration monitoring program will be based on the requirements of WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste* and the *Atomic Energy Act of 1954*.

d. Preoperational monitoring of the liquids in the leachate collection and recovery system will transition to leachate monitoring and management and leak monitoring just prior to starting waste disposal in Trenches 31 and 34.

FY = fiscal year

Table 6-2. Schedule of Evaluation of Updates to Design and Operations Information Research and Development Activities

Information Category	Frequency	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31
Waste Inventory and Inventory Allocation											
Evaluate the evolution of radionuclide inventory and volumes based on updates to SWITS database.	Annually		X		X		X		X		X
Evaluate the evolution of radionuclide inventory allocation among different waste forms based on updates to SWITS database.	Every 2 years		X		X		X		X		X
Evaluate and update, as needed, the radionuclide screening for groundwater and atmospheric pathways.	Every 2 years		X		X		X		X		X
Near-Field Hydrology											
Evaluate ongoing studies of modified RCRA Subtitle C surface barrier (closure cap) designs and other closure cap studies in semiarid environments.	Every 5 years					X					X
Evaluate ongoing studies of properties of backfill materials.	Every 5 years					X					X
Evaluate liner failure mechanism and ongoing studies of properties of the different materials used in liner system.	Every 10 years										X
Corrosion of Reactor Components in Trench 94											
Evaluate ongoing U.S. Navy, national and international research on corrosion.	Every 2 years		X		X		X		X		X

Table 6-2. Schedule of Evaluation of Updates to Design and Operations Information Research and Development Activities

Information Category	Frequency	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31
Cementitious Waste Form Radionuclide Release											
Evaluate ongoing national and international research on grout properties and release models.	Every 2 years		X		X		X		X		X
Evaluate ongoing international research on natural analogs of cementitious materials.	Every 2 years		X		X		X		X		X
Evaluate ongoing research on transport characteristics of cementitious materials using accelerated tests to approximate the effects of aging and weathering.	Every 2 years		X		X		X		X		X
Evaluate transport characteristics (sorption and diffusion) of cementitious materials exposed to partially saturated conditions.	Every 2 years		X		X		X		X		X
Evaluate potential improvement of the reactive chemistry facet of uranium billet release model.	Every 2 years		X		X		X		X		X
Vadose and Saturated Zone Flow and Radionuclide Transport											
Evaluate vadose zone model results and parameter values used in ongoing Central Plateau remediation or related activities.	Every 2 years		X		X		X		X		X
Evaluate undisturbed present-day soil moisture and matric potential profiles for areas near the active trenches.	Every 2 years		X		X		X		X		X

Table 6-2. Schedule of Evaluation of Updates to Design and Operations Information Research and Development Activities

Information Category	Frequency	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31
Evaluate ongoing research and testing related to characterization of present-day natural infiltration.	Every 2 years		X		X		X		X		X
Evaluate saturated zone flow model results and parameter values used in ongoing Central Plateau remediation or related activities.	Every 2 years		X		X		X		X		X
Human Receptor Exposure Pathway and Routes											
Evaluate ongoing national and international research and guidance on models and parameters used to evaluate human receptor exposure pathways and routes.	Every 5 years					X					X
Evaluate ongoing Hanford risk and other related analyses that include models and parameters used to evaluate human receptor exposure pathways and routes.	Every 5 years					X					X

Note: The status of each of these activities is expected to be summarized in annual summary reports identified in Table 6-5.

FY = fiscal year

RCRA = *Resource Conservation and Recovery Act of 1976*

SWITS = Solid Waste Inventory and Tracking System

Table 6-3. Schedule of Evaluation of Research and Development Activities

R&D Activity	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31
Cementitious Waste Form Radionuclide Release										
Evaluate ongoing research on transport characteristics of cementitious materials using accelerated tests to approximate the effects of aging and weathering.	X	X	X							
Evaluate transport characteristics (sorption and diffusion) of cementitious materials exposed to partially saturated conditions.		X	X	X						
Evaluate potential improvement of the reactive chemistry facet of uranium billet release model			X	X	X					
Vadose and Saturated Zone Flow and Radionuclide Transport										
Evaluate undisturbed present-day soil moisture and matric potential profiles for areas near the active trenches.			X	X	X					
Evaluate measurements of natural infiltration.				X	X	X				
Evaluate saturated zone flow models and parameter values developed for use in other Central Plateau remediation or related activities.					X	X	X			

Note: The status of each of these activities is expected to be summarized in annual summary reports identified in Table 6-5.

