DOE/RL-2021-56
Revision 0

ANNUAL STATUS REPORT (FY 2021): COMPOSITE ANALYSIS FOR LOW LEVEL WASTE DISPOSAL IN THE CENTRAL PLATEAU OF THE HANFORD SITE

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

Contractor for the U.S. Department of Energy
under Contract 89303320DEM000030

CPCCo
Central Plateau
Cleanup Company

P.O. Box 1464
Richland, Washington 99352

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INTERA, Inc.

Date Published
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APPROVED
By Sarah Harrison at 10:32 am, Nov 03, 2022

Release Approval   Date

Executive Summary

In accordance with DOE M 435.1-1[1] requirements and as implemented by DOE/RL-2000-29,[2] the U.S. Department of Energy (DOE), Richland Operations Office has prepared this annual summary for fiscal year (FY) 2021. Originally reported in PNNL-11800[3] and PNNL-11800, Addendum 1[4] (hereinafter collectively referred to as the Hanford Site Composite Analysis), the Hanford Site Composite Analysis was approved through issuance of a 2002 memorandum.[5]

As required by DOE/RL-2000-29, an annual evaluation of new information and data developed by a number of onsite programs was completed. The reporting period for this annual evaluation is FY 2021 (October 1, 2020 through September 30, 2021).
The information provided in this evaluation includes the following activities performed in FY 2021 that are considered pertinent to the Hanford Site Composite Analysis:

- Information that could change the source terms considered in the composite analysis, including the following:
  - Performance assessment (PA) development and maintenance activities:
    - 200 East Area Low-Level Burial Grounds PA
    - 200 West Area Low-Level Burial Grounds PA
    - Integrated Disposal Facility PA
    - Waste Management Area C PA

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[1] 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.

[2] DOE/RL-2000-29, 2018, *Maintenance Plan for the Composite Analysis of the Hanford Site*, *Southeast Washington*, Rev. 3, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://www.osti.gov/servlets/purl/1420314.

[3] 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.

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

[5] Frei, M.W., 2002, "Disposal Authorization for the Hanford Site Low-Level Waste Disposal Facilities – Submittal of an Addendum to Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site, PNNL-11800 Addendum 1" (memorandum to R. Schepens, U.S. Department of Energy, Office of River Protection, and K.A. Klein, U.S. Department of Energy, Richland Operations Office), U.S. Department of Energy, Office of Environmental Management, Washington, D.C., July 24.

        - Environmental Restoration Disposal Facility PA
        - Waste Management Area A-AX PA
    - *Resource Conservation and Recovery Act of 1976*[6] remedial activities
    - *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*[7] remedial activities
- Monitoring, including the following:
    - Air monitoring
    - Groundwater flow and contamination monitoring
    - Vadose zone characterization
- Research and Development, including the following:
    - Remediation science and technology
    - Operations studies

This annual evaluation identified no information in any of the above reviewed activities that considered results of data collection and analysis from research, field studies, and monitoring that would invalidate the continued adequacy of the currently approved version of the Hanford Site Composite Analysis. However, based on information reviewed from prior annual status reports, the determination of the FY 2015 annual summary report[8] is that the Hanford Site Composite Analysis requires an update. While the original composite analysis (prepared in 1998, with an addendum in 2001) has been maintained, the accumulation of basis changes reported in the annual summary reports of the preceding 14-year period merits evaluation in an updated analysis. This determination remains in place in this annual summary; new information needs to be incorporated and analyzed using environmental modeling software that meets current DOE quality

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6 *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.

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

8 DOE/RL-2015-66, 2016, *Annual Status Report (FY 2015): Composite Analysis for Low Level Waste Disposal in the Central Plateau of the Hanford Site*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://www.osti.gov/scitech/servlets/purl/1364347.

assurance requirements. Annual maintenance continues under DOE/RL-2000-29 because of the length of time planned for the preparation of an updated Hanford Site Composite Analysis.

On November 21, 2012, DOE issued the final Tank Closure and Waste Management Environmental Impact Statement[9] (hereinafter referred to as the TC & WM EIS) for the Hanford Site pursuant to the *National Environmental Policy Act of 1969*[10] and implementing regulations (Council on Environmental Quality, 2005[11] and 10 CFR 1021[12]). From 2006 until the TC & WM EIS was issued, any revision of the Hanford Site Composite Analysis was deferred. After issuance of the final TC & WM EIS, planning phase activities for preparing an update to the Hanford Site Composite Analysis were completed in FY 2015, and scoping phase activities that commenced in FY 2016 were completed in FY 2017. The culmination of the scoping phase was the preparation of a summary analysis[13] for the composite analysis update. Approval of the summary analysis was granted in May 2017, enabling commencement of the analysis phase.

Following guidance in DOE-STD-5002-2017,[14] this annual summary report is organized as follows:

- Chapter 1 provides an overview of the changes in the reporting period that potentially affect the Hanford Site Composite Analysis.
- Chapter 2 provides an assessment of the cumulative effects of the changes on the Hanford Site Composite Analysis.

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[9] DOE/EIS-0391, 2012, *Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (TC & WM EIS)*, U.S. Department of Energy, Office of River Protection, Richland, Washington. Available at: http://energy.gov/nepa/downloads/eis-0391-final-environmental-impact-statement.

[10] *National Environmental Policy Act of 1969*, 42 USC 4321 et seq. Available at: https://www.govinfo.gov/content/pkg/USCODE-2010-title42/pdf/USCODE-2010-title42-chap55-sec4321.pdf.

[11] Council on Environmental Quality, 2005, *Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act*, Executive Office of the President, Reprint of 40 CFR Parts 1500-1508. Available at: https://energy.gov/sites/prod/files/NEPA-40CFR1500_1508.pdf.

[12] 10 CFR 1021, "National Environmental Policy Act Implementing Procedures," *Code of Federal Regulations*. Available at: https://www.govinfo.gov/content/pkg/CFR-2019-title10-vol4/pdf/CFR-2019-title10-vol4-part1021.pdf.

[13] CP-60649, 2017, *Summary Analysis: Hanford Site Composite Analysis Update*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: https://www.osti.gov/servlets/purl/1412683.

[14] DOE-STD-5002-2017, 2017, *Disposal Authorization Statement and Tank Closure Documentation*, U.S. Department of Energy, Washington, D.C. Available at: https://www.standards.doe.gov/standards-documents/5000/5002-astd-2017.

- Chapter 3 summarizes sources of information that account for waste receipts during the reporting period.
- Chapter 4 provides a review of recent onsite monitoring and characterization activities relevant to the current Hanford Site Composite Analysis.
- Chapter 5 summarizes research and development and operations studies that could affect the Hanford Composite Analysis.
- Chapter 6 reports on planned or contemplated changes to relevant Hanford Site programs that could affect the Hanford Site Composite Analysis and recommended changes to the Hanford Site Composite Analysis maintenance program.
- Chapter 7 summarizes the status of conditions on the disposal authorization statement, as well as key and secondary issues.
- Chapter 8 provides the required certification of the continued adequacy of the Hanford Site Composite Analysis.
- Chapter 9 provides the references cited in this report.
- Appendix A provides a history of the maintenance of the Hanford Site Composite Analysis.
- Appendix B provides a summary of the status of the update of the Hanford Site Composite Analysis that is in progress.
- Appendix C provides a crosswalk of the review criteria for this annual status report to indicate where in this document the required information is provided.

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Appendices

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Tables

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CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CPCCo = Central Plateau Cleanup Company
INTERA = INTERA, Incorporated
DOE-ORP = U.S. Department of Energy, Office of River Protection
DOE-RL = U.S. Department of Energy, Richland Operations Office
PNNL = Pacific Northwest National Laboratory
WRPS = Washington River Protection Solutions

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Terms

AEA	*Atomic Energy Act of 1954*
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CHPRC	CH2M HILL Plateau Remediation Company
COC	contaminant of concern
COPC	contaminant of potential concern
CSM	conceptual site model
CY	calendar year
DAS	disposal authorization statement
DOE	U.S. Department of Energy
DOE-EM	U.S. Department of Energy, Office of Assistant Secretary for Environmental Management
DOE-HQ	U.S. Department of Energy, Headquarters
DOE-ORP	U.S. Department of Energy, Office of River Protection
DOE-RL	U.S. Department of Energy, Richland Operations Office
DQO	data quality objective
DVZ	deep vadose zone
DWS	drinking water standard
Ecology	Washington State Department of Ecology
EE/CA	engineering evaluation/cost analysis
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ERT	electrical resistivity tomography
ETF	Effluent Treatment Facility
FFS	focused feasibility study
FS	feasibility study
FY	fiscal year
HLW	high-level waste
IAMIT	Interagency Management Integration Team

IC	institutional control
IDF	Integrated Disposal Facility
LFRG	Low-Level Waste Disposal Facility Federal Review Group
LLBG	low-level burial ground
LLW	low-level waste
LLWMA	low-level waste management area
MNA	monitored natural attenuation
MSU	modular storage unit
NRC	U.S. Nuclear Regulatory Commission
NRDWL	Nonradioactive Dangerous Waste Landfill
NTCRA	non-time-critical removal action
ODAS	operating disposal authorization statement
OU	operable unit
P&T	pump and treat
PA	performance assessment
PFP	Plutonium Finishing Plant
PNNL	Pacific Northwest National Laboratory
PUREX	Plutonium-Uranium Extraction
QA	quality assurance
RAI	request for additional information
RASCAL	Representative/Analogous Sites Coordinating Agency Liaisons
RCRA	*Resource Conservation and Recovery Act of 1976*
RD/RAWP	remedial design/remedial action work plan
RI	remedial investigation
ROD	record of decision
SALDS	State-Approved Land Disposal Site
SVE	soil vapor extraction
SWL	Solid Waste Landfill
TC & WM EIS	Tank Closure and Waste Management Environmental Impact Statement
TED	total effective dose

Tri-Parties	U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Ecology
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TRU	transuranic
TSD	treatment, storage, and disposal
UDQE	unreviewed disposal question evaluation
WESF	Waste Encapsulation and Storage Facility
WIR	waste incidental to reprocessing
WMA	waste management area
WMIS	Waste Management Information System

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1 Changes Potentially Affecting the Composite Analysis

This chapter identifies potential or actual changes, discoveries, proposed actions, and new information identified during the operation of the Hanford Site during the reporting period (fiscal year [FY] 2021, covering the timeframe of October 1, 2020 through September 30, 2021) that potentially affect the basis of PNNL-11800, *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*, and PNNL-11800, *Addendum to Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*, Addendum 1 (hereinafter collectively referred to as the Hanford Site Composite Analysis) to include the following:

- Deletion of sources considered in the Hanford Site Composite Analysis
- Addition of new sources not considered in the Hanford Site Composite Analysis
- Changes to existing sources (e.g., completion of remedial activities at *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* [CERCLA] sites)
- Availability of new information that reduces uncertainty in characteristics of existing sources

Maintenance of the Hanford Site Composite Analysis is conducted under DOE/RL-2000-29, *Maintenance Plan for the Composite Analysis of the Hanford Site, Southeast Washington*. Change control process evaluations arising from performance assessments (PAs) supported by the Hanford Site Composite Analysis are summarized in Table 1-1. There were no unreviewed disposal question or unreviewed disposal question evaluations (UDQEs) for the reporting period for any PA or for the composite analysis itself.

Table 1-1. Potential Changes Affecting the Composite Analysis

Disposal Facility/Unit	UDQE/UCAQE or Change Control Process Identification Number	Change, Discovery, Proposed Action, New Information Description	Evaluation Results	Special Analysis Number (if applicable)	Composite Analysis Impacts
No changes for the reporting period.					

UCAQE = unreviewed composite analysis question evaluation
UDQE = unreviewed disposal question evaluation

There was no deletion of any sources considered and no addition of any sources not considered in the Hanford Site Composite Analysis identified during review of FY 2021 information.

No major changes to Hanford Site radionuclide inventories were identified during review of FY 2021 information that would have the potential to alter the basis of the Hanford Site Composite Analysis.

Activities in the following categories are reviewed because they have potential to reveal new information that could constitute changes to existing radionuclide sources and/or new information that reduces uncertainty in characteristics of existing radionuclide sources:

- DOE M 435.1-1, *Radioactive Waste Management Manual* (Section 1.1)
- *Resource Conservation and Recovery Act of 1976* (RCRA) remedial activities (Section 1.2)
- CERCLA remedial activities (Section 1.3)

The U.S. Department of Energy's (DOE's) Office of Enterprise Assessments issued an "Assessment of Low-Level Radioactive Waste Disposal Practices at the Hanford Site" (DOE, 2018, *Office of Enterprise Assessments Assessment of Low-Level Radioactive Waste Disposal Practices at the Hanford Site*) report in February 2018. With regard to the Hanford Site Composite Analysis, this report noted the following:

> The Hanford Site [Composite Analysis] CA was originally reported in the Composite Analysis for Low-Level Disposal in the 200 Area Plateau of the Hanford Site in 1998. An addendum was written in 2001. The CA has been maintained without major revisions or additions for the past 16 years while several decisions were made regarding remediation and disposal in the Central Plateau.
>
> A detailed account of that history was succinctly reported in the FY 2016 CA Annual Status Report, which evaluated information based on the updated remediation and disposal decisions and conditions or new information that could change the source terms considered in the CA, including: (1) PA development and maintenance activities for 200 West Area LLBG, 200 East Area LLBG, ERDF, Integrated Disposal Facility, and Waste Management Area C; and (2) monitoring, research, and development results, including groundwater flow and contamination monitoring, and remediation and technology programs.
>
> EA concurs that current information and data validate the adequacy of the present version of the Hanford Site CA evaluation, which indicates that the performance objectives are satisfied. However, based on the 2016 annual review, the site determined that the CA modeling requires rebuilding and updated analysis to better reflect anticipated conditions and improve its accuracy as a land use planning tool. The accumulation of basis changes and model parameter validation data reported in the annual summary reports over the past 15 years constitute sufficient new information to merit evaluation in an updated analysis, using environmental modeling software that meets current DOE QA requirements. EA and the site are in agreement with the need for a rebuilt, QA-approved, up-to-date CA. DOE-RL and its contractors are developing plans and gathering all appropriate input data for a complete update of the CA, which is expected to be completed over the next three years. In discussions with the lead modeling subject matter experts (SMEs), EA reviewed the plans and progress for the CA rebuilding effort, including the approach to scoping the new analysis, technical approach, input parameter validation, and analysis and reporting phases.
>
> The site has identified the following new information and requirements as justification for updating the CA analysis:
>
> - When the original 1998 CA was developed, some remedial action decisions were deferred to determine whether alternate remedies were necessary or available based on additional characterization and development of new remediation technologies. Consensus on many of those decisions has now been reached through negotiations.
> - The Final Tank Closure and Waste Management environmental impact statement provided an updated inventory basis, new modeling capabilities, and new decisions reached in the associated ROD that need to be incorporated into the CA.
> - Pump & Treat systems, which were not evaluated in the original CA, have had significant impact on groundwater flow, contaminant transport, and contaminant removal from groundwater.

- Development of improved cleanup strategies and improvements from cleanup may lead to establishing points of compliance other than the core zone boundary used in the original CA.
- Receding groundwater levels in the unconfined aquifer have led to an improved understanding of future conditions for the flow system.
- The revised ERDF PA (2013) evaluated the updated inventory, as well as the expansion of the facility to about twice the size that was evaluated in the original CA.
- The geologic structural basis for groundwater models has continued to improve with additional data collection and interpretation.
- The risk assessment scenarios currently in use for the Hanford Site CERCLA and RCRA analyses differ from those evaluated in the original 1998 CA.
- The original CA was prepared before DOE required its contractor to apply NQA-1 standards for use of simulation software for environmental modeling. A new analysis, performed with current software tools qualified under DOE O 414.1D, *Quality Assurance*, standards and applied under current, compliant QA plans and procedures, is necessary.

The U.S. Department of Energy, Richland Operations Office (DOE-RL) concurs with the conclusions of the Enterprise Assessment's report with respect to its findings on the Composite Analysis.

Appendix A presents the history of the maintenance of the Hanford Site Composite Analysis, including all prior annual status reports.

1.1 Performance Assessments

Table 1-2 lists the Hanford Site PAs, the scope of the PAs, and the FY 2021 status with respect to phases (planning, scoping, analysis, and maintenance) as identified in DOE guidance for modeling at the Hanford Site (1301789, 2012, "Modeling to Support Regulatory Decisionmaking at Hanford"). Detailed summaries of activities associated with each of these PAs are provided in Sections 1.1.1 through 1.1.4.

1.1.1 200 East and 200 West Low-Level Burial Ground Performance Assessments

In the annual reviews of the Hanford Site Low-Level Burial Ground (LLBG) PAs for FY 2021 [DOE/RL-2021-57, *Annual Status Report (FY 2021): Performance Assessment for the Disposal of Low-Level Waste in the 200 West Area Burial Grounds*; DOE/RL-2021-58, *Annual Status Report (FY 2021): Performance Assessment for the Disposal of Low-Level Waste in the 200 East Area Burial Grounds*], projected dose estimates from radionuclide inventories disposed in the active LLBGs (at locations shown in Figure 1-1) from September 26, 1988 through September 30, 2021, were calculated using the dose estimate methodology developed in the original PAs (WHC-EP-0645, *Performance Assessment for the Disposal of Low-Level Waste in the 200 West Area Burial Grounds*; WHC-SD-WM-TI-730, *Performance Assessment for the Disposal of Low-Level Waste in the 200 East Area Burial Grounds*). These estimates were compared with performance objectives defined in DOE O 435.1, *Radioactive Waste Management*, companion documents DOE M 435.1-1; DOE-STD-5002-2017, *Disposal Authorization Statement and Tank Closure Documentation*. The performance objectives are currently satisfied. Operational waste acceptance criteria (HNF-EP-0063, *Hanford Site Solid Waste Acceptance Criteria*) and waste acceptance practices continue to be sufficient to maintain compliance with performance objectives.

Relevance of the LLBG PAs to the Hanford Site Composite Analysis

The LLBG PAs are supported by the Hanford Site Composite Analysis. Solid waste disposal constitutes one of the sources of radioactive waste inventory. The current estimated inventory disposed and projections of future inventory disposal in the LLBGs are refined regularly as additional data continue to be collected and reported through maintenance of the LLBG PAs. This updated information is pertinent to the composite analysis because of its potential to change the LLBG inventory evaluated in the composite analysis.

Table 1-2. Hanford Site Performance Assessments in Planning, Scoping, Analysis, and Maintenance Phases and Fiscal Year 2021 Status

Performance Assessment	Scope	FY 2021 Status
200 East LLBGs	This PA is for operation of the LLBGs located in the 200 East Area. The LLBGs are operational and continue to receive small, limited quantities of waste.	Maintenance phase: The original PA (WHC-SD-WM-TI-730) continues to be maintained per the approved 1997 maintenance plan (RFSH-9755566). A new PA is in development for the active LLBGs in both 200 East and 200 West, and a closure PA is expected to follow for the inactive LLBGs later.
200 West LLBGs	This PA is for operation of the LLBGs located in the 200 West Area. The LLBGs are operational and continue to receive small, limited quantities of waste.	Maintenance phase: The original PA (WHC-EP-0645) continues to be maintained per the approved 1997 maintenance plan (RFSH-9755566). A new PA is in development for the active LLBGs in both 200 East and 200 West, and a closure PA is expected to follow for the inactive LLBGs later.
Active LLBGs PA (new PA)	This PA will be for operation of the active LLBGs in 200 East and 200 West Areas (namely, Trenches 31, 34, and 94).	Planning phase: Work commenced on development of a new active LLBG PA in FY 2019 and continued in FY 2021. Rev. 0 of the new active LLBG PA was completed and submitted to LFRG. LFRG reviewed this PA in FY 2021 and provided findings. Preparation of Rev. 1 of this PA to resolve LFRG findings is in progress.
ERDF	This PA is for operation of a CERCLA disposal facility located between the 200 East and 200 West Areas. It is operational and continues to receive waste from Hanford Site CERCLA remedial activities.	Maintenance phase: A revised disposal authorization statement (CCN 173929) based on the revised PA was issued in early FY 2014. Maintenance activities under an approved maintenance plan (CP-60150) continued thereafter.
IDF	A PA for an ILAW disposal facility located in the 200 East Area was approved. This facility was constructed and is currently pre-operational. Plans call for use of this facility for future disposal of stabilized tank waste from the Hanford Site Waste Treatment and Vitrification Plant (under construction). A new IDF PA is required to implement these plans.	Analysis phase: The Revision 0 of RPP-RPT-59958 (IDF PA) was completed in FY 2018 and submitted to LFRG for review, which identified 2 key and 30 secondary issues with the Rev. 0 PA and supporting documentation. A conditional ODAS was granted for the facility on June 29, 2018. The IDF PA was revised to address 1 key and 24 of the 30 secondary issues identified in the conditional ODAS. On August 13, 2018, Revision 1 of the IDF PA was issued with LFRG concurrence to close 1 key issue and 24 secondary issues related to the PA. The remaining key issue requires that a waste acceptance criteria document be prepared to include the findings of the revised PA. Development of the waste acceptance criteria was initiated in the fourth quarter of FY 2018 and is expected to be completed in the third quarter of FY 2019. The remaining secondary issues are being addressed in revisions to the PA maintenance plan, PA monitoring plan, PA closure plan, and unreviewed waste disposal question procedure. Revisions to these documents were initiated in the fourth quarter of FY 2018 and are expected to be completed by the third quarter of FY 2019. The WIR determination approval process was initiated in the second quarter of FY 2018. The WIR is in public review under consultation with the NRC since in March 2019. Following the NRC and public comment period for the WIR, the IDF PA may need to be revised.

Table 1-2. Hanford Site Performance Assessments in Planning, Scoping, Analysis, and Maintenance Phases and Fiscal Year 2021 Status

Performance Assessment	Scope	FY 2021 Status
WMA C	This PA will support eventual closure of the C Tank Farm single-shell tank facility following completion of tank retrieval activities.	Analysis phase: The analysis phase was conducted in FYs 2015 and 2016 following the modeling approach set forth in the summary analysis* approved by the Hanford Site Groundwater/Vadose Zone Executive Council. The PA was submitted to the LFRG in FY 2015. The WMA C PA was approved by the LFRG for release and further regulatory review and is currently undergoing regulatory review. In FY 2019, the review of the DOE M 435.1-1 PA document (RPP-ENV-58782) and a WIR evaluation document for WMA C was initiated in FY 2018 with the NRC in support of its consultation role with DOE-ORP. The NRC review was completed in FY 2020.
WMA A-AX	This PA will support eventual closure of the A-AX Tank Farm single-shell tank facilities following completion of tank retrieval activities.	Planning and Analysis Phase: Scoping and planning phase activities commenced in FY 2015 for a new PA, modeled after the scoping approach used for the WMA C PA. Work was suspended in FY 2016 due to funding issues. Work was reinitiated in FY 2017 and a preliminary PA was developed, completed and submitted to ORP for review at the end of FY 2019. A consultation with the LFRG on the technical adequacy of the preliminary PA and PA updates occurred in FY 2021.

Note: Complete reference citations are provided in Chapter 9 of this document.

*The summary analysis is a document for demonstration of compliance with DOE guidance provided in 1301789, 2012, "Modeling to Support Regulatory Decision making at Hanford," which addresses the topical areas covered by both a given PA and TC & WM EIS, evaluation of analyses in the TC & WM EIS, and analyses planned for a given PA, with recommendations for updates to local scale models and a discussion of potential concerns.

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
DOE-ORP = U.S. Department of Energy, Office of River Protection
ERDF = Environmental Restoration Disposal Facility
FY = fiscal year
IDF = Integrated Disposal Facility
ILAW = immobilized low-activity waste
LFRG = Low-Level Waste Disposal Facility Federal Review Group
LLBG = low-level burial ground
NRC = U.S. Nuclear Regulatory Commission
ODAS = operating disposal authorization statement
PA = performance assessment
TC & WM EIS = Tank Closure and Waste Management Environmental Impact Statement
WIR = waste incidental to reprocessing
WMA = waste management area

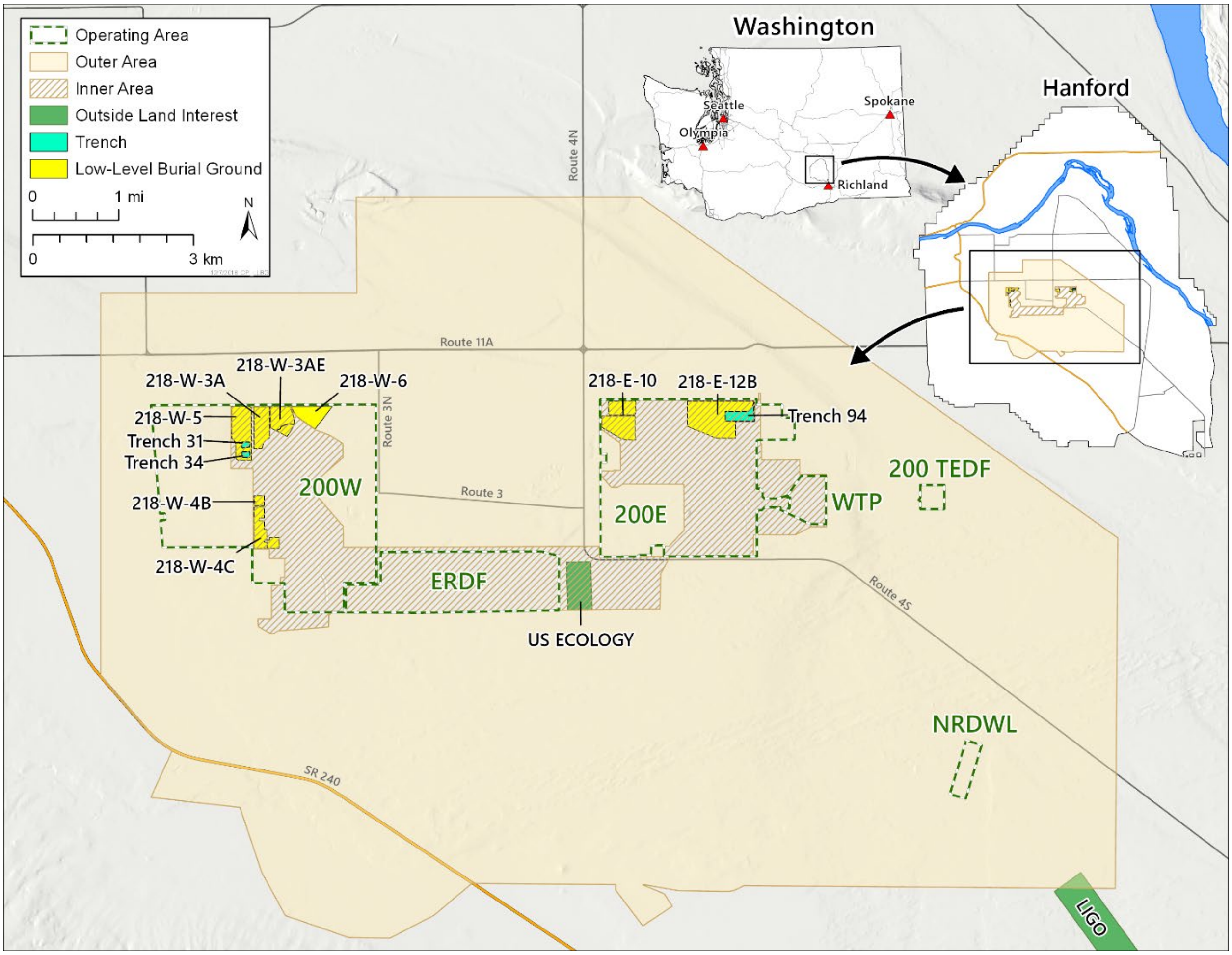

Figure 1-1. Location of the Low-Level Burial Grounds

For the 200 West Area LLBGs (DOE/RL-2021-57), low-level waste (LLW) and mixed LLW were disposed in two lined trenches in the 218-W-5 Burial Ground (Trenches 31 and 34), which will continue to be used until they are either filled or closed. Overall, there are no substantive changes to primary PA assumptions and no changes to the PA analysis conclusion that compliance with DOE O 435.1 is being maintained. All performance objectives are currently satisfied, and operational waste acceptance criteria (HNF-EP-0063) and waste acceptance practices continue to be sufficient to maintain compliance with performance objectives. Estimates of inventory and associated dose estimates from future waste disposal actions are unchanged from previous years' evaluations, which indicate potential impacts well below performance objectives. Therefore, future compliance with DOE O 435.1 is expected.

For the 200 East Area LLBGs (DOE/RL-2021-58), inventory and associated dose estimates from future waste disposal actions are unchanged from previous years' evaluations, which indicate potential impacts well below performance objectives; therefore, future compliance with DOE O 435.1 is expected. Three naval reactor compartments were disposed in Trench 94 during the reporting period for the 200 East Area LLBGs. Overall, there are no substantive changes to primary PA assumptions and no changes to the PA analysis conclusion that compliance with DOE O 435.1 is being maintained.

Dose estimate increases from disposed waste for groundwater contamination scenarios occurred only at the 200 West Area LLBGs and were essentially negligible. No dose increase is expected in 200 East Area LLBGs from the disposal of naval reactor compartments in Trench 94. Waste quantities disposed to these trenches in FY 2021 were 151.5 m^3 (5351.8 ft^3) in Trench 31, 13.5 m^3 (475.3 ft^3) in Trench 34, and 3,398 m^3 (119,999.4 ft^3) in Trench 94.

DOE, 2018, noted the following:

> [T]he computational methods and some assumed parameters and conditions for the PAs for both 200 West Area and 200 East Area LLBGs have become outdated. The software used for both LLBG PAs can be executed only on obsolete computer operating systems. Section 5.3.3 lists several reasons for the rebuilding and reanalysis of the CA, which is currently under way. The PAs for the LLBG provide crucial source input to the CA. With the rebuilding of the CA, it is important to rebuild the LLBG PAs to maintain the required and expected QA standards of the analyses. (OFI-CHPRC-1)

DOE, 2018, further noted:

> The PA criteria for the 200 East and West Area LLBGs are currently satisfied. However, the 200 West Area PA will require rebuilding and reanalysis to support the reanalysis for the CA expected to be completed over the next three years.

In response to the report, DOE-RL directed CH2M HILL Plateau Remediation Company (CHPRC) to commence developing a new PA to cover the active LLBGs in 200 East and 200 West (namely, Trenches 31, 34, and 94). Work started on this active LLBG PA in FY 2019 and the PA Rev. 0 was submitted to LFRG in FY 2021. Based on the LFRG comments, revisions to Rev. 0 are currently ongoing. A closure PA may be developed later to cover the balance of LLBGs in 200 East and 200 West.

Another important consideration overlooked in the LLBG PAs maintenance reports is that these PAs were developed to meet DOE O 5820.2A, *Radioactive Waste Management*, which preceded DOE O 435.1. The PAs were developed to report a peak dose for a 10,000 (rather than 1,000) year performance objective period. The small doses resulting from these PAs updated in the scaling methodology used for annual maintenance for over 20 years have not been explicitly presented as pertaining to a longer performance objective period than DOE O 435.1 requirements. Starting with the FY 2018 annual status reports, appropriate language and footnotes for tabulated doses in maintenance documents are being applied to clarify the objective performance period of the original PAs and addendums for the LLBG PAs. The new active LLBG PA will report to DOE O 435.1 standards, including a comparison of performance objectives and measures to the 1,000-year compliance and post-compliance periods.

Relevance of the IDF PA to the Hanford Site Composite Analysis

The IDF PA is supported by the Hanford Site Composite Analysis. Planned waste disposal at the IDF will constitute the largest source of radioactive waste inventory at the Hanford Site. Estimates of future inventory disposal of glass and secondary waste forms from the Hanford Tank Waste Treatment and Immobilization Plant and tank farms that are considered in the IDF PA must be incorporated into the composite analysis.

1.1.2 Integrated Disposal Facility Performance Assessment

Figure 1-2 shows the location of the Integrated Disposal Facility (IDF). In a 2001 memorandum (Scott, 2001, “Disposal Authorization for the Hanford Site Low-Level Waste Disposal Facilities – Revision 2”), DOE approved DOE/ORP-2000-24, *Hanford Immobilized Low-Activity Waste Performance Assessment: 2001 Version*. Continuation of the disposal authorization statement (DAS) (Frei, 2003, “Review of the Annual Summary of the Hanford Immobilized Low-Activity Waste Preformance Assessment for 2003”) was based in part on RPP-15834, *Integrated Disposal Facility Risk Assessment*. This PA is maintained in accordance with DOE/ORP-2000-01, *Maintenance Plan for the Hanford Integrated Disposal Facility Performance Assessment*.

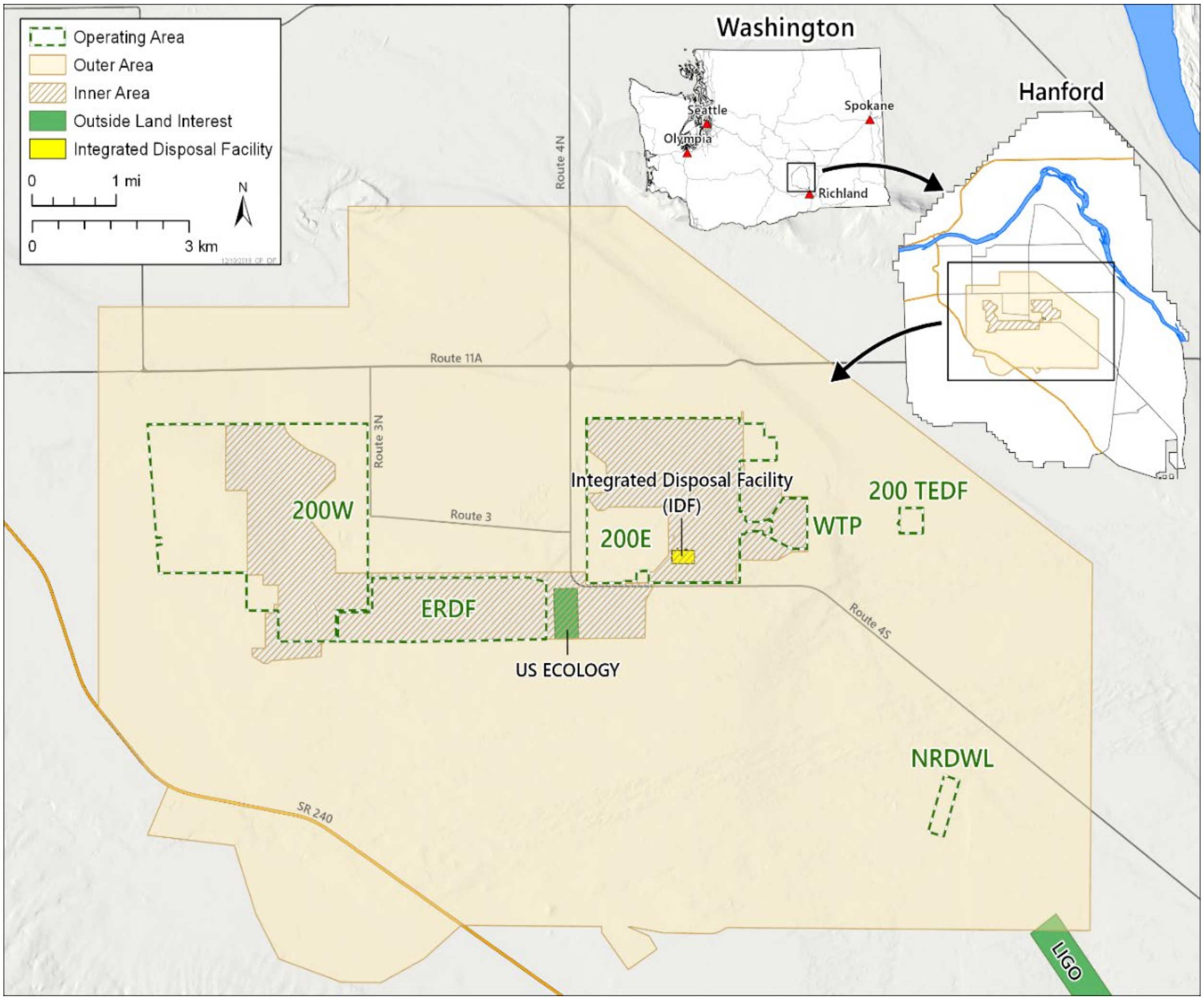

Figure 1-2. Location of the Integrated Disposal Facility

The first construction phase for IDF was completed on April 28, 2006, which included installing cell liners and leachate collection tanks (Figure 1-3). Waste disposal authorizations are needed to dispose of waste in the IDF.

Figure 1-3. Photograph of the Integrated Disposal Facility First Expansion (Current Configuration)

Revision of the original IDF PA (DOE/ORP-2000-24) was deferred from FYs 2006 through 2012 pending issuance of DOE/EIS-0391, *Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (TC & WM EIS)* (hereinafter referred to as the TC & WM EIS). On November 21, 2012, DOE issued the TC & WM EIS for the Hanford Site pursuant to the *National Environmental Policy Act of 1969* and implementing regulations (Council on Environmental Quality, 2005, *Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act*; and 10 CFR 1021, "National Environmental Policy Act Implementing Procedures"). In the second half of FY 2014, DOE-RL authorized planning phase activities in preparation of a revised IDF PA, which included developing a project management plan and quality assurance (QA) project plan and conducting a technical review of existing data packages and TC & WM EIS (DOE/EIS-0391) models for IDF to prepare for the scoping phase. The annual status reports for the IDF PA were not prepared because FY 2012 due to funding prioritization and in recognition that a new PA was required to implement decisions in the TC & WM EIS Record of Decision (ROD) (78 FR 75913, "Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington").

Management for preparing the revised IDF PA was transitioned from DOE-RL to the U.S. Department of Energy, Office of River Protection (DOE-ORP) on October 1, 2014. DOE-ORP and its tank operations contractor (Washington River Protection Solutions) completed the planning and scoping phase activities in FY 2015 and continued to meet with the Washington State Department of Ecology (Ecology) to discuss the PA models and parameters.

