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Revision 1

200-SW-2 Radioactive Landfills Group Operable Unit RCRA Facility Investigation/Corrective Measures Study/Remedial Investigation/Feasibility Study Work Plan

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

U.S. DEPARTMENT OF ENERGY | Richland Operations Office

P.O. Box 550
Richland, Washington 99352

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APPROVED
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Title: *200-SW-2 Radioactive Landfills Group Operable Unit RCRA Facility Investigation/Corrective Measures Study/Remedial Investigation/Feasibility Study Work Plan*

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Executive Summary

This document presents the work plan for a combined *Resource Conservation and Recovery Act of 1976*[1] (RCRA) facility investigation (RFI) corrective measures study (CMS) and *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*[2] (CERCLA) remedial investigation (RI)/feasibility study (FS) to support the final remedy selection for the 200-SW-2 Operable Unit (OU) at the Hanford Site. This work is being performed under RCRA and CERCLA, as amended by the *Hazardous and Solid Waste Amendments of 1984*.[3]

The purpose of the RFI and RI is to determine the nature and extent of contamination and the fate and transport of contaminants in the environment in order to evaluate risks and to select remedies and remedial treatment technologies. This work plan presents the conceptual site models (CSMs) for the 200-SW-2 OU waste sites and identifies the data needs. A sampling and analysis plan (SAP) describing the activities for filling the data needs during the RFI and RI has been prepared and is presented in Appendix A. The results will be documented in the RFI/RI report.

The purpose of the CMS and FS is to develop, screen, and evaluate alternative remedial actions. The results will be documented in the CMS/FS report. The CMS/FS report will also provide the basis for the development of a Proposed Plan/Proposed Corrective Action Decision (PCAD) that describes the preferred remedy for each waste site in the 200-SW-2 OU. The Proposed Plan/PCAD will be issued to the public for review and comment in accordance with 40 CFR 300.430(f)(3).[4] Following the receipt of public comments, a Record of Decision (ROD) will be prepared jointly by the U.S. Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology), and the Corrective Action Decision (CAD) will be prepared by Ecology. Ecology, working in cooperation with the U.S. Department of Energy (DOE)

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[1] *Resource Conservation and Recovery Act of 1976*, 42 USC 6901, et seq. Available at: http://www.epw.senate.gov/rcra.pdf.

[2] *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 USC 9601, et seq., Pub. L. 107-377, December 31, 2002. Available at: http://epw.senate.gov/cercla.pdf.

[3] *Hazardous and Solid Waste Amendments of 1984*, Public Law 98-616, Nov. 8, 1984, 98 Stat. 3221. Available at: https://www.govtrack.us/congress/bills/98/hr2867/text.

[4] 40 CFR 300.430, "National Oil and Hazardous Substances Pollution Contingency Plan," "Remedial Investigation/ Feasibility Study and Selection of Remedy." Available at: http://www.ecfr.gov/cgi-bin/text-idx?SID=461d9723a326c184a2881cba48bda90a&mc=true&node=pt40.28.300&rgn=div5#se40.28.300_1430.

and EPA, will finalize the ROD. The ROD documents the CERCLA remedial action decision for each waste site. The CAD documents the RCRA corrective action decision for each of the waste sites that are subject to corrective action. Although the CAD and ROD could be issued separately, a single CAD/ROD document is recommended to ensure that the selected cleanup decisions are compatible for implementation. The CAD/ROD will also contain responses to public comments.

Background

In 2009, the DOE Richland Operations Office (DOE-RL) developed a cleanup framework to reduce the size of the Hanford Site active cleanup footprint to the area known as the Central Plateau. The Central Plateau is in the central portion of the Hanford Site and encompasses approximately 195 km^2 (75 mi^2). The two major geographic cleanup areas within the Central Plateau are the 170 km^2 (65 mi^2) Outer Area and the 25 km^2 (10 mi^2) Inner Area. The 200-SW-2 OU is located in the west and east Inner Areas.

The 200-SW-2 OU includes 24 landfills (Table ES-1; Figures ES-1 and ES-2) and 14 collocated waste sites. Seven of the landfills are RCRA treatment, storage, and/or disposal units, and 17 of the landfills are past-practice waste sites. The collocated sites include 11 unplanned release sites, the Z Plant burn pit, the T Ponds, and the 216-C-9 Pond. The landfills are excavated trenches that received several waste types, including the following:

- Unsegregated waste, which is defined as waste that was disposed prior to regulations being in effect that would cause it to be defined as one of the following waste categories.
- Low-level waste, which is defined as radioactively contaminated waste that does not meet the criteria for high-level waste or transuranic (TRU) waste.
- Mixed low-level waste and TRU mixed waste, which are defined as low-level waste or TRU waste that contains dangerous waste components.

Table ES-1. Summary Information for the 200-SW-2 OU Landfills

Landfill	Number of Trenches	Volume[a] of Buried Waste		Area[a]	
		m^3	ft^3	ha	ac
Eastern Inner Area (12 Landfills)					
218-C-9[b]	1	7,600	270,000	1.8	4.5
218-E-1	15	3,000	110,000	1.0	2.4
218-E-2	9	9,000	320,000	1.3	3.3
218-E-2A	[c]	[c]	[c]	0.3	0.7
218-E-4	[d]	1,600	57,000	1.2	2.9
218-E-5	2	3,200	110,000	1.1	2.6
218-E-5A	1	6,200	220,000	0.38	0.9
218-E-8	1	2,300	81,000	0.44	1.1
218-E-9	[c]	[c]	[c]	0.56	1.4
218-E-10[e]	14	26,000	920,000	23	57
	Portion that was unused			13	32
218-E-12A	28	15,000	530,000	10	25
218-E-12B[e]	39	66,000	2,300,000	23	57
	Portion that was unused			26	64
	U.S. Navy nuclear reactors (out of scope)			21	52
Western Inner Area (12 Landfills)					
218-W-1	15	7,200	250,000	2.2	5.5
218-W-1A	12	14,000	490,000	3.4	8.4
218-W-2	20	8,200	290,000	2.8	7.0
218-W-2A[f]	27[g]	25,000	880,000	15.3	38
218-W-3	20	11,000	390,000	3.1	7.6
218-W-3A[e]	61[g]	98,000	3,400,000	21	52
218-W-3AE[e,f]	8	34,000	1,200,000	20	49
218-W-4A	22	18,000	640,000	7.0	17
218-W-4B[e]	15	7,300	260,000	3.5	8.6

Table ES-1. Summary Information for the 200-SW-2 OU Landfills

Landfill	Number of Trenches	Volume[a] of Buried Waste		Area[a]	
		m^3	ft^3	ha	ac
218-W-4C[e,h]	16[g]	15,000	530,000	15	37
	Portion that was unused			4.3	11
218-W-5[e]	11	72,000	2,500,000	24	59
	Lined trenches 31 and 34 (out of scope)			10	25
218-W-11	2[i]	1,200	42,000	0.87	2.1
Totals	**339**	**450,000**	**16,000,000**	**257**	**634**

a. All numbers are estimates based on historical information, rounded to two significant figures (including total waste volumes). Waste volumes include in-scope waste only.

b. The 218-C-9 Landfill is collocated with the 216-C-9 Pond.

c. The 218-E-2A and 218-E-9 Landfills may have been used only for aboveground storage of contaminated equipment. There are no records or inventories of disposal.

d. The number of trenches and total length are unknown.

e. Landfill is a permitted treatment, storage, and/or disposal unit landfill under RCRA. These landfills include the "Green Islands" (see Figures ES-1 and ES-2 for Green Island locations).

f. The 218-W-2A and 218-W-3AE Landfills are collocated with the 216-T-4, 216-T-4A, and 216-T-4B Ponds and the 216-T-4-2 Ditch.

g. Five of the trenches in the 218-W-2A Landfill, four in the 218-W-3A Landfill, and one in the 218-W-4C Landfill were not used. These numbers include the unused trenches.

h. The 218-W-4C Landfill is collocated with the Z Plant burn pit.

i. Geophysical investigations conducted in 2006 suggest that only one trench exists.

The 200-SW-2 OU landfills contain approximately 450,000 m^3 (590,000 yd^3) of waste. This waste is a heterogeneous mixture of solid waste generated during various operating periods that began in the mid-1940s and ended in about 2005. All landfill waste included in the 200-SW-2 OU has been buried in trenches that were designed and constructed to varying lengths, widths, and depths. Additional information on each of the landfills is provided in the CSMs (Appendix D).

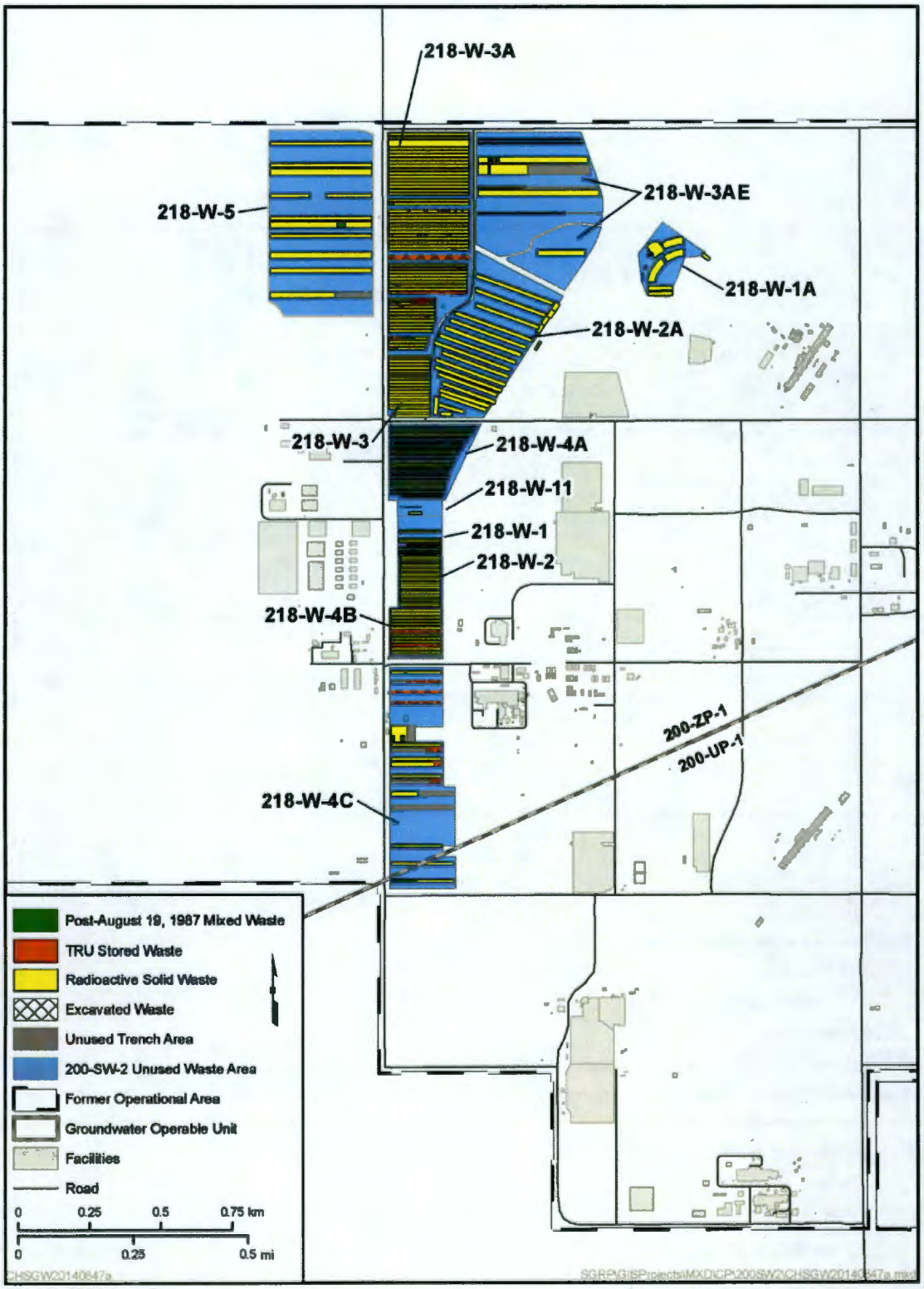

Figure ES-1. Location of 200-SW-2 OU Landfills in the Western Portion of the Inner Area

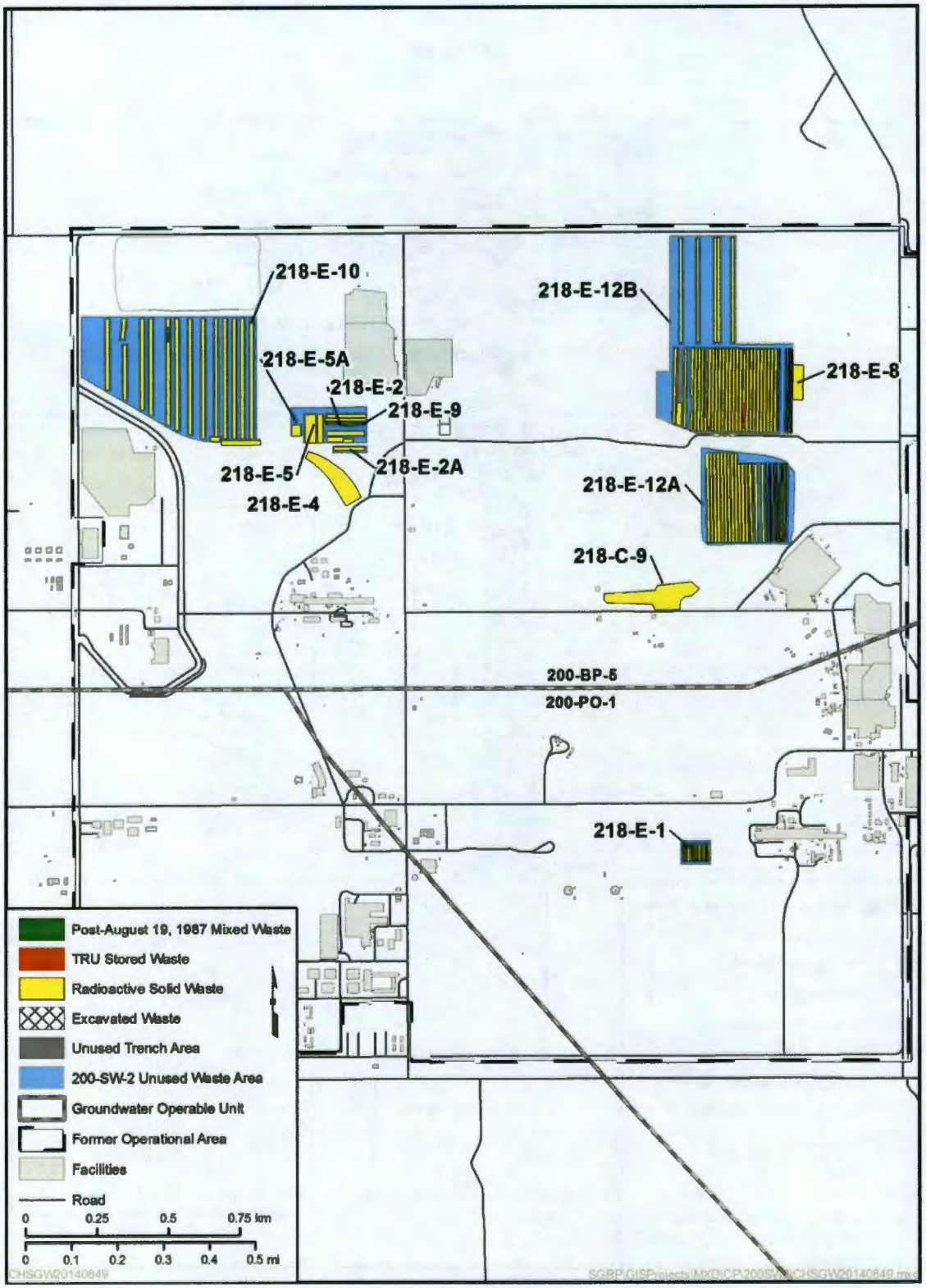

Figure ES-2. Location of 200-SW-2 OU Landfills in the Eastern Portion of the Inner Area

DOE-RL is required to remove post-1970 stored TRU waste in the west and east Inner Areas under Tri-Party Agreement (TPA) (Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Order*[5]) Milestones M-091-40 and M-091-41. This work is ongoing, and the activities described in this work plan will be integrated with the TPA Milestone M-091 removal activities.

The 200-SW-2 OU decision process will include the following activities:

- Investigate the nature and extent of contamination from the ground surface to the groundwater.
- Evaluate potential impacts to human health and the environment.
- Evaluate potential impacts on groundwater.
- Evaluate a combination of proven and emerging technologies for characterizing, remediating, and monitoring the radioactive landfill.
- Evaluate, select, and implement remedial solutions for contamination to protect human health, the environment, and groundwater.

Characterization to investigate the nature and extent of contamination at the 200-SW-2 OU landfills will be conducted using a variety of technologies. The first phase will consist of nonintrusive investigations including aerial radiation surveys, baseline and advanced geophysics (multi-channel analysis of surface waves), and passive soil gas sampling. The results of the nonintrusive investigations will guide the location of the intrusive investigations, which will include horizontal borings, direct-push probes, additional advanced geophysical methods (surface-to-surface and electrical resistivity tomography), active soil gas sampling, and test pits. Soil samples from the horizontal borings and direct pushes will be collected for laboratory analysis.

Work Plan History

The development of the 200-SW-2 OU work plan and the assessment of data needs through the data quality objective (DQO) process occurred in 2014. The DQO summary report is provided in Appendix J. The characterization activities designed to fill the data

[5] Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order*, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington. Available at: http://www.hanford.gov/?page=81.

needs identified during the 2014 DQO process are described in the SAP (Appendix A). The CSMs (Appendix D) support the DQO and SAP.

If during the RFI/CMS/RI/FS processes additional data needs are identified to support development of remedial alternatives, a supplemental DQO summary report and SAP or SAP addendum may be developed.

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Terms

AEA	*Atomic Energy Act of 1954*
amsl	above mean sea level
ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
BRA	baseline risk assessment
CAD	corrective action decision
CCU	Cold Creek unit
CCU_c	CCU – calcic
CCU_g	CCU – gravel dominated
CCU_z	CCU – silt dominated
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
CHPRC	CH2M HILL Plateau Remediation Company
CMI	corrective measures implementation
CMS	corrective measures study
COC	contaminant of concern
COPC	contaminant of potential concern
CSM	conceptual site model
DOE	U.S. Department of Energy
DOE-RL	DOE Richland Operations Office (also known as RL)
DNAPL	dense nonaqueous-phase liquid
DQA	data quality assessment
DQO	data quality objective
DVZ	deep vadose zone
DWS	drinking water standard
Ecology	Washington State Department of Ecology
Eco-SSL	ecological soil screening level

EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ERA	ecological risk assessment
ERDF	Environmental Restoration Disposal Facility
ERT	electrical-resistivity tomography
FS	feasibility study
FY	fiscal year
HAB	Hanford Advisory Board
HCP-EIS	*Final Hanford Comprehensive Land Use Plan Environmental Impact Statement* (DOE/EIS-0222-F)
HHE	human health and the environment
HHRA	human health risk assessment
HMS	Hanford Meteorological Station
IDF	Integrated Disposal Facility
IDW	investigation-derived waste
IRIS	Integrated Risk Information System
K_d	distribution coefficients
LERF	Liquid Effluent Retention Facility
LLBG	low-level burial ground
LLW	low-level waste
LLWMA	low-level waste management area
MASW	multi-channel analysis of surface waves
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MLLW	mixed low-level waste
MNA	monitored natural attenuation
MTCA	"Model Toxics Control Act—Cleanup" (WAC 173-340)
N/A	not applicable
NAPL	nonaqueous-phase liquid
NCEA	National Center for Environmental Assessment

NCP	National Contingency Plan (40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan")
NPL	National Priorities List (40 CFR 300, Appendix B)
O&M	operations and maintenance
OU	operable unit
P&T	pump-and-treat
PCAD	proposed corrective action decision
PCB	polychlorinated biphenyl
PFP	Plutonium Finishing Plant
PNNL	Pacific Northwest National Laboratory
POC	point of compliance
PP	proposed plan
PRG	preliminary remediation goal
PPRTV	provisional peer reviewed toxicity value
PSQ	principal study question
PUREX	Plutonium-Uranium Extraction (Plant or process)
QAPjP	quality assurance project plan
RA	remedial action
RAO	remedial action objective
RAWP	remedial action work plan
RCRA	*Resource Conservation and Recovery Act of 1976*
RCW	*Revised Code of Washington*
RD	remedial design
RDR	remedial design report
RECUPLEX	Recovery of Uranium and Plutonium by Extraction
REDOX	Reduction-Oxidation Plant
RFI	RCRA facility investigation
RI	remedial investigation
RLM	Ringold Formation lower mud (unit)
Rtf	Ringold Formation member of Taylor Flat

Rwia	Ringold Formation member of Wooded Island – unit a
Rwie	Ringold Formation member of Wooded Island – unit e
ROD	Record of Decision
RSW	retrievably stored waste
RTD	remove, treat, and/or dispose
SALDS	State-Approved Land Disposal Site
SAP	sampling and analysis plan
SDWA	*Safe Drinking Water Act of 1974*
SIM	Soil Inventory Model
SMDP	scientific management decision point
SSL	soil screening level
SST	single-shell tank
STOMP	Subsurface Transport Over Multiple Phases
STS	surface-to-surface
SVE	soil vapor extraction
SWITS	Solid Waste Information and Tracking System
TBC	to be considered
TCE	trichloroethene
TEDF	Treated Effluent Disposal Facility
TI	technical impracticability
TNC	The Nature Conservancy
TOC	total organic carbon
TPA	Tri-Party Agreement
Tri-Parties	U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Ecology
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order* (Ecology et al., 1989a)
TRU	transuranic
TRUM	TRU mixed waste
TSD	treatment, storage, and/or disposal
UCL	upper confidence limit

UPR	unplanned release
USG	unsegregated waste
VOC	volatile organic compound
WAC	*Washington Administrative Code*
WIDS	Waste Information Data System
WMA	waste management area

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Glossary

Burial ground: At the Hanford Site, a burial ground is synonymous with the term landfill. Many of the 200 Area landfills that are part of the 200-SW-2 Operable Unit used the term burial ground as part of the formal name (e.g., Equipment Burial Ground 2; also called 218-E-2). A 200-SW-2 Operable Unit burial ground typically had defined disposal trenches used for disposal of solid waste. Trench dimensions varied based on the type of waste being disposed.

Class A and B poisons: As defined in 49 CFR 173,[6] a material, other than a gas, that is known to be so toxic (Class A – Extremely Dangerous Poison) (Class B – Less Dangerous Poison) to humans as to afford a hazard to health during transportation; or which, in the absence of adequate data on human toxicity, is presumed to be toxic to humans because it falls within any one of the following categories when tested on laboratory animals: oral toxicity, dermal toxicity, or inhalation toxicity. Poisons must enter the body to cause injury or illness, and usually only a small amount of material is necessary. The extent of injury depends on the route of exposure, the concentration or strength of the chemical, and the length of exposure time.

Contact-handled waste: Packaged waste for which the external surface dose rate does not exceed 200 mrem/hr and does not create a high radiation area (greater than 100 mrem/hr at 30 cm).

Dangerous waste: Solid waste designated in WAC 173-303-070 through WAC 173-303-100[7] as dangerous or extremely hazardous waste, or mixed waste. Waste disposed before August 19, 1987, is not designated as dangerous waste according to the *Washington Administrative Code*, regardless of the current regulatory status.

Disposal: As used in this document, placement of waste with no intent of future retrieval; statutory or regulatory definitions may differ.

Dump: As used in this document, a dump is a disposal area that is not pre-planned. Designed and constructed "dump" sites (or suspected dumpsites) that once were included in the 200-SW-2 Operable Unit for remedial investigation now reside within the 200-MG-1 Operable Unit.

Gradient: The change in the value of a quantity (e.g., concentration) with change in a given variable per unit distance in a specified direction.

Green Islands: Mixed waste disposed after August 19, 1987, is subject to the RCRA treatment, storage, and disposal unit standards. Mixed waste disposed to the RCRA landfills after the effective date of regulation historically has been coded on the RCRA Part A Permit application maps with the color green. These disposal locations have been referred to as "Green Islands." The Green Islands are subject to regulation as RCRA landfills.

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[6] 49 CFR 173, "Transportation," "Shippers—General Requirements for Shipments and Packagings," *Code of Federal Regulations*. Available at: http://www.ecfr.gov/cgi-bin/text-idx?SID=ddf70b4de104a7b4b688f97a7da5ea0e&mc=true&node=pt49.2.173&rgn=div5.

[7] WAC 173-303-070 through 173-303-100, "Dangerous Waste Regulations," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303.

Hazardous waste; Solid waste that contains chemically hazardous constituents regulated under Subtitle C of RCRA, as amended (40 CFR 261[8]), and regulated as a hazardous waste and/or mixed waste by the U.S. Environmental Protection Agency. May also include solid waste designated by Washington State as dangerous waste. Hazardous constituents were not regulated until August 19, 1987, and are not designated as hazardous waste unless disposed after that date.

Landfill: As defined in WAC 173-303-040,[9] a disposal facility, or part of a facility, where dangerous waste is placed in or on land and that is not a pile, a land treatment facility, a surface impoundment, or an underground injection well; a salt dome formation; a salt bed formation; an underground mine; a cave; or a corrective action management unit. The performance standards for disposal facilities under DOE O 435.1 Chg 1[10] are functionally equivalent to the *Washington Administrative Code* requirements for landfills.

Low-level (radioactive) waste (LLW): Radioactive waste that is not high-level waste, spent nuclear fuel, transuranic waste, byproduct material (as defined in Section 11e (2) of the *Atomic Energy Act of 1954*,[11] as amended), or naturally occurring radioactive material.

Mixed low-level waste (MLLW): Waste that meets the definition of low-level waste and that also contains a hazardous component subject to RCRA, as amended, or WAC 173-303.[12] Mixed low-level waste is considered to be only the type of waste that was disposed after August 19, 1987.

Radioactive waste: Waste that is managed for its radioactive content. Waste material that contains source, special nuclear, or byproduct material is subject to regulation as radioactive waste under the *Atomic Energy Act of 1954*.

Remedial action: Activities conducted under CERCLA authority to reduce potential risks to people and/or harm to the environment from radioactive and/or hazardous substance (including radionuclide) contamination.

Remote-handled waste: Packaged radioactive waste for which the external dose rate exceeds that defined for contact-handled waste (generally less than or equal to 200 mrem/hr at the container surface). This waste requires handling using remotely controlled equipment or placement in shielded containers to reduce human exposure during routine waste management activities. About 1,000 burials are designated as remote handled, but have dose rates much lower than 200 mrem/hr. Most of these exceptions are caisson waste, which always was remotely handled.

Retrievably stored waste (RSW): Waste packaged and stored in a manner that allows retrieval at a future time. Transuranic (TRU) waste was not retrievably stored until May 1970, to distinguish between retrievably stored TRU waste and pre-1970 transuranic-contaminated material.