FY = fiscal year

R&D = research and development

Table 6-4. Schedule of Periodic Reviews of Active Trenches Performance Assessment Related Information

Planned Review	Frequency	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31
LFRG – active trenches PA	As-needed and annual	X	X	X	X	X	X	X	X	X	X
Ecology – risk budget tool and related permit conditions	As-needed		X								
UDQE	As-needed		X	X	X	X	X	X	X	X	X
SA	As-needed										

FY = fiscal year
LFRG = Low-Level Waste Facility Federal Review Group
NEPA = *National Environmental Protection Act of 1969*
PA = performance assessment
SA = special analysis
UDQE = unreviewed disposal question evaluation

Table 6-5. Schedule of Planned Revisions of Active Trenches Performance Assessment and Hanford Composite Analysis Related Documents

Assessment	Frequency	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31
Active trenches PA	5 years					X					X
Active trenches PA maintenance plan	As needed		X	X	X	X	X	X	X	X	X
Active trenches PA monitoring plan	As needed		X	X	X	X	X	X	X	X	X
Active trenches PA closure plan	5 years					X					X
Active trenches DAS	5 years		X					X			
Active trenches WAC	5 years					X					X
Hanford CA	10 years		X								X
Hanford CIE	10 years			X							
ASR	Annual	X	X	X	X	X	X	X	X	X	X

Note: The schedule of completion of various projects and milestones is based on current assumptions and are subject to available funding.

ASR = annual summary report
CA = composite analysis
CIE = cumulative impact evaluation
DAS = disposal authorization statement
WAC = waste acceptance criteria

7 Revisions to DAS Documents

A PA was prepared in 2021 to provide the DOE O 435.1-required assessment of the long-term human health and environmental risk associated with the planned disposal of wastes in the 200 West and 200 East Area active Trenches 31, 34, and 94 (DOE/RL-2021-26). The annual review and assessment of the PA is required according to DOE M 435.1-1, and the results of the annual review will be reported in the ASR. The annual review and assessment of the PA and the monitoring plan should be scheduled in coordination with the ASR so that any revisions to the DAS technical basis documents, and the results of those revisions, are reported in the ASR. Any planned or ongoing revisions of the PA, monitoring plan, or closure plans must be described.

It is required by DOE to ensure the revisions to the DAS, technical documents, and radioactive waste management basis (RWMB) are coordinated with the issuance of the ASR.

The ASR will be completed after the end of the fiscal year and assess the need for changes to the DAS, technical documents, and RWMB. The primary purpose of the ASR is to identify all the changes that have occurred, are ongoing, or are planned to occur at Trenches 31, 34, and 94 to DOE-HQ and the LFRG. The proposed revisions to the DAS, technical documents, and the RWMB are used for planning purposes to identify the need for DOE-HQ/LFRG reviews.

The potential areas of revisions to the active trenches DAS and PA are changes in the following:

- Waste forms or containers
- Radionuclide inventories
- Facility design and operations
- Closure concepts
- Conceptual model
- K_d value to a key radionuclide that significantly affects dose
- The location of the site boundary in land use plans
- DAS conditions (secondary issues verified complete)

This page intentionally left blank.

8 References

40 CFR 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations*. Available at: https://www.govinfo.gov/content/pkg/CFR-2018-title40-vol28/pdf/CFR-2018-title40-vol28-part264.pdf.

Subpart N, "Landfills."

40 CFR 268, "Land Disposal Restrictions," *Code of Federal Regulations*. Available at: https://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title40/40cfr268_main_02.tpl.

49 FR 47649, "National Environmental Policy Act Record of Decision for Disposal of Decommissioned, Defueled Naval Submarine Reactor Plants," *Federal Register*, Vol. 49, No. 236, pp. 47649-47650, December 6, 1984. Available at: https://archives.federalregister.gov/issue_slice/1984/12/6/47647-47650.pdf#page=3.

69 FR 39449, "Record of Decision for the Solid Waste Program, Hanford Site, Richland, WA: Storage and Treatment of Low-Level Waste and Mixed Low-Level Waste; Disposal of Low-Level Waste and Mixed Low-Level Waste, and Storage, Processing, and Certification of Transuranic Waste for Shipment to the Waste Isolation Pilot Plant," *Federal Register*, Vol. 69, No. 125, pp. 39449-39455, June 30, 2004. Available at: http://www.gpo.gov/fdsys/pkg/FR-2004-06-30/pdf/04-14806.pdf.

