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

Author Name:
M. Kozak, S. Mehta, A. Aly – INTERA, Inc.; M. P. Connelly – TecGeo, Inc.
M. P. Bergeron, K. M. Singleton – Washington River Protection Solutions, LLC
Richland, WA 99352
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Abstract: This document provides a high-level synopsis of the performance assessment that has been carried out to fulfil the requirements of Appendix I of the Hanford Federal Facility Agreement and Consent Order (HFFACO). To meet the requirements of the several regulations specified in Appendix I, the U.S. Department of Energy 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).

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M. Kozak
S. Mehta
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M. P. Bergeron
K. M. Singleton
Washington River Protection Solutions, LLC

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washington river protection solutions

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EXECUTIVE SUMMARY

This document provides a high-level synopsis of the performance assessment that has been carried out 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). A set of four complementary reports is shown in Figure ES-1:

- The Analysis of Past Leaks (RPP-RPT-59197, "Analysis of Past Tank Waste Leaks and Losses in the Vicinity of Waste Management Area C at the Hanford Site, Southeast Washington") which provides input to the Revision 1 update of the Baseline Risk Assessment (RPP-RPT-58329, "Baseline Risk Assessment for Waste Management Area C")

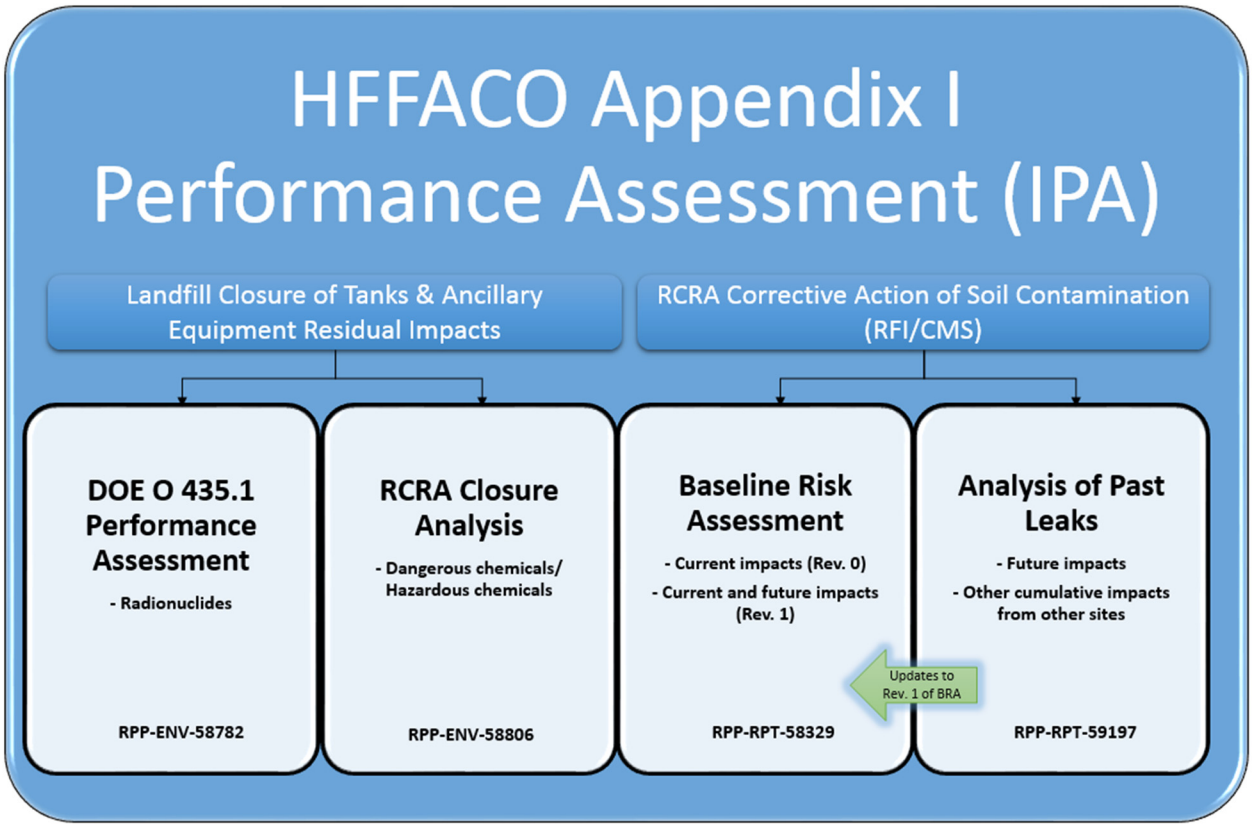
- A revision 1 update of the Baseline Risk Assessment (RPP-RPT-58329) conducted to support a Resource Conservation and Recovery Act of 1976 (RCRA) facility investigation (RFI) for Waste Management Area (WMA) C (RPP-RPT-58339, "Phase 2 RCRA Facility Investigation Report for Waste Management Area C," Draft A)

- A RCRA Closure Analysis (RPP-ENV-58806, "RCRA Closure Analysis of Tank Waste Residuals Impacts at Waste Management Area C, Hanford Site, Washington") addresses regulatory requirements in Washington Administrative Code 173-303, "Dangerous Waste Regulations"

- DOE Order 435.1 Performance Assessment (RPP-ENV-58782, "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, Radioactive Waste Management.

These documents and the extension into the Baseline 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 Appendix I Performance Assessment.



The Analysis of Past Leaks (RPP-RPT-59197) was conducted to analyze groundwater protection under the Baseline Risk Assessment completed for current conditions at WMA C. The Analysis of Past Leaks utilized the site-specific models developed for the performance assessment (RPP-ENV-58782) and RCRA Closure Analysis (RPP-ENV-58806). 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

- 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 Baseline Risk Assessment (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. 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. Key findings of the Baseline Risk Assessment are as follows:

- For Industrial Worker exposure scenario, ^{137}Cs and ^{126}Sn are retained as radiological contaminants for further evaluation

- For all evaluated scenarios, no contaminants were identified to pose elevated risks for non-carcinogenic adverse health effects within WMA C

- The screening level ecological risk evaluation indicated that none of the contaminants within WMA C pose a potential risk for ecological resources

- Evaluation of Groundwater Protection:

  - Technetium-99 is retained as a contaminant of potential concern for further evaluation

  - Examination of nitrate and sulfate show that groundwater has been impacted by a combination of both sources located upgradient and WMA C sources.

  - Because of the potential impacts from nitrate in past releases at WMA C, nitrate is also retained as a contaminant of potential concern for further evaluation.

The RCRA Closure Analysis (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:

- The RCRA Closure Analysis results 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

BRA	baseline risk assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulation
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
RCA	RCRA Closure Analysis
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