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[8] 40 CFR 261, "Identification and Listing of Hazardous Waste," *Code of Federal Regulations*. Available at: http://www.ecfr.gov/cgi-bin/text-idx?SID=8a7691fe4a40d88b69ec75922ca9534b&mc=true&node=pt40.26.261&rgn=div5.

[9] WAC 173-303-040, "Dangerous Waste Regulations," "Definitions," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303-040.

[10] DOE O 435.1 Chg 1, 2007, *Radioactive Waste Management*, U.S. Department of Energy, Washington, D.C. Available at: https://www.directives.doe.gov/directives-documents/0435.1-BOrder-c1.

[11] *Atomic Energy Act of 1954*, 42 USC 2011, Pub. L. 83-703, 68 Stat. 919. Available at: http://epw.senate.gov/atomic54.pdf.

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

Solid waste: As defined in 40 CFR 261.2,[13] any discarded material that is not excluded by 40 CFR 261.4(a)[14] or that is not excluded by variance granted under 40 CFR 260.30[15] and 40 CFR 260.31.[16] A discarded material is any material that is abandoned, recycled, considered inherently waste like, or a military munition.

Transuranic isotope: An isotope of any element having an atomic number greater than -92 (the atomic number of uranium).

Transuranic (TRU) waste: Radioactive waste (generated since 1970) containing more than 100 nCi (3,700 Bq) of alpha-emitting transuranic isotopes per gram of waste with half-lives greater than 20 years.

Transuranic mixed waste (TRUM): Radioactive waste (see definition for "TRU waste") that also contains hazardous constituents. TRUM has mixed waste components disposed after August 19, 1987.

Treatment, storage, and/or disposal (TSD) landfill: A landfill where dangerous waste is placed in or on the land, as defined in WAC 173-303.

Unsegregated (USG) waste: Waste that was disposed prior to regulations being in effect that would cause it to be defined as another type of waste categories.

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[13] 40 CFR 261.2, "Identification and Listing of Hazardous Waste," "Definition of Solid Waste," *Code of Federal Regulations*. Available at: http://www.ecfr.gov/cgi-bin/text-idx?SID=8a7691fe4a40d88b69ec75922ca9534b&mc=true&node=pt40.26.261&rgn=div5#se40.26.261_12.

[14] 40 CFR 261.4, "Identification and Listing of Hazardous Waste," "Exclusions," *Code of Federal Regulations*. Available at: http://www.ecfr.gov/cgi-bin/text-idx?SID=ddf70b4de104a7b4b688f97a7da5ea0e&mc=true&node=pt40.26.261&rgn=div5#se40.26.261_14.

[15] 40 CFR 260.30, "Hazardous Waste Management System: General," "Non-Waste Determinations and Variances from Classification as a Solid Waste," *Code of Federal Regulations*. Available at: http://www.ecfr.gov/cgi-bin/text-idx?SID=ddf70b4de104a7b4b688f97a7da5ea0e&mc=true&node=pt40.26.260&rgn=div5#se40.26.260_130.

[16] 40 CFR 260.31, "Hazardous Waste Management System: General," "Standards and Criteria for Variances from Classification as a Solid Waste," *Code of Federal Regulations*. Available at: http://www.ecfr.gov/cgi-bin/text-idx?SID=ddf70b4de104a7b4b688f97a7da5ea0e&mc=true&node=pt40.26.260&rgn=div5#se40.26.260_131.

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1 Introduction

This document presents the work plan for a combined *Resource Conservation and Recovery Act of 1976* (RCRA) facility investigation (RFI)/corrective measures study (CMS) and remedial investigation (RI)/feasibility study (FS) to support the final remedy selection for the 200-SW-2 Operable Unit (OU) at the Hanford Site. This work is being performed under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) and RCRA, as amended by *Hazardous and Solid Waste Amendments of 1984*.

The Hanford Site consists of approximately 1,517 km^2 (586 mi^2) in the Columbia River Basin of southeastern Washington State. In 1989, the U.S. Environmental Protection Agency (EPA) placed the 100, 200, 300, and 1100 Areas of the Hanford Site on the National Priorities List (NPL) (40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan" [NCP], Appendix B, "National Priorities List") pursuant to CERCLA.[1] Each NPL site is divided into multiple OUs, as outlined in the Tri-Party Agreement (TPA) (Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Order*). The 200-SW-2 OU is part of the 200 Area NPL site.

In 2009, the U.S. Department of Energy (DOE), Richland Operations Office (DOE-RL) developed a cleanup framework to reduce the size of the Hanford Site active cleanup footprint to the area known as the Central Plateau. The Central Plateau is approximately 195 km^2 (75 mi^2) and encompasses the 200 Area NPL site. The two major geographic cleanup areas within the Central Plateau include the 170 km^2 (65 mi^2) Outer Area and the 25 km^2 (10 mi^2) Inner Area (Figure 1-1). The 200-SW-2 OU is located in the Central Plateau Inner Area.

This work plan was prepared in response to TPA (Ecology et al., 1989a) Milestone M-015-113, which requires a revised RFI/CMS/RI/FS work plan for the 200-SW-2 OU to be submitted to the Washington State Department of Ecology (Ecology), the lead regulatory agency for the 200-SW-2 OU. This work plan was prepared in accordance with the following guidance documents:

- DOE/EH-94007658, *Remedial Investigation/Feasibility Study (RI/FS) Process, Elements, and Techniques*
- EPA 530/SW-89-031, *Interim Final RCRA Facility Investigation (RFI) Guidance*
- EPA/240/B-06/001, *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA QA/G-4)
- EPA/540/G-89/004, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (Note: Section 6.2.3.7 associated with cost estimating has been superseded by EPA 540-R-00-002, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*.)
- EPA/540/G-91/011, *Guidance on RCRA Corrective Action Decision Documents*

[1] The 1100 Area was removed from the NPL (40 CFR 300, Appendix B) in September 1996.

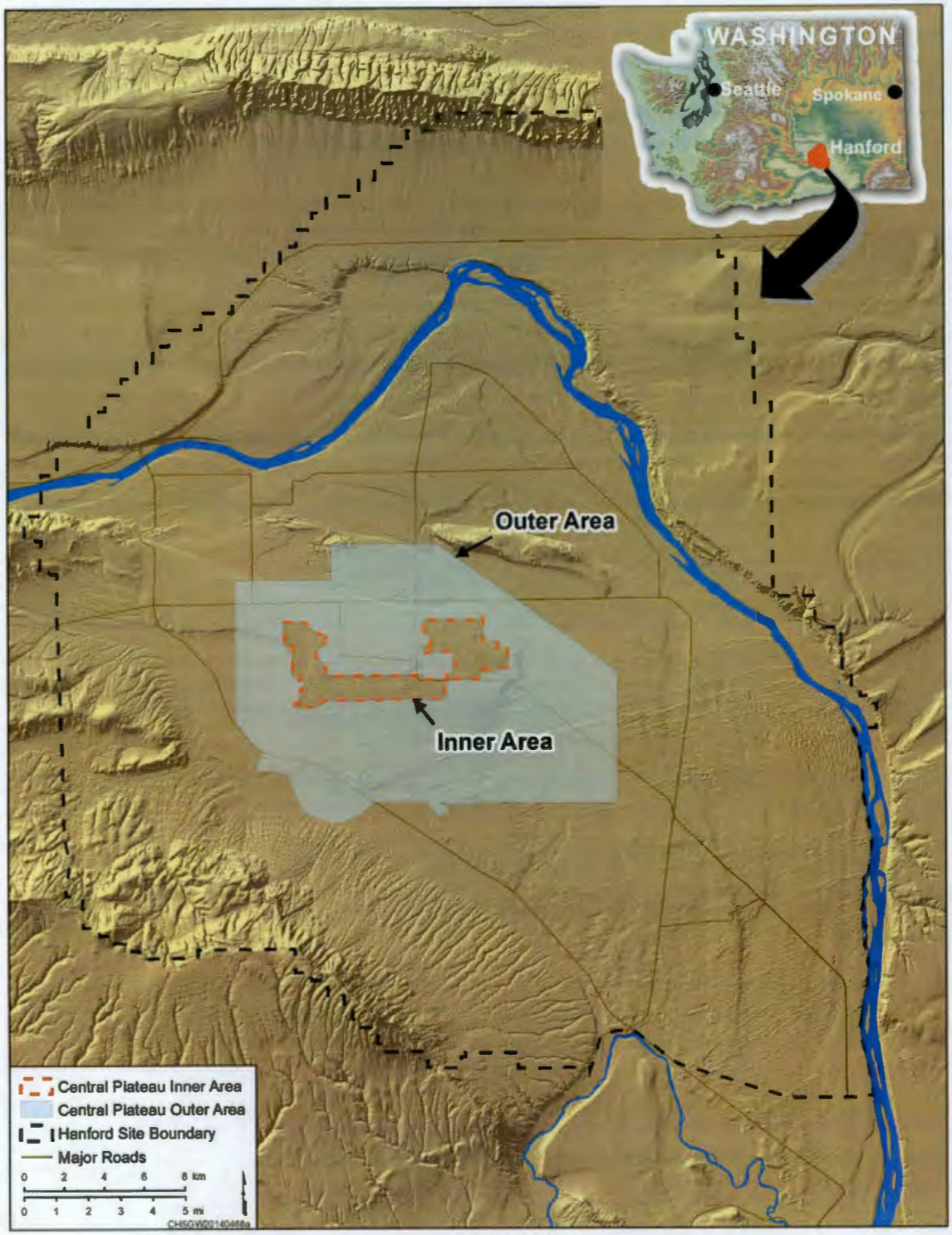

Figure 1-1. Hanford Site

1.1 Scope and Objectives

The goal of the 200-SW-2 OU Project is to implement response actions that will protect human health, the environment, and groundwater from contamination associated with the 200-SW-2 OU waste sites.

Currently, 24 landfills are assigned to the 200-SW-2 OU. The RCRA RFI/CMS process will be combined with the CERCLA RI/FS process. The RFI/CMS/RI/FS report presents the results of the investigation and alternatives analysis. The CERCLA Proposed Plan (PP)/RCRA Proposed Corrective Action Decision (PCAD), the CERCLA Record of Decision (ROD), and RCRA Corrective Action Decision (CAD) processes will be used for decision making. The 200-SW-2 OU decision process will include the following:

- Investigating the nature (type) and extent (special distribution) of contamination from the surface to the groundwater
- Evaluating potential impacts to human health and the environment (HHE)
- Evaluating potential impacts on groundwater and the Columbia River
- Evaluating a combination of proven and emerging technologies for characterizing, remediating, and monitoring contamination
- Evaluating, selecting, and implementing remedial solutions that protect human health, the environment, and groundwater from contamination in the vadose zone

The objectives for the 200-SW-2 OU work plan are as follows:

- Document the current state of knowledge and identify the activities needed to determine a preferred remedy(s).
- Present the rationale and approach for the RFI/CMS/RI/FS.
- Present the available information on the OU and applicable technologies.
- Incorporate the Central Plateau Inner Area cleanup principles.
- Identify data gaps and a data collection strategy.
- Describe the tasks and schedule for the RFI/CMS/RI/FS.
- Achieve concurrence on the scope for the RFI/CMS/RI/FS.

The scope of 200-SW-2 OU includes 24 landfills (see Table 1-1 and Figures 1-2 and 1-3) and 14 collocated waste sites. Seven of the landfills are RCRA treatment, storage, and/or disposal (TSD) units and 17 are past-practice waste sites. The collocated sites include 11 unplanned release (UPR) sites, the Z Plant burn pit, the T Ponds, and the 216-C-9 Pond. The landfills are excavated trenches that received several waste types, including the following:

- Unsegregated waste (USG) is defined as waste that was disposed prior to regulations being in effect that would cause it to be defined as one of the following waste categories.
- Low-level waste (LLW) is defined as radioactively contaminated waste that does not meet the criteria for high-level waste or transuranic (TRU) waste.

Table 1-1. Summary Information for the 200-SW-2 OU Landfills

Landfill	Number of Trenches	Total Length of Trenches (Cumulative)		Volume[a] of Buried Waste		Area[a]	
		km	mi	m^3	ft^3	ha	ac
Eastern Inner Area (12 Landfills)							
218-C-9[b]	1	0.4	0.3	7,600	270,000	1.8	4.5
218-E-1	15	0.9	0.6	3,000	110,000	1.0	2.4
218-E-2	9	0.2	0.2	9,000	320,000	1.3	3.3
218-E-2A	[c]	[c]	[c]	[c]	[c]	0.3	0.7
218-E-4	[d]	[d]	[d]	1,600	57,000	1.2	2.9
218-E-5	2	0.2	0.1	3,200	110,000	1.1	2.6
218-E-5A	1	<0.1	<0.1	6,200	220,000	0.38	0.9
218-E-8	1	0.1	0.1	2,300	81,000	0.44	1.1
218-E-9	[c]	[c]	[c]	[c]	[c]	0.56	1.4
218-E-10[e]	14	5.3	3.3	26,000	920,000	23	57
	Portion that was unused					13	32
218-E-12A	28	7.8	4.8	15,000	530,000	10	25
218-E-12B[e]	39	11.9	7.4	66,000	2,300,000	23	57
	Portion that was unused					26	64
	U.S. Navy nuclear reactors (out of scope)					21	52
Western Inner Area (12 Landfills)							
218-W-1	15	1.2	0.8	7,200	250,000	2.2	5.5
218-W-1A	12	0.5	0.3	14,000	490,000	3.4	8.4
218-W-2	20	2.9	1.8	8,200	290,000	2.8	7.0
218-W-2A[f]	27[g]	4.1	2.6	25,000	880,000	15.3	38
218-W-3	20	2.8	1.8	11,000	390,000	3.1	7.6
218-W-3A[e]	61[g]	14.3	8.9	98,000	3,400,000	21	52
218-W-3AE[e,f]	8	2.9	1.8	34,000	1,200,000	20	49
218-W-4A	22	5.0	3.1	18,000	640,000	7.0	17
218-W-4B[e]	15	2.4	1.5	7,300	260,000	3.5	8.6
218-W-4C[e,h]	16[g]	3.0	1.8	15,000	530,000	15	37
	Portion that was unused					4.3	11

Table 1-1. Summary Information for the 200-SW-2 OU Landfills

Landfill	Number of Trenches	Total Length of Trenches (Cumulative)		Volume[a] of Buried Waste		Area[a]	
		km	mi	m^3	ft^3	ha	ac
218-W-5[e]	11	3.6	2.4	72,000	2,500,000	24	59
	Lined trenches 31 and 34 (out of scope)					10	25
218-W-11	2[i]	0.1	0.1	1,200	42,000	0.87	2.1
Total	**339**	**70**	**44**	**450,000**	**16,000,000**	**257**	**634**

a. All numbers are estimates based on historical information, rounded to the nearest tenth (trench length) or two significant figures (waste volume and area). Waste volumes include in-scope waste only.

b. The 218-C-9 Landfill is collocated with the 216-C-9 Pond.

c. The 218-E-2A and 218-E-9 Landfills may have been used only for aboveground storage of contaminated equipment. There are no records or inventories of disposal.

d. The number of trenches and total length are unknown.

e. Landfill is a permitted treatment, storage, and/or disposal unit landfill under the *Resource Conservation and Recovery Act of 1976*. These landfills include the "Green Islands" (see Figures 1-2 and 1-3 for the Green Island locations).

f. The 218-W-2A and 218-W-3AE Landfills are collocated with the 216-T-4, 216-T-4A, and 216-T-4B Ponds and the 216-T-4-2 Ditch.

g. Five of the trenches in the 218-W-2A Landfill, four in the 218-W-3A Landfill, and one in the 218-W-4C Landfill were not used. These numbers include the unused trenches.

h. The 218-W-4C Landfill is collocated with the Z Plant burn pit.

i. 2006 geophysical investigations suggest that only one trench exists.

- Mixed low-level waste (MLLW) and TRU mixed waste (TRUM) are defined as LLW or TRU waste that contain dangerous waste components.
- TRU waste is defined in DOE G 435.1, *Implementation Guide for Use with DOE M 435.1*, p. III-1, as radioactive waste containing more than 100 nCi (3,700 Bq) of alpha-emitting TRU isotopes per gram of waste, with half-lives greater than 20 years, except for the following:
  - High-level radioactive waste
  - Waste that the Secretary of Energy has determined, with the concurrence of the EPA administrator, does not need the degree of isolation required by 40 CFR 191, "Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes," disposal regulations
  - Waste that the U.S. Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with 10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Waste"

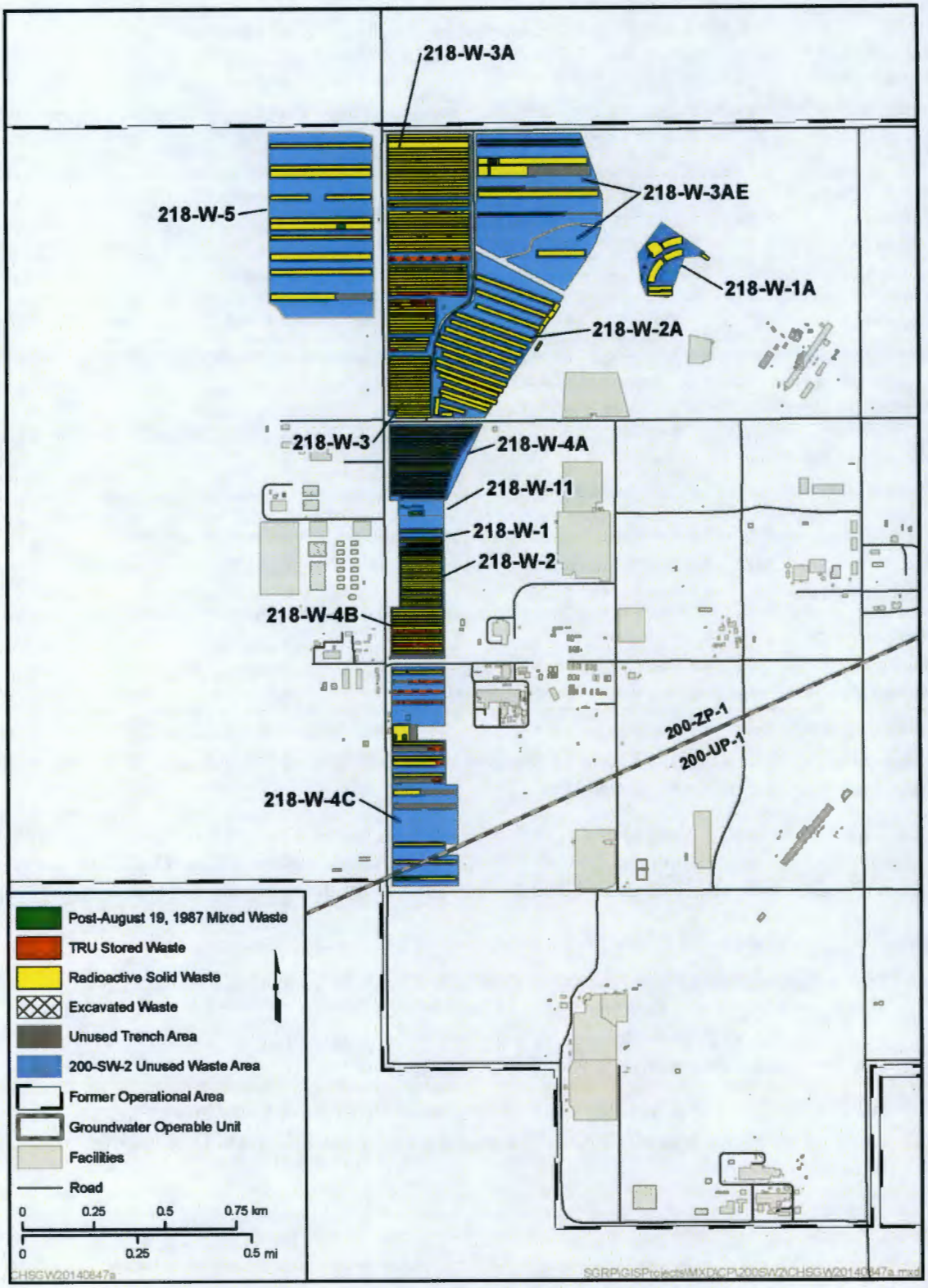

Figure 1-2. Location of 200-SW-2 OU Landfills in the Western Portion of the Inner Area

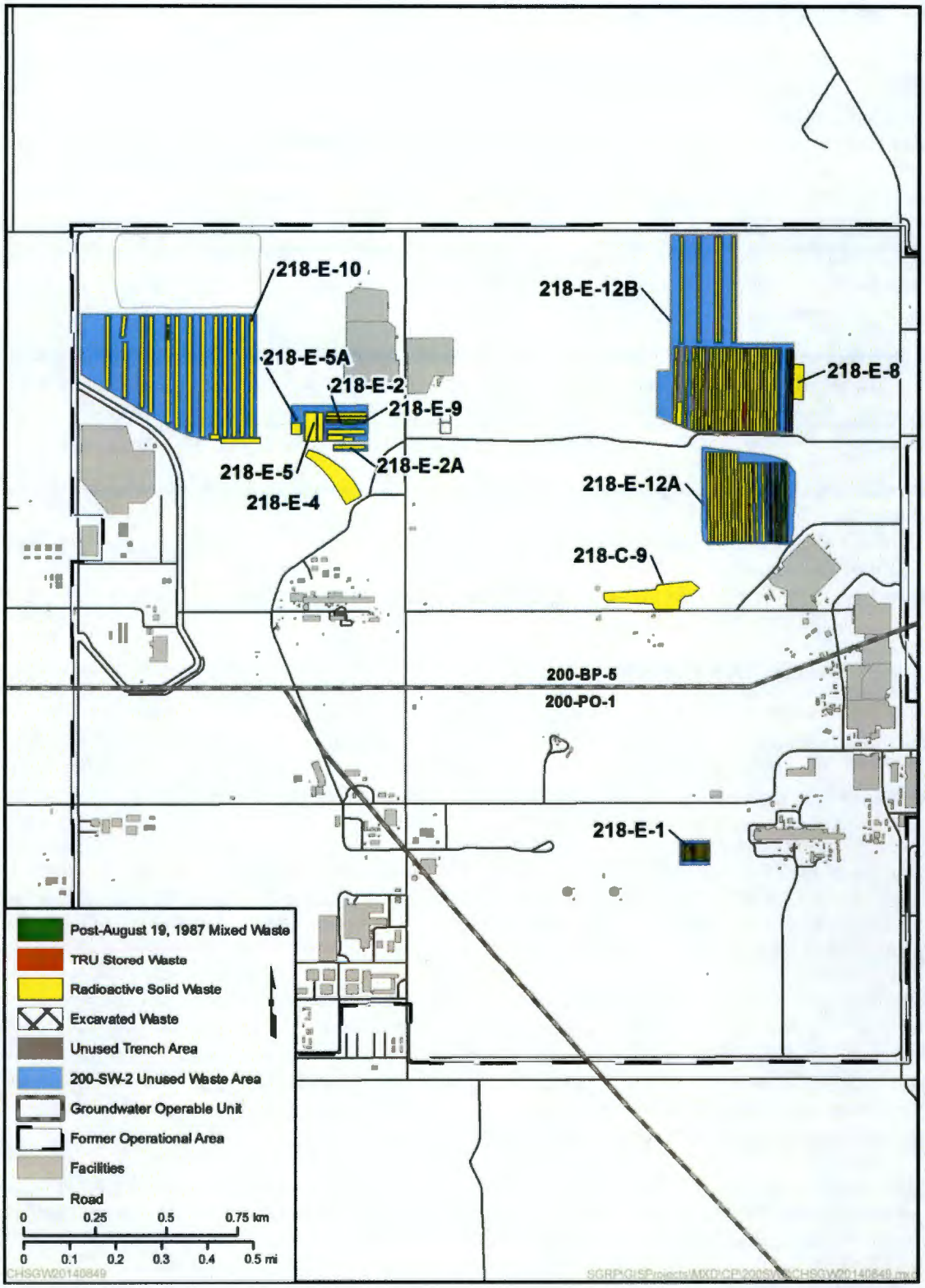

Figure 1-3. Location of 200-SW-2 OU Landfills in the Eastern Portion of the Inner Area

1.2 RCRA-CERCLA Process

RCRA and CERCLA are the principle regulatory authorities for all cleanup activities on the Hanford Site. A detailed description of the CERCLA response action process is provided on the EPA website available at: www.epa.gov/superfund. EPA has delegated the RCRA program to the state of Washington. Ecology implements the program (which includes oversight of permitting, TSD unit closure and RCRA corrective action) via Washington's *Hazardous Waste Management Act* (RCW 70.105, "Hazardous Waste Management"); WAC 173-303, "Dangerous Waste Regulations"; and through facility-specific permitting actions. RCRA closure and post-closure requirements are or will be contained in the Hanford Facility RCRA Permit (*Hanford Facility Resource Conservation and Recovery Act Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste* [hereafter referred to as the "Permit"]), as necessary.

The TPA (Ecology et al., 1989a) implements the agreement among DOE, EPA, and Ecology (referred to as the Tri-Parties) to jointly pursue CERCLA remedial actions, RCRA corrective actions, and RCRA TSD unit (hereafter referred to as "TSD unit") closure on the Hanford Site. Subsequent to 1989, the TPA has been revised and will continue to be updated, as necessary, per agreement by the Tri-Parties.

DOE-RL is the lead agency responsible for conducting CERCLA remedial actions and RCRA corrective actions at the Hanford Site. Ecology is the lead regulatory agency for the 200-SW-2 OU CERCLA remedial action and RCRA corrective action processes and is the lead regulatory agency responsible for oversight of TSD unit closure at the Hanford Site per Section 5.6 and Appendix C of Ecology et al., 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan* (hereafter referred to as the TPA Action Plan).

1.2.1 RCRA-CERCLA Integration

Section 5.0 of the TPA Action Plan (Ecology et al., 1989b) describes the relationship between the applicable environmental regulatory authorities. It includes a coordinated CERCLA remedial action and RCRA corrective action process for past-practice unit management and cleanup, as well as a process for coordinating past-practice unit cleanup with TSD unit closure in a manner that satisfies the relevant regulatory requirements.

Section 5.4 of the TPA Action Plan (Ecology et al., 1989b) further describes the rationale for establishing OUs as either RCRA-CERCLA past-practice (R-CPP) or CERCLA past-practice (CPP) unit categories for cleanup. The 200-SW-2 OU is an R-CPP OU. The R-CPP units and TSD units associated with the 200-SW-2 OU are listed in Appendix C of the TPA Action Plan.

R-CPP units within the 200-SW-2 OU will be remediated through the processes and activities described in Section 7.4 of the TPA Action Plan (Ecology et al., 1989b). Section 5.5 of the TPA Action Plan describes the interface between TSD units and R-CPP units and defines the process for coordinating the TSD unit closure, corrective action, or permitting activity with the past-practice unit investigation and remediation activity. The following apply when coordinating the TSD unit closure process with the CERCLA remedial action/RCRA corrective action processes:

- The TPA Action Plan (Ecology et al., 1989b) envisions coordinating the TSD unit closure or permitting activity with the past-practice investigation and remediation activity to prevent overlap and duplication of work (TPA Action Plan, Section 5.5).
- Results from past-practice investigation activities shall be used whenever possible to supplement TSD unit closure investigation activities.

