DOCUMENT RELEASE AND CHANGE FORM

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This document provides a high-level synopsis of the performance assessment of Waste Management Area C conducted to fulfil the requirements of Appendix I of the Hanford Federal Facility Agreement and Consent Order.

APPROVED
By Lynn M Ayers at 8:51 am, Feb 10, 2021

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Synopsis of HFFACO Appendix I Performance Assessment for Waste Management Area C

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Rev. 0	04-Oct-2016	M. Kozak et. al	Initial Revision
Rev. 1	10-Feb-2021	M. Kozak et. al	Updates to Rev. 0 to reflect changes based on internal and external review of the following complimentary HFFACO Appendix I Performance Assessment documents for WMA C including RPP-RPT-59197, Rev. 2, RPP-RPT-58329, Rev. 3, RPP-ENV-58806, Rev. 1, and RPP-ENV-58782, Rev. 1.

EXECUTIVE SUMMARY

This document provides a high-level synopsis of the performance assessment conducted to fulfil the requirements of Appendix I of the *Hanford Federal Facility Agreement and Consent Order* (HFFACO) (Ecology et al. 1989). To meet the requirements of the several regulations specified in Appendix I, the U.S. Department of Energy (DOE) has produced a set of complementary reports, each addressing specific requirements for individual contamination sources (existing contamination from past unplanned releases and future contamination from tank residuals). The following set of four complementary reports is shown in Figure ES-1.

- An analysis of past leaks (RPP-RPT-59197, *Analysis of Impacts of Past Tank Waste Leaks and Losses in the Vicinity of Waste Management Area C at the Hanford Site, Southeast Washington*) which was conducted to provide a projection of the future evolution of the contamination beneath Waste Management Area (WMA) C. In addition, the analyses provide supporting information that could be relevant to the selection and specific implementation of groundwater mitigation measures being undertaken as a part of the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) Remedial Investigation/Feasibility Study effort in 200-BP-5-OU.

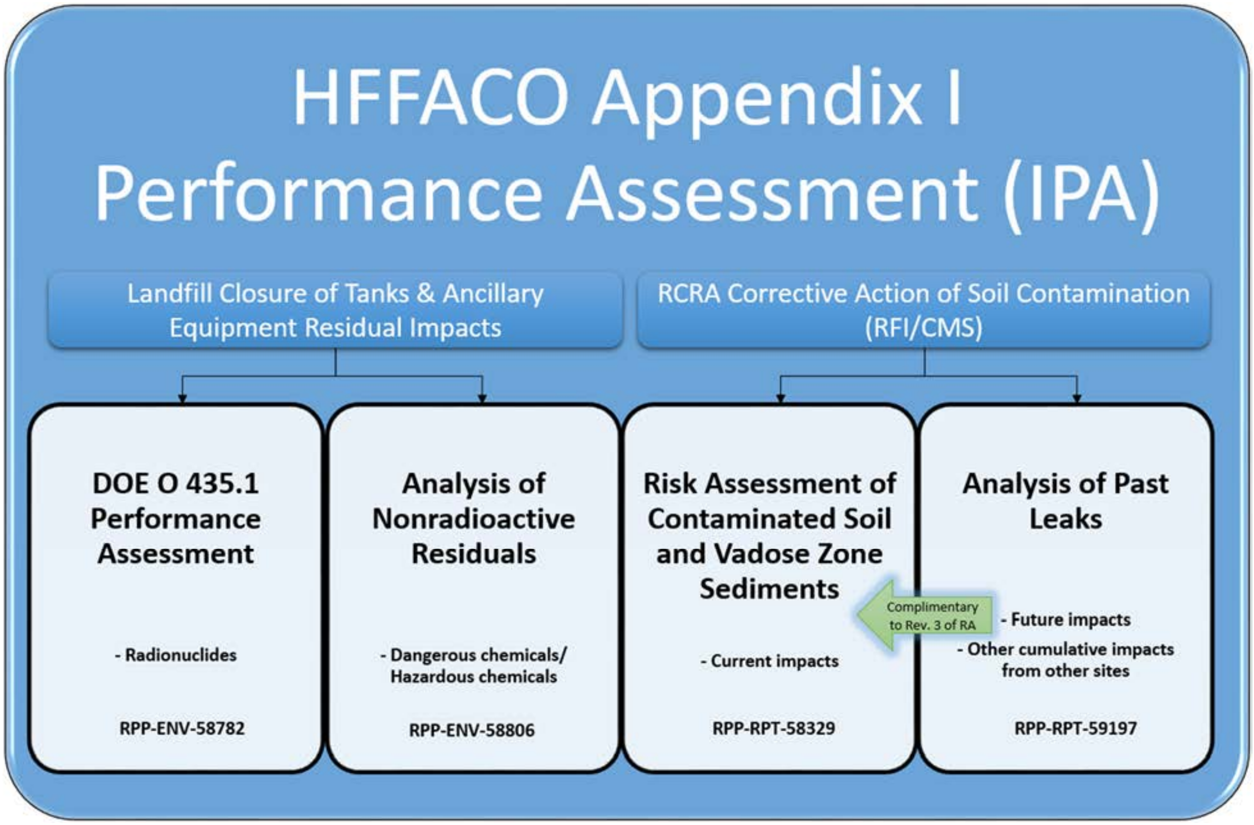
- An update of the risk assessment of contaminated soils and vadose zone sediments (RPP-RPT-58329, *Risk Assessment of Contaminated Soils and Vadose Zone Sediments at Waste Management Area C at the Hanford Site, Southeast Washington*) conducted to support a *Resource Conservation and Recovery Act of 1976* (RCRA) facility investigation for WMA C (RPP-RPT-58339, Rev. 0, *Phase 2 RCRA Facility Investigation Report for Waste Management Area C*) and an associated Corrective Measures Study (RPP-RPT-59379, *Waste Management Area C Phase 2 Corrective Measures Study Report*).

- A hazardous chemical impacts analysis (RPP-ENV-58806, Rev. 1, *Analysis of Post-Closure Groundwater Impacts from Hazardous Chemicals in Residual Wastes in Tanks and Ancillary Equipment at Waste Management Area C at the Hanford Site, Southeast Washington*) addresses regulatory requirements in *Washington Administrative Code* 173-303, "Dangerous Waste Regulations."

- DOE O 435.1, *Radioactive Waste Management* Performance Assessment (RPP-ENV-58782, Rev. 1, *Performance Assessment of Waste Management Area C, Hanford Site, Washington*) is a tank and ancillary equipment residual radiological waste-only performance assessment that addresses regulatory requirements in DOE O 435.1.

These documents and the extension into the Risk Assessment provide the technical basis for the Appendix I Performance Assessment. Key findings of these documents are summarized below.

Figure ES-1. Components of the *Hanford Federal Facility Agreement and Consent Order* Appendix I Performance Assessment.



References:
DOE O 435.1, *Radioactive Waste Management*.
Hanford Federal Facility Agreement and Consent Order (HFFACO) (Ecology et al. 1989).
RPP-ENV-58782, Rev. 1, *Performance Assessment of Waste Management Area C, Hanford Site, Washington*.
RPP-ENV-58806, Rev. 1, *Analysis of Post-Closure Groundwater Impacts from Hazardous Chemicals in Residual Wastes in Tanks and Ancillary Equipment at Waste Management Area C at the Hanford Site, Southeast Washington*.
RPP-RPT-58329, Rev. 3, *Risk Assessment for Contaminated Soils and Vadose Zone Sediments at Waste Management Area C at the Hanford Site, Southeast Washington*.
RPP-RPT-59197, Rev. 2, *Analysis of Impacts of Past Tank Waste Leaks and Losses in the Vicinity of Waste Management Area C at the Hanford Site, Southeast Washington*.

The Analysis of Past Leaks (RPP-RPT-59197) was conducted to analyze groundwater protection for current conditions at WMA C. The Analysis of Past Leaks used the site-specific models developed for the performance assessment (RPP-ENV-58782, Rev. 0) and RCRA Closure Analysis (RPP-ENV-58806, Rev. 0, *RCRA Closure Analysis of Tank Waste Residuals Impacts at Waste Management Area C, Hanford Site, Washington*). Key findings of this analysis were as follows:

- Evaluation for past waste releases at WMA C indicated that groundwater has been impacted by ^{99}Tc
- Model analysis of future impacts shows that concentration levels of ^{99}Tc are at or near their peak values and are expected to decline over the next few decades

- Concentration levels of nitrate and sulfate, which exceed the drinking water standard in some wells at WMA C, show that groundwater has likely been impacted by a combination of sources located upgradient of WMA C, as well as sources within WMA C.

Without remedial actions addressing the upgradient sources, groundwater at WMA C also has the potential to be impacted in the future by a number of contaminants of potential concern originating in those upgradient sources.

The Risk Assessment of Contaminated Soils and Vadose Zone Sediments at WMA C (RPP-RPT-58329) evaluates the potential health impacts to human and ecological receptors from exposure to contamination present in the shallow soils and vadose zone at WMA C. The report also presents the results of the potential impacts to groundwater from migration of nonradiological contaminants in contaminated soil through the vadose zone to the aquifer. Key findings of the Risk Assessment are as follows.

- The human health risk assessment indicated:
  - For Industrial Worker exposure scenario, ^{137}Cs and ^{126}Sn are retained as radiological contaminants for further evaluation
  - No nonradiological contaminants were retained for further evaluation.
- The screening level ecological risk evaluation indicated:
  - ^{90}Sr, ^{3}H and ^{137}Cs are retained as radiological contaminants of ecological concern
  - Boron, molybdenum, selenium, thallium, sulfate and Bis [2-ethylhexyl] phthalate are retained as nonradiological contaminants for ecological concern.
- The protection of groundwater pathway assessment indicated:
  - Cadmium and beta-BHA are retained for further evaluation based on the use of a statistical approach
  - Arsenic, cadmium, hexavalent chromium, thallium and beta-BHC are retained for further evaluation based on the use of a sample-by-sample approach.

The Impacts Analysis in RPP-ENV-58806 evaluates the impacts from hazardous chemical and dangerous waste constituents in waste residuals left in tanks and ancillary equipment at closure. Key findings of this analysis were as follows:

- Results for this Impact Analysis indicate that the regulatory standards for groundwater protection (i.e., target risk, hazard quotients/indices, and groundwater maximum contaminant levels/cleanup levels) were not exceeded for the entire period of analysis

- For all of the sensitivity analyses evaluated, the disposal system also met these same standards.

The DOE O 435.1 Performance Assessment (RPP-ENV-58782) evaluates the impacts from radiological constituents in waste residuals left in tanks and ancillary equipment at closure. Key findings of this analysis were as follows:

- The performance assessment results indicate that the performance objectives and measures for the all-pathways dose, the air pathway dose, the radon flux, groundwater protection, and inadvertent intrusion are met for both the 1,000-year compliance time period (2020 to 3020) and the post-compliance period (3020 to 12020)

- For all of the sensitivity analyses and uncertainty analyses evaluated, the disposal system met the performance objectives.

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LIST OF TERMS

Abbreviations and Acronyms

CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
CMS	corrective measures study
COPC	contaminant of potential concern
DOE	U.S. Department of Energy
DOE-ORP	U.S. Department of Energy, Office of River Protection
DWS	drinking water standard
EA	exposure area
Ecology	State of Washington Department of Ecology
ELCR	excess lifetime cancer risk
ENW	Energy Northwest
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ERDF	Environmental Restoration Disposal Facility
HAMMER	Volpentest Hazardous Materials Management and Emergency Response (HAMMER) Federal Training Center
HFFACO	*Hanford Federal Facility Agreement and Consent Order*
IPA	Appendix I Performance Assessment
LIGO	Laser Interferometer Gravitational Wave Observatory
LLWMA	Low-Level Waste Management Area
µg/L	micrograms per liter

MCL	maximum contaminant level
mg	milligram
mrem/yr	millirem per year
MTCA	*Model Toxics Control Act*
OU	Operable Unit
PA	performance assessment
pCi/g	picocuries per gram
RA	risk assessment
RCRA	*Resource Conservation and Recovery Act of 1976*
RFI	RCRA facility investigation
RI	Remedial Investigation
SLERA	screening level ecological risk assessment
SST	single-shell tank
STOMP	Subsurface Transport Over Multiple Phases
TC&WM EIS	Tank Closure and Waste Management Environmental Impact Statement
UCL	upper confidence limit
UPR	unplanned release
WAC	*Washington Administrative Code*
WMA	Waste Management Area
WTP	Waste Treatment Plant

1.0 INTRODUCTION

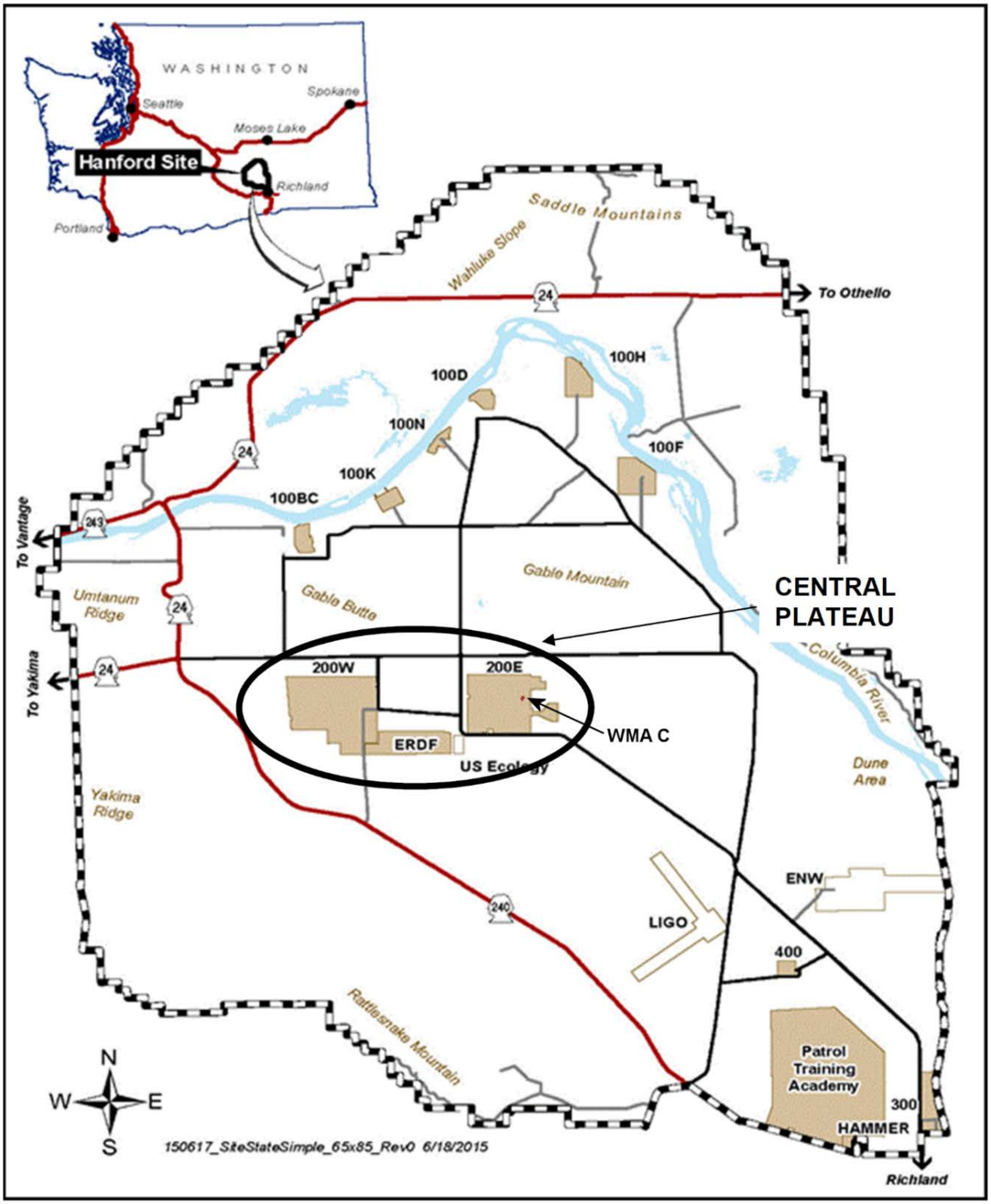
The U.S. Department of Energy, Office of River Protection (DOE-ORP) is pursuing closure on the single-shell tank (SST) Waste Management Area (WMA) C (Figure 1-1) under Federal requirements and forthcoming U.S. Department of Energy (DOE) closure plans, State-approved closure plans, and permits in accordance with the *Hanford Federal Facility Agreement and Consent Order* (HFFACO) (Ecology et al. 1989), Action Plan, Appendix I. In order to close WMA C, the impacts of leaving residual waste in the tanks and ancillary equipment, as well as contaminated soil and groundwater in place after closure, must be understood. This information is used by both DOE and the State of Washington Department of Ecology (Ecology) in the closure plans and *Resource Conservation and Recovery Act of 1976* (RCRA) permits to ensure that appropriate closure decisions are made. The importance of the performance assessment (PA) in the closure process was recognized by Ecology/DOE/U.S. Environmental Protection Agency (EPA) with the addition of Section 2.5 of Appendix I of the HFFACO Action Plan.

This analysis of impacts of leaving residual waste in the tanks and ancillary equipment in conjunction with impact analysis of contaminated soil and groundwater left in place after closure satisfy the requirements for a PA outlined in Appendix I of the HFFACO Action Plan. The first paragraph of Section 2.5 of the HFFACO Action Plan Appendix I states:

> "Ecology, as the lead agency for SST system closure, EPA, and DOE have elected to develop and maintain as part of the SST system closure plan one performance assessment for the purposes of evaluating whether SST system closure conditions are protective of human health and the environment for all contaminants of concern, both radiological and nonradiological. DOE intends that this performance assessment (PA) will document by reference relevant performance requirements defined by RCRA, HWMA, *Clean Water Act, Safe Drinking Water Act*, and the *Atomic Energy Act of 1954* (AEA) and any other performance requirements that might be ARARs under CERCLA. The PA is of larger scope than a risk assessment required solely for nonradiological contaminants. The PA is expected to provide a single source of information that DOE can use to satisfy potentially duplicative functional and/or documentation requirements. A PA will be developed for each WMA and will incorporate the latest information available. These PAs will be approved by Ecology and DOE pursuant to their respective authorities. For Ecology approval means incorporation by reference, into the Site-Wide Permit through the closure plans."

The language above broadens the scope of a PA required by Appendix I beyond that of a "DOE O 435.1 performance assessment." A description of the regulatory framework/documents for residual waste (DOE O 435.1, *Radioactive Waste Management*/RCRA closure) and past contamination under RCRA corrective actions is provided in Appendix I (Figure I-1 of Appendix I). To meet these requirements, DOE has produced a set of complementary reports, each addressing specific requirements for individual contamination sources (existing contamination in the vadose zone, past tank leaks and unplanned releases, and tank residuals [radionuclides/hazardous chemicals]). This document provides a synopsis of the major conclusions of these reports.

Figure 1-1. Hanford Site and its Location in Washington State.



ENW = Energy Northwest
ERDF = Environmental Restoration Disposal Facility
HAMMER = Volpentest Hazardous Materials Management and Emergency Response (HAMMER) Federal Training Center
LIGO = Laser Interferometer Gravitational Wave Observatory

Figure I-1 of the HFFACO Action Plan Appendix I has been modified by adding the green boxes at the bottom to show how these complementary reports feed into the Single-Shell Waste Management Area Waste Retrieval and Closure Process (Figure 1-2). The Appendix I PA (IPA) is represented by the combined results of these complementary documents. The specific documents are listed in Figure 1-3. The first two documents evaluate impacts of existing contamination, while the last two documents evaluate the impacts of residual wastes in tanks and ancillary equipment remaining after closure.

In addition to the documents produced for the IPA, Section 2.4 of HFFACO Action Plan Appendix I states:

> "Ecology, as the lead agency for SST system closure, EPA, and DOE are electing to investigate and remediate groundwater under past practice authority. The information generated through the groundwater RI/FS *[remedial investigation/ feasibility study]* or RFI/CMS *[RCRA facility investigation/corrective measures study]* process will be utilized in the development of SST system closure plans and performance assessment."