In December 2015, a summary analysis describing the modeling approach necessary to address comments received at the scoping workshops was approved by the DOE Hanford Site Groundwater/Vadose Zone Executive Council, and modeling commenced. The summary analysis is a tool used to meet DOE direction (1301789, 2012) by describing the technical approach to be taken in the PA, with justification for any departures from the TC & WM EIS modeling platform or approach. In FY 2016, modeling was performed for chemical and radionuclide releases from the immobilized low-activity waste and secondary waste. Subsequent travel through the vadose zone beneath the facility and subsequent transport through the saturated zone to the point of calculation 100 m (328 ft) downstream of the facility were also evaluated. Parameter sensitivity was evaluated using deterministic model runs documented in calculation reports completed in FY 2017. The deterministic analyses results were used to develop abstractions for use in a probabilistic, integrated system model completed in the third quarter of FY 2017. The system model was used to evaluate parameter uncertainty and assess the long-term dose and groundwater impact from constituents that would be released from the facility over the next 10,000 years.

Washington River Protection Solutions completed a draft of the revised IDF PA in the fourth quarter of FY 2017 that later was issued as RPP-RPT-59958, *Performance Assessment for the Integrated Disposal Facility, Hanford Site, Washington*, Rev. 0. In FY 2018, the IDF PA Rev. 0 was reviewed by the Low-Level Waste Disposal Facility Federal Review Group (LFRG) and the U.S. Department of Energy, Headquarters (DOE-HQ). The LFRG identified 2 key and 30 secondary issues with the Rev. 0 PA and supporting documentation. However, the LFRG recommended that an operating disposal authorization statement (ODAS) be granted for the facility. On June 29, 2018, the Associate Principal Deputy Assistant Secretary for Regulatory and Policy Affairs issued a conditional ODAS for the IDF. The IDF PA was revised to address one key issue and 24 of the 30 secondary issues identified in the ODAS. On August 13, 2018, Rev. 1 of the IDF PA (RPP-RPT-59958, *Performance Assessment for the Integrated Disposal Facility, Hanford Site, Washington*, Rev. 1) was issued with LFRG concurrence to close 1 key and 24 secondary issues related to the PA. The remaining key issue requires that a waste acceptance criteria document be prepared to include the findings of the revised PA. Development of the waste acceptance criteria document was initiated in the fourth quarter of FY 2018. The waste acceptance criteria were completed in FY 2019 and were provided to the LFRG for review and comment. Five of the six remaining secondary issues have been addressed in revisions to the PA maintenance plan, PA monitoring plan, PA closure plan, and unresolved disposal question procedure. Resolution of these five secondary issues was approved by the LFRG in November 2019. The final secondary issue will be addressed when the revision to the composite analysis is completed. In September 2020, a letter to the DOE-RL site manager from both the director of the U.S. Department of Energy, Office of Assistant Secretary for Environmental Management (DOE-EM) Office of Waste Disposal and acting director of the DOE-EM Office of Regulatory Compliance acknowledged the resolution of the LFRG key and secondary issues and removed the conditional status of the ODAS.

The waste incidental to reprocessing (WIR) determination approval process was initiated in the second quarter of FY 2018. A draft WIR was initiated and has undergone several review cycles with DOE-HQ. In May 2020, the U.S. Nuclear Regulatory Commission (NRC), under consultation with DOE, began a review of the draft WIR evaluation; a public review commenced at the same time. The 6-month-long public comment period ended in November 2020. The NRC provided DOE with 26 requests for additional information (RAIs), which have been addressed in DOE/ORP-2021-02, Department of Energy Responses to the Nuclear Regulatory Commission Request for Additional Information on the Draft Waste Incidental to Reprocessing Evaluation for Vitrification of Low Activity Waste, Rev. 1. In addition, review comments from Ecology were received in November 2020. The additional information requested by NRC and comments from Ecology, along with new information collected as part of the IDF Maintenance Program will result in a revision of the IDF PA in CY 2022.

Infrastructure upgrades (e.g., utility installation, security installation, administration building construction, and expanding groundwater monitoring network) at the IDF are underway. However, the IDF remains in "Pre-Active Life," which refers to the facility maintenance period between final construction and the start of active life. At the end of FY 2021, a RCRA permit (WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste* [hereinafter referred to as the Hanford RCRA Permit]) modification was underway to change the status from "Pre-Active Life" to "Active Life." Low-activity waste vitrification hot commissioning is forecast to begin in FY 2023.

In FY 2019, two special analyses were performed. One special analysis evaluated a proposed waste form for liquid secondary waste that was not evaluated in the PA. A powder waste form for liquid secondary waste instead of a solidified waste form was evaluated. Until a decision is made to approve a powder waste form for liquid secondary waste, the contemplated change does not impact the simulated releases provided for the composite analysis update that is underway. A second special analysis evaluated intruder protection requirements necessary to accommodate higher strontium-90 concentrations in vitrified waste. Recent flow sheet modeling that did not account for strontium-90 removal during Direct-Feed Low Activity Waste operations indicated a potential to have higher strontium-90 concentrations in vitrified waste. The implications on disposal limits were evaluated, but the results of this special analysis would not change the input to the composite analysis.

In FY 2020, two additional special analyses were performed. One special analysis evaluated the potential impacts from periodic maintenance of the Wet Electrostatic Precipitator (WESP) in the low-activity waste vitrification plant. The periodic maintenance of the Wet Electrostatic Precipitator to maintain efficiency allows more volatile radionuclides to pass through to the offgas treatment system resulting higher loadings on the secondary waste in the offgas treatment system. The impacts of the regular maintenance were not considered in the flowsheet that developed the radionuclide inventories for the secondary waste simulated in the PA. The special analysis showed that secondary waste could exceed disposal limits for technetium-99 and that the impact to groundwater could exceed drinking water standards (DWSs) beyond 1,000 years after closure. A second special analysis investigated the potential consequences of leaving cooling water in the used low-activity waste melters when they are disposed of in the IDF. For safety reasons during an off-normal event, the cooling system was not designed to drain liquids. Leaving liquid in the system is being considered, and an analysis evaluating the potential impact to the release of radionuclides and hazardous chemicals from other waste streams was requested. Additional water leaking from the cooling system in the future was not considered in the PA simulations. The special analysis concluded that the peak groundwater concentrations would increase by less than 1% if the cooling water were left in the used low-activity waste melters.

In FY 2021, five additional special analyses were performed. One special analysis evaluated the impact of new moisture content information in the H2 sand that result in a change of the H2 sand hydraulic property values. Sensitivity analyses performed with the updated H2 sand hydraulic property values resulted in a change in the predicted fate and transport of radionuclides in the vadose zone beneath the IDF and the corresponding timing of the peak groundwater concentration and all-pathways dose at the point of compliance. The second special analysis investigated the impact of new information collected as part of the IDF maintenance program related to the hydraulic and transport properties of grouts used to encapsulate debris secondary solid waste (SSW) and solidify/stabilize non-debris SSW. The new information was combined with the higher technetium-99 loading on HEPA filters identified in the WESP maintenance special analysis completed in FY 2020 to develop revised predictions of release rate of mobile radionuclides from SSW. The third special analysis investigated the impact of new information collected as part of the IDF maintenance program on the corrosion of ILAW glass. This new information included an assessment of the impact of Stage III glass corrosion on radionuclide release rates from ILAW glass. The fourth special analysis investigated the combined impact of the other three special analyses completed in FY 2021 as well as additional updated vadose zone and saturated zone information collected as part of the IDF maintenance program. This special analysis evaluated the impact of the updated information on the fate and transport of technetium-99 and the associated groundwater concentration and dose at the point of assessment. The special analysis determined that the as-analyzed IDF would not comply with the DOE M 435.1-1 all-pathways dose performance objective without a design modification or other operational or disposal constraints, including but not limited to revised waste acceptance criteria. The special analysis conclusion is a result of the increased release rate of technetium-99 from the HEPA filters combined with the reduced vadose zone radionuclide transport time associated with the updated H2 sand hydraulic properties. The DOE LFRG Site Representative and LFRG Co-chairs were made aware of the preliminary results of this analysis and recommended additional modeling to help inform future decisions. The additional modeling work was still in progress at the time this annual update was prepared. A fifth special analysis evaluated the potential impacts of filling the voids in a used low-activity waste melters with grout that could lead to accelerated rates of the vitrified waste left in the melters when they are disposed of in the IDF. Although the high-pH effluents that flowed past the grout onto the residual waste left in the melters caused accelerated corrosions rates, the volume and inventory of waste impacted by the accelerated corrosion rate would not in of itself change the conclusions of the PA provided that the grouted melters were disposed of away from the containers of vitrified waste.

1.1.3 Waste Management Area C Performance Assessment

Waste Management Area (WMA) C includes the C Tank Farm and ancillary equipment located in the eastern portion of the 200 East Area (Figure 1-4). In FY 2009, a scoping process was initiated to develop the risk assessments and PAs required for closure of WMA C. A series of working sessions were held with the regulatory agencies and stakeholders to solicit input and obtain a common understanding regarding the scope, methods, and data to be used in the planned risk assessments and PAs. In addition to DOE-ORP, Ecology, and Hanford Site contractors, the working session members also included representatives from the U.S. Environmental Protection Agency (EPA), NRC, interested Tribal Nations, other stakeholder groups, DOE-RL personnel and their contractors involved with groundwater/vadose zone or composite analyses efforts, and members of the interested public. NRC staff involvement in the working sessions is a technical resource to assess whether required waste determinations by DOE-RL for the WIR are based on sound technical assumptions, analyses, and conclusions relative to applicable incidental waste criteria. The scoping phase was completed in FY 2011.

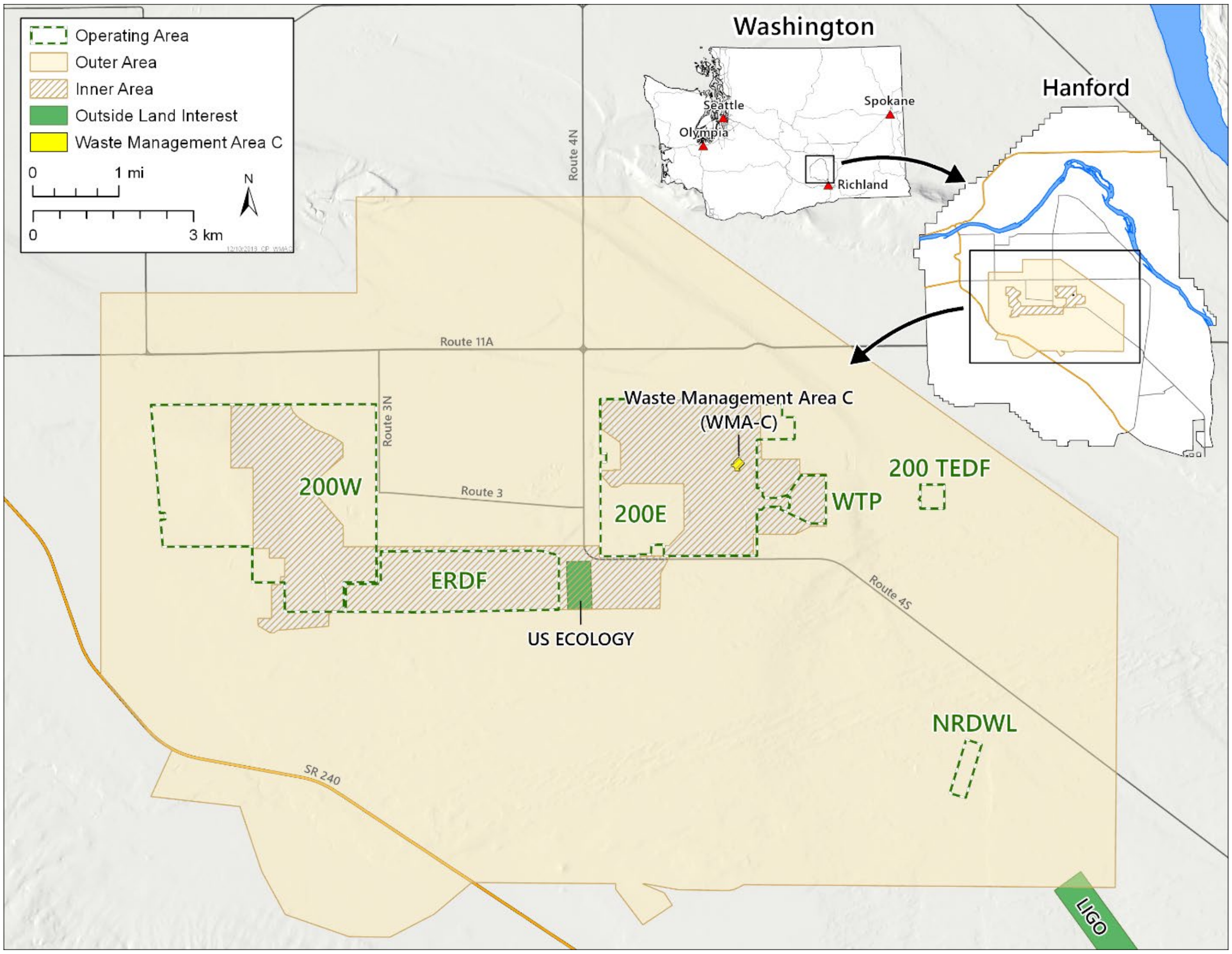

Figure 1-4. Location of Waste Management Area C

An initial analysis (modeling) phase of activities resulting from the WMA C PA scoping process completed in FY 2011 was delayed until FY 2013, awaiting issuance of the final TC & WM EIS (DOE/EIS-0391). In FY 2014, an initial set of PA modeling results of impacts from a closed WMA C was completed for the groundwater pathway, air pathway, and hypothetical inadvertent intruder. Key elements of the WMA C PA modeling effort included implementing the conceptual model for flow and contaminant transport into a three-dimensional numerical model of flow and transport at WMA C implemented in the STOMP[1] (Subsurface Transport Over Multiple Phases) computer code and implementing the conceptual model of flow and transport in a system-level model of WMA C based on the GoldSim® computer software, which included implementing waste release models used to represent contaminant release from waste residuals remaining in tanks and ancillary equipment and exposure scenarios used to evaluate performance objectives and measures for the PA. The GoldSim-based system model has also been used to perform a system sensitivity and uncertainty analysis required as a part of the DOE M 435.1-1 PA effort.

Relevance of the WMA C PA to the Hanford Site Composite Analysis

When complete, the WMA C PA will be supported by the Hanford Site Composite Analysis.

Other PAs discussed in this section were developed to obtain authorization for disposal of radioactive waste in disposal facilities constructed for this purpose. The WMA C PA differs in this respect: its purpose is to authorize closure of a tank waste system with residual waste remaining after retrieval as a disposal system.

As the WMA C PA is completed, the information on residual tank waste inventory and predicted releases will serve to update the basis of the Hanford Site Composite Analysis. Other WMA PAs will follow in the future, providing further refinement.

In FY 2015, an initial set of PA modeling results for WMA C was supplemented with results from additional modeling cases that were identified in stakeholder interactions during FY 2014. Results of these analyses are being used to satisfy the requirements outlined in Appendix I of Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order* (hereinafter referred to as the Tri-Party Agreement) for assessing the radiological impacts of waste residuals in a closed WMA C under DOE O 435.1 and evaluating hazardous chemical impacts for the same wastes under RCRA.

In September 2015, two detailed documents summarizing the results of the radiological and hazardous chemical impact analyses of tank residuals left in a closed WMA C were completed and transmitted for technical review by DOE-ORP. A revised draft of the WMA C PA (RPP-ENV-58782, *Performance Assessment of Waste Management Area C, Hanford Site, Washington*) for the radiological impacts from tank residuals was submitted for review by DOE-ORP to the LFRG on December 30, 2015. This review was intended to ensure that the PA was technically sound prior to it being formally submitted to the NRC to initiate consultation under a process similar to that governed by Section 3116 of the *Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005*. The results of the LFRG review demonstrated that the PA is technically adequate for its intended purpose. DOE-ORP was then authorized to transmit the PA formally to the NRC for consultation and to EPA, Ecology, and the public for review and comments. In addition to the PA, a draft WIR evaluation was prepared for NRC consultation.

[1]STOMP is a copyright of Battelle Memorial Institute, Columbus, Ohio, and is used under the limited government license.

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In September 2016, the following four complementary reports that met the intent of Tri-Party Agreement Appendix I (Ecology et al., 1989) requirements for a PA were transmitted to DOE-ORP for further review by NRC and Ecology:

- RPP-ENV-58782, which addresses the radiological impacts of residual wastes left in tanks and ancillary equipment to meet regulatory requirements in DOE M 435.1-1.
- RPP-RPT-59197, *Analysis of Past Tank Waste Leaks and Losses in the Vicinity of Waste Management Area C at the Hanford Site, Southeast Washington*, which provides input to the baseline risk assessment update (RPP-RPT-58329, *Baseline Risk Assessment for Waste Management Area C*).
- The baseline risk assessment was conducted to support a RCRA facility investigation for WMA C (RPP-RPT-58339, *Phase 2 RCRA Facility Investigation Report for Waste Management Area C*).
- RPP-ENV-58806, *RCRA Closure Analysis of Tank Waste Residuals Impacts at Waste Management Area C, Hanford Site, Washington*, addresses regulatory requirements in WAC 173-303, "Dangerous Waste Regulations."

In FY 2019, the review of the DOE M 435.1-1 PA document (RPP-ENV-58782) and the draft WIR evaluation for WMA C (DOE/ORP-2018-01, *Draft Waste Incidental to Reprocessing Evaluation for Closure of Waste Management Area C at the Hanford Site*), which was initiated in FY 2018 with NRC in support of its consultation role with DOE-ORP, continued. As a part of the consultation, NRC submitted a set of Requests for Additional Information (RAIs) to DOE by letter dated April 30, 2019. DOE-ORP expended efforts to develop responses to the NRC RAIs through the end of FY 2019.

Review of the other three WMA C analysis complementary documents initiated with Ecology in FY 2017 also continued through the end of FY 2019.

In FY 2020, DOE-ORP provided its formal responses to the NRC RAIs on October 22, 2019 in ORP-63747, *Comment Responses for the NRC Staff Request for Additional Information on the Draft Waste Incidental to Reprocessing Evaluation for Waste Management Area C*. As a final deliverable for their consultation with DOE-ORP, NRC issued their Technical Evaluation Report of the WMA C WIR Evaluation and PA to DOE-ORP by letter dated May 11, 2020.

Updates to the WMA C PA and final WIR evaluation (DOE/ORP-2020-03, *Final Waste Incidental to Reprocessing Evaluation for Closure of Waste Management Area C at the Hanford Site*) based on NRC and internal review comments were completed by the end of FY 2020 and revisions of both the WMA C PA and WIR evaluation was submitted to DOE to be cleared for public release in September 2020.

In FY 2020, the comment resolution process with Ecology on the other three complementary WMA C analysis documents was completed in August 2020. Updates to these three WMA C documents based on Ecology and related internal review comments were completed by the end of FY 2020 and revisions for all three documents were submitted to DOE-ORP to be cleared for public release in early FY 2021.

In FY 2021, public release process for all four complementary WMA C analysis documents to address both NRC and Ecology comments was completed. DOE-ORP also worked closely with DOE-HQ to finalize the final WIR evaluation and closure plans for WMA C to support the issuance of a waste determination for managing residual waste left in WMA C tanks and ancillary equipment as LLW.

The WMA C PA and WIR evaluations reports and closure plans will be used with WMA C PA-related maintenance and monitoring plans to support the DOE-HQ decision related to a final closure authorization for WMA C expected in FY 2022.

1.1.4 Environmental Restoration Disposal Facility Performance Assessment

DOE/RL-2021-59, *Annual Status Report (FY 2021): Performance Assessment for the Environmental Restoration Disposal Facility*, provides the annual status of the ERDF PA. Constructed in 1996 to receive waste generated by CERCLA remediation areas within the Hanford Site, ERDF is an active operating disposal facility managed by CHPRC for DOE-RL (Figure 1-5). This section reviews the PA activities during FY 2020. Additional information about ERDF disposal operations during FY 2021 is provided in Section 1.3.3.2.

In 1995, EPA authorized ERDF operations through EPA/ROD/R10-95/100, *Declaration of the Interim Record of Decision for the Environmental Restoration Disposal Facility*, and by DOE-RL with a DAS (Scott, 2001) in accordance with DOE O 5820.2A. The primary technical analyses supporting approval to operate include the remedial investigation (RI)/feasibility study (FS) completed in 1994 (DOE/RL-93-99, *Remedial Investigation and Feasibility Study Report for the Environmental Restoration Disposal Facility*) for the ERDF ROD and a preliminary PA analysis (BHI-00169, *Environmental Restoration Disposal Facility Performance Assessment*) to address DOE O 5820.2A requirements.

> ***Relevance of the ERDF PA to the Hanford Site Composite Analysis***
>
> *The ERDF PA is supported by the Hanford Site Composite Analysis.*
>
> *Similar to the LLBGs, disposal of solid waste at ERDF constitutes one of the sources of radioactive waste inventory. Because this facility is in active use, the current estimated inventory disposed is adjusted annually to reflect waste received. This updated information is pertinent to the composite analysis because of its potential to change the ERDF inventory evaluated in the composite analysis.*
>
> *Information on the current inventory and operations for ERDF is presented in Section 1.3.3.2.*

A crosswalk analysis (Dronen, 1996, "Environmental Restoration Disposal Facility CERCLA/ DOE Order 5820.2a Roadmap") was completed to show that DOE O 5820.2A facility performance requirements would be satisfied. DOE-RL determined that the RI/FS and the preliminary PA analysis adequately evaluated the ability of ERDF to satisfy specific performance objectives in DOE O 5820.2A and showed a reasonable expectation that these objectives would be met. A second crosswalk [Klein, 2000, "Environmental Restoration Disposal Facility (ERDF) Crosswalk to DOE Order 435.1 Requirements"] was completed to demonstrate compliance with DOE O 435.1, which resulted in the issuance of a DAS on June 18, 2001 (Scott, 2001).

Since completion of the preliminary PA analysis, two factors led to the DOE-RL decision to update the PA analysis and complete the formal review process in accordance with DOE M 435.1-1, as DOE O 435.1 is the successor to DOE O 5820.2A. First, ERDF has accepted additional radioactive waste at higher inventory levels than originally foreseen (although still within the limits provided in the preliminary PA analysis). Second, new information has been developed at the Hanford Site that identifies large conservatisms in the initial analysis. The updated PA analysis is intended to provide a more realistic evaluation of ERDF performance and optimize the capability of ERDF to complete its mission for disposal of CERCLA remediation waste for the remainder of Hanford Site cleanup activities.

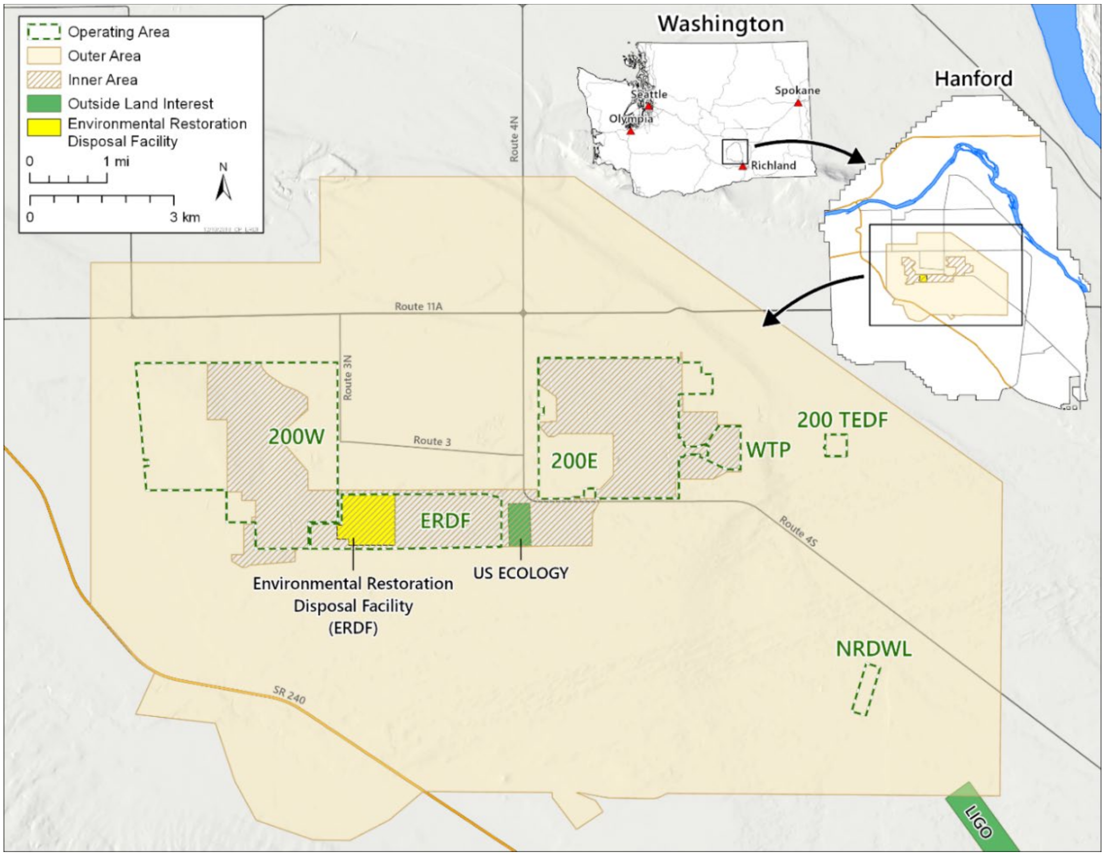

Figure 1-5. Location of the Environmental Restoration Disposal Facility

In FY 2011, WCH-426, *Work Plan for the Revision of a Performance Assessment Analysis for the Environmental Restoration Disposal Facility*, Rev. 0, was prepared and approved (Einan, 2011, "Approval of the *Work Plan for the Revision of a Performance Assessment Analysis for the Environmental Restoration Disposal Facility*, WCH-426, Revision 0, October 2010"), and WCH-462, *ERDF Performance Assessment Modeling Approach*, was developed for the ERDF PA.

The work plan to prepare the new ERDF PA was revised in FY 2012 (WCH-426, *Work Plan for the Revision of a Performance Assessment Analysis for the Environmental Restoration Disposal Facility*, Rev. 1). A draft report was prepared in early FY 2013 for EPA review and was revised to incorporate EPA comments. CP-60089, *Performance Assessment for the Environmental Restoration Disposal Facility, Hanford Site, Washington*, Rev. 00, was published in August 2013, supported by the following data packages:

- WCH-463, *Hydrogeologic Model for the Environmental Restoration Disposal Facility, Hanford Site*
- WCH-464, *Hydrologic Data Package in Support of Environmental Restoration Disposal Facility Performance Assessment Modeling*
- WCH-475, *Biota Description Data Package for the Post Closure Environmental Restoration Disposal Facility Location*
- WCH-476, *Chemical Reactivity of Radionuclides with Waste Material and Subsurface Soils During Release and Migration from the Environmental Restoration Disposal Facility*

- WCH-477, *Conceptual Models for Release and Transport of Environmental Restoration Disposal Facility Waste Contaminants through the Near-Field Environment*
- WCH-478, *Exposure and Inadvertent Scenarios for the Environmental Restoration Disposal Facility*
- WCH-479, *Inventory Data Package for ERDF Waste Disposal*
- WCH-515, *Parameter Uncertainty for the ERDF Performance Assessment Uncertainty and Sensitivity Analysis*

The LFRG formally reviewed the revised ERDF PA during the second half of FY 2013. The LFRG examined the validity of the analyses documented in the PA and determined that the PA and associated documentation were technically adequate. Three key issues were identified for resolution prior to approval of the PA as well as 21 secondary issues. All of the key and most of the secondary issues were subsequently resolved, and CP-60089, *Performance Assessment for the Environmental Restoration Disposal Facility, Hanford Site, Washington*, Rev. 0 (hereinafter referred to as the revised ERDF PA), published in August 2013, was submitted for compliance evaluation. Based on the LFRG recommendation, DOE issued the DAS in November 2013, which permitted continued ERDF operations.

Stipulated conditions in the revised DAS included developing both a demonstration that an as low as reasonably achievable analysis is not needed and a closure plan, monitoring plan, maintenance plan, UDQE procedure, and revised waste acceptance criteria. The plans and UDQE procedure were all developed and submitted to the LFRG in March 2014. The LFRG comments were received in September 2014, and responses were returned to the LFRG in April 2015. DOE-HQ accepted the responses and removed all outstanding conditions of the DAS in August 2015.

Results of the revised ERDF PA (CP-60089, Rev. 0) and an evaluation thereof against the basis of the Hanford Site Composite Analysis were presented in DOE/RL-2013-40, *Annual Status Report (FY 2013): Composite Analysis of Low Level Waste Disposal in the Central Plateau at the Hanford Site*.

1.1.5 Waste Management Areas A/AX Performance Assessment

Waste Management Area (WMA) A includes the A and AX Tank Farms and ancillary equipment located in the eastern portion of the 200 East Area (Figure 1-6). Figure 1-7 is a map on the scale of the 241-A and 241-AX Tank Farms. The six underground SSTs in A Farm are numbered 241-A-101 (A-101) through 241-A-106 (A-106). The four underground SSTs in AX Farm include tanks 241-AX-101 (AX-101), 241-AX-102 (AX-102), 241-AX-103 (AX-103), and 241-AX-104 (AX-104).

Scoping and planning phase activities for a new WMA A-AX PA was initiated in FY 2015, largely based on the scoping approach used for the WMA C PA. Work was suspended in FY 2016 due to funding issues and was reinitiated in FY 2017.

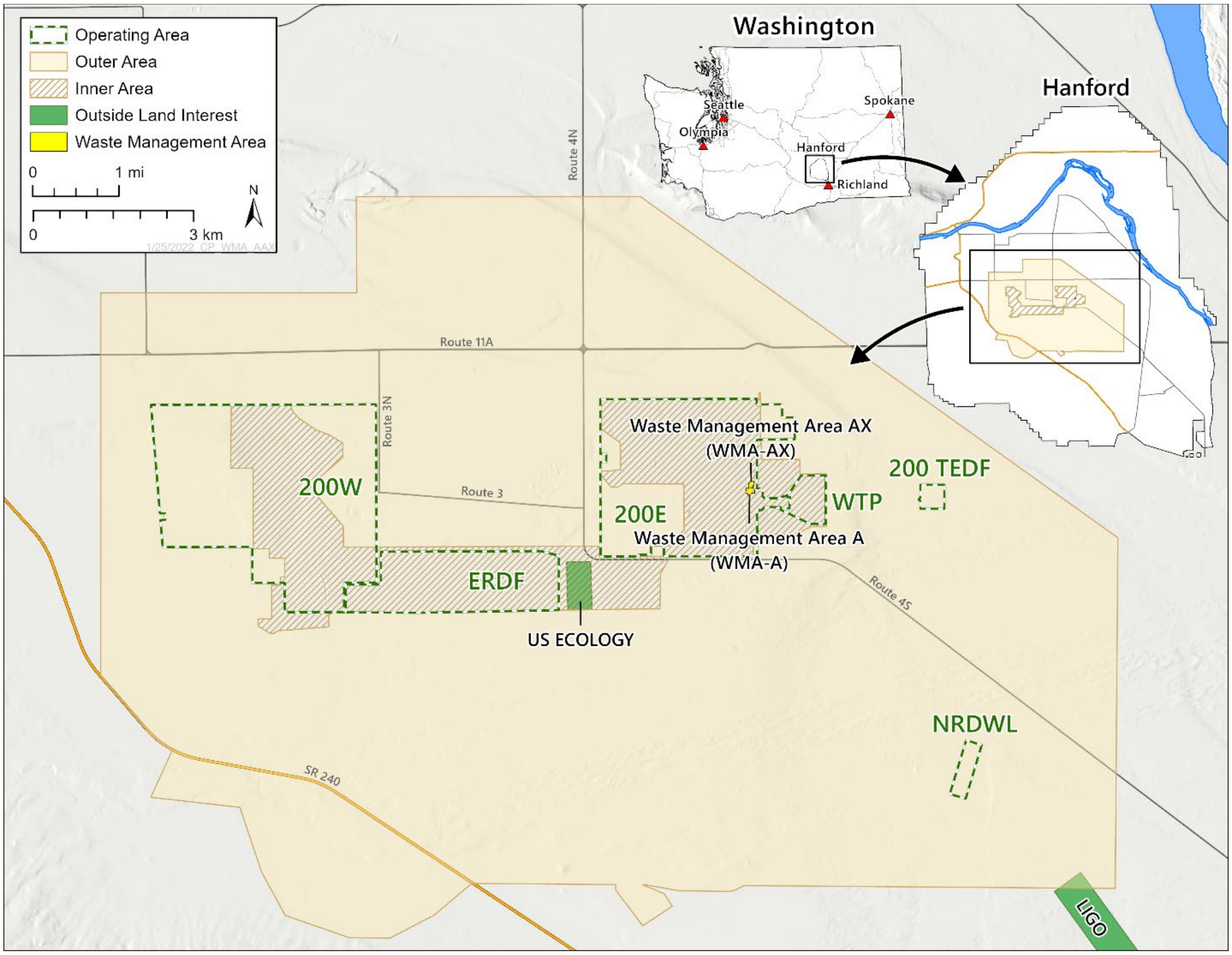

Figure 1-6. Location of Waste Management Area A-AX

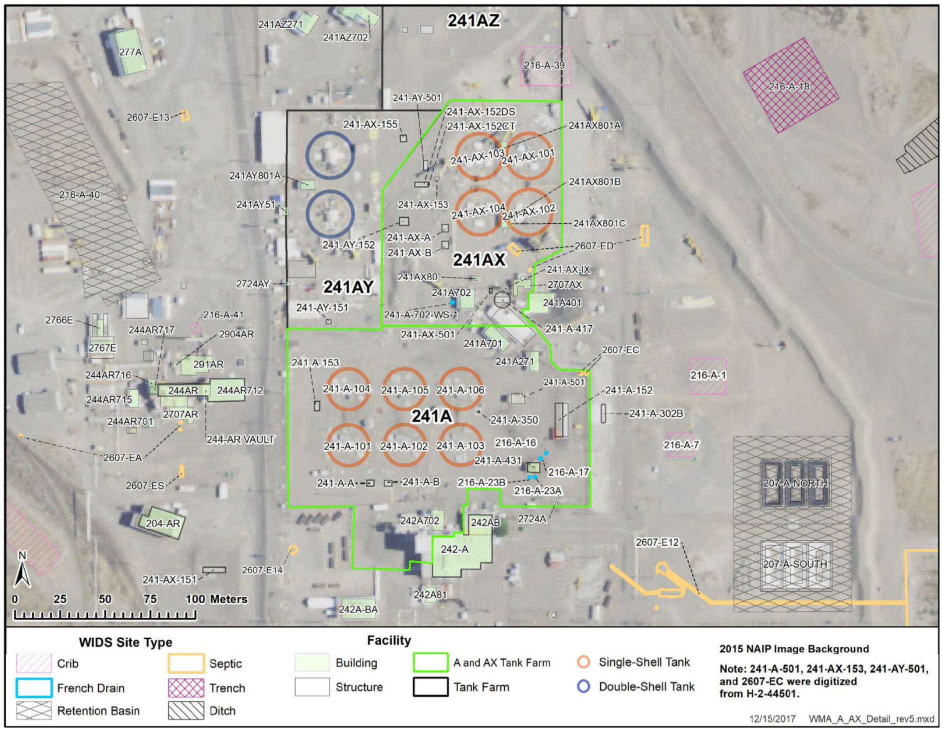

Figure 1-7. Map of 241-A and 241-AX Tank Farms

In FY 2017 and 2018, the preparation of a draft preliminary PA analysis and supporting technical documentation for WMA A-AX was initiated. Other WMA A-AX HFFACO Appendix I PA documentation will be prepared to meet federal, state, and TPA (Ecology et al. 1989a) requirements. The work supports risk assessment and modeling efforts needed to help guide retrieval and RCRA Facility Investigation/Corrective Measures Study characterization activities. The draft preliminary PA documents prepared in FY 2017 and 2018 include model package reports for the geologic framework model and the flow and contaminant transport numerical model, a tank residual data package, a soil inventory data package, and an engineered system data package. Efforts to evaluate the potential impacts from past leaks from WMA A-AX at SST A-105 and A-104 were also initiated.

In FY 2019, a draft preliminary PA for WMA A-AX was prepared to meet the requirements of DOE O 435.1. Other WMA A-AX HFFACO PA documentation (See Appendix in Attachment 2, TPA Action Plan) will be prepared to meet federal, state, and TPA (Ecology et al. 1989a) requirements. The work supports risk assessment and modeling efforts needed to help guide retrieval and RCRA Facility Investigation/Corrective Measures Study characterization

Relevance of the WMA A-AX PA to the Hanford Site Composite Analysis

When complete, the WMA A-AX PA will be supported by the Hanford Site Composite Analysis.

Other PAs discussed in this section were developed to obtain authorization for disposal of radioactive waste in disposal facilities constructed for this purpose. The WMA A-AX PA differs in this respect: its purpose is to authorize closure of a tank waste system with residual waste remaining after retrieval as a disposal system.

As the WMA A-AX PA is completed, the information on residual tank waste inventory and predicted releases will serve to update the basis of the Hanford Site Composite Analysis. Other WMA PAs will follow in the future, providing further refinement.

activities. The draft preliminary PA supporting documents were prepared in CY 2019 that included model package reports of the flow and contaminant transport numerical model and the system model, and environmental model calculation files that document all calculations included in the Preliminary PA. Efforts to evaluate the potential impacts from past leaks from WMA A-AX at SST A-105 and A-104 also continued in FY 2019.

In FY 2020, a preliminary PA for WMA A-AX examined the radiological impacts from residual wastes in a closed WMA A-AX was completed to meet the requirements of DOE O 435.1 and a TPA milestone. The DOE Low-Level Waste Disposal Facility Federal Review Group performed a consultative review of the preliminary PA that was completed in April 2020. Revisions to the preliminary PA to address comments from the Low-Level Waste Disposal Facility Federal Review Group consultative review were completed in September 2020. Additional comments made during the consultative review are being addressed in the final PA before seeking a closure authorization from DOE. A preliminary Closure Analysis, which evaluates the hazardous chemical impacts from residual wastes in a closed WMA A-AX and is complementary to the preliminary PA for WMA A-AX, was also completed as a part of a TPA milestone.

Efforts to evaluate the potential impacts from past leaks from WMA A-AX at SST A-105 and A-104 have also continued in FY 2020.

In FY 2021, the PA and supporting technical documentation has continued to be updated in response to comments made during the consultative review with LFRG that were not addressed in the preliminary PA. Updates to the PA and supporting documentation have also considered additional comments on preliminary PA and the Closure Analysis made by the Washington State Department of Ecology. The next draft revision of the PA will be prepared and submitted for approval by the DOE-ORP in FY 2023 in preparation for the next more formal review of this revised PA by the LFRG currently planned for FY 2024.