- Closure plans will be incorporated into the Permit through Permit modification.
- In accordance with the Permit, Permit modification is unnecessary for non-TSD units because the cleanup decision is made directly through issuance of the CAD/ROD.
- The Permit provides for closure of TSD units per the closure performance standard under WAC 173-303-610(2), "Closure and Post-Closure."
- The Permit provides for work under other authorities or programs (including work under the TPA) to satisfy corrective action requirements.
- Ecology authority can be applied for alternative closure standards under WAC 173-303-610(1)(e) for eligible TSD units.

As stipulated in the TPA (Ecology et al., 1989a) and the Permit, documentation of the TSD unit closure and the remedy evaluation and selection processes is a requirement of the coordinated TSD unit closure and R-CPP cleanup action process. Figure 1-4 illustrates the flow of the coordinated evaluation and selection processes and the required documentation. The numbers included in Figure 1-4 correspond to the following steps, which describe the major activities associated with documentation of cleanup and closure actions in greater detail:

1. *Complete the RFI/CMS and RI/FS work plan* (TPA Milestone M-015-113). A combined RFI/CMS/RI/FS work plan will define the 200-SW-2 OU scope, identify the waste sites that comprise the OU, assemble and evaluate existing data and information about the waste sites, and identify the activities needed to make decisions pursuant to R-CPP unit and TSD unit investigation and cleanup activities and TSD unit closure. The CERCLA remedial action and RCRA corrective action processes will be coordinated and will include TSD unit permitting and closure activities as required by the Permit. The RFI/CMS/RI/FS work plan includes the sampling and analysis plan (SAP), which will identify characterization to satisfy all 200-SW-2 OU waste site data needs.

2. *Complete the RFI/CMS and RI/FS report and petition for a Director's determination for alternative closure requirements*. A single RFI/CMS/RI/FS report will coordinate the evaluations required by the CERCLA RI/FS and the RCRA RFI/CMS. The report will be prepared and delivered as two volumes constituting the RFI/RI and the CMS/FS. Any completed early actions (e.g., removal actions) will be documented in one or both of these volumes.

   Based on results of the RFI/RI, DOE-RL will provide Ecology with a list of TSD units that have had releases likely to have commingled with contamination from R-CPP unit releases and, if applicable, petition Ecology's Director for alternative closure requirements under WAC 173-303-610(1)(e). Petition for alternative closure requirements will be made through a revised closure plan submitted as a modification to the Permit. The RFI/RI/CMS/FS report should provide the technical information necessary to support the Director's determination.

   Section 5.10 in Chapter 5 of this work plan discusses the process for coordinating TSD unit closure with CERCLA remedial action/RCRA corrective action evaluations, and Section 5.11 provides additional information on the RFI/CMS/RI/FS report.

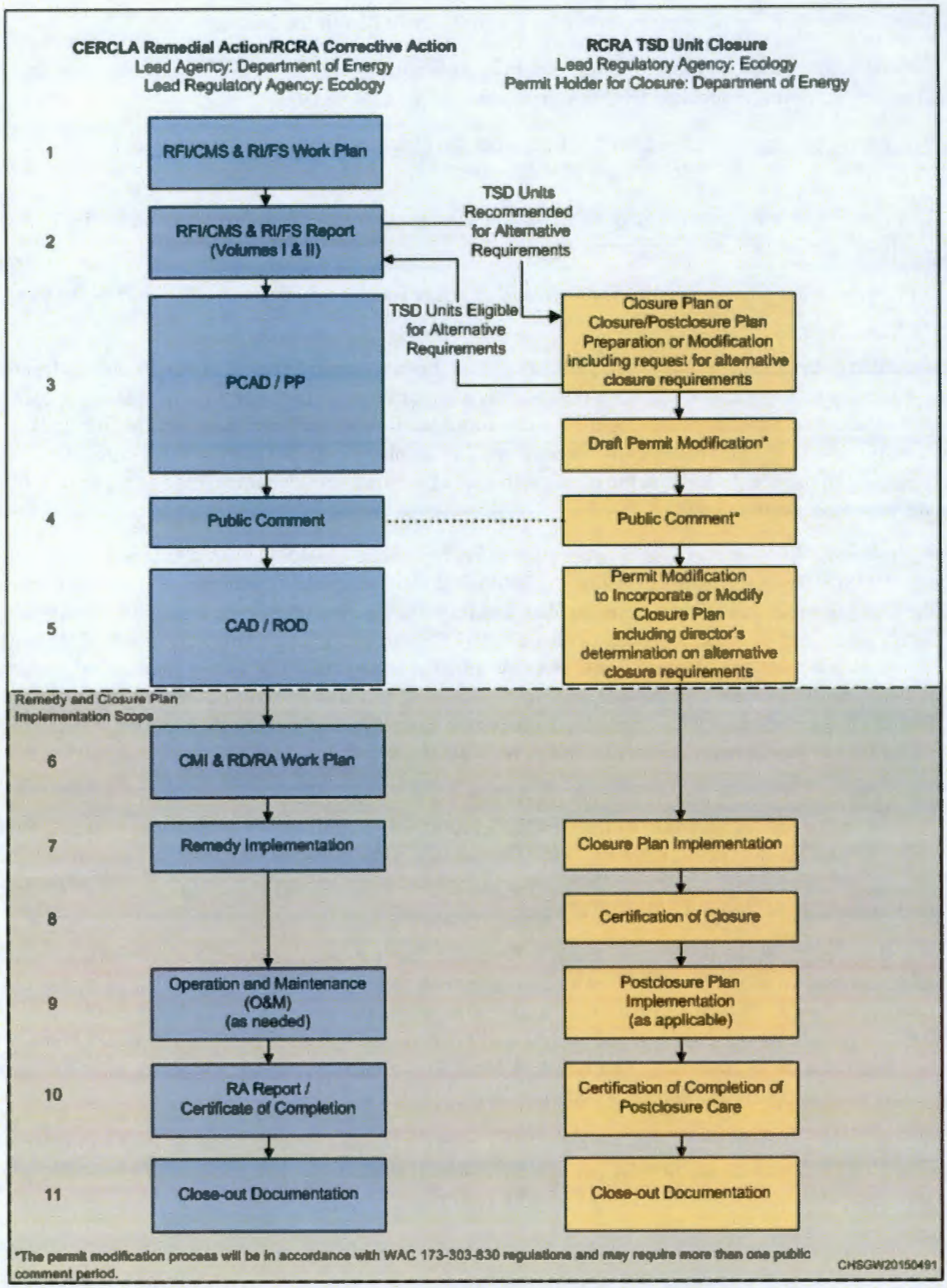

Figure 1-4. Coordinated CERCLA Remedial Action/RCRA Corrective Action and TSD Unit Closure Process

3. *Complete a PCAD/PP, prepare or modify a TSD unit closure or closure/post-closure plan, and prepare a draft Permit modification.* A PCAD/PP will be prepared to identify the proposed 200-SW-2 OU waste site remedial/corrective action.

   For TSD units associated with the 200-SW-2 OU, each closure or closure/post-closure plan will be prepared using information presented in the RFI/CMS/RI/FS report. The coordinated process intent is to ensure the following:

   a. The closure plan meets all TSD unit closure requirements (WAC 173-303-610) and is consistent with the Permit.

   b. TSD units may be clean closed or closed as a landfill per WAC 173-303-610 or closed to alternative requirements per WAC 173-303-610(1)(e).

   Ecology will prepare a draft Permit modification, which includes the TSD unit closure requirements and a draft determination of the applicability of alternative closure requirements. See Section 5.12.1 in Chapter 5 for additional information.

4. *Provide the public with the opportunity to offer comments.* The PCAD/PP and draft Permit modification will be available in parallel for the public involvement process. See Section 5.12.1 in Chapter 5 for additional information.

5. *Develop and approve a CAD/ROD and issue a Permit modification.* Ecology, working in cooperation with DOE and EPA, will finalize the CAD/ROD for the cleanup decision. Although the CAD and ROD could be issued separately, a single CAD/ROD document is recommended to ensure that the selected CERCLA remedial action and RCRA corrective action decisions are compatible for implementation. Concurrent with issuing the CAD/ROD, Ecology will issue a Permit modification to incorporate the TSD unit closure plan and post-closure care plan (as applicable) into the current Permit. See Section 5.12.2 in Chapter 5 for additional information.

The following describes the remedy and closure plan implementation scope:

6. *Complete a corrective measures implementation (CMI) and remedial design/remedial action (RD/RA) work plan.* The CMI/RD/RA work plan will describe the activities necessary to implement and coordinate the selected CERCLA remedial actions, RCRA corrective actions, and TSD unit closure. It will also include the closure performance standards, associated closure details for the TSD units, and the applicable closure plan as an appendix. Depending on the selected corrective and remedial action complexity, the CMI/RD/RA work plan may include the remedial design report. The CMI/RD/RA work plan and associated SAP will identify remedy implementation and closure sampling. See Section 5.12.3 in Chapter 5 for additional information.

7. *Implement the remedy and TSD closure plan.* The CERCLA remedial action and RCRA corrective action decisions presented in the CAD/ROD and the TSD unit closure plan(s) will be implemented. Closure plan(s) will be implemented consistent with the schedule within the applicable closure plan.

8. *Submit certification of closure.* After TSD unit closure requirements have been performed, DOE-RL will submit a certification of closure to Ecology that has been signed by an independent qualified registered professional engineer per WAC 173-303-610(6).

9. *Develop and implement an operations and maintenance (O&M) plan (as needed) and implement the post-closure plan (as applicable).* Once the remedial action and corrective action have been completed and the O&M plan to describe post-cleanup management and control of the sites is under development, the TSD unit post-closure plan will be implemented. If waste is left in place, the post-closure plan will be revised, as applicable. The post-closure plan may be a stand-alone document or it can be incorporated into the O&M plan for implementation.

10. *Complete a remedial action report, issue a certificate of completion, and submit a certification of completion of post-closure care.* Following completion of remediation and corrective action, closeout activities will be performed and documented in the remedial action report, and Ecology will issue a certificate of completion to DOE-RL. When TSD unit post-closure care requirements have been satisfied (if applicable), DOE-RL will submit a certification of completion of post-closure care to Ecology per WAC 173-303-610(11).

11. *Complete closeout documentation.* In accordance with RL-TPA-90-0001, *Tri Party Agreement Handbook Management Procedures*, Guideline Number TPA-MP-14, "Maintenance of the Waste Information Data System (WIDS)," update waste unit information contained in WIDS, as appropriate, and update Appendix C of the TPA Action Plan (Ecology et al., 1989b) based on WIDS changes.

1.3 Hanford Site Cleanup Completion Framework and Inner Area Principles

This section discusses the framework for completing cleanup on the Hanford Site, as well as the cleanup principles for the Central Plateau Inner Area.

1.3.1 Hanford Site Cleanup Completion Framework

The DOE site cleanup strategy and approach to completing the remainder of the cleanup mission is described in DOE/RL-2009-10, *Hanford Site Cleanup Completion Framework*. The framework document defines the principal components of cleanup and provides the context for individual cleanup actions by establishing the approaches and common goals for those decisions needed to complete the cleanup mission.

The framework document (DOE/RL-2009-10) defines the overarching goals for cleanup. These goals embody more than 20 years of dialogue among the Tri-Parties, Tribal Nations, state of Oregon, stakeholders, and the public. The goals consider key values captured in forums, such as the Hanford Future Site Uses Working Group, Tank Waste Task Force, Hanford Summits, Tribal Nation values statements, and the Hanford Advisory Board (HAB). The goals serve as a guide for all aspects of Hanford Site cleanup and help set priorities to apply resources and sequence cleanup efforts for the greatest benefit.

To achieve these goals, the Hanford Site cleanup is organized into three major components: River Corridor, including the Hanford Reach National Monument and the Manhattan Project National Historical Park; Central Plateau; and tank farms/tank waste. Each component of cleanup is complex and challenging, involving multiple projects and contractors and requiring many years and billions of dollars to complete. Environmental cleanup of waste sites and facilities in the River Corridor is nearing completion, with substantial progress made on groundwater remediation. Closure of tanks and tank farms was evaluated in DOE/EIS-0391, *Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (TC & WM EIS)*, with a ROD issued in December 2013 (78 FR 240, "Record of Decision for the Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington").

The Hanford Site cleanup mission began in 1989 following a plutonium-production era from 1943 to 1989. During plutonium production, the Hanford Site was divided into production areas, including the eastern Inner Area and western Inner Area, which contain the major nuclear fuel processing, waste management, and disposal facilities. This work plan presents information related to the primary sources of contamination from plutonium production in the eastern and western Inner Areas.

The Central Plateau encompasses the 200 Area NPL (40 CFR 300, Appendix B) site and includes two principal areas, as shown in Figure 1-1:

- **Inner Area:** Defined as the final footprint area of the Hanford Site, the Inner Area is required for permanent waste management and control of residual contamination. The boundary of the Inner Area is defined by waste disposal decisions already in place and the anticipated future decisions that will result in the requirement for continued waste management and control of residual contamination. The Inner Area is approximately 26 km^2 (10 mi^2) in size and will remain under federal ownership and control as long as a potential hazard exists.

- **Outer Area:** The Outer Area is that portion of the Central Plateau beyond the boundary of the Inner Area. Contaminated soil and debris removed as part of Outer Area cleanup will be placed within the Inner Area for final disposal. Completion of cleanup for the approximately 170 km^2 (65 mi^2) Outer Area will shrink the active footprint of cleanup for the Central Plateau to the Inner Area.

The 200-SW-2 OU is located within the Inner Area.

1.3.2 Central Plateau Inner Area Cleanup Principles

In 2013 and 2014, the Tri-Parties undertook an initiative to develop a set of cleanup principles for the Inner Area of the Central Plateau. The outcome of this initiative is the establishment of an overarching and consistent set of cleanup principles that the Tri-Parties have agreed are the foundation for evaluating waste sites and making cleanup decisions in each of the OUs within the Inner Area pursuant to the TPA (Ecology et al., 1989a).

The overarching goals of the principles are to (1) provide a consistent approach for assessment of risks to HHE and evaluation of remedial alternatives within the Inner Area; and (2) identify and implement regulatory strategies that will optimize assessment resources, streamline documentation requirements, and promote consistency in decisions.

The substantive components of these principles related to land use, baseline risk assessments (BRAs), cleanup levels, points of compliance, and regulatory strategies are defined below. The principles, as they apply to the 200-SW-2 OU, are reflected in the appropriate sections of this work plan.

1.3.2.1 Land Use

- Inner Area land use is industrial.

- The agencies are in agreement that the current 25.9 km^2 (10 mi^2) Inner Area footprint will not be reduced further.

1.3.2.2 Baseline Risk Assessment

- BRA for direct contact will use the default EPA industrial scenario (multiple pathway) to determine need for action at a cumulative cancer risk level of 1 in 10,000 and 1 in 100,000 and a hazard index of 1 for noncarcinogenic effects.

- State requirement for cumulative cancer risks under the "Model Toxic Controls Act–Cleanup" (MTCA) Method C (WAC 173-340) at 1 in 100,000 will be considered because of future corrective action requirements.
- Once a basis for action is determined, cleanup standards for chemicals will be based on MTCA Method C industrial cleanup levels for direct contact.
- The only institutional control (IC) incorporated in the BRA is for industrial land use.
- BRA for direct contact will not include a residential scenario.
- BRAs for soils will be done on an OU-by-OU basis (each work plan).
- BRA for groundwater and groundwater protection will be based on beneficial use (drinking water).
- Groundwater protection evaluation will consider up-gradient contamination as evaluated through a cumulative risk evaluation tool that incorporates present and future groundwater contamination and contaminant sources in the vadose zone.
- DOE will develop RI/FS work plan sections that describe the principles and specific parameters on BRAs that will serve as guiding principles for all work plans.

1.3.2.3 Cleanup Levels

- Preliminary remediation goals (PRGs) for human health direct contact with radionuclides will be risk-based.
- PRGs for chemicals will be based on MTCA Method C (direct contact).
- The approach to ecological cleanup will be the same as for the River Corridor, as applied for the 100-D/H Area RI/FS (DOE/RL-2010-95, *Remedial Investigation/Feasibility Study for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units*) and 100-F/IU area RI/FS (DOE/RL-2010-98, *Remedial Investigation/Feasibility Study for the 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units*).
- Groundwater protection modeling will be based on natural recharge and will not consider irrigation.
- Groundwater protection modeling and PRG development will be based on the process defined in DOE/RL-2011-50, *Regulatory Basis and Implementation of a Graded Approach to Evaluation of Groundwater Protection*. DOE will identify specific parameters in the *Technical Guidance Document for the Tank Closure & Waste Management Environmental Impact Statement* (DOE/EIS-0391) that will be applied or make adjustments where appropriate.
- Groundwater protection PRGs will be developed, discussed, and approved through a single process to develop PRGs applicable to each of the five unique areas of the Central Plateau.

1.3.2.4 Conditional Point of Compliance for Groundwater

- FSs will present an evaluation of groundwater protection at the standard point of compliance immediately beneath each waste site or facility under consideration. DOE may also choose to perform an analysis in the first Inner Area FS to evaluate a conditional point of compliance at the boundary of the Inner Area for groundwater protection. The resulting decision will serve as the basis for the justification for the remainder of the OUs in the Inner Area.

- The basis for the decision will be developed in the first FS, but all OUs will need to justify the decision. The subsequent OU discussions will reference the first and include an overview of similarities and differences between the first and subsequent OUs to ensure the approach is justified.

1.3.2.5 Human Health and Ecological Depth Point of Compliance

- FSs will present alternatives that will evaluate compliance with human health (direct contact) and ecological PRGs at the standard point of compliance of 4.6 m (15 ft). DOE may also choose to present alternatives in the first Inner Area FS to evaluate a conditional point of compliance for the terrestrial ecological evaluation. In addition, DOE may also choose to evaluate an alternative point of compliance for soil cleanup actions (human health (direct contact)) according to the procedures in WAC 173-340-740-(6)(f).
  - A framework for decisions will be developed in the first FS, but all OUs will need to justify the decisions. All OUs in the Central Plateau are expected to present this comparison of alternatives to ensure all potential remedies are protective of human health and the environment.
- Unlike in the River Corridor, engineered structures and/or mass of contamination will not be removed unless it is a risk management decision.

1.3.2.6 Regulatory Strategies

- Similar site approaches can be used with proper analysis and use of available information, data, and process knowledge.
- Characterization strategies will consider multiple remedial technologies, risk reduction, regulatory requirements, and cost avoidance. The observational approach can also be a valid strategy where removal, treatment, and disposal (RTD) is appropriate.
- The regulatory agencies are willing to consider a plug-in approach. They generally believe that it applies primarily to RTD sites but could be applied to other potential remedies if justified.
- Post-ROD characterization (meaning limited pre-ROD characterization) is a valid approach but may result in interim action RODs.

1.4 Integration with Other Activities

To facilitate consistent remedial decisions across the Central Plateau Inner Area, the Tri-Parties modified the TPA (Ecology et al., 1989a) in 2010 to restructure Central Plateau remediation activities. Restructuring included consolidating some of the Inner Area waste sites into geographical area-based OUs, resulting in the creation of the 200-EA-1 OU and the 200-WA-1 OU. An additional OU, 200-DV-1, was created to include waste sites in the Inner Area with deep vadose zone (DVZ) contamination. On the Central Plateau, the DVZ is defined as the region below the practical depth of surface remedy influence (e.g., shallow excavation or barriers) and above the regional aquifer. The Tri-Parties created the 200-DV-1 OU to support investigation and remedy selection for this challenging type of DVZ waste site.

Figure 1-5 illustrates the CERCLA OUs that are currently assigned in the Central Plateau Inner Area. The existing groundwater OUs in the Central Plateau remained unchanged.

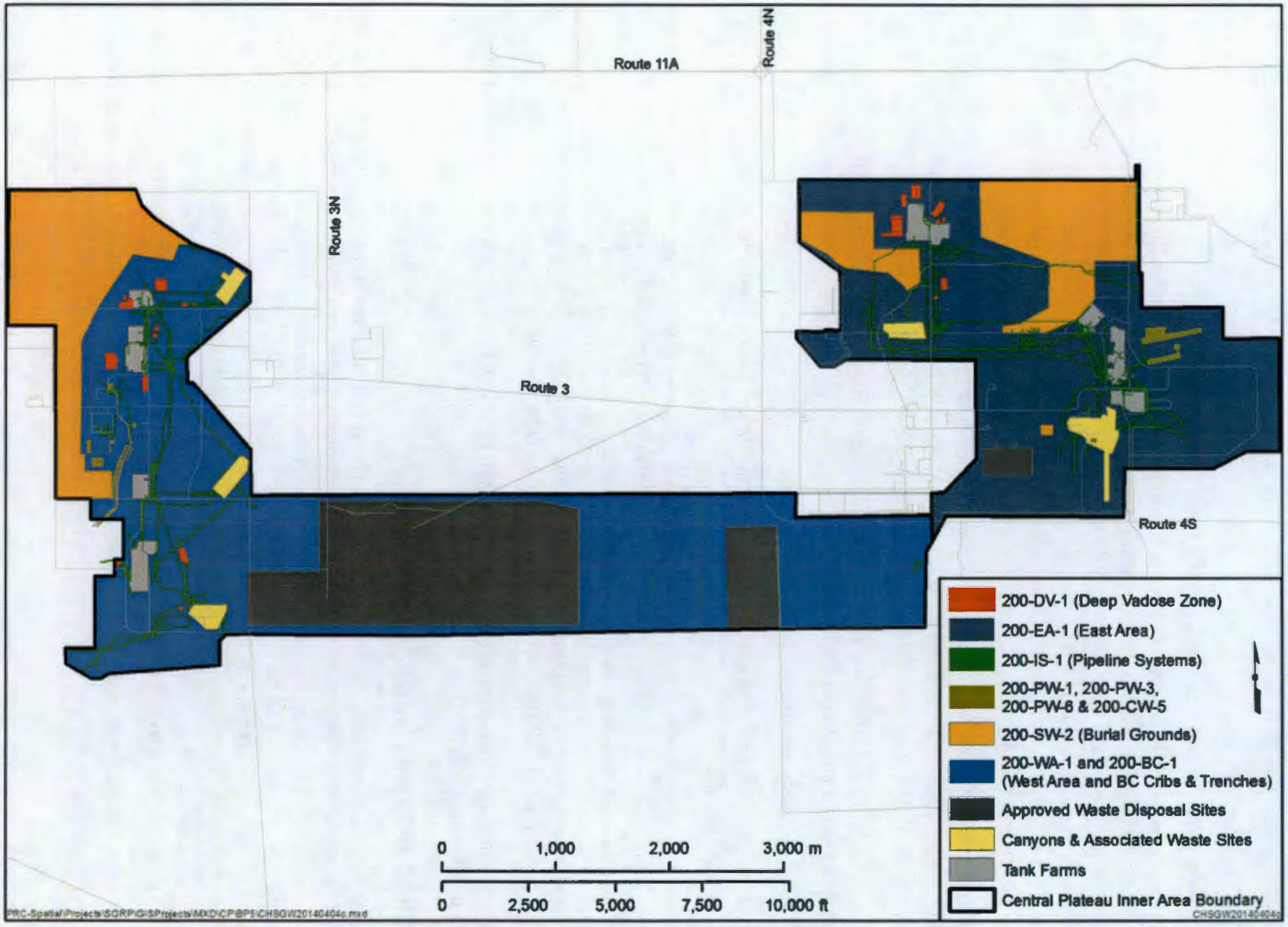

Figure 1-5. Central Plateau Inner Area OUs

This RFI/CMS/RI/FS work plan and subsequent decision documents must be closely integrated with the overall Hanford Site closure strategy. Integration with other regulatory programs and other OUs in the Inner Area is discussed in the following subsections. Specific ongoing sampling, analysis, and remedial action activities that are critical to the 200-SW-2 OU decision process are provided.

1.4.1 Tank Farm Waste Management Areas

The single-shell tanks (SSTs) are grouped into waste management areas (WMAs), which will be closed following a defined closure process. Each WMA contains part of the SST RCRA TSD unit that includes tanks and ancillary equipment. Closure of the tanks and tank farms was evaluated in the TC & WM EIS (DOE/EIS-0391), with a ROD issued in December 2013 (78 FR 240). The WMAs are not included in the 200-SW-2 OU.

Remedial action alternatives developed in the 200-SW-2 OU FS/CMS report for waste sites adjacent to tank farm WMAs will take into consideration the proximity of the TSD units. The detailed evaluation of alternatives in the 200-SW-2 OU FS/CMS report will determine whether a closure action planned for the nearby TSD unit would also be an appropriate remedy for the waste sites.

1.4.2 Central Plateau Source Operable Units

The current OUs in the Central Plateau Inner Area contain waste sites that received liquid waste (200-EA-1 OU; 200-WA-1 OU and 200-BC-1 OU; 200-PW-1 OU, 200-PW-3 OU, 200-PW-6 OU, 200-CW-5 OU; and 200-DV-1 OU); waste sites that received solid waste (200-SW-2 OU); and waste sites associated with inactive waste-transfer pipelines (200-IS-1 OU). The Inner Area also contains OUs for former processing plants (canyons) and associated waste sites. The OUs are depicted in Figure 1-5.

In 1989, waste sites on the Central Plateau were initially grouped into 42 OUs (32 source OUs, 6 tank farm OUs, and 4 groundwater OUs) that were primarily geographically based (DOE/RL-96-67, *200 Areas Soil Remediation Strategy – Environmental Restoration Program*).

The Tri-Parties conducted a supplemental data quality objective (DQO) evaluation in 2005 and 2006 to review all of the process and characterization data available for the Central Plateau waste sites and to identify residual data needs. The elements of the DQO evaluation were integrated into the supplemental work plan issued in 2007 (DOE/RL-2007-02, *Supplemental Remedial Investigation/Feasibility Study Work Plan for the 200 Areas Central Plateau Operable Units Volume I: Work Plan and Appendices*). The supplemental work plan included a SAP to collect additional data at those waste sites for which existing data were determined to be insufficient for decision making. The 200-SW-2 OU landfills were not included in this supplemental work plan.

The OUs that contain structures or waste sites that are in close physical proximity to 200-SW-2 OU landfills are described in the following sections.

1.4.3 200-PW-1, 200-PW-3, 200-PW-6, and 200-CW-5 Operable Units

The plutonium- and organic-rich group process-based OUs include the 200-PW-1, 200-PW-3, 200-PW-6, and 200-CW-5 OUs. The 200-PW-1, 200-PW-6, and 200-CW-5 OUs are in the western portion of the Inner Area, and the 200-PW-3 OU waste sites are in the eastern portion of the Inner Area. The remedies for these OUs will be applied outside of the landfill locations; therefore, no activities critical to the 200-SW-2 OU decision process are expected.