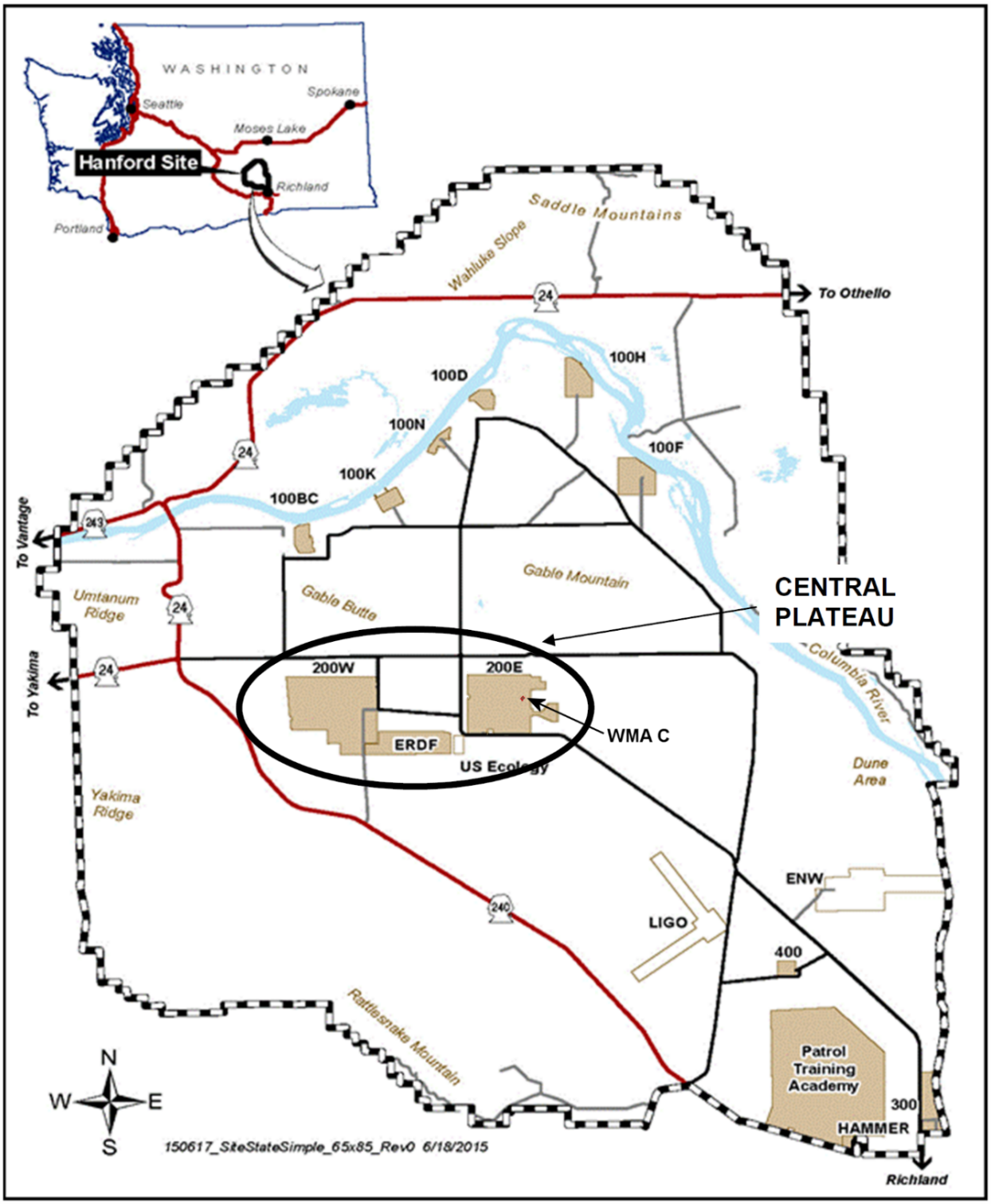
The U.S. Department of Energy, Office of River Protection (DOE-ORP) is pursuing closure on the single-shell tank (SST) Waste Management Area (WMA) C (Figure 1-1) under Federal requirements and forthcoming U.S. Department of Energy (DOE) closure plans, State-approved closure plans, and permits in accordance 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 will 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, baseline risk assessment (BRA), 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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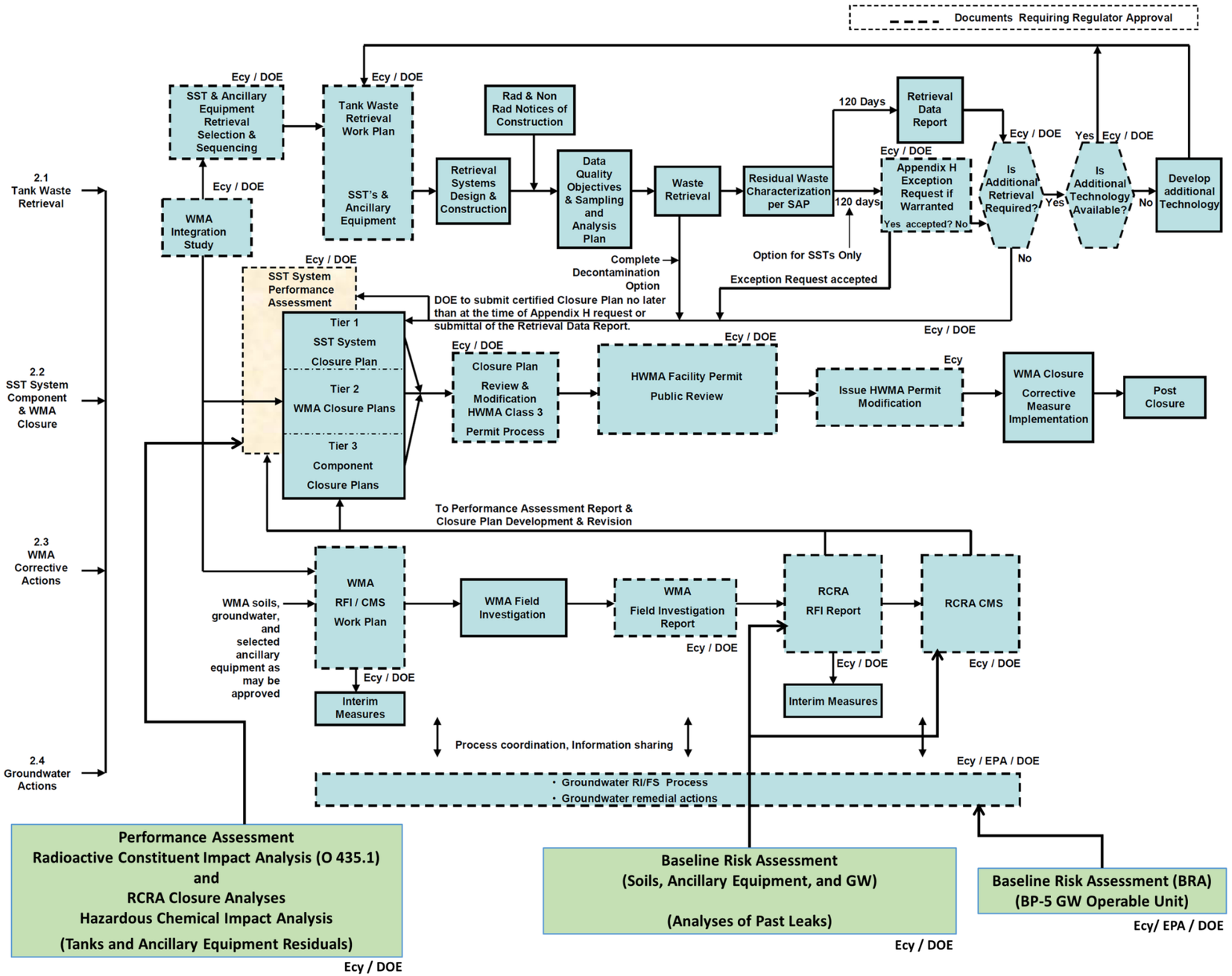
Figure 1-2. Single-Shell Waste Management Area Waste Retrieval and Closure Process.

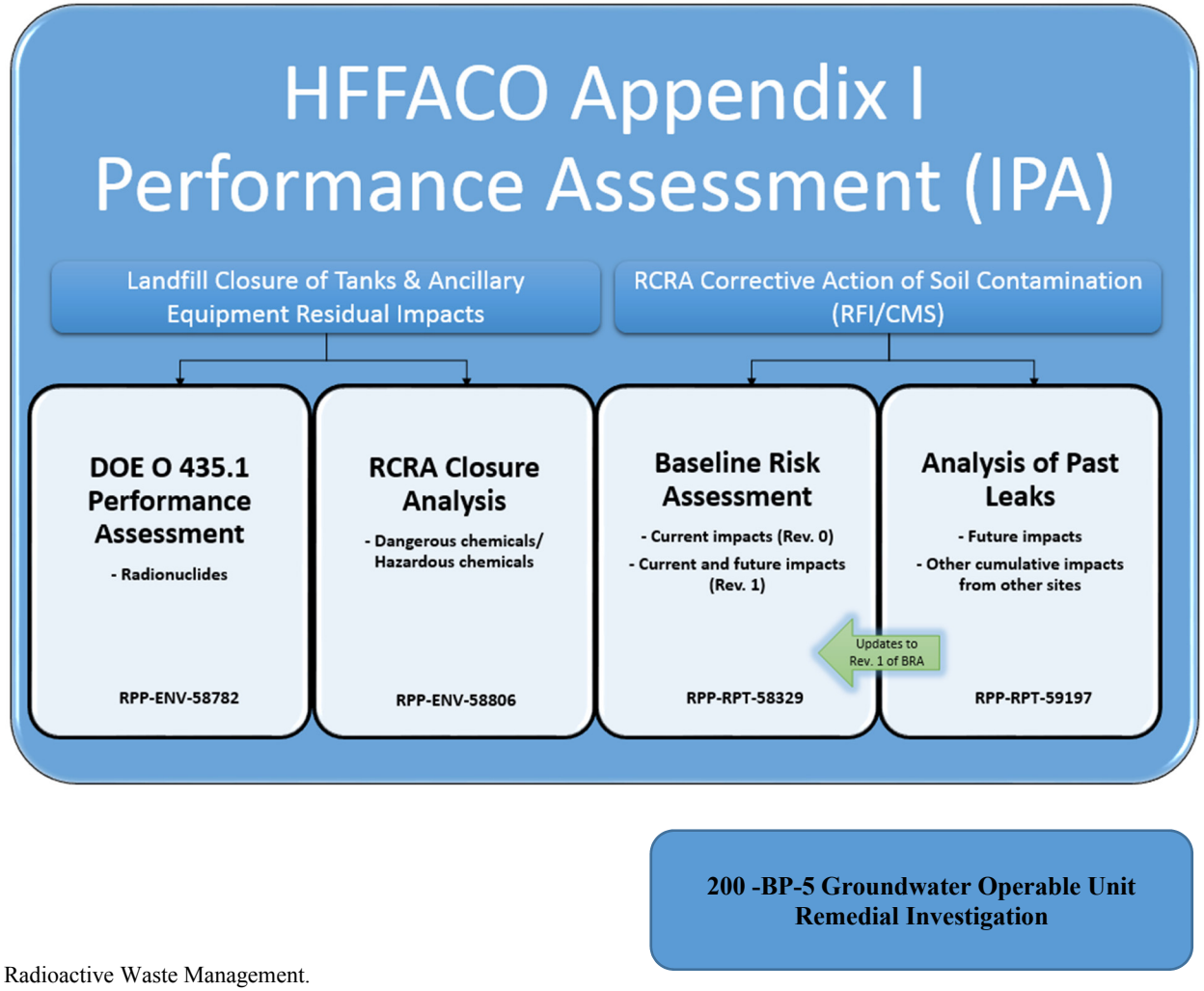


CMS = corrective measures study
DOE = U.S. Department of Energy
Ecy = State of Washington Department of Ecology
GW = groundwater
HWMA = Hazardous Waste Management Act
RCRA = Resource Conservation and Recovery Act of 1976
RFI = RCRA facility investigation
RI/FS = remedial investigation/feasibility study
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 Appendix I Performance Assessment.