DOE submitted the 200-BP-5 Remedial Investigation (RI) Report (DOE/RL-2009-127, *Remedial Investigation Report for the 200-BP-5 Groundwater Operable Unit*, Draft A) for review by the regulatory agencies (Ecology is the lead agency for this groundwater Operable Unit [OU]) in August 2015. The RI was prepared in accordance with the RI Work Plan (DOE/RL-2007-18, *Remedial Investigation/Feasibility Study Work Plan for the 200-BP-5 Groundwater Operable Unit*). The RI provides information about the conceptual site model, nature and extent of contamination, risk assessment (RA), and contaminant fate and transport. Conclusions from the RI report include demonstration of basis for action (drinking water standards [DWSs] and risk thresholds are currently exceeded and are expected to stay exceeded for a long time horizon) and identification of contaminants of potential concern (COPCs) (those that should be targeted for remediation or monitoring) at different interest areas within the groundwater aquifer.

WMA C is located on the southern portion of 200-BP-5 OU (Figure 1-4). The results of the 200-BP-5 RI provide the current risk present at a number of the groundwater wells in and around WMA C, as well as impacts from upgradient contamination in groundwater that may impact WMA C sometime in the future.

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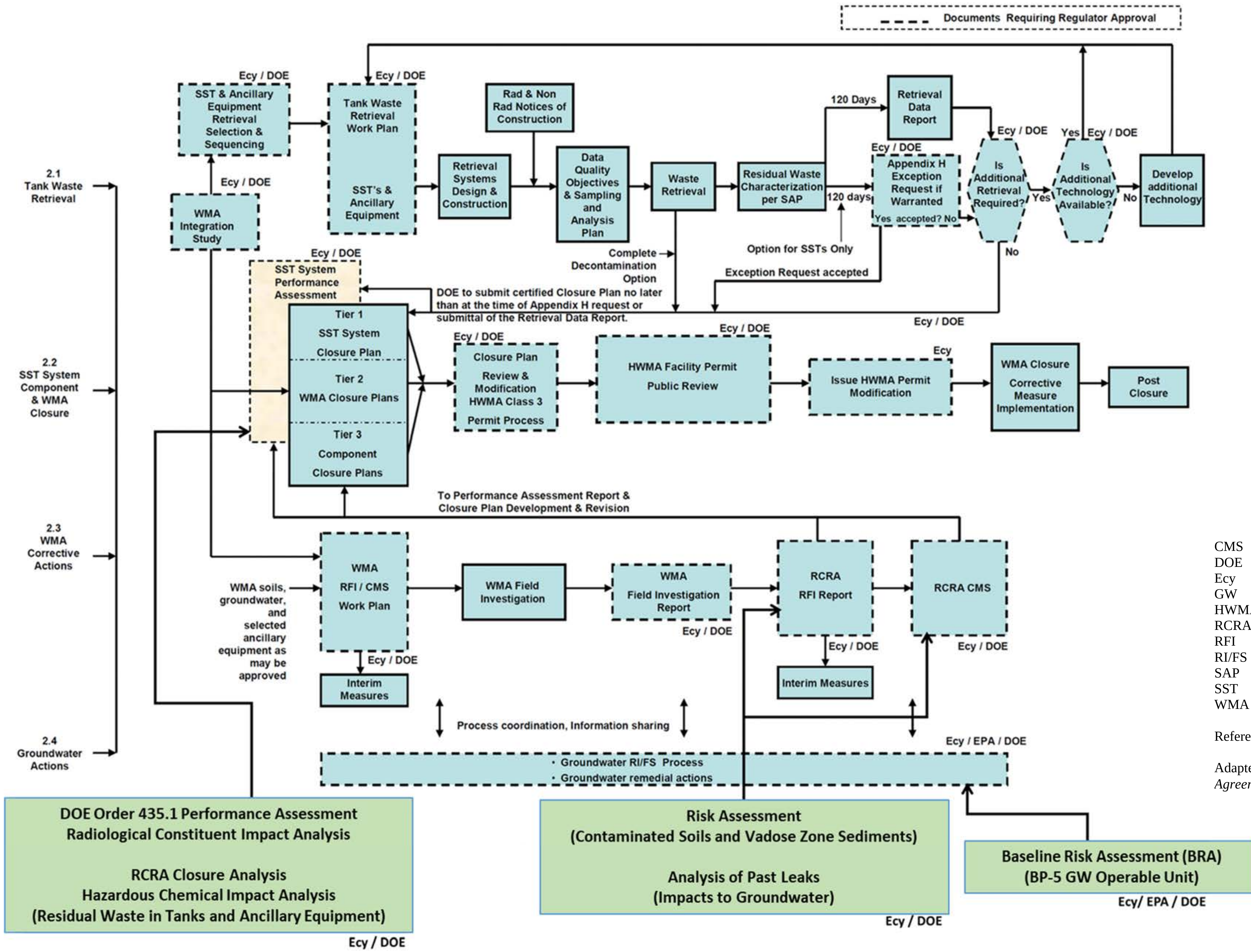
Figure 1-2. Single-Shell Waste Management Area Waste Retrieval and Closure Process.

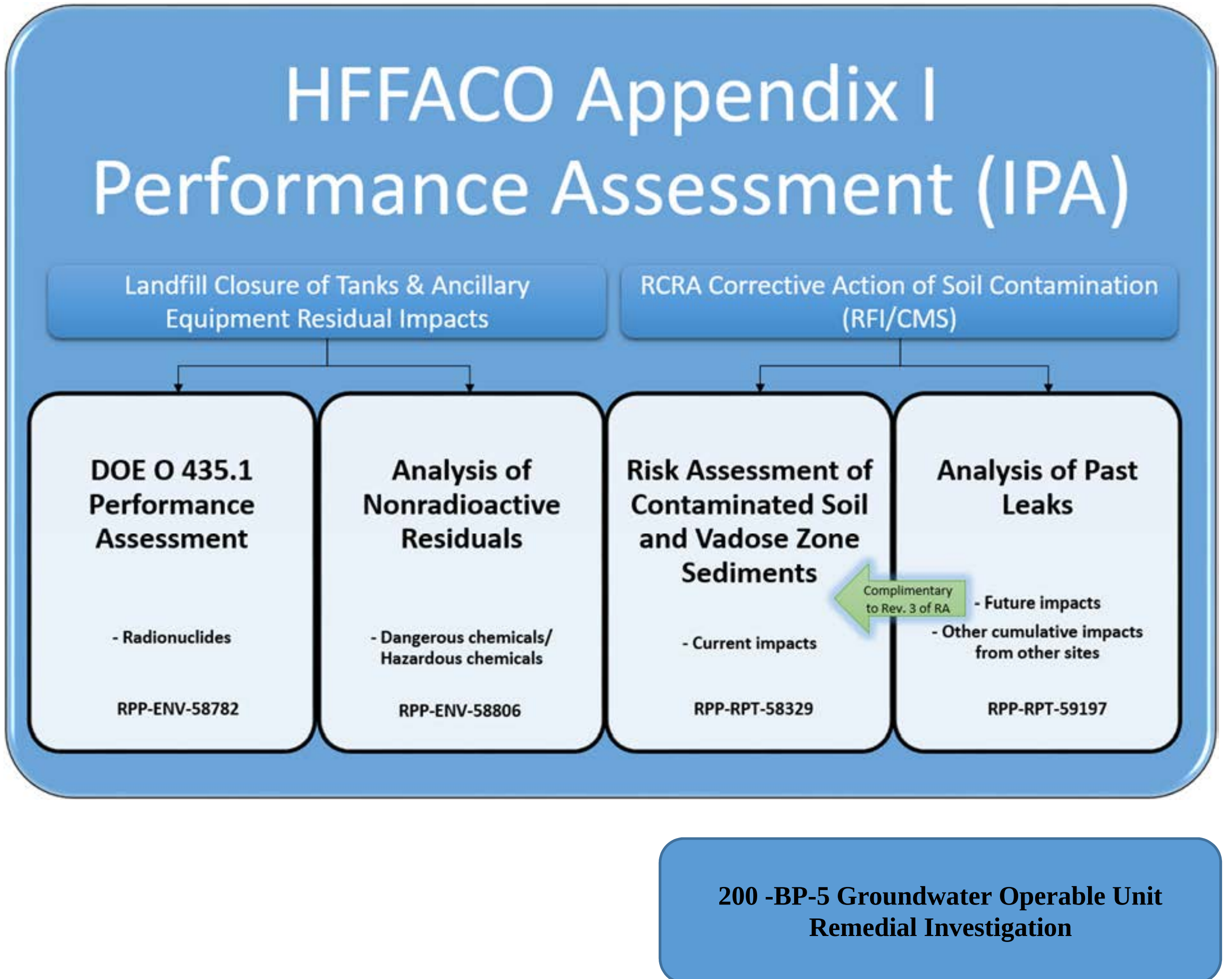


CMS = corrective measures study
DOE = U.S. Department of Energy
Ecy = State of Washington Department of Ecology
GW = groundwater
HWMA = Hazardous Waste Management Act
RCRA = *Resource Conservation and Recovery Act of 1976*
RFI = RCRA facility investigation
RI/FS = remedial investigation/feasibility study
SAP = sampling and analysis plan
SST = single-shell tank
WMA = Waste Management Area

Reference: DOE O 435.1, *Radioactive Waste Management*.

Adapted from Figure I-1 in Appendix I of the *Hanford Federal Facility Agreement and Consent Order – Tri Party Agreement* (Ecology et al. 1989).

Figure 1-3. The Components of the *Hanford Federal Facility Agreement and Consent Order* Appendix I Performance Assessment.



References:
DOE O 435.1, *Radioactive Waste Management.*
RPP-ENV-58782, Rev. 1, *Performance Assessment of Waste Management Area C, Hanford Site, Washington.*
RPP-ENV-58806, Rev. 1, *Analysis of Post-Closure Groundwater Impacts from Hazardous Chemicals in Residual Wastes in Tanks and Ancillary Equipment at Waste Management Area C at the Hanford Site, Southeast Washington.*
RPP-RPT-58329, Rev. 3, *Risk Assessment of Contaminated Soils and Vadose Zone Sediments at Waste Management Area C at the Hanford Site, Southeast Washington.*
RPP-RPT-59197, Rev. 2, *Analysis of Impacts of Past Tank Waste Leaks and Losses in the Vicinity of Waste Management Area C at the Hanford Site, Southeast Washington.*

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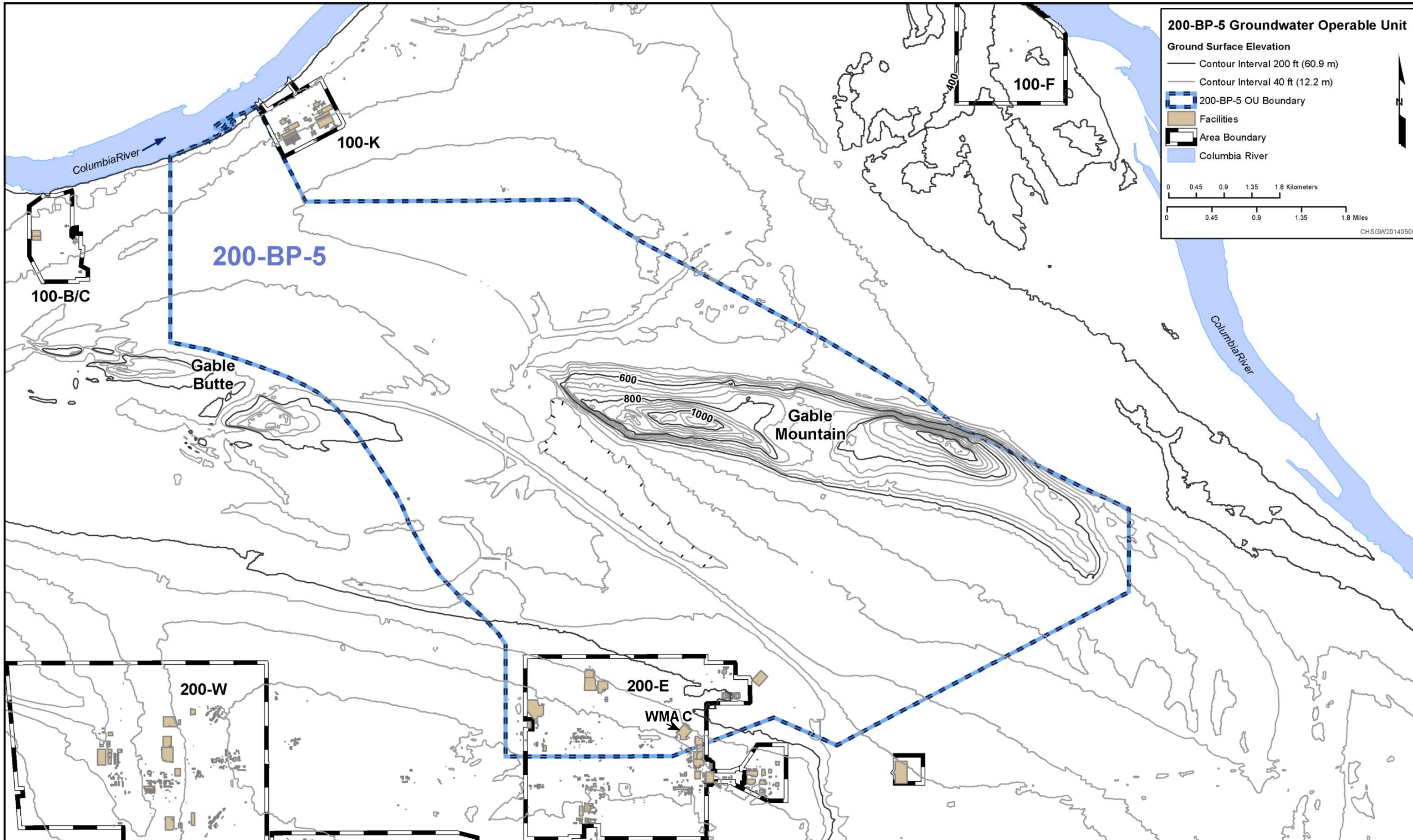
Figure 1-4. Surface Topography and Boundaries of the 200-BP-5 Groundwater Operable Unit.



OU = Operable Unit WMA = Waste Management Area

1.1 PURPOSE AND SCOPE OF THE REPORT

The purpose of this report is to provide the reader a brief and concise synopsis of the results of the four documents included in the WMA C IPA, along with the results for the 200-BP-5 RI, as it pertains to WMA C.

The scope of this report is to provide a high-level summary of the conclusions and implications of the Appendix I WMA C PA. For detailed information on the data, the methodology, and the results of the analyses, the reader is referred to the original documentation.

In the remainder of Section 1, a general description of WMA C and anticipated closure conditions is provided.

Section 2 provides the key conclusions from RPP-RPT-59197, *Analysis of Impacts of Past Tank Waste Leaks and Losses in the Vicinity of Waste Management Area C at the Hanford Site, Southeast Washington*. The strategy for analysis of past leaks has been to define and analyze a suite of-scoping cases to evaluate the uncertainties associated with them. The scoping cases provide a band of analyses that are in reasonable agreement with observed concentrations in groundwater monitoring wells.

Section 3 provides the key conclusions from RPP-RPT-58329, *Risk Assessment of Contaminated Soils and Vadose Zone Sediments at Waste Management Area C at the Hanford Site, Southeast Washington* from calculating risk for both nonradiological and radiological contaminants for various exposure scenarios.

Section 4 provides the key conclusions of post-closure analyses of residual waste in SSTs and ancillary equipment as documented in both RPP-ENV-58806, Rev. 1, *Analysis of Post-Closure Groundwater Impacts from Hazardous Chemicals in Residual Wastes in Tanks and Ancillary Equipment at Waste Management Area C at the Hanford Site, Southeast Washington* and RPP-ENV-58782, Rev. 1, *Performance Assessment of Waste Management Area C, Hanford Site, Washington*.

Section 5 provides summary conclusions taken from the groundwater Baseline Risk Assessment (BRA) included in the 200-BP-5 RI as it pertains to WMA C.

In addition, Appendix A provides a review comment record of dispositions that address general overall comments received from Ecology during their review of a three of the four WMA C HFFACO Appendix I Analyses and related documentation that include the following documents:

- RPP-RPT-58329, Rev. 2, *Baseline Risk Assessment for Waste Management Area C*
- RPP-RPT-59197, Rev. 1, *Analysis of Past Tank Waste Leaks and Losses in the Vicinity of Waste Management Area C at the Hanford Site, Southeast Washington*
- RPP-RPT-58806, Rev. 0, *RCRA Closure Analysis of Tank Waste Residuals Impacts at Waste Management Area C, Hanford Site, Washington*.

1.2 BACKGROUND INFORMATION

This section provides a brief description of WMA C and anticipated closure conditions.

1.2.1 General Description of Waste Management Area C

Waste Management Area C is located in the 200 East Area of the Central Plateau at the Hanford Site in south-central Washington (Figure 1-1) and is one of 12 tank farms grouped into 7 WMAs (A-AX, B-BX-BY, C, S-SX, T, TX-TY, and U) containing 149 SSTs and ancillary equipment built from 1943 to 1964 (see Figure 1-5). Both 200 East and 200 West Areas of the Central Plateau are designated to be Industrial-Exclusive (DOE/EIS-0222-F, *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*).

The WMA C boundary is the fenceline surrounding the 241-C Tank Farm (C Farm) (Figure 1-5). The WMA C facility contains twelve 100-series tanks and four 200-series tanks (see Figure 1-6). The 100-series tanks are 23 m (75 ft) in diameter, with a maximum 5-m (~16-ft) depth and 2,006,000-L (~530,000-gal) design capacity. The 200-series tanks are 6 m (~20 ft) in diameter with a maximum 7-m (~24-ft) depth and 208,000-L (~55,000-gal) design capacity. The tanks sit below grade with at least 2 m (7 ft) of soil cover to provide shielding from radiation exposure to operating personnel. Tank pits are located on top of the tanks and provide access to the tanks, pumps, and associated monitoring equipment. To support the transfer and storage of waste within WMA C SSTs, there is a complex waste-transfer system of pipelines (transfer lines), diversion boxes, vaults, valve pits, and other miscellaneous structures. These miscellaneous features of the tank farm are referred to in this document by the general term "ancillary equipment and components."

1.2.2 Anticipated Closure Conditions

The Tank Closure and Waste Management Environmental Impact Statement (TC&WM EIS) (DOE/EIS-0391, *Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*) Record of Decision (78 FR 75913, "Record of Decision: Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington") was published on December 13, 2013. Among other things, the Record of Decision provides as follows:

> "SST closure operations include filling the tanks and ancillary equipment with grout to immobilize the residual waste. Disposal of contaminated equipment and soil will occur on site. The tanks will be grouted and contaminated soil may be removed. The SSTs will be landfill-closed, which means they will be stabilized, and an engineered modified RCRA Subtitle C barrier put in place followed by post-closure care."

Figure 1-5. Hanford Site Tank Farms.