1.4.4 200-IS-1 Operable Unit

The 200-IS-1 OU consists of waste sites that are associated with inactive, buried waste-transfer pipelines and pipeline components (e.g., diversion boxes, catch tanks, valve pits, vaults, and control structures) located within the Central Plateau Inner Area. The 200-IS-1 OU also includes contaminated soil that is the result of previously identified UPRs from the pipeline and pipeline components.

Part of the coordination of activities across OU waste sites is to understand and define specific interface conflict points. Interface conflict points are defined as the boundary location(s) where a waste site in one OU physically exists within the geographic boundary of another OU waste site or tank farm WMA. Boundary interface points are predominantly associated with pipeline waste sites in the 200-IS-1 OU that extend into or are adjacent to soil waste sites, canyons, and WMAs. A few boundary interface points exist between soil waste sites, canyons, and WMAs.

Pipeline boundary interface points are associated with the following:

- 200-PW-1, 200-PW-3, and 200-PW-6/200-CW-5 OUs (as defined in EPA et al., 2011, *Record of Decision Hanford 200 Area Superfund Site 200-CW-5 and 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units*)
- 200-DV-1, 200-WA-1, 200-BC-1, and 200-EA-1 OUs
- All canyons
- All WMAs

A pipeline interface point is located between the 200-SW-2 OU landfills and the pipelines that fed the T Ponds (Section 2.3.1.4).

1.4.5 200-EA-1 and 200-WA-1/200-BC-1 Operable Units

The types of waste sites in the 200-EA-1 and 200-WA-1/200-BC-1 OUs are diverse but correspond to one of the following general categories: cribs, trenches, reverse wells, French drains, basins, ponds and ditches, vaults, underground storage tanks, septic systems, UPRs, solid waste sites, or process sewers. Detailed descriptions of these waste sites are provided in DOE/RL-88-30, *Hanford Site Waste Management Units Report*. Some of these sites have contamination adjacent to landfill locations. Therefore, activities critical to the 200-SW-2 OU decision process could occur, and remedial actions will be coordinated with these OUs.

1.4.6 Canyons

The U Plant, Reduction-Oxidation (REDOX) Plant (S Plant), T Plant, B Plant, and Plutonium-Uranium Extraction (PUREX) Plant canyons are located in the Inner Area. The canyons will be closed under their own specific decision documents and the appropriate RCRA closure documents. However, the remedies for these facilities will be applied outside of the landfill locations; therefore, no activities critical to the 200-SW-2 OU decision process are expected.

1.4.7 200-DV-1 Operable Unit

The remedial action alternatives for 200-DV-1 OU DVZ waste sites adjacent to the 200-SW-2 OU landfills will take into consideration the proximities of the waste sites to the landfills. However, the remedies for 200-DV-1 OU waste sites will be applied outside of the landfill locations; therefore, no activities critical to the 200-SW-2 OU decision process are expected.

1.4.8 Groundwater Operable Units

The 200-SW-2 OU waste sites are underlain by the 200-ZP-1, 200-UP-1, 200-PO-1, and 200-BP-5 Groundwater OUs. A groundwater pump-and-treat (P&T) remediation system was constructed to address contaminated groundwater present in the 200-ZP-1 and 200-UP-1 Groundwater OUs. The ROD for the 200-ZP-1 OU was issued in 2008 (EPA et al., 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington*). The interim ROD for the 200-UP-1 OU was issued in 2012 (EPA et al., 2012, *Record of Decision for Interim Remedial Action Hanford 200 Area Superfund Site 200-UP-1 Operable Unit*). Separate RI reports for the 200-BP-5 OU and the 200-PO-1 OU are currently being prepared. A combined FS/PP is being prepared for the 200-BP-5 and 200-PO-1 OUs, and Draft A is scheduled to be completed by September 2016. The remedies for these groundwater OUs will be coordinated with the 200-SW-2 OU decision process. This coordination would be applicable to locations of extraction or injection wells within close proximity of the landfills.

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2 Background

This chapter summarizes the background information and environmental setting for the 200-SW-2 OU investigation areas. It also provides a summary of the landfill operational history, processes, activities, waste streams, and contaminant sources.

The landfills were pre-planned, designed, constructed, and operated with the intention of long-term, permanent disposal of solid waste. The 200-SW-2 OU solid waste disposal areas have been referred to by a variety of names, but this work plan uses the term "landfill" to refer to the locations that have the "218" prefix in their Waste Information Data System (WIDS) waste site code. This term is in agreement with the state of Washington's definition of a landfill under WAC 173-303-040, "Dangerous Waste Regulation," "Definitions":

> *...a disposal facility, or part of a facility, where dangerous waste is placed in or on land and which is not a pile, a land treatment facility, a surface impoundment, or an underground injection well, a salt dome formation, a salt bed formation, an underground mine, a cave, or a corrective action management unit.*

Several liquid disposal waste sites (with "216" prefixes in the WIDS waste site code) and one miscellaneous site (a former burn pit) are also part of the 200-SW-2 OU.

2.1 Hanford Site Solid Waste Disposal Operations

Landfills were used at the Hanford Site beginning in 1944 and generally consisted of one or more types of trenches and/or caissons. Caissons are solid waste disposal structures that were built into two landfills (218-W-4A and 218-W-4B) that began operations in the 1960s. Hanford Site production processes and support activities used and disposed of a variety of chemical and/or radioactively contaminated waste. The chronological evolution of Central Plateau waste disposal practices is as follows:

- From 1944 to August 19, 1987 (i.e., the effective date of RCRA waste regulation at the Hanford Site), it was a common practice for solid LLW and waste containing components that would currently be regulated under WAC 173-303 to be disposed in trenches in the Inner Area landfills.
- From 1970 to 1988, TRU waste was stored in retrievable storage units. Beginning in 1988, waste was sent directly to the Waste Receiving and Processing Facility to be repackaged for shipment and disposal at the Waste Isolation Pilot Plant.
- Beginning in the mid-1990s, disposal of MLLW took place in lined Trenches 31 and 34 of the 218-W-5 Low-Level Burial Ground in the western Inner Area, while LLW (no RCRA component) continued to be disposed in landfills that are TSD units. These landfills are 218-E-10, 218-E-12B, 218-W-3A, 218-W-3AE, 218-W-4C, and the remaining trenches of 218-W-5.
- Today, the 200-SW-2 OU solid waste landfills no longer receive waste, with the exception of two trenches in 218-W-5 in the western Inner Area and one trench in the 218-E-12B Landfill in the eastern Inner Area. The remaining landfills in the OU are classified as "inactive" in the WIDS database.

The 200-SW-2 OU is composed of 24 landfills and includes about 20 caissons that are located below grade in the 218-W-4A and 218-W-4B Landfills. This OU also includes 11 UPRs that have been consolidated with the landfills where they occurred and six collocated waste sites. Appendix C provides a summary of the trenches, containment barriers, and caissons used in the landfills. No facilities or

aboveground structures are present in the 200-SW-2 OU, nor are any included or proposed for inclusion in Appendix C of the TPA Action Plan (Ecology et al., 1989b).

2.2 Landfill Types

To aid in the organization of this work plan, landfills and the structures (caissons) they contain are divided into six landfill types in Table 2-1, based on the materials they received and their age. Table 2-2 presents historical and other names associated with each of the landfills. Figures 2-1 and 2-2 present the landfill locations in the western and eastern portions of the Inner Area, respectively. Figure 2-3 presents a timeline of landfill operations, associated site (ponds and burn pit) operations, and key regulatory milestones. Detailed descriptions of the landfills are presented in Section 2.3. The associated sites are described in Section 2.4.

- **Dry waste landfills:** These are past-practice landfills that received radioactive waste packaged primarily in fiberboard or small wooden boxes, wrapped in heavy brown paper or burlap, or placed in the trench without packaging. Small-sized miscellaneous waste, ranging from contaminated soils and potentially contaminated rags, paper, and wood, has been placed in these landfills. This landfill type includes the 218-E-1 and 218-E-12A Landfills.

- **Dry waste alpha landfills:** These past-practice landfills contain waste that is highly contaminated with alpha-emitting radionuclides, mainly plutonium and uranium. A variety of miscellaneous waste, including contaminated soils and potentially contaminated rags, paper, wood, and small pieces of equipment such as tools, has been placed in these sites. A small proportion of the waste is packaged in metal drums. Some larger equipment (e.g., motor vehicles, large canyon processing equipment) is known to have been disposed to these sites. This landfill type includes the 218-W-1, 218-W-2, 218-W-3, and 218-W-4A Landfills.

- **Industrial landfills:** These past-practice landfills received radioactive waste that usually was packaged in large wooden or concrete boxes containing large pieces of failed or obsolete equipment. Some equipment was shrouded in plastic or placed directly in the ground after partial decontamination in the facility from which it came, mainly 200 Area chemical processing facilities, although some items came from the 100 Area. Landfills of this type include the 218-W-2A, 218-E-5A, 218-E-2, 218-E-2A, 218-E-5, 218-E-9, 218-W-1A, and 218-W-11 Landfills.

- **Construction landfills:** These are past-practice landfills mainly limited to disposal of low-activity waste resulting from construction/demolition work on existing facilities. Landfills of this type include the 218-C-9, 218-E-8, and 218-E-4 Landfills.

- **Caissons or vertical pipe units:** These are engineered structures built directly into a trench within a landfill. They were used for disposal of hot cell waste or high-dose-rate waste and are located within the 218-W-4A and 218-W-4B Landfills. The caissons in the 218-W-4A Landfill, also called vertical pipe units, were made of 208 L (55 gal) drums welded end to end, or pipes about 1 m in diameter (WHC-EP-0912, *The History of the 200 Area Burial Ground Facilities*; Hanford Site Drawing H-2-33692, *Dry Waste Disposal Caisson in 218-W4 Site*). The caissons in the 218-W-4B Landfill were larger and made of corrugated metal and concrete (WHC-EP-0912). These structures do not constitute an entire landfill, but are called a landfill type in the context of this work plan for ease of discussion.

- **TSD unit landfills:** These are RCRA TSD units that contain waste forms similar to those in past-practice landfills such as dry waste packaged in small fiberboard cartons, directly disposed dirt and weeds, large concrete and wooden boxes containing used equipment, and construction debris. This landfill type includes the 218-E-10, 218-E-12B, 218-W-3A, 218-W-3AE, 218-W-4B, 218-W-4C, and 218-W-5 Landfills.

Table 2-1. Summary of 200-SW-2 OU Landfill Types

Landfill Type (Amount)	Site Code	General Features
TSD unit landfills (7)	218-E-10 218-E-12B 218-W-3A 218-W-3AE* 218-W-4B 218-W-4C 218-W-5	Potential for areas of subsidence High dose rates Potential for small volumes of sorbed, containerized liquids Some contain retrievably stored TRU waste (M-091 Project) Burial records more numerous, better quality than for other landfill types
Industrial landfills (8)	218-E-2 218-E-2A 218-E-5 218-E-5A 218-E-9 218-W-1A 218-W-2A* 218-W-11	Potential for subsidence High dose rates High internal void volume Disposal of failed/obsolete equipment Waste typically contained in large wooden or concrete boxes
Dry waste alpha landfills (4)	218-W-1 218-W-2 218-W-3 218-W-4A	Low potential for subsidence Contain approximately 90 percent of the alpha-contaminated low-level waste Waste direct-dumped scrap or packaged in fiberboard cartons/boxes/drums Some waste in 218-W-3 and 218-W-4A is industrial, such as large equipment
Dry waste landfills (2)	218-E-1 218-E-12A	Low potential for subsidence Medium dose rate (up to 2,000 mR/hr) Primarily beta-gamma-contaminated waste Waste primarily packaged in fiberboard cartons, boxes, or drums Surface stabilized with fly ash (218-E-1) or plastic barriers/gravel (218-E-12A)
Construction landfills (3)	218-C-9* 218-E-4 218-E-8	Low potential for areas of subsidence Low-activity waste (<100 mR/hr) Primarily construction/demolition debris and concrete rubble
Caissons (~20)	218-W-4A 218-W-4B	Some high-dose-rate waste Some remote-handled waste in small containers, 3.8 to 18.9 L (1 to 5 gal) cans Some high beta-gamma radiation Potential for small volumes of sorbed organics (lab packs) 6 to 8 caissons/vertical pipe units in 218-W-4A (up to 4 potentially unused) 5 alpha caissons (M-091 Program; out of 200-SW-2 scope; 1 may be unused) 7 dry-waste caissons in 218-W-4B (2 with <10 packages of waste each)

Table 2-1. Summary of 200-SW-2 OU Landfill Types

Landfill Type (Amount)	Site Code	General Features

* Site is collocated with a former liquid disposal site.

TRU = radioactive waste (as defined in DOE G 435.1-1, *Implementation Guide for use with DOE M 435.1-1*)

TSD = treatment, storage, and disposal

1

Table 2-2. Site Code and Alias (Other) Names Given to 200-SW-2 OU Landfills

Site Code	Alias (Other) Site Names/Codes	Landfill Type
218-C-9	218-C-9, Dry Waste No. 0C9, 218-C-9 Burial Ground	Construction landfills
218-E-1	218-E-1, 200 East Dry Waste No. 001	Dry waste landfills
218-E-10	218-E-10, 200 East Industrial Waste No. 10, Equipment Burial Ground #10	TSD unit landfills
218-E-12A	218-E-12A, 200 East Dry Waste No. 12A	Dry waste landfills
218-E-12B	218-E-12B, 200 East Dry Waste No. 12B	TSD unit landfills
218-E-2	218-E-2, 200 East Industrial Waste No. 002, Equipment Burial Ground #2	Industrial landfills
218-E-2A	218-E-2A, Regulated Equipment Storage Site No. 02A, Burial Trench	Industrial landfills
218-E-4	218-E-4, 200 East Minor Construction No. 4, Equipment Burial Ground #4	Construction landfills
218-E-5	218-E-5, 200 East Industrial Waste No. 05, Equipment Burial Ground #5	Industrial landfills
218-E-5A	218-E-5A, 200 East Industrial Waste No. 005A, Equipment Burial Ground #5A	Industrial landfills
218-E-8	218-E-8, 200 East Construction Burial Grounds	Construction landfills
218-E-9	218-E-9, 200 East Regulated Equipment Storage Site No. 009, Burial Vault (Hanford Inactive Site Survey [HISS])	Industrial landfills
218-W-1	218-W-1, 200-W Area Dry Waste No. 001, Solid Waste Burial Ground #1	Dry waste alpha landfills
218-W-11	218-W-11, Regulated Storage Site	Industrial landfills
218-W-1A	218-W-1A, 200-W Area Industrial Waste Burial Ground #1, Equipment Burial Ground #1	Industrial landfills
218-W-2	218-W-2, 200-W Area Dry Waste No. 002, Dry Waste Burial Ground No. 2	Dry waste alpha landfills

Table 2-2. Site Code and Alias (Other) Names Given to 200-SW-2 OU Landfills

Site Code	Alias (Other) Site Names/Codes	Landfill Type
218-W-2A	218-W-2A, Industrial Waste No. 02A, Equipment Burial Ground #2	Industrial landfills
218-W-3	218-W-3, Dry Waste No. 003	Dry waste alpha landfills
218-W-3A	218-W-3A, Dry Waste No. 003A	TSD unit landfills
218-W-3AE	218-W-3AE, Industrial Waste No. 3AE, Dry Waste No. 3AE	TSD unit landfills
218-W-4A (includes caissons)	218-W-4A, Dry Waste No. 04A	Dry waste alpha landfills
	Caissons: 218-W-4A-C1, 218-W-4A-C2, 218-W-4A-C3, 218-W-4A-C4, and 218-W-4A-C5, 218-W-4A-C6, 218-W-4A-C7, and 218-W-4A-C8	Caissons
218-W-4B (includes caissons)	218-W-4B, Dry Waste No. 04B	TSD unit landfills
	Caissons: 218-W-4B-CA1, 218-W-4B-CA2, 218-W-4B-CA3, 218-W-4B-CA4, 218-W-4B-CA5, 218-W-4B-C1, 218-W-4B-C2, 218-W-4B-C3, 218-W-4B-C4, 218-W-4B-C5, 218-W-4B-C6, and 218-W-4B-CU1	Caissons
218-W-4C	218-W-4C, Dry Waste No. 004C	TSD unit landfills
218-W-5	218-W-5, Dry Waste Burial Ground, Low-Level Radioactive Mixed Waste Burial Grounds	TSD unit landfills

TSD = treatment, storage, and disposal

2.3 Landfill Descriptions

This section presents detailed descriptions of the landfills in the 200-SW-2 OU. A list of all WIDS sites physically located in the 200-SW-2 OU geographic boundary and site-specific information are included in Appendix B; CSM and data summaries for each of the landfills are provided in Appendix D. This section consists of Section 2.3.1 (which describes the TSD unit landfills) and Section 2.3.2 (which describes the past-practice landfills).

2.3.1 200-SW-2 Operable Unit Treatment, Storage, and Disposal Unit Landfills

The TSD units consist of seven landfills: five are in the western Inner Area, and two are in the eastern Inner Area, as depicted in Figures 2-1 and 2-2, respectively. These landfills also contain MLLW disposed to unlined trenches after August 19, 1987, also known as the "Green Island" waste. A detailed report on Green Island waste is presented in Appendix F (Section F5.1).

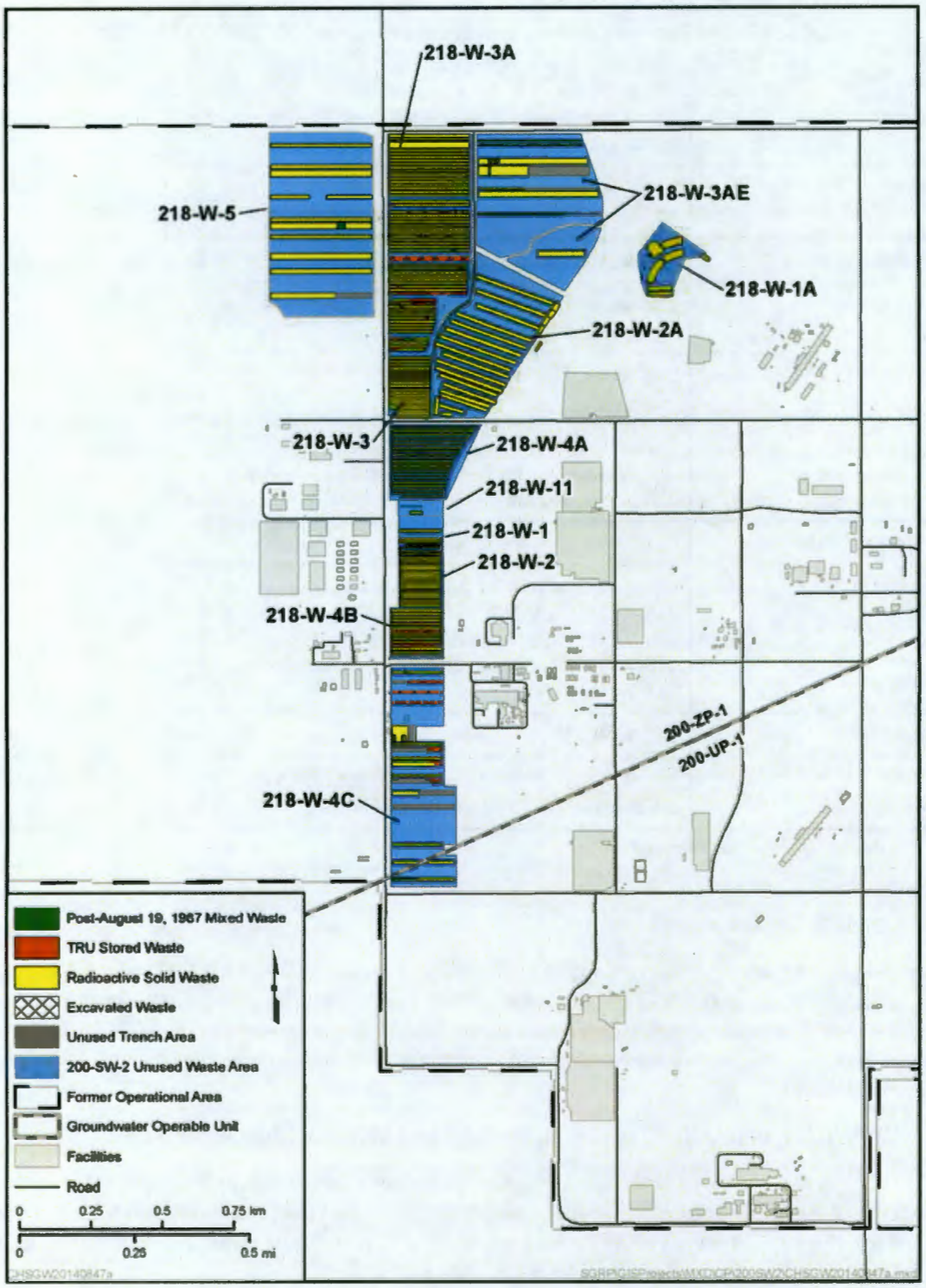

Figure 2-1. Location and Landfill Types of 200-SW-2 OU Landfills in the Western Inner Area

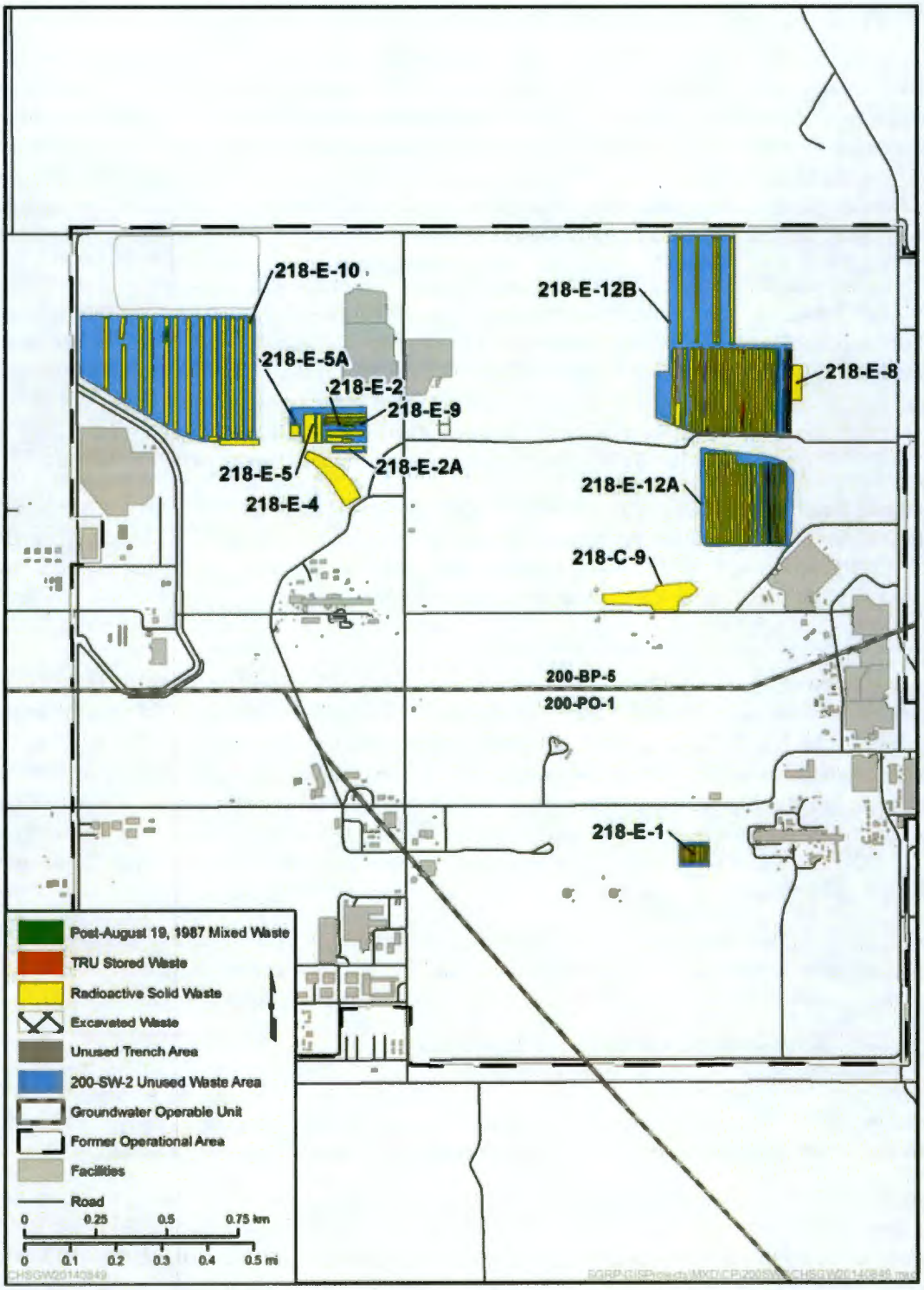

Figure 2-2. Location and Landfill Types of 200-SW-2 OU Landfills in the Eastern Inner Area

2.3.1.1 218-E-10 Landfill (Eastern Inner Area)

The 218-E-10 Landfill covers about 23 ha (57 ac) and contains remote-handled and contact-handled USG and LLW. These dimensions include an area referred to in WIDS and historical literature as an "unused annex" that was originally intended for expansion of the landfill. It was eventually decided that the annex was not needed for burial of waste and never was used for that purpose. The 218-E-10 Landfill is located about 610 m (2,000 ft) northwest of B Plant and directly west of the 218-E-5A Landfill. It received waste mostly from the PUREX Plant, B Plant, T Plant, offsite (mainly Formerly Utilized Sites Remedial Action Program waste), and the 100 Area (mainly N Reactor waste).

The 218-E-10 Landfill consists of 13 trenches running north-south and 1 trench running east-west. Trench 1 is 7.3 m (24 ft) deep with surface dimensions of 430 m (1,420 ft) long by 18 m (60 ft) wide. Trenches 2 through 9, 11, 12, 14, and 16 are 4.6 m (15 ft) deep, 18 m (60 ft) wide at the surface, and vary in length from 264 to 433 m (865 to 1,420 ft). The trench running east-west has surface dimensions of 165 m (540 ft) long by 17 m (55 ft) wide (WIDS). Most of the waste buried before 1990 is in concrete boxes, while waste buried later is typically soil and construction debris dumped from trucks (Solid Waste Information Tracking System [SWITS]). There is no retrievably stored waste (RSW) in this landfill.

Waste forms include failed equipment and mixed industrial waste (e.g., concrete canyon cover blocks, centrifuge blocks, tubing bundles, jumper vessels, pumps, columns, and filters). The trenches contain LLW, MLLW, and unsegregated remote-handled waste. Trench 9 currently is identified as containing some MLLW disposed after the effective date of mixed waste regulation.