1.2 Central Plateau RCRA Remedial Activities

Interim surface barriers have been constructed over portions of the 241-T, 241-TY, 241-SX, and 241-TX Tank Farms. The barriers divert meteoric water away from contaminated vadose zone soils within the tank farms. Infiltration of water into subsurface soils with pre-existing contamination can accelerate the mobilization of contaminants towards the water table. The interim surface barriers at 241-T Tank Farm and 241-TY Tank Farm were constructed as part of the Interim Surface Barrier Demonstration Project (PNNL-16538 and PNNL-19772) and were completed in 2008 and 2010, respectively. The interim surface barriers at 241-SX Tank Farm were completed in 2019, and the interim surface barrier at 241-TX Tank Farm was completed in 2021. The design for a new interim surface barrier at the 241-U Tank Farm was completed in 2021 and construction will complete in 2023.

The temporary structures were constructed as interim measures under agreement between the DOE, Ecology, and EPA. Monitoring is conducted in accordance with RPP-RPT-61684, *Maintenance and Performance Monitoring Plan for the Interim Barriers Program*. The annual interim surface barrier monitoring report for FY 2020 (RPP-RPT-63200, *FY2020 Annual Interim Surface Barrier Monitoring Report) was released in August 2021*.

1.3 Central Plateau CERCLA Remedial Activities

CERCLA remedial activities directed by DOE-RL are pertinent to the Hanford Site Composite Analysis because they result in planned redistributions of radioactive inventory considered in the Hanford Site Composite Analysis in time, location, and waste form. Updated knowledge and information acquired while conducting remedial actions have the potential to change the analysis evaluated in the Hanford Site Composite Analysis; these are reviewed in this section to assess any such impact.

The Central Plateau is located near the middle of the Hanford Site and covers an area of approximately 195 km^2 (75 mi^2). Most activities are concentrated in two main processing areas: the 200 East Area and the 200 West Area. The Central Plateau contains facilities formerly used in the plutonium production process, including five large chemical processing facilities (commonly known as canyons) and the Plutonium Finishing Plant (PFP), which was completely cleaned up as of December 2021, as well as individual waste sites that include both buried solid waste and contaminated soil. Key elements of the Central Plateau are shown on Figure 1-8. The approach for Central Plateau cleanup focuses on the following three major components:

- Inner Area: the final footprint area of the Hanford Site that will be dedicated to waste management and containment of residual contamination.
- Outer Area: contains the balance of the Central Plateau.
- Groundwater: composed of contaminant plumes underlying the Central Plateau and originating from waste sites on the Central Plateau.

Several operating waste disposal facilities in the Inner Area will continue to receive waste from Hanford Site cleanup activities and limited offsite sources. ERDF was constructed for the disposal of waste generated during cleanup of the Hanford Site. Additional cells will be constructed in ERDF as needed to implement cleanup decisions. The LLW or radioactive mixed waste generated from Hanford Site activities may also be disposed in LLBGs or mixed waste trenches, as appropriate. IDF has a final status Hanford RCRA Permit for disposal future of some waste generated from radioactive liquid waste tank cleanup. Additional physical and permit modifications are in progress to enable active operations and include other potential Hanford Site waste streams.

As CERCLA units are remediated, changes will occur in the composite analysis inventory. When waste has been removed from one of these sites, it is considered “generated” waste and is added to the inventory of the specific disposal facility for which it is intended. These inventory changes are tracked in the various PA annual summary reports and have been included in the most recent facility PAs (Chapter 3). These changes will be reflected in the location of the activity but not necessarily as a change in the total site inventory unless unexpected circumstances are encountered. Some residual activity will remain in the waste sites after remediation has been finalized, but it is not expected to contribute significantly at that location in the composite analysis given that cleanup has been based on numerical modeling calculations and meets Washington State regulations.

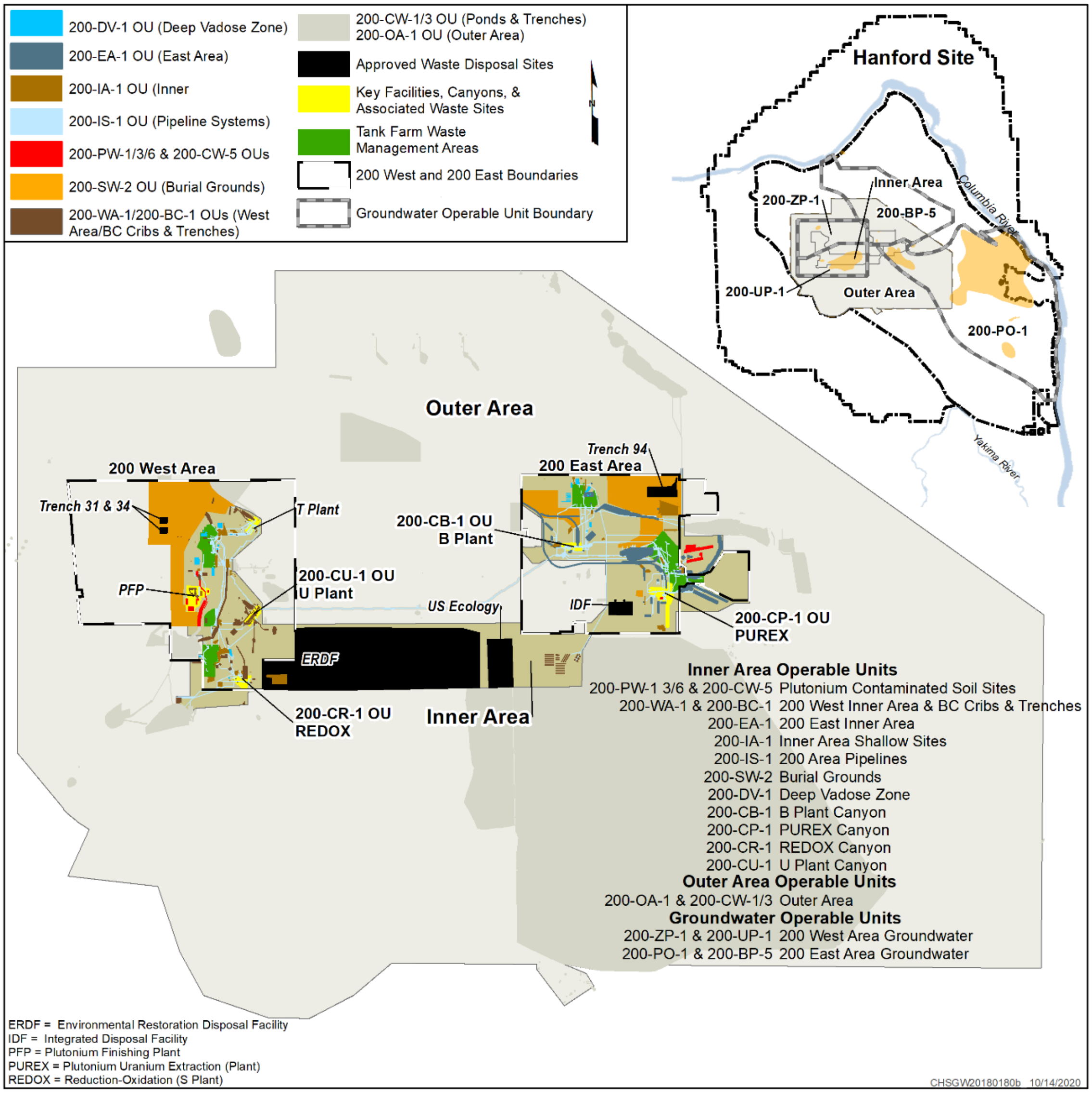

Figure 1-8. Central Plateau CERCLA Remedial Activities and Operable Units

Cleanup activities have already begun for some areas in the Central Plateau. The U Plant facility (221U Building) is one of five massive processing facilities at the Hanford Site. Commonly referred to as a canyon, U Plant was built during World War II to extract plutonium from fuel rods irradiated in Hanford Site production reactors. It was used for training and equipment testing and was later converted to recover uranium from waste generated at other canyon facilities. Issued in October 2005, EPA et al., 2005, *Record of Decision 221-U Facility (Canyon Disposition Initiative) Hanford Site, Washington*, determined that the U Plant Canyon would be disposed in place with a suitable surface barrier to prevent infiltration of water and/or intrusion by human or ecological receptors. In FY 2011, existing contaminated equipment from the canyon deck (near the ground-level portion of the facility) was size-reduced (as necessary), placed in the canyon process cells (below the ground-level portion of the facility), and grouted in place. The upper portion of the canyon building will be demolished to the approximate level of the canyon deck or higher. Debris from the partial demolition will be placed on (or adjacent to) the canyon deck. Appropriate actions (e.g., grouting) will be taken when necessary to minimize void space. The partially demolished building and debris will be covered with a surface barrier.

Final decisions for the remaining canyons and storage tunnels located at the Plutonium-Uranium Extraction (PUREX) Plant will be made as part of future CERCLA and RCRA cleanup decisions.

On May 9, 2017, workers discovered a partial collapse of the timber roof structure in a portion of PUREX Tunnel 1. Actions were immediately taken to protect personnel in the area, monitor for potential releases, notify the regulatory agencies and public of the event, and implement response actions. Initial work included backfilling the collapsed zone with soil to provide radiation shielding, performing contamination control, protecting from ambient conditions, and locally stabilizing the tunnel support structure. The threat of further failure of Tunnel 1 was eliminated by void filling the tunnel with engineered concrete/grout (grout) in FY 2018.

A structural evaluation also identified a future threat of failure for Tunnel 2, which contains 28 railcars with contaminated processing equipment and materials generated during Hanford's weapons production mission. DOE-RL addressed this threat by void filling Tunnel 2 with engineered grout in FY 2019. Grouting was placed in Tunnel 2 from October 2018 through April 26, 2019. The filling required approximately 4,000 truckloads (40,000 yd^3) of grout. Cameras in the tunnel were used to ensure the grout flowed the length of the tunnel and around the contaminated equipment inside. The grout was injected in several lifts, or layers, and each lift was allowed to set before the next began. Final closure of the tunnels will be coordinated with future remedial actions of the PUREX canyon as part of the 200-CP-1 Operable Unit (OU). PNNL-11800, Addendum 1 provides a bounding sensitivity analysis for the impact of the composite analysis results of the PUREX tunnels. The inventories of technetium-99 and iodine-129 as representative mobile constituents were used to evaluate potential impact of the PUREX tunnels. The results of the original composite analysis (PNNL-11800) indicated that these two radionuclides were key constituents in the projected dose and could be used as a general indicator of potential impacts. The inventory of technetium-99 and iodine-129 in the PUREX tunnels was obtained from an in-development inventory database (the best available estimate at that time [2001–02]). Table 1-3 provides the inventory of the PUREX tunnels evaluated in PNNL-11800, Addendum 1.

Table 1-3. Inventory of PUREX Tunnels Evaluated in the Composite Analysis Addendum

Site Name	Best Estimate of Inventory	
	Technetium-99 (Ci)	Iodine-129 (Ci)
218-E-14 (Tunnel 1)	0.27	0.001
218-E-15 (Tunnel 2)	1.6	27
PUREX Plant Tunnels Total	**1.9**	**27***

*The inventory in Tunnel 2 analyzed in PNNL-11800, *Addendum to Composite Analysis for Low Level Waste Disposal in the 200 Area Plateau of the Hanford Site*, Addendum 1, is now considered high. Appendix A of CP-60195, *Hanford Site Composite Analysis Technical Approach Description: Radionuclide Inventory and Waste Site Selection Process*, estimates the inventory of iodine-129 to be in the range 0.60 to 9.49 Ci for the total of processing canyons and PUREX Tunnel 2.

PUREX = Plutonium-Uranium Extraction

The assumed end state for the PUREX tunnels in the composite analysis addendum was injection of grout matrix and placement of an engineered barrier that would reduce facility infiltration rates to 5 mm/yr (PNNL-11800, Addendum 1). The waste form release was assumed to be a diffusion-controlled, cement-release model. The analysis predicted that release would not occur from the PUREX tunnels in the groundwater pathway for the next 500 to 1,000 years. This result was attributed to the assumed end state of grout injection and an engineered barrier. A sensitivity analysis was also evaluated for an upper-end estimate of the inventory, which also predicted no release during the 1,000-year analysis period. The grout fill of void space in PUREX Tunnels 1 and 2 is consistent with the assumed end state in the composite analysis.

Disposition of the remaining facilities (including PFP) is being addressed using a combination of *National Environmental Policy Act of 1969*, CERCLA, and RCRA processes. For example, workers recently completed final cleanup activities at PFP, putting a cap on what was once one of the most hazardous facilities in the DOE complex. Final project demobilization and documentation activities — including pressure-washing equipment, surveying for contamination, and removing fencing — were finished in December 2021. In November 2021, crews spread more than 900 truckloads of sand and gravel over the former plant’s footprint, which once included four large facilities and several support buildings that produced nearly two-thirds of the nation’s supply of plutonium metal and oxides.

Radioactive or other hazardous substances resulting from disposition of facilities are removed and treated (if necessary) and then packaged for disposal in approved disposal facilities. Debris and rubble from the demolition process are disposed onsite at ERDF or offsite in solid waste landfills (SWLs), as appropriate. Limited volumes of transuranic (TRU) wastes generated during demolition are packaged for disposal at the Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico. RCRA closure requirements are integrated into the process, where necessary. Potential subsurface contaminants will be addressed in a manner consistent with waste site remedial alternatives, which are provided in the following discussion.

Approximately 15,000 m^3 (20,000 yd^3) of suspect TRU waste was placed in retrievable storage trenches in four LLBGs beginning in 1970. When waste is retrieved from the trenches, it is characterized to determine whether it is TRU or LLW. Approximately 12,000 m^3 (15,700 yd^3) have been retrieved to date. Following the incident at the WIPP in 2014 that involved an accidental radiological release that involved a three-year shutdown of primary operation, waste shipments from Hanford to WIPP were paused and are still yet to be resumed. Negotiated changes to the TPA call for resumption of TRU waste shipments to WIPP by 2028 with 99 percent of Hanford’s TRU waste emplaced at WIPP by 2040, and a revised deadline of 2050.

The following extensive and significant inventory of radionuclides exists in other forms that require disposition:

- **Cesium and strontium capsules**: Approximately 2,000 cesium and strontium capsules are stored underwater at the Waste Encapsulation and Storage Facility (WESF) are now being transferred to a new dry storage facility for long-term storage. DOE/RL-2012-47, *Mission Needs Statement for the Management of the Cesium and Strontium Capsules*, established an approach for extended storage of the capsules that improves safety and reduces operating costs compared to the current storage configuration by transferring the capsules into dry storage containers to be placed in a RCRA permitted storage area near the WESF. The construction of a new RCRA-permitted capsule storage area began in FY 2020.

  Tri-Party Agreement (Ecology et al., 1989) interim milestone M-092-21 requires the transfer of cesium and strontium capsules from WESF to a new interim dry storage facility by August 31, 2025.

  Tri-Party Agreement Milestone M-092-20 requires completion of a capsules’ disposition pathway evaluation by March 31, 2022, and every 4 years thereafter until a final date for completion is established.

  The capsules are being managed according to the specific hazard they pose to workers, the public, and the environment and as such, are managed as high-activity waste. There has been debate over the years as to whether or not these capsules can be classified as high-level waste (HLW).

If the capsules are eventually classified as HLW, there is no direct disposal option for them with the shutdown of the Yucca Mountain National Repository. OAS-L-14-04, *Audit Report Long-Term Storage of Cesium and Strontium at the Hanford Site*, states that DOE's new goal, as of January 2013, is to have a repository sited by 2026 and to begin operating by 2048. Therefore, an HLW repository will not be available for at least 34 years.

DOE is storing the capsules for the time being, in a manner that is protective of human health and the environment. Because the isotopes in these capsules are short lived, according to 10 CFR 61.55, storage over the next 34 to 50 years will result in considerable reduction in concentration.

- **German log casks**: Pacific Northwest National Laboratory (PNNL) produced 34 borosilicate glass-filled canisters for the Federal Republic of Germany to serve as isotopic heat sources for a repository-testing program. The "German log" casks were shipped to the Central Waste Complex in the 200 West Area in 1997 and are currently managed as remote-handled TRU waste, pending decisions on final disposition.

  The activity level in the German logs is estimated to be 2.1 million Ci of cesium-137 in 2024. Continued storage will be necessary to allow the total activity level to decay before final disposition. Alternative evaluations for Tri-Party Agreement (Ecology et al., 1989) interim Milestone M-091-52 identified a strategy using monitored natural attenuation (MNA) for waste packages containing more than 100 Ci of cesium-137 prior to final disposition (CHPRC-03264, *M-091-52 Alternative Evaluation*).

  Since the issuance of DOE O 435.1, baseline characterization information has been evaluated, and it was determined that the calculated TRU activity for each of the eight German log casks is under 100 nCi/g and could be classified as LLW in accordance with DOE M 435.1-1 (HNF-30810, *Acceptable Knowledge Document for the 325 Building Radiochemistry Laboratory Mixed Debris Waste Stream, RLM325D*). A disposal pathway for the German logs was developed in 2012 that considered disposing the waste at ERDF (CHPRC-1203550, "Contract Number DE-AC06-08RL14788 – Disposal Pathway for Hanford's German Logs"). This disposal pathway was supported by engineering calculations [ECF-Hanford-12-0064, *Preliminary Evaluation of Radiological Dose from Burial of German Logs in a Disposal Facility under the Inadvertent Intruder Scenario per DOE Order 435.1 (Radioactive Waste Management)*; ECF-Hanford-12-0065, *Preliminary Evaluation of Thermal Effects from Burial of German Logs in a Disposal Facility*].

- **Spent nuclear fuel is stored in multi-canister overpacks at the Canister Storage Building in the 200 East Area**: Examples include N Reactor and single-pass production reactor fuel received from the K Basins and Shippingport pressurized water reactor core blanket fuel assemblies. Located adjacent to the Canister Storage Building, the 200 Area Interim Storage Area is used to store other nondefense-related spent nuclear fuel in aboveground dry cask storage containers, including material from the Fast Flux Test Facility, commercial origin light water reactor spent nuclear fuel, and TRIGA® (a class of small research nuclear reactors) from the Neutron Radiography Facility and Oregon State University. The Canister Storage Building/interim storage area is designed for interim storage until a suitable, long-term repository is established.

The Central Plateau includes more than 800 soil waste sites consisting of cribs, ponds, ditches, trenches, landfills, pipelines, diversions boxes, unplanned releases, and other types of sites used for liquid or solid waste disposal. Remedial or interim removal actions have been conducted for some of the soil waste sites located in the Outer Area. Sites in the 200 North Area have been remediated in accordance with

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EPA/ROD/R10-99/039, *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington (100 Area Remaining Sites)*, issued in 1999. Interim action has been conducted in other parts of the Outer Area to remove surface and shallow contamination and reduce the footprint of areas requiring radiological controls.

Issued in September 2011, EPA et al., 2011, *Record of Decision Hanford 200 Area Superfund Site 200-CW-5 and 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units*, provided remedies for 20 plutonium-contaminated soil waste sites and pipelines in the 200 West Area (near PFP) and five cesium-contaminated soil waste sites in the 200 East Area. The selected remedies included removing, treating, and disposing plutonium-contaminated sludge and soils at 18 sites; constructing a surface barrier over the remaining waste at 9 of the 18 sites; and enhancing existing soil covers over 3 of the 5 cesium-contaminated sites. Two plutonium-contaminated and two cesium-contaminated sites were determined to pose no threat to human health and the environment and require no remedial action.

Implementation of the selected remedies is described in DOE/RL-2015-23, *Remedial Design/Remedial Action Work Plan for the 200-CW-5, 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units* (hereinafter referred to as the remedial design/remedial action work plan [RD/RAWP]), approved by DOE-RL and EPA in May 2016 (16-AMRP-0187, "Remedial Design/Remedial Action Work Plan for the 200-CW-5, 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units, DOE/RL-2015-23, Revision 0, Sampling And Analysis Plan for the 200-CW-5, 200-PW-1, and 200-PW-6 Operable Units, DOE/RL-2015-22, Revision 0"). Excavated soils that meet ERDF waste acceptance criteria (ERDF-00011, *Environmental Restoration Disposal Facility Waste Acceptance Criteria*) will be disposed at ERDF. Excavated soils and sludge from 12 of the sites are expected to require disposal at the Waste Isolation Pilot Plant as TRU waste.

Two additional waste sites on the Central Plateau (inactive Nonradioactive Dangerous Waste Landfill [NRDWL] and adjacent inactive SWL) located outside of the 200 Areas are to be closed in accordance with a closure plan being negotiated with Ecology.

Remediation of the remaining Central Plateau soil waste sites will be completed in accordance with CERCLA and RCRA corrective action requirements. CERCLA guidance requires that a range of alternatives be evaluated, including the following:

- No action
- Removal of contaminants as the primary remedy
- Containment as the predominant remedy
- Treatment of the contaminants to reduce their toxicity, mobility, or volume as the primary remedy

Evaluation of remedial alternatives conducted for the Central Plateau OUs will consider these and other alternatives that use a combination of those key features.

Alternatives that involve removal will include treatment (where appropriate) and disposal in an approved facility such as ERDF. Containment remedies may involve maintaining or enhancing existing soil covers, capping with suitable engineered surface barrier, or performing other containment remedies. Treatment-based remedies may involve MNA to allow radioactive materials to decay, immobilization, or other forms of treatment. Surface barriers will be designed to limit the infiltration of water and thereby slow the movement of contaminants currently in the vadose zone into the underlying groundwater. Barriers will also be designed to prevent intrusion by plants and animals so that underlying contamination is not dispersed.

All alternatives are expected to result in the need for institutional controls (ICs) as long as the hazards are present to maintain environmental monitoring and surface barriers, limit access to authorized users, and prevent unapproved excavation and inadvertent intrusion. DOE-RL has committed to retain the Central Plateau and other areas of the Hanford Site under federal control for the foreseeable future.

1.3.1 Central Plateau Source Operable Units

The CPCCo Soil and Groundwater Operations and Regulator Strategy and Integration organizations implements the RI/FS process for several source OUs in the Central Plateau. Since the inception of CERCLA programs at the Central Plateau, the configuration of the waste site OUs has been modified as needed to support the RI/FS process. In 2010, DOE, EPA, and Ecology (hereinafter collectively referred to as the Tri-Parties) agreed to restructure the OUs to promote consistency in decision making and facilitate a geographic approach to implementing cleanup. Some of the existing OUs were retained, while others were absorbed into new geographic-based OUs. In 2020, selected waste sites in the 200-WA-1 and 200-EA-1 OUs were identified as part of a joint activity with the Tri-Parties known as the Representative/Analogous Sites Coordinating Agency Liaisons (RASCAL) initiative. The RASCAL initiative selected waste sites with shallow contamination (typically <15 ft below grade) and transferred them into a new 200-IA-1OU to simplify the characterization approach and accelerate remediation for those sites. Table 1-4 lists the current Central Plateau source OUs and FY 2021 activity. The location of the OUs and key facilities is depicted in Figure 1-8.

The decision-making process for these OUs will incorporate data and analyses previously conducted for the predecessor OUs, as appropriate. The OUs listed in Table 1-4 are subject to completion of the RI/FS process and remediation in accordance with the negotiated major and interim Tri-Party Agreement (Ecology et al., 1989) milestones to track the progress listed in Table 1-5.

Table 1-4. Central Plateau Source Operable Unit Activity During Fiscal Year 2021

OU Group	Description	FY 2020 Activity
Inner Area		
200-PW-1/3/6 and 200-CW-5	Plutonium-contaminated soil sites located near PFP and cesium-contaminated sites near PUREX	Stabilization of two waste sites in the 200-PW-1 OU (216-Z-9 and 241-Z-361) was completed in FY 2021 to mitigate the risk of age-related failure by filling the void spaces with engineered grout. The stabilization action will not preclude future remedial action as stabilization is part of the selected remedy for both sites.
200-WA-1 and 200-BC-1	Soil waste sites located in the 200 West Inner Area that are not included in the 200-SW-2, 200-CR-1, 200-PW-1/6, 200-CW-5, 200-IS-1, and 200-IA-1 OUs Soil waste sites in the BC cribs and trenches	Characterization activities in accordance with the approved RI/FS work plan (DOE/RL-2010-49) are on hold pending available funding. Revision of the work plan to incorporate the RASCAL approach was initiated in FY 2021.
200-EA-1	200 East Inner Area sites not included in the 200-SW-2, 200-CB-1, 200-CP-1, 200-PW-3, and 200-IA-1 OUs	No activity in FY 2021. Work will resume subject to available funding.
200-IS-1	Pipelines, diversion boxes, catch tanks, and neutralization tanks in the 200-IS-1 OU	No activity in FY 2021. Work will resume subject to available funding.

Table 1-4. Central Plateau Source Operable Unit Activity During Fiscal Year 2021

OU Group	Description	FY 2020 Activity
200-SW-2	Solid Waste Burial Grounds and waste sites in the footprint of the burial grounds	No activity in FY 2021. Work will resume subject to available funding.
200-DV-1	Selected soil waste sites in the Inner Area with deep vadose zone contamination	The laboratory analysis of PCB congener samples collected in FY 2020 and the updating of data summary reports continued into FY 2021. Extraction and treatment of uranium-contaminated water in the perched zone continues in accordance with the Removal Action Work Plan (DOE/RL-2014-37). A new perched water extraction well was drilled in FY 2021. Drilling of a second new perched water well will be completed in FY 2022. To date, approximately 8 million L (1.8 million gal) of perched water has been treated to remove more than 350 kg of uranium. Additional laboratory-scale treatability testing of deep vadose zone remediation technologies will be performed in accordance with the 200-DV-1 Laboratory Test Plan (DOE/RL-2019-28) subject to available funding.
200-IA-1	Selected waste sites with shallow contamination suitable for simplified characterization and accelerated remediation	Preparation of a draft focused feasibility study was initiated in FY 2021.
200-CB-1	B Plant Canyon Associated waste sites	No activity in FY 2021. Work will resume subject to available funding. Removal actions for stabilization/mitigation of canyon hazards and removal of nearby structures being planned in accordance with CERCLA policies.
200-CP-1	PUREX Canyon Associated waste sites	Ecology comments were received on the draft RI/FS work plan for the 200-CP-1 OU (DOE/RL-2020-27) in FY 2021. Responses to comments were developed and provided to Ecology. Resolution of Ecology comments will continue in FY 2022. Removal actions for stabilization/mitigation of canyon hazards and removal of nearby structures being planned in accordance with CERCLA policies.
200-CR-1	REDOX Canyon Associated waste sites	No activity in FY 2021. Work will resume subject to available funding. Removal actions for stabilization/mitigation of canyon hazards and removal of nearby structures being planned in accordance with CERCLA policies.
200-CU-1	U Plant Canyon Associated structures	No activity in FY 2021. Work will resume subject to available funding.
Outer Area		
200-OA-1, 200-CW-1, and 200-CW-3	Sites located in the Outer Area	No activity in FY 2021. Work will resume subject to available funding. Removal actions for confirmatory sampling of selected waste sites in the 200-OA-1 OU is planned for FY 2022.

Note: Complete reference citations are provided in Chapter 9 of this document.

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
Ecology = Washington State Department of Ecology
FS = feasibility study
FY = fiscal year
OU = operable unit
PCB = polychlorinated biphenyl
PFP = Plutonium Finishing Plant
PUREX = Plutonium-Uranium Extraction
RASCAL = Representative/Analogous Sites Coordinating Agency Liaisons
REDOX = Reduction-Oxidation (Plant)
RI = remedial investigation

Table 1-5. Central Plateau CERCLA/RCRA Deliverables, Fiscal Years 2017 Through 2023

Tri-Party Agreement Milestone Number	Title	Due Date	Status	Completion Date
M-015-21A	*Submit 200-BP-5 and 200-PO-1 OU FS Report & Proposed Plan(s) for an Interim Action to Ecology*	March 31, 2019	Completed	March 27, 2019
M-015-38B	*Submit a FS Report & PP for 200-CW-1, 200-CW-3 & 200-OA-1 OUs to EPA*	July 31, 2023	In negotiation	In progress
M-015-84	*Complete RI of 200-WA-1 and 200-BC-1 Waste Sites in Accordance with RI/FS Work Plan*	December 31, 2021	In negotiation	In progress
M-015-91B	*Submit FS Report & Proposed Plan for the 200-BC-1/200-WA-1 OUs to EPA*	July 31, 2023	In negotiation	In progress
M-015-92A	*Submit RCRA RFI/CMS & RI/FS Work Plan for 200-EA-1 OU to Ecology*	July 31, 2018	Completed	July 12, 2018
M-015-92B	*Submit RFI/CMS & RI/FS Report & PCAD/PP for 200-EA-1 OU to Ecology*	November 30, 2022	In negotiation	In progress
M-015-92C	*Submit RFI/CMS and RI/FS Report and PCAD/PP for 200-IS-1 OU to Ecology*	March 31, 2023	In negotiation	In progress
M-015-93B	*Submit RCRA FI/CMS & RI/FS Report & Proposed CA Decision/PP for 200-SW-2 OU*	January 31, 2023	In negotiation	In progress
M-015-93C	*Initiate Characterization Field Work for 200-SW-2 OU Landfills*	September 30, 2018	In negotiation	In progress
M-015-98	*Complete RI of U Plant Related Waste Sites Located in 200-WA-1*	June 30, 2019	In negotiation	In progress
M-015-99	*Complete RI of PFP Related Waste Sites Located in 200-WA-1*	December 31, 2019	In negotiation	In progress
M-015-110B	*Submit CMS & FS & Proposed Plan/CA Decision for 200-DV-1 OU to Ecology*	September 30, 2023	In negotiation	In progress
M-015-112	*Submit Draft B 200-IS-1 RFI/CMS/RI/FS Work Plan to Ecology with Schedule Dates*	November 30, 2020	In negotiation	In progress
M-016-193	*Investigate Southeast Chromium Plume, Install Wells, Evaluate Groundwater Monitoring Data, & Install Monitoring Wells*	September 30, 2018	Completed	September 25, 2018
M-016-250B	*Submit a 3-Year Rolling Prioritized Schedule to Implement Waste Site Removal Actions*	March 31, 2017	Completed	March 30, 2017
M-016-250C	*Submit a 3-Year Rolling Prioritized Schedule to Implement Waste Site Removal Actions*	March 31, 2018	Completed	March 28, 2018

Table 1-5. Central Plateau CERCLA/RCRA Deliverables, Fiscal Years 2017 Through 2023

Tri-Party Agreement Milestone Number	Title	Due Date	Status	Completion Date
M-016-250D	*Submit a 3-Year Rolling Prioritized Schedule to Implement Waste Site Removal Actions*	March 31, 2019	Completed	March 27, 2019
M-016-250E	*Submit a 3-Year Rolling Prioritized Schedule to Implement Waste Site Removal Actions*	September 30, 2020	Completed	September 30, 2020
M-016-250F	*Submit a 3-Year Rolling Prioritized Schedule to Implement Waste Site Removal Actions*	March 31, 2021	On schedule	In progress
M-016-250G	*Submit a 3-Year Rolling Prioritized Schedule to Implement Waste Site Removal Actions*	March 31, 2022	On schedule	In progress
M-016-250H	*Submit a 3-Year Rolling Prioritized Schedule to Implement Waste Site Removal Actions*	March 31, 2023	On schedule	In progress
M-016-257	*Complete CS/NFA for All Waste Sites as Identified in CCF M-16-20-01 in FY2021*	September 30, 2021	On schedule	In progress
M-016-258	*Complete CS/NFA and RTD for All Waste Sites as Identified in CCF M-16-20-01 in FY2022*	September 30, 2022	On schedule	In progress
M-016-259	*Complete RTD for All Waste Sites as Identified in CCF M-16-21-01 in FY2023*	September 30, 2023	On schedule	In progress
M-085-70	*Submit RI/FS Work Plan for 200-CB-1*	September 30, 2019	In negotiation	In progress
M-085-72	*Submit Removal Action Work Plan for 224-B*	September 30, 2020	Completed	September 19, 2019
M-085-74	*Submit Approval Proposal(s) for Expedited Response Action(s) for Tier 1 & 2 Facilities in B Plant*	June 30, 2018	Completed	November 17, 2016
M-085-80	*Submit RI/FS Work Plan for 200-CP-1*	September 30, 2020	Completed	September 22, 2020
M-085-80A	*Submit Data Quality Objective Report to Ecology on Structural Integrity of the PUREX Storage Tunnels 1 and 2*	September 30, 2017	Completed	September 12, 2017
M-085-82	*Submit Approval Proposals(s) for Expedited Response Action(s) for Tier 1 & 2 Facilities in PUREX*	December 31, 2017	Completed	December 7, 2017
M-085-100	*Submit Removal Action Work Plan for 224-T*	September 30, 2020	Completed	August 12, 2020

Tri-Party Agreement = Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order*

1.3.2 Central Plateau Groundwater Operable Units

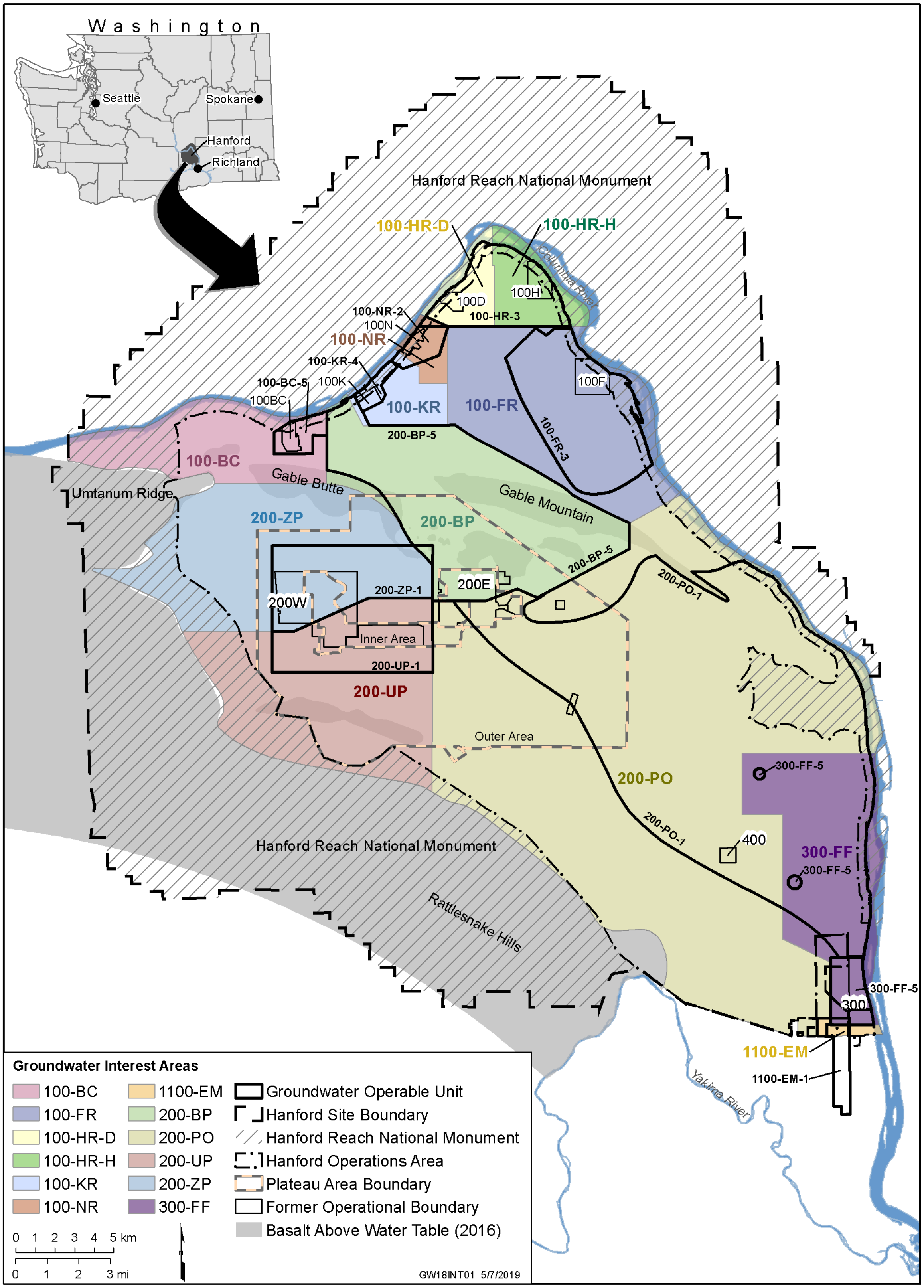
This section presents the results of the DOE-RL groundwater monitoring program for the Central Plateau groundwater OUs for CY 2020 (January 1, 2020 through December 31, 2020) relating to the Hanford Site Composite Analysis. The groundwater monitoring data and interpreted results for CY 2020 are drawn from information presented in DOE/RL-2020-60, *Hanford Site Groundwater Monitoring Report for 2020*, which describes the monitoring results for RCRA treatment, storage, and disposal (TSD) units; CERCLA groundwater OUs; and the *Atomic Energy Act of 1954* (AEA), as required by DOE orders.

1.3.2.1 Central Plateau Groundwater Background

When the Hanford Site was in operation, irradiated fuel reprocessing, isotope recovery, and associated waste management activities occurred on the Central Plateau. Since the 1990s, DOE-RL has worked to characterize, contain, and treat groundwater and to remove and dispose soil contamination from past operations from all onsite locations. The contaminant sources primarily included unlined cribs, trenches, ponds, ditches, and leakage from underground storage tanks (in WMAs).