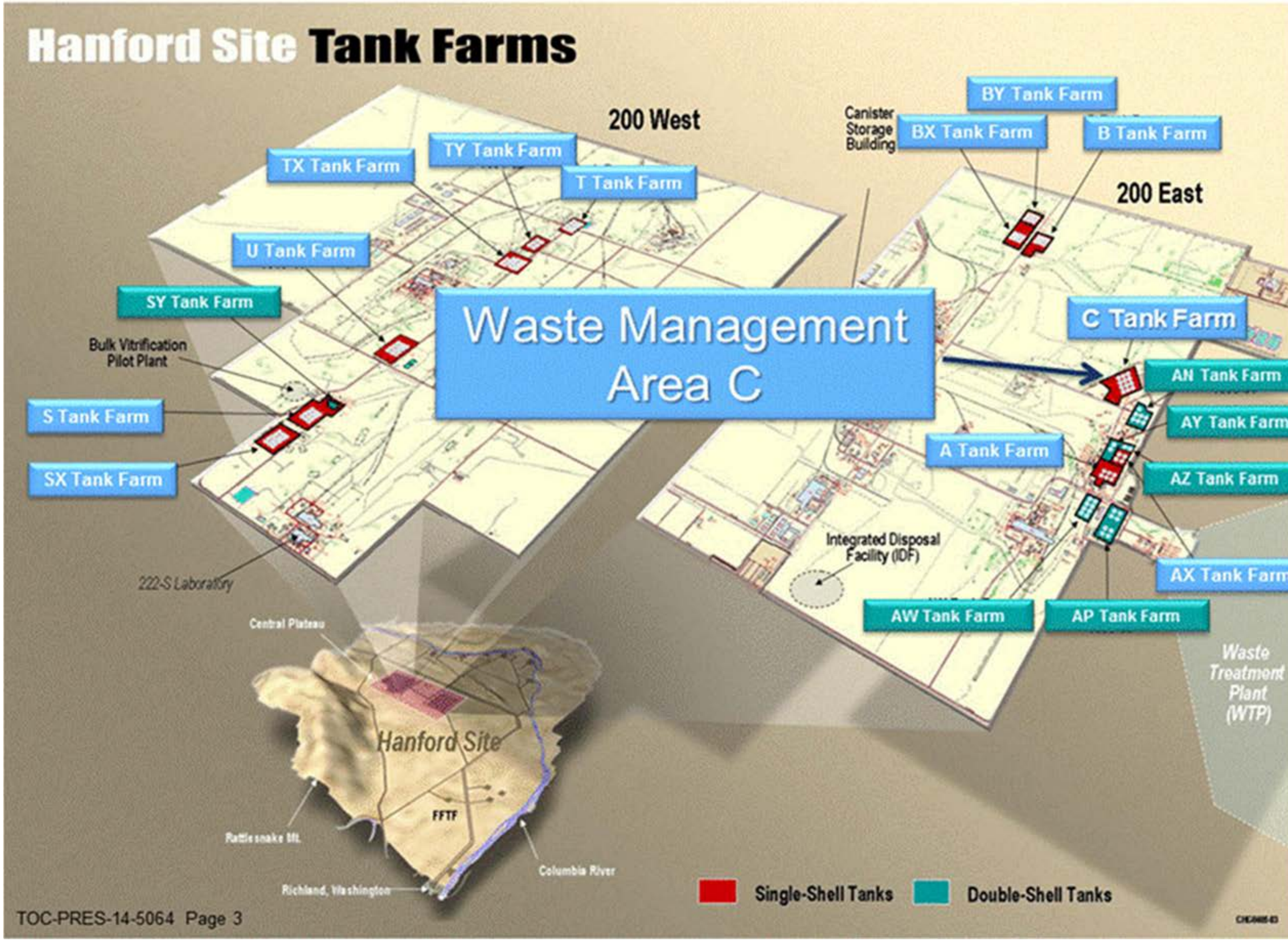
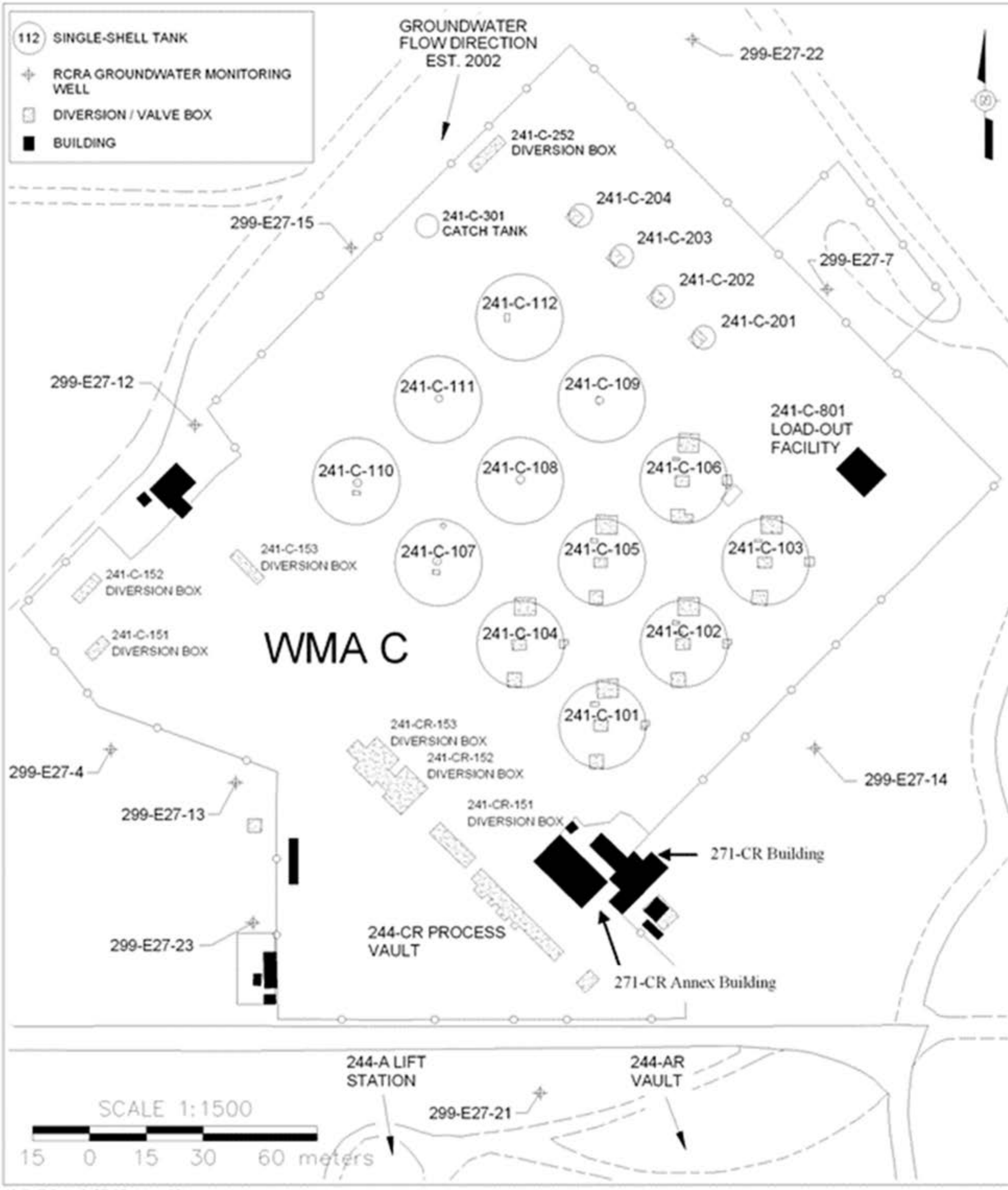


Figure 1-6. Location of Facilities at Waste Management Area C and Surrounding Area.



RCRA = *Resource Conservation and Recovery Act of 1976* WMA = Waste Management Area

Note: Groundwater flow direction in the vicinity of WMA C under current conditions is generally to south and southeast.

In the original version of the IPA, the evaluation of radiological impacts from residual wastes left in tanks and ancillary equipment left in WMA C after closure was based on an assumption of a facility closure date of 2020, consistent with planning assumptions in the TC&WM EIS and HFFACO at the time. This assumption is now clearly unrealistic, and has been modified in Revision 1 of the IPA. However, the appropriate revised time period for assumption of institutional controls is unclear, and as a result several alternative assumptions have been evaluated. Assumptions about institutional control primarily affect the analysis of inadvertent intrusion in the DOE O 435.1 PA (RPP-ENV-58782). The results of the groundwater and air pathway evaluations for the post-closure period are not significantly affected by these changed assumptions about facility closure timing.

During closure, the tanks will be filled with grout and covered with a final closure cover. However, while the tanks most likely will be filled with grout following retrieval of the waste in the tanks, the final closure cover may be delayed because of the proximity to nearby single-shell and double-shell tanks just to the east of WMA C.

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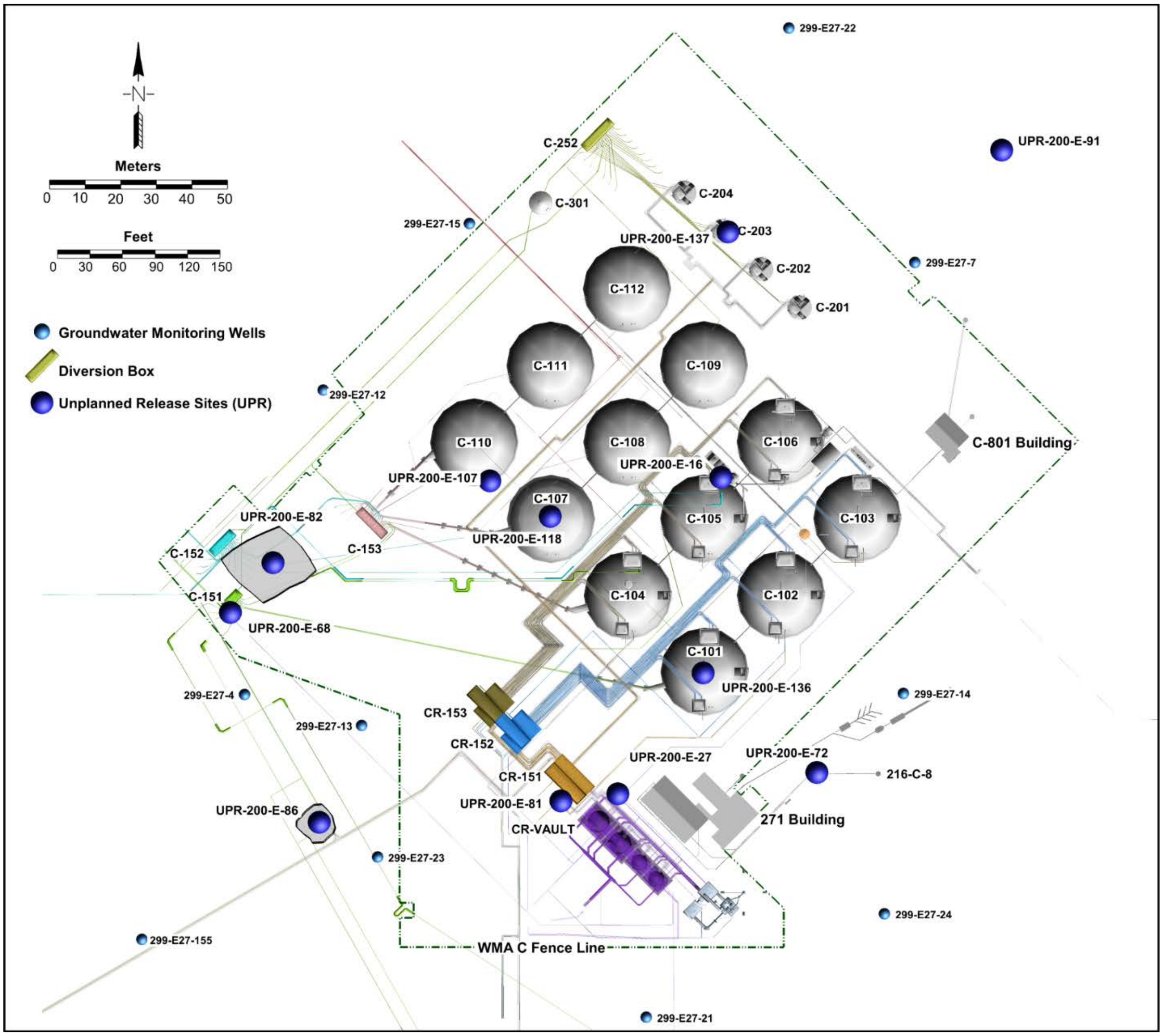
2.0 ANALYSIS OF IMPACTS OF PAST TANK WASTE LEAKS AND LOSSES AT WASTE MANAGEMENT AREA C (RPP-RPT-59197, REV. 2)

During the decades when WMA C was in active use as a tank farm, a number of documented leaks, or unplanned releases, occurred within or near to the WMA. The largest ones were associated with leaks in pipelines and diversion boxes, with the inlets or outlets of the tanks, or with leaks from the tanks themselves (Figure 2-1). Contaminants were released to the soil associated with these leaks; estimates of the quantities of contaminants released are presented in Table 2-1.

Figure 2-1. Waste Management Area C Tanks, Infrastructure, and Associated Unplanned Releases.



WMA = Waste Management Area

Table 2-1. Inventory Estimates for Releases at Waste Management Area C.

Waste Release	Waste Volume (gal)	^{60}Co (Ci)	^{99}Tc (Ci)	^{129}I (Ci)	^{137}Cs (Ci)	$Fe(CN)_6$ (kg)	NO_3 (kg)	SO_4 (kg)	Total U (kg)
241-C-101	37,000	0.14	0.25	0.04	580	0	5,900	1.3	4.3
241-C-104	28,000	0.11	0.03	0.03	52	0	4,500	90	3.3
241-C-105	2,000 to 20,500	0.01 to 0.1	1 to 9.8	5.9E-4	2,700 to 27,000	0	3 to 430	690	0.18 to 1.8
241-C-108	18,000	0.07	0.02	0.02	33	0	2,900	58	2.1
241-C-110	2,000	0.05	3.4	0.003	230	0	1,800	210	0.73
241-C-112	7,000	0.03	0.0075	0.007	13	0	1,100	23	0.82
UPR-81	36,000	0.9	0.11	0.1	220	0	23,000	350	17
UPR-82	2,600	0.01	1.3	7.5E-5	3,500	0	55	88	0.2
UPR-86	17,000	0.03	2.7	1.6E-4	7,400	0	120	190	0.5
216-C-8 French Drain	>32,000	0.0	0.0	0.0	0.3	0	0.15	0.14	6.0E-05
Surface Releases	1,000	0.004	0.001	0.001	1.9	0	160	3.2	0.12
Total	201,000	1.5	18	0.2	39,000	0	40,000	1,800	31

Note: Values are rounded to two significant digits.
Radionuclide values are decayed to January 1, 2020.
No $Fe(CN)_6$ was identified in the supernate for Hanford Defined Waste waste types.

UPR = unplanned release

References: RPP-ENV-33418, *Hanford C-Farm Leak Inventory Assessments Report* and RPP-19822, *Hanford Defined Waste Model – Revision 5.0*.

Key Findings from Analysis of Past Leaks:

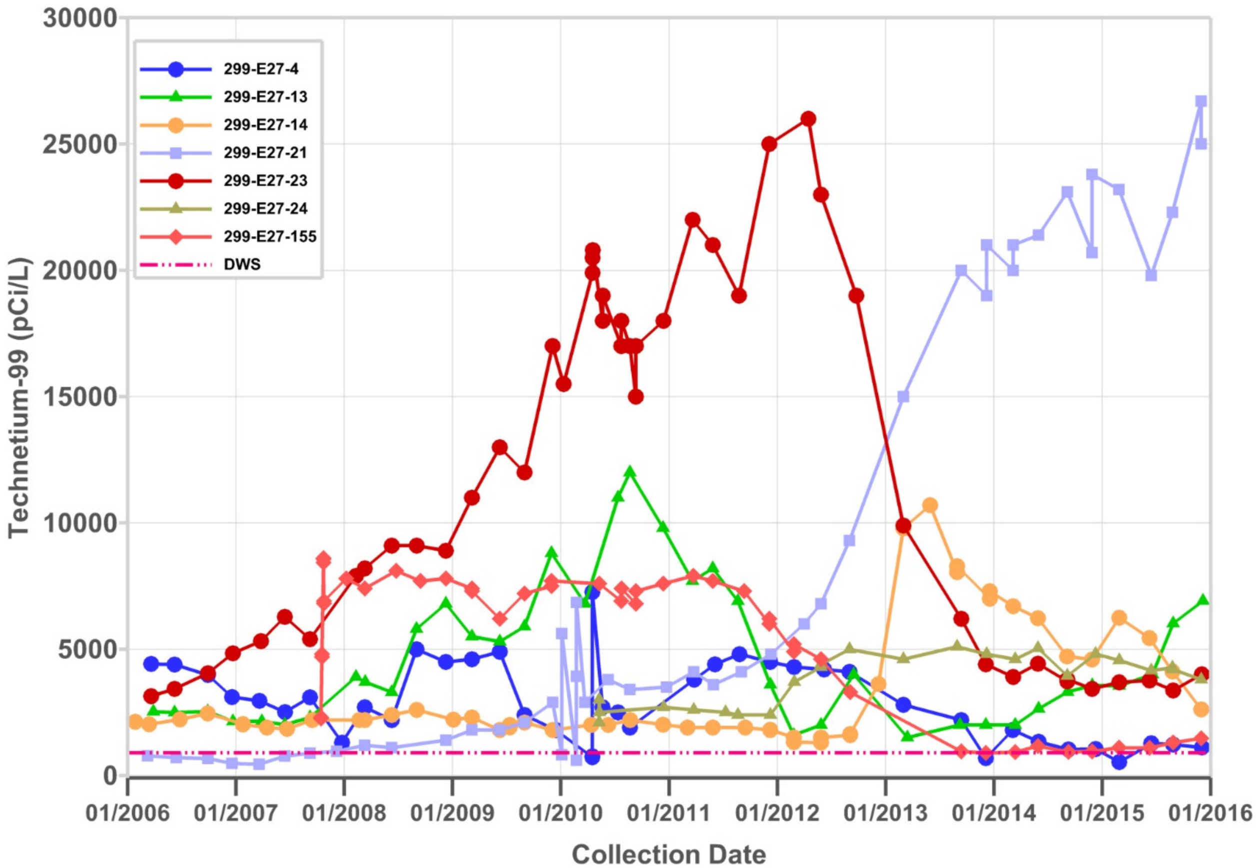
- Evaluation for past waste releases at WMA C has indicated that groundwater has been impacted by ^{99}Tc.
- Model analysis of future impacts shows that concentration levels of ^{99}Tc are at or near their peak values and are expected to decline over the next few decades.
- Concentration levels of nitrate and sulfate, which exceed DWS in some wells at WMA C, show that groundwater has likely been impacted by a combination of both upgradient and tank farm sources.
- Without specific mitigation, groundwater at WMA C also has the potential to be impacted in the future by a number of contaminants of potential concern originating in sources upgradient from WMA C.

An analysis of the impact of past leaks on groundwater resources has been undertaken using the site-specific models developed for the DOE O 435.1 residual waste PA (RPP-ENV-58782) and Hazardous Chemical Impacts Analysis (RPP-ENV-58806). The strategy for this analysis of leaks has been to define and analyze a suite of scoping cases to evaluate the uncertainties associated with past leaks. These scoping cases were used to investigate alternative conceptual models for the leak behavior to develop a band of analyses that are in reasonable agreement with observed concentrations in groundwater monitoring wells. For these comparisons, the calculated groundwater concentrations have been compared to observed ^{99}Tc concentrations in groundwater, since ^{99}Tc is a key risk driver and the contamination levels observed in groundwater monitoring wells are unambiguously the result of WMA C past leaks (Figure 2-2). Therefore, observed ^{99}Tc concentration measurements in groundwater monitoring wells have been used to evaluate the model assumptions that are consistent with the arrival times and concentration levels of ^{99}Tc historically observed near WMA C.

The analysis of past leaks has been structured to meet several goals in addition to the requirements of RPP-RPT-58329.

First, the analysis was intended to be responsive to ideas and concerns expressed by stakeholders in the 2009 – 2011 PA scoping sessions. This was accomplished by including specific stakeholder-identified features, events and processes in the past leaks analysis, because of their potential to influence the migration of contaminants from WMA C. Particular attention was paid to the potential for fine-scale heterogeneities to influence flow and contaminant transport in the vadose zone (RPP-RPT-61239, *Multiple Lines of Evidence and Modeling Results for Heterogeneous Alternative Conceptual Models of the Subsurface at Waste Management Area C*). Second, the analysis was intended to be consistent, to the extent possible, with the PA (RPP-ENV-58782) and hazardous chemical impact analysis (RPP-ENV-58806) for disposal of residual wastes in WMA C. Third, the goal has been to provide an understanding of the key features and processes that influence the migration of contaminants. Fourth, the goal was to use the understanding gained by the analysis to provide a projection of the future evolution of the contamination beneath WMA C. Finally, the analyses provide supporting information that could be relevant to the selection and specific implementation of groundwater mitigation measures being undertaken as a part of the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) Remedial Investigation/Feasibility Study (RI/FS) effort in 200-BP-5-OU.