2.3.1.2 218-E-12B Landfill (Eastern Inner Area)

The in-scope area of the 218-E-12B Landfill covers about 23 ha (57 ac) and contains USG and LLW, and portions of two trenches contain RSW. This landfill is located about 305 m (1,000 ft) north of the C Tank Farm. The 218-E-12B Landfill, not including Trench 94, received solid USG and LLW generated mostly from facilities located in the eastern Inner Area. These include tank farms; B Plant; PUREX general trash, failed equipment, vent risers, and filter boxes; liquid-level risers from the 216-B-14 Crib; and strontium-90-contaminated soil dredged from the 216-B-63 Ditch after UPR-200-E-138 occurred (DOE/RL-92-05, *B Plant Source Aggregate Area Management Study Report*). Most of the in-scope waste in this site was dumped from trucks or buried in cardboard cartons (SWITS).

The original landfill was designed to have 29 trenches. An expansion to the north and west enlarged this landfill to include the potential for many additional (138) trenches oriented north-south. However, only 39 total trenches were filled, leaving more than two-thirds of the designated landfill area unused.

The RSW was partially removed from Trench 17 and fully removed from Trench 27 under TPA Milestone M-091-40 (Ecology et al., 1989a).

The southeastern portion of this landfill (Trenches 1 through 17) was interim stabilized in 1981 with 46 to 61 cm (18 to 24 in.) of uncontaminated soil (additional top cover over previous backfill).

In 1986, water inflow was observed in unfilled Trench 36. The source of water was seepage from the nearby 216-B-2-3 Ditch flowing about 61 m (200 ft) south of the landfill. The 216-B-2-3 Ditch conveyed water roughly 1,219 m (4,000 ft) from the 207-B retention basins to a diversion structure capable of routing the water to either B Pond or Gable Mountain Pond at the time. An investigation into the incident was conducted and documented in 1986 (SD-WM-TI-260, *Water Inflow Investigation at the 218-E-12A and 218-E-12B Burial Grounds*). Interim actions were taken to remove vegetation and debris restricting flow in the ditch, and bentonite clay was added to minimize seepage of water from the ditch. The ditch eventually was replaced with a pipeline and is out of service.

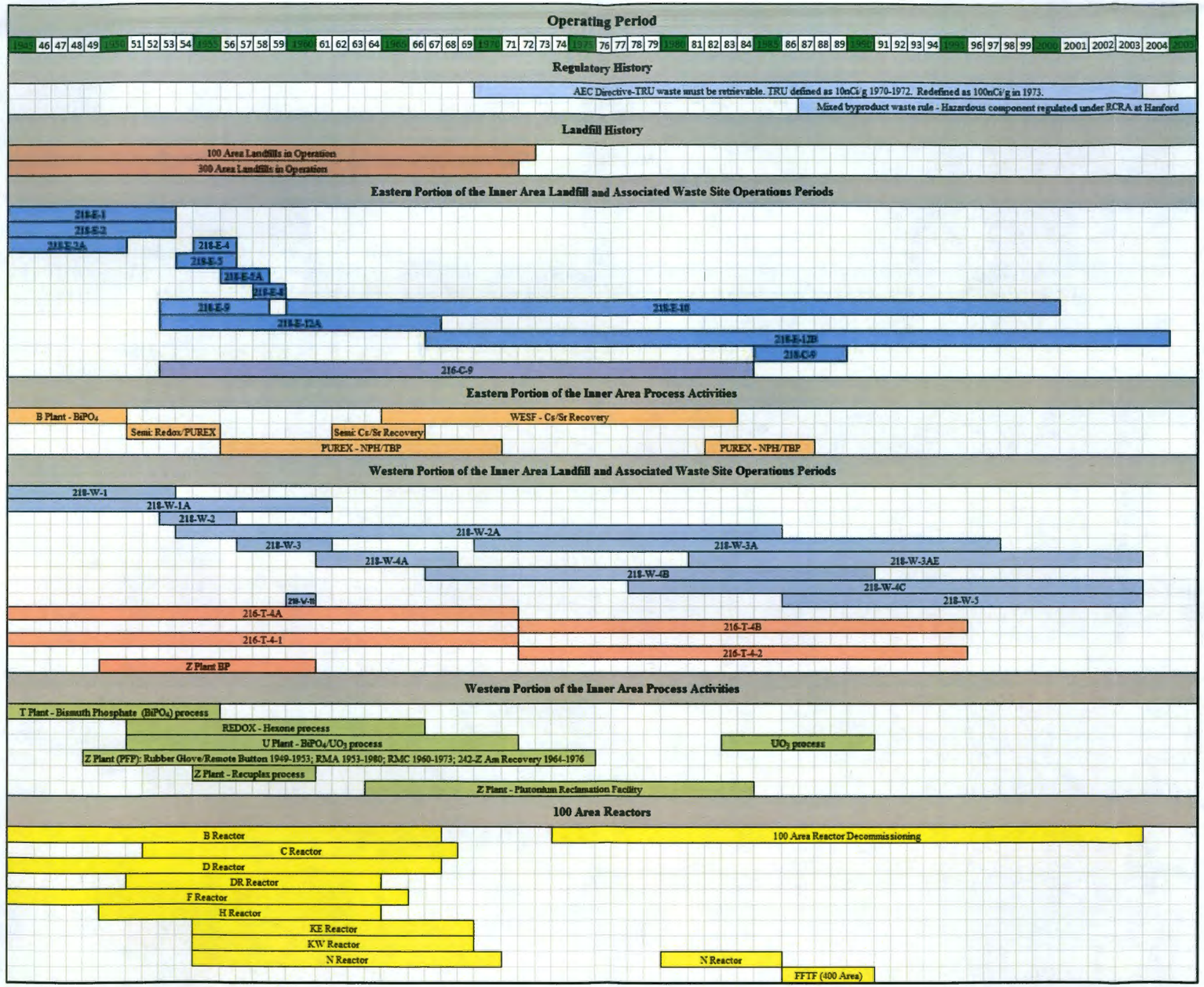

Figure 2-3. Timeline Illustrating Hanford Site Operations (Including Landfills and Associated Sites) and Regulatory History

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2.3.1.3 218-W-3A Landfill (Western Inner Area)

The 218-W-3A Landfill was placed in service in 1970 with a reported end date of 1998. It covers about 21 ha (52 ac) and contains USG, LLW, MLLW, TRU, and TRUM (SWITS). This landfill is west of the 221-T Building and immediately north of the 218-W-3 Landfill. The 218-W-3A Landfill is known to include sorbed containerized organic liquid. The landfill consists of 57 used trenches of varying sizes.

Portions of 14 trenches contain, or once contained, post-1970 RSW, which is out of the scope of this work plan. The RSW was partially removed under TPA Milestone M-91-40/41 (Ecology et al., 1989a).

Most of the waste in this unit is from the 100 Area (21 percent by volume), various facilities in the western Inner Area (34 percent), the 300 Area (23 percent), and the tank farms (14 percent). Less than 3 percent by volume is from offsite facilities, and the remaining 5 percent is from Hanford Site facilities in the eastern Inner Area and other miscellaneous site locations.

The 218-W-3A Landfill was covered with standing water that was almost continuous from the dirt road on the east side to the asphalt road on the west side (WHC-EP-0912) in the winter of 1979–1980. Several inches of snow had fallen on top of frozen ground followed by a quick warming and rapid snowmelt, leaving standing water for some time. Groundwater monitoring data were reviewed and indicated no detectable increases in monitored radioactive constituents.

2.3.1.4 218-W-3AE Landfill (Western Inner Area)

The 218-W-3AE Landfill covers about 20 ha (49 ac). The landfill contains MLLW and LLW, including large equipment. The 218-W-3AE Landfill is located directly east of and adjacent to the 218-W-3A Landfill in the western Inner Area. The location designated as the 218-W-3AE Landfill includes an area that previously had been used as a portion of the 216-T-4B seepage ponds for T Plant condensate effluent. The pond area (about 0.6 ha [1.5 ac] in size) often was dry, because the majority of the effluent infiltrated the ground within the 216-T-4-2D Ditch.

The irregularly shaped landfill consists of eight trenches of varying sizes. Trench depth varied from 4.9 to 6.1 m (16 to 20 ft), and the length of the trenches varied from 29 to 436 m (95 to 1,430 ft). Trenches 5 and 8 are wide-bottom, stacking trenches and contain large equipment, such as portions of railcars. Trench 26 was also dug with a wide bottom to dispose of large tanks. The landfill received miscellaneous waste, such as rags, paper, rubber gloves, disposable supplies, and broken tools. The landfill also received industrial waste, such as failed equipment, tanks, pumps, ovens, agitators, heaters, hoods, jumpers, and accessories. All eight trenches received remote-handled LLW.

The waste is mainly from the 100 Area (23 percent by volume), the eastern and western portions of the Inner Area (13 percent), the 300 Area (16 percent), and other miscellaneous Hanford Site areas and facilities, such as the tank farms and the 1100 Area (22 percent). The remaining 26 percent is from offsite generators, the major contributors being Energy Systems Group, Argonne National Laboratory, Fermi National Accelerator Laboratory, and Battelle Columbus.

Portions of Trenches 5 and 8 contain post-1987 MLLW regulated under RCRA, also known as Green Island waste.

The T Ponds were used for disposal of liquid waste. In later years, the 218-W-2A and 218-W-3AE Landfills were located within portions of the original footprint of the T Ponds. Four T Ponds are included as part of the 200-SW-2 OU. The interface between the ditches that fed the T Ponds and the 200-SW-2 OU is just east of the road that parallels the east side of 218-W-3AE.

A detailed summary of the T Ponds and Ditches, including a summary of data from groundwater wells associated with these waste sites, is presented in Appendix I of this work plan. The following subsections are brief descriptions of these liquid waste disposal sites.

216-T-4-1D Ditch and 216-T-4A Pond

The 216-T-4-1D Ditch is collocated with the 218-W-3AE Landfill. From 1944 to 1966, it received process cooling water and steam condensate from T Plant. From 1951 to 1955 and 1965 to 1972, it received condenser cooling water and steam condensate from the 242-T evaporator at the T Tank Farm. From 1964 to 1970, it received decontamination waste from the 2706-T Building.

The ditch operated from November 1944 to May 1972 and received waste streams from the 207-T retention basin via pipeline 200-W-164-PL and waste from pipeline 200-W-163-PL, which connected to pipeline 200-W-164-PL.

The original bottom dimensions were 259 m (850 ft) by 2.4 m (8 ft). The ditch was replaced by the 216-T-4-2D Ditch in 1972. The first 15 m (50 ft) of the 216-T-4-1D Ditch was reused in the replacement ditch construction. Both the original and replacement ditches were surface stabilized in 1995.

The 216-T-4A Pond is collocated with the 218-W-3AE Landfill. It was a natural surface depression that received discharge from the 216-T-4-1D Ditch. The dimensions of the pond were about 549 m (1,800 ft) by 182 m (600 ft), essentially covering 6.5 ha (16 ac). The pond became active in 1944 and was exhumed in 1972 to make room for the expansion of the 218-W-2A Landfill. In 1995, the pond was interim stabilized with uncontaminated backfill and revegetated.

216-T-4-2D Ditch and 216-T-4B Pond

The 216-T-4-2D Ditch is collocated with the 218-W-3AE Landfill. From 1972 to 1995, it received condenser cooling water and steam condensate from the 242-T evaporator at the T Tank Farm. From 1972 to 1995, it received nonradioactive wastewater from 221-T air conditioning filter units and floor drains. The ditch operated from 1972 to 1995 and received waste streams from the 207-T retention basin via the 200-W-164-PL and waste from pipeline 200-W-163-PL, which connected to pipeline 200-W-164-PL. It was dug as a replacement for the 216-T-4-1D Ditch. The first 15 m (50 ft) of the original ditch (216-T-4-1D) was reused in the 216-T-4-2D Ditch construction. The ditch discharged to the 216-T-4B Pond. The original bottom dimensions were 533 m (1,750 ft) long by 2.4 m (8 ft) wide by 1.2 m (4 ft) deep. The ditch was backfilled and interim stabilized in July 1995 and permanently isolated by filling the last pipeline manhole.

The 216-T-4B Pond is collocated with the 218-W-3AE Landfill. The size of the pond is estimated at 6,100 m^2 (1.5 ac). The pond was often dry, since the majority of the effluent was absorbed in the 216-T-4-2D Ditch. The pond was constructed in 1972 to replace the exhumed 216-T-4A Pond. The 216-T-4B Pond was considered dry by 1977. However, the pond was not isolated from the ditch until 1995; therefore, a potential existed for effluent to reach the pond until that time.

2.3.1.5 218-W-4B Landfill (Western Inner Area)

The 218-W-4B Landfill covers about 3.5 ha (8.6 ac) and contains USG, LLW, and TRU waste, some of which is contained in caissons (SWITS). A detailed discussion of caissons, their use, and photographs of their construction and contents are provided in Appendix D.

The 218-W-4B Landfill is located in the central portion of the western Inner Area, about 150 m (500 ft) northwest of the 234-5Z Building, directly west of the 231-Z Building. The landfill contains RSW that has been partially retrieved under TPA Milestone M-91-40. This landfill does not contain MLLW or TRUM that was disposed after the effective date of RCRA regulation at the Hanford Site (August 19, 1987).

The trenches are approximately 177 m (580 ft) long and 3.1 to 3.7 m (10 to 12 ft) deep (Drawing H-2-33055, *Dry Waste Burial Ground 218-W-4B*).

The waste is mainly from the western Inner Area (53 percent by volume) and the 300 Area (35 percent). The remaining 12 percent is from the 100 Area (3 percent), offsite generators (mainly national laboratories in the DOE complex) (4 percent), and the tank farms (5 percent).

A 1980 document (RHO-65463-80-126, "Inconsistencies in 218-W-4B Site Data") indicates that the 218-W-4B Landfill is composed of 13 trenches and one row (Trench 14) of 12 caissons. Trench 6 contains LLW only. Trenches 7 and 11 and four alpha caissons in Trench 14 contain post-1970 suspect TRU waste. The RSW-TRU waste in Trench 11 has been partially retrieved under TPA Milestone M-91-40.

A small volume of liquid was disposed as tritium in metal cylinders or plutonium liquid. Trench 14 contains 11 caissons used for the disposal of 3.8 to 18.9 L (1 to 5 gal) cans of remote-handled waste (SWITS) and one empty alpha caisson. The caisson waste was received from 200 Area facilities, the 300 Area, and the 100-N Area. The four filled alpha caissons containing post-1970 RSW are CA1, CA2, CA3, and CA4.

A portion of the landfill was covered with standing water (WHC-EP-0912) in the winter of 1979–1980. Several inches of snow had fallen on top of frozen ground followed by a quick warming and rapid snowmelt, leaving standing water. Groundwater monitoring data were reviewed and indicated no detectable increases in monitored radioactive constituents.

Trenches 1 through 6 were backfilled and surface stabilized with clean fill in 1983. The surface was revegetated with grass. Trench 7 is covered with a 1.2 m (4 ft) soil mound. The remaining trenches were backfilled after use and stabilized with clean gravel in 1995. Stabilization of surfaces with clean gravel (rather than revegetation with grasses) has been shown to increase natural recharge to up to 80 percent of the annual precipitation because of a lack of moisture removal by evaporation and plant transpiration. Trenches stabilized with clean gravel would be a good location for initial investigations of subsurface moisture distributions with direct pushes.

2.3.1.6 218-W-4C Landfill (Western Inner Area)

The 218-W-4C Landfill covers approximately 15 ha (37 ac) and contains TRU waste (some combustible) and test reactor fuel waste. The largest portion of the 218-W-4C Landfill is located west and southwest of the Plutonium Finishing Plant (PFP). A smaller unused section (218-W-4C annex) is located directly south of the plant and north of 16th Street. The 218-W-4C Landfill contains low-level, TRU, and mixed waste.

The Z Plant burn pit is collocated with the 218-W-4C Landfill. This burn pit was exhumed during construction of the 218-W-4C Landfill.

Trenches 1, 4, 7, 20, 29, and the east end of Trench 24 contain RSW. The RSW in the 218-W-4C Landfill has been fully retrieved under TPA Milestone M-91-40. Trenches NC, 14, 19, 23, 28, 33, 48, 53, 58, and the remainder of Trench 24 received LLW. In addition, some waste in Trenches NC, 14, and 58 is currently identified as containing post-1987 MLLW (Green Islands).

The waste in the 218-W-4C Landfill (that is within the scope of this project) is mainly from the western Inner Area (24 percent by volume), the 100 Area (12 percent), the 300 Area (9 percent), and offsite generators (47 percent). The remaining 8 percent is from miscellaneous Hanford Site areas and the tank farms. The eastern annex portion of this unit never received waste.

The northernmost trench (Trench NC) contains a number of core barrels originating from the U.S. Department of the Navy. Trench 1 contains drums generated from mining the 216-Z-9 Crib and about 500 cans of ash received in the early 1980s. The ash was generated by the 232-Z Waste Incinerator Facility, which incinerated miscellaneous waste (e.g., rubber gloves, rags, paper, spent solvent, and cutting oils).

During the latter part of calendar year 1979 and the early part of 1980, a heavy snowfall on frozen ground and rapid melting caused ponding of water within lower areas in the 218-W-4C Landfill trenches. TRU drums were observed floating in one trench that had not been backfilled. Workers retrieved the drums undamaged (WHC-EP-0912; WHC-EP-0225, *Contact-Handled Transuranic Waste Characterization Based on Existing Records*). No sampling to confirm that there was not a release was done. As discussed in DOE/RL-92-03, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1991*, perched water was detected beneath the 218-W-4C Landfill in 1991. Groundwater monitoring data were reviewed and indicated no detectable increases in monitored radioactive constituents.

Z Plant Burn Pit

The Z Plant burn pit was a disposal site for combustible nonradioactive construction, office, and nonhazardous laboratory waste, including unnamed chemicals. The burn pit was exhumed during construction of the 218-W-4C Landfill. It was located near the west end of Trench 33. The burn pit was reported to have received 2,000 m^3 (2,600 yd^3) of waste for burning, including less than 1,000 m^3 (1,300 yd^3) of laboratory chemicals. The burn pit was 15 m (50 ft) long, 12 m (40 ft) wide, and 3 m (10 ft) deep. It was used from 1950 to 1960 (WIDS; BHI-00175, *Z Plant Aggregate Area Management Study Technical Baseline Report*).

2.3.1.7 218-W-5 Landfill (Western Inner Area)

The in-scope area of the 218-W-5 Landfill covers approximately 24 ha (59 ac). This landfill began receiving waste in 1985 and stopped receiving waste in 2004. The landfill is at the southwest corner of the intersection of 27th Street and Dayton Avenue. Original plans called for the area to contain 18 LLW trenches and 4 MLLW trenches. The landfill was expanded to the west and north and was designed for 56 trenches, all oriented east-west. Of these, only 11 LLW trenches were constructed and received waste.

Trenches 31 and 34 are large rectangular excavations in the southwest corner of the 218-W-5 Landfill, currently operated as disposal units for MLLW. They are out of the scope of this work plan and currently in use. They are both RCRA TSD landfills. The trenches are constructed with polyethylene liners and leachate collection systems.

The trenches (other than the currently active MLLW trenches) range from 4.6 m (15 ft) to 12 m (40 ft) wide at the bottom and from 5.2 to 6.1 m (17 to 20 ft) deep. The length of the trenches varies from 350 to 130 m (1,160 to 430 ft) long.

About 13 percent of the volume of in-scope waste disposed to the 218-W-5 Landfill was generated from the 100 Area; 12 percent from the 300 Area, 28 percent offsite, 35 percent from the 200 Areas, 5 percent from Battelle, and the remaining 7 percent from other miscellaneous Hanford Site areas. It is mainly packaged in drums, other metal containers, and wooden boxes. It contains miscellaneous LLW such

as demolition and cleanup debris from various facilities, dirt, and building maintenance items (e.g., filters).

A small portion of Trench 22 is currently identified as containing MLLW disposed after the effective date of RCRA regulation at the Hanford Site (August 19, 1987).

2.3.2 200-SW-2 Operable Unit Past-Practice Landfills

Seventeen radioactive past-practice landfills are within the scope of this work plan. Seven are in the western Inner Area and 10 are in the eastern Inner Area. The following subsections describe the past-practice landfills.

2.3.2.1 218-C-9 Landfill (Eastern Inner Area)

The 1.8 ha (4.5 ac) 218-C-9 Landfill received liquid and solid waste. The reported dimensions have varied widely from source to source over time. This landfill is located north of the C Plant/Hot Semiworks Facility.

The entire 218-C-9 Landfill has been backfilled and surface stabilized with fly ash from the 284-E powerhouse ash pit. While fly ash is an effective medium to control plant intrusion because of its sterility, it was difficult to conduct geophysical surveys of the site in support of nonintrusive investigations. A routine radiological survey is performed annually.

There are 724 burial records associated with the disposal and use of the 218-C-9 Landfill. This is believed to encompass all of the burials that took place at the 218-C-9 Landfill. Each burial record, at a minimum, contains the location (northing and easting), container weight, container volume, generating company, source facility, total radionuclide activity, and a component description. Additional information, such as more detailed descriptions of waste forms and specific radionuclide activities, may be available in specific records. No Hanford Site drawings have been found that describe the 218-C-9 Landfill.

Debris at the landfill consists of potentially contaminated concrete rubble, large equipment, roofing material, metal scrap, and other Hot Semiworks demolition waste. Contaminated soil from UPR-200-E-37 and UPR-200-E-98 also was placed in the 218-C-9 Landfill. Although the majority of the waste in the 218-C-9 Landfill consists of noncontainerized demolition rubble, the landfill also contains approximately 270 drums (208 L [55 gal]) of LLW.

2.3.2.2 216-C-9 Pond

Before it was used as a liquid waste disposal site and a solid waste landfill, this excavation was the foundation of the planned (but never built) plutonium separation building (221-C). For 30 years (1953 to 1983), the 216-C-9 Pond received about 1 billion L (264 million gal) of mildly radioactive steam condensate liquid discharge from the 209-E Critical Mass Laboratory and the Hot Semiworks (201-C) source facilities. Two years after liquid discharges to the site ceased, solid waste was disposed to the previously used pond for a 4-year period (1985 to 1989). A large portion of the 216-C-9 Pond area was assigned the facility designation of "218-C-9" to signify its use as a solid waste landfill.

2.3.2.3 218-E-1 Landfill (Eastern Inner Area)

The 218-E-1 Landfill was also called the Dry Waste Burial Garden 1. This landfill received packaged waste materials from the B Plant complex. The landfill covers approximately 1 ha (2.4 ac). This landfill is located approximately 150 m (500 ft) west of the PUREX Plant.

Although some literature sources report 21 trenches (e.g., RHO-CD-673, *Handbook 200 Areas Waste Sites*), a more recent geophysics survey performed in 2006 (D&D-30708, *Geophysical Investigations Summary Report; 200 Areas Burial Grounds: 218-E-1, 218-E-2A, 218-E-8, 218-E-12A, 218-W-1, 218-W-2, 218-W-3, and 218-W-11*) shows 15 trenches running north-south, about 60 m (200 ft) long, consistent with the site reference drawings.

Waste trenches were backfilled shallowly at the time of burial. At an unknown later date, they were filled to ground level with cinders from the nearby 284-E powerhouse ash disposal pile. The cinders made a comparatively sterile seed bed, acting as a deterrent against plant growth that could have taken up some of the radioactivity through the roots. The surface of the cinders was covered with coarse gravel to guard against wind erosion, and a dry moat was bladed around the zone perimeter inside the post line to discourage vehicle travel over the surface of the landfill (WHC-EP-0912). The landfill was surface stabilized in 1981 with 0.5 m (1.5 ft) of clean fill, revegetated, and load tested.

2.3.2.4 218-E-2 Landfill (Eastern Inner Area)

The 218-E-2 Landfill covers approximately 1.3 ha (3.3 ac). The landfill is collocated with the 218-E-2A, 218-E-4, 218-E-5, 218-E-5A, and 218-E-9 Landfills.

The landfill consists of eight industrial trenches that run east-west. The trench lengths vary from 27 to 142 m (90 to 465 ft). The landfill received unsegregated material contaminated with mixed fission products (WIDS), uranium, and plutonium (SWITS). The unit was surface stabilized in 1979 with 0.3 m (1 ft) of clean backfill material and vegetated with wheatgrass (WIDS).

2.3.2.5 218-E-2A Landfill (Eastern Inner Area)

The 218-E-2A Landfill was originally called Regulated Equipment Storage Site 2A. Service dates are not known, but are estimated at 1945 to 1950, with the landfill retired by 1975 (WHC-EP-0845, *Solid Waste Management History of the Hanford Site*). The site is about 0.3 ha (0.7 ac). The landfill is located directly south of the 218-E-2 Landfill, across the railroad tracks, north of B Plant. This landfill was originally used for the aboveground storage of equipment that has since been removed.

The drawings conflict slightly in their depictions of a singular trench location. The trench is about 14 m (46 ft) wide. No records or burial inventories are available to indicate that this landfill was used as a disposal facility, and waste volumes are not known. On February 21, 1978, an inspection of the trench disclosed a number of sinkholes along the centerline, indicating that the trench had been dug and used for dry waste burials. In the summer of 1979, at least 0.3 m (1 ft) of clean soil was used to fill the trench to ground level (WHC-EP-0912).

2.3.2.6 218-E-4 Landfill (Eastern Inner Area)

The 218-E-4 Landfill was historically called the 200 East Minor Construction No. 4 and Equipment Landfill 4. The landfill covers an area of approximately 1.2 ha (2.9 ac) and contains mainly construction debris that is unsegregated.

The landfill is a wedge-shaped polygon located between two railroad tracks and north of B Plant. It received repair and construction waste from the 221-B Building (B Plant) modifications. The landfill is collocated with the 218-E-2, 218-E-2A, 218-E-5, 218-E-5A, and 218-E-9 Landfills.

2.3.2.7 218-E-5 Landfill (Eastern Inner Area)

The 218-E-5 Landfill was originally called Industrial Burial Garden 5. It was used from 1954 to 1965. The 218-E-5 Landfill covers about 1.1 ha (2.6 ac). The landfill is contiguous with the western boundary of the 218-E-2 Landfill, north of B Plant. This landfill received miscellaneous contaminated equipment from the tank farm uranium recovery process and the PUREX Plant.

Extensive research was conducted during 1979 to determine the location of all the trenches within the bounds of the 218-E-2, 218-E-5, 218-E-5A, and 218-E-9 Landfills. This research was performed to support interim site stabilization. The research included viewing aerial photographs and construction drawings, analyzing plant growth patterns, and load testing the ground surface. Four previously unrecorded trenches were identified; these trenches are now numbered 1, 2, 4, and 5 on Hanford Site Drawing H-2-55534, *218-E2, E2A, E4, E5, E5A, & E9 Industrial Burial Ground Plan & Details*. The trenches in the 218-E-2, 218-E-2A, 218-E-4, 218-E-5, 218-E-5A, and 218-E-9 Landfills were stabilized with the addition of 0.3 m (1 ft) of soil (WHC-EP-0912).