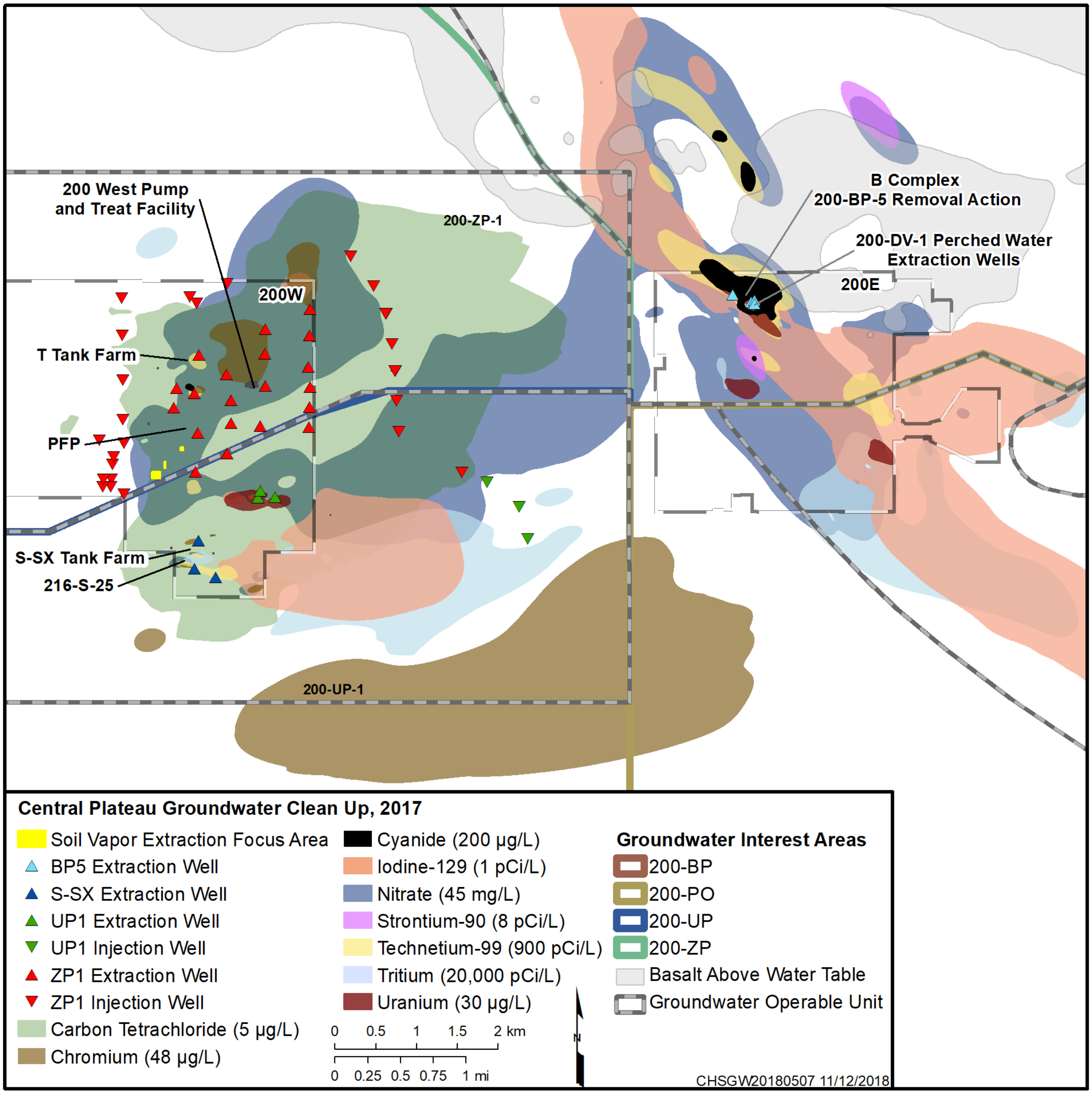
Figure 1-9 shows the locations and boundaries of the Hanford Site groundwater OUs and groundwater interest areas. Four groundwater OUs are located within the Central Plateau, and four groundwater interest areas are associated with the OUs. The groundwater OUs are the 200-ZP-1 and 200-UP-1 OUs in the 200 West Area, and the 200-BP-5 and 200-PO-1 OUs in the 200 East Area. Figure 1-10 depicts the extent of groundwater contaminant plumes above cleanup standards in 2020 and the active cleanup systems. Activities for each of the four groundwater OUs that provide new information on radionuclide constituents relevant to the Hanford Site Composite Analysis are discussed below. Remedial actions directed at nonradioactive contaminants are also discussed wherever it was deemed that these actions could potentially influence the characterization, extent, or remediation of radioactive constituents and thereby become relevant to the Hanford Site Composite Analysis.

Cleanup activities on the Central Plateau are being performed to protect human health and the environment, and the Columbia River. Consistent with strategy for Hanford Site remediation (DOE/RL-2009-10, *Hanford Site Cleanup Completion Framework*), more progress has been made remediating waste sites within the River Corridor compared with the Central Plateau to reduce the active cleanup footprint to the 195 km^2 (75 mi^2) in the center of the Hanford Site. Remediation of the Central Plateau waste sites is expected to accelerate once many of the River Corridor sites transition into long-term stewardship. Until that time, cleanup activities on the Central Plateau are focused on completing decision documents, remediating groundwater plumes in the 200 East and 200 West Areas, decontaminating and decommissioning facilities (including PFP), and initiating waste site cleanup in the Outer Area.



Source: Figure 1-1 in DOE/RL-2020-60, *Hanford Site Groundwater Monitoring Report for 2020.*

Figure 1-9. Hanford Site Groundwater Interest Areas and Groundwater Operable Units



Source: Plume contours from Figure ES-7 in DOE/RL-2020-60, *Hanford Site Groundwater Monitoring Report for 2020*.

Figure 1-10. Central Plateau Groundwater Contaminant Plumes and Cleanup

1.3.2.2 Central Plateau Groundwater Decisions

Groundwater interim and final remedial actions either were operated during the reporting period or were active in the recent past, including those in the 200-ZP-1 OU (soil vapor extraction [SVE] and groundwater pump and treat [P&T]), 200-UP-1 OU (groundwater P&T), and 200-BP-5 OU (groundwater P&T and perched water P&T). The remedial actions and supporting key documentation are as follows:

- **200-UP-1 OU interim remedial action (1997 and amended in 2009)**: A pilot-scale treatability test (DOE/RL-95-02, *Treatability Test Report for the 200-UP-1 Operable Unit – Hanford Site*) consisting of an onsite treatment system and single extraction and injection wells was conducted adjacent to the

216-U-17 Crib. Phase I P&T operations commenced on September 25, 1995 and continued until February 7, 1997. The treatability test demonstrated that the ion exchange resin and granular activated carbon effectively removed technetium-99, uranium, and carbon tetrachloride from groundwater. On February 25, 1997, EPA/ROD/R10-97/048, *Interim Remedial Action Record of Decision for the 200-UP-1 Operable Unit, Hanford Site, Benton County, Washington*, was issued.

This cleanup action started in 1997 and included operation of extraction wells and transfer of extracted groundwater to the 200 East Effluent Treatment Facility (ETF) for treatment with ultimate infiltration of the treated water at the State-Approved Land Disposal Site (SALDS) located immediately north of 200 West Area. The remedial action objectives were met, and the system was shut down in 2011. This ROD was amended through an explanation of significant differences in 2009 (EPA et al., 2009a, *Explanation of Significant Differences for the Interim Action Record of Decision for the 200-UP-1 Groundwater Operable Unit Hanford Site Benton County, Washington*), which updated the uranium cleanup level from 48 to 30 µg/L. This system removed nearly 886 million L (234 million gal) of contaminated groundwater with 220 kg of uranium, 127 g (2 Ci) of technetium-99, 41 kg of carbon tetrachloride, and 49,000 kg of nitrate.

- **WMA S-SX groundwater extraction system**: A groundwater extraction system for technetium-99 at the WMA S-SX Tank Farms was implemented under the revised DOE/RL-97-36, *200-UP-1 Groundwater Remedial Design/Remedial Action Work Plan*, and began operating in CY 2012. The design consists of a three-well extraction system, aboveground pipelines, and a transfer building to pump extracted groundwater to 200 West P&T. This system was designed for a nominal combined flow rate of 300 L/min (80 gal/min). Extracted groundwater co-contaminants are also treated through the 200 West P&T. During CY 2020, 157 million L (41.5 million gal) of water were pumped and treated, removing 0.24 Ci (13.9g) of technetium-99 from the aquifer (plus 0.9 kg of chromium and 10.72 kg of carbon tetrachloride). From system inception through CY 2020, 1.3 billion L (343.8 million gal) of water were pumped and treated, removing 3. 53 Ci of technetium-99 from the aquifer.

- **200-UP-1 OU interim action ROD (2012)**: The 1997 ROD was superseded by an interim action ROD approved in September 2012 (EPA et al., 2012, *Record of Decision for Interim Remedial Action Hanford 200 Area Superfund Site 200-UP-1 Operable Unit*) that addresses contamination within the entire OU. The selected remedies identified in the 2012 ROD include a combination of groundwater P&T, MNA, hydraulic containment, and ICs.

  An RD/RAWP (DOE/RL-2013-07, *200-UP-1 Groundwater Operable Unit Remedial Design/Remedial Action Work Plan*) was developed to implement the 2012 ROD. The WMA S-SX groundwater extraction system will continue as a remedy under the work plan, and it is being operated in accordance with the requirements of the 2012 ROD.

  In CY 2015, a P&T system for the uranium, technetium-99, and nitrate plumes near U Plant and injection wells for hydraulic containment of the iodine-129 plume were implemented as part of the 200-UP-1 OU groundwater remedy. Operation of both remedies started in late CY 2015.

  The U Plant P&T system consists of three extraction wells and aboveground, dual-walled pipelines to convey extracted groundwater to the 200 West P&T radiological building for treatment. The U Plant P&T system was designed to operate at a nominal combined flow rate of 568 L/min (150 gal/min). The combined flow rate from the three extraction wells in 2020 was567 L/min (150 gal/min). The total volume of water extracted from the aquifer during 2020 was299 million L (79 million gal/min), removing 23 kg of carbon tetrachloride, 0.09 Ci of technetium-99, and 10.2 kg of uranium. From system inception through CY 2020, 1.58 billion L (418 million gal) of water were pumped and treated, removing128.3 kg of carbon tetrachloride, 101,3709 kg of nitrate, 1.25 Ci of technetium-99, and 67.5 kg of uranium from the aquifer.

The iodine-129 plume hydraulic containment system consists of three injection wells where treated effluent from the 200 West P&T is injected at a nominal flow rate of 189 to 379 L/min (50 to 100 gal/min) per well. The wells are located east of the iodine-129 plume boundary. Operation of these wells slows eastward plume migration by increasing the water table elevation downgradient of the plume. The combined average flow rate for all three wells in CY 2020 was778 L/min (206 gal/min). The total volume of water injected into the aquifer during 2020 was 410 million L (108 million gal). Since startup in October 2015, the total volume of water injected into the aquifer was 2.0 billion L (532.9 million gal).

- **200-ZP-1 OU interim remedial action (1995)**: In 1996, a groundwater P&T system was implemented to reduce the mass of carbon tetrachloride and contain the plume where concentrations exceeded 2 mg/L. This action was completed, and the interim P&T system was deactivated in 2012. EPA/ROD/R10-95/114, *EPA Superfund Record of Decision: Hanford 200-Area (USDOE) OU 200-ZP-1, Benton County, WA 5/254/95*, was issued on June 5, 1995.

  SVE was implemented as an expedited response action to remove and treat carbon tetrachloride contamination in the vadose zone at 200-PW-1 OU waste sites. The SVE systems that operated from 1992 to 2012 were effective in removing and treating carbon tetrachloride. SVE was incorporated into the September 2011 ROD (EPA et al., 2011) for the vadose waste sites. The systems were maintained in standby mode from October 2012 through 2015 to allow sufficient time for carbon tetrachloride vapor concentrations to rebound. The results for 2014 and 2015 rebound sampling are reported in DOE/RL-2014-48, *Response Action Report for the 200-PW-1 Operable Unit Soil Vapor Extraction Remediation*. Calculations presented in the response action report indicate that remaining contamination in the vadose zone is not causing groundwater cleanup levels to be exceeded. The response action report established that the removal and remedial actions for carbon tetrachloride and methylene chloride in the vadose zone at the 200-PW-1 OU carbon tetrachloride waste sites have achieved the remedial action objective applicable to the SVE remedy in the 200-PW-1 OU ROD. The SVE removed over 80,000 kg of carbon tetrachloride during its operation between 1992 and 2012 (DOE/RL-2014-48, Chapter 3). In August 2016, DOE-RL and EPA approved DOE/RL-2014-48, thereby closing the SVE remedy and permanently discontinuing SVE operations and vadose zone monitoring.

- **200-ZP-1 OU ROD (2008)**: The use of P&T technology, MNA, flow-path control, and ICs to remediate contaminated groundwater are identified in EPA et al., 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington*. Groundwater pumping from this activity affects the direction of groundwater flow and the levels of carbon tetrachloride present in the 200 West Area (including the 200-UP-1 OU). Commencing operation in 2012, 200 West P&T receives extracted groundwater from the 200-ZP-1, 200-UP-1, and 200-BP-5 OUs; extracted perched water from the 200-DV-1 OU; and leachate from ERDF. In 2018, conveyance piping was installed to transfer and treat purgewater from the modular storage units (MSUs) to the 200 West P&T as part of an optimization pilot test (DOE/RL-2018-28, *Optimization Test Plan for Treating Water from Modular Storage Units at 200 West Pump and Treat Facility*). The MSU pilot test demonstrated that MSU water can be successfully treated at the 200 West P&T without impact to the facility operations (DOE/RL-2018-70, *Optimization Pilot Test Results of Treating Water from Modular Storage Units at 200 West Pump & Treat Facility*), making the transfer of MSU purgewater from the MSUs to the 200 West P&T a routine feed stream.

In 2019, an optimization study (DOE/RL 2019 38, *200-ZP-1 Operable Unit Optimization Study Plan*) was initiated to evaluate treatment facility modifications, 200 West P&T operational effectiveness, and cost implications for increasing the 200 West P&T treatment design capacity for carbon tetrachloride. Implementation of the optimization study provides an overall approach to conduct well network optimization to increase overall treatment capacity and accelerate carbon tetrachloride treatment and mass removal. The study will also evaluate transitioning to MNA for nitrate and the effect of suspending the biological treatment component of the 200 West P&T. In 2020, the optimization study implementation continued with layup activities of the biological treatment processes and equipment (suspension of biological treatment for nitrate), which increased the volume of water treated in 2020.

The total volume treated in CY 2020 through the 200 West P&T was 4.32 billion L (1.14 billion gal), removing 1,999 kg of carbon tetrachloride, 6.54 kg of chromium (total and hexavalent chromium (Cr(VI)),11.3 kg of trichloroethene (TCE); and 111 g (1.90 Ci) of technetium-99. Iodine-129 removal was negligible: 2020 concentrations were at or below the minimum detectable activity in over 50% of the influent and effluent samples.

- **200-PO-1 OU RI (2012)**: The final RI for the 200-PO-1 OU was completed and released in 2012 (DOE/RL-2009-85, *Remedial Investigation Report for the 200-PO-1 Groundwater Operable Unit*). An RI addendum report (DOE/RL-2009-85-ADD1, *Remedial Investigation Report for the 200-PO-1 Groundwater Operable Unit Addendum 1*) released in September 2018 updated the risk assessment and contaminants of potential concern (COPCs) for the OU. The report recommended that the OU should advance to the next step in the CERCLA process, which is an FS to develop alternatives to remediate groundwater contamination. The RI identified tritium, iodine-129, nitrate, strontium-90, technetium-99, gross alpha, sulfate, and uranium as final COPCs.

  DOE-RL prepared a deep vadose zone (DVZ) treatability test plan in 2007 to study the effects of desiccation on soil-bound contaminants. The work began at the BC Cribs and Trenches in the 200-BC-1 OU in November 2010, with nitrogen injection and vacuum extraction concluding in June 2011. Two treatability test reports were published, with the final report issued in May 2012:

  - DOE/RL-2007-56, *Deep Vadose Zone Treatability Test Plan for the Hanford Central Plateau*
  - DOE/RL-2012-34, *Deep Vadose Zone Treatability Test for the Hanford Central Plateau: Soil Desiccation Pilot Test Results*

  Since 2011, post-test monitoring has been conducted and reported annually. Post-test monitoring concluded in 2017, and a final comprehensive post-test monitoring report was issued in February 2018 (PNNL-26902, *Deep Vadose Zone Treatability Test of Soil Desiccation for the Hanford Central Plateau: Final Report*). Overall, the desiccation test at the 200-BC-1 OU field test site provides sufficient information for desiccation to be applied in conjunction with a surface infiltration barrier and to be considered as a potential vadose zone remedy in future feasibility studies.

- **200-BP-5 OU RI (2013)**: Issued in September 2018, DOE/RL-2009-127, *Remedial Investigation Report for the 200-BP-5 Groundwater Operable Unit*, describes the nature and extent of contamination and identifies COPCs to support a future FS. This RI identified 15 COPCs: arsenic, cesium-137, cobalt-60, cyanide, Cr(VI), fluoride, gross alpha, iodine-129, nitrate, plutonium-239/240, strontium-90, sulfate, technetium-99, tritium, and uranium. An interim action FS covering both 200-BP-5 and 200-PO-1 OUs (DOE/RL-2018-30) was issued in December 2019 to target remediation of uranium and technetium-99 groundwater contaminants. The proposed plan (DOE/RL-2018-58) was issued in March 2020 for public comment in May 2020. The preferred alternative includes P&T

to capture and remove uranium and technetium-99 from groundwater in the B Complex plume area, and the C Farm and A-AX Farms plume area. Extracted groundwater would be transferred to the 200 West P&T for treatment. This alternative also includes ICs to prevent exposure to contaminated groundwater until cleanup levels are achieved.

- **200-BP-5 OU Treatability Test (2015)**: A three-phase treatability test was initiated in September 2015 (DOE/RL-2010-74, *Treatability Test Plan for the 200-BP-5 Groundwater Operable Unit*). The test consisted of one extraction well located west of the BY Tank Farm. Conveyance of the extracted groundwater to the 200 West P&T radiological building for treatment was completed through an aboveground, dual-walled pipeline. Testing continued through November 19, 2015. The total volume of water extracted from the aquifer during the test was 17.5 million L (4.62 million gal), removing 2.25 kg of uranium and 0.13 Ci of technetium-99. Other contaminants of concern (COCs) removed included 7,419 kg of nitrate, 6.1 kg of cyanide, 0.19 Ci of tritium, and 3.08E-05 Ci of iodine-129. Based on the test results, extraction continued into 2016.

- **200-BP-5 OU removal action (2016)**: An engineering evaluation/cost analysis (EE/CA) was submitted to Ecology in June 2015 (DOE/RL-2015-26, *Engineering Evaluation/Cost Analysis for 200-BP-5 Operable Unit Groundwater Extraction*, to transition the extraction of contaminated water from a treatability test to a non-time-critical removal action (NTCRA). Approved in December 2016 by the Tri-Parties with the issuance of DOE/RL-2016-41, *Action Memorandum for 200-BP-5 Operable Unit Groundwater Extraction*, the removal action was implemented to recover elevated levels of groundwater contamination while awaiting completion of the CERCLA RI/FS process and issuance of a 200-BP-5 OU ROD. The B Complex groundwater removal action continued groundwater extraction at well 299-E33-360 and 29-E33-361, in 2020. Approximately 1.26 billion L (334 million gal) of contaminated groundwater has been extracted from the B Complex, of which225 million L (59.4 million gal) were removed in 2020. Groundwater sample results collected periodically between September 2015 and December 2020 indicate that approximately6.27 Ci of technetium-99 and 212 kg of uranium have been removed from the B Complex unconfined aquifer.

- **200-BP-5 and 200-PO-1 interim action ROD (2021)**: An interim action FS covering both 200-BP-5 and 200-PO-1 OUs (DOE/RL-2018-30, *200-BP-5 and 200-PO-1 Groundwater Operable Units Feasibility Study for Interim Action*) was issued in December 2019 to target remediation of uranium and technetium-99 groundwater contaminants. The proposed plan (DOE/RL-2018-58, *Proposed Plan for Interim Action Remediation of the 200-BP-5 and 200-PO-1 Operable Units*) was issued in March 2020 for public comment in May 2020 and an interim record of decision was approved in September 2021 (EPA et. al., 2021, *Interim Record of Decision, Hanford 200 Area Superfund Site, 200-BP-5 and 200-PO-1 Operable Units*). The selected remedy includes P&T to capture and remove uranium and technetium-99 from groundwater in the B Complex plume area, and the C Farm and A-AX Farms plume area. Extracted groundwater would be transferred to the 200 West P&T for treatment. Other elements of the selected remedy include P&T system O&M, installation of new groundwater monitoring wells, performance monitoring, and ICs.

- **200-DV-1 OU perched water removal action (2011)**: A perched water pumping/pore water extraction treatability test commenced in 2011, near the north boundary of the B Tank Farm as part of the DVZ treatability testing project. By the end of CY 2014, perched water extraction using well 299-E33-344 had removed 945,289 L (249,727 gal) of contaminated perched water, including

53.0 kg of uranium, 0.031 Ci of technetium-99, and 495 kg of nitrate. The following two documents were completed in 2014 for transition of the perched water treatability test to an NTCRA:

- DOE/RL-2013-37, *Engineering Evaluation/Cost Analysis for Perched Water Pumping/Pore Water Extraction*
- DOE/RL-2014-34, *Action Memorandum for 200-DV-1 Operable Unit Perched Water Pumping/Pore Water Extraction*

In August 2015, perched water extraction was temporarily discontinued to enhance water removal by adding two new wells to the system. The perched water treatability test transitioned to a CERCLA NTCRA (DOE/RL-2014-34) when extraction began using all three wells in 2016. In CY 2020, the perched water extraction wells removed783,580 L (207,000 gal) of perched water containing 34.5 kg of uranium, 2.0 g of technetium-99, and850 kg of nitrate. Since perched water extraction began in 2011,6,092,408 L (1,609,444 gal) of perched water containing 328 kg of uranium,12.7 g (0.215 Ci) of technetium-99, and 5,837 kg of nitrate has been removed from the perched zone.

1.3.2.3 Central Plateau Groundwater Remedial Activities

Central Plateau groundwater and vadose zone remediation systems have removed more than 112,967 kg of carbon tetrachloride from groundwater since 1992. During 2020, 5 new wells in the Central Plateau were installed for monitoring, remediation, and/or characterization. Samples from 451 monitoring wells and16 shoreline aquifer tubes for the Central Plateau groundwater interest areas were collected and analyzed to determine the distribution and movement of contaminants. Many of the wells and aquifer tubes were sampled multiple times during the reporting period, resulting in 928 well sampling events. The samples were analyzed for a variety of radionuclides and other constituents.

The P&T systems located in the Central Plateau target radionuclides (including technetium-99 in the 200-ZP-1, 200-UP-1, and 200-BP-5 OUs) and are of direct interest with respect to the Hanford Site Composite Analysis. P&T systems are also of indirect interest because perturbations to the hydraulic flow system induced by P&T systems were not included in the features, events, and processes modeled for the current Hanford Site Composite Analysis. The groundwater model for the Hanford Site Composite Analysis was developed in the 1990s before remedial decisions for groundwater had been made. At that time, it was not possible to anticipate the locations, pumping or injection rates, and pumping or injection durations of extraction and injection wells that since have been used to accomplish groundwater remedial actions. Table 1-6 summarizes the status of Central Plateau P&T systems for the reporting period.
The radionuclide activity removed to date and hydraulic perturbations induced by P&T systems reviewed are not yet considered to have a significant impact if they were to be included in the Hanford Site Composite Analysis model. However, it is reasonable to assume that the impact of inclusion of this feature in the model would result in a reduction in the projected radiological dose estimate from the groundwater pathway. The P&T systems are planned to operate for an extended time, and consideration of the impact of these systems on the all-pathways dose will be addressed in the upcoming revision of the Hanford Site Composite Analysis that was prepared in FY 2021 and is under review by the LFRG in FY 2022.

Activities in the four Central Plateau groundwater OUs that provide new information on radionuclide constituents relevant to the Hanford Site Composite Analysis are discussed in the following sections for each respective OU. The remediation status for each OU is presented if remediation information exists for the OU for the reporting period. If remedial action was not in progress during the reporting period, the groundwater concentration status was summarized as well as any other relevant work that occurred during the reporting period.

Table 1-6. Status of Central Plateau Groundwater Remediation in Calendar Year 2020

OU	CERCLA Decision Status	Groundwater Contaminants of (Potential) Concern[a]	Current Groundwater Remediation	Mass Removed in 2020 (and Since Startup)[b]
200-BP-5	Implemented treatability test (2015) and action memorandum (2016); FS released in 2019; proposed plan issued in 2020; interim action ROD approved in 2021.	Cyanide, iodine-129, nitrate, strontium-90, technetium-99, tritium, and uranium	Groundwater extraction removal action (2015–2020)	Cyanide: 14.4 kg (221 kg) Technetium-99: 55.0 g (368.8 g) Uranium: 24.6 kg (211.9 kg)
200-PO-1	FS released in 2019; proposed plan issued in 2020; interim action ROD approved in 2021.	Iodine-129, tritium, nitrate, strontium-90, technetium-99, and uranium	None to date; pending interim action ROD	Not applicable
200-UP-1	ROD for interim remedial action signed (2012).	Technetium-99, uranium, carbon tetrachloride, Cr(VI), total chromium, iodine-129, nitrate, tritium, trichloroethene, chloroform, tetrachloroethene, strontium-90, and 1,4-dioxane	Interim actions: • P&T near U Plant (2015–2020) • P&T at WMA S-SX (2012–2020) • Hydraulic containment for iodine-129 (2015–2020) • MNA	Technetium-99: 20.7 g (424 g[c]) Uranium: 10.3 kg (9,778 kg[c])
200-ZP-1	ROD for final remedial action signed (2008).	Carbon tetrachloride, Cr(VI), total chromium, iodine-129, nitrate, technetium-99, trichloroethene, and tritium	P&T and MNA (2012–2020)	Carbon tetrachloride: 1,999 kg (32,950 kg[c]) Chromium: 6.55 kg (512 kg) Technetium-99: 33.9 g (252.6 kg) Trichloroethene: 11.3 kg (87.0 kg)
200-DV-1[d]	Implemented treatability test (2011) and action memorandum (2016); characterization of the deep vadose zone in progress.	Nitrate, technetium-99, uranium, tritium, total chromium, and Cr(VI) (perched water)	Removal action: Perched water extraction (2011–2020)	Technetium-99: 2.0 g (12.7 g[b]) Uranium: 34.5 kg (328 kg[b])

Source: DOE/RL-2020-60, *Hanford Site Groundwater Monitoring Report for 2020*

a. Contaminants of concern are listed for OUs with RODs for final action and implemented action memoranda. The primary contaminants of potential concern are listed for the other OUs.

b. A total of 2,186,276 kg of nitrate was also removed by the 200 West Area groundwater treatment facility. Nitrate is no longer treated, following suspension of biological treatment in October 2019 for the 200-ZP-1 OU optimization study.

c. Totals includes mass from P&T systems under earlier RODs for interim action and 200-DV-1 OU treatability test.

d. Deep vadose zone OU.

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*

Cr(VI) = hexavalent chromium

FS = feasibility study

MNA = monitored natural attenuation

OU = operable unit

P&T = pump and treat

ROD = Record of Decision

WMA = waste management area

1.3.2.4 200-BP-5 Groundwater Operable Unit

The 200-BP-5 OU includes groundwater beneath the northern portion of 200 East Area and the region to the northwest, where mobile contaminants have migrated between Gable Mountain and Gable Butte. Nitrate, iodine-129, and technetium-99 form the most extensive contaminant plumes in this OU. These contaminants originated mainly from local sources except for iodine-129, which migrated into the 200-BP-5 OU from the 200-PO-1 OU in the late 1980s and early 1990s. These mobile contaminants have migrated beyond the 200 East Area to the northwest due to past artificial groundwater gradients.

Cyanide and uranium are present as smaller plumes associated with past releases in the B Complex, located in the northwest corner of the 200 East Area, which includes the BY Cribs and B-BX-BY Tank Farms. Strontium-90 is present as two localized plumes, mainly beneath the originating waste sites 216-B-5 injection well and Gable Mountain Pond. Two other localized plumes are also present at the 216-B-5 injection well: cesium-137 and plutonium-239/240. RI drilling in 2010 provided evidence of a concentrated plume in the lower part of the aquifer near the 216-B-12 Crib and B Plant. Two additional wells, one north (Well 299-E28-31) and one south (Well 299-E28-32) of B Plant, were drilled in this area during 2015 to improve characterization of the extent of tritium at depth. Tritium concentrations in the well north of B Plant ranged from 45,200 to 52,500 pCi/L at three depth-discrete sample intervals: 7.4, 13.5, and 15.8 m (24, 44, and 52 ft) below the water table. In the new well south of B Plant, tritium increased with depth with concentrations of 18,900 pCi/L, 49,000 pCi/L, and 91,600 pCi/L at depth-discrete sample intervals 7.4, 13.2, and 19 m (24, 43, and 62 ft) below the water table, respectively. In 2017, the tritium concentrations were 53,700 pCi/L at well 299-E28-31 and 34,900 pCi/L at well 299-E28-32. Tritium also exceeded the 20,000 pCi/L DWS beneath the former B Pond in 2017, with a maximum concentration of 28,700 pCi/L.

Most groundwater contamination in the 200-BP-5 OU is concentrated beneath WMA B-BX-BY and adjacent waste sites in the northwestern portion of the OU. Radionuclide COPCs for the 200-BP-5 Groundwater OU include cesium-137, cobalt-60, gross alpha, iodine-129, plutonium-239/240, strontium-90, technetium-99, tritium, and uranium (DOE/RL-2009-127). The selected remedy in the 200-BP-5 and 200-PO-1 OU interim ROD (EPA et., al, 2021) targets remediation of uranium and technetium-99 groundwater contaminants. Extracted groundwater would continue to be transferred to the 200 West P&T for treatment.

RCRA Monitoring. Six TSD units are monitored under RCRA in coordination with CERCLA and AEA requirements: Low-Level Waste Management Area (LLWMA)-1, LLWMA-2, WMA B-BX-BY, WMA C, the Liquid Effluent Retention Facility, and the 216-B-63 Trench. RCRA monitoring of the six TSD units is conducted in accordance with the following:

- The LLBG WMA-1 is monitored under an interim status indicator evaluation program as described in DOE/RL-2009-75, *Interim Status Groundwater Monitoring Plan for the LLMA-1,* effective in August 2016.
- LLBG WMA-2 is monitored under an interim status indicator evaluation program described in DOE/RL-2009-76, *Interim Status Groundwater Monitoring Plan for the LLWMA-2*.
- WMA B-BX-BY is monitored in accordance with the revised assessment plan DOE/RL-2012-53, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area B-BX-BY*, effective in May 2019.
- WMA C is monitored in accordance with the revised assessment plan DOE/RL-2009-77, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area C*, issued in June 2019.

- In the third and fourth quarters of 2020, monitoring of WMA B-BX-BY and WMA C was performed in compliance with a new assessment plan, DOE/RL 2019 74 (effective in July 2020) implementing the monitoring network recommended in SGW 60587, *Engineering Evaluation Report for Single Shell Tank Waste Management Area B-BX-BY Groundwater Monitoring*, and SGW 60588, *Engineering Evaluation Report for Single-Shell Tank Waste Management Area C Groundwater Monitoring*.
- Groundwater at the liquid effluent retention facility is monitored under a final status detection monitoring program under the Hanford RCRA Permit (Part III, OUG-3, Addendum D, "Groundwater Monitoring Plan" [modification date of January 23, 2018]).
- 216-B-63 Trench is monitored under an interim status indicator evaluation program as defined in DOE/RL-2008-60, *Interim Status Groundwater Monitoring Plan for the 216-B-63 Trench,* effective in October 2012.

Since 2011, continued declining groundwater elevation in the 200 East Area has resulted in a changing flow direction in the northwest corner of the 200 East Area. Flow began changing from northwest to south-southeast in June 2011. By August 2011, a statistically significant gradient to the south-southeast was measured. The south-southeast flow direction has continued to present. This reversal is further documented by the southeast migration of groundwater contaminants extending from WMA B-BX-BY and the BY Cribs. The effects of the new groundwater flow direction are apparent beneath WMA C. During FY 2013, groundwater contamination west of WMA C began to decrease significantly, while concentrations increased in the south and southeast portion of WMA C. The following quarterly reports for WMA C explain the groundwater flow dynamics:

- SGW-59669, *WMA C October through December 2015 Quarterly Groundwater Monitoring Report*
- SGW-59914, *WMA C January through March, 2016 Quarterly Groundwater Monitoring Report*
- SGW-60442, *WMA C April through June 2016 Quarterly Groundwater Monitoring Report*
- SGW-60494, *WMA C July through September 2016 Quarterly Groundwater Monitoring Report*

Several wells were selected for low-gradient monitoring across the 200 East Area to define the groundwater flow near WMA C more accurately. The wells were precision surveyed and corrected for borehole deviation through gyroscope surveys. Data correction for barometric response was evaluated for these wells and the expanded water level network in FY 2014. The expanded 200 East Area low hydraulic gradient water level network and the relationship between the Treated Effluent Disposal Facility discharges and gradient magnitude are discussed in SGW-58828, *Water Table Maps for the Hanford Site 200 East Area, 2013 and 2014*.

Treatability Testing. DOE-RL designed and published a treatability test (DOE/RL-2010-74) to evaluate P&T of groundwater for remediation of uranium and technetium-99 contamination near WMA B (B-BX-BY Tank Farms). In 2011, installation began for an extraction well to support the test, and the well was completed in 2012.

The treatability test (DOE/RL-2010-74) was completed between August and November 2015 to evaluate the groundwater extraction rate that could be sustained in the unconfined aquifer at the B Complex. The test results are documented in DOE/RL-2015-75, *Aquifer Treatability Test Report for the 200-BP-5 Groundwater Operable Unit*.

Removal Action. The EE/CA for B Complex groundwater extraction (DOE/RL-2015-26) was issued in April 2016 to evaluate the implementation of a NTCRA for the extraction and treatment of groundwater near the B Complex in the 200-BP-5 OU. The EE/CA recommended groundwater extraction for conveyance to the 200 West Treatment Plant. The removal scope was approved by the Tri-Parties in December 2016 with the issuance of an action memorandum for 200-BP-5 OU groundwater extraction (DOE/RL-2016-41). The transition to the NTCRA provided authorization to revise the extraction network for more optimal removal of uranium and technetium-99. DOE/RL-2017-11, *Removal Action Work Plan for 200-BP-5 Operable Unit Groundwater Extraction*, was approved in March 2018 and established a formal removal action-monitoring network to assess the progress of plume size reduction. Four additional monitoring wells were drilled in 2019 to assess concentration changes more thoroughly to the north and south/southeast of B Complex. Comparing the 2015 technetium-99 and uranium plumes to conditions through 2020, the technetium-99 plume areal extent has been reduced 62% and the uranium plume has been reduced 71%.

Perched Water. A fine-grained geologic unit beneath the B Complex has created an area of saturated sediments (perched water) in the DVZ above the regional water table. The perched water is contaminated with uranium, technetium-99, and other contaminants. To address the groundwater impact associated with infiltration from the perching horizon, DOE-RL initiated a perched water pumping treatability test in 2011 (DOE/RL-2011-40, *Field Test Plan for the Perched Water Pumping/Pore Water Extraction Treatability Test*). Well 299-E33-344 was used for extraction during the test. Pumping began in August and continued until early December 2011, when extracted perched water contaminant concentrations increased significantly and required a different waste disposal path. Pumping resumed in April 2012. The uranium concentration increased from 4,500 µg/L in September to 63,600 µg/L in October 2012. The increase in concentration was confirmed in December with a result of 71,500 µg/L. These were the highest uranium concentrations detected at the Hanford Site during 2011.

In December 2014, the action memorandum for 200-DV-1 OU perched water pumping/pore water extraction (DOE/RL-2014-34) was signed to document the selected alternative for perched water removal under CERCLA. The selected alternative extracts perched water and transfers the water by tanker truck or pipeline to the 200 West P&T, where it is treated and injected into the aquifer below the 200 West Area. DOE/RL-2014-37, *Removal Action Work Plan for 200-DV-1 Operable Unit Perched Water Pumping/Pore Water Extraction*, was approved in November 2015.

Two additional perched water extraction wells (299-E33-350 and 299-E33-351) were drilled in 2014. The two new wells were added to the extraction system in 2016 when the perched water treatability test transitioned to a CERCLA removal action (DOE/RL-2014-34).

In 2019, a hydraulic analysis examined extraction well configuration options for increasing the rate of contaminated perched water removal (SGW-63236, *200-DV-1 Future Perched Water Well Evaluation*). The analysis concluded that the low hydraulic conductivity and relatively thin saturated thickness of the perched water zone severely limits the flow of perched water into extraction wells (SGW-65178, *Evaluation of Two Alternative Drilling Scenarios (Horizontal Drilling and Drilling of Vertical Wells within Tank Farms) for Increasing Extraction within the Perched Water Zone*). The outcome of the analysis was that a horizontal well was not recommended for the perched water zone.

This analysis, as well as other existing information for the perched water zone and the overall hydrogeological system, is used to guide planning to install an additional 8 extraction wells and 4 monitoring wells within the perched water zone. Drilling of the first extraction well began in 2020 and was completed in 2021.

AEA Monitoring. AEA groundwater monitoring was conducted at 200-BP groundwater interest area wells in accordance with DOE/RL-2015-56, *Hanford Atomic Energy Act Sitewide Groundwater Monitoring Plan*. The primary AEA constituents for 200-BP groundwater interest area are iodine-129, nitrate, technetium-99, strontium-90, uranium, and tritium. For 2019, radionuclide concentrations detected in groundwater samples from 146 wells were used to estimate the cumulative total effective dose (TED) and to compare the cumulative beta/photon emitters, alpha emitters, and uranium mass to DWSs. The estimated TED exceeded the 100 mrem/yr standard at four groundwater wells in 200-BP. The cumulative drinking water dose from beta/photon emitters exceeded the 4 mrem/yr standard at 82 locations in the 200-BP groundwater interest area. None of the wells exceeded the DWSs for cumulative alpha emitters and the EPA net alpha activity standard. The 30 µg/L uranium DWS was exceeded at17 locations. None of these locations is adjacent to the Columbia River, which is the primary potential offsite exposure pathway to Hanford Site contaminated groundwater. The public is protected from exposure to onsite groundwater through the implementation of ICs that restrict access to groundwater. Details of the AEA evaluations are presented in Section 9.11 of DOE/RL-2020-60.

Review of FY 2019 CERCLA investigations and CERCLA/RCRA/AEA monitoring activities reported in DOE/RL-2020-60 and evaluated in FY 2021 did not reveal any new information associated with the 200-BP-5 OU with potential to significantly alter the conclusions of the Hanford Site Composite Analysis.