Figure 2-2. Measured Technetium-99 Concentrations in Excess of the Drinking Water Standard in Monitoring Wells near Waste Management Area C.



DWS = drinking water standard

Comparisons of the scoping cases with available ^{99}Tc observations indicate the following.

- Several of the scoping cases produced results that are inconsistent with observations, indicating that the assumptions in those cases are not representative of conditions in WMA C. These negative results are valuable in improving the understanding of the migration of ^{99}Tc from WMA C. Most notably, analyses evaluating the inventory of the tank 241-C-105 leak showed that the lower bound activity estimate of 1 Ci is inconsistent with observations, and the upper bound estimate of 10 Ci is consistent with observations.

- The remaining scoping analyses produced comparable results to each other, and none were obviously superior to others in terms of explaining the ^{99}Tc observations. When uncertainties in groundwater fluxes were taken into account, these scoping analyses were capable of producing both arrival times and concentrations consistent with observed groundwater conditions for ^{99}Tc.

The analysis that showed the greatest fidelity to the observation well data was the transient water table analysis. However, to implement this case it was necessary to make alterations to the boundary conditions to achieve the good agreement with data. Due to the lack of available historical gradients measurements, these alterations are based on reproducing observed concentrations. They serve to provide insight into the evolution of the observed concentrations at groundwater wells in the vicinity of WMA C. Key factors that most strongly influenced the comparison with measured concentrations at wells 299-E27-23 and 299-E27-21 were:

- The local direction of flow and hydraulic gradient at WMA C at the time that the releases reached the water table

- The direction of flow to northwest inferred in other areas to the northwest of WMA C in the early 2000 time frame, when releases from WMA C sources reached groundwater, may not have been representative of local flow conditions at WMA C

- Observations of ^{99}Tc concentrations seen historically in wells to the north, south, and southeast sides of WMA C suggest that the primary directions of flow in the farm may have been variable, ranging from southwest to southeast at the time when past releases started to impact groundwater

- The time-varying responses and concentration levels at individual monitoring wells is directly related to the timing of dynamic changes in the flow direction and hydraulic gradients as groundwater continues its evolution into more natural conditions.

Representative models were next used to implement a forward projection of a suite of contaminants of concern, to show how the contamination associated with past leaks can be expected to evolve in the future. The forward projection results lead to several observations, as follows.

- Model analysis results indicate that current high concentrations of ^{99}Tc below WMA C are at or near their peak in time and are expected to decline over the next several decades.

- Modeling results indicate that concentrations of ^{129}I at the fenceline of WMA C may slightly exceed the ^{129}I DWS for a short time in about calendar year 5900. At farther distances and other calculation times, the concentration of ^{129}I remains below the DWS.

- Modeling results related to past waste releases for nitrate and sulfate were found to be less than observed concentrations for these specific constituents. Concentration levels of both nitrate and sulfate show that groundwater has likely been impacted by a combination of upgradient and tank farm sources. Like ^{99}Tc, model-calculated concentration levels for these constituents from tank farm sources are at or near their peak in time and are expected to decline over the next several decades.

- Model analysis results indicate that concentrations of other COPCs remain below their respective DWSs at all locations and calculation times.

- There are not significant overlaps between short-term releases and impacts from leaks and the long-term releases and impacts from residual wastes left in tanks and ancillary equipment in a closed WMA C.

3.0 RISK ASSESSMENT OF CONTAMINATED SOILS AND VADOSE ZONE SEDIMENTS AT WASTE MANAGEMENT AREA C (RPP-RPT-58329, REV. 3)

This risk assessment report presents the potential health impacts to human and ecological receptors from exposure to contamination present in the shallow soils and vadose zone at WMA C. The report also presents the results of the potential impacts to groundwater from migration of nonradiological contaminants in contaminated soil through the vadose zone to the aquifer. Past operations at the Site have resulted in releases of chemicals and radionuclides to environmental media that may pose risks to human and ecological receptors.

Thirteen locations were selected for sampling the contaminated soils within WMA C. The selection was documented in the WMA C Phase 2 RCRA facility investigation (RFI)/corrective measures study (CMS) Work Plan (RPP-PLAN-39114, *Phase 2 RCRA Facility Investigation/Corrective Measures Study Work Plan for Waste Management Area C*). Soil sampling results collected from 13 locations were validated, evaluated and segregated into 10 exposure areas (EAs). Two screening steps – data reduction screen and weight of evidence – were performed to identify COPCs for both human health and ecological receptors at each EA. Those contaminants were further evaluated in the human health RA (HHRA) and the screening level ecological risk assessment (SLERA).

Two types of HHRAs were conducted for contaminants present in the soil and vadose sediment within WMA C – (1) an HHRA based on statistical approach and (2) a HHRA based on sample-by-sample approach. In addition, three supplemental RAs that were conducted to support the CMS alternatives evaluation process (see RPP-RPT-59379, *Waste Management Area C Phase 2 Corrective Measures Study Report*) were also included in the RPP-RPT-58329 document. These CMS-related RAs included (1) a supplemental HHRA for the ten exposure areas; (2) a supplemental HHRA for unplanned releases; and (3) a supplemental HHRA for past leaks, surface releases and French drain.

The HHRA based on statistical approach addressed potential exposures to industrial worker, construction worker, maintenance/surveillance worker, trespasser, hypothetical onsite residential receptors and two Native American residential receptors to contaminants detected in shallow vadose soils (upper 15 ft). The HHRA based on sample-by-sample approach was performed for radiological COPCs under CERCLA industrial worker and CERCLA residential receptor scenarios and for nonradiological COPCs under *Washington Administrative Code* (WAC) industrial worker under Method C Standard and WAC residential receptor under Method B Standard. HHRA results based on both approaches of both nonradiological and radiological risk assessments for each EA were then compared against their corresponding acceptable risk criteria established by Federal and State regulatory agencies. Table 3-1 presents the results of radiological risk assessments for CERCLA industrial worker and CERCLA residential receptors based on statistical approach and sample-by-sample approach. For industrial worker and maintenance/surveillance worker scenario and statistical-based approach, the total excess lifetime cancer risks (ELCRs) for five EAs were greater than the EPA upper risk threshold of 1×10^{-4}. Results for the industrial worker scenarios are shown in Figure 3-1. For trespasser youth, the total ELCRs for two EAs were greater than 1×10^{-4}. For all three human receptors, two major risk contributors, ^{137}Cs and ^{126}Sn, were retained as radiological contaminants for further evaluation. While the WMA is not expected to be used as a residential area, the RA evaluated a residential receptor. Based on a statistical approach, except for one EA, the total ELCRs for all EAs are greater than the EPA upper risk threshold of 1×10^{-4} (results illustrated in Figure 3-2). Cesium-137, ^{60}Co, ^{63}Ni, ^{79}Se, ^{90}Sr, ^{126}Sn and ^{99}Tc were identified as major risk contributors at various EAs.

Table 3-1. Human Health Risk Assessments for Radiological Contaminants Based on Statistical Sample Approach and Sample-By-Sample Approach.

Exposure Area	CERCLA Industrial Worker		CERCLA Residential Receptor	
	Statistical Approach	Sample-by-Sample Approach	Statistical Approach	Sample-by-Sample Approach
	ELCR	Range of ELCRs	ELCR	Range of ELCRs
A+B	5E-04	1E-4 to 5E-4	3E-03	5E-4 to 2E-3
C	**6E-04**	2E-4 to 5E-4	**3E-03**	7E-4 to 2E-3
E	**2E-04**	4E-5 to 2E-4	**1E-03**	1E-4 to 8E-4
F+G	4E-05	7E-8 to 4E-5	3E-04	4E-7 to 1E4
H+I	8E-05	8E-8 to 1E-4	5E-04	5E-6 to 3E-4
J	**3E-05**	8E-8 to 3E-5	**5E-04**	7E-6 to 2E-4
L1+L2	1E-04	5E-8 to 9E-5	6E-04	6E-7 to 3E-4
P	2E-04	1E-7 to 4E-4	2E-03	1E-6 to 3E-3
R	**8E-07**	1E-7 to 1E-7	**7E-06**	8E-7 to 6E-6
U	**8E-05**	4E-5 to 6E-5	**5E-04**	1E-4 to 3E-4

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
ELCR = excess lifetime cancer risk

Note: ELCR values in **bold** are calculated using exposure point concentrations based on maximum soil concentration.

Table 3-2 presents the results of nonradiological risk assessments for WAC industrial worker and WAC residential receptors based on statistical approach and sample-by-sample approach. No nonradiological contaminants were identified as risk and hazard contributors.

Table 3-2. Results of Risk and Hazard Evaluations for Nonradiological Contaminants Based on Statistical Sample Approach and Sample-By-Sample Approach.

Exposure Area	Model Toxics Control Act Method C				Model Toxics Control Act Method B			
	Statistical Approach	Sample-by-Sample Approach	Statistical Approach	Sample-by-Sample Approach	Statistical Approach	Sample-by-Sample Approach	Statistical Approach	Sample-by-Sample Approach
	Excess Lifetime Cancer Risk	Range of Excess Lifetime Cancer Risks[1]	Hazard Index	Range of Hazard Indices[2]	Excess Lifetime Cancer Risk	Range of Excess Lifetime Cancer Risks	Hazard Index	Range of Hazard Indices
A+B	4E-07	3E-7 to 6E-7	3E-02	3E-2 to 3E-2	6E-06	4E-6 to 8E-6	1.4	0.01 to 1.5
C	2E-06	4E-7 to 2E-6	5E-02	3E-2 to 5E-2	3E-05	6E-6 to 3E-5	2.4	1.4 to 2.1
E	6E-07	3E-7 to 6E-7	3E-02	3E-2 to 3E-2	8E-06	4E-6 to 8E-6	1.5	1.2 to 1.4
F+G	4E-07	2E-7 to 5E-7	3E-02	9E-10 to 3E-2	5E-06	3E-6 to 6E-6	1.3	<0.01 to 1.3
H+I	6E-07	2E-7 to 8E-7	4E-02	5E-10 to 3E-2	8E-06	3E-6 to 1E-5	1.5	<0.01 to 1.3
J	9E-07	4E-7 to 9E-7	4E-02	2E-2 to 3E-2	1E-05	5E-6 to 1E-5	1.6	1.1 to 1.5
L1+L2	4E-07	2E-7 to 5E-7	3E-02	1E-8 to 3E-2	5E-06	3E-6 to 7E-6	1.3	<0.01 to 1.4
P	6E-07	2E-7 to 7E-7	3E-02	4E-9 to 3E-2	8E-06	3E-6 to 9E-6	1.5	<0.01 to 1.4
R	7E-07	2E-13 to 7E-7	4E-02	7E-8 to 4E-2	9E-06	3E-12 to 9E-6	1.6	<0.01 to 1.6
U	8E-07	1E-12 to 8E-7	3E-02	2E-9 to 3E-2	1E-05	2E-11 to 1E-5	1.5	<0.01 to 1.4

[1] The range of excess lifetime cancer risks represents the minimum and the maximum excess lifetime cancer risk within the different depth interval.
[2] The range of hazard indices represents the minimum and the maximum hazard index within the different depth interval.

Reference: *Revised Code of Washington* 70.105D, “Hazardous Waste Cleanup—Model Toxics Control Act.”

Key Findings from Risk Assessment of Contaminated Soils and Vadose Zone Sediments:

- The HHRA showed that for the CERCLA industrial worker exposure scenario, ^{137}Cs and ^{126}Sn were retained as radiological contaminants for further evaluation. No nonradiological contaminants were retained for further evaluation.

- The SLERA showed that three radiological (^{90}Sr, ^{3}H and ^{137}Cs) and six nonradiological (boron, molybdenum, selenium, thallium, sulfate and Bis [2-ethylhexyl] phthalate) contaminants of potential ecological concern were retained for further evaluation.

- The protection of groundwater pathway assessment showed that:

    - Based on a statistical approach, two nonradiological contaminants (cadmium and beta-BHC) are retained for further evaluation

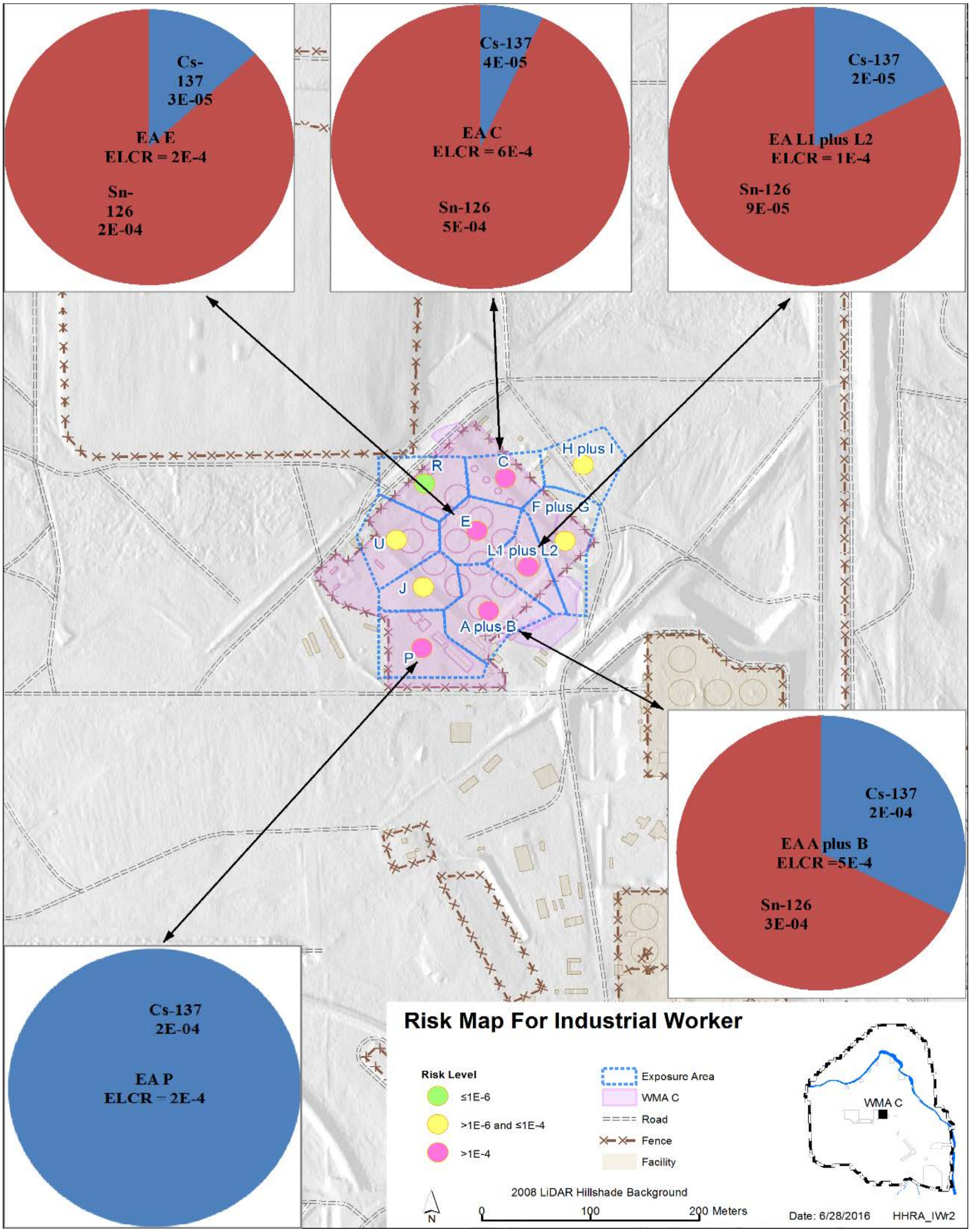
    - Based on a sample-by-sample approach, five nonradiological contaminants (arsenic, cadmium, hexavalent chromium, thallium and beta-BHC) are retained for further evaluation.

In the CMS alternatives evaluation process (see RPP-RPT-59379), a supplemental HHRA for EAs was performed for the same CERCLA industrial worker scenario considered in the RA to determine the impacts of a 4-in. barrier on reduction for each EA. The result showed that the maximum ELCR assuming barrier installation for each EA evaluated is within or less than EPA's acceptable target risk range of 10^{-4} to 10^{-6}.

In the CMS alternatives evaluation process (see RPP-RPT-59379), a supplemental HHRA was also performed for the same CERCLA industrial worker scenario considered in the RA at three unplanned release (UPR) locations—UPR-81, UPR-82, and UPR-86—by assuming no cover condition and a 3-ft concrete cover condition. Under no cover condition, the radiological ELCRs for all UPRs are greater than EPA's target risk threshold of 10^{-4}. Under a 3-ft concrete cover condition, the radiological ELCRs for all UPRs are within or less than EPA's acceptable target risk range of 10^{-4} to 10^{-6}. No nonradiological risk and hazard contributors were identified for three UPR locations.

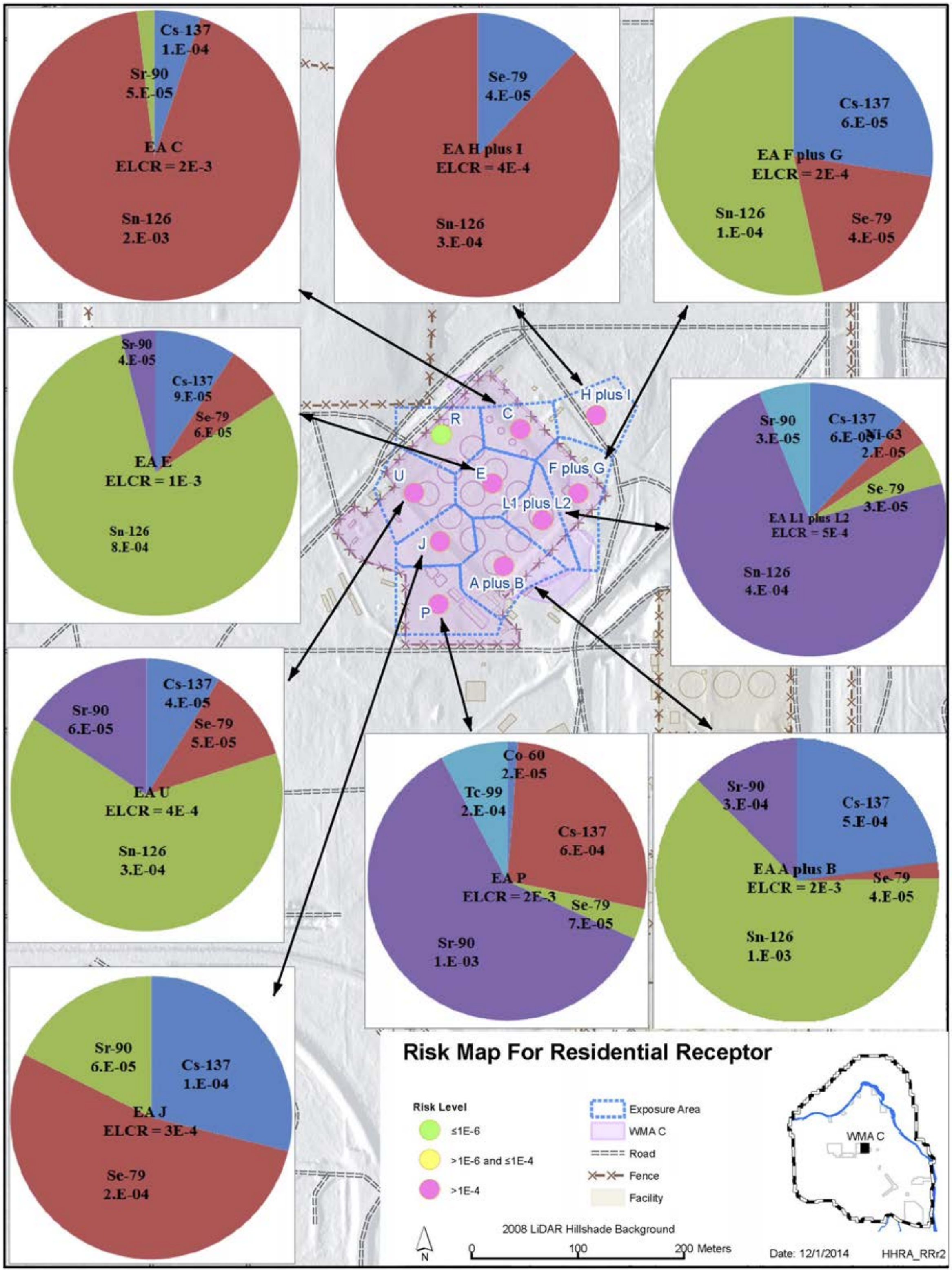
In the CMS alternatives evaluation process (see RPP-RPT-59379), supplemental HHRAs were performed for the radionuclide soil contamination associated with past leaks originating from six SSTs (241-C-101, 241-C-104, 241-C-105, 241-C-108, 241-C-110, and 241-C-112). The CERCLA construction worker scenario was evaluated as releases that occurred at 6.1 m (20 ft) below ground surface (bgs) by assuming subsurface contamination is brought to the surface from excavation activities. The results of the HHRA showed that the total cumulative ELCRs for all six past tank leaks are greater than EPA's target threshold of 10^{-4} and the maximum doses for all six past tank leaks are greater than 500 mrem/yr.