Source literature (RHO-CD-673) indicates that trench locations for this landfill may not be accurately represented on the drawing. Geophysics data collected in 2006 (D&D-28379, *Geophysical Investigations Summary Report 200 Area Burial Grounds: 218-C-9, 218-E-2A, 218-E-5, 218-E-5A, 218-E-8, 218-W-1A, 218-W-2A, and 218-W-11*) suggest that the trench locations are slightly different from depicted on Hanford Site Drawing H-2-55534.

2.3.2.8 218-E-5A Landfill (Eastern Inner Area)

The 218-E-5A Landfill was originally called Industrial Burial Garden 5A. The 218-E-5A Landfill covers approximately 0.38 ha (0.9 ac). The landfill is located contiguous with the western boundary of the 218-E-5 Landfill, north of B Plant.

This landfill received failed equipment and industrial waste that consisted of three or four very large (15 by 4.6 by 5.5 m [50 by 15 by 18 ft]) wooden burial boxes containing a PUREX "K-2" column package, a PUREX "L" cell package, and a PUREX "J-2" pulse column package. The boxes were partially buried in 1958 and backfilled in 1961. The large box burial locations are well documented and photographed. The photographs show foaming used during the backfilling operation to contain contamination because of a box collapse. In 1979, the landfill was stabilized with 0.3 m (1 ft) of clean soil and vegetated with wheatgrass.

2.3.2.9 218-E-8 Landfill (Eastern Inner Area)

The 218-E-8 Landfill was once known as the Construction Burial Garden (originally no facility number was assigned to it). This landfill covers approximately 0.44 ha (1.1 ac). The 218-E-8 Landfill is located at the northwest edge of the eastern Inner Area burn pit, north of the PUREX Plant. The location and number of trenches in this landfill are not known. However, historical aerial photographs revealed that several pallets of debris remained exposed for several years, possibly suggesting the low-risk nature of the waste. Older source literature (HW-60807, *Unconfined Underground Radioactive Waste and Contamination in the 200 Areas-1959*) shows a different size and location for the landfill than do current site maps (e.g., Hanford Site Drawing H-2-821555, Sheet 5, *Subsidence Drawing Burial Ground 218-E-12B*) and WIDS.

A 2005 geophysical survey showed no clear indications of any distinct trenches or concentration of large debris. The 2006 geophysical survey indicated buried objects or debris located outside the area of the landfill. The 200 East burn pit is a nonradioactive burial site located adjacent to the 218-E-8 Landfill; its proximity complicates the interpretation of geophysical surveys and historical photographs because it is difficult to distinguish between the two sites.

This landfill received contaminated equipment and material from 1958 to 1959 during construction of the 293-A PUREX dissolver offgas building and removal of the PUREX temporary ventilation barrier during the PUREX second crane addition. The site contains USG only.

In 1979, the landfill was stabilized with at least 0.5 m (1.5 ft) of backfill. There are no known individual drawings of the landfill; however, drawings of the 218-E-12B Landfill (e.g., Hanford Site Drawing H-2-821555, Sheet 5) often show the 218-E-8 Landfill, which is near the southeast corner of the 218-E-12B Landfill.

2.3.2.10 218-E-9 Landfill (Eastern Inner Area)

The 218-E-9 Landfill was originally known as East Regulated Equipment Storage Site No. 009 and covers approximately 0.56 ha (1.4 ac). The landfill is collocated with the 218-E-2, 218-E-2A, 218-E-4, 218-E-5, and 218-E-5A Landfills and was stabilized in 1980. Part of the footprint of the 218-E-9 Landfill is shared with 218-E-2. The landfill was used as an aboveground storage site for fission product equipment that became contaminated in the uranium recovery process operations at the tank farms. It is not certain that the landfill was used for burials; however, sink holes were noticed in the landfill in the late 1970s, indicating the likelihood that it had been used. The landfill was restabilized in 1991 when contaminated vegetation was found growing on the surface.

2.3.2.11 218-E-12A Landfill (Eastern Inner Area)

The 218-E-12A Landfill was originally known as Dry Waste Burial Garden 12. The 218-E-12A Landfill covers approximately 10 ha (25 ac). The landfill is located north of B Plant, about 30 m (100 ft) northwest of the C Tank Farm.

This landfill contains 28 trenches 137 to 311 m (450 to 1,020 ft) long. Hanford Site Drawing H-2-32560, *As-Built Dry Waste Burial Site #218-E-12A*, indicates that Trenches 4 through 11, 15 through 16, and 26 through 28 contain acid-soaked material, but little is understood about the nature of this material. However, interviews with former PUREX Plant workers indicate that this waste is likely rags that were once saturated with a nitric acid solution and used to decontaminate equipment in the PUREX facility. These acid-soaked material trenches are narrower (1.5 to 3.7 m [5 to 12 ft] wide) and presumably shallower than other trenches (9.2 m [30 ft] wide) in this landfill.

Unpublished logbooks from the 1960s suggest that much of the waste at this landfill consists of bulk trash from the PUREX Plant, placed in fiberboard boxes or dumped from trucks. Other recorded items buried include tank farm pumps, animal carcasses from the 108-F Biology Laboratory, and miscellaneous construction waste. About 35 metal drums of depleted uranium from offsite generators were buried in April 1962 in Trench 12. Offsite uranium was typically buried in the western Inner Area; however, two shipments were diverted to the 218-E-12A Landfill when a criticality accident in the Recovery of Uranium and Plutonium by Extraction (RECUPLEX) facility the same week closed down operations in the western Inner Area for several days. This is the only known record of offsite uranium in the 218-E-12A Landfill.

In 1986, water inflow was observed in unfilled Trench 36 in the 218-E-12B Landfill directly to the north of the 218-E-12A Landfill. The source of water was seepage from the nearby 216-B-2-3 Ditch, which flowed between the 218-E-12A and 218-E-12B Landfills. The 216-B-2-3 Ditch conveyed water roughly 1,219 m (4,000 ft) from the 207-B retention basins to a diversion structure capable of routing the water to either B Pond or Gable Mountain Pond at the time. An investigation into the incident was conducted and documented in 1986 (SD-WM-TI-260). Interim actions were taken to remove vegetation and debris restricting flow in the ditch, and bentonite clay was added to minimize seepage of water from the ditch. The ditch eventually was replaced with a pipeline and is out of service.

Potential water inflow from the 216-B-2-3 Ditch into the 218-E-12A Landfill also was investigated by excavating trenches and drilling boreholes. The 218-E-12A Landfill is topographically higher than the 216-B-2-3 Ditch. Furthermore, the 216-B-2-3 Ditch had been previously treated with bentonite clay adjacent to the 218-E-12A Landfill, restricting seepage from the ditch. Finally, no saturated sediments were encountered during the investigation of the 218-E-12A Landfill. It was concluded that no water inflow occurred above the bottom of the trenches in the 218-E-12B Landfill. In 1979-1980, and again in 1994, the landfill was stabilized with 0.5 to 0.6 m (1.5 to 2.0 ft) of backfill.

2.3.2.12 218-W-1 Landfill (Western Inner Area)

The 218-W-1 Landfill is located on the east side of Dayton Avenue, west of the TX Tank Farm. It is about 460 m (1,500 ft) northwest of the 234-5Z Building and lies between the 218-W-2 and 218-W-11 Landfills. This landfill covers approximately 2.2 ha (5.5 ac).

The 218-W-1 Landfill contains alpha-contaminated solid waste and miscellaneous dry waste. Photographic evidence suggests that the landfill received waste packaged mainly in small wooden boxes or fiberboard containers or wrapped in heavy brown paper. Property disposal records from the 1940s and 1950s indicate that waste disposed included small- to medium-sized equipment (e.g., dip tubes, laboratory sample cups, and laundry machines). This landfill also may contain tools, air filters, and protective clothing (e.g., masks). Waste with dose rates of up to 35 rem/hr at the container surface was reported in early source literature (HW-28471, *Unconfined Underground Radioactive Waste and Contamination in the 200 Areas*).

The landfill consists of 15 trenches that run east to west. The landfill currently appears as a field with an undisturbed, flat surface that has been seeded with field grass. A small area near the center of the landfill once contained contaminated mulch with a maximum reading of 12,000 d/min. Evidence exists that waste boxes once were buried less than 1.2 m (4 ft) from the surface (WHC-EP-0912).

2.3.2.13 218-W-1A Landfill (Western Inner Area)

The 218-W-1A Landfill was originally called Industrial Burial Garden 1 and Industrial Waste No 1. The landfill is located 600 m (2,000 ft) northwest of T Plant. A railroad spur passes through the central portion. This landfill covers approximately 3.4 ha (8.4 ac).

In addition to process equipment and process waste buried in 10 trenches, pieces of equipment were stored aboveground that later were removed. This landfill was the first large-equipment burial site in the western Inner Area. Literature indicates burials of REDOX Plant pots, silver reactors, condensers (HW-30372, *Manufacturing Department Radiation Incident Investigation*), tank samplers from Oak Ridge National Laboratory, and general trash from chemical separations plants in the western Inner Area.

Most of the equipment was buried in wooden boxes with a double liner of waterproof paper (HW-30372). The boxes tended to collapse and cause settling of the ground surface. Most of the sinkholes were filled with clean soil in 1975, but a number of deep sinkholes remained north of the railroad tracks (WIDS). A large number of 2 m (6 ft) thick concrete cellblocks were stored aboveground south of the railroad tracks, but eventually they were disposed to this landfill. Nearly all of the surface radioactive contamination that was on the blocks when they were stored in the landfill has since decayed (WHC-EP-0912). The ground surface is currently free of contamination (WIDS).

2.3.2.14 218-W-2 Landfill (Western Inner Area)

The 218-W-2 Landfill was originally called Dry Waste Burial Garden 2. The landfill is contiguous with the south boundary of the 218-W-1 Landfill. Early literature sources do not distinguish between the 218-W-1 and 218-W-2 Landfills; for example, HW-28471 refers to the 218-W-1 and 218-W-2 Landfills as "solid waste landfills" and indicates there were 18 trenches as of the time of publication (1953). HW-41535, *Unconfined Underground Radioactive Waste and Contamination in the 200 Areas*, published in 1956, indicates 20 trenches. This landfill covers approximately 2.8 ha (7.0 ac).

This landfill received packaged waste materials from the western Inner Area. No material was stored aboveground. The waste disposed to the 218-W-2 Landfill likely is similar to those in the 218-W-1 Landfill. Some of the landfill trenches did not receive the required 1.2 m (4 ft) of backfill before stabilization, when waste boxes were observed to be within 0.5 m (1.5 ft) of the ground surface. Sink holes were filled in 1974 (WHC-EP-0912).

2.3.2.15 218-W-2A Landfill (Western Inner Area)

The 218-W-2A Landfill was originally called Industrial Burial Garden 2. This landfill covers approximately 15 ha (38 ac) and is located northeast of the corner of 23rd Street and Dayton Avenue. Interim stabilization activities were initiated during the summer and fall of 1979 and completed in 1980. The purpose of the work was to eliminate the hazards of subsurface voids, reduce wind-surface erosion, remove ground-surface contamination, and establish deterrents against undesirable vegetation growth.

Records suggest that most of the waste in this landfill was added to the trenches via dump truck or was packaged in concrete or wooden boxes. The landfill received contaminated soil, debris, and process equipment, including laboratory equipment and waste from the 300 Area, some with dose rates up to 500 R/hr; failed REDOX equipment; contaminated rails; a 1951 International Harvester panel truck used in solid waste operations; filters from B Plant; and tube bundles from the PUREX Plant. Based on logbook records and SWITS, much of the waste in this landfill (at least 20 percent by volume) is contaminated soil from stabilization of the 216-T-4-2D Ditch and 216-T-4B Pond (Trench 27). It also received waste from the U Tank Farm and the 216-U-14 Laundry Ditch. DOE/RL-2007-02, *Supplemental Remedial Investigation/Feasibility Study Work Plan for the 200 Areas Central Plateau Operable Units: Volume I: Work Plan and Appendices*, and *Volume II: Site-Specific Field-Sampling Plan Addenda*, addresses characterization of the 216-T-4B Pond and a portion of the 216-T-4-2D Ditch. Cell cover blocks, 2 m (6 ft) thick, were buried in the 218-W-2A Landfill along the west side of the railroad tracks in Trenches 12 through 15 (ARH-2757, *Radioactive Contamination In Unplanned Releases To Ground Within the Chemical Separations Area Control Zone Through 1972 (Exclusive of Liquid Waste Storage Tank Farms)*). Trench 27 contains contaminated soil scraped from the 216-T-4B Pond.

Historical records (e.g., HW-41535) indicate that in 1954 two sections of railroad track, contaminated during the fall of 1954 to maximum dose rates of 350 mrem/hr, were buried in Trench 16, which is located outside and across the railroad tracks from the 218-W-2A Landfill. ARH-2015, *Radioactive Contamination in Unplanned Releases to Ground Within the Chemical Separations Area Control Zone through 1970, Part 4* (Appendix A), indicates that the rails were removed in 1971. Geophysics survey results in 2006 (D&D-28379), which did not indicate the presence of rails in Trench 16, corroborate this.

Trenches 17, 18, 19, 25, and 26 were never excavated or used.

2.3.2.16 218-W-3 Landfill (Western Inner Area)

The 218-W-3 Landfill was originally called Dry Waste Burial Garden 3. This landfill covers approximately 3.1 ha (7.6 ac) and is located northeast of the corner of 23rd Street and Dayton Avenue. The landfill is west of the 218-W-2A Landfill. According to the current Hanford Site Drawing

(H-2-32095, Sheet 1, *218-W-2A Industrial Burial Ground & 218-W-3 Dry Waste Burial Ground*), the landfill is composed of 20 trenches running east-west. However, trench configurations as depicted on the current site drawing (H-2-32095) are based on field observations made during stabilization work in the early 1980s. Geophysics data collected in 2006 (D&D-30708) and unpublished logbook notations suggest that the trench locations, lengths, orientations, and numbering systems are somewhat different from those indicated on the drawing.

Logbooks suggest that much of the waste in this landfill is packaged in fiberboard containers and that the sources of the waste include PFP (about 50 percent by volume), other western Inner Area facilities (38 percent), the 108-F Biology Laboratory (5 percent), the 300 Area (5 percent), and offsite generators (2 percent). Known items buried at the landfill include miscellaneous small- to medium-sized equipment, process hoods, tools, contaminated laundry, a 1951 International Harvester panel truck once used for transporting waste within the landfills, metal drums of depleted uranium from offsite generators, and building debris (e.g., ductwork and lumber).

Waste from PFP that was heavily contaminated with plutonium and organics may also have been disposed at this landfill. HW-59645, *Disposition of Plutonium to Burial 234-5 Building*, describes 149 cardboard boxes (about 0.112 m^3 [4 ft^3] per box) disposed to burial. The burial location is not specified, but from the source facility location (western Inner Area), period (1959), and type of waste (dry waste), the burial location may be surmised to be the 218-W-3 Landfill. The waste is described as rubber gloves, plastic, and paper cartons that may have been damp with carbon tetrachloride and/or tributyl phosphate, and, to a lesser extent, damp with nitric and hydrofluoric acid. The boxes initially were stored at PFP and Gable Mountain vaults where they decomposed. Upon discovery of the decomposition, the boxes were wrapped in plastic and disposed. The landfill was stabilized in 1983; the north end was restabilized with fill and gravel in 2001.

2.3.2.17 218-W-4A Landfill (Western Inner Area)

The 218-W-4A Landfill covers approximately 7 ha (17 ac). The landfill is located southeast of the intersection of 23rd Street and Dayton Avenue and contains 21 miscellaneous dry waste trenches oriented east-west and six to eight vertical pipe units or caissons. The landfill also includes an unnumbered trench, oriented north-south, near the east end of Trench 11 that contains a REDOX column (Hanford Site Drawing H-2-32487, *218-W-4A Dry Waste Burial Site*).

Source facilities include offsite uranium drums and equipment from 231-Z, 234-5Z, the facility for the RECUPLEX process, REDOX, 222-U, and the 300 Area laboratories. The landfill contains miscellaneous waste, including failed equipment, plutonium-contaminated laboratory waste, and about 1,800 containers of depleted uranium. It is estimated that the landfill contains 394,000 kg of uranium. It is believed, but not known for certain, that most of the uranium inventory at the 218-W-4A Landfill is in the 1,800 containers of depleted uranium.

Burial records suggest that about two-thirds of the waste in this landfill is packaged in fiberboard containers. Trenches 16 and 20 received high-concentration plutonium waste from PFP. Trench 19 is marked as RECUPLEX on Hanford Site Drawing H-2-32487.

2.3.2.18 218-W-11 Landfill (Western Inner Area)

The 218-W-11 Landfill was used as an aboveground, regulated storage area for low-level contaminated equipment in the 1960s. Equipment was sometimes buried here until radiation levels decayed to an acceptable value and then exhumed for reuse. Some material was buried here permanently. The 218-W-11 Landfill covers approximately 0.87 ha (2.1 ac) and is located between the 218-W-1 and 218-W-4A Landfills.

Geophysics data (D&D-30708) from 2005 and 2006 suggest that one trench in the landfill runs 45 m (150 ft) east and west and corresponds approximately with the northernmost trench location in Hanford Site Drawing H-2-94250, *Dry Waste Burial Ground 218-W-11*. There may be a pit to the east of this trench (D&D-30708). The trench was used in 1960 for burial of low-level contaminated sluicing equipment that had been used in the uranium recovery process. Some of the equipment was later removed from the trench and used in the strontium-cesium recovery process (WHC-EP-0912).

2.4 Associated Sites

Several of the landfill-associated waste sites (Z Plant burn pit, 216-C-9 Pond, and T Ponds) are described in Section 2.3, along with their associated landfills. They are briefly described in Table 2-3. There are also 11 UPR waste sites within or near the 200-SW-2 OU landfills that are summarized in Table 2-4. The locations of all the landfill-associated waste sites are presented in Figure 2-4. For more information on the liquid waste sites, refer to Appendix I.

Table 2-3. Liquid Waste Sites and Burn Pit Collocated with 200-SW-2 OU Landfills

WIDS Site Code	Site Name(s)	Site Description	Landfill with Collocated Site
216-C-9	216-C-9; 216-C-9 C Canyon Excavation Semiworks Swamp; 216-C-9 Pond; 216-C-9 Swamp; former 221-C Canyon Excavation; Semi-Works Swamp; 216-C-7 Swamp	The excavation was originally intended to be the foundation for the 221-C Canyon Facility that was never built. It was modified to receive cooling water from the 201-C Semiworks Facility. The Hot Semiworks ceased operation in 1967 and remained in a standby mode until 1983. During that time, the pond decreased in size until it was only a small marshy area in the excavation bottom. No radioactivity was identified along the swamp perimeter in a radiological survey performed in 1978. The pond area was backfilled with approximately 0.9 m (3 ft) of washed gravel. The Semiworks facility decommissioning began in 1983. All liquid discharge pipes were isolated. In December 1985, the east end of the dried pond excavation began to be used as a solid waste burial ground for waste associated with the Semiworks decommissioning (refer to the 218-C-9 waste site). The area was backfilled to grade and interim stabilized in 1989 with material from the 200 East powerhouse ash pile. The site name designation was changed to 218-C-9 to reflect the dry waste inventory added to the pit from the Hot Semiworks decommissioning activities.	218-C-9
216-T-4-1	216-T-4-1; 216-T-4-1 Ditch	The 216-T-4-1D Ditch is collocated with the 218-W-3AE Landfill. From 1944 to 1966, it received process cooling water and steam condensate from T Plant. From 1951 to 1955 and 1965 to 1972, it received condenser cooling water and steam condensate from the 242-T evaporator at the T Tank Farm. From 1964 to 1970, it received decontamination waste from the 2706-T Building. During its operating years, the ditch emptied into the 216-T-4A Pond.	218-W-3AE

Table 2-3. Liquid Waste Sites and Burn Pit Collocated with 200-SW-2 OU Landfills

WIDS Site Code	Site Name(s)	Site Description	Landfill with Collocated Site
216-T-4-2	216-T-4-2; 216-T-4-2 Ditch	This unit was dug as a replacement for the 216-T-4-1 Ditch in May 1972. The first 15 m (50 ft) of the new ditch is common with the original ditch. It received T Plant cooling water and condensate waste via the 207-T retention basin. A 1978 radiological survey found the first 15 m (50 ft) to be contaminated, but the remainder of the ditch was not radiologically contaminated. The ditch was constructed with riprap at the head end. A 76 cm (30 in.) diameter, 12-gauge corrugated galvanized inlet pipe was located 0.9 m (3 ft) below grade. Most of the effluent was absorbed in the first quarter of the ditch length. The distal end of the ditch and the 216-T-4B Pond were often dry. The ditch was backfilled and interim stabilized in July 1995. Permanent isolation was accomplished by filling the last manhole along the effluent pipeline with concrete. The site received steam condensate and condenser cooling water from the 242-T evaporator and nonradioactive wastewater from 221-T air conditioning filter units and floor drains.	218-W-3AE
216-T-4A	216-T-4A; 216-T-4 Swamp; 216-T-4-1 (P); 216-T-4-1 Pond	The pond received cooling water and steam condensate from 221-T and 224-T via the 207-T retention basin and the 216-T-4-1 Ditch. The pond became active in November 1944 with the startup of the 221-T chemical separation plant. The wastewater in the ditch flowed through a culvert that went under the 218-W-2A Burial Ground railroad spur and then ran into a shallow ditch cut to a natural surface depression in the desert floor. The pond no longer exists. The entire surface of the bottom of the original pond (216-T-4A) was scraped to a depth of 15 to 23 cm (6 to 9 in.) and placed in the 218-W-2A Burial Ground (Trench 27). The scraped area was covered with clean soil in February 1973. In April 1973, 20,000 m^2 (5 ac) of the scraped pond bottom was seeded with Siberian wheatgrass to help stabilize the ground surface. In May 1972, an earthen dike was built to separate the replacement pond area (216-T-4B) from the 218-W-2A Burial Ground expansion. In 1995, the area was interim stabilized with 46 to 61 cm (18 to 24 in.) of uncontaminated backfill and revegetated.	218-W-2A; 218-W-3AE
216-T-4B	216-T-4B; 216-T-4 new pond; 216-T-4-2 (P); 216-T-4-2 Pond	The pond was located east of the old 216-T-4A Pond. A portion of the 218-W-3AE Burial Ground was built over the dry pond location. The pond's size has been estimated as 0.6 ha (1.5 ac). The pond was a natural depression that received overflow runoff from the 216-T-4-2 Ditch. The effluent was usually absorbed in the ditch, leaving the pond area dry. This unit was constructed in May 1972 to replace the old	218-W-3AE

Table 2-3. Liquid Waste Sites and Burn Pit Collocated with 200-SW-2 OU Landfills

WIDS Site Code	Site Name(s)	Site Description	Landfill with Collocated Site
		216-T-4A Pond. An earthen dike (396 m [1,300 ft] long, 3.7 m [12 ft] top width, and an average height of 0.5 m [1.5 ft]) was built to keep the new pond water from seeping into the 218-W-2A Landfill. The original ditch from the 207-T retention basin (216-T-4-1) was redirected to the new pond area. The volume of water in the new ditch (216-T-4-2 Ditch) was usually not large enough to fill the pond. The effluent was usually absorbed in the first quarter of the ditch, leaving the pond area dry. The pond was considered to be dry after 1977. Since the ditch was not physically isolated from the pond, a potential existed for effluent to reach the pond area until 1995, which is the discharge end date into the 216-T-4-2 Ditch.	
Z PLANT BP	Z Plant burn pit	This burn pit was a disposal site for combustible nonradioactive construction, office, and nonhazardous laboratory waste, including unnamed chemicals. The burn pit was exhumed during construction of the 218-W-4C Landfill. It was located near the west end of Trench 33. The burn pit was reported to have received 2,000 m^3 (2,600 yd^3) of waste for burning, including less than 1,000 m^3 (1,300 yd^3) of laboratory chemicals. The burn pit was 15 m (50 ft) long, 12 m (40 ft) wide, and 3 m (10 ft) deep. It was used from 1950 to 1960 (BHI-00175).	218-W-4C

Source: BHI-00175, *Z Plant Aggregate Area Management Study Technical Baseline Report.*

Table 2-4. UPR Sites Consolidated Within 200-SW-2 OU Landfills

WIDS Site Code	Site Name(s)	Site Description	Landfill with Consolidated Site
UPR-200-E-53	UPR-200-E-53, UN-200-E-53, contamination in 218-E-1	Contamination spread by bulldozer when shallow buried contaminated waste was unearthed during backfilling activities. The area is approximately 15 m by 46 m (50 ft by 150 ft) and is located at the south end of 218-E-1. Contamination at levels of up to 150 mR/hr was recorded at this site. Status: Inactive	218-E-1
UPR-200-E-23	UPR-200-E-23, UPR-200-W-158, burial box collapse at 218-E-10	Airborne contamination spread over the 218-E-10 Landfill when a burial box containing two PUREX process steam tube bundles collapsed during backfill operations. Three days after partially backfilling, the landfill was found generally contaminated with levels ranging from 10 to 60 mR/hr. Initially, this site was in	218-E-10

Table 2-4. UPR Sites Consolidated Within 200-SW-2 OU Landfills

WIDS Site Code	Site Name(s)	Site Description	Landfill with Consolidated Site
		WIDS under the alias UPR-200-W-158 before being determined the event took place in the eastern Inner Area. Status: Inactive	
UPR-200-E-24	UPR-200-E-24, UN-200-E-24, contamination plume from 218-E-10 Landfill	This site is associated with UPR-200-E-23 because of the same incident, but this site documents the large plume of contamination that resulted. Airborne contamination was generated when a burial box containing two PUREX process steam tube bundles collapsed during backfill operations within the 218-E-10 Landfill. Status: Inactive	218-E-10
UPR-200-E-30	UPR-200-E-30, UN-200-E-30, contamination within 218-E-10	Contamination occurred when a large wooden drag-off box collapsed as it was being backfilled in place within the 218-E-10 Landfill. The majority of contamination was located within the landfill. Contamination was spread over 37,160 m^2 (400,000 ft^2) at a maximum of 500 mR/hr. Status: Inactive	218-E-10
UPR-200-W-16	UPR-200-W-16, fire at 218-W-1 Landfill	This is a duplicate of the occurrence described in UPR-200-W-11. It was incorrectly reported in BHI-00175. The correct location (UPR-200-W-16) was confirmed by the map in HW-54636. A fire occurred within the waste boxes spreading plutonium (alpha) contamination. Maximum contamination levels were found to be 20,000 dpm/100 cm^2 within the 218-W-1 Landfill and 30,000 dpm/100 cm^2 outside of the landfill. Contamination outside of the landfill boundaries is not within the scope of this work plan. Status: Inactive	218-W-1
UPR-200-W-11	UPR-200-W-11, UN-200-W-11, UPR-200-W-16, 218-W-1 Landfill fire	This is a duplicate of the occurrence described in UPR-200-W-16. The correct location (UPR-200-W-16) was confirmed by the map in HW-54636. In 1952, a fire occurred within the waste boxes spreading plutonium (alpha) contamination. Maximum contamination levels were found to be 20,000 dpm/100 cm^2 within the 218-W-1 Landfill and 30,000 dpm/100 cm^2 outside of the landfill. Status: Inactive	218-W-1
UPR-200-W-26	UPR-200-W-26, contamination spread during burial operation	Wind dispersed contamination while a box of used connectors was being unloaded from a flatcar. Contamination spread onto the flatcar and onto the surrounding ground. This release is probably associated with the 218-W-1A Landfill, near T Plant. Radiation incident investigation at the time did not report any recommendations for reducing contamination at the landfill. Status: Inactive	218-W-1A