1.3.2.5 200-PO-1 Groundwater Operable Unit

The 200-PO-1 OU is located in the southern portion of the 200 East Area. Disposal of large volumes of liquid waste from PUREX and its related facilities created regional groundwater plumes of tritium, iodine-129, and nitrate. Concentrations of tritium are declining as the plume attenuates naturally from radioactive decay and dispersion, and the tritium plume area above the 20,000 pCi/L cleanup level has decreased in size by about 57% since 1996. The area of the iodine-129 plume above the 1 pCi/L DWS has decreased slightly over the past decade, and maximum concentrations have declined due to dispersion. Radioactive decay has not decreased the level of iodine-129 noticeably because the isotope has a low decay rate (15.7 million year half-life). The nitrate plume covers a large area, but concentrations within the far-field area have decreased to below the DWS, except near the 618-11 Burial Ground. Other contaminants include strontium-90, technetium-99, and uranium in smaller areas near their sources. The selected remedy in the 200-BP-5 and 200-PO-1 OU interim ROD (EPA et., al, 2021) targets remediation of uranium and technetium-99 groundwater contaminants by groundwater extraction and treatment. Extracted groundwater would be transferred to the 200 West P&T for treatment.

Soil Desiccation Test. A soil desiccation treatability test (DOE/RL-2009-119, *Characterization of the Soil Desiccation Pilot Test Site*) was performed from 2010 to 2011 in an interval containing high moisture and associated technetium-99 contamination near the BC Cribs and Trenches. This technology is being considered as a potential remedy in the DVZ. For 6 months, nitrogen was injected into a well and soil gas was extracted from another well. A combination of in situ sensors and geophysical measurements provided data to monitor performance. As anticipated, desiccation occurred more rapidly from higher permeability sediment. The active portion of the test was completed, and the pilot test results were reported in DOE/RL-2012-34. Post-test monitoring concluded in 2017, and a final comprehensive post-test monitoring report was issued in February 2018 (PNNL-26902). Overall, the desiccation test at the 200-BC-1 OU field test site provides sufficient information for desiccation to be applied in conjunction with a surface infiltration barrier and consideration as a potential vadose zone remedy in future feasibility studies.

RCRA Assessment Monitoring. During 2020, monitoring continued at seven RCRA units: WMA A-AX single-shell tanks, 216-A-36B Crib, 216-A-37-1 Crib, 216-A-29 Ditch, IDF, 216-B-3 Pond, and NRDWL. RCRA monitoring of the seven TSD units are conducted in accordance with the following:

- WMA A-AX was monitored under an interim status assessment program (DOE/RL-2015-49, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management*

Area A-AX) since 2005 when specific conductance exceeded the critical mean value. In September and December 2020, WMA A-AX was monitored under an indicator evaluation monitoring plan (DOE/RL-2019-44, *Interim Status Groundwater Monitoring Plan for the Single-Shell Tank Waste Management Area A-AX*) because a first determination assessment report (DOE/RL-2019-21, *Groundwater Assessment First Determination Report for Waste Management Area A-AX*) concluded that no dangerous waste groundwater contamination is attributed to releases from WMA A-AX.

- The 216-A-36B Crib is monitored under an interim status indicator evaluation program described in DOE/RL-2010-93, *Interim Status Groundwater Monitoring Plan for the 216-A-36B PUREX Plant Crib*.
- The 216-A-37-1 Crib is monitored under an interim status indicator evaluation program described in DOE/RL-2010-92, *Interim Status Groundwater Monitoring Plan for the 216-A-37-1 PUREX Plant Crib.*
- In January 2016, the 216-A-29 Ditch was placed into a groundwater assessment program because specific conductance in wells 299-E25-32P, 299-E25-35, and 299-E25-48 exceeded the critical mean value in 2015. During the second half of 2020, the ditch was monitored under an indicator evaluation program because assessment results indicated that no dangerous waste groundwater contamination was attributed to releases from the 216-A-29 Ditch (DOE/RL-2019-27, *Groundwater Assessment First Determination Report for the 216-A-29 Ditch*). Interim status indicator evaluation monitoring was reinstated under DOE/RL-2008-58, *Interim Status Groundwater Monitoring Plan for the 216-A-29 Ditch*, during the third quarter of 2020.
- The 216-B-3 main pond is monitored under an interim status indicator evaluation program described in DOE/RL-2008-59, *Interim Status Groundwater Monitoring Plan for the 216-B-3 Pond*; as modified by RCRA-CN-01_DOE/RL-2008-59_R2, *RCRA Interim Status Change Number 1: Interim Status Groundwater Monitoring Plan for the 216-B-3 Pond*.
- The IDF is monitored under a pre-operational final status detection monitoring program under the Hanford RCRA Permit (Part III, OUG-11, Chapter 5.0, "Groundwater Monitoring" [modification date of June 30, 2010]). In 2019, DOE submitted a plan for a revised groundwater monitoring program to Ecology (DOE/RL-2019-29, *Groundwater Monitoring Plan for the Integrated Disposal Facility*). The revised monitoring program will be incorporated into the Hanford RCRA Permit in the future. Ecology approved DOE's request to begin baseline sampling under the revised monitoring program in 2020. Because the IDF is not yet operating, the current monitoring objective is to collect baseline groundwater information.
- The NRDWL entered a groundwater quality assessment monitoring program in 2017, which continued in 2019 in accordance with DOE/RL-2017-19, *Groundwater Quality Assessment Plan for the Nonradioactive Dangerous Waste Landfill, Hanford Site.* Five quarters of assessment monitoring data were evaluated for potentially dangerous waste constituents attributable to the NRDWL. Beginning in August 2020, the site was monitored under an indicator parameter monitoring plan (DOE/RL-2015-32, *Groundwater Monitoring Plan for the Nonradioactive Dangerous Waste Landfill*) because assessment monitoring concluded that no dangerous waste groundwater contamination is attributed to releases from the NRDWL (DOE/RL-2019-22, *Groundwater Assessment First Determination Report for the Nonradioactive Dangerous Waste Landfill*).

AEA Monitoring. AEA groundwater monitoring was conducted at 200-PO-1 groundwater wells and aquifer tubes in accordance with DOE/RL-2015-56. The primary AEA constituents for 200-PO-1 are tritium, iodine-129, nitrate, strontium-90, technetium-99, and uranium. Radionuclide concentrations detected in groundwater samples from 137 wells were used to estimate the cumulative TED and to compare the cumulative beta/photon emitters, alpha emitters, and uranium mass to DWSs. None of the wells in 200-PO exceeded the estimated TED 100 mrem/yr standard. None of the DWSs for cumulative alpha emitters and EPA net alpha activity standard were exceeded. The cumulative drinking water dose from beta/photon emitters exceeded the 4 mrem/yr standard at 67 locations in the 200-PO-1 groundwater interest area. One location exceeded the 30 µg/L uranium DWS. One location that exceeded the beta/photon emitters (aquifer tube C6353) is adjacent to the Columbia River, which is the primary potential pathway for offsite exposure to Hanford Site contaminated groundwater. Members of the public are protected from exposure to groundwater through the implementation of ICs that restrict access to groundwater. Details of the evaluation are presented in Section 10.12 of DOE/RL-2020-60.

The review of FY 2019 CERCLA investigations and CERCLA/RCRA/AEA monitoring activities reported in the Hanford Site groundwater monitoring annual report for CY 2020 (DOE/RL-2020-60) did not reveal any new information associated with the 200-PO-1 OU with potential to significantly alter the conclusions of the Hanford Site Composite Analysis.

1.3.2.6 200-UP-1 Groundwater Operable Unit

The 200-UP-1 OU includes the southern portion of the 200 West Area and adjacent areas to the east and south. Primary contaminant sources in the OU include cribs, ditches, ponds, and single-shell tanks associated with Reduction-Oxidation Plant operations for plutonium and uranium separation and/or the U Plant for uranium recovery. Technetium-99, uranium, tritium, iodine-129, nitrate, chromium, and carbon tetrachloride plumes are present in groundwater. Strontium-90 and TCE also exceed their respective DWSs in isolated areas. The carbon tetrachloride plume originated from the 200-ZP-1 OU. Technetium-99 concentrations in the 200-UP-1 OU are the highest measured in groundwater on the Hanford Site. Near U Plant, the areal extent of the technetium-99 plume above the 900 pCi/L cleanup level has decreased substantially due to operation of an interim action P&T system from 1997 until 2011 and operation of the current P&T system since September 2015. In contrast, the technetium-99 plume near WMA S-SX has increased in areal extent over time, and concentrations increased to over 4,000 pCi/L through CY 2020 downgradient of the northern SX Tank Farm where no extraction well is present. A groundwater extraction system began operating in 2012 to address the plumes downgradient of the S Tank Farm and the southern portion of the SX Tank Farm (where technetium-99 concentrations are greatest, exceeding 12,000 pCi/L in 2020). The tritium plume is attenuating due to dispersion and radioactive decay and has not migrated substantially, and the areal extents of other plumes in the OU have remained largely unchanged or have decreased slightly in the past decade.

A P&T system for the uranium, technetium-99, and nitrate plumes near U Plant and injection wells for hydraulic containment of the iodine-129 plume were implemented as part of the 200-UP-1 groundwater remedy. Operation of both remedies started in late CY 2015.

An iodine-129 treatment technology evaluation was completed in September 2019, as summarized in DOE/RL-2013-07. The conclusion of this evaluation was that the practicability of all candidate remediation technologies for the iodine-129 plume is low, driven by site and contaminant properties that hinder effectiveness and/or implementability of the technologies. Because a viable remediation technology is not available for the iodine-129 plume, a technical impracticability waiver may be pursued in accordance with 40 CFR 300.430(f)(l)(ii)(c), “National Oil and Hazardous Substances Pollution Contingency Plan,” “Remedial Investigation/Feasibility Study and Selection of Remedy.”

Decision Documents. In 2012, DOE-RL released the final RI/FS report (DOE/RL-2009-122, *Remedial Investigation/Feasibility Study for the 200-UP-1 Groundwater Operable Unit*) and DOE/RL-2010-05, *Proposed Plan for Remediation of the 200-UP-1 Groundwater Operable Unit*. The ROD for interim remedial action (EPA et al., 2012) was signed in September 2012 for all 200-UP-1 OU contaminants of concern (COCs). The selected remedies use a combination of groundwater P&T, MNA, hydraulic containment for iodine-129 while treatment technologies are investigated, and ICs. The RD/RAWP (DOE/RL-2013-07) was issued in September 2013 and revised in August 2020.

Remedial Actions. Although originally designed as a remedy under the 1997 ROD (EPA/ROD/R10-97/048), the WMA S-SX groundwater extraction system is now operating under the current ROD (EPA et al., 2012) The remedial actions identified in the 2012 ROD for groundwater extraction near U Plant and hydraulic containment of iodine-129 were implemented in CY 2015.

RCRA Monitoring. In the 200-UP-1 OU, RCRA monitoring included interim status groundwater quality assessment monitoring at WMA S-SX and WMA U as well as interim status indicator parameter evaluation monitoring at the 216-S-10 Pond and Ditch. The monitoring results did not show major changes in the extent of contamination. Indicator parameters did not exceed statistical comparison values at the 216-S-10 Pond and Ditch during 2020. RCRA monitoring of the three TSD units are conducted in accordance with the following:

- In 2019, the WMA S-SX assessment plan was revised to update the well network (DOE/RL-2009-73, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area S-SX*). The objective of RCRA monitoring at WMA S-SX is to assess the rate and extent of migration and the concentration of the dangerous waste constituent chromium in the groundwater.
- The revised groundwater quality assessment plan (DOE/RL-2009-74, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area U*) was released in 2019.
- In the third and fourth quarters of 2020, monitoring of WMA S-SX and WMA U was performed in compliance with a new assessment plan, DOE/RL-2019-74 (effective in July 2020) implementing the monitoring network recommended in SGW-60577, *Engineering Evaluation Report for Single-Shell Tank Waste Management Area S-SX Groundwater Monitoring*, and SGW-60578, *Engineering Evaluation Report for Single-Shell Tank Waste Management Area U Groundwater Monitoring*.
- 216-S-10 Pond and Ditch is monitored under an interim status indicator evaluation program described in DOE/RL-2008-61, *Interim Status Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*.

Groundwater monitoring in the 200-UP-1 OU also includes ERDF monitoring. Groundwater monitoring at ERDF is regulated under a CERCLA ROD (EPA/ROD/R10-95/100). The site was designed to meet RCRA standards, although it is not actually permitted as a RCRA facility. (Note: The ERDF PA is discussed in Section 1.1.4, and ERDF operations are discussed in Section 1.3.3.2 of this report.) In 2020, groundwater monitoring results continued to indicate that the facility has not adversely affected groundwater quality.

AEA Monitoring. AEA groundwater monitoring was conducted at 200-UP-1 groundwater wells in accordance with DOE/RL-2015-56. The primary AEA constituents for 200-UP-1 are iodine-129, nitrate, technetium-99, tritium, and uranium. Radionuclide concentrations detected in groundwater samples from 94 wells were used to estimate the cumulative TED and to compare to cumulative beta/photon emitters, alpha emitters, and uranium mass to DWSs. The estimated TED exceeded the 100 mrem/yr standard at one groundwater well in 200-UP. The cumulative drinking water dose from beta/photon emitters exceeded the 4 mrem/yr standard at 50 locations in the 200-UP-1 groundwater interest area. No locations exceeded the DWSs for cumulative or net alpha emitters. The 30 µg/L uranium DWS was exceeded at 10 locations. None of these locations is adjacent to the Columbia River, which is the primary potential pathway for offsite exposure to Hanford Site contaminated groundwater. The public is protected from groundwater exposure through the implementation of ICs that restrict access to groundwater and through remedial action measures (e.g., P&T) to control the migration of contaminated groundwater to exposure points. Details of the evaluation are presented in Section 11.12 of DOE/RL-2020-60.

Review of FY 2020 CERCLA investigations and CERCLA/RCRA/AEA monitoring activities reported in the Hanford Site groundwater monitoring report for CY 2020 (DOE/RL-2020-60) and evaluated in FY 2021 did not reveal any new information associated with the 200-UP-1 OU with potential to significantly alter the conclusions of the Hanford Site Composite Analysis.

1.3.2.7 200-ZP-1 Groundwater Operable Unit

The 200-ZP-1 OU includes groundwater beneath the northern portion of the 200 West Area and adjacent areas to the east and north. The COCs for the 200-ZP-1 OU are carbon tetrachloride, TCE, iodine-129, technetium-99, nitrate, Cr(VI), total chromium, and tritium.

The 200-ZP-1 OU also includes groundwater beneath four TSD units (LLWMA-3, LLWMA-4, WMA T, and WMA TX-TY), which are monitored under RCRA (in coordination with CERCLA and AEA), and one SALDS unit.

Since 1994, DOE-RL has implemented a groundwater P&T system to prevent carbon tetrachloride in the upper portion of the aquifer from spreading. Operated from 1994 through May 2012, the interim P&T system limited the movement of shallow, high-concentration portions of the plume but did not address contamination deeper in the aquifer and at the periphery of the plume. The current 200 West P&T implements the 2008 200-ZP-1 ROD to remediate groundwater throughout the entire aquifer thickness and provide treatment for carbon tetrachloride, TCE, technetium-99, nitrate, Cr(VI), and total chromium.

Two SVE systems for soil vapor remediation operated from 1992 to 2012 to remove and treat carbon tetrachloride. The SVE systems were maintained in standby mode from October 2012 through April 2015 to allow time for carbon tetrachloride vapor concentrations to rebound. The results for the rebound sampling were reported in DOE/RL-2014-48. In August 2016, DOE-RL and EPA approved DOE/RL-2014-48 (agency approvals contained within the document), thereby closing the SVE remedy and permanently discontinuing SVE operations and vadose zone monitoring.

Two wells in the 200-ZP groundwater interest area had iodine-129 concentrations exceeding the 1 pCi/L cleanup level in at least one sample in 2020: well 299-W14-13, located east of WMA TX-TY (6.76 pCi/L), and new extraction well 299-W6-17 located in the northeastern 200 West Area (1.18 pCi/L). Iodine-129 sources include past leaks from single-shell tanks (containing metal and liquid waste) and chemical processing at T Plant. The minimum detectable activity for iodine-129 varies from about 0.3 to 1.2 pCi/L.

Technetium-99 exceeds the 900 pCi/L final cleanup level in two distinct plumes east of WMA T and WMA TX-TY. Technetium-99 sources in 200-ZP groundwater interest area were leaks from tanks and pipelines, and liquid waste disposal from plutonium-processing operations to cribs and trenches adjacent to the WMAs. Technetium-99 is found primarily in the upper 15 m (50 ft) of the unconfined aquifer (Section 2.8 in DOE/RL-2008-01, *Hanford Site Groundwater Monitoring for Fiscal Year 2007*). Technetium-99 exceeded the 900 pCi/L cleanup standard at three monitoring wells in the 200-ZP-1 OU in 2020. The biggest increase in concentration was at monitoring well 299-W11-13 at13,100 pCi/L in 2020 compared to5,910 pCi/L in 2019. In 2020, an internal evaluation was performed for technetium-99 and determined that there was strong evidence for continuing sources in this area.

Tritium concentrations in groundwater have declined below the 20,000 pCi/L cleanup level in most of 200-ZP groundwater interest area due to radioactive decay, dispersion, and mixing from groundwater extraction and injection. The only results above the cleanup level in 2020 occurred at well 299-W14-13 (east of WMA TX-TY) where concentrations increased to 170,000 pCi/L in June 2020, then declined to about 1,000 pCi/L in November. Prior to the June 2020 increase, tritium concentrations in well 299-W14-13 had been <10,000 pCi/L since 2013. The tritium spike corresponded to a temporary water-level rise of 2.8 m (9.2 ft).

RCRA Monitoring. Two LLWMAs that overlie the 200-ZP-1 OU are monitored under RCRA interim status contaminant indicator parameter programs. At LLWMA-3, upgradient well 299-W9-2 was installed in 2011 and sampled quarterly to establish background levels used to calculate new critical mean values to enable statistical evaluations to resume. No significant changes occurred at LLWMA-3 or LLWMA-4 in 2020.

RCRA assessment monitoring continued at WMA T and WMA TX-TY. The concentrations and extent of dangerous waste constituents from these facilities are generally declining; however, total cyanide concentrations are trending upward at two monitoring wells downgradient of WMA T and WMA TX-TY. Changes in concentrations of all analytes are expected because of the new wells extracting contaminated groundwater upgradient and downgradient of these WMAs. SALDS receives treated water from the ETF and is regulated under a Washington State waste discharge permit. The declining water table in the 200 West Area has caused several of the SALDS monitoring wells to go dry over the years; this issue is being addressed during the permit renewal process. RCRA monitoring of the four TSD units is conducted in accordance with the following:

- WMA T is monitored under the RCRA assessment program described in DOE/RL-2009-66, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area T*. The revised assessment plan, issued in 2019, implemented the monitoring network recommended in SGW-60575, *Engineering Evaluation Report for Single-Shell Tank Waste Management Area T Groundwater Monitoring*, including three proposed new wells.
- WMA TX-TY is monitored under an interim status assessment program (DOE/RL-2009-67, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area TX-TY*), revised in 2019. The revised assessment plan implements the monitoring network recommended in SGW-60576, *Engineering Evaluation Report for Single-Shell Tank Waste Management Area TX-TY Groundwater Monitoring.*
- In the third and fourth quarters of 2020, monitoring of WMA T and WMA TX-TY was performed in compliance with a new assessment plan, DOE/RL-2019-74 (effective in July 2020) implementing the monitoring network recommended in SGW-60575 and SGW-60576.
- In 2020, LLBG WMA-3 was monitoring under an interim status groundwater assessment program due to 2019 critical mean exceedances of specific conductance and TOX at wells 299-W10-31 and 299-W10-30, respectively (DOE/RL-2019-32, *Interim Status Groundwater Quality Assessment Plan for the Low-Level Burial Grounds Waste Management Area-3*).
- RCRA monitoring for LLBG WMA-4 is conducted under DOE/RL-2009-69, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-4*, as modified by TPA-CN-718, *DOE/RL-2009-69 Interim Status Groundwater Monitoring Plan for the LLBG WMA-4 Revision 2*.

AEA Monitoring. AEA groundwater monitoring was conducted at 200-ZP groundwater interest area wells in accordance with DOE/RL-2015-56. The primary AEA constituents for the 200-ZP groundwater interest area are iodine-129, nitrate, technetium-99, radium-226, and tritium. Radionuclide concentrations detected in groundwater samples from 79 wells were used to estimate the cumulative TED and to compare the cumulative beta/photon emitters, alpha emitters, and uranium mass to DWSs. The estimated TED did not exceed the 100 mrem/yr standard in 200-ZP groundwater interest area wells. None of the DWSs for cumulative alpha emitters were exceeded, nor was the 30 µg/L uranium DWS exceeded. The net alpha dose exceeded the 15 mrem/yr at one location in 200-ZP groundwater interest area. The cumulative drinking water dose from beta/photon emitters exceeded the 4 mrem/yr standard at19 locations in the 200-ZP groundwater interest area. None of these locations are adjacent to the Columbia River, which is the primary potential pathway for offsite exposure to Hanford Site contaminated groundwater. Members of the public are protected from exposure to groundwater through the implementation of ICs that restrict access to groundwater and through remedial action measures (e.g., P&T) to control the migration of contaminated groundwater to exposure points. Details of the evaluation are presented in Section 12.13 of DOE/RL-2020-60.

Review of FY 2020 CERCLA investigations and CERCLA/RCRA/AEA monitoring activities reported in the Hanford Site groundwater monitoring report for CY 2020 (DOE/RL-2020-60) and evaluated in FY 2021 did not reveal any new information associated with the 200-ZP-1 OU with potential to significantly alter conclusions of the Hanford Site Composite Analysis.

1.3.3 Other Central Plateau Remediation Activities

Other remediation activities on the Central Plateau (aside from source and groundwater OU activities) are presented in this section. For FY 2018, confined aquifer monitoring and ERDF operations are activities reported in this category.

1.3.3.1 Confined Aquifer Monitoring

Although most Hanford Site groundwater contamination is found in the unconfined aquifer, wells in deeper aquifers are monitored because of potential downward movement of contamination and their potential migration offsite through confined aquifers. There is no evidence of offsite migration via the confined aquifers. Appendix D of DOE/RL-2014-32, *Hanford Site Groundwater Monitoring Report for 2013*, provides more detailed information about confined aquifer monitoring.

One confined aquifer occurs within sand and gravel at the base of the Ringold Formation. Carbon tetrachloride, nitrate, and technetium-99 have contaminated this unit in a portion of the 200 West Area where the upper confining unit is absent. New wells were installed in recent years to monitor and remediate this contamination. The Ringold confined aquifer is the uppermost aquifer in a region east of the 200 East Area (within portions of the 200-BP-5 and 200-PO-1 OUs). Iodine-129 and tritium are detected in wells at this location, but the contamination has not migrated farther to the east and/or southeast.

Groundwater within basalt fractures and joints, interflow contacts, and sedimentary interbeds make up the upper basalt-confined aquifer system. No significant contamination is detected in the basalt-confined aquifer except in the northwestern 200 East Area, where poor well construction and temporary drilling effects allowed local migration of groundwater from the overlying unconfined aquifer.

1.3.3.2 Environmental Restoration Disposal Facility Operations

As authorized by CERCLA, Hanford Site low-level radioactive, hazardous, dangerous, and low-level mixed waste generated during waste site closures and remediation activities from Hanford Site contractors is disposed at ERDF.

ERDF began operating in July 1996. Located between the 200 East and 200 West Areas, the facility currently consists of 10 cells and covers an area of approximately 43.3 ha (107 ac). The configuration of ERDF cells is shown in Figure and Figure 1-12.

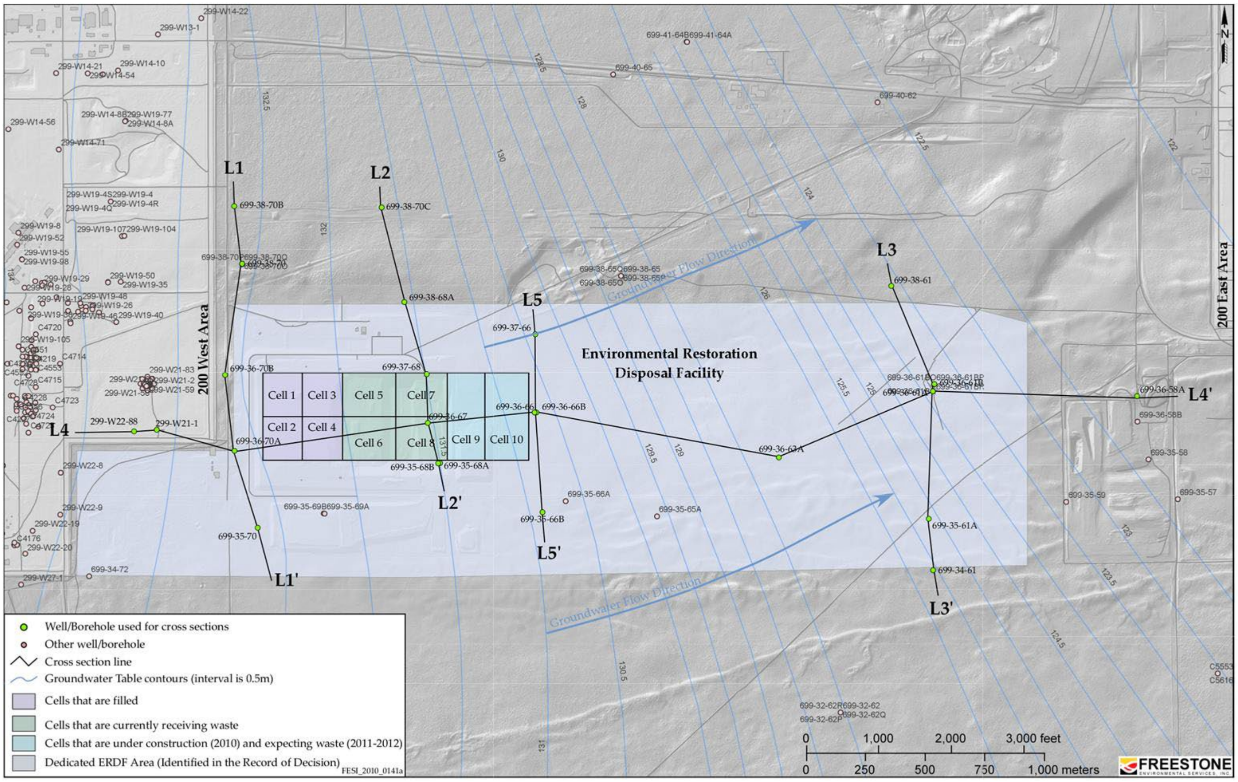


Figure 1-11. Configuration of Disposal Cells at the Environmental Restoration Disposal Facility

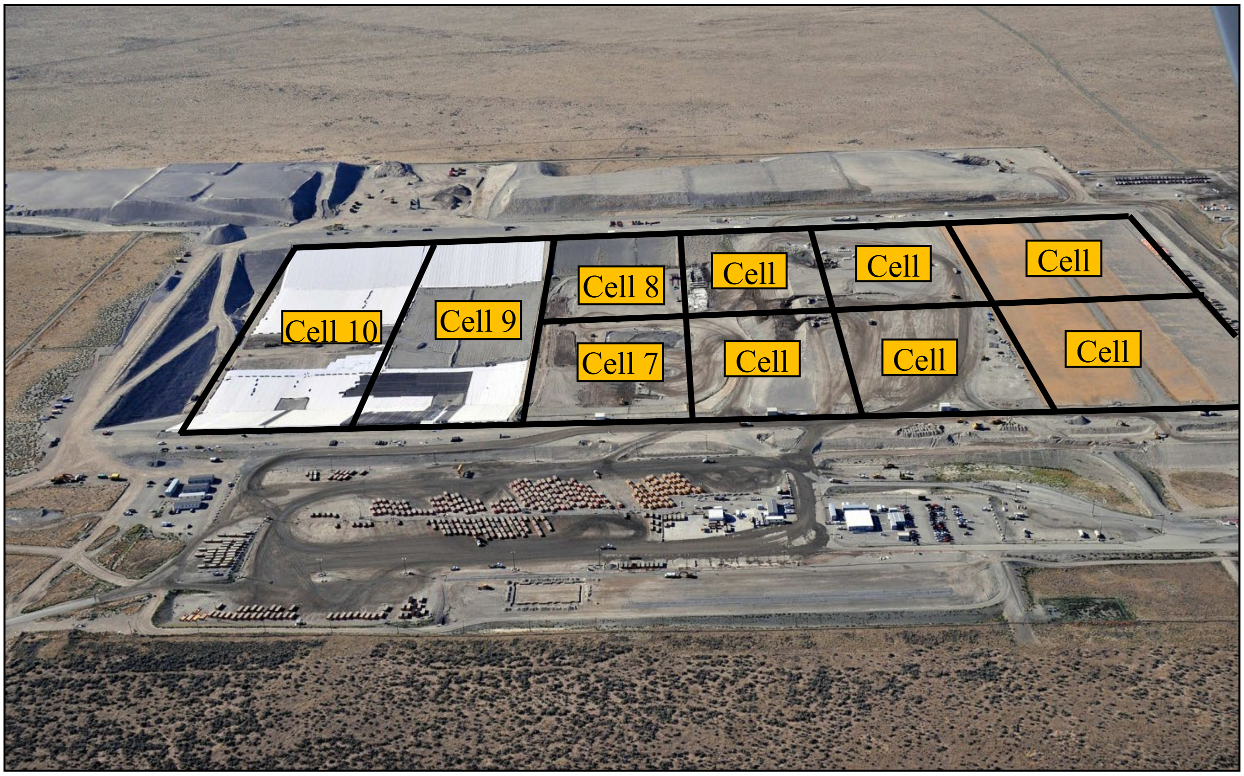


Figure 1-12. Photograph of the Environmental Restoration Disposal Facility with Indication of Disposal Cells

Requirements associated with the facility are identified in the following RODs and amendments:

- EPA/ROD/R10-95/100, *Declaration of the Record of Decision for the Environmental Restoration Disposal Facility*
- EPA/ESD/R10-96/145, *Explanation of Significant Differences: USDOE Environmental Restoration Disposal Facility, Hanford Site, Benton County, Washington*
- EPA/AMD/R10-97/101, *Record of Decision Amendment: U.S. Department of Energy Environmental Restoration Disposal Facility Hanford Site – 200 Area Benton County, Washington*
- EPA/AMD/R10-99/038, *Record of Decision Amendment: U.S. Department of Energy Environmental Restoration Disposal Facility Hanford Site – 200 Area Benton County, Washington*
- EPA/AMD/R10-02/030, *Record of Decision Amendment: U.S. Department of Energy Environmental Restoration Disposal Facility Hanford Site – 200 Area Benton County, Washington*
- EPA et al., 2007, *Amendment to the Record of Decision for the USDOE Hanford Environmental Restoration Disposal Facility*
- EPA et al., 2009b, *U.S. Department of Energy Environmental Restoration Disposal Facility Hanford Site 200 Area Benton County, Washington, Amended Record of Decision and Explanation of Significant Differences*
- EPA et al., 2015a, *Explanation of Significant Differences for the U.S. Department of Energy Environmental Restoration Disposal Facility, Hanford Site – 200 Area Benton County, WA*

- EPA et al., 2015b, *Amendment to the Record of Decision for the USDOE Hanford Environmental Restoration Disposal Facility*

Leachate Monitoring. Each ERDF cell is double lined to collect leachate resulting from water added as a dust suppressant and precipitation. The liner is sloped to a sump in each cell, and the leachate is pumped from the sump to holding tanks. The leachate is then pumped to the 200 West Area P&T or the ETF for treatment.

ERDF leachate is sampled for constituents identified in EPA/AMD/R10-99/038 and CP-60070, *Environmental Restoration Disposal Facility Leachate Sampling and Analysis Plan, formerly WCH-173 Rev. 2*. The 1999 ERDF ROD amendment (EPA/AMD/R10-99/038) delisted leachate and identified the necessary sampling parameters. Leachate samples are obtained directly from the holding tanks. Constituents detected in ERDF leachate samples are then compared with the groundwater monitoring analyte list to determine whether additional analytes should be added to the groundwater PA project. Leachate data are also evaluated for trends and compared to specific action levels. Target analytes for groundwater monitoring are consistent with the leachate monitoring program. Based on groundwater sampling and leachate data, no impact to groundwater has occurred from ERDF facility or operations. An annual report is prepared for ERDF that summarizes the leachate and groundwater monitoring data, providing conclusions and recommendations as appropriate. The most recent report is ERDF-00105, *Groundwater, Leachate, and Lysimeter Monitoring and Sampling at the Environmental Restoration Disposal Facility, Calendar Year 2019*.

Current Inventory Estimates. DOE/RL-2021-59 provides the annual activity inventory of key radionuclides placed in ERDF from the inception of ERDF operations (July 1, 1996) through September 30, 2020. In more than two decades since operation began, over 196,000 Ci has been disposed at ERDF. The data source for this summary is the “Inventory Disposed by Radionuclide (WMIS983)” report from the Waste Management Information System (WMIS) database.

A DOE O 435.1 PA (the revised ERDF PA [CP-60089, Rev. 0]) was completed in FY 2013 (Section 1.1.4), and the revised DAS was issued in November 2013. The inventory data package developed for that PA (WCH-479) indicates the ERDF inventory estimate is conservative. ERDF inventories are derived from data accumulated in WMIS database, which documents the ERDF waste acceptance process using waste profiles, onsite waste tracking forms (online manifest for wastes that will be shipped to ERDF), truck scale weights, and disposal records to calculate and accumulate the disposed inventory. One of the functions of the WMIS database is to ensure that waste above ERDF waste acceptance criteria limits (ERDF-00011) is not accepted for ERDF disposal. The waste acceptance process biases system inputs (e.g., profiles and onsite waste tracking forms [i.e., ERDF manifest]) to the highest expected levels before comparison with waste acceptance criteria. The net effect of this bias is to inflate ERDF radionuclide inventory. While this bias does not allow for precise knowledge of the actual inventory, it does provide assurance that inventory limits are not being exceeded, which is the intent of this process. Because of this deliberate bias, it is inappropriate to expect that the listed ERDF inventories (DOE/RL-2020-58) will match best estimate inventories prepared for other purposes (e.g., the PA inventory data package or the inventory for the Hanford Site Composite Analysis).

In the current annual status report for the ERDF PA (DOE/RL-2021-59), there are no unreviewed disposal questions to report for the reporting period (FY 2021).

2 Cumulative Effects of Changes

Based on Chapter 1 with respect to the Hanford Site Composite Analysis, information was not noted that would be expected to result in higher dose estimates if included in a revised calculation. The final TC & WM EIS (DOE/EIS-0391) states that DOE would continue to defer the importation of offsite waste at the Hanford Site, at least until the Hanford Tank Waste Treatment and Immobilization Plant is operational. Any future decision to import offsite waste will be subject to appropriate *National Environmental Policy Act of 1969* review.

The radioactive waste management basis (RWMB) for the Hanford Site is provided in CPCC-MP-WM-52872, Waste Management Basis. Appendix E of CPCC-MP-WM-52872 provides the facility specific information and documents.

Some activities continue to be considered qualitatively that would be expected to result in lower dose estimates if included in a revised calculation. The CERCLA P&T systems on the Central Plateau that are qualitatively evaluated as likely to reduce the projected dose are the most notable. Such dose reduction would be due to removal of contaminant mass from the groundwater pathway. The Hanford Site Composite Analysis did not account for remedial actions such as P&T systems. Hydraulic perturbations to the unconfined aquifer in the Central Plateau and contaminant mass reduction in groundwater resulting from P&T systems will be considered in the update of the Hanford Site Composite Analysis (Revision 1 expected to be completed in FY 2022). Potential for closure of the 200-SW-2 Burial Ground is another change qualitatively evaluated as likely to reduce the projected dose. The dose reduction for this site would be due to the lower realized inventory than was considered in the Hanford Site Composite Analysis, resulting from cessation of the use of the unlined trenches (with the unused portions being withdrawn from the Hanford RCRA Permit because they will not be used at this time). Based on this change, the inventory reduction at this site will also be considered in a future revision of the Hanford Site Composite Analysis.

The Hanford Site vadose zone is extensive and deep (on the order of 100 m [328 ft] thick in the Central Plateau), and radioactive contamination is present at numerous locations as a result of past practices as simulated in the Hanford Site Composite Analysis. At present, all LLBGs (except Trench 94) in active operation in the 200 West and 200 East Area LLBGs (as discussed in Section 1.1.1) and ERDF (as discussed in Section 1.1.4) have liner/leachate collection and removal systems. Naval reactor disposal site Trench 94 is located in the 200 East Area LLBGs and has an exemption from the liner/leachate collection and removal system requirements because each reactor compartment is sealed; consequently, these PA sites have not affected the vadose zone or groundwater. The presence of radiological contamination in the vadose zone at past-practice disposal sites represent continuing sources of groundwater contamination at several locations in the Central Plateau as well as potential future continuing source that have not emerged in groundwater at several other locations. Many past-practice disposals involved large liquid discharges of waste, with the associated hydraulic influences on vadose zone hydraulics (including transient perched water impacts above the Cold Creek unit in the 200 West Area and the enduring perched water impact below the B Complex in the 200 East Area). These impacts then influence the subsurface transport of radionuclide contaminants in the impacted vadose zone in these locations. The Hanford Site Composite Analysis simulates the vadose zone for the past, present, and future to represent the distribution of water and radiological contaminants in the vadose zone from past practices and future releases. Hanford Site cleanup is being performed under the Tri-Party Agreement (Ecology et al., 1989), which divides the Central Plateau into source OUs (vadose zone only) and groundwater OUs for CERCLA. The source OUs are discussed in Section 1.3.1, and the groundwater OUs are discussed in Section 1.3.2.