Figure 3-1. Exposure Areas with Unacceptable Risks under CERCLA Industrial Worker Scenario.



CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
EA = Exposure Area
ELCR = excess lifetime cancer risk
WMA = Waste Management Area

Figure 3-2. Exposure Areas with Unacceptable Risks under CERCLA Residential Receptor Scenario.



CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
EA = Exposure Area ELCR = excess lifetime cancer risk WMA = Waste Management Area

In the CMS, supplemental HHRAs were also performed for the soil contamination associated with surface releases within WMA C based on the CERCLA industrial worker exposure scenario, assuming no soil cover. The radiological ELCR for surface releases is less than EPA's target risk threshold of 10^{-4}. No nonradiological risk and hazard contributors were identified for the surface releases.

In the CMS, a supplemental HHRA was also performed based on the CERCLA industrial worker scenario for the soil contamination associated with past discharges to the 216-C-8 French drain by assuming no cover condition and a 0.1-m (4-in.) concrete cover condition. Under no cover condition, the radiological ELCRs for all UPRs are greater than EPA's target risk threshold of 10^{-4}. Under a 0.1-m concrete cover condition, the radiological ELCRs are within EPA's acceptable target risk range of 10^{-4} to 10^{-6}. No nonradiological risk and hazard contributors were identified.

SLERA was evaluated through a three-tiered RA – generic screening, Tier 1 screening (for all contaminants) and Tier 2 (only for nonradiological contaminants) SLERA. The results of the Tier 1 screening for radiological contaminants identified a potential for ecological risk at EA P (only) and ^{90}Sr, ^{3}H and ^{137}Cs were retained as radiological contaminants of ecological concern. The results of the Tier 2 screening identified six nonradiological contaminants—boron, molybdenum, selenium, thallium, sulfate and Bis [2-ethylhexyl] phthalate—as ecological concerns.

Assessments referred to as the "protection of groundwater pathway" were performed using a statistical-based approach and a sample-by-sample approach as part of the WMA C RA to understand the potential impacts to groundwater from migration of nonradiological contaminants in contaminated soil through the vadose zone to the aquifer. Soil samples collected from both shallow zone (0 to 15 ft bgs) and deep vadose zone (>15 ft bgs) were utilized to perform the assessment for protection of groundwater pathway. The results of the protection of groundwater pathway assessment based on a statistical approach retained two COPCs: cadmium and beta-BHC. The results of the protection of groundwater pathway assessment based on a sample-by-sample approach retained five COPCs: arsenic, cadmium, hexavalent chromium, thallium and beta-BHC. It should be noted that hexavalent chromium was not measured during site characterization. The reported sample results for total chromium were assumed to be present only as hexavalent chromium during the data evaluation. Additionally, screening value for thallium was used for screening purposes and should not be used as cleanup level.

Examination of other constituents—nitrate and sulfate—show that groundwater has been impacted by a combination of upgradient and tank farm sources. Because of the potential impacts from nitrate in past releases to exceed DWS at WMA C, nitrate is also retained as a COPC for further evaluation.

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4.0 HUMAN HEALTH AND ENVIRONMENTAL IMPACTS FROM TANK WASTE RESIDUALS LEFT IN TANKS AND ANCILLARY EQUIPMENT LEFT IN A CLOSED WASTE MANAGEMENT AREA C

Closure of the individual SSTs and WMA C in its entirety occurs in three major steps: 1) SST waste retrieval, 2) filling the tanks with grout for stabilization, and 3) surface cover barrier placement. The final state of a tank farm that is considered in the PA is therefore a set of grouted tanks with associated ancillary equipment containing residual wastes that remain at the end of retrieval, covered by a modified RCRA Subtitle C surface cover, residing in the native geological setting.

Two regulations apply to the closed end state of the WMA as input to the IPA: 1) DOE O 435.1 contains regulatory requirements relevant to radioactive materials left in tanks and ancillary equipment pursuant to the *Atomic Energy Act of 1954*, and 2) WAC 173-340, "Model Toxics Control Act—Cleanup" (as implemented in the *Model Toxics Control Act* [MTCA] [*Revised Code of Washington* 70.105D, "Hazardous Waste Cleanup—Model Toxics Control Act"] and RCRA) contain regulatory requirements for hazardous materials. Application of the requirements of these two regulations is intended to provide assurance that the closed WMA will be protective of human health and the environment in the long-term future. The two regulations take somewhat different approaches to providing this assurance, and have distinct and different technical requirements for the analysis of performance; as a result, DOE has elected to address the regulatory requirements in the following two separate documents.

1) **Hazardous Chemical Impacts Analysis –** The hazardous chemical impact analysis provides an evaluation of hazardous chemicals and dangerous waste contaminant impacts from tank waste residuals left in tanks and ancillary equipment at a closed WMA C, and represents an input to the RCRA regulatory process. This component of the IPA is documented in RPP-ENV-58806.

2) **DOE O 435.1 Performance Assessment –** The PA provides an evaluation of radioactive residual waste contaminants in tanks and ancillary equipment at the closed WMA C. The PA is required by DOE O 435.1 for closing DOE-operated facilities that will manage radioactive waste generated during departmental activities as low-level waste. This component of the IPA is documented in RPP-ENV-58782.

Key Findings from Hazardous Chemical Impacts Analysis:

- The analysis results indicate that the regulatory standards for groundwater protection (i.e., target risk, hazard quotients/indices, and groundwater maximum contaminant levels/cleanup levels) are not exceeded for the entire period of analysis (see Table 4-1).
- For all of the sensitivity analyses evaluated, the disposal system also met these same standards.

Table 4-1. Comparison of Waste Management Area C Hazardous Chemical Impact Analysis with Regulatory Standards (Target Risk, Hazard Index/Quotient, and Federal and State Maximum Contaminant Levels/2007 Model Toxics Control Act Method B Groundwater Cleanup Levels) for Period of Analysis.

Exposure Scenario	Regulatory Standards		Period of Analysis (0 to 10,000 years post-closure)
Tap Water (Resident) Scenario	**Hazardous Chemicals**		
	Target Risk Level[b]	1E-6	—
	Hazardous Quotient	1	3.7E-02 (Nitrite) 1.8E-02 (Fluoride) 7.6E-3 (Nitrate)
	Cumulative Risk Level[b]	1E-5	—
	Hazard Index	1	0.069
	Radionuclides		
	Target Risk Range	1E-6 to 1E-4	1.58E-06 (primarily for ^{99}Tc)[c]

Exposure Scenario	Federal and State Maximum Contaminant Level 2007 Model Toxics Control Act Groundwater Cleanup Levels			
Groundwater Protection	**Contaminant of Potential Concern**	**Federal and State[d] Maximum Contaminant Level (μg/L)**	**2007 Model Toxics Control Act B Groundwater Cleanup Levels[e] (μg/L)**	**Concentration (μg/L)[a]**
	Chromium, Total	100	24,000	4.9E-01
	Chromium VI	—	48	4.9E-01
	Cobalt	—	4.8	4.7E-05
	Cyanide	200	4.8	1.4E-02
	Fluoride	4,000	960	2.3E+01
	Nitrate	45,000	113,600	2.4E+02
	Nitrite	4,500	4,800	7.5E+01
	Selenium	50	80	1.8E-03
	Tin	—	9,600	1.3E-06
	Uranium, Total	30[f]	48	4.9E-02

[a] The point of highest projected concentration beyond a 100-meter buffer zone surrounding the disposed waste.

[b] Peak target and cumulative chemical cancer risk is not presented because carcinogenic chemicals were not found to arrive at any of the points of calculation during the 10,000-year period of analysis.

[c] Peak total risk is primarily from ^{99}Tc; peak risk from all other individual radionuclides evaluated were found to be less than 2.4E-08 during the 10,000-year period of analysis.

[d] *Washington Administrative Code* 246-290-310, "Maximum Contaminant Levels (MCLs) and Maximum Residual Disinfectant Levels (MRDLs)."

[e] ECF-100NPL-10-0462, Rev. 2, *Calculation of Standard Method B Groundwater Cleanup Levels for Potable Groundwater for the 100 Areas and 300 Area Remedial Investigation/Feasibility Study Reports.*

[f] 40 CFR 141, "National Primary Drinking Regulations" criteria.

MTCA = Washington State Model Toxics Control Act RCRA = *Resource Conservation and Recovery Act of 1976*

These documents represent different and complementary evaluations of the performance of the system in the post-closure period. The technical approaches in the two analyses are generally consistent, but differ in regards to addressing specific regulatory requirements. Exposure pathways and risk assumptions differ for the two analyses, and the required regulatory reviews for the two analyses are conducted by different regulators using different regulatory processes.

The PA and hazardous chemical impacts analysis carry out technical evaluations of the safety concept of a closed WMA C disposal system. The safety concept for this system is composed of a set of safety functions of manmade as well as natural components that act together to provide the long-term performance of a closed facility required in closure regulations. The safety functions represent multiple and redundant barriers, so that the loss of one or some of the safety functions continues to result in adequate performance of the overall system. A schematic depiction of these safety functions for the closed WMA C is provided in Figure 4-1. The manmade components of the system that influence contaminant migration include a closure surface barrier, and the distribution of waste in the subsurface tanks and ancillary equipment. The natural components of the system that influence contaminant migration are the several underlying, nearly-horizontal stratigraphic layers within the vadose zone and the unconfined aquifer.

Key Findings from DOE O 435.1 Performance Assessment:

- The PA results indicate that the performance objectives and measures for the all-pathways dose, the air pathway dose, the radon flux, groundwater protection, and inadvertent intrusion are met for both the 1,000-year compliance time period (2020 to 3020) and the post-compliance period (3020 to 12020) (see Table 4-2).
- For all of the sensitivity analyses and uncertainty analyses evaluated, the disposal system met the performance objectives.

The WMA C PA has been structured to evaluate the behavior of the closed tank farm under a variety of potential future conditions. An analysis case has been defined in which the safety functions evolve in a nominal manner without unusual behavior or unanticipated disruption: this is termed the "base case." The nominal assumptions are a blend of assumptions representing the expected behavior of the safety functions, and several that have a conservative bias. The base case is the main analysis used to compare against the performance objectives, but is not the sole analysis for such comparisons. In addition, a set of deterministic sensitivity analyses have been conducted that show the effects when the safety functions are degraded compared to their expected behavior as defined in the base case. The specific safety functions examined in this way relate to the various physical components of the disposal system that included model evaluations of groundwater impacts with the following:

- Higher-than-expected infiltration rates; these may be the result of a number of potential effects, ranging from unexpectedly poor performance of the cover, through changes in land use with irrigation on top of the facility

- Changes in the effectiveness of the tanks and infill grout to act as barriers, by assuming that the hydraulic conductivity of the tanks increases at times earlier than expected
- Changes in the leachability of the residual wastes, by assuming that the material would dissolve instantly and completely upon contact with water
- Bounding inventories for unretrieved tanks
- Alternative conceptualizations of the stratigraphy of the vadose zone
- Alternative assumptions about dilution in the aquifer.

In addition to these deterministic analyses of the effect of the safety functions, a probabilistic analysis of the base case was conducted in the PA to show the effects of parameter uncertainty on the performance of the system. A number of parameters were assigned probability density functions, the PA was run probabilistically, and uncertainty estimates in dose were evaluated. As discussed above, such analyses were not included in the hazardous chemical impact analysis, owing to its differing regulatory requirements.

The hazardous chemical impact analysis results indicate that regulatory standards (i.e., target risk, hazard quotients/indices, and groundwater maximum contaminant levels/cleanup levels) were not exceeded for the entire period of analysis (see Table 4-1). For all of the sensitivity analyses evaluated, the disposal system also met these same standards. Similarly, the PA results indicate that the performance objectives and measures for the all-pathways dose, the air pathway dose, the radon flux, groundwater protection, and inadvertent intruder are met for both the 1,000-year compliance time period (2020 to 3020) and the post-compliance period (3020 to 12020) (see Table 4-2). For all of the sensitivity analyses and uncertainty analyses evaluated, the disposal system met the performance objectives.

These results demonstrate the robustness of the PA and hazardous chemical impact analysis to alternative assumptions with respect to the behavior of the safety functions and input parameters. There is therefore high confidence that the closed disposal system meets all relevant regulatory requirements in the post-closure period.

Figure 4-1. A Schematic Depiction of the Safety Functions for a Closed Waste Management Area C.

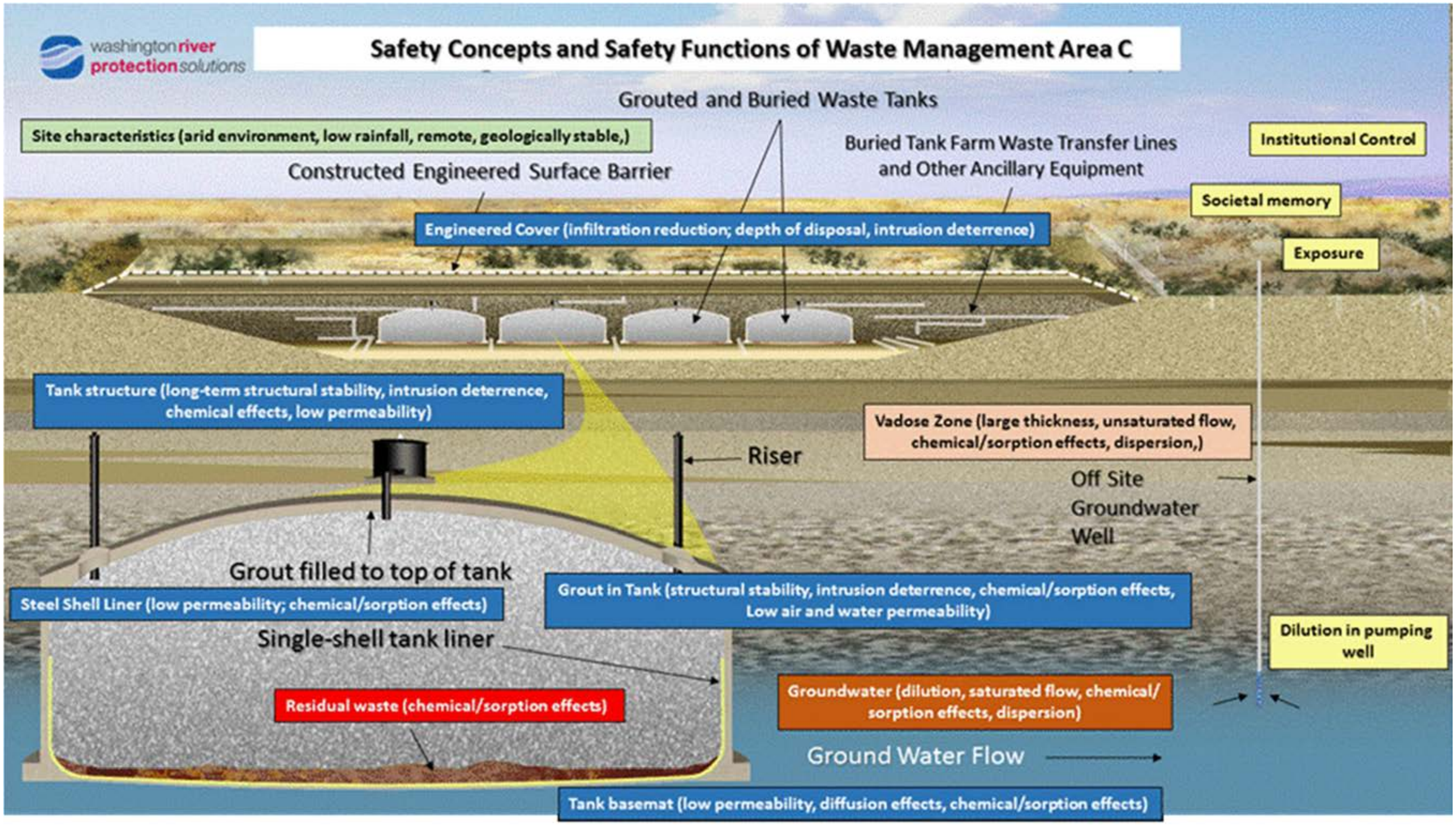


Table 4-2. Comparison of Performance Objectives and Measures with the Waste Management Area C Performance Assessment Results for the Compliance and Post-Compliance Periods.

Performance Objective and/or Measure	**Standard**	**Performance Assessment Results**	
		Compliance Period (2020–3020)[a]	**Post-Compliance Period (3020–12020)[a]**
All Pathways (DOE O 435.1 Chg 1)	25 mrem/yr EDE	4E-3 mrem/yr	0.1 mrem/yr
Atmospheric (40 CFR 61, Subpart H)	10 mrem/yr EDE	4E-3 mrem/yr	2E-5 mrem/yr
Atmospheric (40 CFR 61, Subpart Q)	20 $pCi.m^{-2}.s^{-1}$ radon flux (at surface of disposal facility)	2E-4 $pCi.m^{-2}.s^{-1}$	7E-3 $pCi.m^{-2}.s^{-1}$
Acute Inadvertent Intruder (DOE O 435.1 Chg 1)	500 mrem EDE[b]	0.65 mrem	—
Chronic Inadvertent Intruder (DOE O 435.1 Chg 1)	100 mrem/yr EDE[b]	0.2 mrem/yr[f]	—
Groundwater Protection (water resources) (40 CFR 141)	Beta-gamma dose equivalent ≤ 4 mrem/yr	5E-4 mrem/yr	0.13 mrem/yr[c]
	Gross alpha activity concentration (excluding radon and uranium) ≤ 15 pCi/L	0 pCi/L	1E-10 pCi/L[d]
	Combined Ra-226 and Ra-228 concentration ≤ 5 pCi/L	0 pCi/L	7E-7 pCi/L[d]
	Uranium concentration ≤ 30 µg/L	0 µg/L	0.05 µg /L[d]
	Sr-90 concentration ≤ 8 pCi/L[e]	Not applicable	Not applicable
	H-3 concentration ≤ 20,000 pCi/L	0 pCi/L	1E-10 pCi/L[d]

[a] Compliance at 100 m downgradient of Waste Management Area C except for inadvertent intruder scenarios.

[b] Not applicable for post-compliance time period.

[c] Beta-gamma dose equivalent ≤ 4 mrem/yr (based on Federal MCL) and calculated as (C_{Peak}/MCL) × 4 mrem/yr. For Tc-99, which contributes almost the entire dose, C_{Peak} = 731 pCi/L and MCL = 900 pCi/L, so the equivalent dose is calculated to be 3.3 mrem/yr.

[d] Concentrations less than 1E-10 pCi/L are essentially zero.

[e] Not applicable; Sr-90 was screened out during evaluation of the groundwater pathway due to its relatively short half-life and its low mobility in the subsurface.

[f] Peak dose based on assumed inadvertent intrusion into a waste transfer line at an assumed loss of institutional control in Year 2278 using a rural pasture exposure scenario. Peak dose occurs at the assumed loss of institutional control in Year 2278.

EDE = effective dose equivalent MCL = maximum contaminant level

References:

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, *Code of Federal Regulations*, as amended.

40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," Subpart Q—National Emission Standards for Radon Emissions From Department of Energy Facilities, *Code of Federal Regulations*, as amended.