78 FR 75913, 2013, "Record of Decision: Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington," *Federal Register*, Vol. 78, No. 240, pp. 75913-75919, December 13, 2013. Available at: https://www.energy.gov/sites/prod/files/2013/12/f5/EIS-0391-ROD%231-2013.pdf.

Atomic Energy Act of 1954, Pub. L. 83-703 as amended, 42 USC 2011 et seq., 68 Stat. 919. Available at: https://www.govinfo.gov/content/pkg/STATUTE-68/pdf/STATUTE-68-Pg919.pdf#page=30.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 USC 9601, et seq., Pub. L. 107-377, December 31, 2002. Available at: https://www.csu.edu/cerc/researchreports/documents/CERCLASummary1980.pdf.

Cowan, S.P., 1996, "Conditional Acceptance of the Hanford 200 West Area Burial Ground Performance Assessment," memorandum to C. Hansen, U.S. Department of Energy, Richland Operations Office, dated June 27, 1996, U.S. Department of Energy, Washington, D.C.

CP-ENG-0020, *Functional Requirements Document and Conceptual Design for Trench 31 and 34, Modified RCRA Subtitle C, Cap Cover,* Rev. 0, CH2M HILL Plateau Remediation Company. Richland, Washington.

DOE-0431, 2019, *Recommendations for Institutional Control Time Period for Conducting DOE Order 435.1 Performance Assessments at the Hanford Site*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/EA-1889, 2012, *Final Environmental Assessment on the Disposal of Decommissioned, Defueled, Naval Reactor Plants from USS ENTERPRISE (CVN 65)*, U.S. Department of the Navy, Bremerton, Washington. Available at: https://www.energy.gov/sites/prod/files/EA-1889-FEAandFONSI-2012.pdf.

DOE/EIS-0222-F, 1999, *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*, U.S. Department of Energy, Washington, D.C. Available at: https://pdw.hanford.gov/document/D199158842. https://pdw.hanford.gov/document/D199158843. https://pdw.hanford.gov/document/D199158844. https://pdw.hanford.gov/document/D199158845. https://pdw.hanford.gov/document/D199158846. https://pdw.hanford.gov/document/D199158847.

DOE/EIS-0286D, 2002, *Draft Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement, Richland, Washington*, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/EIS-0286F, 2004, *Final Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement, Richland, Washington*, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://www.energy.gov/sites/prod/files/EIS-0286-FEIS-01-2004.pdf. https://www.energy.gov/sites/prod/files/EIS-0286-FEIS-02-2004.pdf.

DOE/EIS-0391, 2012, *Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*, U.S. Department of Energy, Washington, D.C. Available at: http://energy.gov/nepa/downloads/eis-0391-final-environmental-impact-statement.

DOE M 435.1-1 Chg 3 (LtdChg), 2021, *Radioactive Waste Management Manual*, U.S. Department of Energy, Washington, D.C. Available at: https://www.directives.doe.gov/directives-documents/400-series/0435.1-DManual-1-chg3-ltdchg-1/@@images/file.

DOE O 435.1 Chg 1 (PgChg), 2007, *Radioactive Waste Management*, U.S. Department of Energy, Washington, D.C. Available at: https://www.directives.doe.gov/directives-documents/400-series/0435.1-BOrder-chg1-PgChg.

DOE/RL-88-20, 1997, *Hanford Facility Dangerous Waste Permit Application, Low-Level Burial Grounds*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/D196113598.

DOE/RL-91-50, *Hanford Site Environmental Monitoring Plan*, Rev.7, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://www.hanford.gov/files.cfm/DOE-RL-91-50-Rev-7.pdf.

DOE/RL-2000-70, 2000, *Closure Plan for Active Low-Level Burial Grounds*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/D8532666.

DOE/RL-2000-72, 2000, *Performance Assessment Monitoring Plan for the Hanford Site Low-Level Burial Grounds*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/0082376H.

DOE/RL-2000-72, 2006, *Performance Assessment Monitoring Plan for the Hanford Site Low-Level Burial Grounds*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://www.osti.gov/servlets/purl/878238.

DOE/RL-2004-60, 2016, *200-SW-2 Radioactive Waste Landfills Group Operable Unit RCRA FI/CMS/RI/FS Work Plan*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/0075017H.

DOE/RL-2009-68, 2012, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-3*, Rev. 2, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/document/0091407.