2.1 Relative Contribution of DOE O 435.1-Regulated Sources to All-Pathways Dose

The initial Hanford Site Composite Analysis presented in PNNL-11800 and PNNL-11800-Addendum-1 (subject of the maintenance program for this annual status report) did not identify the relative contribution to total dose resulting from DOE O 435.1 regulated sources and other sources. The modeling tools used to develop the initial Hanford Site Composite Analysis are no longer available to assess the portion of the total dose estimate attributable to only DOE O 435.1 sources. However, the updated Hanford Site Composite Analysis (currently under LFRG review) includes a sensitivity case that compares the all-pathways dose contributed by DOE O 435.1 facilities only to the total dose calculated for all contributing sources. This calculation is documented in ECF-HANFORD-22-0002, Composite Analysis Vadose Zone Transport of Selected Radionuclides Released from DOE O 435.1 Sources. The DOE O 435.1-regulated tank closure and waste management facilities evaluated in the sensitivity case are:

- 200 East Area LLBG
- 200 West Area LLBG
- ERDF (active)
- IDF (standby)
- WMA A/AX
- WMA B/BX/BY
- WMA C
- WMA T
- WMA TX/TY
- WMA S/SX
- WMA U

To evaluate the impact of DOE O 435.1 regulated facilities on the predicted releases, transfer to groundwater, and groundwater concentration and dose, the vadose zone models constructed for the updated Hanford Site Composite Analysis are run with only the inventory associated with the DOE O 435.1 regulated facilities. The other radionuclide sources associated with past leaks or anthropogenic liquid discharge sites and other sources not associated with DOE O 435.1, including the US Ecology site, are not included in the sensitivity analysis. The predicted releases to the vadose zone and associated predicted transfer to groundwater for Tc-99, I-129, and U-238 (major dose contributors) for the DOE O 435.1 facilities are presented in ECF-HANFORD-22-0002. The results are compared to the total releases and transfer to groundwater for all radionuclide sources from vadose zone models constructed for the updated Hanford Site Composite Analysis.

The following observations are made in ECF-HANFORD-22-00002 related to the predicted groundwater concentrations associated with the DOE O 435.1 regulated sources:

- The DOE O 435.1 sources do not contribute to any significant predicted Tc 99, I 129, or U 238 concentrations at or beyond the CA compliance boundary, as noted by the observation that the base case and DOE O 435.1 sensitivity case yield similar results in these model zones. The predicted peak concentrations beyond the CA compliance boundary are a result of the initial (2018) contamination of these radionuclides that dissipates with time.
- The predicted groundwater concentration results for the DOE O 435.1 sources are masked by the initial concentration which is assumed to be the observed concentration in 2018. This masking is evident in the predicted Tc 99 and I 129 concentrations along or beyond the CA compliance boundary which are invariant with time and are the same as the base case results.

- The DOE O 435.1 sources contribute to a low predicted Tc 99 concentration of less than 30 pCi/L at the CA compliance boundary at about CY 4000.
- The timing of the peak groundwater concentrations beneath the DOE O 435.1 sources corresponds to the timing of the peak transfer rate to groundwater.

In summary, the DOE O 435.1 sources do not contribute significantly to groundwater contamination on the Central Plateau of the Hanford Site. Evaluation of dose results confirmed the insignificance of the DOE O 435.1 sources at or beyond the CA compliance boundary.

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3 Waste Receipts

Waste receipts are accounted for in the following individual PA annual summary reports:

- ERDF PA annual status report: DOE/RL-2021-59
- 200 East Area LLBG PA annual status report: DOE/RL-2021-58
- 200 West Area LLBG PA annual status report: DOE/RL-2021-57
- US Ecology commercial LLW disposal facility annual utilization report: US Ecology, 2016, *US Ecology Washington – 2016 Facility Utilization Report*

Waste disposal authorizations are needed to dispose of waste in the IDF, and so it has not received waste yet.

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4 Monitoring

This chapter describes the Hanford Site monitoring results for CY 2020 (the CY 2020 results are the latest available in the reporting period of FY 2021) relevant to the Hanford Site Composite Analysis. Compliance monitoring activities are summarized in Table 4-1 and discussed in this chapter.

4.1 Summary of Air Monitoring

Air monitoring results for CY 2020 are summarized in DOE/RL-2021-15, *Hanford Annual Site Environmental Report for Calendar Year 2020*, specifically Section 6.0, “Air Monitoring.” The following information was drawn from that report.

Air monitoring reported in the annual site environmental report pertains to current conditions that result from radioactive emission point sources (i.e., stacks and vents) that will not be present during the compliance period evaluated in the Composite Analysis. The maintained CA (PNNL-11800; PNNL-11800, Addendum 1) compliance period begins in CY 2050, and the updated CA in development (Appendix B) starts the compliance period in CY 2070; all sources reported in the annual site environmental report will no longer exist after site closure. Hence, the air monitoring results summarized below are provided for reference to current conditions but have limited applicability to the CA basis.

Air quality is monitored using stack sampling at the sources and air monitoring at receptor locations. The specific objectives are to measure airborne radionuclides to calculate the doses to humans, plants, and animals. Measured and calculated results are compared with the DOE, EPA, and/or Washington State Department of Health standards.

Small quantities of radionuclides and industrial air pollutants are emitted to the environment through radioactive emission point sources (i.e., stacks and vents). The federal and state permit requirements contained in the Hanford Site air operating permit (Ecology, 2019, *Hanford Site Air Operating Permit 00-05-06, Renewal 3*) define which stacks require sampling, how and how often to collect the samples, and the isotopes to be measured. The commonly measured isotopes include tritium (i.e., hydrogen-3), strontium-90, iodine-129, cesium-137, plutonium-238, plutonium-239/240, and americium-241. Emission points are sampled and monitored continuously if they have the potential to emit radionuclides that exceeds 1% of the 40 CFR 61, “National Emission Standards for Hazardous Air Pollutants,” Subpart H, “National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities” public dose limit of 10 mrem/yr or 100 microsievert (μSv)/yr. Continuous sampling is defined and described in more detail in the ANSI/HPS N13.1, *Sampling and Monitoring Releases of Airborne Radioactive Substances From the Stacks and Ducts of Nuclear Facilities*. For other release points, periodic confirmatory measurements are made to verify low emissions.

Offsite radiological dose assessments related to stack releases are ideally based on direct measurements of radionuclide concentrations in specific environmental media such as air, water, and food measured at offsite locations. However, amounts of many radioactive materials released to the atmosphere from Hanford Site sources are too small to be measured in media after they are released from stacks and diluted through miles of dispersion in the environment. Radioactive air emissions from the Hanford Site have been generally decreasing over time because the production and processing of nuclear materials ceased more than 30 years ago. For the radionuclides present in measurable amounts, it can be difficult to distinguish the small contribution of Hanford Site stacks from other contributions caused by fallout from historical nuclear weapons testing and naturally occurring radionuclides such as uranium and its decay products. As a result, the dose assessment process incorporates conservative assumptions to ensure that calculated doses are likely to be overestimated. For more information on doses due to radiological releases, the reader is referred to Section 4.2 of DOE/RL-2021-15.

Radioactive air emission points are located on the Hanford Site in the 100, 200, 300, and 400 Areas. The quantity of radionuclide air emissions reported in 2020 were similar in magnitude to those reported in 2019.

4.1.1 Air Effluent Monitoring for Radioactive Airborne Emissions

DOE contractors monitor airborne pollutants from site facilities to quantify emissions, determine compliance with federal and state regulatory requirements, and assess the effectiveness of emission control equipment. Most facility radioactive air emission point sources are actively ventilated stacks sampled prior to the point of release to the ambient environment. Airborne emissions with potential to contain radioactive materials are sampled for gross alpha, gross beta, and radionuclides specified in the Hanford Site air operating permit (Ecology, 2019).

Small quantities of radionuclides are emitted to the environment through radioactive emission point sources (i.e., stacks and vents) during routine operations. The federal and state permit requirements contained in the air operating permit define which stacks require sampling, how often to collect the samples, and the isotopes to be measured. The commonly measured isotopes include tritium (i.e., hydrogen-3), strontium-90, iodine-129, cesium-137, plutonium-238, plutonium-239/240, and americium-241. Emission points are sampled and monitored continuously if they have the potential to emit radionuclides that exceed 1% of the 40 CFR 61 Subpart H public dose limit of 10 mrem/yr or 100 μSv/yr. Continuous sampling is defined and described in more detail in ANSI/HPS N13.1. For other release points, periodic confirmatory measurements are made to verify low emissions.

The quantity of radionuclide air emissions reported in 2020 were similar in magnitude to those reported in 2019. Table 4-2 summarizes Hanford Site radioactive airborne emissions in 2020.

4.1.2 Air Monitoring for Radionuclides

Atmospheric releases of radioactive materials from Hanford Site facilities and operations to the surrounding region are potential sources of exposure to humans. Radioactive constituents in air are monitored at Hanford Site facilities and operations at locations away from site facilities, offsite around the perimeter, and in nearby and distant communities. Information about these ambient air monitoring efforts, including detailed descriptions of air sampling and analysis techniques, is provided in the DOE/RL-91-50, *Hanford Site Environmental Monitoring Plan*.

A network of continuously operating samplers at 78 locations across the Hanford Site was used during 2020 to monitor radioactive airborne materials in air near Hanford Site facilities and operations (details are reported in Table 6-4 of DOE/RL-2021-15). The samplers were primarily located at or within approximately 500 m (1,640 ft) of sites and facilities that have the potential for or a history of environmental releases. The samplers were primarily located in the prevailing downwind direction. Samples were collected according to a schedule established before the 2020 monitoring year.

Airborne particle samples were collected at each location by drawing air through a cellulose filter. The filters were collected bi-weekly, field-surveyed for gross radioactivity, held for at least 5 days, and then analyzed for gross alpha and beta activity. The 5-day holding period is necessary to allow for the decay of naturally occurring, short-lived radionuclides that would otherwise obscure the detection of longer-lived radionuclides associated with emissions from nuclear facilities. The gross radioactivity measurements were used to indicate changes in trends in the onsite facility environment.

Table 4-1. Compliance Monitoring

Disposal Facility/Unit	Monitoring Type	Monitoring Results and Trends	Performance Objective Measure or Other Regulatory Limit	Action Level	Action Taken	Performance Assessment/ Composite Analysis Impacts
Sitewide	Air	Stable; comparable to widespread background concentrations	--	--	Monitoring	None
Central Plateau groundwater OUs: 200-ZP-1, 200-UP-1, 200-BP-5, and 200-PO-1	Groundwater	Groundwater flow system continues recession since cessation of large-volume liquid discharges in the early 1990s Groundwater radioactive contaminant plumes of tritium, iodine-129, strontium-90, technetium-99, and uranium formed when waste discharged to ponds and cribs reached the aquifer	RCRA, CERCLA, and AEA	Determined in OU decision documents	200 West Area pump and treat system; 200-BP-5 OU treatability tests	Reduction of groundwater contamination not evaluated in the Hanford Site Composite Analysis; this feature will be addressed in composite analysis update
Selected source OUs: 200-DV-1, 200-WA-1, and 200-EA-1	Vadose zone	Characterization	CERCLA	To be determined	Characterization	Data will support refined analysis of vadose zone in Hanford Site Composite Analysis update

Reference: DOE/RL- 2021-15, *Hanford Annual Site Environmental Report for Calendar Year 2020*.

AEA = *Atomic Energy Act of 1954*

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*

OU = operable unit

RCRA = *Resource Conservation and Recovery Act of 1976*

Table 4-2. Hanford Site Radioactive Airborne Emissions in Calendar Year 2020

Radionuclide	100 Area (Ci)	200 East Area (Ci)	200 West Area (Ci)	300 Area (Ci)	400 Area (Ci)	Total (Ci)
Actinium-227	N/A	N/A	N/A	2.1E-10	N/A	2.1E-10
Americium-241	3.10E-06	1.00E-07	2.00E-07	2.30E-11	N/A	3.40E-06
Americium-243	N/A	N/A	N/A	4.10E-08	N/A	4.10E-08
Carbon-14	N/A	N/A	N/A	1.00E-05	N/A	1.00E-05
Cesium-137	3.80E-06	1.50E-06	1.60E-06	5.60E-08	1.10E-11	6.90E-06
Cobalt-60	ND	ND	ND	3.70E-08	N/A	3.70E-08
Curium-243/244	N/A	N/A	N/A	ND	N/A	0.00E+00
Europium-152	ND	ND	ND	7.10E-10		7.10E-10
Europium-154	ND	ND	ND	4.30E-08		4.30E-08
Gadolinium-153	N/A	N/A	N/A	4.00E-10	N/A	4.00E-10
Gross Alpha	1.30E-05	9.40E-07	4.00E-06	1.60E-07	5.60E-08	1.90E-05
Gross Beta	1.40E-05	6.00E-06	5.20E-06	4.90E-06	4.40E-07	3.70E-05
Iodine-129	N/A	5.30E-04	N/A	N/A	N/A	5.30E-04
Krypton-85	N/A	N/A	N/A	2.10E-07	N/A	2.10E-07
Neptunium-237	N/A	N/A	N/A	1.40E-08	N/A	1.40E-08
Plutonium-238	4.40E-07	ND	1.80E-08	3.50E-08	N/A	4.90E-07
Plutonium-239/240	3.40E-06	2.30E-08	2.20E-06	5.60E-09	2.30E-13	5.60E-06
Plutonium-241	1.20E-05	ND	1.7E-07	ND	N/A	1.20E-05
Radium-226	N/A	N/A	N/A	3.80E-10	N/A	3.80E-10
Radon-219	N/A	N/A	N/A	3.0E-01	N/A	3.0E-01
Ruthenium-106	ND	ND	ND	1.60E-08	N/A	1.60E-08
Sodium-22	N/A	N/A	N/A	N/A	2.10E-10	2.10E-10
Strontium-90	1.00E-06	7.10E-07	9.60E-07	3.80E-08	N/A	2.70E-06
Technicium-99	N/A	N/A	N/A	4.3E-06	N/A	4.3E-06
Tritium (elemental)	N/A	N/A	N/A	4.90E+01	N/A	4.90E+01
Tritium (tritiated water vapor)	N/A	N/A	N/A	2.02E+02	1.00E-02	2.02E+02
Uranium-232	N/A	N/A	N/A	8.5E-09	N/A	8.5E-09
Uranium-233	N/A	N/A	N/A	1.9E-08	N/A	1.9E-08

Source: Table 6-2 of DOE/RL- 2021-15, *Hanford Annual Site Environmental Report for Calendar Year 2020*.

Ci = curies

N/A = not applicable

ND = not detected

The results of this monitoring program with respect to the Central Plateau (focus of the Composite Analysis) were reported in DOE/RL- 2021-15 as follows:

- **200 East Area**: Air sampling was conducted at 28 locations in the 200 East Area during 2019. Generally, radionuclide levels measured were similar to those measured in previous years. Cesium-137 was detected in approximately 10% of the samples. Uranium-234 and uranium-238 were detected in approximately 15% of the samples.
- **200 West Area**: Air sampling was conducted at 23 locations in the 200 West Area during 2019. In general, radionuclide levels measured were similar to results for previous years. Uranium-234 and uranium-238 were detected in less than 10% of the samples. Plutonium-239/240 and americium-241 were detected in approximately 20% of the samples.
- **ERDF**: Air sampling in support of ERDF operations was conducted at five locations at ERDF (200 West Area): three project-specific stations and two upwind stations that are part of the 200 West Area monitoring network. Radionuclide levels measured at this site were similar to those seen in previous years. Uranium-233/234 and uranium-238 were detected in approximately 50% and 40% of the samples, respectively. All other radionuclides of concern were below analytical detection limits.

4.1.3 Perimeter and Offsite Air Monitoring for Radionuclides

Airborne radionuclide samples were collected in 2020 by 19 continuously operating samplers in the vicinity of the Hanford Site. The stations were grouped into three proximity categories: perimeter (11 stations), nearby Hanford Site communities (7 stations), and distant community (1 station). Perimeter samplers were located around the site boundary with emphasis on prevailing downwind directions to the south and east. Samplers located in Basin City, Benton City, Kennewick, Mattawa, Othello, Pasco, and Richland, Washington, provided data for the nearest population centers. A sampler in Yakima, Washington, provided background data from a community essentially unaffected by Hanford Site operations.

Sample results in 2020 showed low radiological concentrations in air. Gross alpha and gross beta concentrations in the air samples collected in 2020 from the perimeter and nearby Hanford Site communities were comparable to each other and slightly higher than samples from the distant community. Concentrations in 2020 were comparable to concentrations seen in the previous 5 years. Gross beta and gross alpha concentrations in air peak during the fall and winter months, exhibiting a pattern of natural radioactivity fluctuations (Eisenbud, 1987, *Environmental Radioactivity: From Natural, Industrial, and Military Sources*). This fluctuation is seen in both Hanford Site and distant location concentrations.

Uranium-234 and -238 were both detected in approximately 35% of the air samples collected in 2020 from all locations. Uranium-234 and -238 concentrations were at levels similar to those measured in previous years. The maximum concentrations measured in all locations were less than 10% of the EPA concentration values for both radionuclides.

Tritium was detected in two (less than 2%) of the offsite samples at concentrations similar to those seen

in previous years. Cesium-137, strontium-90, and plutonium isotopes were not detected in any of the offsite air samples collected during 2020.

4.2 Summary of Groundwater Flow Conditions and Extent of Contamination

A plan has been developed to address groundwater and vadose zone contamination from DOE-RL in consultation with EPA and Ecology. Key elements associated with managing the Hanford Site groundwater and vadose zone contamination are to protect the Columbia River and groundwater, develop a cleanup decision process, and achieve final cleanup.

DOE is committed to protecting the Columbia River and human health and the environment from Hanford Site contaminated groundwater. As part of this commitment, the following four cornerstone documents have been developed for the monitoring and remediation of Hanford Site contaminated soils and groundwater:

- DOE/RL-2002-59, *Hanford Site Groundwater Strategy: Protection, Monitoring, and Remediation*
- DOE/RL-2002-68, *Hanford's Groundwater Management Plan: Accelerated Cleanup and Protection*
- DOE/RL-2007-20, *Hanford Integrated Groundwater and Vadose Zone Management Plan*
- DOE/RL-2009-10, *Hanford Site Cleanup Completion Framework*

Due to the reporting cycle for the groundwater monitoring program, the results discussed in the following sections reflect sampling and analyses completed in CY 2020 that were reported in DOE/RL-2020-60. Groundwater at the Hanford Site is monitored under various sampling and analysis plans that are reviewed and/or approved by DOE-RL, Ecology, and EPA.

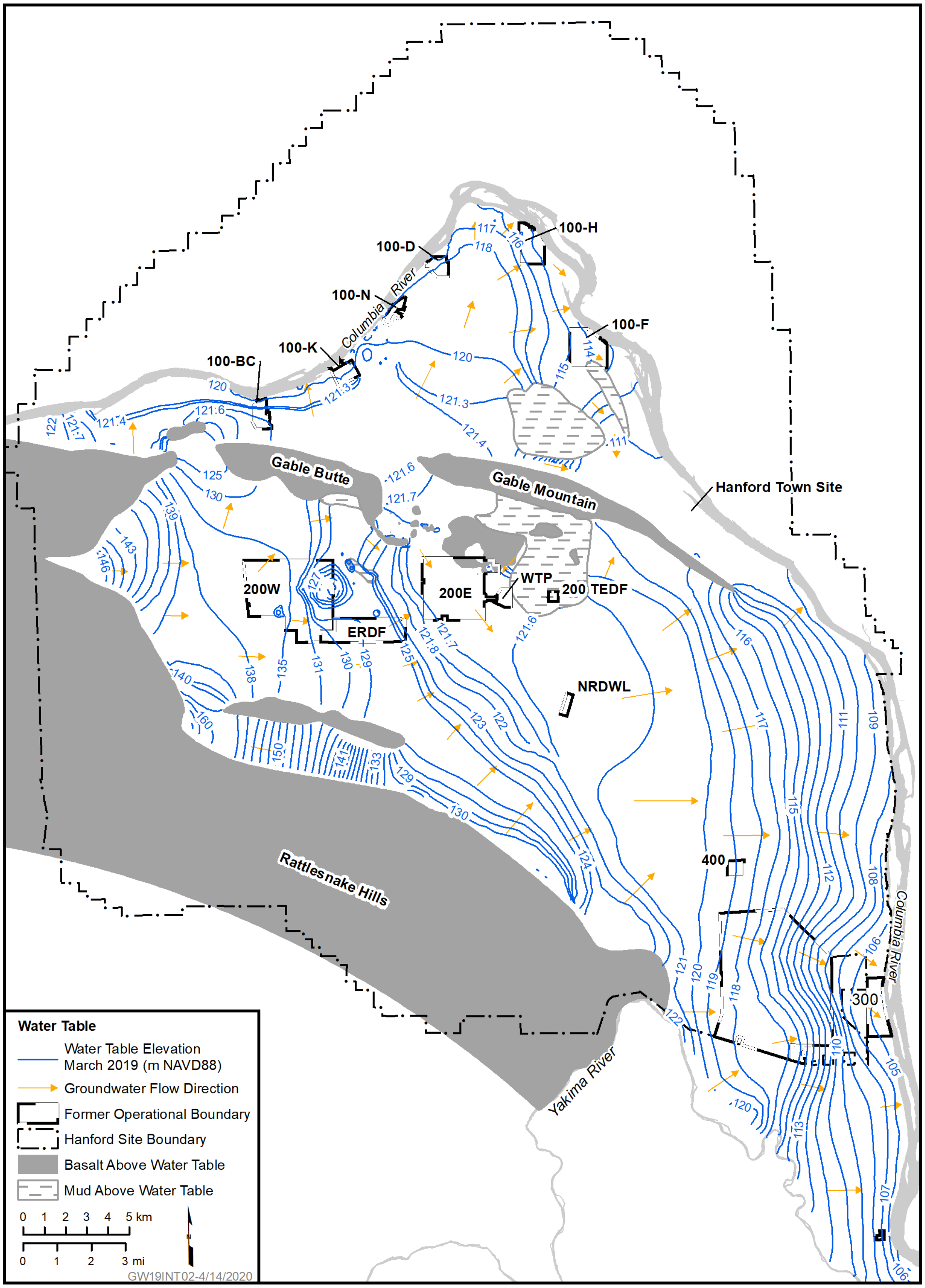
Relevance of Groundwater Monitoring to the Composite Analysis

The groundwater monitoring program provides additional data that serve to validate or revise the modeling basis used in the Hanford Site Composite Analysis. The unconfined aquifer at the Hanford Site was subject to large volume liquid discharges during the Hanford Site operational phase (1944 to 1989), and the water table is now experiencing a slow decline to pre-Hanford Site flow conditions. It is also subject to pumping stresses associated with P&T actions. Historical water-level data predominantly reflect the operational phase. Consequently, later data continue to support improvement in the predictive capability of groundwater flow models as the system approaches long-term flow conditions.

Similarly, monitoring of groundwater contamination provides important data to validate or revise the modeling basis used.

4.2.1 Groundwater Flow

The natural pattern of groundwater flow was altered during Hanford Site operational years by water table mounds created by the discharge of large volumes of wastewater to the ground. The 100 Area's mounds declined as reactor operations ceased, and since effluent disposal in the Central Plateau decreased substantially in the 1990s, the mounds in the 200 Areas have dissipated considerably. Declining water levels from mounding continue to affect groundwater flow and depth to water. Additionally, active groundwater P&T remediation systems in both the 200 East and the 200 West Areas have resulted in local changes to groundwater gradients near associated extraction and injection wells. Figure 4-1 shows the Hanford Site water table and inferred groundwater flow directions for January to March 2020.



Sources: Figure 1-2 in DOE/RL-2020-60, *Hanford Site Groundwater Monitoring Report for 2020*.
NAVD88, *North American Vertical Datum of 1988*.

Figure 4-1. Water Table and Inferred Groundwater Flow Directions for the Hanford Site, 2020

The determination of hydraulic gradients over much of the Hanford Site is readily accomplished by analyzing water level measurements from monitoring wells. However, the unconfined aquifer beneath the 200 East Area exhibits a low hydraulic gradient magnitude (i.e., flat water table); therefore, water-level measurements have a low signal-to-noise ratio, making the determination of hydraulic gradients in this region difficult. SGW-54165, *Evaluation of the Unconfined Aquifer Hydraulic Gradient Beneath the 200 East Area, Hanford Site*. To improve measurement accuracy, wells used for water level mapping in the gyroscopic surveys performed to correct for verticality error, and resurveys of well casings have been performed using a highly accurate leveling technique. The results indicate that flow is toward the southeast over most of the 200 East Area. Hydraulic gradients at 200 East Area RCRA sites generally range between 3.7×10^{-6} m/m at the 216-B-63 Trench to 1.6×10^{-5} m/m at the 216-A-29 Ditch (ECF-HANFORD-20-0066, *Hydraulic Gradient and Average Linear Velocity Calculations – Quarter 1 Calendar Year 2020*).

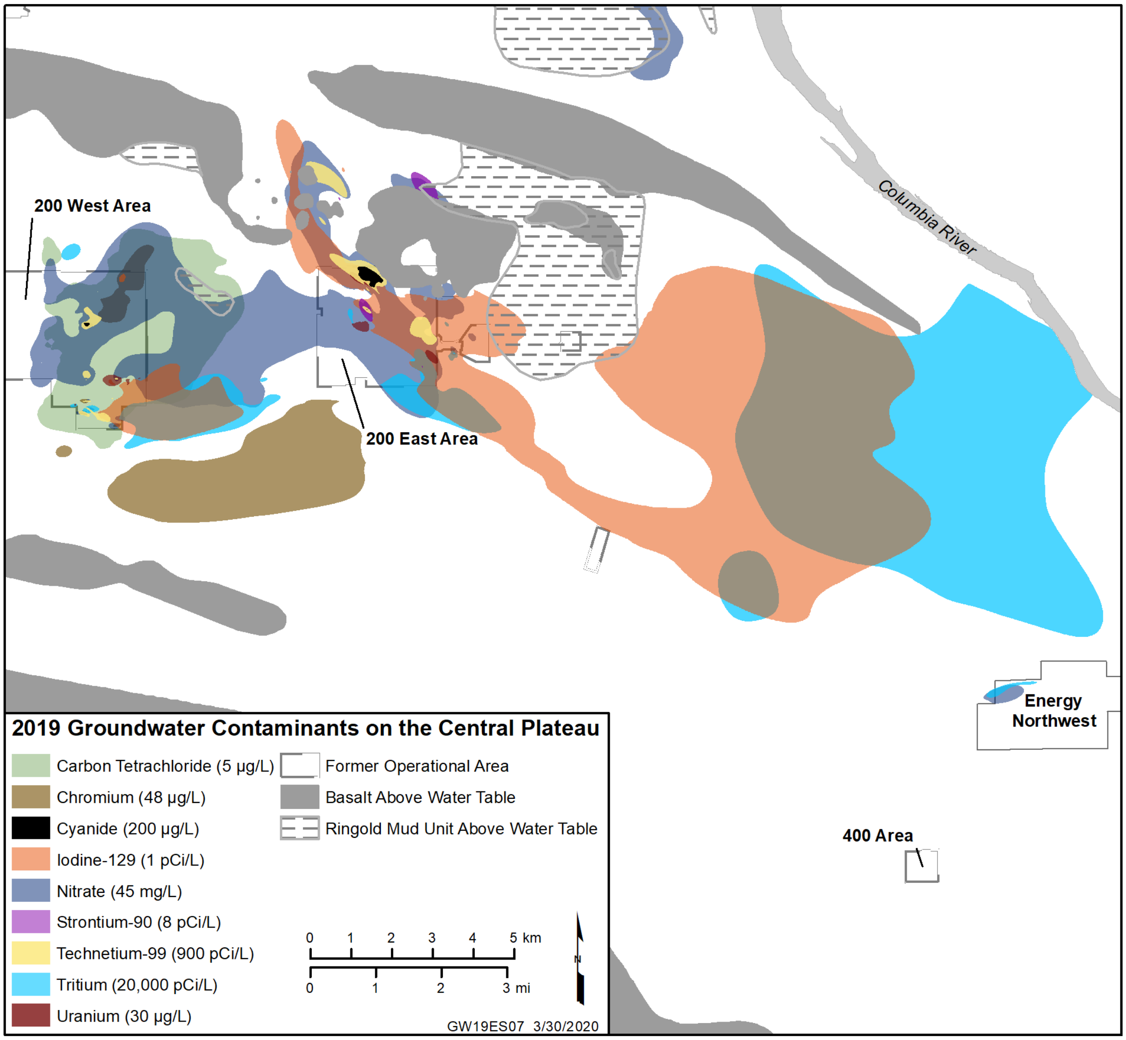
4.2.2 Extent of Contamination

Groundwater contaminant plumes of tritium, iodine-129, strontium-90, technetium-99, and uranium formed when waste that was discharged to ponds and cribs reached the aquifer. Cesium-137 and plutonium-239/240 have also been found in groundwater above their respective DWS values, but only in the 200-BP-5 OU adjacent to the decommissioned 216-B-5 injection well, where waste was discharged directly into the aquifer in the past. In 2020, cesium-137 concentrations exceeded the 200 pCi/L DWS in two wells near the 216-B-5 injection well. The maximum plutonium-239/240 concentration in this area was below the 15 pCi/L DWS (for gross alpha). Thus, plume extents for cesium-137 and plutonium-239/240 are not further discussed.

Figure 4-2 shows the distribution of radionuclide contaminant plumes originating from sources on the Central Plateau that are at concentrations above respective DWSs in the unconfined aquifer.

The status of the plumes for tritium, iodine-129, strontium-90, technetium-99, and uranium are summarized as follows:

- Tritium occurs above the 20,000 pCi/L DWS within all four Central Plateau groundwater OUs with a combined plume extent of 61 km^2 (the largest plume extent is 57 km^2 within 200-PO-1). The highest tritium result detected within a Central Plateau groundwater OU during 2020 was273,000 pCi/L at the PUREX Cribs (200-PO-1 OU) in the 200 East Area (the highest concentration during 2019 within this area was 4,240,000 pCi/L at a well that was not sampled during 2020). Thus, the PUREX Cribs are a continuing source of tritium to the aquifer. Tritium continues to attenuate in areas away from operational areas due to dispersion and radioactive decay. Within the 200-PO-1 OU, tritium is discharging to the Columbia River, but sampled concentrations at the river boundary have declined to below the DWS (maximum concentration of 17,600 pCi/L in a groundwater seep).



Source: Figure ES-7 in DOE/RL-2020-60, *Hanford Site Groundwater Monitoring Report for 2020.*

Figure 4-2. Distribution of Radionuclide Contaminant Plumes Originating from the Hanford Site Central Plateau at Concentrations Above Drinking Water Standards in the Unconfined Aquifer

- The largest iodine-129 plume occurs within the 200-PO-1 OU, extending from the 200 East Area. At the 1 pCi/L contour level (the DWS), the 200-PO-1 plume extends 12 km (7.5 mi) east of the 200 East Area and covers an extent of 54 km^2; its range has changed very little over the past 20 years. While the contaminant continues to migrate downgradient, concentrations at the leading edge of the plume are being reduced by dispersion, and the contour position at 1 pCi/L is stable. There is no significant reduction in concentrations due to radioactive decay because iodine-129 has a long half-life (15.7 million years). Concentrations in 200-PO-1 along the Columbia River are less than the DWS. Iodine-129 concentrations also exceed the DWS in plumes from the 200 West Area. The extent of the plumes from all Central Plateau sources is 64 km^2. The maximum concentration beneath the Central Plateau during 2020 was16.4 pCi/L in the 200-UP-1 OU. An iodine-129 treatment technology evaluation for the 200-UP-1 OU was completed in September 2019 (PNNL-29148, *Assessment of Technologies for I-129 Remediation in the 200-UP-1 Operable Unit*), which concluded that a viable treatment technology for the iodine-129 plume is not available. Thus, a technical impracticability waiver may be pursued under 40 CFR 300.430(f)(l)(ii)(c), "Remedial Investigation/Feasibility Study and Selection of Remedy."

- The most substantial uranium plumes occur within the 200-BP-5 and 200-UP-1 OUs. The 200-BP-5 OU plume originates from the B Complex, where uranium is entering the aquifer from a perched zone above the unconfined aquifer. The maximum uranium concentration in this area during 2020 was 625 µg/L, a slight decline from the maximum 641 µg/L in 2019. A P&T system has been operating in this plume since 2015. Since startup, this system has removed 212 kg of uranium from the aquifer, and its operation has reduced concentrations in the aquifer and the size of the plume. In December 2014, the Tri-Parties signed an action memorandum (DOE/RL-2014-34) that specifies extraction of water from the perched zone beneath the B Complex and transfer to the 200 West P&T for treatment and injection into the aquifer. Perched water extraction continued in 2020. The maximum measured concentration in the perched zone was 110,000 µg/L, and approximately 34 kg of uranium was removed in 2020. Since 2011, a total of 328 kg of uranium has been removed. To increase the removal rate of uranium from the perched zone, 8 additional extraction wells, along with 4 monitoring wells, are planned for drilling (DOE/RL-2019-42, *Sampling and Analysis Plan for Perched Water Extraction and Monitoring Wells in the 200-DV-1 Operable Unit*). Uranium plumes in the 200-UP-1 OU occur near U Plant, originating from the 216-U-1 and 216-U-2 Cribs and in a second area near the 216-U-10 Pond. The highest uranium concentration in Central Plateau groundwater during 2020 occurred in the 216-U-1 and 216-U-2 Cribs plume at 1,840 µg/L, a decrease from 2,100 µg/L in 2019. A P&T remedy for uranium at the 200-UP-1 OU began operating in September 2015. The system consists of three extraction wells and the water is treated at the 200 West P&T. During 2020, a total of 10.3 kg of uranium was removed from the aquifer, and 69.2 kg has been removed since startup. When including the previous P&T remedies that operated within this plume, a total of 977 kg of uranium has been removed from the aquifer.

- Technetium-99 plumes are present within all four Central Plateau OUs, but the largest (0.85 km^2) occurs within the 200-BP-5 OU. This plume originates from the B Complex (BY Cribs) and extends to the northwest beyond the 200 East Area. The highest concentration in this area during 2020 was 29,500 pCi/L, which was the highest concentration in groundwater beneath the Central Plateau (the DWS is 900 pCi/L). Technetium-99 concentrations at the B Complex have been declining in many wells due to operation of a P&T system but concentrations increased from 2019 to 2020 in response to a temporary shutdown of groundwater extraction due to work restrictions related to COVID-19. Since startup in 2015, the P&T system has removed 6.27 Ci of technetium-99 from the aquifer. Technetium-99 plumes also occur in association with the tank farms in both the 200 East and 200 West Areas. The maximum concentration downgradient from the WMA U Tank Farm in the 200 West Area had increased substantially in recent years (maximum of 13,800 pCi/L in 2018), but concentrations were lower in 2020 (maximum of 9,180 pCi/L, . Downgradient from the WMA TX-TY Tank Farm, concentrations increased in a single well from 968 pCi/L in 2016 to 24,300 pCi/L in 2019. This is likely caused by a continuing source. Technetium-99 is removed from the aquifer by two extraction wells near U Plant, from a P&T system at the WMA S-SX Tank Farm, and from extraction wells near the WMA T and WMA TX-TY Tank Farms. Since startup, 1.22 Ci and 3.44 Ci of technetium-99 have been removed by the U Plant and S-SX Tank Farm extraction wells, respectively. The highest technetium-99 concentration in groundwater beneath the Central Plateau during 2019 was 24,800 pCi/L downgradient from the WMA C Tank Farm in 200 East Area. Two extraction wells are planned to be installed in this plume.

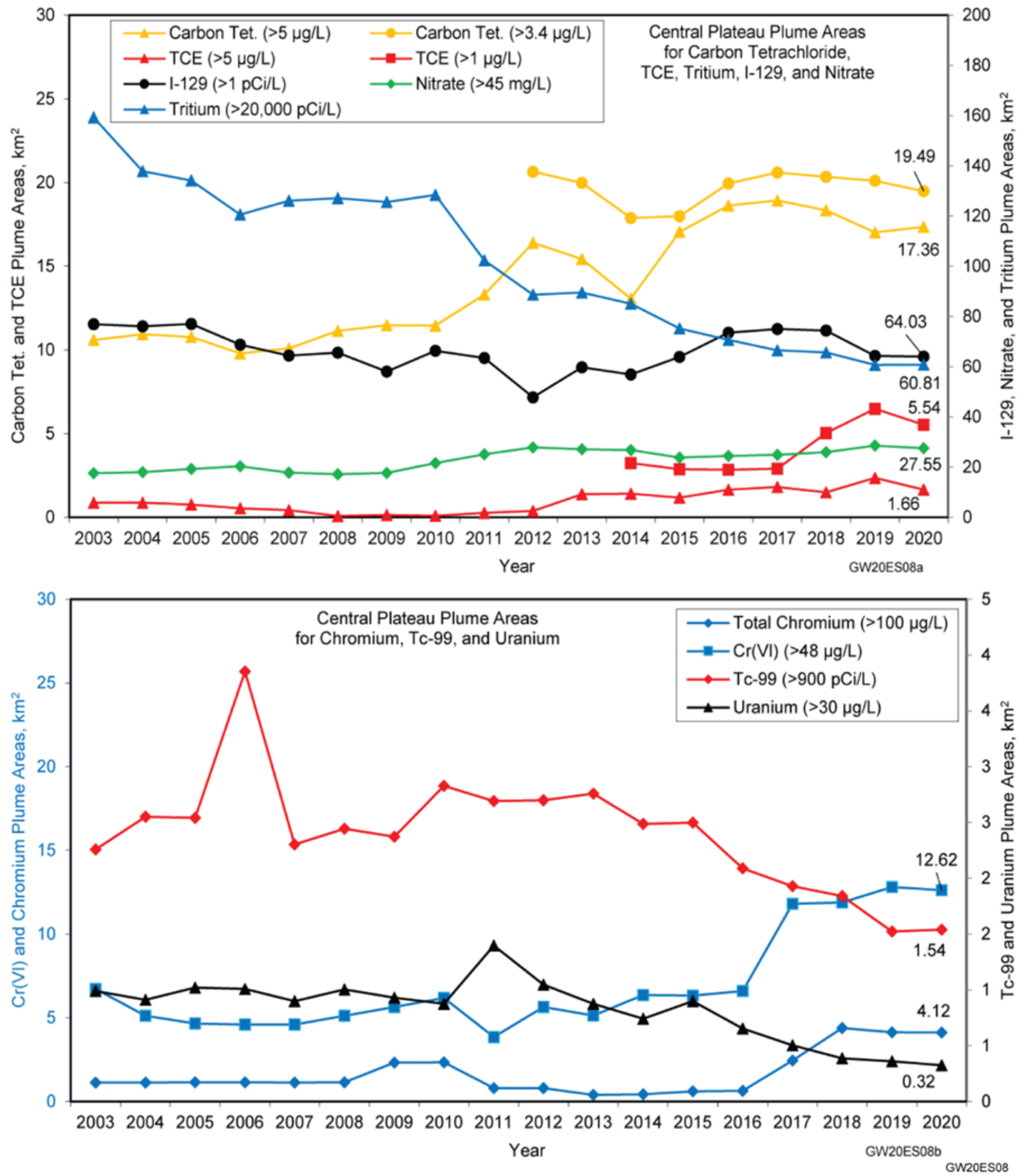
- Strontium-90 plumes are present within the 200-BP-5, 200-PO-1, and 200-UP-1 OUs. The highest concentrations occur within the 200-BP-5 OU, where strontium-90 is detected above the DWS

(8 pCi/L) at the former Gable Mountain Pond and 216-B-5 reverse well. The maximum concentration at Gable Mountain Pond was 211 pCi/L. The highest concentration of strontium 90 detected beneath the Central Plateau in 2020 was 331 pCi/ L adjacent to the 216-B-5 reverse well. Concentrations at 216-B-5 are declining at a faster rate than can be accounted for by radiological decay. Strontium-90 exceeds the DWS in a small area near the PUREX Cribs within the 200-PO-1 OU (11.1 pCi/L during 2020) and in a single well near the 216-S-1 and 216-S-2 Cribs in the 200-UP-1 OU (50.1 pCi/L during 2020).