40 CFR 141, "National Primary Drinking Water Regulations," *Code of Federal Regulations*, as amended.

DOE O 435.1, 2001, *Radioactive Waste Management*, Change 1, U.S. Department of Energy, Washington, D.C.

5.0 INTEGRATION WITH RESULTS FROM 200-BP-5 GROUNDWATER OPERABLE UNIT REMEDIAL INVESTIGATION (DOE/RL-2009-127, DRAFT A)

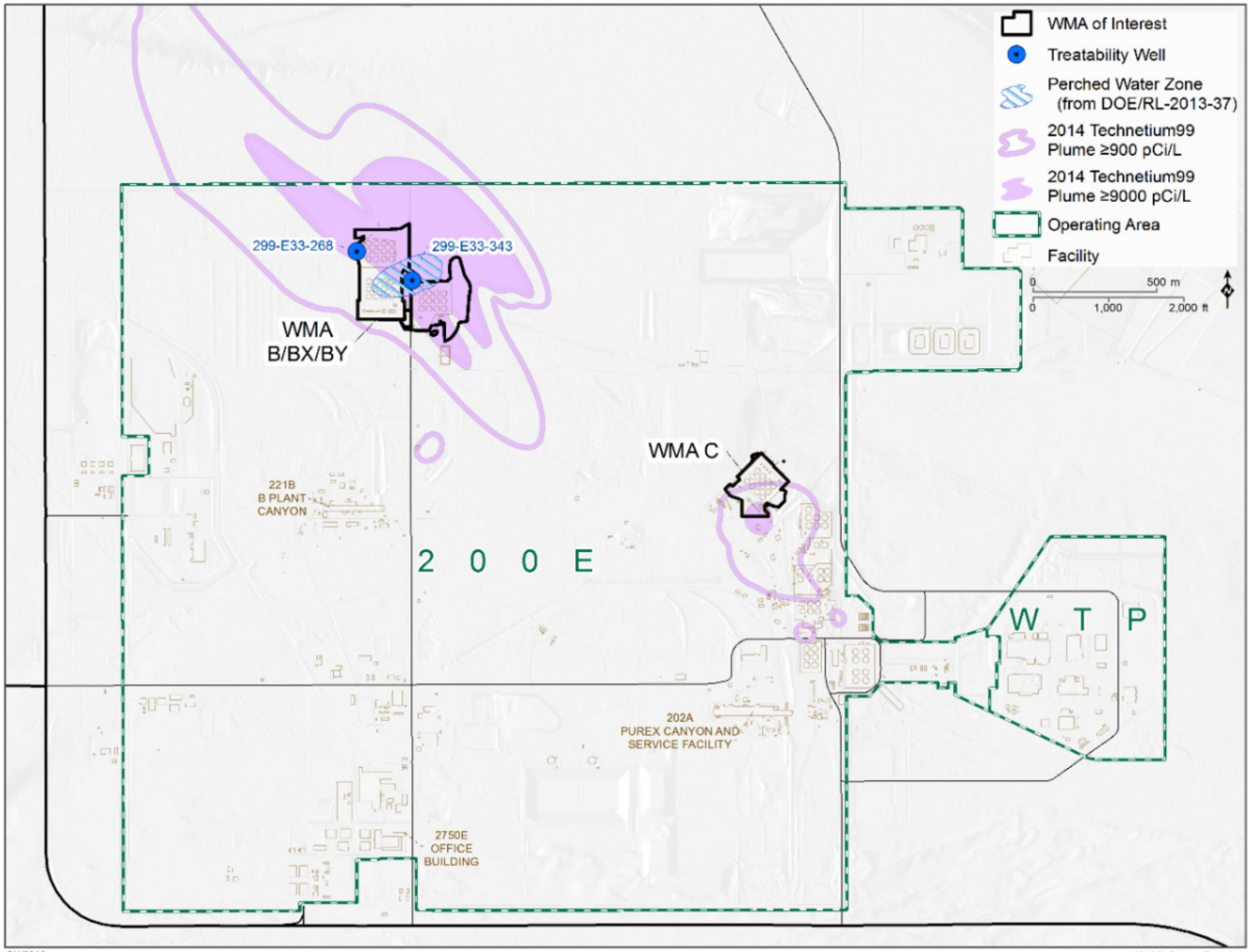
The groundwater under WMA C is part of CERCLA OU 200-BP-5, since it has received contamination from a number of sources within the Central Plateau, including sources in the B Complex (which includes WMA B-BX-BY) as well as WMA C. Therefore, investigations and evaluations associated with the 200-BP-5 OU provide a general context for contamination at WMA C. DOE submitted the 200-BP-5 RI Report (DOE/RL-2009-127, Draft A) for review by the regulatory agencies in August 2015. The RI was prepared in accordance with the RI Work Plan (DOE/RL-2007-18). The RI provides information about the conceptual site model, nature and extent of contamination, BRA, and contaminant fate and transport in 200-BP-5. Conclusions from the RI report include demonstration of basis for action (DWSs and risk thresholds are currently exceeded and are expected to stay exceeded for a long time) and identification of COPCs (those that should be targeted for remediation or monitoring) at different interest areas within the groundwater aquifer. Figure 5-1 shows some of the major groundwater elements around WMA C.

Key Findings from 200-BP-5 Remedial Investigation:

- Cancer risks downgradient from WMA C are predominantly associated with ^{99}Tc.
- Upgradient wells are dominated by the presence of ^{129}I, but the groundwater concentration levels are not sufficiently elevated to exceed the EPA upper risk threshold value.
- Cyanide is the major driver for non-carcinogenic adverse health.
- In addition to ^{99}Tc, ^{129}I, and cyanide, other groundwater COPCs at WMA C include nitrate and sulfate.

Chapter 4 in the 200-BP-5 RI (DOE/RL-2009-127, Draft A) describes the current distribution of contaminants in the 200-BP-5 OU, including a discussion of groundwater contaminant sources. A discussion of the nature and extent of contamination in this chapter addresses the ten COPCs identified in Section 4.5 and Chapter 6: ^{137}Cs, cyanide, Cr(VI), ^{129}I, nitrate, $^{239/240}$Pu, ^{90}Sr, ^{99}Tc, tritium, and uranium. This chapter also describes five contaminants and indicators that are recommended for monitoring: arsenic, ^{60}Co, fluoride, gross alpha, and sulfate. The most widely distributed COPCs exceeding DWSs within the OU are nitrate, ^{99}Tc, and ^{129}I. Waste Management Area C is identified as one of the sources of contamination that has already impacted groundwater. Additional analysis of contaminant fate and transport (Chapter 5) concludes that contamination sources will continue to impact groundwater under WMA C for years or decades. However, the contamination sources within WMA C are significantly smaller than sources upgradient at the B Complex area, which includes SSTs as well as liquid waste discharge facilities known as the BY Cribs.

Figure 5-1. Waste Management Area C, B Complex, Existing Technetium-99 Groundwater Contamination, and Perched Water Area.



WMA = Waste Management Area WTP = Waste Treatment Plant

Reference: DOE/RL-2013-37, *Engineering Evaluation/Cost Analysis for Perched Water Pumping/Pore Water Extraction*.

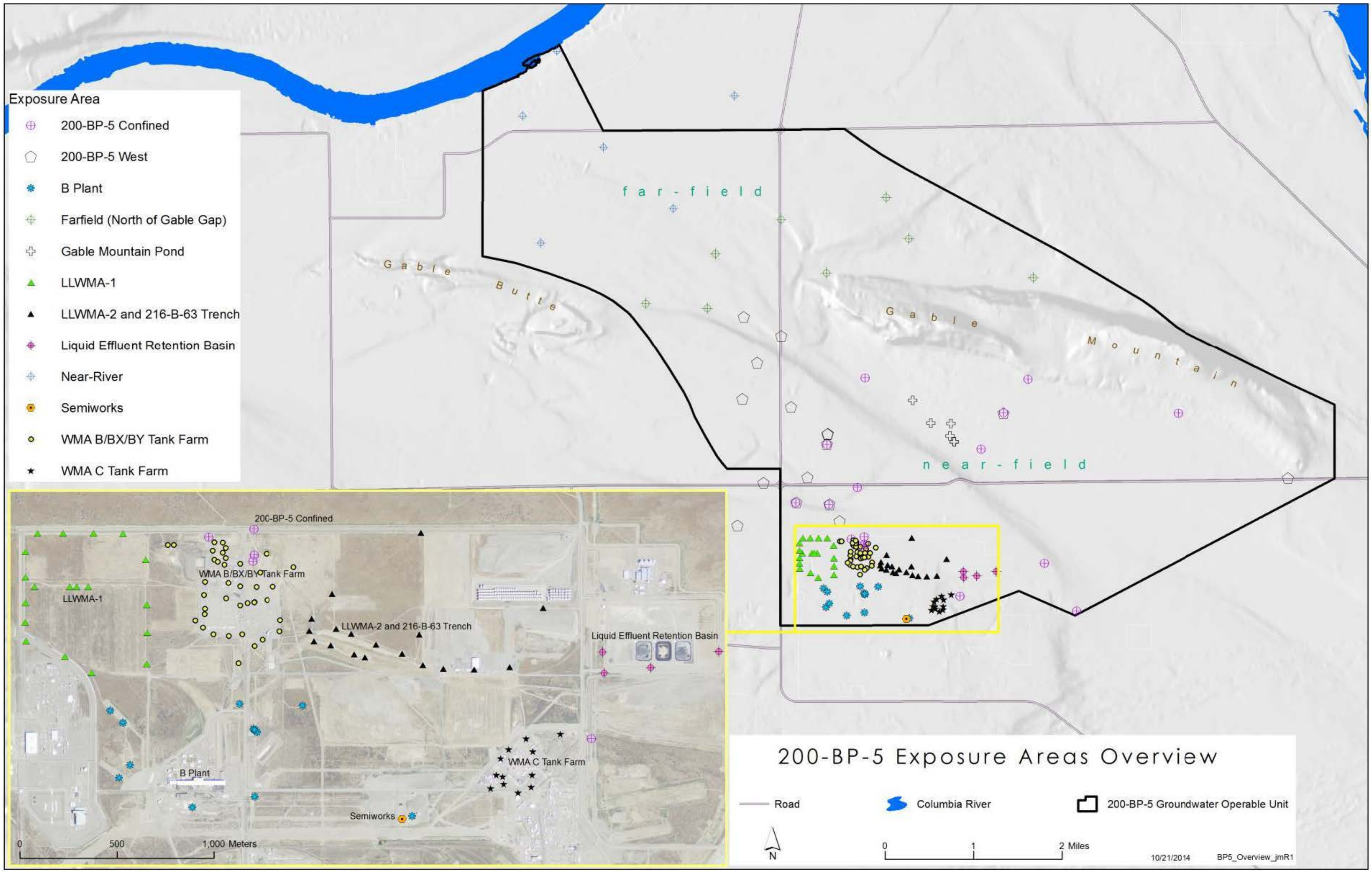
The 200-BP-5 BRA (Chapter 6, DOE/RL-2009-127, Draft A) provided risk characterization results for 12 distinct areas within the OU, with WMA C as one of those areas. Figure 5-2 shows the EAs identified within the 200-BP-5 OU.

Table 5-1 (adapted from Table 4-8 in the 200-BP-5 RI) provides a high-level summary of the nature and extent of contamination in the groundwater aquifer. The table shows the different areas identified within the 200-BP-5 OU, including WMA C. This analysis concluded that cyanide, ^{129}I, nitrate, ^{99}Tc, and sulfate are COPCs in groundwater in the vicinity of WMA C.

The risk characterization results for groundwater in the vicinity of WMA C indicate that total ELCRs were greater than the EPA upper risk threshold of 1×10^{-4}. Furthermore, the hazard index (which evaluates non-carcinogenic adverse health effects) also exceeds the EPA upper threshold of one.

Figures 5-3 and 5-4 (Figures H-28 and H-29, respectively, in the 200-BP-5 RI) show a summary of the risk characterization results for a number of upgradient and downgradient groundwater wells in the vicinity of WMA C. Similar graphics are provided for other areas within the 200-BP-5 OU. The results show that cancer risks downgradient from WMA C are mostly driven by the presence of ^{99}Tc. Upgradient wells are dominated by the presence of ^{129}I, but the groundwater concentration levels are not sufficiently elevated to exceed the EPA upper risk threshold value. For non-carcinogenic adverse health effects, the major driver downgradient from WMA C is cyanide. In the upgradient well, arsenic is the driver but the measured concentrations values are within background limits.

Figure 5-2. Exposure Areas and Associated Monitoring Wells for the 200-BP-5 Operable Unit.



LLWMA = Low-Level Waste Management Area WMA = Waste Management Area

Table 5-1. Summary of 200-BP-5 Operable Unit Evaluation of Measured Groundwater Concentrations.

Retained as a COPC	Retained as a COPC for Monitoring
Low-Level Waste Management Area-1	
Cyanide, iodine-129, nitrate, technetium-99, tritium, and uranium	Gross alpha*
Low-Level Waste Management Area-2	
Cyanide, iodine-129, nitrate, technetium-99, tritium, and uranium	Sulfate
Waste Management Area B-BX-BY Tank Farms and 216-B-63 Trench	
Cyanide, Cr(VI), iodine-129, nitrate, technetium-99, tritium, and uranium	Arsenic, cobalt-60, gross alpha,* and sulfate
Waste Management Area C Tank Farm	
Cyanide, Iodine-129, nitrate, and technetium-99	Sulfate
B Plant	
Cesium-137, cyanide, iodine-129, nitrate, plutonium-239/240, strontium-90, technetium-99, and uranium	Fluoride and gross alpha*
Semiworks	
Iodine-129	None identified
Liquid Effluent Retention Facility	
Nitrate	Sulfate
Gable Mountain Pond	
Nitrate and strontium-90	Sulfate
200-BP-5 West	
Cyanide, iodine-129, nitrate, and technetium-99	Strontium-90
200-BP-5 Far Field (North of Gable Gap)	
None identified	None identified
200-BP-5 Near River	
None identified	None identified
200-BP-5 Confined	
Cyanide, iodine-129, and technetium-99	None identified
Retained for Monitoring	
Based on evaluation of data collected from January 2008 through December 2013.	

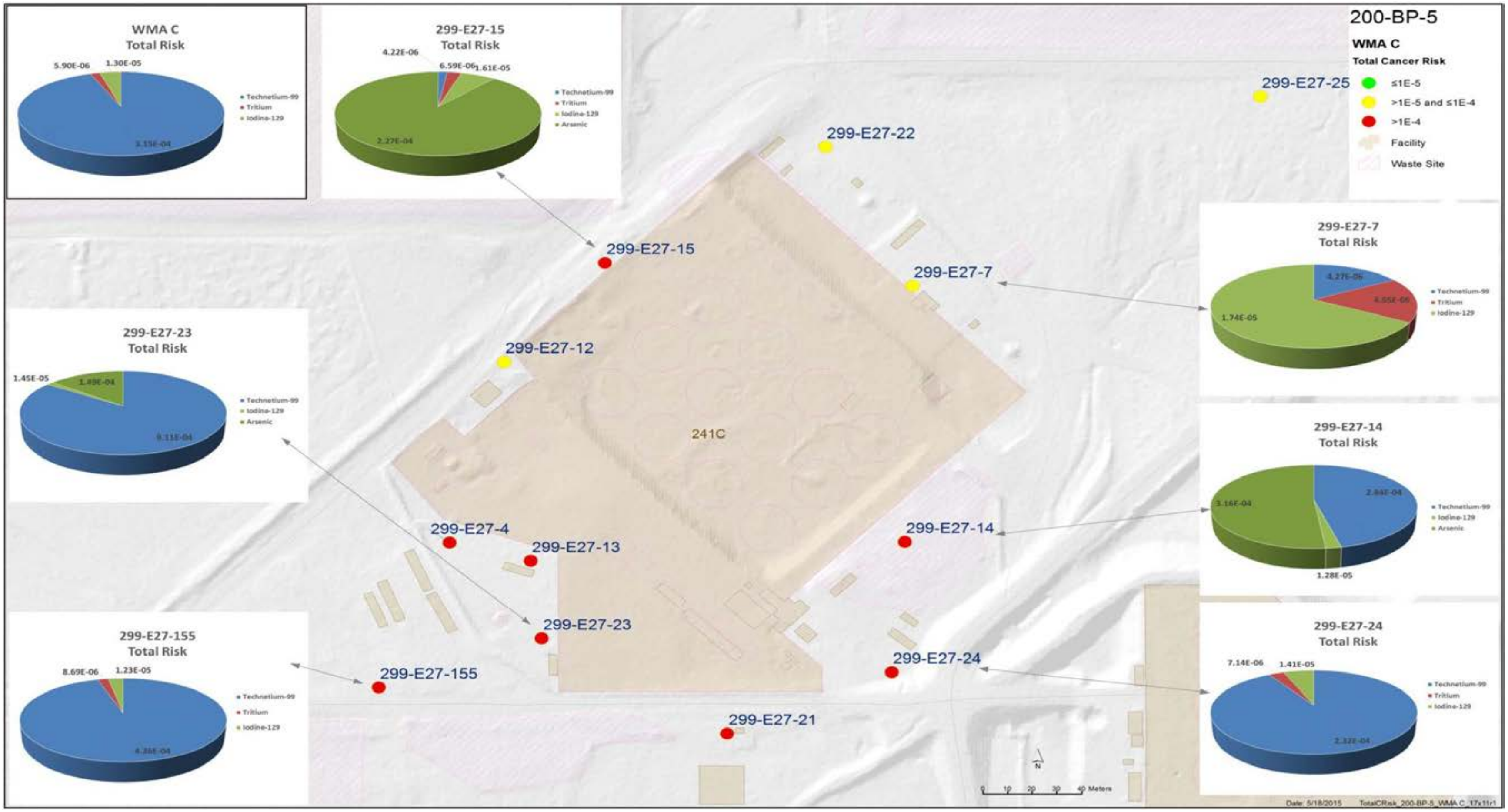
* Gross alpha is an indicator of the presence of uranium.

COPC = contaminant of potential concern

Cr(VI) = hexavalent chromium

Reference: DOE/RL-2009-127, *Remedial Investigation Report for the 200-BP-5 Groundwater Operable Unit*, Draft A, Table 4-8.

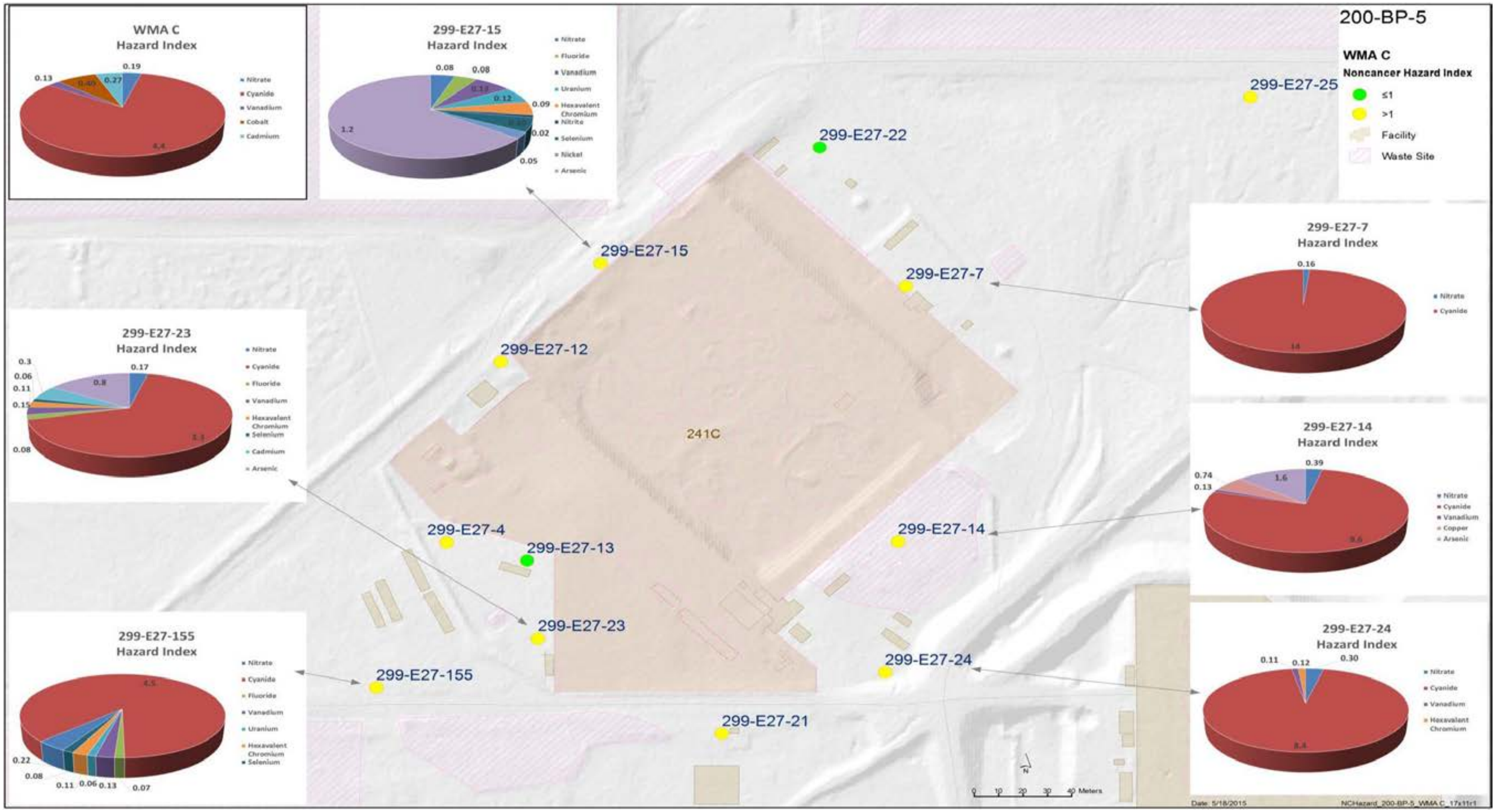
Figure 5-3. Cancer Risk Contributors for Wells Within the Waste Management Area C Exposure Area.