Table 2-4. UPR Sites Consolidated Within 200-SW-2 OU Landfills

WIDS Site Code	Site Name(s)	Site Description	Landfill with Consolidated Site
UPR-200-W-53	UPR-200-W-53, burial box collapse	Collapse of a burial box in 218-W-2A containing REDOX Plant cell jumpers occurred during backfilling operations releasing fission product contamination. Contamination levels ranged from 50 mR/hr at the landfill to 60,000 c/min at T Plant. Status: Inactive	218-W-2A
UPR-200-W-84	UPR-200-W-84, ground contamination during burial operation at 218-W-3A	A liquid spill occurred in the 218-W-3A Landfill during burial operations of a pump. This spill resulted in contamination of the truck transporting the pump and the ground around the truck. Some confusion has occurred in other documents associating this event with the 218-W-1 Landfill. The occurrence report for this incident did not take place at the same time 218-W-1 was in operation. Status: Inactive	218-W-3A
UPR-200-W-72	UPR-200-W-72, contamination at 218-W-4A	Soil erosion occurred in the 218-W-4A Landfill resulting in contaminated laboratory waste, with gross alpha and mixed fission product contamination to be released to the surrounding ground surface. Speculation that disposal depth requirements were not met resulted in waste exposure. Status: Inactive	218-W-4A
UPR-200-W-37	UPR-200-W-37, contaminated boxes found in a burn pit (Z Plant burn pit)	Contamination resulted when three boxes reportedly containing high-level waste mistakenly were placed in a burn pit in the western Inner Area. Upon removal of the boxes, the pit was decontaminated. When the mistake was rectified, it was noted that one of the boxes had released contamination levels of 100 mR/hr because it was broken open during placement, while the other two boxes remained sealed. Through historical research, the pit where the incident occurred was identified as the Z Plant burn pit. The Z Plant burn pit is located within the boundary of the 218-W-4C Landfill. Status: Inactive The burn pit was exhumed during construction of the 218-W-4C Landfill.	218-W-4C

Sources:

BHI-00175, *Z Plant Aggregate Area Management Study Technical Baseline Report.*

HW-54636, *Summary of Environmental Contamination Incidents at Hanford 1952-1957.*

PUREX = Plutonium-Uranium Extraction (Plant)

REDOX = Reduction-Oxidation Plant

WIDS = Waste Information Data System

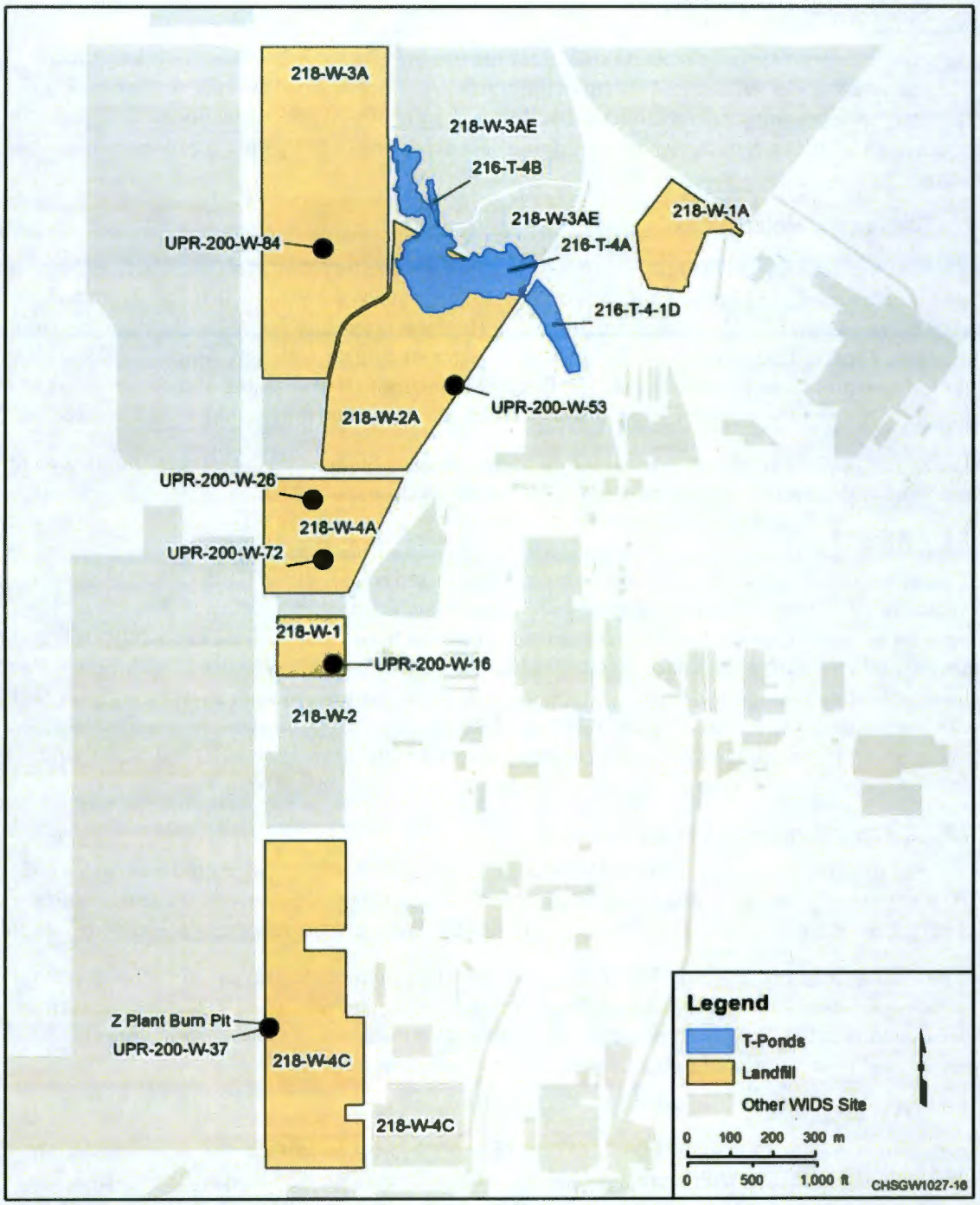


Figure 2-4. Other Sites and UPRs Associated with the 200-SW-2 OU Landfills

2.5 Environmental Setting

This section describes the environmental setting for the Central Plateau Inner Area. The descriptions include characteristics of surface and subsurface features and processes that are relevant to developing a preliminary understanding of contaminant distribution for the 200-SW-2 OU landfills. This understanding provides a foundation for identifying data needs and investigation approaches to address data gaps.

2.5.1 Climate and Meteorology

The Pacific Ocean moderates the temperatures throughout the Pacific Northwest. The Cascade Mountains (located approximately 113 km [70 mi] west of the site) generate a rain shadow that limits rain and snowfall in the eastern half of Washington State. The Hanford Site is located within the driest part of that rain shadow. The Cascade Mountains also serve as a source of cold air drainage, which has a considerable effect on the Hanford Site's wind regime. The Rocky Mountains to the north and east of the region shield the area from most of the severe winter storms and cold air masses that move south from Canada.

Climatological data are compiled at the Hanford Meteorological Station (HMS), which is located on the Central Plateau just outside the northeastern corner of the western Inner Area.

2.5.1.1 Wind

The Cascade Mountains have a considerable effect on the wind regime at the Hanford Site by serving as a source of cold (more dense) air drainage. This orographic drainage results in a northwest to west-northwest prevailing wind direction. Summertime winds from the northwest frequently exceed 13 m/s (30 mi/hr), although the fastest wind speeds at the HMS are usually associated with flow from the southwest. Monthly average wind speeds of 15 m (50 ft) above the ground were slower during the winter months, averaging 2.7 to 3.1 m/s (6 to 7 mi/hr), and faster during the spring and summer months, averaging 3.6 to 4.0 m/s (8 to 9 mi/hr). The maximum speed of the drainage winds (and their frequency of occurrence) tends to decrease as they move southeast across the Hanford Site.

2.5.1.2 Temperature and Humidity

The average monthly temperatures at the HMS range from a low of -0.7°C (31°F) in January to a high of 24.7°C (76°F) in July, based on data collected from 1946 through 2004. Daily maximum temperatures at the HMS vary from an average of 2°C (35°F) in late December and early January to 36°C (96°F) in late July.

From mid-November through early March, the average daily minimum temperature is below freezing, with a daily minimum in late December and early January averaging -6°C (21°F). The annual average relative humidity at the HMS is 55 percent. It is highest during the winter months, averaging about 76 percent, and lowest during the summer, averaging about 36 percent.

2.5.1.3 Precipitation

Average annual precipitation at the HMS is 17 cm (6.8 in.). Most precipitation occurs during the late autumn and winter months, with more than one-half of the annual amount occurring from November through February. Average snowfall ranges from 0.25 cm (0.1 in.) during October to a maximum of 13.2 cm (5.2 in.) during December, decreasing to 1.3 cm (0.5 in.) in March. Snowfall accounts for about 38 percent of all precipitation from December through February.

2.5.1.4 Hanford Site Ambient Air Monitoring

During 2012 a network of continuously operating ambient air samplers at 74 locations across the Hanford Site were used to monitor radioactive materials in the air near site facilities and operations (DOE/RL-2013-18, *Hanford Site Environmental Report for Calendar Year 2012*). The data indicated

a large degree of variability by location. Air samples collected at or directly adjacent to Hanford Site facilities had higher radionuclide concentrations than samples collected farther away. In general, analytical results for most radionuclides were at or near Hanford Site background levels, which are much less than EPA concentration values (40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," Appendix E, "Compliance Procedures Methods for Determining Compliance with Subpart I," Table 2) but greater than those measured offsite. The following summaries are for the 2012 results from the eastern and western portions of the Inner Area:

- Air sampling was conducted at 21 locations in the eastern Inner Area during 2012. Radionuclide levels measured in the ambient air composite samples were generally similar to those measured in previous years. Uranium-234 and uranium-238 were detected in 40 percent of the samples, and americium-241 and cesium-137 were detected in 25 percent and 15 percent of the samples, respectively. A review of the biweekly air sample results during 2012 did not reveal elevated alpha or beta concentrations.

- Air sampling was conducted at 25 locations in the western Inner Area during 2012. Generally, radionuclide levels measured were similar to results for previous years. Uranium-234 and uranium-238 were detected in 42 percent of the samples. Plutonium-239/240 was detected in 33 percent of the samples.

2.5.2 Physiography and Topography

The Hanford Site lies within the Pasco Basin. The physiographic setting of the Hanford Site is relatively low relief (Figure 2-5), resulting from river and stream sedimentation filling the synclinal valleys and basins between the anticlinal ridges. The 200-SW-2 OU waste sites are located on the Cold Creek bar, a large compound flood bar formed during the Pleistocene Ice Age floods. The elevation (amsl) of the upper surface of the bar ranges from about 221 m (725 ft) in the northwestern Inner Area to about 197 m (647 ft) in the southwestern Inner Area. No natural surface water drainage channels are located in the Inner Area.

2.5.3 Geologic Setting

The geology of the Hanford Site has been extensively characterized during past investigation activities. The Inner Area is located in the central part of the Pasco Basin. Over the last 16 million years, the basin filled with materials that formed bedrock (i.e., volcanic lava flows) and sediments (e.g., silt, sand, and gravel). Unconsolidated and partly consolidated fluvial (river-derived), lacustrine (lake), and cataclysmic flood sediments of the Miocene through Holocene ages (about 10.5 million years to the present) overlie the basalts. Beneath the ground surface, the major geologic units of interest (from oldest to youngest) include the following: (1) Elephant Mountain Member basalt of the Saddle Mountains Basalt Formation (a part of the Columbia River Basalt Group), (2) Ringold Formation, (3) Cold Creek unit (CCU), (4) Hanford formation, and (5) recent Holocene surficial deposits.

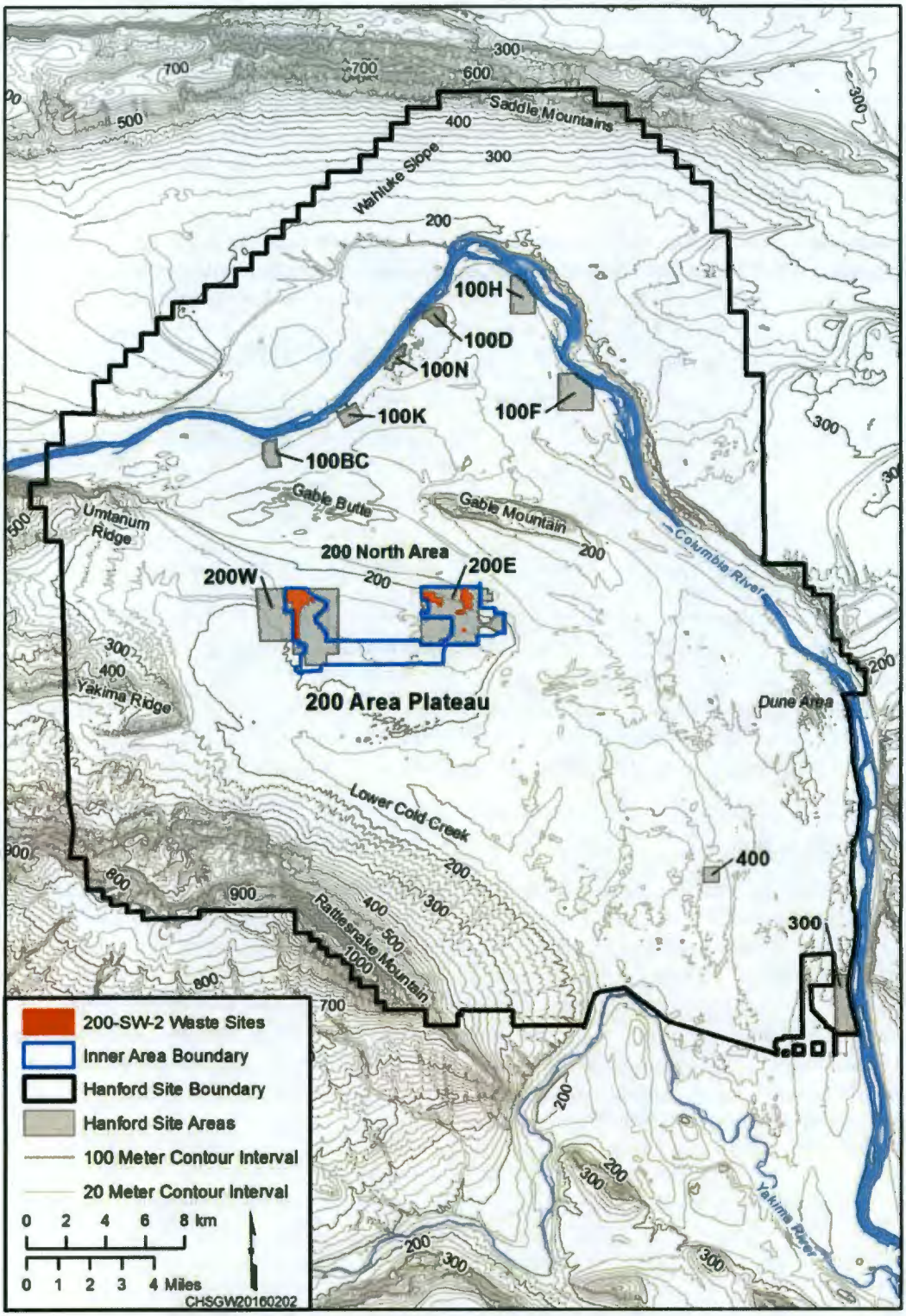
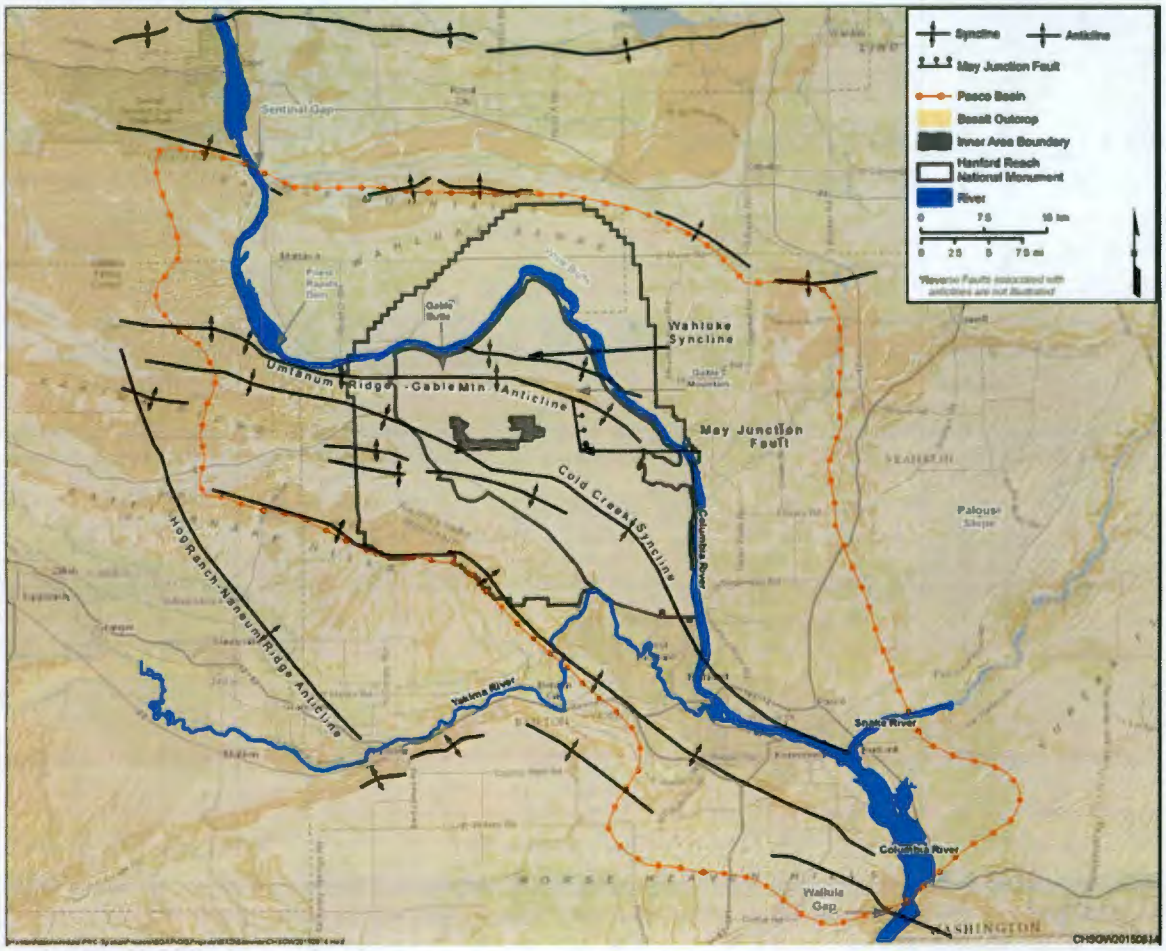


Figure 2-5. Topographic Map of the Hanford Site

A generalized geological structure of the Pasco Basin and a stratigraphic column of the Hanford Site are presented in Figures 2-6 and 2-7. Previous studies containing geologic interpretations, related maps, and cross sections pertaining to the 200-SW-2 OU include the following:

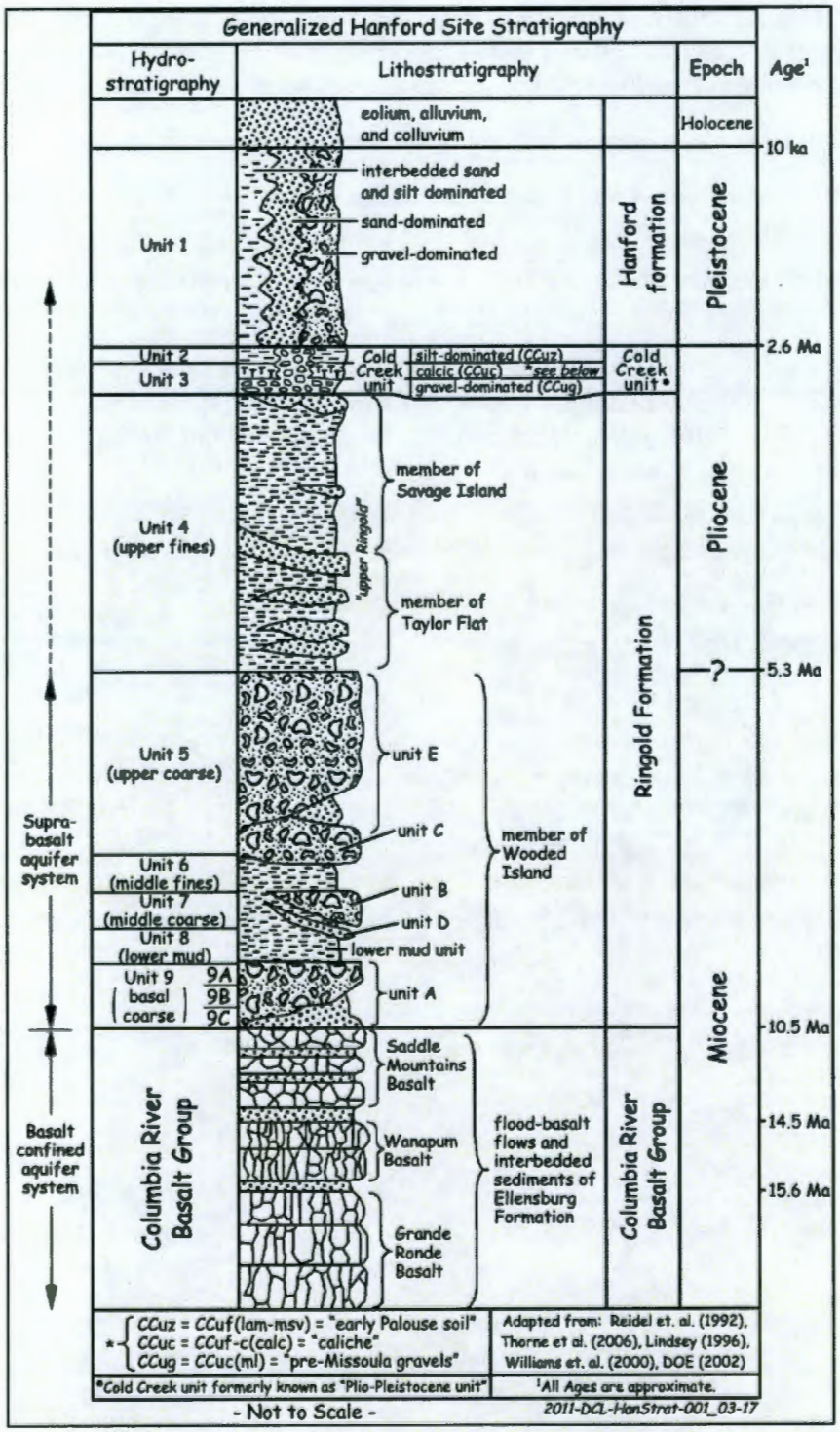
- DOE/RL-92-16, *200 West Groundwater Aggregate Area Management Study Report*
- DOE/RL-2009-122, *Remedial Investigation/Feasibility Study for the 200-UP-1 Groundwater Operable Unit*
- PNNL-19277, *Conceptual Models for Migration of Key Groundwater Contaminants Through the Vadose Zone and into the Unconfined Aquifer Below the B-Complex*

The hydrogeologic interpretations for the 200-SW-2 OU waste sites are based on PNNL-13858, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-West Area and Vicinity, Hanford Site, Washington*; and PNNL-12261, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington.*



Note: This figure has been modified from PNNL-6415, *Hanford Site National Environmental Policy Act (NEPA) Characterization.*

Figure 2-6. Generalized Geologic Structure Map of the Pasco Basin



Note: Complete citations for figure references are provided in Chapter 8.

Source: PNNL-18819, *Hanford Site Guidelines for Preparation and Presentation of Geologic Information.*

Figure 2-7. Generalized Stratigraphic Column for the Hanford Site

2.5.3.1 Columbia River Basalt

Basalt is an igneous rock ejected from the earth during volcanic eruptions. The basalt flows of the Columbia River Basalt Group were deposited during Miocene time (23.7 to 10.5 million years ago) from source vents in southeastern Washington, northern Oregon, and western Idaho. These basalt flows form the basement rock for much of the overlying sedimentary deposits. Beneath the Hanford Central Plateau, the youngest and uppermost basalts belong to the Saddle Mountains Basalt Formation (RHO-BWI-ST-4, *Geologic Studies of the Columbia Plateau: A Status Report*). Here the Saddle Mountains Basalt Formation is divided into the Ice Harbor, Elephant Mountain, Pomona, Esquatzel, Asotin, Wilbur Creek, and Umatilla Members. The Elephant Mountain Member is the uppermost basalt unit present beneath the Central Plateau and is about 35 m (115 ft) thick beneath most of the Hanford Site. The Rattlesnake Ridge interbed of the Ellensburg Formation typically occurs between the Elephant Mountain Member and the underlying Pomona Member and comprises the uppermost basalt confined aquifer beneath the Central Plateau.

In the central portion of the Pasco Basin, the Ellensburg Formation interbed ranges from 1.5 to 15 m (5 to 50 ft) thick and is composed of clayey basalt conglomerates, fluvial floodplain deposits, and ash tuffs and tuffites (RHO-RE-ST-12P, *An Assessment of Aquifer Intercommunication in the B Pond-Gable Mountain Pond Area of the Hanford Site*).

In the 200-SW-2 OU, the basalt surface is interpreted as the basal hydrogeologic boundary for the overlying sedimentary vadose zone and/or aquifer system that has been affected by historical liquid effluent disposal practices.

2.5.3.2 Ringold Formation

The fluvial-lacustrine Ringold Formation, which overlies basalt in much of the Hanford Site, is present beneath the western Inner Area and is limited in extent in the eastern Inner Area. The Ringold Formation is described as an unconsolidated to semiconsolidated sedimentary sequence deposited unconformably on the basalt and consists of clay, silt, sand, and granule- to cobble-sized gravel deposited by the ancestral Columbia River (PNNL-12261; PNNL-13858). The Ringold Formation was deposited during the late Miocene through Pliocene between approximately 10.5 and 3.4 million years ago. The Ringold Formation beneath the Inner Area has been grouped into four distinct hydrostratigraphic units (informally designated as units 4, 5, 8, and 9); not all units may be present in all areas. These units generally correspond to, from youngest to oldest, the Ringold Formation member of Taylor Flat (Rtf [unit 4]), which is composed of predominantly fine-grained silt and sand; Ringold Formation member of Wooded Island–unit E (Rwie [unit 5]), which is a fluvial deposit composed of silty, sandy gravel; Ringold Formation member of Wooded Island–lower mud unit (RLM [unit 8]), which is composed predominantly of fine-grained lacustrine silt and clay; and Ringold Formation member of Wooded Island–unit A (Rwia [unit 9]), which is a fluvial deposit composed of silty, sandy gravel (PNNL-13858).