References:
DOE O 435.1, Radioactive Waste Management.
RPP-ENV-58782, "Performance Assessment of Waste Management Area C, Hanford Site, Washington."
RPP-ENV-58806, "RCRA Closure Analysis of Tank Waste Residuals Impacts at Waste Management Area C, Hanford Site, Washington."
RPP-RPT-58329, "Baseline Risk Assessment for Waste Management Area C."
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."

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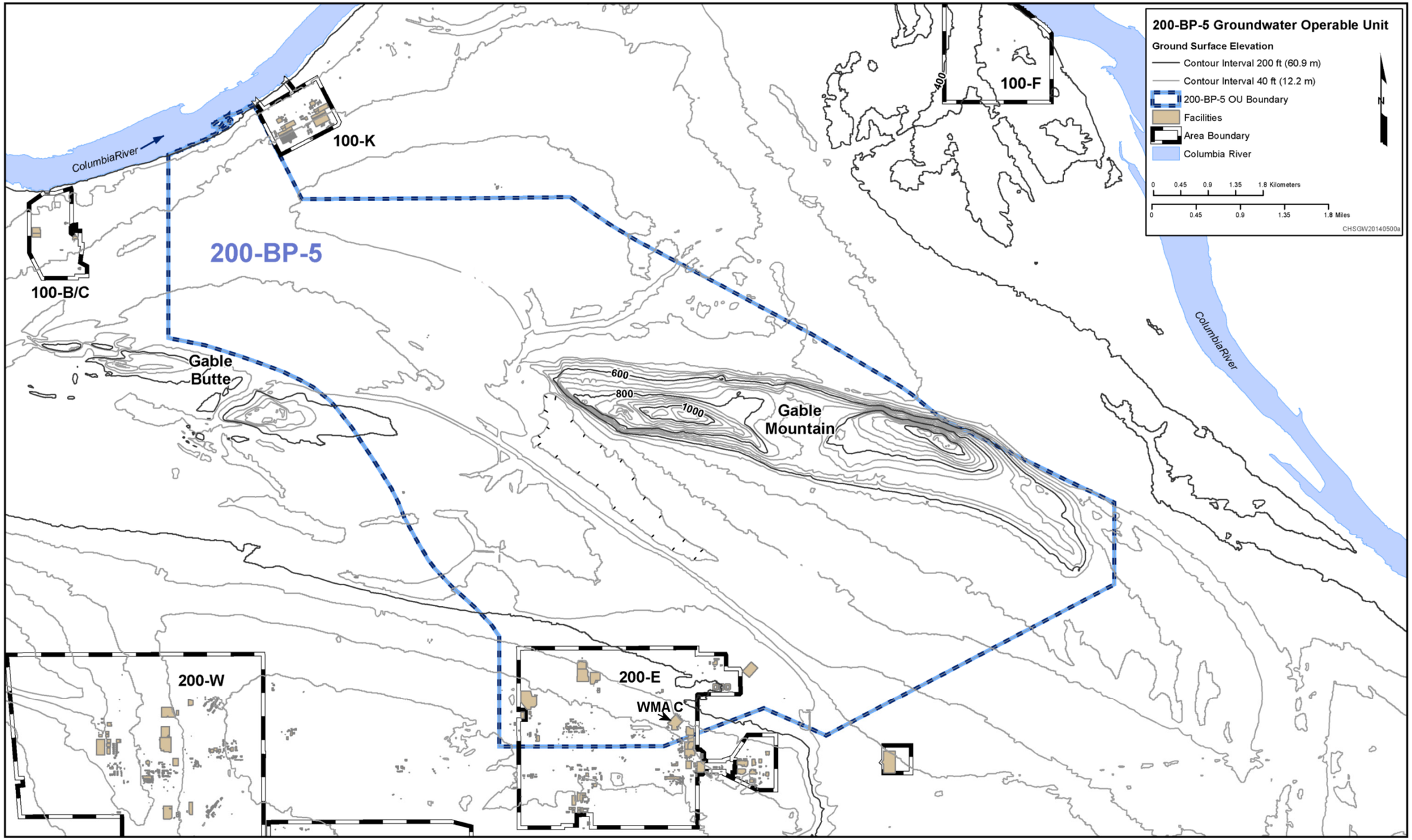
Figure 1-4. Surface Topography and Boundaries of the 200-BP-5 Groundwater Operable Unit.



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 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.

In Section 3 providesthe key conclusions from RPP-RPT-58329, "Baseline Risk Assessment for Waste Management Area C," from calculating risk for both nonradiological and radiological contaminants for different 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, "RCRA Closure Analysis of Tank Waste Residual Impacts at Waste Management Area C, Hanford Site, Washington" and RPP-ENV-58782, "Performance Assessment of Waste Management Area C, Hanford Site, Washington."

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

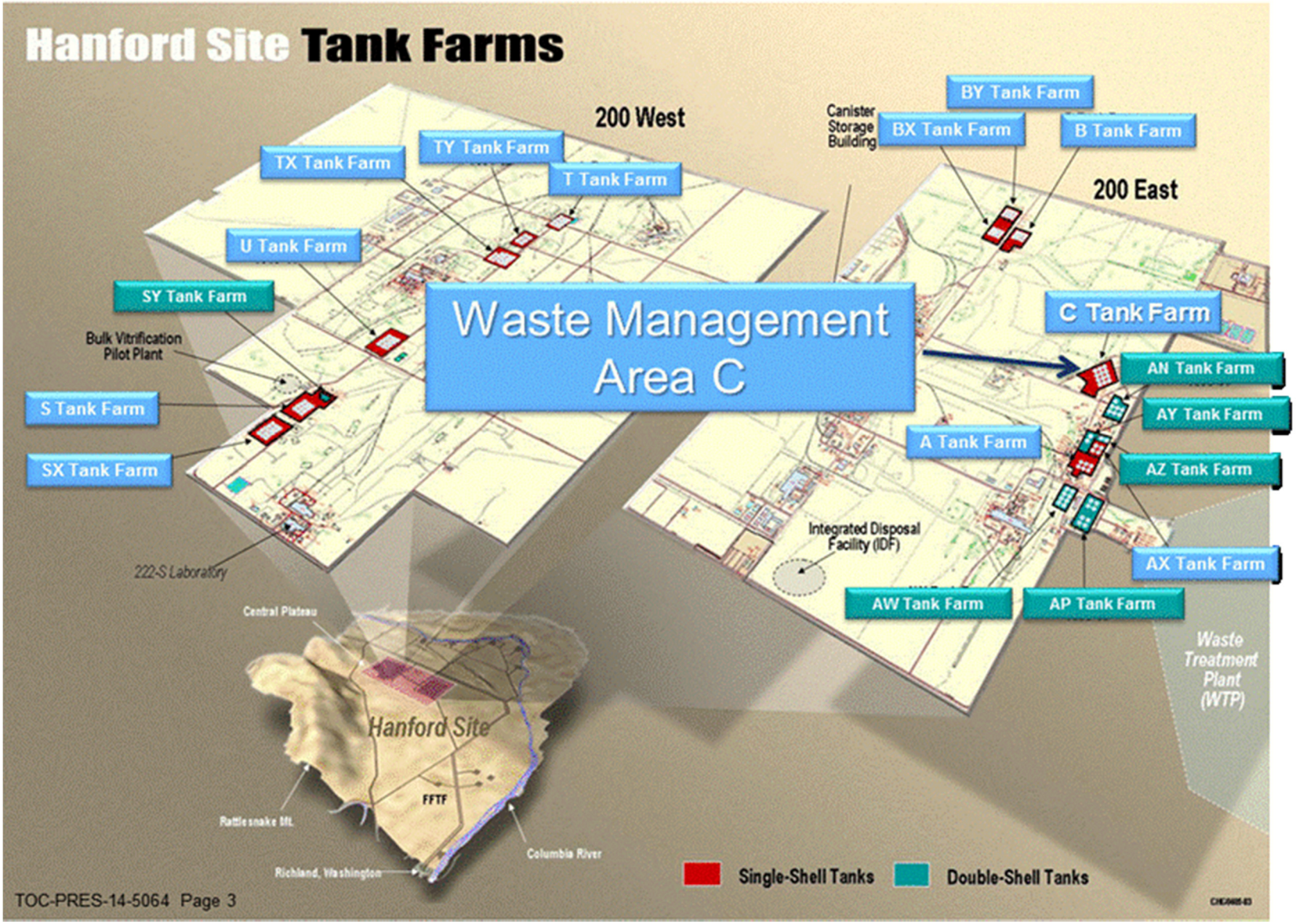
1.2 BACKGROUND INFORMATION

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").

Figure 1-5. Hanford Site Tank Farms.



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."