RCRA and *Washington Administrative Code*-regulated groundwater monitoring continued in CY 2019 at facilities in all four Central Plateau OUs. The Nonradioactive Dangerous Waste Landfill (NRDWL) and WMA A-AX Tank Farm, both in the 200-PO-1 OU, are transitioning to assessment monitoring for 2021 due to exceedances of specific conductance (NRDWL and WMA A-AX) and an initial exceedance of total organic carbon (WMA A-AX). Both sites were in assessment monitoring for the first half of 2020 due to exceedances in 2019, but it was concluded that no dangerous waste groundwater contamination was attributed to releases from these facilities and indicator evaluation programs were implemented for the second half of 2020. No other potential new impacts to groundwater quality were detected in CY 2019, although several sites remain in assessment monitoring.

Groundwater monitoring to meet AEA requirements was performed for all four Central Plateau groundwater OUs during CY 2020. The objectives of this monitoring are to determine the location of radionuclide contamination in Hanford Site groundwater and to estimate impacts to human health and the environment in terms of the TED received by potential receptors. The TED at each groundwater well was calculated as the cumulative dose from all radionuclides detected in groundwater samples collected from that well in 2020. Estimated TEDs for five wells on the Central Plateau exceeded the DOE 100 mrem/yr dose standard; three of these were in the perched zone beneath the B Complex (200-DV-1 OU). The maximum TED in the regional groundwater was 185 mrem/yr at a well in the U Plant area of the 200-UP-1 OU (uranium plumes). The other exceedance in the regional aquifer was 107 mrem/yr (uranium and technetium-99 plumes at B Complex in the 200-BP-5 OU). Estimates of cumulative dose to beta/photon emitters and alpha emitters were also calculated and are discussed in DOE/RL-2020-60. The AEA monitoring did not identify any new or emerging contamination issues on the Central Plateau during 2020.

Considering all the radionuclide contaminant plumes present in groundwater at the Hanford Site, tritium and iodine-129 have the largest areas with concentrations above DWSs. The most expansive of these plumes have sources in the 200 East Area, extending east and southeast toward the Columbia River. Less expansive tritium, uranium, iodine-129, strontium-90, and technetium-99 plumes are present in the 200 West Area. Figure 4-3 provides a comparison of the areal extent of tritium, iodine-129, technetium-99, and uranium contaminant plumes in groundwater (at levels above DWSs) for CY 2003 through CY 2020.



Source: Figure ES-8 in DOE/RL-2020-60, *Hanford Site Groundwater Monitoring Report for 2020.*

Figure 4-3. Central Plateau Plume Areas, 2003 Through 2020

4.3 Summary of Vadose Zone Characterization

A variety of vadose zone characterization efforts have taken place recently at the Central Plateau. The Central Plateau source OUs responsible for characterization of the vadose zone are 200-WA-1/200-BC-1, 200-EA-1, 200-DV-1, 200-IS-1, 200-IA-1, 200-PW-1/3/6/CW-5, 200-SW-2, and 200-OA-1/200-CW-1/3.

4.3.1 Characterization Approaches for Source Operable Units

This section provides a summary of the approaches DOE is taking to characterize the vadose zone on the Central Plateau. These include the analogous waste site approach to revising the source OU RI/FS work plans and the opportunistic sampling approach to collecting vadose zone data while drilling groundwater wells. The combination of both approaches should help accelerate cleanup decisions on the Central Plateau.

4.3.1.1 Analogous Waste Site Approach to Characterization

In FY 2020 the Tri-Party Agencies formed the RASCAL team to develop a representative and analogous site approach for the 200-BC-1, 200-EA-1, and 200-WA-1 OUs. The Interagency Management Integration Team (IAMIT) determination number 2020-006, *Representative Analogous Site Coordinating Agency Liaison (RASCAL) Recommendations for Expediting Remedial Cleanup on the Hanford Central Plateau* (IAMIT, 2020), was signed in June of 2020 to implement this approach for the Central Plateau Inner Area. This approach was developed to accomplish the following objectives:

- Accelerate cleanup decisions
- Ensure consistent remedies for analogous waste sites
- Implement early remedial actions
- Reduce characterization pre-ROD
- Conduct focused confirmatory characterization post-ROD

Through the RASCAL approach the waste sites in these OUs were binned into five conceptual site model (CSM) groups and evaluated to select representative and analogous sites, Table 4-3. Representative sites are considered to be a reasonable representation of the range of conditions for the CSM group and analogous sites within. A representative site will be the CSM group specific data source to define a basis for action, evaluate response actions, identify response actions, and select an alternative in the ROD. Analogous sites are considered to be waste sites that pose a similar risk through similar exposure pathways and have similar configuration of contamination.

The RASCAL team identified four CSM groups with representative and analogous sites and one unique CSM group that will be excluded from the representative and analogous site approach (CSM 7a-e). One-hundred and one waste sites from these three OUs were binned into the four representative and analogous CSM groups, and 111 were binned into the “unique” waste site group and its subgroups. CSM groups 1c, 2, 4, and 6 are representative site groups applicable to the 200-BC-1, 200-EA-1, and 200-WA-1 OUs. CSM 1a and CSM 1b apply to a newly formed early action OU (designated 200-IA-1) created by the RASCAL team and CSM 7 consists of unique sites that require individual site characterization to determine remedy decisions.

Six representative sites were selected from the 200-BC-1, 200-EA-1, and 200-WA-1 OUs. Pre-ROD characterization at these six sites will be used to define the range of response actions and determine the alternative for each respective CSM group it belongs in. Post-ROD characterization will focus on confirming the remedy selection for analogous sites and implementing a plug-out approach to move waste sites into new CSM groups should confirmatory sampling indicate an analogous site does not fit its current CSM group and selected remedy. Using the representative and analogous site approach for these CSM groups should reduce pre-ROD characterization needs by nearly 75% and accelerate cleanup decisions for 101 waste sites on the Central Plateau.

Table 4-3. Conceptual Site Model Grouping Overview and Representative Waste Sites

CSM Group/ Subgroup	Description	Waste Site Count			Representative Site (OU)	Additional Pre-ROD Information Needs
		200-EA-1	200-WA-1	200-BC-1		
1a	Shallow zone only – RTD bias; Moved to new 200-IA-1 OU	25	22	0	11 sites	None
1b	Shallow zone only – CS/NFA bias; Moved to new 200-IA-1 OU	21	33	0	3 sites	None
1c	Shallow zone only but requires coordination with collocated waste sites	1	2	0	Not applicable[a]	None
2	Intermediate and deep zone	3	2	0	216-A-36B (200-EA-1)	Four field penetrations, consistent with WP Draft A SAP
3	Large area plutonium waste sites (addressed in existing ROD)	Not applicable to OUs				
4	Small to medium transuranic cribs	0	3	1	216-Z-7 (200-WA-1)	No additional data needs, consistent with WP SAP
5	Ponds and related waste sites (addressed in other OUs)	Not applicable to OUs				
6a	Shallow and intermediate	5	15	19	216-B-26 and 216-B-58	No additional data needs
6b	Shallow, intermediate[b], and deep[c]	23	21	6	216-A-37-1 and 216-U-1&2	216-A-37-1: three field penetrations and sampling from within crib consistent with WP Draft A SAP 216-U-1&2: no additional data needs
7a	Hot semi-works sites	23	0	0	Not applicable to RASCAL approach	Not applicable to RASCAL approach
7b	Other pipelines in 200-WA-1 or 200-EA-1	0	13	0	Not applicable to RASCAL approach	Not applicable to RASCAL approach
7c	Railroad tracks	9	8	0	Not applicable to RASCAL approach	Not applicable to RASCAL approach
7d	U Plant barrier sites and other sites under anticipated barriers	2	37	0	Not applicable to RASCAL approach	Not applicable to RASCAL approach
7e	Unique site	2	16	1	Not applicable to RASCAL approach	Not applicable to RASCAL approach

a. Collocated single sites will not need a representative site.

b. Intermediate is between 15 and 70 ft below ground surface.

c. Deep is greater than 70 ft below ground surface.

CSM = conceptual site model

CS/NFA = Confirmatory Sampling and/or No Further Action

OU = operable unit

RASCAL = Representative Analogous Site Coordinating Agency Liaison

ROD = record of decision

RTD = removal, treatment, and disposal

SAP = sampling and analysis plan

WP = work plan

Newly Formed 200-IA-1 Operable Unit. The IAMIT determination number 2020-006 signed in June 2020 implemented a new early action Inner Area OU (200-IA-1) to accelerate cleanup at waste sites that have sufficient existing site knowledge to define a remedial action bias towards Removal, Treatment, and Disposal or Confirmatory Sampling and/or No Further Action. TPA-CCF C-20-02, "Waste Site Re-Assignment from the 200-EA-1 and 200-WA 1 OUs to the new 200-IA-1 OU," based on IAMIT Determination 2020-006 reassigned waste sites from the 200-EA-1 and 200-WA-1 OUs to the 200-IA-1 OU: 46 waste sites from the 200-EA-1 OU and 55 waste sites from the 200-WA-1 OU for a total of 101 waste sites. This new early action OU will implement accelerated actions by following a focused feasibility study (FFS) document path and applying the following concepts to the waste sites within this OU:

- Basis for action will leverage waste sites with existing data to quantify risk
- Only Removal, Treatment, and Disposal; Confirmatory Sampling and/or No Further Action; and No Action will be considered in the FFS

A ROD for these Inner Area waste sites using the FFS and RASCAL approach at this new OU is expected in approximately 3 years and reduce post-ROD characterization by using focused confirmatory sampling at analogous sites to confirm the remedy selected for a CSM group.

4.3.1.2 Opportunistic Sampling Characterization Approach

The CERCLA OUs, WMAs, and RCRA facilities of the Central Plateau often overlap geographically. If a borehole is being drilled for one project's monitoring needs, it is possible that another project in the vicinity may have data needs that can be satisfied by collecting data at that borehole site. In the interest of integrating these investigations and maximizing the efficiency of every borehole drilled in the Central Plateau, a collaborative process called opportunistic sampling has been developed. Following the opportunistic sampling process below led to the development of opportunistic sampling instructions implemented in FY 2021.

Figure 4-4 shows the general workflow followed in the opportunistic sampling process. After a borehole location is finalized, the opportunistic sampling process begins with the compilation of integration information about that borehole location to communicate to the various project managers, scientists, subject matter experts and DOE OU leads. Examples of this borehole information include the following:

- Borehole purpose and objective
- Location (coordinates and map)
- Proposed total depth
- Predicted stratigraphic units and lithologies
- Nearby waste sites and WMAs, including a short description of each
- OUs
- Nearby planned wells from other projects
- Nearby existing boreholes and past sampling
- Model domains
- Planned sampling analyses for the borehole (including standard grab samples, geophysical logs, etc.)

- Special considerations and challenges (e.g., short drilling timeline, milestones, unusual borehole diameter, selected drilling methods)

The information is distributed to the point-of-contact for every nearby identified project, including technical integration and drilling. A collaborative meeting is scheduled with DOE, representatives from each project (may be several different contractors), and other subject matter experts to discuss whether the borehole being drilled presents an opportunity for characterization that may satisfy other projects' data needs.

If it is determined in the collaborative team meeting that the borehole is in a good location to provide information for one of the other projects or objectives, an opportunistic sampling instruction will be developed. If the data needs are identified in another sampling and analysis plan or data quality objective (DQO), the opportunistic sampling instruction will reference those DQOs and samples will be collected accordingly. If data needs are identified in the team meeting that are not covered by an existing sampling and analysis plan or DQO, the DQO process may be initiated for the opportunistic sampling instruction.

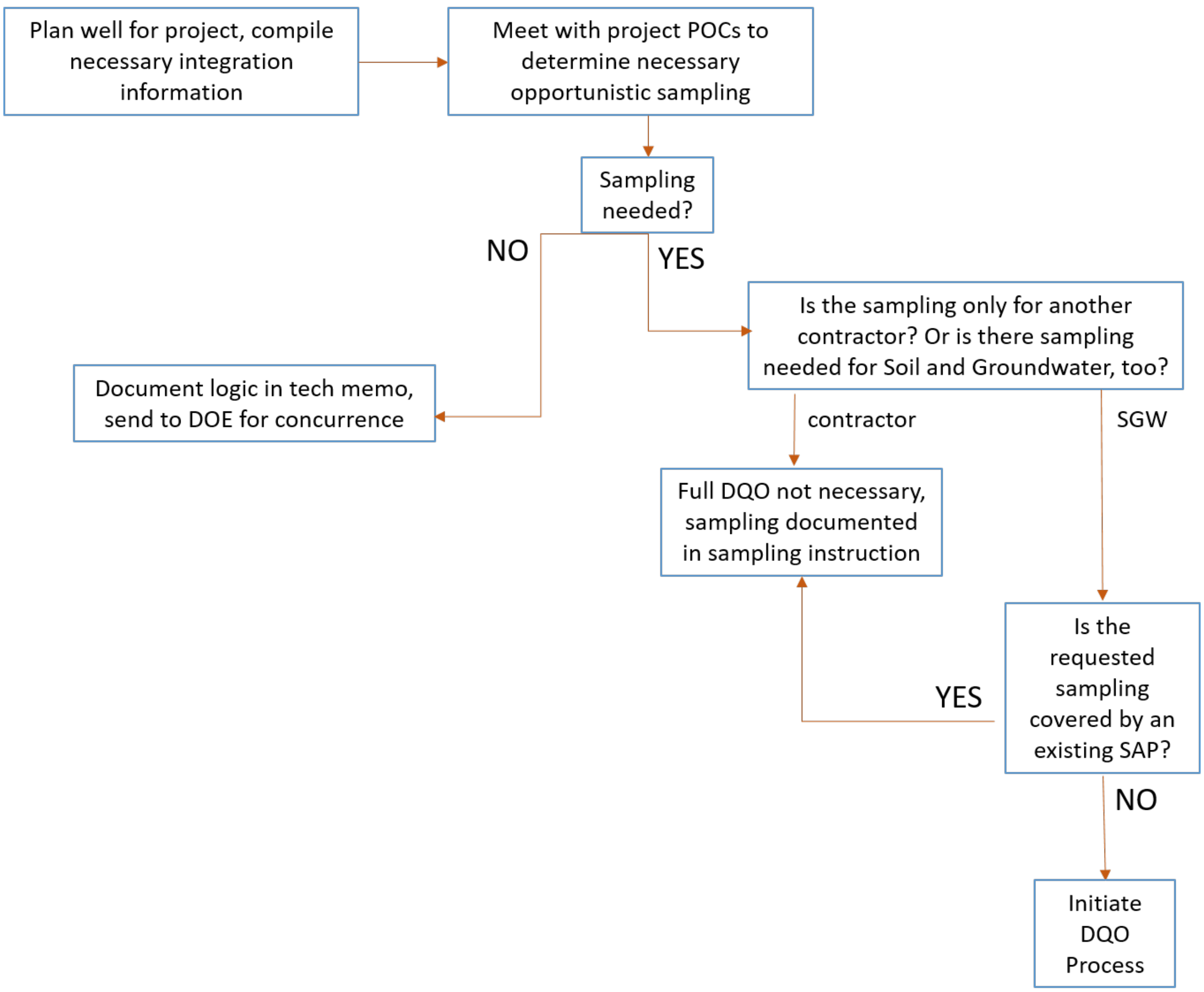


Figure 4-4. Flow Diagram for the Initiation of the Opportunistic Sampling Process

Agreements made in the 2020 collaborative meetings between DOE and the various projects and SMEs were documented and form the basis for the opportunistic sampling instructions. Seven opportunistic sampling instructions are in various stages of development for the drilling of 20 RCRA monitoring wells in FY 2021. Table 4-4 shows the summary of vadose zone samples collected during drilling of the RCRA monitoring wells, as well as samples collected during drilling of one Atomic Energy Act well.

Table 4-4. Summary of FY 2021 Opportunistic Sampling During Drilling

Well Name	Groundwater OU	OU or TSD of Interest	Number of Samples	Chemical/ Radiological Analyses	Hydraulic/ Physical Properties	OSAI
299-E28-35	200-BP-5	LLWMA-1	13		X	SGW-65024
299-E33-272	200-BP-5	LLWMA-1	14		X	SGW-65024
299-E33-272	200-BP-5	LLWMA-1	16	X	X	SGW-65024
699-44-42B	200-BP-5	216-B-3	7		X	SGW-65216
699-43-43C	200-PO-1	216-B-3	9		X	SGW-65216
699-43-44B	200-PO-1	216-B-3	8		X	SGW-65216
699-43-44C	200-PO-1	216-B-3	8		X	SGW-65216
299-E25-242	200-PO-1	216-A-29	7		X	SGW-65258
299-E25-241	200-PO-1	216-A-29	8		X	SGW-65258
299-E26-82	200-PO-1	216-A-29	14	X	X	SGW-65258
299-W27-3	200-UP-1	216-S-10	18	X	X	SGW-65582
299-W26-16	200-UP-1	216-S-10	31	X	X	SGW-65582
699-32-77B	200-UP-1	216-S-10	19	X	X	SGW-65582
299-W22-123*	200-UP-1	200-WA-1	18	X		DOE/RL-2019-07-ADD1

Note: Complete reference citations are provided in Chapter 9 of this document.

*Well installed in the 200-UP-1 OU as part of the *Atomic Energy Act* monitoring program.

OSAI = Opportunistic Sampling and Analysis Instruction

OU = operable unit

TSD = treatment, storage, and disposal

A total of 172 opportunistic samples and an additional eighteen 200-WA-1/200-UP-1/AEA samples were collected during drilling. Hydraulic and physical properties analyses samples were 117 of the 172 samples collected, with select samples to be analyzed in the future.

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5 Research and Development

This chapter summarizes for the reporting period research and development, including field studies and other details that have the potential to affect the basis of the Hanford Site Composite Analysis, usually through reduction of uncertainty. Table 5-1 is a required table for this report to summarize the research and development documents for the reporting period.

Table 5-1. Research and Development Activities

<table>
<tr><th>Document Number</th><th>Results</th><th>Performance Assessment/Composite Analysis Impacts</th></tr>
<tr><td>PNNL-32016</td><td>Documents the potential use of electrical resistivity tomography (ERT) for monitoring the migration of the leaked tank waste through the soil column to groundwater. Hypothetical scenarios were simulated based on existing tank leak information using different electrode configurations to demonstrate that ERT down-borehole electrodes are a viable method for monitoring the long-term migration of tank farm leaks to groundwater.</td><td rowspan="3">Strengthening the monitoring program provides for validation of remedial actions and early detection of vadose zone sources of contamination that will be considered with respect to the composite analysis basis.</td></tr>
<tr><td>PNNL-30441, Rev. 1</td><td>New paradigm for long-term monitoring that extends beyond the reasonable timeframe anticipated for passive remedies such as monitored natural attenuation. Guidance is provided on sampling locations, frequency of sampling, and tools for monitoring for potential exposure pathways. The second revision of this document is re-organized for more concise communication and provides hypothetical examples with the new monitoring approach</td></tr>
<tr><td>PNNL-30440, Rev. 1</td><td>Demonstrated successful use of SIP to monitor both high- and low-conductivity amendments that may be used to treat vadose zone and perched water contaminants that pose a potential threat to groundwater. The second revision of this document provides additional laboratory-based data that can be used to interpret field-scale applications.</td></tr>
<tr><td>PNNL-31959</td><td>This report provides the technical basis for 200-DV-1 treatability testing, identifying the best combinations of amendments for a two-step remedy approach. The first step creates a reducing environment and temporarily immobilizes the contaminant, and is then followed by a precipitation step to permanently immobilize the contaminant. The results of these batch studies demonstrated that reduction by sulfur modified iron (SMI) and sequestration in apatite or calcite was the most effective combination for removing technetium-99 and uranium from aqueous solutions.</td><td>Identifying potential remedy approaches for focused treatments of radionuclides in the vadose and perched water zones supports soil remediation activities that are protective of both the groundwater and the Columbia River.</td></tr>
</table>

Note: Complete reference citations are provided in Chapter 9 of this document.

2D = two-dimensional

3D = three-dimensional

DWS = drinking water standard

ERT = electrical resistivity tomography

FY = fiscal year

SIP = spectral induced polarization

5.1 Remediation Science and Technology

The Hanford Site uses science and technology to provide new knowledge, data, and tools necessary to accomplish the site cleanup mission. This mission includes investigating technologies and approaches to improve characterization and remediation of contaminated soil sites and groundwater, as well as resolving key technical issues that help to inform and influence decisions for remediation, waste management, and site closure. The Pacific Northwest National Laboratory has conducted applied science and technology work that supports Hanford soil and groundwater characterization and remediation activities. Work has been funded under the site soil and groundwater contractor (CPCCo) and with direct funding from DOE RL. Summaries of applied science and technology efforts in FY 2021 relevant to radionuclide migration in the Central Plateau are as follows:

- Based on historical waste releases, identified impacts of plutonium and americium co-disposal with high-salt and organic-bearing wastes. Although operational conditions enhanced plutonium and americium mobility, their mobility is limited under current conditions. This information provides the technical basis to address the nature of plutonium and americium contamination and to provide defensibility for associated remedy decisions.

- Continued to identify quantitative conceptual models to determine the impacts of the P&T system on the aquifer and provide performance evaluations of operational changes and aquifer-system injection limits. The 200 West P&T system was designed for supporting 200-ZP-1 remedial action objectives, but other current and potential sources vary the geochemical signatures of the influent waste stream. The combined operational and influent changes were characterized in laboratory column experiments to support remedy optimization efforts and short- and long-term remedy decisions related to multiple OUs within the Central Plateau.

- Determined the performance of 200 West P&T resins under projected geochemical conditions that will occur as the P&T system expands to treat other regions of the aquifer within the Central Plateau. Other regions of the aquifer contain higher concentrations of nitrate and sulfate, known resin foulants that can reduce P&T performance. Resins were also tested for their ability to capture multiple contaminants to promote efficiency in P&T operations.

- Identified bismuth-based materials that can sequester multiple, collocated radionuclides and metals in situ (e.g., technetium-99, iodine-129, uranium, and chromium). Chemical stabilization relies on the reduction of contaminant mobility by physical or chemical reactions with the contaminant, without unintended interactions due to the presence of other contaminants. These materials are critical for identifying viable treatment options for challenging, waste-specific species of technetium-99 and iodine-129 for which existing commercial methods are ineffective.

- Identified deployment effectiveness for two-step in situ remedy approaches for targeted treatment of sources within the deep vadose and perched water zones. This amendment delivery testing supports 200-DV-1 treatability testing. Remediation of radionuclides in Hanford Site source zones will reduce the inventory that contributes to the dose from those radionuclides in the current composite analysis.

- Provided additional interpretation of a seismic landstreamer data set collected in 2011 to interpret the top of basalt in Gable Gap. This new interpretation provides input into the Hanford Site geologic framework model with information on basalt surface elevation and permeability, providing information on potential vertical flow between the confined and unconfined aquifers.

- Continued evaluating a multi-level pore-fluid sampler that can be used down borehole for repeat aqueous and gas-phase sampling over long timescales in the vadose zone. The ability to provide repeat sampling can provide information on unsaturated zone contaminants and their potential flux to groundwater.
- Two-dimensional electrical resistivity tomography (ERT) surveys were conducted in the Central Plateau and southeast of this area to support the delineation of a high hydraulic conductivity zone that impacts the transport of contaminants from the Central Plateau to the Columbia River. ERT provided a first line of evidence for the existence of high conductivity sediments at depth in areas of sparse borehole coverage.
- Provided updates to several web-based tools within SOCRATES (socrates.pnnl.gov) qualified to NQA-1 standards that support data visualization and analytics for Hanford Site data. Updates included custom charting capabilities to support web-based reporting, and visualization of waste site contaminant inventory data to support risk assessment and prioritization of remedial activities.
- (CRATES) within the SOCRATES toolbox (PNNL, 2020, "SOCRATES"). CRATES was developed to support retirement of the Virtual Library online tool for visualizing trends in groundwater concentration data at monitoring wells. In addition, an NQA-1 release of ORIGEN, provides access to the site-wide geologic framework model. Rapid online access to data and data analytics relevant to contaminant transport and remedy decisions is needed to identify transitions from active to passive remediation. The tools provide data filtering, statistical, and analysis capabilities so that users can evaluate contaminant plume dynamics.
- Provided geochemical and physical characterization of borehole sediments to assess contaminant mobility and attenuation in the vadose zone for the WMA A and AX Tank Farm. This enables improved assessment of contaminant flux in the vadose zone and potential impacts to groundwater, and technical defensibility for tank farm closure activities.
- Provided geochemical, physical, and hydraulic characterization of the perched water unit in the Hanford 200-DV-1 OU. The perched water zone contains elevated levels of uranium, technetium-99, nitrate, and other COCs and is a potential continuing source for the unconfined aquifer in the 200-BP-5 OU. A removal action is designed to recover as much perched water as practical, which contributes to the composite analysis basis.
- Continued to provide technical support for updating the RD/RAWP, performance monitoring plan, and operations and maintenance plans for the 200-ZP-1 OU. The updates to the 200-ZP-1 plans apply appropriate technical defensibility for managing the active portion of the remedy and the future transition to the passive component of the remedy. The adaptive management of the 200-ZP-1 remedy impacts the risk evaluation associated with the composite analysis basis.
- Continued to support the characterization plan for the 200-ZP-1 OU deep portion of the aquifer (Ringold A aquifer unit) to support remedy optimization. The sampling and analysis plan supports both active remedy optimization and the transition to the passive component of the remedy. A field hydraulic testing plan was developed to further characterize aquifer properties. This characterization is needed because the deep contamination may require a different approach and timeframe than the shallower contamination that is the current focus of remedy actions.

5.2 Operations Studies

The following activities have been pursued in the reporting period (FY 2021):

1. **Optimization study plan**: An optimization study plan (DOE/RL-2019-38, *200-ZP-1 Operable Unit Optimization Study Plan*) has been developed and approved by EPA (TPA-CN-1102, *DOE/RL-2019-38,200-ZP-1 Operable Unit Optimization Study Plan, Rev. 0*) to monitor wells and optimize to carbon tetrachloride remediation as DOE expands treatment capability within the Central Plateau by 1,250 gpm (284 m^3/hr) to a total of 3,750 gpm (852 m^3/hr) for both 200 West and 200 East OUs with potential to expand the system further.

2. **Comprehensive plume evaluation**: A comprehensive plume evaluation is underway to evaluate the shallow groundwater plumes in proximity to continuing source areas (i.e., at T, S/SX, U, B, C/AX Tank Farms and other locations). The current P&T configuration is being reevaluated to capture/contain contaminants in proximity to these locations. Vertical contaminant distribution and well screen intervals are being assessed to address containment of source area plumes as well as additional optimization of carbon tetrachloride and TCE remediation timeframes (carbon tetrachloride is the limiting factor with respect due to the extent of its plume size). Additional characterization within the Ringold a and Ringold b formations are ongoing. The comprehensive plume evaluation is inclusive of the carbon tetrachloride plume and will provide crucial information regarding treatment capacity requirements to address an "integrated cleanup/containment/treatment" of the Central Plateau groundwater. The scope of the comprehensive plume evaluation is currently under development and has been initiated with evaluation of the existing data, as well as the proposed data collection associated with the ongoing optimization study plan. This information is crucial in developing efficient designs for the cleanup/treatment/containment of the Central Plateau and to perform the effort in a timely fashion.

6 Planned or Contemplated Changes

This chapter summarizes the changes affecting the Hanford Site Composite Analysis that occurred during FY 2021. This summary includes any changes resulting from special analyses (DOE M 435.1-1; DOE-STD-5002-2017) and any expected changes to future conditions (e.g., site land-use plans or remediation plans). Table 6-1 summarizes the planned or contemplated changes.

Table 6-1. Planned or Contemplated Changes

<table>
<tr><th>Planned or Contemplated Changes</th><th>Change Basis</th><th>Performance Assessment/Composite Analysis Impacts</th><th>Schedule</th></tr>
<tr><td colspan="4">A project to update the Hanford Site Composite Analysis is in progress (see Appendix B in this document for status) following the technical approach defined in CP-60649, Summary Analysis: Hanford Site Composite Analysis Update, approved by the Hanford Site Groundwater/Vadose Zone Executive Council in May 2017. CP-60649 is supported by a series of technical approach description documents developed under a graded approach in a workshop process with participation by representatives for management of Hanford Site Performance Assessments and leadership from the Low-Level Waste Disposal Facility Federal Review Group.</td></tr>
</table>

No outstanding current information needs (e.g., data gaps or uncertainties) were identified in the Hanford Site Composite Analysis or in any of the prior annual reviews.

Based on information reviewed from prior annual status reports, the determination of the FY 2015 annual summary report (DOE/RL-2015-66, *Annual Status Report (FY 2015): Composite Analysis for Low Level Waste Disposal in the Central Plateau of the Hanford Site*) is that the Hanford Site Composite Analysis requires an update. While the original composite analysis (prepared in 1998, with an addendum in 2001) has been maintained, the accumulation of basis changes reported in the annual summary reports of the preceding 14-year period merits evaluation in an updated analysis. This determination remains in place in this annual summary: new information needs to be incorporated and analyzed using environmental modeling software that meets current DOE QA requirements. Annual maintenance continues under DOE/RL-2000-29 because of the length of time planned for the preparation of an updated Hanford Site Composite Analysis. The progress on the update of the Hanford Site Composite Analysis is summarized in Appendix B of this document. An updated composite analysis report (DOE/RL-2019-52, *Composite Analysis for Low-Level Waste Disposal in the Hanford Site Central Plateau [FY 2020]*) was issued in November 2020 and submitted to the LFRG for review. The LFRG review commenced in December 2020.

6.1 Special Analyses

Special analyses were not conducted in FY 2021 for the Composite Analysis itself.

As noted in Section 1.1.2, five special analyses were performed for the IDF PA in FY 2021:

- The first special analysis evaluated the impact of new moisture content information in the H2 sand that result in a change of the H2 sand hydraulic property values. Sensitivity analyses performed with the updated H2 sand hydraulic property values resulted in a change in the predicted fate and transport of radionuclides in the vadose zone beneath the IDF and the corresponding timing of the peak groundwater concentration and all-pathways dose at the point of compliance.

- The second special analysis investigated the impact of new information collected as part of the IDF maintenance program related to the hydraulic and transport properties of grouts used to encapsulate debris secondary solid waste (SSW) and solidify/stabilize non-debris SSW. The new information was combined with the higher technetium-99 loading on HEPA filters identified in the Wet Electrostatic Precipitator (WESP) maintenance special analysis completed in FY 2020 to develop revised predictions of release rate of mobile radionuclides from SSW.

- The third special analysis investigated the impact of new information collected as part of the IDF maintenance program on the corrosion of ILAW glass. This new information included an assessment of the impact of Stage III glass corrosion on radionuclide release rates from ILAW glass.

- The fourth special analysis investigated the combined impact of the other three special analyses completed in FY 2021 as well as additional updated vadose zone and saturated zone information collected as part of the IDF maintenance program. This special analysis evaluated the impact of the updated information on the fate and transport of technetium-99 and the associated groundwater concentration and dose at the point of assessment. The special analysis determined that the as-analyzed IDF would not comply with the DOE M 435.1-1 all-pathways dose performance objective without a design modification or other operational or disposal constraints, including but not limited to revised waste acceptance criteria. The special analysis conclusion is a result of the increased release rate of technetium-99 from the HEPA filters combined with the reduced vadose zone radionuclide transport time associated with the updated H2 sand hydraulic properties. The DOE LFRG's Site Representative and LFRG Co-chairs were made aware of the preliminary results of this analysis and recommended additional modeling to help inform future decisions. The additional modeling work was still in progress at the time this annual update was prepared.

- The fifth special analysis evaluated the potential impacts of filling the voids in a used low-activity waste melters with grout that could lead to accelerated rates of the vitrified waste left in the melters when they are disposed of in the IDF. Although the high-pH effluents that flowed past the grout onto the residual waste left in the melters caused accelerated corrosions rates, the volume and inventory of waste impacted by the accelerated corrosion rate would not in of itself change the conclusions of the PA provided that the grouted melters were disposed of away from the containers of vitrified waste.

6.2 Changes in Site Land Use and Remediation Plans

There have been no changes in site land use in FY 2021 that will affect the Central Plateau. Remediation planning continued to implement approved decision documents.

The overall cleanup strategy for the 195 km^2 (75 mi^2) Central Plateau is described in DOE/RL-2009-10. The cleanup strategy is the result of thousands of hours of work that considered input from the regulatory agencies, Tribal Nations, the public, and stakeholders. Selection of cleanup remedies that are consistent with the reasonably anticipated future land use is one of the foundational elements of the Central Plateau strategy. The strategy calls for cleanup on the Central Plateau to be organized into the following three major components:

- **Inner Area**: The final footprint area of the Hanford Site that will be dedicated to waste management and containment of residual contamination.

- **Outer Area**: All of the Central Plateau beyond the boundary of the Inner Area.

- **Groundwater**: Contaminant plumes underlying the Central Plateau and originating from waste sites on the Central Plateau.

These components are consistent with land uses designated for the Central Plateau in DOE/EIS-0222F, *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*; subsequent ROD (64 FR 61615, "Record of Decision: Hanford Comprehensive Land-Use Plan Environmental Impact Statement [HCP EIS]"); 2008 supplement analysis (DOE/EIS-0222-SA-01, *Supplement Analysis: Hanford Comprehensive Land-Use Plan Environmental Impact Statement*); subsequent ROD (73 FR 55824, "Amended Record of Decision for the Hanford Comprehensive Land-Use Plan Environmental Impact Statement"); and 2015 supplement analysis (DOE/EIS-0222-SA-02, *Supplement Analysis of the Hanford Comprehensive Land-Use Plan Environmental Impact Statement*). Designated land uses on the Central Plateau are industrial-exclusive for 50 km^2 (20 mi^2) at the core of the Central Plateau (including the Inner Area and a portion of the Outer Area) and conservation (mining) in the surrounding 145 km^2 (55 mi^2) area (which includes the majority of the Outer Area).

6.2.1 Engineered Barriers (in Remediation Plans)

In the original Hanford Site Composite Analysis (PNNL-11800), transport through the vadose zone to the water table was simulated under transient flow conditions. The recharge rate in the vadose zone was allowed to vary with the application of different surface treatments and covers (i.e., barriers). Thus, performance was evaluated with and without surface infiltration barriers.

The Hanford Site disposition baseline (PNNL-15829, *Inventory Data Package for Hanford Assessments*) compiled a suite of all remedial actions for waste sites at the Hanford Site. The Hanford Site disposition baseline was developed to represent the most credible end state of the Hanford Site based on information made available by DOE and its contractors, including interim and final RODs. Therefore, the Hanford Site disposition baseline is a combination of remedial actions based on interim and final RODs and remedial actions proposed by DOE, but not yet interim or finally approved by the regulatory agencies. This baseline was updated in preparation for the Hanford Site Composite Analysis (CP-60254, *Hanford Site Composite Analysis Technical Approach Description: Hanford Site Disposition Baseline*) to reflect new decisions and changed projections since the original compilation in 2005 and finalized for use in the updated Hanford Site Composite Analysis in CP-63386, *Hanford Site Disposition Baseline Data Package for Hanford Site Composite Analysis*. The use of infiltration barriers will be evaluated in accordance with the expected use of these barriers at various source sites rather than globally with, and without, as was presented in the original composite analysis (PNNL-11800).

6.2.2 Operational Controls for Subsidence

The annual status reports for the 200 West and 200 East Area LLBGs (DOE/RL-2019-50, *Annual Status Report [FY 2019]: Performance Assessment for the Disposal of Low-Level Waste in the 200 West Area Burial Grounds*; DOE/RL-2019-51, *Annual Status Report [FY 2019]: Performance Assessment for the Disposal of Low-Level Waste in the 200 East Area Burial Grounds*) noted that LLBG waste acceptance criteria (HNF-EP-0063) address disposal in a physically stable configuration with minimal void space, minimal gas emission, and elimination of pyrophoric characteristics. These criteria are also used to minimize long-term subsidence. These requirements are being administered by LLBG operations and typically involve solidification or void-fill processes. As necessary, waste packages are grouted or placed into concrete boxes that are high-integrity containers (or equivalent). Surveillance for local subsidence is performed routinely by LLBG staff, and any cavities that form are filled in with dirt or grout.

The ERDF waste acceptance criteria document (ERDF-00011) states that packaged waste will be structurally stable for ERDF disposal to limit potential subsidence. Packaged waste that is not structurally stable may be accepted at ERDF on a case-by-case basis and stabilized before and during disposal. Depending on the waste stream, stabilization may be accomplished using soil, cement-based agents, or other stabilization agents with acceptable structural characteristics, size reduction, a mixture of biodegradable waste and stabilizing agents, and/or voids filled with stabilization agents. Additional physical limits for waste forms including concrete, steel plate, piping and tube steel, building debris, structural steel, containerized waste, equipment, soft waste, and rebar are defined in ERDF-00003, *Supplemental Waste Acceptance Criteria for the Environmental Restoration Disposal Facility*.