DOE/RL-2015-74, 2015, *Hanford Facility Dangerous Waste Part B Permit Application; Low-Level Burial Grounds Trenches 31-34-94, T Plant Complex, and Central Waste Complex – Waste Receiving and Processing Facility*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at:
http://pdw.hanford.gov/document/0078648H.
http://pdw.hanford.gov/document/0078647H.
http://pdw.hanford.gov/document/0078646H.
http://pdw.hanford.gov/document/0078645H.
http://pdw.hanford.gov/document/0078644H.

DOE/RL-2019-52, 2023, *Composite Analysis for Low-Level Waste Disposal in the Hanford Site Central Plateau (FY 2020)*, Rev. 2, U.S. Department of Energy, Richland Operation Office, Richland, Washington. Available at: https://www.osti.gov/servlets/purl/2003366.

DOE/RL-2019-66, 2020, *Hanford Site Groundwater Monitoring Report for 2019*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/AR-04023.

DOE/RL-2020-08, 2020, *Radionuclide Air Emissions Report for the Hanford Site, Calendar Year 2019*, Rev.0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/AR-03884.

DOE/RL-2021-26, 2023, *Performance Assessment of Active Trenches in 200 East and West Low-Level Burial Grounds at the Hanford Site*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2021-39, 2023, *Performance Assessment Monitoring Plan for the Active Low-Level Burial Ground Trenches 31 and 34 at the Hanford Site*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2021-40, 2023, *Performance Assessment Closure Plan for the Active Low-Level Burial Ground Trenches 31 and 34 at the Hanford Site*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-STD-5002-2017, 2017, *Radioactive Waste Management Disposal Authorization Statement Technical Basis Documentation*, U.S. Department of Energy, Washington, D.C. Available at: https://www.standards.doe.gov/standards-documents/5000/5002-astd-2017.

Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order – Tri-Party Agreement*, 2 vols., as amended, State of Washington Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington. Available at: https://www.hanford.gov/page.cfm/TriParty/TheAgreement.

ECF-HANFORD-19-0069, 2022, *Inventory in the Active Trenches of the Low-Level Burial Grounds, Hanford Site, Washington*, Rev. 1, Central Plateau Cleanup Company, Richland, Washington.

Frei, M.W., 1997, "Conditional Acceptance of the Hanford 200 East Area Burial Ground Performance Assessment," memorandum to C. Hansen, U.S. Department of Energy, Richland Operations Office, dated June 30, 1997, U.S. Department of Energy, Washington, D.C.

HNF-2005, 1998, *Addendum to the Performance Assessment Analysis for Low-Level Waste Disposal in the 200 East Area Active Burial Grounds*, Rev. 0, Waste Management Federal Services of Hanford, Inc., Richland, Washington. Available at: http://pdw.hanford.gov/document/0082374H.

HNF-58315, 2019, *Solid Waste Information and Tracking System (SWITS) User's Manual – Waste Generation*, Rev. 1, CH2M HILL Plateau Remediation Company, Richland, Washington.

HNF-EP-0063, 1998, *Hanford Site Solid Waste Acceptance Criteria*, Rev. 5, Fluor Daniel Hanford, Inc., Richland, Washington. Available at: https://pdw.hanford.gov/document/D198195595.

HNF-EP-0063, 2021, *Hanford Site Solid Waste Acceptance Criteria*, Rev. 21, CH2M HILL Plateau Remediation Company, Richland, Washington.

HNF-MR-0533, 1997, *Uranium Disposition Strategy for the Hanford Site*, Rev. 0, B&W Hanford Company, Richland, Washington.

HNF-SD-WM-ES-355, 2002, *Low-Level Burial Grounds Disposal Plan*, Rev. 5, Fluor Hanford, Inc., Richland, Washington.

HNF-SD-WM-TI-798, 1996, *Addendum to the Performance Assessment Analysis for Low-Level Waste Disposal in the 200 West Area Active Burial Grounds*, Rust Federal Services of Hanford Inc., Richland, Washington. Available at: http://www.osti.gov/scitech/servlets/purl/325651.

National Environmental Policy Act of 1969, 42 USC 4321, et seq. Available at: https://www.gpo.gov/fdsys/pkg/USCODE-2010-title42/pdf/USCODE-2010-title42-chap55-sec4321.pdf.

PNNL-11800, 1998, *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*, Pacific Northwest National Laboratory, Richland, Washington. Available at: https://pdw.hanford.gov/document/0079141H.

PNNL-11800 Addendum 1, 2001, *Addendum to Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*, Pacific Northwest National Laboratory, Richland, Washington. Available at: https://pdw.hanford.gov/document/0084085.