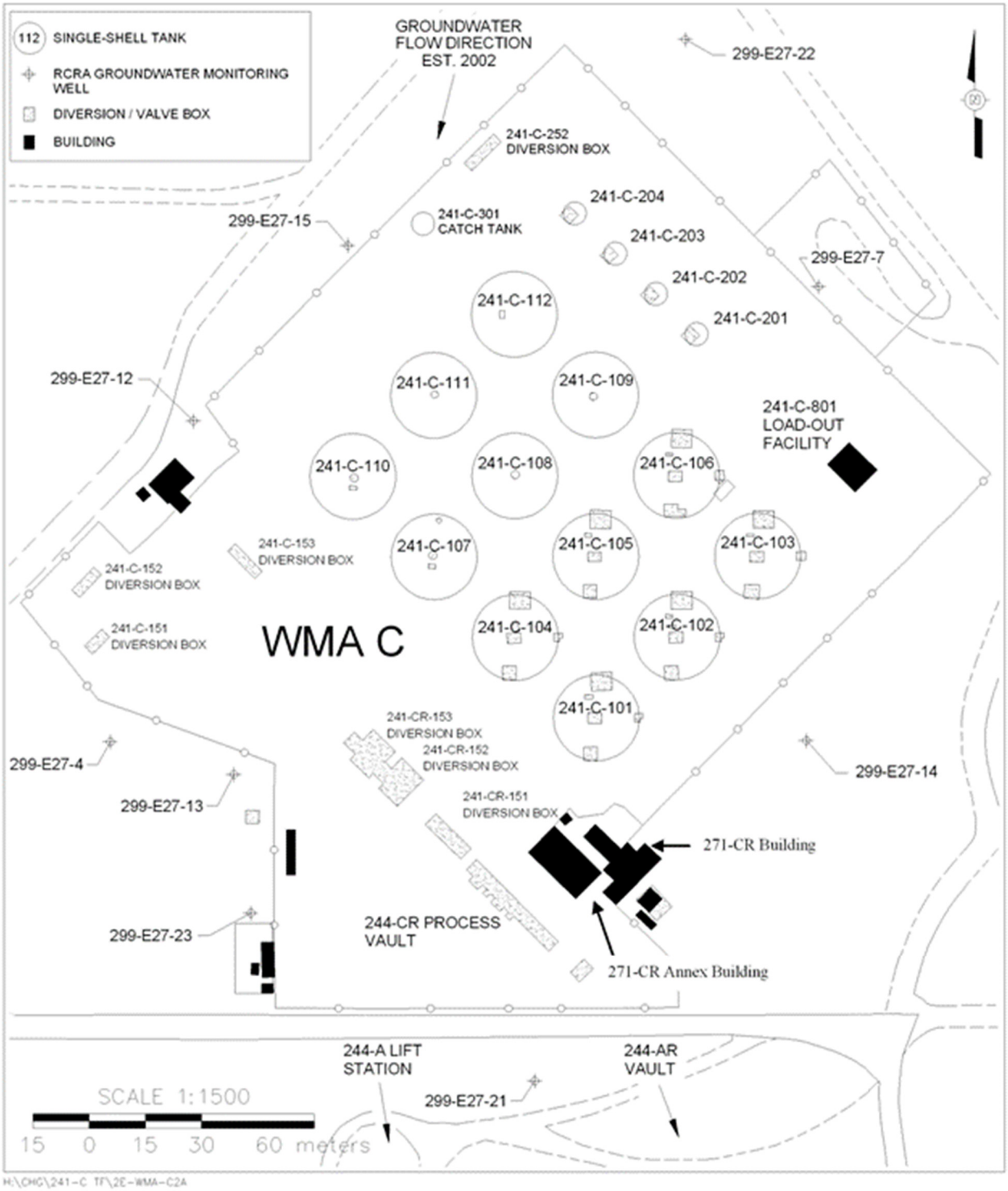
1.2.2 Anticipated Closure Conditions

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 ROD 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.

For purposes of this analysis, WMA C closure is assumed to occur at year 2020, at which time 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.

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.

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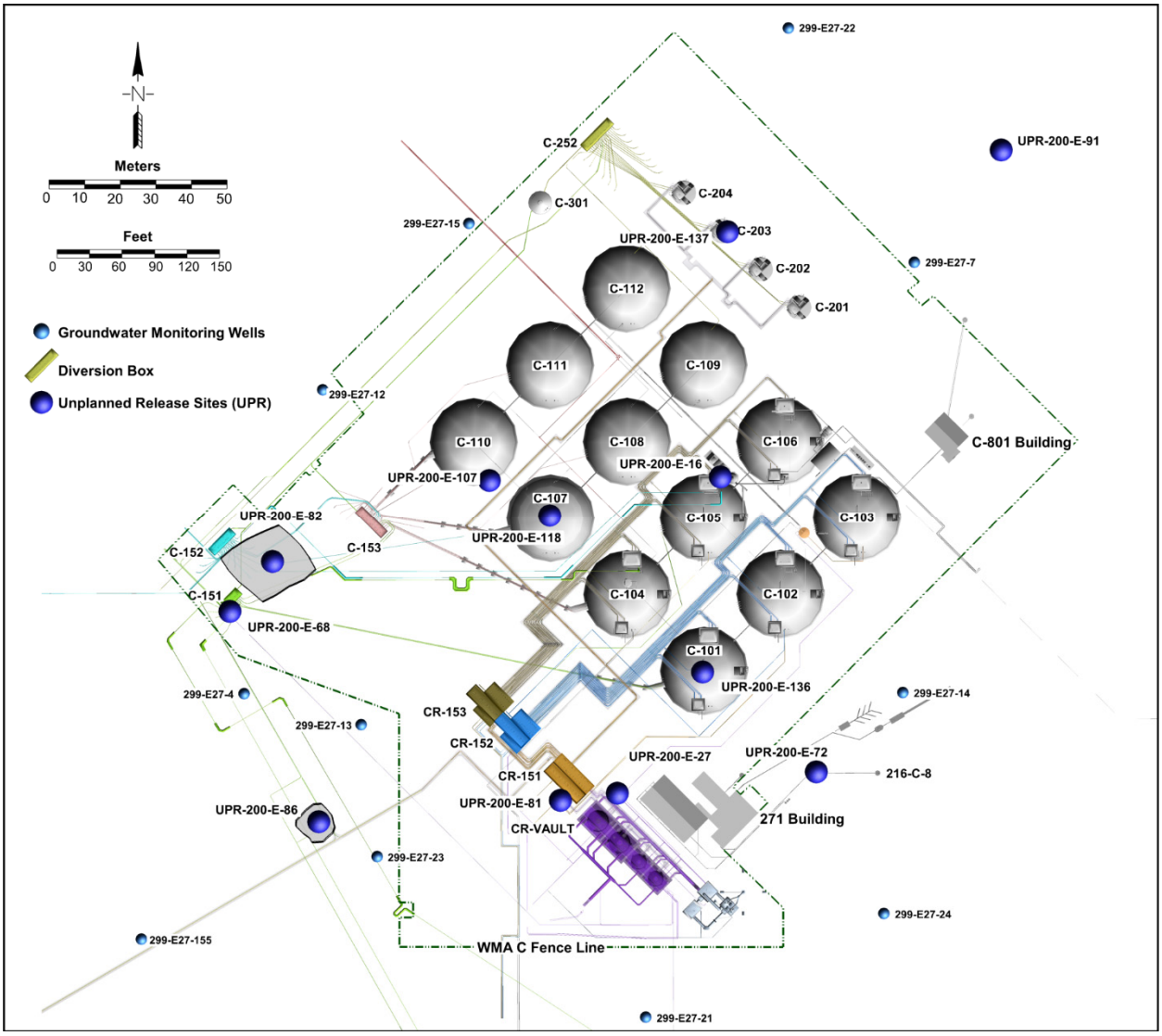
2.0 IMPACT FROM PAST TANK WASTE LEAKS AND LOSSES AT WASTE MANAGEMENT AREA C FROM ANALYSIS OF PAST LEAKS (RPP-RPT-59197, REV. 0)

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:

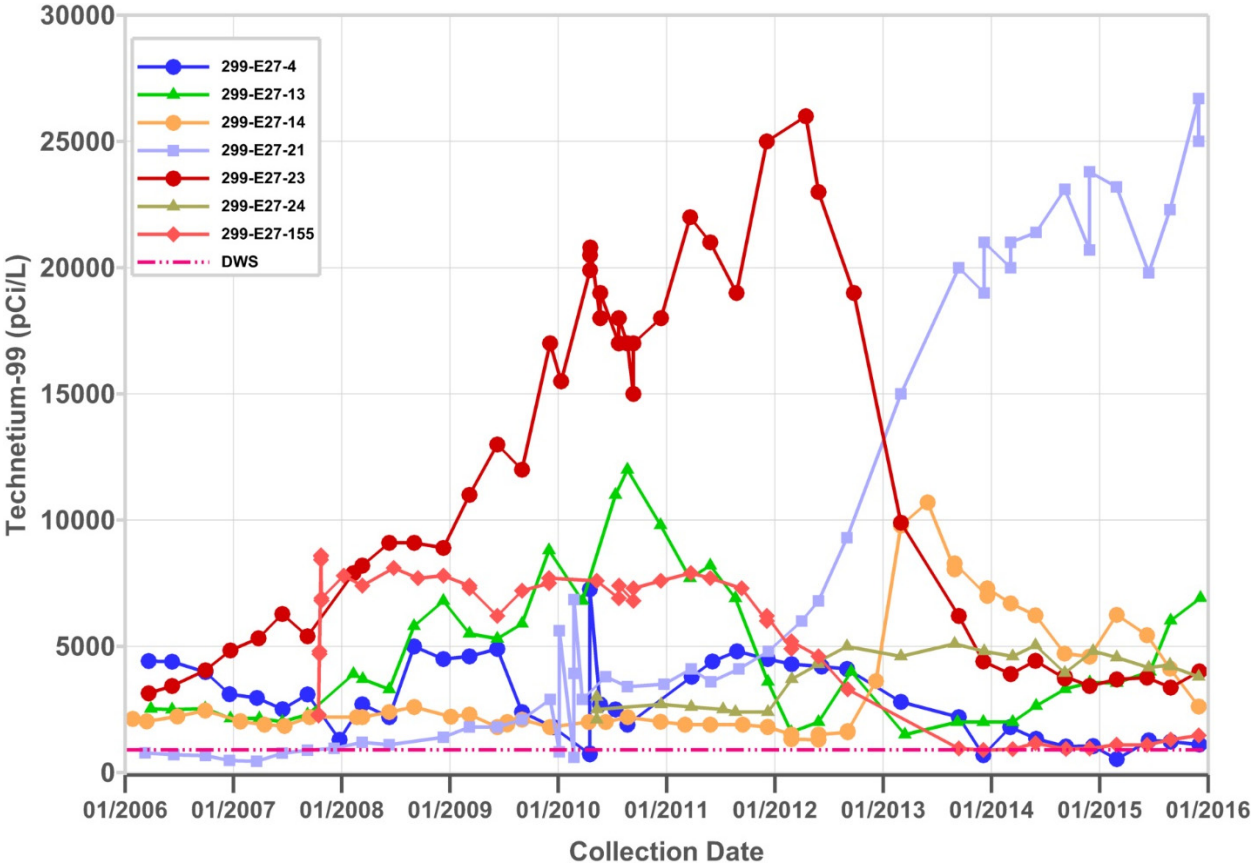
- Evaluation for past waste releases at WMA C has indicated that groundwater has been impacted by ^{99}Tc.
- Analysis of future impacts shows that concentration levels of ^{99}Tc are at or near their peak values and are expected to decline over the next few decades.
- Concentration levels of nitrate 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 is required in the BRA. The analysis has been undertaken using the site-specific models developed for residual waste PA (RPP-ENV-58782) and RCRA Closure Analysis (RCA) (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 observed historically in the vicinity of WMA C.

Analysis of past leaks has been structured to meet several goals in addition to the BRA requirements.

First, the analysis is 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, as documented in the scoping session's data package, because of their potential to influence the migration of contaminants from WMA C. Second, the analysis is intended to be consistent, to the extent possible, with the PA (RPP-ENV-58782) and RCA (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 is to use the understanding gained by the analysis to provide a projection of the future evolution of the contamination beneath WMA C and to provide support to the BRA.

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 WMA = Waste Management Area

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 downgradient 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 reach 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 then 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 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.

- Model 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.

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

- There are not significant overlaps between releases from residual wastes in a closed WMA C and the releases from leaks.

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3.0 BASELINE RISK ASSESSMENT FOR WASTE MANAGEMENT AREA C (RPP-RPT-58329)

This BRA 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. 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 RFI/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 BRA and the screening level ecological risk assessment (SLERA).

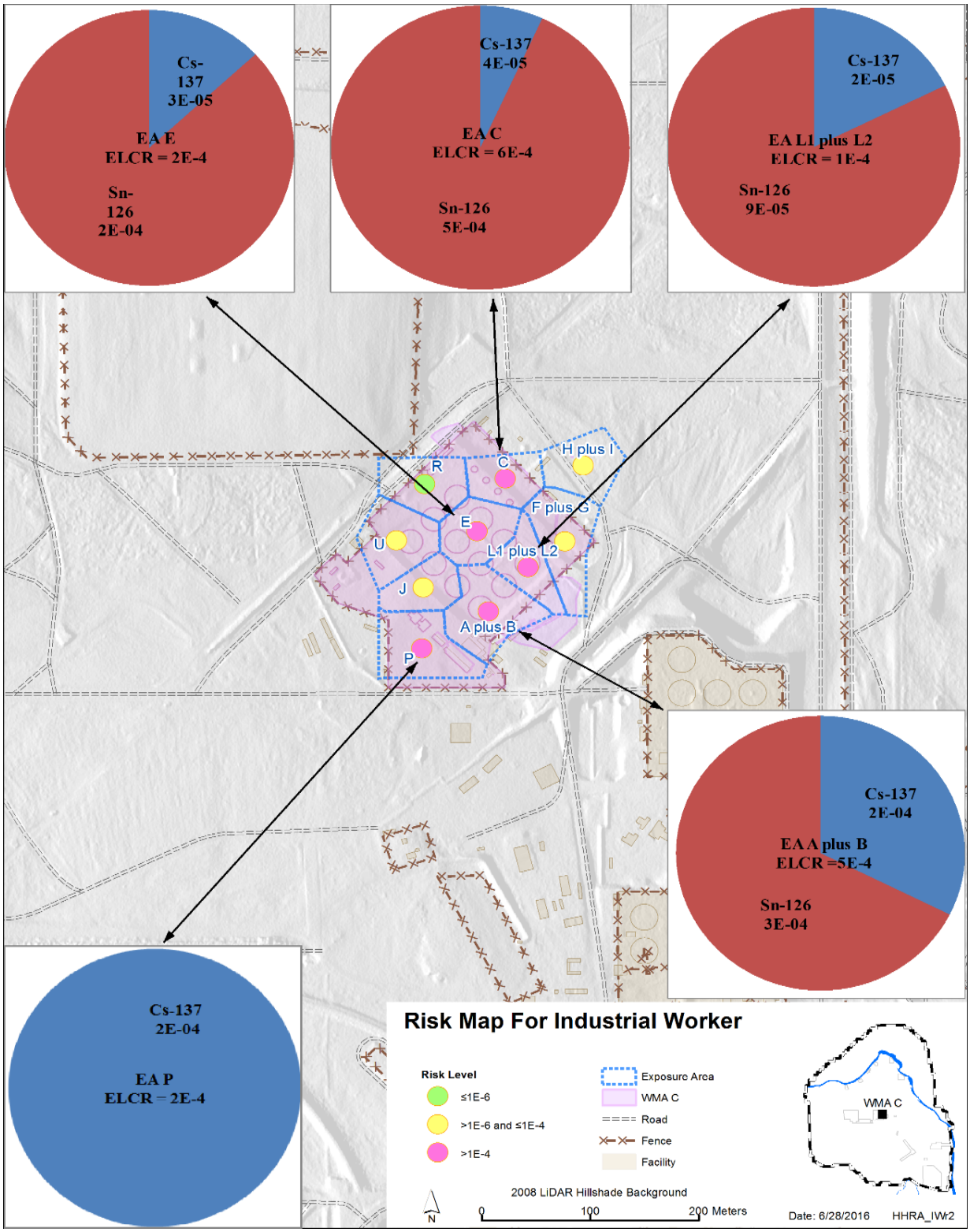
The human health risk assessment addressed potential exposures to industrial worker, construction worker, maintenance/surveillance worker, trespasser, hypothetical onsite residential receptors and two Native American residential receptors to contaminants detected in shallow vadose soils (upper 15 ft). Results 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. For all evaluated scenarios, no contaminants were identified to pose elevated risks for non-carcinogenic adverse health effects within WMA C.

Key Findings from Baseline Risk Assessment:

- For the Industrial Worker exposure scenario, ^{137}Cs and ^{126}Sn are retained as radiological contaminants for further evaluation of shallow vadose zone.
- For all evaluated scenarios, no contaminants were identified to pose elevated risks for non-carcinogenic adverse health effects within WMA C.
- The screening level ecological risk evaluation showed that none of the contaminants within WMA C pose a potential risk for ecological resources.
- Evaluation of Groundwater Protection:
  - Technetium-99 is retained as a COPC for further evaluation.
  - Examination of nitrate and sulfate show that groundwater has been impacted by a combination of both upgradient and tank farm sources.
  - Because of the potential impacts from nitrate in past releases at WMA C, nitrate is also retained as a COPC for further evaluation.

For industrial worker and maintenance/surveillance worker scenario, 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, are retained as radiological contaminants for further evaluation.

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

While the WMA is not expected to be used as a residential area, the BRA evaluated a residential receptor. 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.

Risks to ecological receptors were evaluated through a three-tiered risk assessment – generic screening, Tier 1 screening (for all contaminants) and Tier 2 (only for non-radiological contaminants) SLERA. Following EPA guidance for ecological risk assessment, all contaminants identified in the SLERA were considered for further evaluation as part of the scientific management decision point. This evaluation showed that no contaminants can have potential risks to ecological receptors because their concentrations are either less than background values (e.g., vanadium), or their exposure point concentrations (EPCs) are below screening values (e.g., cadmium, zinc, ^{90}Sr, ^{3}H and ^{137}Cs). Finally, the scientific management decision point evaluation for Tier 2 contaminants of potential ecological concern showed that the site-wide EPCs for six contaminants of potential ecological concern (boron, molybdenum, selenium, thallium, sulfate and Bis [2-ethylhexyl] phthalate) are less than their corresponding Tier 2 screening values; hence, resultant hazard quotients are less than 1.