Following the partial collapse of PUREX Tunnel 1 in May 2017, both Tunnel 1 and Tunnel 2 were filled with engineered grout to reduce the risk of further collapse and increase the protection for workers, the public, and the environment from radiological hazards, while not precluding future remedial actions or final closure decisions. Subsequently, other older structures on the Central Plateau were analyzed to determine if any other structures are at risk of significant subsidence or collapse. Twenty-seven structures were identified that may have a potential risk of subsidence that requires mitigation. In 2019, a further structural evaluation was performed for 11 of the 27 structures. The evaluation report identified three underground liquid waste disposal structures (216-Z-2 Crib, 216-Z-9 Crib, and 241-Z-361 Settling Tank) that represented the highest risk, requiring stabilization to prevent a potential collapse that could spread contamination to the environment. Stabilization of the 216-Z-9 and 241-Z-361 by void filling with engineered grout was completed in FY 2021 to mitigate the risk of subsidence without interfering with the final remedy. After further field investigation at 216-Z-2, it was determined that sufficient soil overburden exists to cover/sequester the source term in the event of collapse and no further action was taken. Remaining sites will continue to be evaluated and stabilization plans developed as needed to mitigate potential future risks.

7 Status of Disposal Authorization Statement Conditions and Key and Secondary Issues

Table 7-1 summarizes the DAS conditions pertaining to the Hanford Site Composite Analysis. Appendix B in this document provides the status of the current effort to update this Composite Analysis.

Table 7-1. Status of Disposal Authorization Statement Conditions, Key, and Secondary Issues

Disposal Facility/Unit	Key/Secondary Issue or Disposal Authorization Statement Condition Number	Issue Description	Initial Resolutions Scheduled Date	Projected Resolution Scheduled Date	Disposition Documentation and Date Completed	Composite Analysis Impact
CA	1	High-level waste tank inventories did not account for chemical effects that may increase inventories of certain radionuclides in the residual tank solids.	2002	2004	Closed; however, requires further evaluation. Closure of this issue was based on "a sitewide effort is underway to address this and other inventory-related concerns." The SAC effort was suspended in 2006.	This issue will be addressed in the composite analysis update.
CA	2	Use of a K_d "switch depth" needs additional justification.	2002	2004	Closed; addressed in 2002 ASR (Hildebrand and Bergeron, 2002); issue closed in Chung, 2004.	None
CA	3	Need justification for not using reduction-oxidation as a K_d discriminator.	2002	2004	Closed; addressed in 2002 ASR (Hildebrand and Bergeron, 2002); issue closed in Chung, 2004.	None
CA	4	Numerical modeling grid spacing was used as a constraint for selecting the dispersivity values in the analysis. This had no physical basis and leads to increased dispersion.	2002	2004	Closed; addressed in 2002 ASR (Hildebrand and Bergeron, 2002); issue closed in Chung, 2004.	None
CA	5	Sensitivity analysis should be conducted to investigate the effect of potential fast paths.	2002	2004	Addressed in 2002 ASR; issued closed in Chung, 2004. However, closure of this issue was based on major studies of groundwater and vadose zone systems are underway. A new analytical method (SAC) was developed for analytical purposes; however, the SAC effort was suspended in 2006.	This issue will be addressed in the composite analysis update
CA	6	Sensitivity analysis that investigates the consequences of temporally overlapping plumes should be conducted to determine effects of alternative assumptions.	2002	2004	Addressed in 2002 ASR; issue closed in Chung, 2004. However, closure of this issue was based on a new analytical method (SAC) that was developed to address this issue; however, the SAC effort was suspended in 2006.	This issue will be addressed in the composite analysis update

Table 7-1. Status of Disposal Authorization Statement Conditions, Key, and Secondary Issues

Disposal Facility/Unit	Key/Secondary Issue or Disposal Authorization Statement Condition Number	Issue Description	Initial Resolutions Scheduled Date	Projected Resolution Scheduled Date	Disposition Documentation and Date Completed	Composite Analysis Impact
CA	7	Modeled releases of technetium-99 from liquid discharge zones are based on quicker and smaller releases than observed with existing plumes.	2002	2004	Addressed in 2002 ASR; issue closed in Chung, 2004. However, closure of this issue was based on studies underway address this issue. Inventory issues were evaluated and transporting and modeling issues were studied separately. In addition, a new model (SAC) was developed; however, the SAC effort was suspended in 2006.	This issue will be addressed in the composite analysis update.
CA	8	Provide justification for the assumption that the basalt aquifers and interbeds do not contain significant contaminants.	2002	2002	Issue closed in disposal authorization statement (Frei, 2002).	None

References: Chung, 2004, "Low-Level Waste Disposal Facility Federal Review Group Review of the Maintenance Plan for the Composite Analysis of the Hanford Site, Southeast Washington, April 2003."

Frei, 2002, "Disposal Authorization for the Hanford Site Low-Level Waste Disposal Facilities – Submittal of an Addendum to Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site, PNNL-11800 Addendum 1."

Hildebrand and Bergeron, 2002, *Annual Status Report: Composite Analysis for Low Level Waste Disposal in the 200 Area of the Hanford Site*.

ASR = annual status report

CA = composite analysis

K_d = distribution coefficient

SAC = systems assessment capability

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8 Certification of the Continued Adequacy of the Composite Analysis

The Hanford Site Composite Analysis was approved in 2002 (Frei, 2002, "Disposal Authorization for the Hanford Site Low-Level Waste Disposal Facilities – Submittal of an Addendum to Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site, PNNL-11800 Addendum 1"). The DAS (Scott, 2001) conditions on the Hanford Site Composite Analysis have all previously been met through PNNL-11800, Addendum 1 and prior maintenance activities. The Hanford Site Composite Analysis has been maintained since that time in accordance with DOE M 435.1-1 requirements.

The Hanford Site Composite Analysis results gave a peak dose of 6 mrem/yr beyond the exclusive waste management area and buffer zone (PNNL-11800, Executive Summary) for the agricultural exposure scenario. The agricultural exposure scenario yielded the highest dose of the four scenarios evaluated (the others were residential, industrial, and recreational scenarios with doses of 2.2, 0.7, and 0.04 mrem/yr, respectively). This peak dose was predicted for a compliance period that began in CY 2050, then considered the best estimated date of final remedial actions at the Hanford Site. This peak dose was also calculated assuming the strontium-90 plume at Gable Mountain Pond, which is just beyond the buffer zone boundary, would be included in the waste management area and buffer zone.

It is noted that the peak dose prediction provided in PNNL-11800 are dominated by sources not regulated under DOE O 435.1. Examination of PA results for the 435.1-regulated disposal facilities (i.e., IDF, ERDF, 200-East and 200-West LLBGs) demonstrate that peak doses from those facilities are expected to occur far later in time (after 1,000-years post-closure) while the peak dose for the Hanford Site Composite Analysis occurs near the beginning of the 1,000-year compliance period. PNNL-11800 notes, "the Composite Analysis has shown that the active and planned dry disposals are safe and will not contribute significantly to radiation dose to hypothetical future members of the public for the 1000-year period following Hanford Site closure." Here, all 435.1-regulated facilities are covered by "planned dry disposals". The past-practice liquid discharges are the dominant contributor to the predicted peak dose within the 1,000-year compliance period.

Based on this annual evaluation of new information obtained from a review of PAs, remedial actions, and operations (Chapter 1), a review of the data collected and analyzed from monitoring (Chapter 4), and other changes (Chapter 5), no new information was identified in FY 2021 that would invalidate the continued adequacy of the Hanford Site Composite Analysis. That is, a peak dose well below the 30 mrem/yr dose constraint, as well as below the 100 mrem/yr dose limit, is still expected based on the review of new information identified in FY 2021. However, a determination was reached that an update to the composite analysis is necessary based on information reviewed in a previous annual status report, for FY 2015 (DOE/RL-2015-66) based on all prior annual status reports. The following reasons this determination was made in FY 2015 remain applicable:

- The original Hanford Site Composite Analysis was prepared in 1998 with an addendum in 2001. While maintained since that time, the accumulation of basis changes reported in the annual summary reports over the past 15 years merits evaluation in an updated analysis (DOE/RL-2015-66). The following new information needs to be incorporated in an updated analysis:
  - The original Hanford Site Composite Analysis deferred evaluation of planned remedial actions to the second iteration of the composite analysis because time and information were insufficient to determine if alternate remedies would be necessary from the results of the composite analysis and identify them through the negotiation process. Accordingly, a single remedial action (i.e., leave in place and cover with surface barrier) was analyzed in the composite analysis. Significant changes

have been made through decision making in the CERCLA process since that time, and a detailed Hanford Site baseline disposition was prepared to project remedial activities through site closure that should be incorporated into an updated Hanford Site Composite Analysis.

- Issuance of the TC & WM EIS (DOE/EIS-0391) in FY 2013 provided an updated inventory basis, new modeling capabilities, and new decisions reached in the associated ROD (78 FR 75913) that need to be incorporated into the Hanford Site Composite Analysis. Updates to the Hanford Site Composite Analysis were deferred from 2006 until 2013, awaiting final issuance of DOE/EIS-0391 and transfer of the modeling capability developed for that study. The modeling capability developed for and applied in the TC & WM EIS was transferred from the DOE-ORP to DOE-RL during FY 2013 (DOE-ORP, 2012, *Tank Closure and Waste Management Environmental Impact Statement Technology Transfer Document*). Development of a Hanford Site groundwater model from the baseline provided in DOE-ORP, 2012, commenced in FY 2014 and continued in FYs 2015 and 2016.

- The P&T systems, which were not evaluated in the original Hanford Site Composite Analysis, have had significant impact on behavior of the groundwater flow system, contaminant transport, and contaminant removal from Hanford Site groundwater (Section 1.3.2).

- Development of the Central Plateau cleanup strategy (Section 6.2) may lead to establishing a different point of compliance for evaluation of DOE M 435.1-1 performance metrics for the Hanford Site Composite Analysis than the core zone boundary used in the original 1998 composite analysis (PNNL-11800).

- Data collected as the unconfined aquifer water levels continue to recede since the cessation of large liquid discharges during the operational era (Section 4.1) have led to marked improvement in understanding the flow system for future conditions, particularly regarding northward flow potential in the critical Gable Gap area.

- The revised ERDF PA was completed in 2013 (WCH-520, Rev. 1) (Section 1.1.4). The updated inventory for this PA and evaluation of expanding this facility to about twice the size that was evaluated in the original Hanford Site Composite Analysis are needed.

- The geologic structural basis for groundwater models has continued to improve with additional data collection and interpretation (ECF-HANFORD-13-0020, *Process for Constructing a Three-dimensional Geological Framework Model of the Hanford Site's 100 Area*; ECF-HANFORD-13-0029, *Development of the Hanford South Geologic Framework Model, Hanford Site, Washington*).

- Tank residual inventory estimates have improved with the incorporation of tank retrieval inventory data for those tanks that have completed retrieval. In contrast, the original Hanford Site Composite Analysis (PNNL-11800) was necessarily reliant upon assumptions regarding future retrieval and associated retrieval losses.

- The first PA for a tank farm closure decision was completed in FY 2016 for WMA C. A PA is currently being prepared for WMA A-AX and is expected to be completed during the period required to prepare a revised Hanford Site Composite Analysis.

- An update to the IDF PA was completed in FY 2017, during the period required to prepare a revised Hanford Site Composite Analysis.

   - The risk assessment scenarios currently used for Hanford Site CERCLA and RCRA analyses differ from those evaluated in the original 1998 Hanford Site Composite Analysis (PNNL-11800). Therefore, a revision should use current risk assessment scenarios.

- The original Hanford Site Composite Analysis (PNNL-11800) was prepared before DOE required that NQA-1 standards be applied by its contractors for use of simulation software for environmental modeling. DOE has required CHPRC through the Plateau Remediation Contract (Section C.3.2.4, "Quality," of DE-AC06-08RL14788) to develop documented QA program(s) that implement(s) DOE O 414.1D, *Quality Assurance*. A new analysis performed with current software tools qualified under DOE O 414.1D standards and applied under current, compliant QA plans and procedures would support confidence in the analysis.

DOE-RL plans maintenance activities for the original Hanford Site Composite Analysis until the updated composite analysis is completed to maintain the current DAS. Continuing the maintenance program will provide support for periodic collection and reporting of information affecting the basis of the composite analysis in the annual status reports during the period required to develop an updated composite analysis.

This annual summary identifies additional data and information from FY 2021 to be considered for purposes of updating the Hanford Site Composite Analysis. Appendix B in this document summarizes the plans and status for developing an updated composite analysis.

Certification by the Field Element Manager or Designee

I certify to the best of my knowledge, that information presented in this annual status report is true, accurate, and complete and that any proposed or implemented changes associated with the PA or other technical basis documents provide a reasonable expectation that the performance objectives/measures identified in DOE O 435.1 will be met.

Certified in Draft A (next page)	(4/1/2022)
B.T. Vance, Manager DOE Richland Operations Office	Date

Certification by the Field Element Manager or Designee

I certify to the best of my knowledge, that information presented in this annual status report is true, accurate, and complete and that any proposed or implemented changes associated with the PA or other technical basis documents provide a reasonable expectation that the performance objectives/measures identified in DOE O 435.1 will be met.

Brian T. Vance
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B.T. Vance, Manager DOE Richland Operations Office	Date

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Appendix A

History of Hanford Site Composite Analysis Maintenance

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A1 History of Hanford Site Composite Analysis Maintenance

DOE O 435.1, *Radioactive Waste Management*, requires that the Hanford Site maintain site performance assessments (PAs) and composite analyses. Requirements for composite analysis maintenance under DOE M 435.1-1, *Radioactive Waste Management Manual*, are the same as those for PA maintenance and are described in Chapter 3 of DOE, 1999, *Maintenance Guide for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessments and Composite Analyses*. The plan for maintaining the Hanford Site Composite Analysis (PNNL-11800, *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*; PNNL-11800, *Addendum to Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*, Addendum 1) is described in DOE/RL-2000-29, *Maintenance Plan for the Composite Analysis of the Hanford Site, Southeast Washington* (multiple revisions). Revision 2 of DOE/RL-2000-29 was approved in 2004 (Talarico, 2004, "Low-Level Disposal Facility Federal Review Group Review of Maintenance Plan for the Composite Analysis of the Hanford Site, Southeast Washington, April 2003"). Revision 3 of DOE/RL-2000-29 was prepared in fiscal year (FY) 2017 to conform to DOE-STD-5002-2017, *Disposal Authorization Statement and Tank Closure Documentation*, and was issued in FY 2018.

DOE M 435.1-1 requires routine review and revision of PAs and composite analyses. The objective of routine review and revision is to ensure that the PAs and composite analyses are updated appropriately whenever changes in their bases (e.g., assumptions and parameters) are contemplated or affected in order to maintain the validity and effectiveness of the controls that are based on the PA and composite analysis. These reviews provide a mechanism for routine assessment of the site plans (e.g., remediation, closure, decommissioning, and land use) developed from the results of a composite analysis. This review process allows potential problems to be identified and managed at an early stage. The revisions ensure cohesive documentation, providing a reasonable basis to conclude that U.S. Department of Energy requirements for radiological protection of the public and the environment will be met in the future. The composite analysis is a planning tool that allows for evaluation of the cumulative effects of all sources of radioactive materials that may interact with those in the Low-Level Waste Disposal Facility. The impact of future activities on the dose to hypothetical future members of the public can be evaluated using the composite analysis, and the results can be used to develop land-use plans, remediation plans, or long-term stewardship documents. The annual review of the composite analysis is used to determine whether actual and planned conditions are consistent with those contained in the composite analysis. Revisions and special analyses provide a mechanism for evaluating conditions not originally included in the composite analysis to determine if these conditions could be accommodated without violating the conclusions of the composite analysis.

Chapter 4 in DOE G 435.1-1, *Implementation Guide for use with DOE M 435.1-1*, states the following:

> IV.P (4) Performance Assessment and Composite Analysis Maintenance. The performance assessment and composite analysis shall be maintained to evaluate changes that could affect the performance, design, and operating bases for the facility. Performance assessment and composite analysis maintenance shall include the conduct of research, field studies, and monitoring needed to address uncertainties or gaps in existing data. The performance assessment shall be updated to support the final facility closure. Additional iterations of the performance assessment and composite analysis shall be conducted as necessary during the post-closure period.

> Performance assessments and composite analyses shall be reviewed and revised when changes in waste forms or containers, radionuclide inventories, facility design and operations, closure concepts, or the improved understanding of the performance of the waste disposal facility in combination with the features of the site on which it is located alter the conclusions or the conceptual model(s) of the existing performance assessment or composite analysis.

The statements also appear in DOE M 435.1-1 and constitute the requirements for maintaining a PA or composite analysis. Further guidance is provided in DOE-STD-5002-2017.

Table A-1 lists the documents that have been prepared to maintain the Hanford Site Composite Analysis (PNNL-11800; PNNL-11800, Addendum 1) since maintenance commenced in FY 2000.

Table A-1. Hanford Site Composite Analysis Maintenance Documents

Reporting Period(s)	Document
FY 2000	DOE/RL-2000-29, *Maintenance Plan for the Composite Analysis of the Hanford Site, Southeast Washington*, Rev. 0
	DOE/RL-2000-29, *Maintenance Plan for the Composite Analysis of the Hanford Site, Southeast Washington*, Rev. 1
FY 2001	Hildebrand and Bergeron, 2002, *Annual Status Report: Composite Analysis for Low-Level Waste Disposal in the 200 Area of the Hanford Site*
FY 2002	DOE/RL-2003-26, *Annual Status Report: Composite Analysis of Low-Level Waste Disposal in the Central Plateau at the Hanford Site*, Rev. 0
FY 2003	DOE/RL-2000-29, *Maintenance Plan for the Composite Analysis of the Hanford Site, Southeast Washington*, Rev. 2
	DOE/RL-2004-12, *Annual Status Report (FY 2003): Composite Analysis of Low-Level Waste Disposal in the Central Plateau at the Hanford Site*, Rev. 0
FY 2004	DOE/RL-2005-58, *2004 Annual Status Report: Composite Analysis of Low-Level Disposal in the Central Plateau at the Hanford Site*, Rev. 0
FY 2005	DOE/RL-2006-28, *Annual Status Report (FY 2005): Composite Analysis of Low-Level Waste Disposal in the Central Plateau at the Hanford Site*, Rev. 0
FY 2006, FY 2007	DOE/RL-2008-43, *Annual Status Report (FY 2007): Composite Analysis of Low-Level Waste Disposal in the Central Plateau at the Hanford Site*, Draft B
FY 2008	DOE/RL-2009-82, *Annual Status Report (FY 2008): Composite Analysis of Low-level Waste Disposal in the Central Plateau at the Hanford Site*, Rev. 1
FY 2009	DOE/RL-2009-132, *Annual Status Report (FY 2009): Composite Analysis of Low-Level Waste Disposal in the Central Plateau at the Hanford Site*, Rev. 0
FY 2010	DOE/RL-2010-105, *Annual Status Report (Fiscal Year 2010): Composite Analysis of Low-Level Waste Disposal in the Central Plateau at the Hanford Site*, Rev. 0
FY 2011	DOE/RL-2011-108, *Annual Status Report (Fiscal Year 2011): Composite Analysis of Low-Level Waste Disposal in the Central Plateau at the Hanford Site*, Rev. 1
FY 2012	DOE/RL-2012-56, *Annual Status Report (Fiscal Year 2012): Composite Analysis of Low-Level Waste Disposal in the Central Plateau at the Hanford Site*, Rev. 0
FY 2013	DOE/RL-2013-40, *Annual Status Report (FY 2013): Composite Analysis of Low Level Waste Disposal in the Central Plateau at the Hanford Site*, Rev. 0
FY 2014	DOE/RL-2014-45, *Annual Status Report (FY 2014): Composite Analysis of Low Level Waste Disposal in the Central Plateau at the Hanford Site*, Rev. 0

Table A-1. Hanford Site Composite Analysis Maintenance Documents

Reporting Period(s)	Document
FY 2015	DOE/RL-2015-66, *Annual Status Report (FY 2015): Composite Analysis for Low Level Waste Disposal in the Central Plateau of the Hanford Site*, Rev. 1
FY 2016	DOE/RL-2016-62, *Annual Status Report (FY 2016): Composite Analysis for Low Level Waste Disposal in the Central Plateau of the Hanford Site*, Rev. 0
FY 2017	DOE/RL-2017-55, *Annual Status Report (FY 2017): Composite Analysis for Low Level Waste Disposal in the Central Plateau of the Hanford Site*, Rev. 0
	DOE/RL-2000-29, *Maintenance Plan for the Composite Analysis of the Hanford Site, Southeast Washington*, Rev. 3
FY 2018	DOE/RL-2018-60, *Annual Status Report (FY 2018): Composite Analysis for Low Level Waste Disposal in the Central Plateau of the Hanford Site*, Rev. 0
	DOE/RL-2000-29, *Maintenance Plan for the Composite Analysis of the Hanford Site, Southeast Washington*, Rev. 4
FY 2019	DOE/RL-2019-49, *Annual Status Report (FY 2019): Composite Analysis for Low Level Waste Disposal in the Central Plateau of the Hanford Site*, Rev. 0
FY 2020	DOE/RL-2020-48, *Annual Status Report (FY 2020): Composite Analysis for Low Level Waste Disposal in the Central Plateau of the Hanford Site*, Rev. 0
FY 2021	DOE-RL-2021-56, *Annual Status Report (FY 2021): Composite Analysis for Low Level Waste Disposal in the Central Plateau of the Hanford Site*, Rev. 0 (this report)

Notes: Complete reference citations are provided in Chapter A2 in this appendix.

Hanford Site Composite Analysis refers to PNNL-11800, *Composite Analysis for Low Level Waste Disposal in the 200 Area Plateau of the Hanford Site*, and corresponding PNNL-11800, *Addendum to Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*, Addendum 1.

FY = fiscal year

A2 References

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Appendix B

Status of Hanford Site Composite Analysis Update

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Tables

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B1 Status of Hanford Site Composite Analysis Update

In fiscal year (FY) 2015, the planning phase for preparing an updated Hanford Site Composite Analysis was undertaken and was completed under U.S. Department of Energy, Richland Operations Office (DOE-RL) direction and at the request of U.S. Department of Energy, Headquarters (DOE-HQ) in its review of the FY 2013 annual status report for the composite analysis (Gilbertson and Marcinowski, 2015, "Review of Richland Fiscal Year 2013 Annual Summaries for 200 West and 200 East Burial Grounds, Composite Analysis, Environmental Restoration Disposal Facility, and Integrated Disposal Facility").

Consistent with DOE-HQ direction (1301789, 2012, "Modeling to Support Regulatory Decisionmaking at Hanford"), a strategy for the update was developed in FY 2015 and used to guide planning phase activities that were completed by the end of FY 2015. DOE-RL approved the baseline change request and funded scoping phase activities that commenced at the start of FY 2016 and completed in FY 2017.

The high-level plan for revision is provided with respect to phases defined in memorandum direction (1301789, 2012); planning phase activities completed in FY 2015 are listed in Table B-1; scoping phase activities completed in FYs 2016 and 2017 are listed in Table B-2; and analysis phase activities completed are listed in Table B-3.

Table B-1. Planning Phase Activities

Task	FY	Deliverable	Description	Status
Develop strategy for composite analysis update	2015	White paper	Top-level strategy for the update of the composite analysis (provided to DOE-RL and the Low-Level Waste Disposal Facility Federal Review Group).	**COMPLETED**: "White Paper: Strategy for Update of the Hanford Site Composite Analysis," submitted to DOE-RL in June 2015.
Develop project schedule for FY 2016	2015	Detailed project schedule	Support baseline change request.	**COMPLETED**: Schedule developed for baseline change request in August 2015.
Update Maintenance Plan	2015	Revision to Composite Analysis Maintenance Plan	Current maintenance plan requires update; plans for update of composite analysis to be added.	**COMPLETED**: DOE/RL-2000-29 (submitted as a companion document to this annual status report).
Hanford Site Scale-Appropriate Fate and Transport Model Development and Maintenance	2015	Revision to CP-57037	Develop multiple fate and transport models that link to the Hanford Site groundwater model for boundary conditions and other information, providing an integrated system of groundwater models to support decision making at appropriate scales.	**COMPLETED**: CP-57037, issued in July 2015.

Table B-1. Planning Phase Activities

Task	FY	Deliverable	Description	Status
Hanford SIM Upgrade: Hardware	2015	Hardware update	Past work demonstrates that development of a sitewide inventory to support composite analysis modeling is the longest duration activity; new data from completed tank retrievals and CERCLA and RCRA activities, as well as inventory basis provided by the TC & WM EIS (DOE/EIS-0391), need to be incorporated into the revised composite analysis basis. Update of the SIM is a key activity.	**COMPLETED**: SIM computer hardware platform replaced in FY 2015.

Note: Complete reference citations are provided in Chapter B2 in this appendix.

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
DOE-RL = U.S. Department of Energy, Richland Operations Office
FY = fiscal year
RCRA = *Resource Conservation and Recovery Act of 1976*
SIM = Soil Inventory Model
TC & WM EIS = Tank Closure and Waste Management Environmental Impact Statement

Table B-2. Scoping Phase Activities

Task	FY	Deliverable	Description	Status
Project management planning	2016	Project management plan	Management plan to direct project execution.	**COMPLETED**: PRC-MP-EP-53107, approved and issued May 2016.
Project quality assurance planning	2016	Quality assurance plan	Quality assurance and quality control planning for control of modeling activities for the composite analysis.	**COMPLETED**: Project quality assurance plan issued as part of PRC-MP-EP-53107.
Phase 1 scoping	2016	*Hanford Site Composite Analysis Technical Scope & Approach* document	Establish high-level scope of the composite analysis, including period of evaluation, inclusion or exclusion of Columbia River and atmospheric pathways, inclusion or exclusion of atmospheric pathway, strategy for addressing uncertainty, extent of groundwater pathway domain, handling of historical simulation period, and identification of compliance boundary.	**COMPLETED**: Key Aspects Workshop conducted in May 2016. Key aspects scope summarized in preliminary summary analysis document submitted to DOE-RL in September 2016.

Table B-2. Scoping Phase Activities

Task	FY	Deliverable	Description	Status
Hanford SIM Upgrade: Software	2016	Software update (issue new SIM version and documentation, featuring operational implementation in new, maintainable software framework)	During FY 2016, the focus was on updating the software platform, which is obsolete and cannot be migrated to new hardware.	**COMPLETED**: New model implementation completed in FY 2016.
Update Hanford Site Disposition Baseline (End States)	2016	Hanford Site disposition baseline 2016 (database and description report)	Update disposition baseline – the database of the evolution of site remedial decisions, surface cover, and other actions (past and future) needed to support vadose zone modeling for the hundreds of waste sites to be simulated in the composite analysis based on Records of Decision, anticipated decisions, and planning.	**COMPLETED**: CP-60254
Draft data packages	2017	Series of draft data packages to support the composite analysis	Develop draft data packages to define detailed technical approach for models and framework to conduct the composite analysis.	**COMPLETED**: Draft technical approach description documents were prepared for all facets of the composite analysis update in 2017; these are listed under "Finalize Data Packages."
Phase 2 scoping	2017	Workshop summary reports	Conduct series of workshop to define the context, scope, and general methodology of the composite analysis.	**COMPLETED**: Technical Approach Workshop to present and refine detailed technical approach was conducted March 29-30, 2017.
Finalize data packages	2017	Series of final data packages to support the composite analysis	Finalize data packages based on scoping workshops.	**COMPLETED**: CP-60195 CP-60405 CP-60406 CP-60408 CP-60409 CP-60410

Table B-2. Scoping Phase Activities

Task	FY	Deliverable	Description	Status
Develop and submit Summary Analysis	2017	Summary analysis for the Hanford Site Composite Analysis	Define modeling approach and identify departures from TC & WM EIS (DOE/EIS-0391) modeling approach with justification in a summary analysis document and submit to Groundwater/Vadose Zone Executive Council for approval of modeling approach.	**COMPLETED**: CHPRC-60649, approved May 10, 2017, and issued June 5, 2017.

Note: Complete reference citations are provided in Chapter B2 in this appendix.

DOE-RL = U.S. Department of Energy, Richland Operations Office

FY = fiscal year

SIM = Soil Inventory Model

TC & WM EIS = Tank Closure and Waste Management Environmental Impact Statement

Table B-3. Analysis Phase Activities

Task	FY(s)	Deliverable	Notes
Hanford SIM Upgrade: Content	2017-2018	Hanford SIM Version 2	**COMPLETED**: CP-59798 ECF-HANFORD-17-0079
Update Sitewide Inventory	2018	Comprehensive sitewide inventory data set to support composite analysis using upgraded SIM and current versions of Hanford Site defined waste model and other source information	**COMPLETED**: CP-61786
Prototype development and testing for Composite Analysis computational approach	2017	Hanford Site Composite Analysis model integrated computational framework function and requirements specification	**COMPLETED**: CP-60407 CP-60411
Develop Waste Form Release Model and Software Implementation	2017	Waste form release models for the Hanford Site Composite Analysis	**COMPLETED**: CP-60410
Implement the approach developed in Hanford Site Composite Analysis Model Integrated Computational Framework Function and Requirements Specification	2019–2020		**COMPLETED**: Integrated modeling framework constructed and tested. (Work was deferred in FY 2018 due to funding reduction.)

Table B-3. Analysis Phase Activities

Task	FY(s)	Deliverable	Notes
Analysis of performance	2017–2020		**COMPLETED**: Modeling and analyses conducted to provide basis for evaluation of cumulative impacts and supporting sensitivity analyses. (Work was extended into FY 2020 due to funding reductions in FY 2017 and FY 2018. Demonstration runs were completed in FY 2019.)
Prepare Composite Analysis Draft and supporting documentation	2018–2020	Hanford Site Composite Analysis, Draft A	**COMPLETED**: Documentation prepared. • Annotated outline prepared in FY 2018. • Document will be prepared in FY 2020.
Issue Composite Analysis Decisional Draft for DOE-RL review	2020		**COMPLETED**: Decisional draft document was submitted to DOE-RL on September 30, 2020.
DOE-RL Comment Resolution	2020		**COMPLETED**: Comment resolution was completed on October 28, 2020.
Prepare Composite Analysis Revision 0	2021	Hanford Site Composite Analysis, Revision 0	**COMPLETED**: Revision 0 document was submitted to DOE-RL on November 24, 2020.
Submit Composite Analysis Revision 0 to LFRG	2021		**COMPLETED**: DOE-RL conveyed the Revision 0 document to the LFRG on December 2, 2020.
Prepare Composite Analysis Revision 1	2022	Hanford Site Composite Analysis, Revision 1	**ON GOING** (expected delivery June 2022)

Note: Complete reference citations are provided in Chapter B2 in this appendix.

DOE-RL = U.S. Department of Energy, Richland Operations Office

FY = fiscal year

LFRG = Low-Level Waste Disposal Facility Federal Review Group

SIM = Soil Inventory Model

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Appendix C

Crosswalk of LFRG Review Criteria to Annual Status Report Content

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Contents

Table

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C1 Crosswalk of LFRG Review Criteria to Annual Status Report Content

This appendix provides a crosswalk (Table C-1) to support review of this annual status report by identifying where the review criteria specified in DOE-STD-5002-2017, *Disposal Authorization Statement and Tank Closure Documentation*, are met in the content of this report.

Table C-1. Crosswalk of LFRG Review Criteria to Annual Status Report Content

ID	Review Criteria*	Where Criteria are Met
ASR-1	**9.2.1 Executive Summary**	
	Provide an overview of the documents and data used to make the certification of the continued adequacy of the PA, CA, DAS, other DAS technical basis documents, and the radioactive waste management basis (RWMB) to meet the DOE O 435.1 performance objectives/measures. If these documents need revision a corrective action plan should be developed and implemented. (9.2.1 Executive Summary)	The Executive Summary includes mention of the PA, MP, CA, and DAS. Closure plans, monitoring plans, and UDQE are also addressed in Table 1-2. MPs or activities are addressed in Sections 1.1, 1.2, Table 1-2, and Table 7-1. The WAC is mentioned in Sections 1.1.2 and 1.1.3. Performance Objectives are discussed in Sections 1.1.1, 1.1.3, 1.1.4, and Table 4-1. Directed by DOE-ORP, the RCRA corrective action program is pertinent to the Hanford Site CA because the actions result in planned redistributions of radioactive inventory in time, location, and waste form (Section 1.2). The CERCLA remedial activities directed by DOE-RL are discussed in (Section 1.3). Both maintenance and closure activities will be strongly affected by CERCLA remediation efforts, particularly for the unlined trenches that received DOE O 435.1 waste. Once the remedial decision actions have been clarified, any necessary additional closure actions can be identified, and the maintenance, PA monitoring, and closure plans will be updated as necessary and included in the next iteration of the CA.
ASR-2	**9.2.2 Changes Potentially Affecting the PA, CA, DAS or RWMB**	
	All Change Control Process evaluations (called UDQE/UCAQE in Chapter 8) or other change control processes (e.g., non-conformances, corrective action) used to evaluate proposed actions, changes and new information to determine if these activities are within the boundaries analyzed in the approved PA and CA. Their potential effect on the continued adequacy of the DAS, PA, CA and RWMB should be provided. Specific information for each identified change should be described. Specific information for each identified change should be described in Table 9-1 below. (9.2.2 Changes Potentially Affecting the PA, CA, DAS or RWMB)	No change control process evaluations arising from PAs supported by the Hanford Site CA, and no UDQEs were listed for the reporting period for any PA or for the CA itself (Chapter 1 and Table 1-1). Changes potentially effecting the PA, CA, DAS, or RWMB are discussed in Chapter 6, Sections 6.1 and 6.2.
ASR-3	**9.2.3 Cumulative Effects of Changes**	
	An evaluation and discussion of the cumulative effects of all the changes that have been identified in “Changes Potentially Affecting the PA, CA, DAS or RWMB” during the year. (9.2.3 Cumulative Effects of Changes)	Cumulative effects of information provided in Chapter 1 is discussed in the first three paragraphs in Chapter 2. The land use, engineered barriers, and operational controls for subsidence are not expected to have major changes in the CA results; however, subsidence is routinely surveilled in the active burial grounds (Sections 6.2.1 and 6.2.2).

Table C-1. Crosswalk of LFRG Review Criteria to Annual Status Report Content

ID	Review Criteria*	Where Criteria are Met
ASR-4	**9.2.4 Waste Receipts**	
	The information regarding waste receipts should be provided and discussed. In addition, a discussion regarding waste receipts should be included (Table 9.3). (9.2.4 Waste Receipts)	Waste Receipts are accounted for in the individual PA Summary Reports (Chapter 3 first sentence). There is notice that there were no waste receipts during the reporting period in the 200 East LLBGs and there were 3 naval reactor compartment disposals in Trench 94 during the reporting period (Section 1.1.1).
ASR-5	**9.2.5 Monitoring**	
	This section should include monitoring results using the following table format. In addition, a discussion regarding monitoring results should be included. For compliance monitoring (Table 9-5), action levels that are exceeded should be documented along with any corrective actions in the ASR. For performance monitoring, results differing from expected behavior should be documented and discussed with any corrective actions. (9.2.5 Monitoring)	The latest summary of groundwater monitoring information (DOE/RL-2020-60.) describes data collected during CY 2020 (January 1 through December 31). It represents the latest available information for purpose of this annual summary report. Compliance monitoring information is provided in Table 4-1 in Chapter 4. This table summarizes air and groundwater monitoring as well as ongoing monitoring in the vadose zone. Hanford Site Radioactive Airborne Emissions in CY 2020 are given in Table 4-2. Performance Monitoring is discussed in each PA's ASR.
ASR-6	**9.2.6 Research and Development**	
	R&D, field studies, etc. results should be provided and discussed. See Table 9-8 for information. (9.2.6 Research and Development)	Chapter 5 summarizes all R&D activities with potential to affect the CA, including science and technology tools necessary to accomplish the cleanup mission. Table 5-1 summarizes the R&D documents and potential impacts to the CA.
ASR-7	**9.2.7 Planned or Contemplated Changes**	
	Planned or contemplated changes (including completion schedules) in disposal facility design, construction, operations, closure, R&D, land use or in technical basis documents (MP, CP, WAC, MonP, Change Control Process) presented in a table following the format in Table 9-11. (9.2.7 Planned or Contemplated Changes)	See responses to ASR-1 and ASR-2. The schedules for the PAs covered by this CA are discussed in Table 1-2. The table indicates what phase (i.e., planning analysis, maintenance) each PA covered by this CA is in and expected completion dates as available (see Section 1.1).

Table C-1. Crosswalk of LFRG Review Criteria to Annual Status Report Content

ID	Review Criteria*	Where Criteria are Met
ASR-8	**9.2.8 Status of DAS Conditions, Key and Secondary Issues**	
	Provide a status update on any DAS conditions and key or secondary issues resulting from an LFRG review of the facility's PA and CA and other technical basis documents (e.g., MonP, CP, etc.). See Table 9-13 for information. (9.2.8 Status of DAS Conditions, Key and Secondary Issues)	The CA has eight Key/Secondary Issues or Disposal Authorization Statement Conditions. These are provided in Table 7-1 along with the initial resolutions schedule date, projected resolution Scheduled date and disposition documentation and date completed. Appendix B in this report provides the status of the current effort to update this CA.
ASR-9	**9.2.9 Certifications of the Continued of the Adequacy of the PA, CA, DAS and RWMB**	
	The following statement signed by the FEM or designee should be included in the ASR. *I certify to the best of my knowledge that information in this ASR is true, accurate and complete and that any proposed or implemented changes associated with the PA or other technical basis documents provide a reasonable expectation that the performance objectives/measures identified in DOE O 435.1 will be met.* (9.2.9 Certifications of the Continued of the Adequacy of the PA, CA, DAS and RWMB)	Section 8.1 contains the certification.

Note: Complete reference citations are provided in Chapter C2 in this appendix.

*Review criteria are verbatim text from Table 9-15 in DOE-STD-5002-2017, *Disposal Authorization Statement and Tank Closure Documentation*.

ASR = annual status report
CA = composite analysis
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CP = closure plan
CY = calendar year
DAS = disposal authorization statement
DOE-ORP = U.S. Department of Energy, Office of River Protection
DOE-RL = U.S. Department of Energy, Richland Operations
FEM = field element manager
LFRG = Low-Level Waste Disposal Facility Federal Review Group
LLBG = low-level burial ground
MonP = monitoring plan
MP = maintenance plan
PA = performance assessment
R&D = research and development
RCRA = *Resource Conservation and Recovery Act of 1976*
RWMB = radioactive waste management basis
UCAQE = unreviewed composite analysis question evaluation
UDQE = unreviewed disposal question evaluation
WAC = waste acceptance criteria

C2 References

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