PNNL-14859, 2007, *Interim Status Groundwater Monitoring Plan for Low-Level Waste Management Areas I to 4, RCRA Facilities, Hanford, Washington*, Rev. 2 (per Interim Change Notice 2), Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/document/D6541642. http://pdw.hanford.gov/document/DA04316831.

PNNL-16688, 2007, *Recharge Data Package for Hanford Single-Shell Tank Waste Management Areas*, Pacific Northwest National Laboratory, Richland, Washington. Available at: https://pdw.hanford.gov/document/0911240242.

PNNL-19945, 2010, *Soil Water Balance and Recharge Monitoring at the Hanford Site – FY 2010 Status Report*, Pacific Northwest National Laboratory, Richland, Washington. Available at: https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-19945.pdf.

RCW 70.105, "Hazardous Waste Management," *Revised Code of Washington*. Available at: https://apps.leg.wa.gov/rcw/default.aspx?cite=70.105&full=true%23.

Resource Conservation and Recovery Act of 1976, Pub. L. 94-580, 42 USC 6901 et seq. Available at: https://www.govinfo.gov/content/pkg/STATUTE-90/pdf/STATUTE-90-Pg2795.pdf.

RFSH-9755566, 1997, "Transmittal of Program Plan for Maintenance of Hanford Burial Ground Performance Assessment (PA) Analyses, that Fulfills Performance Agreement WM 1.8.1" (memorandum to T.K. Teynor, U.S. Department of Energy, Richland Operations Office, from D.E. McKenney), Rust Federal Services of Hanford, Inc., Richland, Washington, June 25.

RPP-PLAN-60324, *2017 Integrated Disposal Facility (IDF) Performance Assessment Project Execution Plan*, Rev. 0, AREVA Federal Services, LLC, Richland, Washington.

Scott, R.S., 2001, "Disposal Authorization for the Hanford Site Low Level Waste Disposal Facilities – Revision 2" (memorandum to H.L. Boston, U.S. Department of Energy, Office of River Protection, and K.A. Klein, U.S. Department of Energy, Richland Operations Office, from R.S. Scott), U.S. Department of Energy, Washington, D.C., November 1.

SGW-59564, 2018, *Engineering Evaluation Report for Low-Level Burial Grounds Trenches 31 and 34 Groundwater Monitoring*, Rev. 1, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: https://pdw.hanford.gov/document/0063843H.

USN/EIS-0259, 1996, *Final Environmental Impact Statement on the Disposal of Decommissioned, Defueled Cruiser, Ohio Class, and Los Angeles Class Naval Reactor Plants*, U.S. Department of the Navy, Puget Sound Naval Shipyard, Bremerton, Washington. Available at: https://www.energy.gov/sites/prod/files/EIS-0259-FEIS-02-1996_0.pdf.

WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste*, Revision 8c, as amended, Washington State Department of Ecology, Richland, Washington. Available at: https://fortress.wa.gov/ecy/nwp/permitting/hdwp/rev/8c/index.html.

WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code*, Olympia, Washington. Available at: https://apps.leg.wa.gov/WAC/default.aspx?cite=173-303.

173-303-140, "Land Disposal Restrictions."

173-303-610, "Closure and Post-Closure."

173-303-665, "Landfills."

WCH-520, 2013, *Performance Assessment for the Environmental Restoration Disposal Facility, Hanford Site, Washington*, Rev. 1, Washington Closure Hanford, Richland, Washington. Available at: http://pdw.hanford.gov/document/0083701.

WHC-EP-0645, 1995, *Performance Assessment for the Disposal of Low-Level Waste in the 200 West Area Burial Grounds*, Westinghouse Hanford Company, Richland, Washington. Available at: https://pdw.hanford.gov/document/0075582H.

WHC-SD-EN-AP-015, 1989, *Revised Ground-Water Monitoring Plan for the 200 Areas Low-Level Burial Grounds*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: https://pdw.hanford.gov/document/D195063349.

WHC-SD-WM-ES-355, 1995, *Low-Level Burial Grounds Disposal Plan*, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

WHC-SD-WM-TI-730, 1996, *Performance Assessment for the Disposal of Low-Level Waste in the 200 East Area Burial Grounds*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: https://pdw.hanford.gov/document/0071840H.

Zhang, Z.F., and R. Khaleel, 2010, "Simulating Field-Scale Moisture Flow Using a Combined Power-Averaging and Tensorial Connectivity-Tortuosity Approach," *Water Resources Research* 46, W09505.