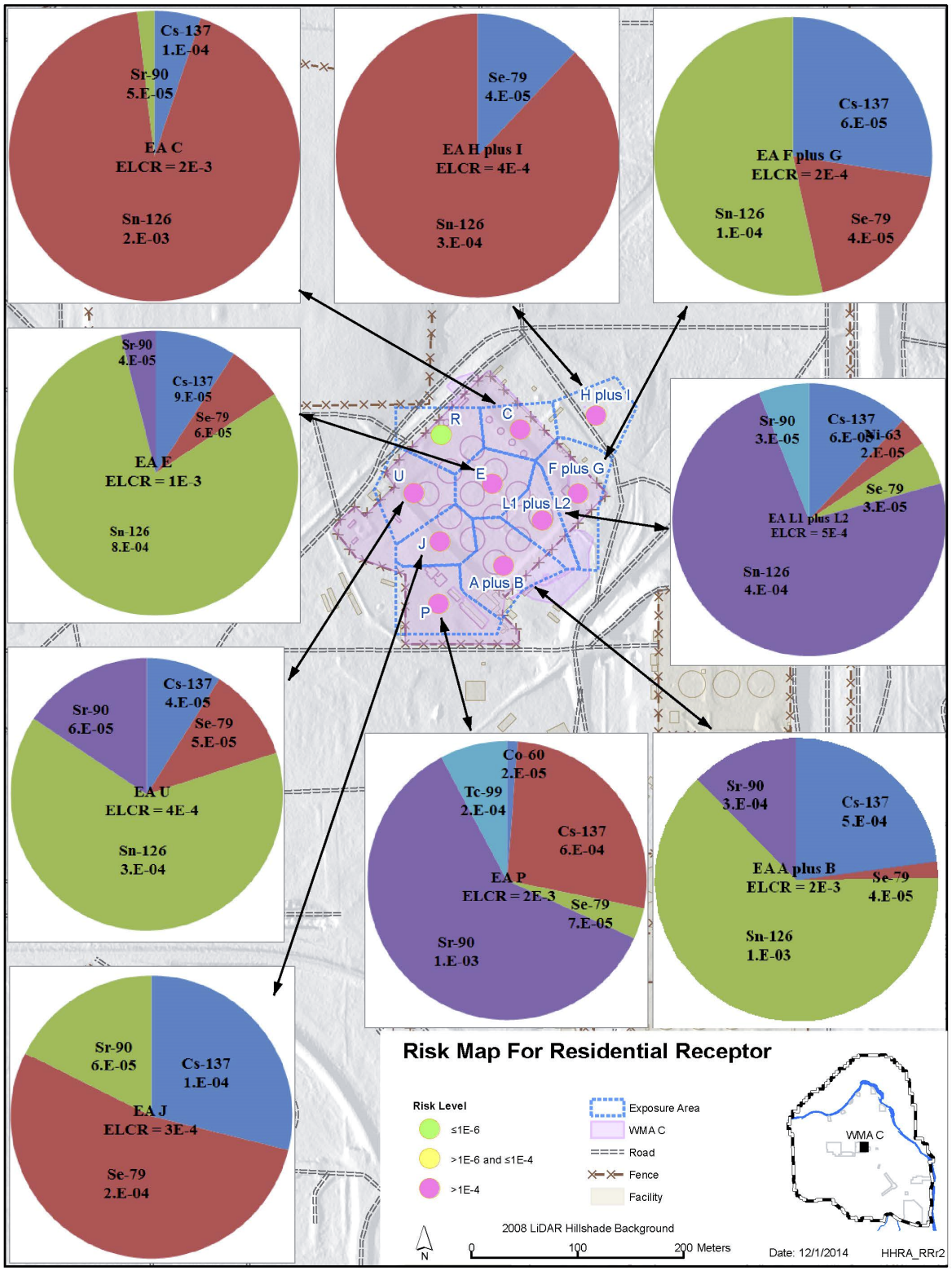
Therefore, none of those chemicals are expected to pose a potential risk to ecological resources and are not proposed for retention or further ecological evaluation at WMA C. Following a generic Tier 1 and Tier 2 screen, none of the chemicals identified initially as contaminants of potential ecological concern are recommended for further baseline risk evaluation at WMA C.

The "protection of groundwater pathway" assessment was performed as part of the WMA C BRA to understand the potential impacts to groundwater from migration of contaminants in contaminated soil through the vadose zone to the aquifer. The EPCs for nonradiological contaminants in the vadose zone were evaluated to their corresponding 2007 Washington Administrative Code (WAC) 173-340-747, "Deriving Soil Concentrations for Groundwater Protection," subsection (4) "Fixed-parameter three-phase partitioning model" (hereinafter referred to as the three-phase model) cleanup levels and background concentration. The results of the data evaluations showed that the EPCs for three COPCs (cadmium, beta-BHC and lindane) exceeded their corresponding three-phase model concentrations and background levels at a number of EAs. Cadmium concentrations slightly exceeded background levels at a handful of measurements (6 out of 136) and no EPCs exceeded background values. Therefore, cadmium was not considered to be present at levels that have the potential to impact groundwater.

For lindane and beta-BHC, a site-specific fate and transport model was developed using the software Subsurface Transport Over Multiple Phases (STOMP)©[1] to determine whether soil concentrations within WMA C have the potential to impact groundwater. The results showed that both lindane and beta-BHC did not reach the water table within the 1,000-year period of analysis.

[1] Subsurface Transport Over Multiple Phases (STOMP)© is copyrighted by Battelle Memorial Institute, 1996.

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

Protection of groundwater at WMA C was also evaluated for all contaminants released from WMA C by utilizing the STOMP© three-dimensional groundwater flow and transport model documented in RPP-RPT-59197. The model was used to determine the peak concentrations for the following radiological and nonradiological contaminants – ^{99}Tc, NO_3, ^{3}H, ^{60}Co, ^{79}Se, ^{126}Sn, ^{129}I, ^{238}U and total uranium – over a period of 10,000 years. The results were compared against their corresponding DWSs to determine the magnitude of the groundwater impact. The results show that the peak concentrations for ^{99}Tc and ^{129}I are greater than their respective DWSs. For ^{99}Tc, the peak concentrations are much higher as compared to its DWS and they will occur in the near future (around 2019). However, for ^{129}I, the peak concentrations at the WMA C fenceline are slightly higher than its DWS of 1 pCi/L and they will occur after about 6,000 years.

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) **RCRA Closure Analysis** – The RCA provides an evaluation of hazardous chemicals and dangerous waste residual contaminant impacts from tank waste residuals left in tanks and ancillary equipment at a closed WMA C. 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 RCRA Closure Analysis:

- The RCA results 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 entire period of analysis (see Table 4-1).
- For all of the sensitivity analyses evaluated, the disposal system also met these

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 RCA 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 an expected manner without unusual behavior or unanticipated disruption: this is termed the "base case." 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 RCA, owing to its differing regulatory requirements.

The RCA results indicate that regulatory standards (i.e., target risk, hazard quotients/indices, and groundwater maximum contaminant levels/cleanup levels) were not exceeded for 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 RCA 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.