WMA = Waste Management Area

Source: DOE/RL-2009-127, *Remedial Investigation Report for the 200-BP-5 Groundwater Operable Unit*, Draft A, Figure H-28.

Figure 5-4. Non-Cancer Hazard Contributors for Wells Within the Waste Management Area C Exposure Area.



WMA = Waste Management Area

Source: DOE/RL-2009-127, *Remedial Investigation Report for the 200-BP-5 Groundwater Operable Unit*, Draft A, Figure H-29.

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6.0 REFERENCES

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RPP-RPT-59197, 2020, *Analysis of Impacts of Past Tank Waste Leaks and Losses in the Vicinity of Waste Management Area C at the Hanford Site, Southeast Washington*, Rev. 2, Washington River Protection Solutions, LLC, Richland, Washington.

RPP-RPT-59379, 2016, *Waste Management Area C Phase 2 Corrective Measures Study Report*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

RPP-RPT-61239, 2020, *Multiple Lines of Evidence and Modeling Results for Heterogeneous Alternative Conceptual Models of the Subsurface at Waste Management Area C*, Rev. 0, TecGeo, Inc./Pacific Northwest National Laboratory/INTERA, Inc./CH2M HILL Plateau Remediation Company/Washington River Protection Solutions, LLC, Richland, Washington.

WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code*, as amended.

WAC 173-340, "Model Toxics Control Act—Cleanup," *Washington Administrative Code*, as amended.

WAC 246-290-310, "Maximum Contaminant Levels (MCLs) and Maximum Residual Disinfectant Levels (MRDLs)," *Washington Administrative Code*, as amended.

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APPENDIX A

REVIEW COMMENT RECORD
WASTE MANAGEMENT AREA C
HFFACO APPENDIX I ANALYSES AND RELATED DOCUMENTATION

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LIST OF TERMS

3-D	three-dimensional
BRA	Baseline Risk Assessment
C Farm	WMA C Tank Farm
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	Code of Federal Regulations
CHPRC	CH2M HILL Plateau Remediation Company
CMS	corrective measures study
COPC	constituent of potential concern
CY	calendar year
DOE	U.S. Department of Energy
DOE-RL	U.S. Department of Energy, Richland Operations Office
Ecology	State of Washington Department of Ecology
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
FLTF	Field Lysimeter Test Facility
FS	Feasibility Study

FY	fiscal year
H2 unit	Hanford formation – sand sequence
HFFACO	*Hanford Federal Facility Agreement and Consent Order*
IAMIT	Interagency Management Integration Team
IDF	Integrated Disposal Facility
IPA	Appendix I Performance Assessment
MTCA	*Model Toxics Control Act*
NRC	U.S. Nuclear Regulatory Commission
ORP	(U.S. Department of Energy,) Office of River Protection
OU	operable unit
PA	performance assessment
PNNL	Pacific Northwest National Laboratory
RCA	RCRA Closure Analysis
RCRA	*Resource Conservation and Recovery Act of 1976*
RFI	RCRA facility investigation
RI	Remedial Investigation
ROD	Record of Decision
SST	single-shell tank
STOMP	Subsurface Transport Over Multiple Phases (computer code)
SWL	Solid Waste Landfill lysimeter
TC&WM EIS	Tank Closure and Waste Management Environmental Impact Statement
TPA	Tri-Party Agreement (*Hanford Federal Facility Agreement and Consent Order*)
TSD	treatment, storage or disposal
UPR	unplanned release
WAC	*Washington Administrative Code*
WFM	water flux meter
WMA	Waste Management Area
WRPS	Washington River Protection Solutions, LLC

A1.0 INTRODUCTION

This Appendix provides a review comment record for general comments received from the State of Washington Department of Ecology (Ecology) during their review of three of the four Waste Management Area (WMA) C *Hanford Federal Facility Agreement and Consent Order* (HFFACO, Ecology et al. 1989) Appendix Analyses and related documentation that include the following documents:

- RPP-RPT-58329, *Baseline Risk Assessment for Waste Management Area C*, Rev. 2
- 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*, Rev. 1
- RPP-ENV-58806, *RCRA Closure Analysis of Tank Waste Residuals Impacts at Waste Management Area C, Hanford Site, Washington*, Rev. 0.

The set of WMA C HFFACO Appendix I performance assessment analyses and documentation was provided to Ecology in October 2016. To facilitate Ecology's review, the U.S. Department of Energy (DOE) provided a briefing to Ecology staff on an overview of the HFFACO Appendix I analyses and documentation and separate briefings of these specific analysis and documents on October 26, November 19, November 22 and December 12 of 2016.

On July 14, 2017, Ecology provided DOE comments on all of the HFFACO Appendix I analyses and documentation to DOE [Letter 17-NWP-085, "Re: Department of Ecology's (Ecology) Review and Comments of Appendix 1 Performance Assessment for Waste Management Area C (WMA C) Documents"]. In October 2017, the DOE Office of River Protection (ORP) entered into a comment resolution process with Ecology staff to address all of the analyses and related documents. This process involved well over 100 individual meetings with Ecology staff that continued until August 2020. ORP provided a response to each comment provided by Ecology and was able to reach agreement on a large majority of the comments. Although secondary documents are normally not subject to dispute resolution, ORP worked closely and in good faith with Ecology to reach agreements on some key technical issues that were resolved with documented Interagency Management Integration Team determinations.

Table A-1. Review Comment Record From General Comments from State of Washington Department of Ecology from Review of the Waste Management Area C *Hanford Federal Facility Agreement and Consent Order* Appendix Performance Assessment Analyses and Documentation. (sheet 1 of 8)

TOC - REVIEW COMMENT RECORD (RCR)

1. Date: 10/13/2020	2. Review No.:	3. Project No.:	Page 1 of 1	
5. Document Number(s)/Title(s): General Comments from Washington State Department of Ecology from Review of the WMA C HFFACO Appendix PA Analyses and Documentation	6. Program/Project/Building Number: Waste Management Area C HFFACO Appendix I Performance Assessment	7. Reviewer: Lead Reviewer - Elizabeth Rochette	8. Organization/Group: Washington State Department of Ecology	9. Location/Phone: Richland, WA (509)372-7922

10. Agreement with Indicated Comment Disposition(s):

Reviewer/Point of Contact: Print First and Last Name; Signature; Date

Author/Originator: Print First and Last Name; Signature; Date

11. CLOSED:

Reviewer/Point of Contact: Print First and Last Name; Signature; Date

Author/Originator: Print First and Last Name; Signature; Date

17. Comment Submittal Approval::

Organization Manager *(Optional)*: Print First and Last Name; Signature; Date

12. Item	13a. Comments	13b. Basis/Category	13c. Recommendation	14. Reviewer Concurrence Yes	14. Reviewer Concurrence No	15. Disposition *(provide justification if **NOT** accepted)*	16. Status
				○	○		

A-6005-747 (REV 4)

Table A-1. Review Comment Record From General Comments from State of Washington Department of Ecology from Review of the Waste Management Area C *Hanford Federal Facility Agreement and Consent Order* Appendix Performance Assessment Analyses and Documentation. (sheet 2 of 8)

Comment Number	Location	Comment	Basis	Recommendation	Final Disposition
G1	General	At least one of the PA documents must include a section showing how the vadose zone fate and transport model meets the requirements of WAC 173-340-747(8) for alternative fate and transport models. All documents that do not contain the WAC 173-340-747(8) compliance section should reference the document that does contain the WAC 173-340-747(8) compliance demonstration section.	If the WAC 173-340 criteria are not met this modeling cannot be used to develop soil concentrations protective of groundwater for this unit.	Provide a point by point comparison of this modeling against the requirements of WAC 173-340-747(8) for WMA C in this IPA. Citing demonstrations developed for other units without a specific comparison for this unit is not sufficient to show compliance for this unit.	The site-specific flow and transport used in the evaluation of the impacts of landfill closure at WMA C is not used to derive soil cleanup levels protective of groundwater and, as such, the review of alternative models using the regulatory framework and related criteria outlined in WAC 173-340-747 do not specifically apply. However, in the spirit of cooperation with and to support Ecology's review of this modeling effort, a crosswalk will be provided that will be generally consistent with responding to criteria defined in WAC 173-340-747(8) for use of alternative fate and transport models to standard methods used to establish soil cleanup levels protective of groundwater. The draft cross walk currently provided in Appendix D of RPP-ENV-58806 will be expanded to respond to all criteria. Each of the criteria will be listed in tabular form with a simple response, followed by an explanation, justification, and cross reference to where the information is found elsewhere in the main document that summarizes the technical approach and results for the impact analysis of landfill closure at WMA C. The focus of this crosswalk will be on the key assumptions and parameterization used in this site-specific flow and transport model as well as the demonstration of the suitability of the STOMP code itself for use in this analysis.
G2	General	So many documents are cited in this IPA. It would be very helpful to have these as hot links to the specific document and/or to state exactly where in the referenced document the citation can be found. A useful search engine would also be very useful. Also, this entire four volume tome needs a good technical edit to eliminate typos and reduce inconsistencies.	—	Please consider.	Currently, all major references in the IPA documents have been uploaded to the WMA C part of the WRPS PA-related website at: http://wirtest2.wpengine.com/. The majority of references can be found in the "General Reference" part of the "Library" pull-down menu on the upper right side of the WMA C PA home page. All of the IPA documents including the supporting data packages and environmental model calculation files can be found by clicking directly on the "Library" link. If a particular reference has not been uploaded to this web site, we would be glad to provide any additional reference as requested by Ecology. On the last part of the comment, if specific information on typos and inconsistencies can be provided, we would be glad to rectify these issues in updated versions of all of the IPA documentation.
G3	General	There is no clear and complete presentation of any topic in any one document. Rather, there is a complex system of referencing back to other volumes in this four volume set that complicates understanding of this PA. This will lengthen Ecology's review and make understanding by stakeholders and public that much more difficult.	—	Please correct.	We do not intend to make comment resolution and the timely release of the WMA C IPA documents contingent on having a discussion with Ecology on the format of the Appendix I set of analyses that will be conducted at WMA A-AX.
G4	General	The term "groundwater flux" is used throughout but not clearly defined as to whether you mean movement of contaminants from the vadose zone to groundwater or something else.	—	Please clarify throughout these four volumes.	See response to PLG-8 related to review of RPP-RPT-59197.
G5	General, RPP-RPT-59625, Rev. 1, ii, 2nd bullet and pg.2-5, 5th bullet and others	One of the key findings of the numerical modeling is that "Analysis of future impacts shows that concentration levels of Tc-99 are at or near their peak values and are expected to decline over the next few decades". This conclusion seems to be contradicted by increasing trends of measured concentrations of $^{Tc-99}$ in wells 299-E27-21 and 299-E27-13.	This conclusion seems to be contradicted by the measured concentrations of Tc-99 in well 299-E27-21, which exhibit an increasing trend since ~2008, with the rate of increase having risen sharply since ~2012 (see Figure 2-2). Figure 5-9 in RPP-RPT-59197 also shows an increasing trend of Tc-99 since 2013 in well 299-E27-13. Well 299-E27-21 is adjacent to the southern fence line. It is screened from the water table to 34 feet below the water table, while other monitoring wells at WMA C are screened only 15 feet below the water table. It is not apparent if the modeling addressed the difference in the screened depth in various wells.	Please address the apparent discrepancy between the conclusions based on numerical modeling and the measured concentrations of $^{Tc-99}$ in monitoring wells. A clear justification is needed before it can be concluded that "concentration levels of $^{Tc-99}$ are at or near their peak values and are expected to decline over the next few decades". Also please discuss how the modeling addressed the difference in the screened depth in various wells	See response to PL6-23 related to review of RPP-RPT-59197.

Table A-1. Review Comment Record From General Comments from State of Washington Department of Ecology from Review of the Waste Management Area C *Hanford Federal Facility Agreement and Consent Order* Appendix Performance Assessment Analyses and Documentation. (sheet 3 of 8)

Comment Number	Location	Comment	Basis	Recommendation	Final Disposition
G6	General	Define the area/volume and associated uncertainty of the impact from WMA C contamination to which this analysis applies, beyond DOE Order 435.1 boundaries. A RCRA TSD unit is the facility, the waste contained therein, and *all media* impacted by releases from the facility.	It's more than the area/volume within the perimeter fences which are a security construct to limit access. The WMA C for closure includes the structures and ancillary equipment within the perimeter fences as well as the full extent of contaminated media (soil and groundwater) impacted by releases from the facility. That closure WMA extends well past the perimeter fences. Additionally, the vadose inventory will continue to supply contaminants to groundwater well into the future. 200-BP-5 seems to solely address groundwater.	USDOE must describe the interface of WMA C with CERCLA OUs to include BP-5, EA-1, IS-1; all contamination from WMA C must be addressed. Please provide a clear definition of the area/volume and associated uncertainty of WMA C, including its full spatial extent so it is clear what the extent is for closure.	A synopsis document (RPP-RPT-59625, Rev. 0, *Synopsis of HFFACO Appendix I Performance Assessment for Waste Management Area C*) has been provided to give the broader context and the scope covered in each of the four IPA documents that have been submitted to Ecology for review. These impact analyses are not decision documents. They provided technical information that will be used in final closure decision plans and permit modification that will address the concerns raised in this comment.
G7	General	Ecology requests an analysis using an anisotropy ratio of 50:1, vertical to horizontal. We are interested in the lateral extent of contamination under these conditions.	This would be a simple variable to change and it could reveal in a general way how the presence of fine-grained units within coarse-grained units might affect the areal extent of contamination.	Include a sensitivity case with a vertical to horizontal anisotropy of 50:1. Show the distribution of contamination in this case.	Given the recent work we have completed at the request of Ecology on the effects of heterogeneity, we question whether this comment is still one for us to address. The scope of this requested case is included in the body of work that has already been completed.
G8	General	The point of assessment (given in RPP-RPT-58806, Section 2.2.1, p. 2-3, lines 27-40) (based on the NRC document NUREG-1854, and stated to be "also consistent with the requirements for points of assessment in DOE O 435.1 performance assessment of radiological impacts") is downgradient from the WAC 173-340-720(8)(a) and (b) standard point of compliance. For RCRA it will be necessary to show protectiveness that is consistent with WAC 173-303-610 and the WAC sections it references.	WAC 173-340-720(8)(b): "The standard point of compliance shall be established throughout the site from the uppermost level of the saturated zone extending vertically to the lowest most depth which could potentially be affected by the site."	Conditional points of compliance must be negotiated with Ecology (see WAC 173-340-720(8)(c) and (d)).	This past leaks analysis cited is a general evaluation of future impacts from selected radiological and hazardous chemicals and dangerous waste contaminants associated with past leaks and losses at WMA C. Thus, some limited information changes in concentrations of some constituents is provided at both the fence line and 100 m downgradient of WMA C. It is not meant to provide a comprehensive analysis to demonstrate regulatory compliance. This analysis of past leaks is intended to provide supporting information that could be relevant to the selection and specific implementation of groundwater mitigation measures being undertaken as a part of the CERCLA RI/FS effort in 200-BP-5-OU. Implementation of a pump and treat system to expedite the remediation of groundwater contaminant plumes at C Farm is under way under the 200 BR-5 OU RI/FS process. The timeline for this implementation is slated to be initiated in FY 2022. The preliminary evaluation and design of this specific pump and treat system at WMA C is currently using continuing sources of a number of contaminants developed under this past leaks analysis.

Table A-1. Review Comment Record From General Comments from State of Washington Department of Ecology from Review of the Waste Management Area C *Hanford Federal Facility Agreement and Consent Order* Appendix Performance Assessment Analyses and Documentation. (sheet 4 of 8)

Comment Number	Location	Comment	Basis	Recommendation	Final Disposition
G9	General	For groundwater and groundwater protection, Ecology will expect that all pathways given in WAC 173-340-720(4)(b), including protection of surface water beneficial uses, will be evaluated. Note that the EPA tap water evaluation is not a RCRA requirement.	The WAC 173-340 Sections 700-760 define the scenarios, parameters, points of compliance and equations necessary to meet WAC 173-303 requirements. Ecology will use all of this information in decision making.	Use WAC 174-340 methods to address groundwater risk assessment requirements for WAC 173-303. To be consistent with WAC 173-303-610(2)(b)(i), use WAC 173-340-700 through -760 methods to address groundwater risk for RCRA. Ecology can use the EPA tap water evaluation as supplemental information and an additional line of evidence.	This report evaluates all of the potentially complete exposure pathways associated with WMA C tank waste residuals. This RCRA closure analysis does provide a screening level comparison of tank waste residuals to WAC 173-340-747(4) as described in Appendix E. Additionally, the Baseline Risk Assessment performed for contaminated vadose zone sediments impacted by past leaks (RPP-RPT-58329) evaluated groundwater protection based on the fixed parameter three-phase partition model referenced in WAC 173-340-747 (4) to identify hazardous chemical COPCs for consideration in the RCRA facility investigation/corrective measures study at WMA C. Future groundwater concentrations for the point of assessment defined in Section 2.2.1 are compared to groundwater cleanup levels defined in WAC 173-340-720 for hazardous substances. Radiological contaminants and hazardous substances are both evaluated for the tap water scenario for comparison purposes. The surface water pathway is not a potentially complete exposure pathway for WMA C based on the defined point of assessment. However, potential risks from current groundwater contamination were evaluated in a separate BRA done to support the Remedial Investigation and Feasibility Study for the 200-BP-5 groundwater operable unit to identify CERCLA groundwater remedial actions (DOE/RL-2009-127 Rev. 0). This groundwater risk assessment evaluated the impacts to aquatic receptors from groundwater discharge to the Columbia River. The results of the ecological evaluation identified nitrate as a contaminant of potential ecological concern. The recent TPA agreement (IAMIT 2018-002) on the path forward for the 200-BP-5 Interim Record of Decisions addresses how groundwater under WMA C is evaluated. DOE believes this agreement provides a clear path forward that addresses Ecology's concerns about current and future groundwater risks at WMA C. In the RCRA Closure Analysis, we used the EPA tap water scenario to address the carcinogen risk impacts, which in this specific evaluation comes from only radionuclide releases from the closed facility. For consistency sake, the tap water scenario was also used in the evaluation of non-carcinogen hazard impacts. We could add the same impacts calculated based on WAC 173-340-720(4)(b) but the changes in estimated hazard impacts using this methodology would likely be similar to those estimated using the EPA tap water scenario. We disagree with Ecology's view on including an evaluation of protection of surface water uses as a part of this analyses. The RCA and the PA are focused on evaluating local-scale impacts and given the magnitude of estimated impacts from these analysis in vicinity of WMA C and distance to the nearest surface water, we believe that potential impacts to nearby surface water would not be significant and that an evaluation of protection of surface water is not warranted. In the RCRA Closure Analysis, as was done in the pipeline feasibility study, we provided comparisons of residual waste concentrations left in tanks and ancillary equipment to MTCA soil cleanup levels for direct contact and groundwater protection. The detailed comparison information is provided in Appendix E of the RCA. These results indicated that estimated concentrations of some dangerous waste constituents remaining in tanks and ancillary equipment were determined to be well above cleanup standards for direct contact per WAC 173-340 and for groundwater protection per WAC 173-340-747 default methodology. From these findings, we would conclude that actions associated with WMA C tanks and ancillary equipment are warranted to protect human health and the environment. The actions included in the ROD from the TC&WM EIS for SST WMAs including WMA C, which provide the basis for closure conditions assumed in the RCA and DOE Order 435.1 PA, assume the following actions will take place at closure: 1. Residual waste in tanks and ancillary equipment left in WMA C would be landfill closed; 2. All tanks would be filled with grout; 3. An engineered surface barrier is constructed over the site that meets the requirements of landfill closure under WAC 173-303, "Dangerous Waste Regulations" and DOE O 435.1; 4. The barrier and the associated post-closure maintenance, monitoring, and institutional controls ensure access to the site is restricted; and 5. The engineered barrier is designed to reduce infiltration by a factor of ten or more. Items 1 through 4 protect human health and the environment from the direct contact pathway considered under WAC 173-340 by limiting direct access to the residual wastes. Items 2 and 5 would protect the groundwater by limiting infiltration through the residual wastes left in tanks and in waste transfer lines. The key elements of this landfill closure condition for waste residuals includes some of the same closure measures recommended in the RFI/CMS for contaminated vadose zone soils which Ecology has already approved.