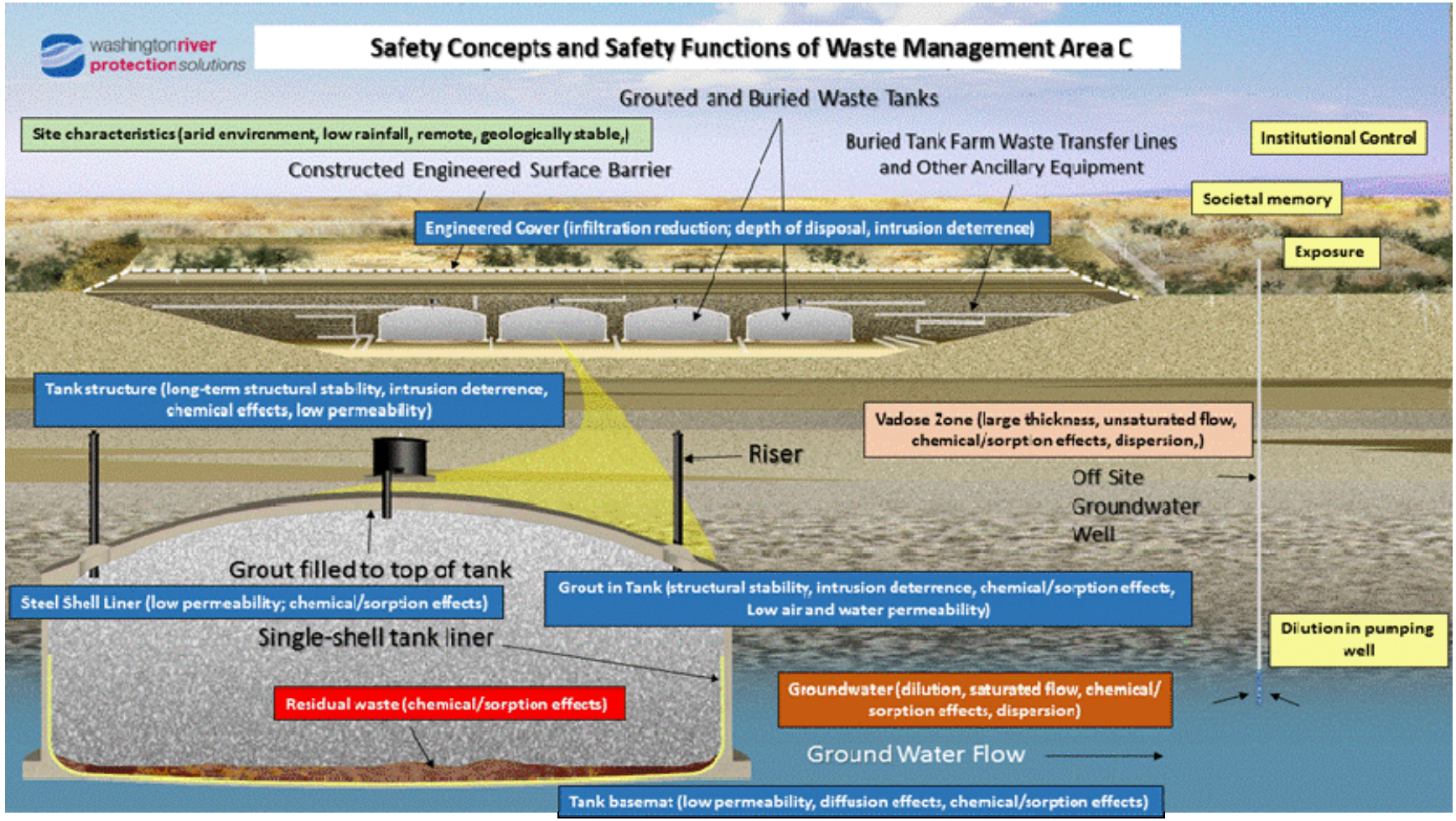


Table 4-1. Comparison of Waste Management Area C RCRA Closure Analysis with Regulatory Standards (Target Risk, Hazard Index/Quotient, and Federal and State Maximum Contaminant Levels/2007 Model Toxics Control Act Method B Groundwater Cleanup Levels) for Period of Analysis. (2 sheets)

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]
Groundwater Protection	**Federal and State Maximum Contaminant Level 2007 Model Toxics Control Act Groundwater Cleanup Levels**			
	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 (WAC) 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

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. (2 sheets)

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]	36 mrem	11.1 mrem
Chronic Inadvertent Intruder (DOE O 435.1 Chg 1)	100 mrem/yr EDE[b]	8.2 mrem/yr[f]	7E-02 mrem/yr[g]
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 100 years following loss of institutional control using a rural pasture exposure scenario. Peak dose occurs at 100 years after closure.

[g] Peak dose based on assumed inadvertent intrusion into a waste transfer line after 1,000 years following loss of institutional control using a suburban garden exposure scenario. Peak dose occurs at 1,000 years after closure.

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.

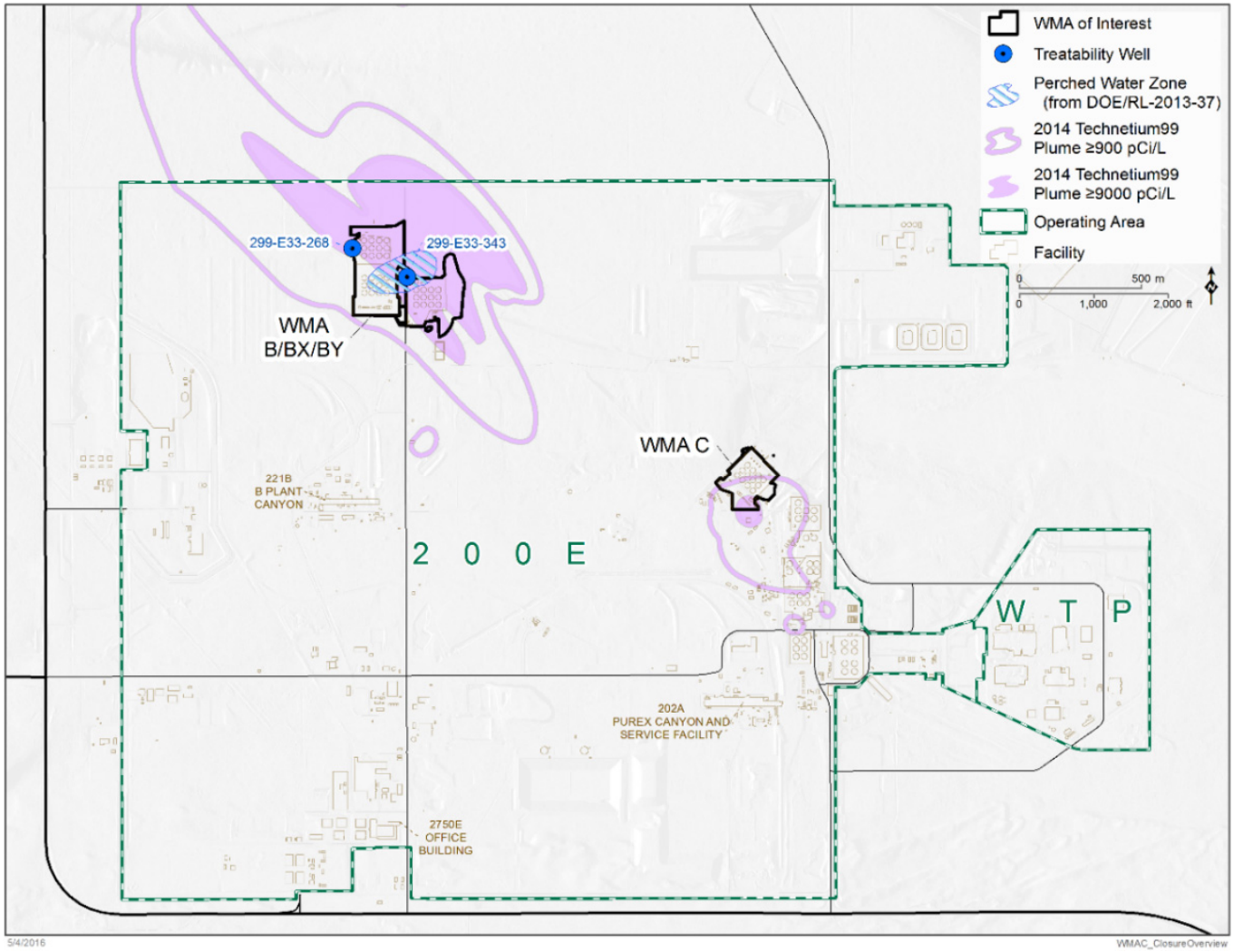
Key Findings from 200-BP-5 Remedial Investigation:

- Cancer risks downgradient from WMA C are 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.
- 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.

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.

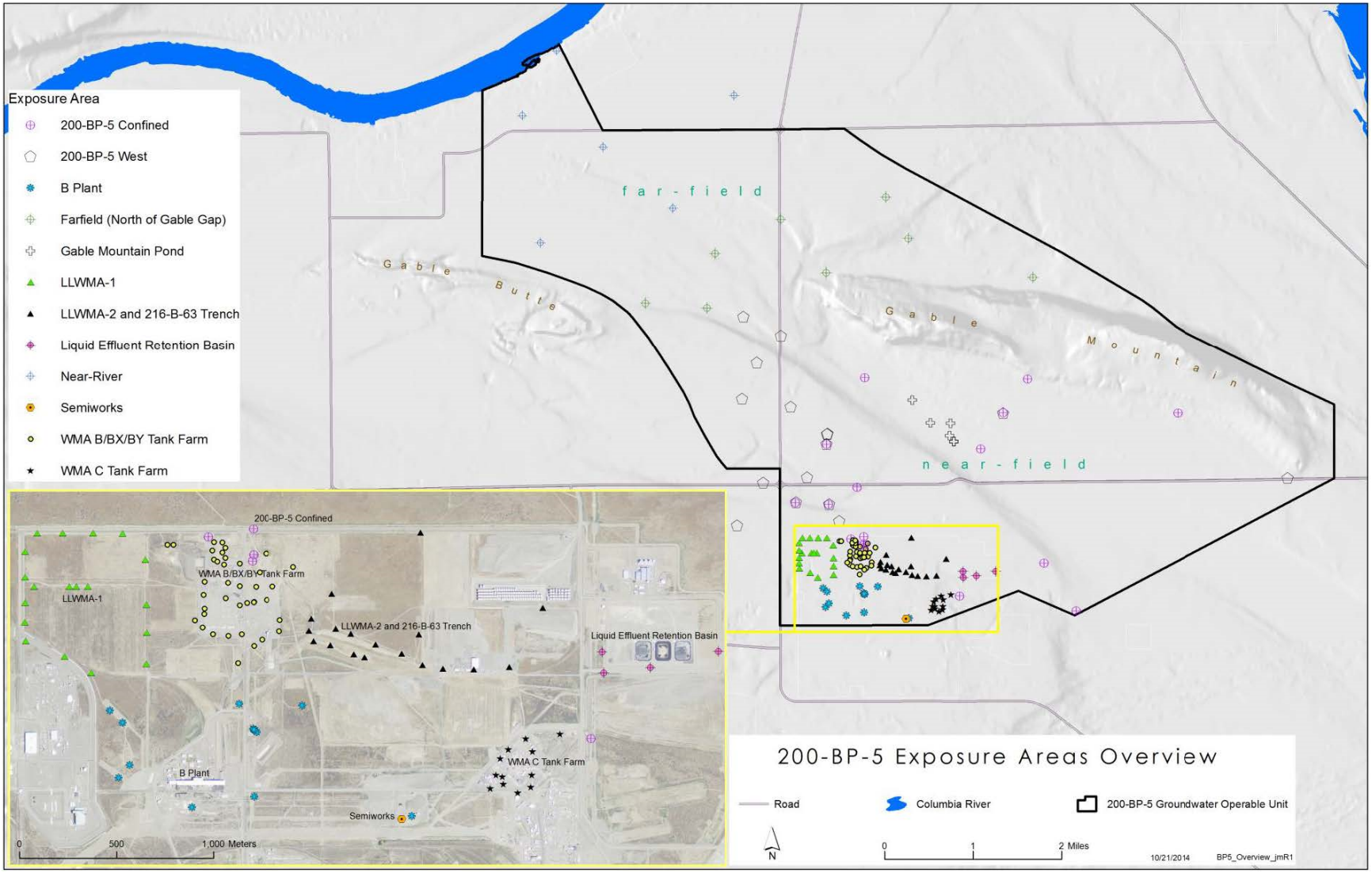
Figure 5-1. Waste Management Area C, B Complex, Existing Technetium-99 Groundwater Contamination, and Perched Water Area.



WMA = Waste Management Area WTP = Waste Treatment Plant

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

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 (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.

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

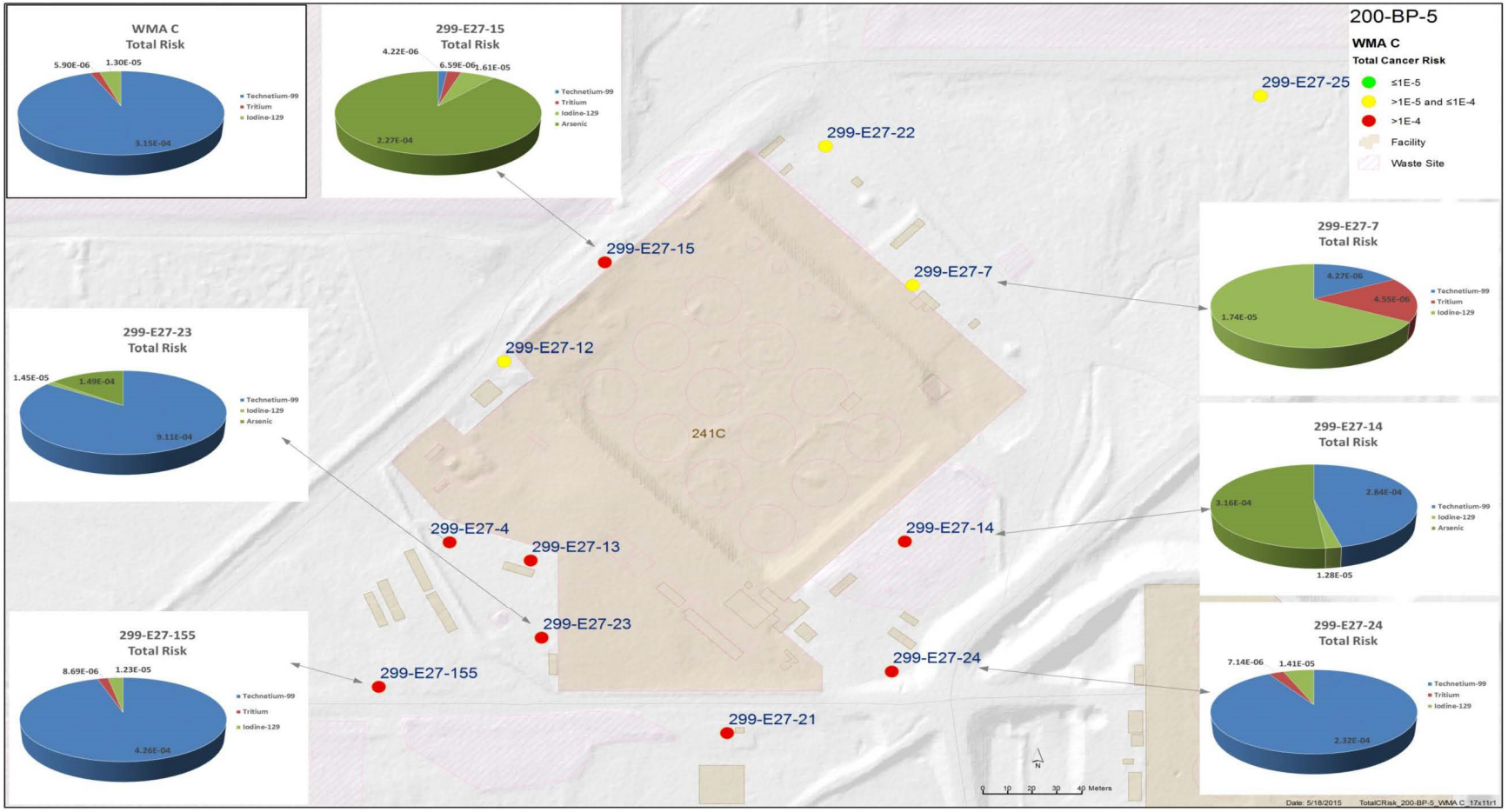
Retained as a COPC	Retained as a COPC for Monitoring
Low-Level Waste Management Area-1	
Cyanide, iodine-129, nitrate, technetium-99, tritium, and uranium	Gross alpha*
Low-Level Waste Management Area-2	
Cyanide, iodine-129, nitrate, technetium-99, tritium, and uranium	Sulfate
Waste Management Area B-BX-BY 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.

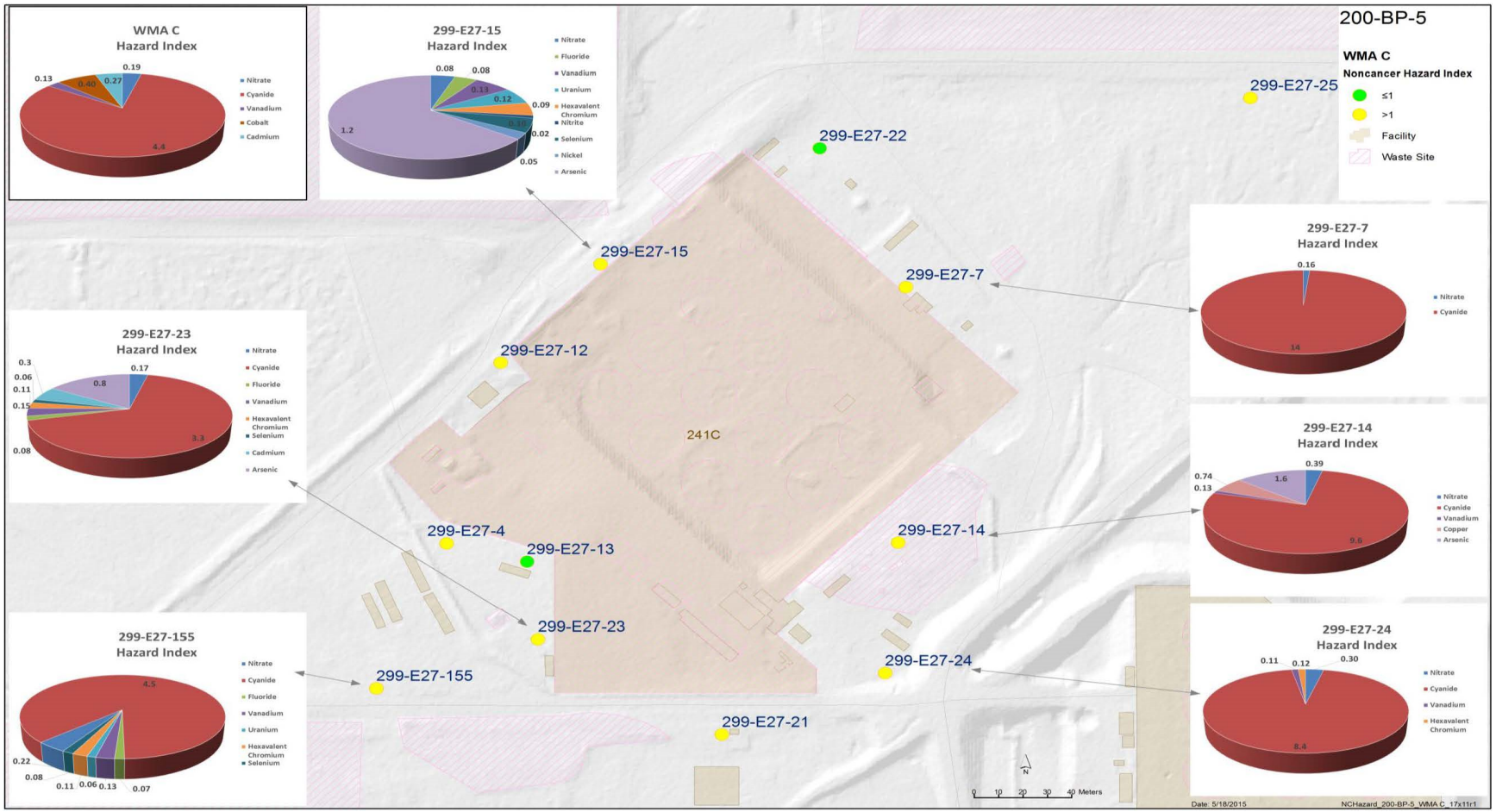
Figure 5-3. Cancer Risk Contributors for Wells Within the Waste Management Area C Exposure Area.



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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