Table A-1. Review Comment Record From General Comments from State of Washington Department of Ecology from Review of the Waste Management Area C *Hanford Federal Facility Agreement and Consent Order* Appendix Performance Assessment Analyses and Documentation. (sheet 5 of 8)

Comment Number	Location	Comment	Basis	Recommendation	Final Disposition
G10	General	It is not clear that the average annual natural recharge rates have been developed using measurements of local monthly (or more frequent) recharge.	Winter precipitation is more effective at recharging groundwater than spring and summer precipitation because evapotranspiration rates are much lower in winter months than during spring and summer months. Local precipitation occurs largely during the winter.	Please include a section in the Past Leaks and/or the RCRA closure documents discussing how average annual natural recharge rates were developed. Deferring to literature, without providing a clear explanation in at least one of the PA documents, will not be sufficient.	Following text has been added to recharge section in RPP-ENV-58806: "Net infiltration rates applicable to WMA C are based on the type of surface vegetation assumed to be present inside and outside the WMA boundary and the number of years (i.e., duration) that the vegetation type is assumed to be present. Significant effort has gone into site-specific determinations of recharge rates across the Hanford Site based on data from lysimeter measurements over extended periods (20+ years) and chlorine isotopic measurements (Gee et al. 1992, PNNL-13033, PNNL-14744, Murphy et al. 1996, Gee et al. 2005a, Gee et al. 2005b, PNNL-16688, and PNNL-17841). These data have been compiled and summarized in terms of major baseline soil types and plant community (vegetation) that are relevant to the WMA C PA modeling for the following conditions: • No vegetation/Waste Management Area surface • No vegetation/Disturbed reworked surface • Grass vegetation/Waste Site surface • Modified RCRA C surface barrier • Mature shrub steppe (xerophyte) assemblage. The recharge rate estimate applicable to WMA surfaces with no vegetation is estimated to be 100 mm/yr [3.9 in.]. This estimate includes as its basis data collected from gravel-covered small tube lysimeters, gravel mulch lysimeters, and sandy gravel and gravel pit lysimeters at FLTF, and drainage rates observed through the prototype barrier gravel side slope during the first few years when there was little or no vegetation. The lysimeter and barrier side slope data include the effects of late fall and winter precipitation on water accumulation in the soil, namely that water received from that precipitation tends to remain in the soil until the soil drains or the temperatures warm and the water evaporates. The gravel-covered lysimeters allowed 48 and 59 percent of the precipitation applied to them during 1988-1989 to drain (Gee et al. 1992, Northwest Science, Vol. 66, No. 4, "Variations in Recharge at the Hanford Site"). With annual precipitation averaging 173 mm/yr, the percentages equate to 83 to 102 mm/yr of recharge (Gee et al. 1992). Drainage rates from the gravel mulch lysimeters at FLTF during the 20-year period from 1990 to 2010 averaged 84.4 and 317 mm/yr (49% and 77%) for the ambient and enhanced (tripled) precipitation treatments, respectively (PNNL-19945). Drainage from the sandy gravel pit lysimeter averaged 49.3 mm/yr from January 2006 to August 2009, and drainage from the 5/8-inch gravel pit lysimeter averaged 31.1 mm/yr from January 2006 to August 2009 (PNNL-19945). Annual drainage rates through the prototype barrier gravel side slope during the first few years of its existence measured between 52 mm/yr and 88 mm/yr (30% to 50% of the precipitation) (PNNL-14744). The recharge rate applicable to disturbed areas that are reworked such that vegetation does not grow is 63 mm/yr [2.5 in./yr]. The value of 63 mm/yr is based on lysimeter field data collected at the 300-N Lysimeter site near the 618-10 Burial Ground. The data collected there represent recharge measurements that approximate bare, coarse-grained surfaces. The lysimeter was constructed in 1978 and filled with Hanford formation sand, 96% of which was screened to a medium-grained size fraction containing less than one percent gravel (PNNL-16688). The lysimeter has remained essentially void of vegetation over its lifetime, and the surface of the lysimeter still appears to be very different from the surrounding surface soil (PNNL-16688). The recharge rate applicable to disturbed areas that have mostly grass vegetation, such as surface stabilized waste sites, is 22 mm/yr [0.9 in/yr]. There are no data for recharge in Hanford formation sediment surface stabilized with Hanford formation sand and seeded with grasses or shallow rooted plants. Analogue data range from 1 mm/yr to 48 mm/yr, so the estimate of 22 mm/yr represents close to the midpoints of the estimates. PNNL-14702 estimates the recharge in the eastern 200 East Area where Burbank loamy sand and Rupert sand existed prior to surface disturbances to be 26 mm/yr and 22 mm/yr, respectively. These estimates represent the assumption that cheatgrass would reduce bare surface recharge through Burbank loamy sand and Rupert sand included in PNNL-14702 by 50 percent. PNL-10285 (1995) infers recharge to have been 25.4 mm/yr at the Grass Site in the 300 Area, where cheatgrass and Sandberg's bluegrass cover Rupert sand, on the basis of water contents data collected from below the root zone from 1982 to 1990. Later, two water flux meters (WFMs), installed together during the mid-2000s at the Grass Site, measured 4.16 mm and 0.64 mm during the 4 ½ years from early 2005 to mid-2009 (i.e., less than 1 mm/yr, PNNL-18807). PNNL-18807 notes that it is uncertain whether the difference between the flux meter measurements was caused by natural measurement variation, variability in soil properties, or differences caused by installation or malfunction of the WFMs, and further indicates that both WFMs require operational verification. The Solid Waste Landfill lysimeter (SWL) was constructed in 1992 from nonorganic solid waste mixed with Hanford formation sands and gravels and covered by 0.5 m (1.6 ft) of sandy-gravel backfill material, which has since become populated with a sparse (~24%) cover of Indian Ricegrass (PNNL-16688 and PNNL-17841). From September 1996 to September 2010, the drainage has averaged 48.2 mm/yr. The recharge rate applicable to the post-closure surface barrier during its design life is assumed to be 0.5 mm/yr. This value represents the design specification contained in WHC-EP-0673. This value is consistent with the recharge estimate for the preferred alternative in DOH 320-031, *Final Environmental Impact Statement Commercial Low-Level Radioactive Waste Disposal Site Richland, Washington* and DOE/EIS-0391, *Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington* (TC & WM EIS). The value is greater than many other estimates of barrier performance: PNNL-16688 recommends a value of 0.1 mm/yr on the basis of field and modeling studies described within PNNL-14744, and the results of Hanford Barrier testing (PNNL-14143, *The Hanford Site 1000-Year Cap Design Test*).

Table A-1. Review Comment Record From General Comments from State of Washington Department of Ecology from Review of the Waste Management Area C *Hanford Federal Facility Agreement and Consent Order* Appendix Performance Assessment Analyses and Documentation. (sheet 6 of 8)

Comment Number	Location	Comment	Basis	Recommendation	Final Disposition
G10 continued	General	—	—	—	G10 Disposition (continued) The recharge rate applicable to undisturbed or revegetated areas with mature shrub steppe (xerophyte) assemblage or the surface barrier after its design life is assumed to be 3.5 mm/yr. This value exceeds most of the recommended values developed in other data packages for undisturbed areas, e.g., PNNL-16688 recommends 1.7 mm/yr and 1.9 mm/yr for Rupert sand and Burbank loamy sand, respectively, and PNNL-14744 recommends the value of 0.9 mm/yr for the Rupert and Burbank soil at the IDF site. PNNL-14702 recommends 0.9 mm/yr for Rupert Sand near the IDF and 5 mm/yr for Rupert Sand near the US Ecology site, and 3.0 mm/yr for Burbank loamy sand. After the design life of the surface barrier, the barrier performance is assumed to evolve into that of the undisturbed mature shrub steppe (xerophyte) assemblage. PNNL-14702, PNNL-14744, and PNNL-16688 indicate that no deterioration in barrier performance is expected to occur after the barrier's design life, and that the recharge rate should not change. Annual recharge estimates incorporate the effects of episodic infiltration events and spatial heterogeneity within individual soil types and surface conditions into a single steady-state value. Although infiltration is an inherently episodic process, data measuring the net infiltration of winter rains through bare sand surfaces at the Hanford Site show that the pulses do not appear to penetrate beyond 3 m (9.8 ft) below the surface, and a near steady-state drainage condition prevails below this depth (PNNL-14115, *Hydrologic Characterizations Using Vadose Zone Monitoring Tools: Status Report*). Water storage measurements in the top 1 meter appear to capture most of the transient changes in water content within the sediment profile (PNNL-14115). Similar multiyear evaluations of soil moisture content data collected from vegetated desert soils throughout the United States indicate that water potentials remain very low and relatively invariant below depths of 2–5 m (Seyfried et al. 2005). In response to intermittent years of elevated precipitation, such as those caused by El Nino in the southwestern United States, the biomass usage of water increases, depleting the excess water, and no net increase in groundwater recharge occurs (Scanlon et al. 2006; Leary, 1990). These factors that dampen the oscillations in moisture content and matric potential dampen the oscillations in deep drainage and allow for the use of time-averaged recharge rates for risk assessment applications of vadose zone modeling."
G11	General	The post-closure evaluation of contaminant migration to groundwater should consider the impacts of recharge through the barrier side slopes. It appears to be assumed that the impacts are negligible. No justification for this assumption is provided.	RPP-RPT-58806, Section 7.3.2.2.2, p. 7-62, lines 39-46 state "Although the side slopes and berm are likely to function and perform differently than the surface of the barrier, they are included as part of the barrier surface. The impact of the side slopes on the overall recharge rate is expected to be relatively negligible."	Cite the work in Last, et al. (2006) *Vadose Zone Hydrogeology Data Package for Hanford Assessments*, PNNL-14702, Rev.1, Section 4.5.4. As of 3/11/19, this comment was rescinded.	No disposition provided.
G12	General	It is almost 2017 and the surface at WMA C is gravel covered. These documents use a recharge value of 3.5 mm/y starting in 2020 for WMA C. This is not protective or correct.	See RPP-RPT-58806, Section 7.3.3.4, p. 7-81, Table 7-12, and p. D-23, Table D-7.	Please revise to something realistic and protective, considering a later barrier placement, surface disturbance along with immature vegetation after barrier placement, and ultimately, cheatgrass and other invasives after institutional controls expire.	The change in recharge at Year 2020 from 100 mm/yr to 0.5 mm/yr is based on assumption of emplacement of surface cover under landfill closure configuration. The releases from tank residuals and ancillary equipment are modeled to occur following closure. If the closure gets delayed, the net effect on the PA results will be translated by equivalent time lag due to the primary dose/risk contributing radionuclides being long-lived and given that the release from tank residuals and ancillary equipment are not modeled prior to closure. So, the source-term release rates will not be affected except that they will start whenever the closure is assumed. The timeline for change in recharge rates would still be the same: 100 mm/yr prior to surface cover (and closure) followed by 0.5 mm/yr for 500 years. We have also evaluated a number of sensitivity analyses that examine alternatives including an extreme recharge of 100 mm/yr after an assumed 100-year period of institutional control. Other cases could be run to examine other conditions not currently evaluated.

Table A-1. Review Comment Record From General Comments from State of Washington Department of Ecology from Review of the Waste Management Area C *Hanford Federal Facility Agreement and Consent Order* Appendix Performance Assessment Analyses and Documentation. (sheet 7 of 8)

Comment Number	Location	Comment	Basis	Recommendation	Final Disposition
G13	General	Consistent with WAC 173-340-720(1)(d)(iii) and -740(1)(c)(i) and (ii), Ecology is pursuing an evaluation of human exposure to nonradionuclides in produce grown at the WMA C location on contaminated soil using local groundwater, at a time after institutional controls are lost and partial barrier removal has occurred (for instance, during residential construction).	WAC 173-340-720(1)(d)(iii) and -740(1)(c)(i) and (ii) make reference to protecting soils and biota in soils from concentrations of contaminants that could impair agriculture or result in food chain contamination. Food chain pathways are already examined for radionuclides.	Evaluate food chain transfers (to biota and humans) resulting from use of contaminated soil and contaminated groundwater at the WMA C location, in a residential setting.	This item was under dispute in the BRA and will not be discussed here. The issue of consideration of food chain for hazardous chemical was resolved in IAMIT Determination 2019-008.
G14	General	The RCRA Closure document (RPP-RPT-58806, Rev. 0, Section 7.3.2.2.2, p. 7-62, lines 39-42) states "The hydrogeologic conceptual model developed for the WMA C RCA (RPP-RPT-46088 and RPP-RPT-56356) provides the information basis and data necessary to prepare the 3-D geologic inputs used in the 3-D numerical model." Ecology is concerned that our input on these cases has not been incorporated.	Document RPP-RPT-46088 is *Flow and Transport in the Natural Systems at Waste Management Area C*. This was a data package that Ecology reviewed in 2010. The disposition for our comment 11 (see p. H-3) for this data package states "Proposed cases in this situation will evaluate a range of saturated hydraulic conductivity values that would be representative of saturated sands typical of Hanford H2 sands unit and reported in the literature."	Please provide a table in one of the PA documents that compares the cases that were given in the 2010 data package (RPP-RPT-46088) with the cases that are being used in the PA.	RPP-RPT-46088 has been updated and provides the requested information (see Section 7.5).
G15	General	A drawdown aquifer test spanning 3 days and then 27 days was run for the unconfined 200-BP-5 groundwater operable unit (DOE/RL-2015-75). A pumping well as well as several observation wells were used. The test was run in the northern part of the 200 East Area near WMA B-BX-BY. The interpreted results for Kh in that area was 18,000 m/d. These results were then used in the WMA C PA. The results at B-BX-BY reflected the highly conductive sediments in the paleochannel.	—	Because this is a unique situation, these results should not be extrapolated to the aquifer at WMA C, especially given the highly heterogeneous sediments that constitute both the vadose zone and aquifer at WMA C. Please use the hydraulic conductivity values from the Tank Waste EIS Technical Guidance Document or justify why the hydraulic conductivities used are valid.	Please see responses to RC7-19, RC7-26, RC9-5, and RCD-13 in review of RPP-ENV-58806. These aquifer test results, performed at a location within the unconfined 200-BP-5 groundwater operable unit and documented in DOE/RL-2015-75, were not used as a basis for aquifer hydraulic properties in the WMA C PA STOMP-based process model. The basis of the estimates used in the STOMP-based model is provided in Appendix C of RPP-ENV-58806.
G16	General	The estimated soil inventory plus the estimated groundwater inventory should approximate the estimated volume/mass of releases.	There are estimates of the released inventory, estimates of the soil inventory, and estimates of the groundwater inventory for C Farm.	Please discuss mass balance for released contaminant inventories in various media.	Information of the modeled release of contaminants from the past leaks with temporal changes in inventory within the vadose zone and groundwater is provided in Section 6.3.3 in the Past Leaks Analysis (RPP-RPT-59197).
G17	General	The groundwater analysis for the PA stops in 2013. This is problematic.	Cyanide concentrations in wells have been changing since 2013; it is clearer that the cyanide is from WMA C.	Please include cyanide in all of the IPA evaluations for WMA C, and resume analyzing for cyanide in wells associated with WMA C.	The plots of various constituents including cyanide show trends through the end of CY 2015 (see Figure 2-25 in RPP-RPT-59197). We plan to update the plots to include the most currently available monitoring in updates of the IPA documents. Within RPP-RPT-59197, all forward projections of constituents that we had inventories for in past waste leaks or losses were evaluated out to the year 2120 for mobile constituents like nitrate or Tc-99 and out to year 12040 for sorbed species like I-129 and uranium. Because we did not have previously developed inventories for cyanide, it was not specifically evaluated in Section 6 like the other constituents in the current draft of RPP-RPT-59197. However, as a part of the comment resolution process, we have agreed to expand the information on cyanide in RPP-RPT-59197 with a new appendix that estimates the cyanide inventory in past leaks and evaluates its resulting potential future impacts to groundwater. A summary of this information will be included in the updated draft of RPP-RPT-59197.

Table A-1. Review Comment Record From General Comments from State of Washington Department of Ecology from Review of the Waste Management Area C *Hanford Federal Facility Agreement and Consent Order* Appendix Performance Assessment Analyses and Documentation. (sheet 8 of 8)

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G18	General	Ecology will need to see how radiological risks in the future compare with USEPA's CERCLA risk threshold range of 1E-04 to 1E-06. See §300.430 Remedial investigation/feasibility study and selection of remedy, section (e)(2)(1)(a)(2) at the link in the Basis column.	https://www.ecfr.gov/cgi-bin/text-idx?SID=f67b82edaa330fe3264d7d0435aadbc5&mc=true&node=se40.30.300_1430&rgn=div8	For all comparisons of radiological risks for humans against dose thresholds also include comparisons against the CERCLA threshold range of 1E-04 to 1E-06 risk.	The requested information is provided in Appendix I of RPP-ENV-58806.
G19	General	The UPR could be a source of Tc-99 contamination at WMA C and would impact placement of pump and treat wells.	Cyanide historically has been detected in most wells in C farm, however, detection has been very sporadic with no discernible pattern to me. In 2016 wells E27-14 and E27-24 have shown consistent above detection limits for cyanide. These recent high levels of cyanide confirm the change in groundwater flow to the south south-east. The cyanide is coming from the central portion of WMA C as upgradient wells E27-12, E27-15 and E27-22 have remained as non-detects for cyanide. Technetium at WMA C In 2016 well E27-13 has shown a dramatic in Tc-99 concentration approx. 10,500 pCi/L well above the average 2013 concentration of approx. 2000 pCi/L in 2013. The latest sampling of E27-23 Dec. 2016 had a Tc-99 value of 11,500 pCi/L a sharp increase from the 2013 and 2014 samplings. I note a general increase in the values at this well. With the change in groundwater flow at WMA C these recent changes suggest to me a source to the north north-east of these wells; UPR-200 E-82 would be a likely suspect.	Consider this additional source in WMA C and address the remediation needs that it may require.	DOE-RL and CHPRC have responsibility of design and implement pump and treat system at WMA C. These questions should be discussed with them.
G20	General	WAC 173-340 (MTCA) was very slightly revised in 2013, so that should be the date cited in the documents. This will not change the values that are used.		Cite WAC 172-230 2013, rather than 2007.	We concur with the recommendation.

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