The entire Ringold Formation sequence is present beneath most of the western Inner Area; only a portion of the RLM is absent in the northern 200 West Area where the formation generally thins or has been removed by erosion against uplifted basalt. The uppermost unconfined aquifer occurs entirely within the Ringold Formation in the western Inner Area.

Most of the Ringold Formation is absent from the eastern Inner Area; depositional thinning or removal by paleo-erosion along the northern, uplifted basalt surface resulted in the loss of most of the formation. Currently, only remnants of the older Rwia and RLM can be identified in the northern portion of the 200 East Area. Farther south, the formation thickens and Rwie can be defined. The uppermost unconfined aquifer occurs mostly within younger formation sediments, but includes the remnant Ringold units present.

2.5.3.3 Cold Creek Unit

The CCU includes several post-Ringold Formation and pre-Hanford formation units beneath portions of the Inner Area (DOE/RL-2002-39, *Standardized Stratigraphic Nomenclature for Post-Ringold Formation Sediments within the Central Pasco Basin*) (Figure 2-8). Three different facies deposits generally comprise the CCU within the Inner Area: these are (from youngest to oldest) a fine-grained, silt-dominated deposit (CCU_z), a variably cemented calcium carbonate fine- to coarse-grained deposit (caliche) (CCU_c), and a coarse-grained (gravel) deposit (CCU_g).

The CCU_z is a fine-grained silt to sand facies that overlies the CCU_c in the western Inner Area and the CCU_g in the northwest part of the eastern Inner Area. This unit grades laterally from fluvial to eolian deposits ranging from a sandy silt to a silt; where silt content dominates, perched water horizons have been found (e.g., in the B Complex area). Calcium carbonate in this sequence varies from a few percent to absent. Where higher calcium carbonate content is found, clumps of silt and sand are generally reported.

The CCU_c (caliche) is a paleo-surface deposit that developed in situ atop the exposed Ringold Formation and extended partially into the underlying Ringold Formation (PNL-6820). The CCU_c is a secondary deposit (mineral coating or cement) that accumulated on and within older sediment; it is composed of calcium carbonate that precipitated in available pore spaces between sediment grains (sand, silt, or gravel). The caliche binds the sediment grains together, forming one or more hardpan layers; the location and amount of calcium carbonate cement are variable, so the physical properties of this unit vary from soil-like to rock-like. This facies primarily formed during the late Pliocene on the exposed upper surface of the Ringold Formation in the vicinity of the western Inner Area and is not present in the eastern Inner Area which most likely was at a lower elevation during that time.

The CCU_g was deposited during the late Pliocene between approximately 3.4 and 2.0 million years ago as the ancestral Columbia River eroded Ringold Formation sediment across the central portion of the Pasco Basin (RHO-BW-SA-318P, *Paleodrainage of the Columbia River System on the Columbia Plateau of Washington State: A Summary*). The CCU_g is predominantly sandy gravel with occasional cobble-size clasts and minor silty sand and extends from the Gable Butte/Gable Mountain Gap southeastward, traversing the eastern Inner Area from the northwest to southeast. The CCU_g is best distinguished from the underlying Ringold Formation sediments by the significantly higher hydraulic conductivity and higher drilling rate. In addition, the CCU_g generally lacks significant weathering and consolidation due to its younger age. The CCU_g is very permeable and extends throughout most of the saturated zone (i.e., beneath the water table) underlying the 200-SW-2 OU waste sites in the 200 East Area. The CCU_g influences aquifer boundaries and groundwater contaminant flow throughout the eastern portion of the Central Plateau.

The fine-grained (CCU_z) and the underlying carbonate-cemented (CCU_c) units are present in the vadose zone throughout the western Inner Area (including beneath the 200-SW-2 OU waste sites in the). Within the western Inner Area, the relatively thin CCU sequence (CCU_z plus CCU_c) forms a significant liquid flow barrier (perching horizon) within the deep vadose zone because of relatively low hydraulic properties. Both of these CCU facies have unique geophysical properties that allow easy identification and correlation.

The fine-grained (CCU_z) and the underlying coarse-grained (CCU_g) units are the predominant CCU facies underlying portions of the eastern Inner Area (including beneath some of the 200-SW-2 OU waste sites); The CCU_g is typically encountered in the saturated zone.

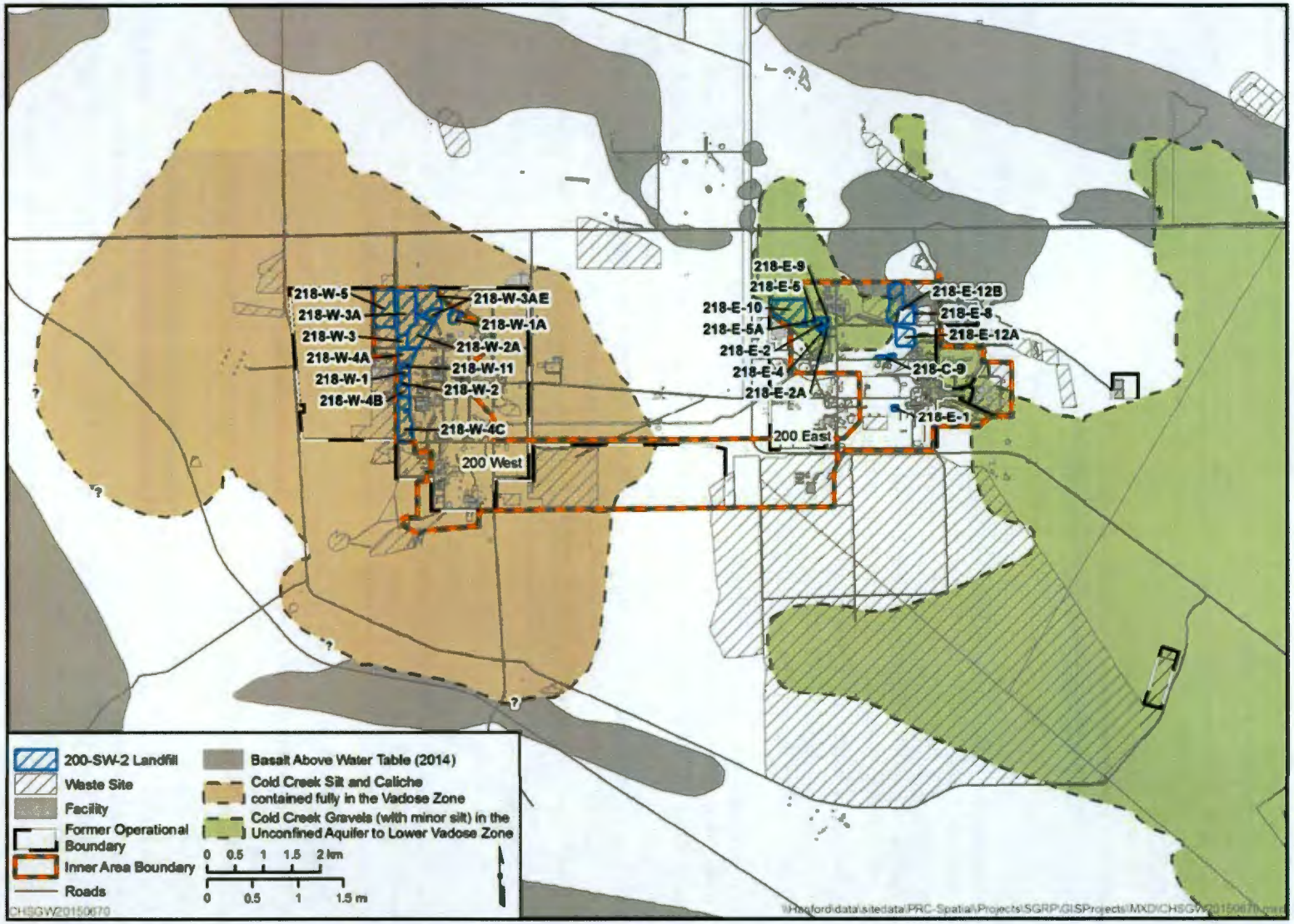


Figure 2-8. CCU Lateral Extent in the Central Plateau

The properties of the CCU underlying the 200-SW-2 OU waste sites are important for two primary reasons: the CCU_z is located in the vadose zone and generally exhibits much lower hydraulic conductivity than the overlying Hanford formation (PNNL-23380, *Field-Derived Hydraulic Properties for Perched-Water Aquifer Wells 299-E33-350 and 299-E33-351, Hanford Site B-Complex Area*); and the CCU_z exhibits much higher retention capacity (PNNL-19277). The hydraulic properties of the CCU_z have historically resulted in accumulation and subsequent lateral spread of perched water within the vadose zone atop this unit and beneath high-volume discharge facilities (e.g., ditches, ponds, and cribs).

2.5.3.4 Hanford Formation

The Hanford formation is the informal stratigraphic name given to the Pleistocene cataclysmic flood deposits in the Pasco Basin (DOE/RL-2002-39). The Hanford formation overlies the Ringold Formation, the CCU, and/or basalt within the Inner Area. The cataclysmic floodwaters eroded or reworked much of the pre-existing Ringold Formation and CCU sediment across the Gable Gap area and unconformably deposited thick, unconsolidated, basalt-rich sediments known as the Hanford formation. The floodwaters deposited a thick sand and gravel bar (Cold Creek bar) that constitutes the Central Plateau. The Hanford formation is divided into three representative facies associations that are referred to as the gravel-dominated, sand-dominated, and silt-dominated intervals. These lithologic units are not laterally continuous, but can be correlated if present within the area. Remnant erosional channels, preserved during the waning stages of the paleo-floods, created large-scale surface features visible north of the Inner Area near West Lake and the former Gable Mountain Pond.

The Hanford formation is the primary geologic formation (comprising about one-half of the vadose zone thickness in the western Inner Area and nearly all of the vadose zone thickness in the eastern Inner Area); contaminants released at the surface must pass through the Hanford formation to reach the groundwater. The Hanford formation consists predominantly of unconsolidated mafic-dominant sediments that range from boulder-size gravel to sand, silty sand, and silt. The sorting ranges from poorly sorted (for gravel facies) to well-sorted (for fine sand and silt facies). Under the 200-SW-2 OU on the Central Plateau, the Hanford formation consists predominantly of gravel- and sand-dominated facies, depending on the depositional location within the Cold Creek flood bar. The gravel-dominated facies is typically poorly sorted and may contain sand with lesser amounts of silt. In some areas, the gravel-dominated facies may be open framework, containing no fine-grained sediment (sand or silt). The sand-dominated sequence is fairly well sorted and contains distinct, limited lateral extent silt stringers or thin beds marking sand bed depositional boundaries. In most areas on the Cold Creek flood bar (Central Plateau), the coarse-grained gravel sequence overlays a much thicker Hanford sand sequence. Gravel deposits may also occur beneath the sand-dominated sequence within and near the base of the Hanford formation in some areas.

2.5.3.5 Holocene Surficial Deposits

Overlying the Hanford formation are recently deposited surficial deposits of eolian (windblown) silt and sand. These surficial materials, particularly in those areas that constitute most of the 200-SW-2 OU waste sites, have been removed or reworked extensively by construction or operational activities.

2.5.3.6 Hanford Site Soil Monitoring

Radiological monitoring of soil is conducted at a variety of locations: onsite near facilities and operations, onsite away from facilities and operations (sitewide), and offsite at perimeter and distant locations (DOE/RL-2013-18). Soil samples are analyzed for radionuclides that are expected to occur in the areas sampled (i.e., gamma-emitting radionuclides, strontium-90, uranium isotopes, and/or plutonium isotopes). Historically, the predominant radionuclides detected were activation and fission products in the 100 Areas, fission products in the 200 and 600 Areas, and uranium in the 300 and 400 Areas. In general, radionuclide concentrations in soil samples collected from or adjacent to waste disposal facilities in 2012

were higher than the concentrations in samples collected farther away, including concentrations measured offsite. Soil samples collected in 2012 at locations in the eastern and western portions of the Inner Area were comparable to previous years.

2.5.4 Hydrogeology

This section provides a general overview of the hydrogeologic characteristics of the Hanford Site, along with descriptions of the 200-SW-2 OU subsurface features relevant to contaminant migration.

2.5.4.1 Hydrostratigraphy

The Inner Area hydrogeologic designations were determined through an evaluation of available borehole and geophysical logs and integration of these data with stratigraphic correlations from existing reports (e.g., PNNL-12261; PNNL-13858). The hydrostratigraphic units of interest in the Inner Area include the following:

- Recent surficial deposits and the Hanford formation (hydrostratigraphic unit 1) located primarily within the vadose zone
- CCU (hydrostratigraphic units 2 and 3) located in the vadose zone in the western Inner Area and in the saturated zone in the eastern Inner Area
- Ringold Formation:
  - Rtf (hydrostratigraphic unit 4) located primarily in the vadose zone
  - Rwie (hydrostratigraphic unit 5) located in the lower vadose zone and unconfined aquifer in western Inner Area
  - RLM (hydrostratigraphic unit 8) defined primarily as an aquifer confining unit and located primarily within the western Inner Area
  - Rwia (hydrostratigraphic unit 9) defined as an unconfined to confined aquifer dependent on spatial location within the Inner Area
- The Elephant Mountain Member basalt (hydrostratigraphic unit 10) defined as the base of the suprabasalt aquifer system and a confining horizon
- The Rattlesnake Ridge interbed located below the Elephant Mountain basalt as a confined water-bearing zone

2.5.4.2 Vadose Zone

The thickness and stratigraphy of the vadose zone varies across the Inner Area. In the western Inner Area, the vadose zone thickness ranges from about 67 to 78 m (221 to 255 ft), and the vadose zone is composed of the Hanford formation, the CCU_z (silt) and CCU_c (caliche) units, the Ringold Formation upper fines (Rtf), and part of the Ringold Formation unit E. In the eastern Inner Area, the vadose zone ranges from 70 to 82 m (230 to 270 ft) thick and is composed of the Hanford formation, the CCU_z (silt) unit, and part of the CCU_g (gravel) unit.

The water table lies within the Rwie in the western Inner Area (PNNL-12261). The water table in the eastern Inner Area is contained primarily within the CCU_g (gravel) and/or the Hanford formation (gravel-dominated unit).

2.5.4.3 Uppermost Aquifer

The uppermost aquifer is important because it is the first groundwater to be potentially affected by contaminants originating from the 200-SW-2 OU landfills. In the western Inner Area, the uppermost aquifer is contained within the Ringold Formation and displays unconfined to locally confined or semiconfined conditions. In the eastern Inner Area, the uppermost aquifer occurs in the CCU_g (gravel) unit, the Hanford formation, and locally within the fractured Elephant Mountain basalt.

In the western Inner Area, the saturated thickness of the unconfined aquifer ranges from 73 to 108 m (240 to 355 ft) from north to south. In the eastern Inner Area, the saturated thickness of the unconfined aquifer ranges from 61 m (200 ft) in the southern portion to zero in the northeastern portion where the aquifer thins and eventually terminates against the basalt located above the water table.

The water table elevation, and subsequently the groundwater gradient, flow direction, and flow velocity within the uppermost aquifer, have been historically altered by discharges of large quantities of wastewater to the vadose zone in the Inner Area. Historically, large groundwater elevation mounds formed beneath high-volume wastewater discharge sites. Although these large-volume discharges have been discontinued, the transient groundwater elevation mounds have not completely dissipated, particularly in the western Inner Area, where the hydraulic conductivity of the aquifer (located within Rwie) is lower than the unconfined aquifer (located within the Hanford formation and CCU) in the eastern Inner Area. The groundwater elevation mounds that existed during operations within the eastern Inner Area (i.e., those associated with B Pond and Gable Mountain Pond) have generally dissipated. Currently the water table across the 200 East Area is essentially flat. The water table across the Inner Area shows a generally west to east groundwater flow direction from the western Inner Area to the eastern Inner Area.

2.5.4.4 Perched Groundwater

The CCU silt and caliche unit (CCU_z and CCU_c) and the RLM within the vadose zone beneath the Inner Area have the soil-water retention capacity and relatively low permeability to create local perched water conditions. The historical moderate to high-volume contaminated liquid waste discharged to areas overlying these two perching intervals created localized perched water and lateral spreading of the liquid waste that most likely mixed effluent from various disposal sources before it reached the groundwater. During operations, these perched conditions persisted, but most perched water eventually drained or moved laterally downgradient to the unconfined aquifer following cessation of waste disposal operations.

Cold Creek Unit

Where present above the water table, primarily within the western Inner Area, the CCU_c and CCU_z consist of fine sandy silt to silt and/or caliche-rich intervals. These intervals exhibit very low hydraulic properties (relative to the overlying coarse unconsolidated Hanford formation deposits) that result (depending on the infiltration rate) in impeded downward liquid migration, which have led to temporary saturation or perching conditions and lateral spreading along and/or within the low-permeability sediment horizons. Data show that, over time, the perched water conditions diminish when the liquid source is reduced or stopped, but that some areas take many years to decades to drain. Residual elevated moisture and contamination have continued to exist in these intervals long after active liquid disposal ceased. While the perching CCU_c is present as a continuous mapped unit that dips to the south beneath most of the western Inner Area, it has variable thickness and the hydraulic properties, while generally very low, vary laterally.

Within the western Inner Area, perched water conditions have occurred on and/or within the CCU and have been documented from the northernmost liquid disposal waste sites (e.g., State-Approved Land Disposal Site [SALDS] and the 216-T Ponds and Ditches) (Figure 2-9) to the southernmost liquid disposal waste sites (U Pond and the 216-S-10 Pond and Ditch). These legacy waste sites, with the exception of the SALDS, are no longer operational and the perched water conditions have dissipated. Several wells were completed and monitored conditions within the perched interval above the CCU near the 216-S-10 Ditch and farther north near the U Ditches.

In the eastern Inner Area beneath the B Complex area, past-practice liquid disposal and unintentional tank leaks have been accumulating on and within the CCU; recent contaminated perched zone drainage is known to occur from these liquid waste accumulations within the CCU and impacts the unconfined aquifer. Overall, the CCU_c and CCU_z have demonstrated to be a significant perching interval beneath the 200-SW-2 OU.

Ringold Formation Lower Mud Unit

The second prominent perching horizon, the RLM (Figure 2-7), consists of a relatively continuous, very fine-grained silt- to clay-rich interval that is located in most areas below the water table. However, on the eastern margin of the eastern Inner Area, the RLM unit is positioned above the regional water table, due to structurally uplifted basalt and other related suprabasalt sediments associated with geologic formation of the Gable Mountain structural lineament (PNNL-12261). Historical high-volume liquid effluent disposal in the eastern Inner Area to the B Ponds and related liquid waste transfer ditches (e.g., 216-A-29 and 216-B-2) created a huge water table mound caused by effluent infiltration and perching on top of the RLM (PNNL-12261). This lower mud unit enhanced the artificial water table creating a huge mound and caused a radial groundwater flow pattern across the entire eastern Inner Area during that time; groundwater and contaminants flowed through Gable Gap to the northwest and to the east and southeast near the eastern portion of the eastern Inner Area.

Active effluent disposal ceased at most liquid waste disposal sites during the late 1990s, and the mound has rapidly decreased to near pre-Hanford Site conditions, again exposing the RLM above the regional water table (Figure 2-10). This exposure now creates an eastern, downgradient groundwater flow barrier where it is present above the current water table; groundwater flow downgradient out of the eastern Inner Area now is constrained farther south by this exposed formation, and flow to the northwest through Gable Gap is almost undetectable as groundwater conditions return to pre-Hanford Site operations levels. Currently, when active, the nearby effluent disposal at the Treated Effluent Disposal Facility (TEDF), located downgradient of the eastern Inner Area, creates similar, but much smaller, perching and lateral spreading on the elevated Ringold Formation lower mud surface.

Overall, the CCU_c and CCU_z have demonstrated to be significant perching intervals beneath the western Inner Area and some portions of the eastern Inner Area within the Central Plateau. In addition, the RLM creates a groundwater flow-path restriction east of the eastern Inner Area.

2.5.4.5 Hydrogeology at Low-Level Waste Management Areas 3 and -4

The northwestern landfills associated with the 200-SW-2 OU are located in the northwestern part of the western Inner Area. The following summary is from the investigations and groundwater monitoring conducted at the 218-W-3A, 218-W-3AE, and 218-W-5 Landfills, also known as Low-Level Waste Management Area (LLWMA) 3, and pertains to the 218-W-1A, 218-W-2A, 218-W-3, 218-W-3A, 218-W-3AE, 218-W-4A, and 218-W-5 Landfills (Figure 2-11).

Figure 2-12 is a west-east regional cross section passing through the northern part of the western Inner Area. LLWMA-3 is just west of well 299-W6-3 in the cross section. These landfills are underlain by suprabasalt sediments composed of the Hanford formation, the CCU, and the Ringold Formation. The depth to the water table is 69 to 78 m (227 to 255 ft) bgs, and the suprabasalt aquifer thickness ranges from 60 to 78 m (197 to 256 ft). The unconfined aquifer is entirely within the upper coarse gravels of the Ringold Formation beneath the majority of the waste sites. The base of the unconfined aquifer is the Ringold Formation lower mud, except where this unit is not present in the northern portions of LLWMA-3; there, the aquifer base is the top of basalt.

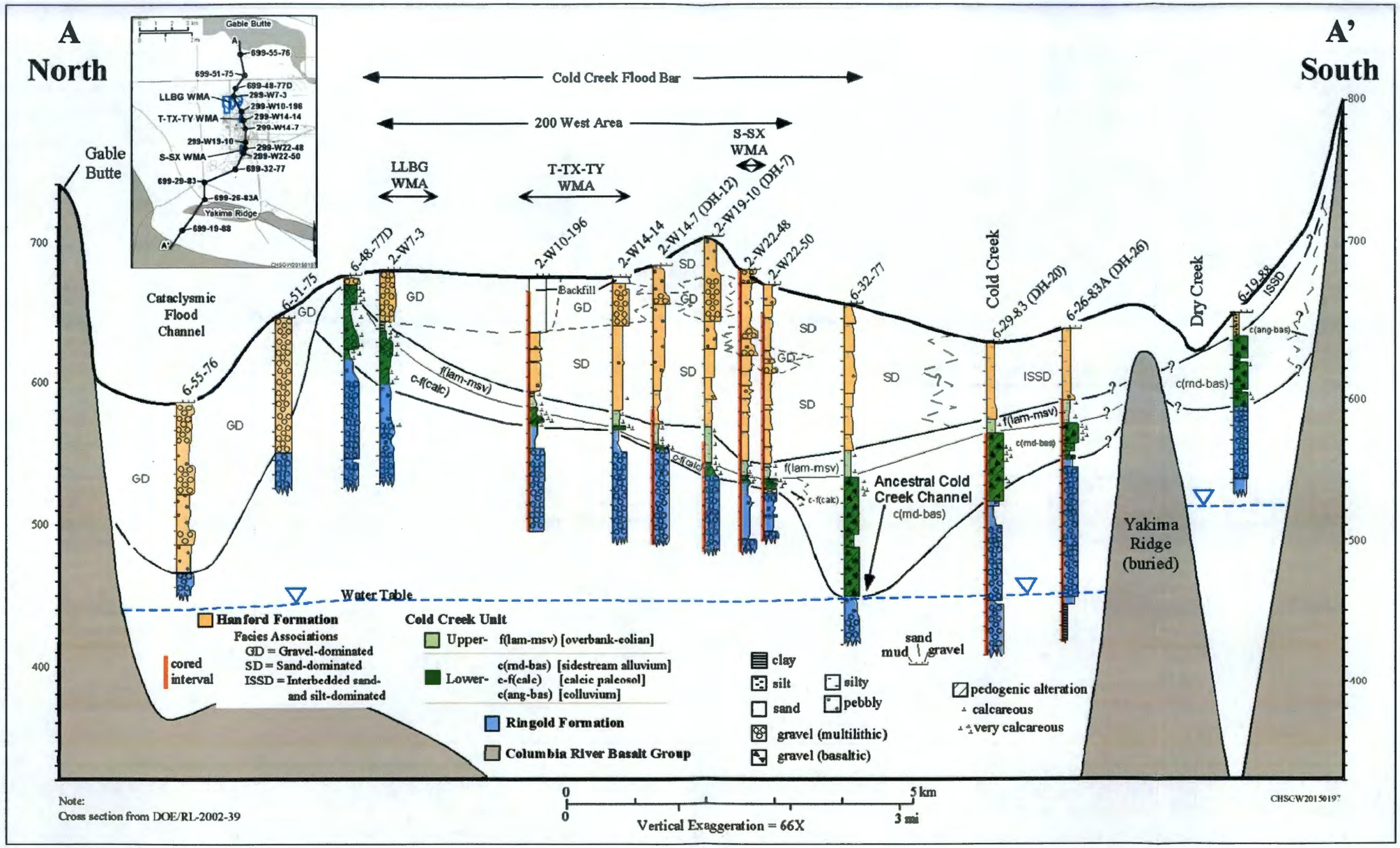
Regionally, the groundwater flow beneath LLWMA-3 is generally toward the east, with a calculated gradient of 0.0048 based on data from the groundwater annual report for 2013 (DOE/RL-2014-32, *Hanford Site Groundwater Monitoring Report for 2013*). As previously documented, both water table elevation and flow direction changed because of cessation of most Hanford Site operational practices (DOE/RL-2010-11, *Hanford Site Groundwater Monitoring and Performance Report for 2009 Volumes 1 & 2*). However, the flow direction is returning to pre-Hanford Site conditions and is expected to continue to change until the direction is predominantly toward the east (west to east). The expanded 200-ZP-1 OU P&T system will affect groundwater flow in the direction of the recovery wells located just south and east of the 200-SW-2 OU landfills (Figure 2-13).

The 200-ZP-1 OU P&T system is designed to address regional groundwater contaminant plumes composed of carbon tetrachloride and nitrate underlying portions of LLWMA-3 at levels exceeding their drinking water standards (DWSs). Trichloroethene and chloroform also are elevated but do not exceed standards. Radionuclide concentrations are low or undetectable. The capture zone of the 200-ZP-1 OU P&T system is intended to operate for approximately 25 years and, as planned, should capture any groundwater moving downgradient beneath the 200-SW-2 OU landfills (Figure 2-13).

The southwestern landfills associated with the 200-SW-2 OU are located in the west-central part of the western Inner Area. The following is a summary from the investigations and groundwater monitoring conducted at the 218-W-4B and 218-W-4C Landfills, also known as LLWMA-4, and pertains to the 218-W-1, 218-W-2, 218-W-4B, 218-W-4C, and 218-W-11 Landfills (Figure 2-11).

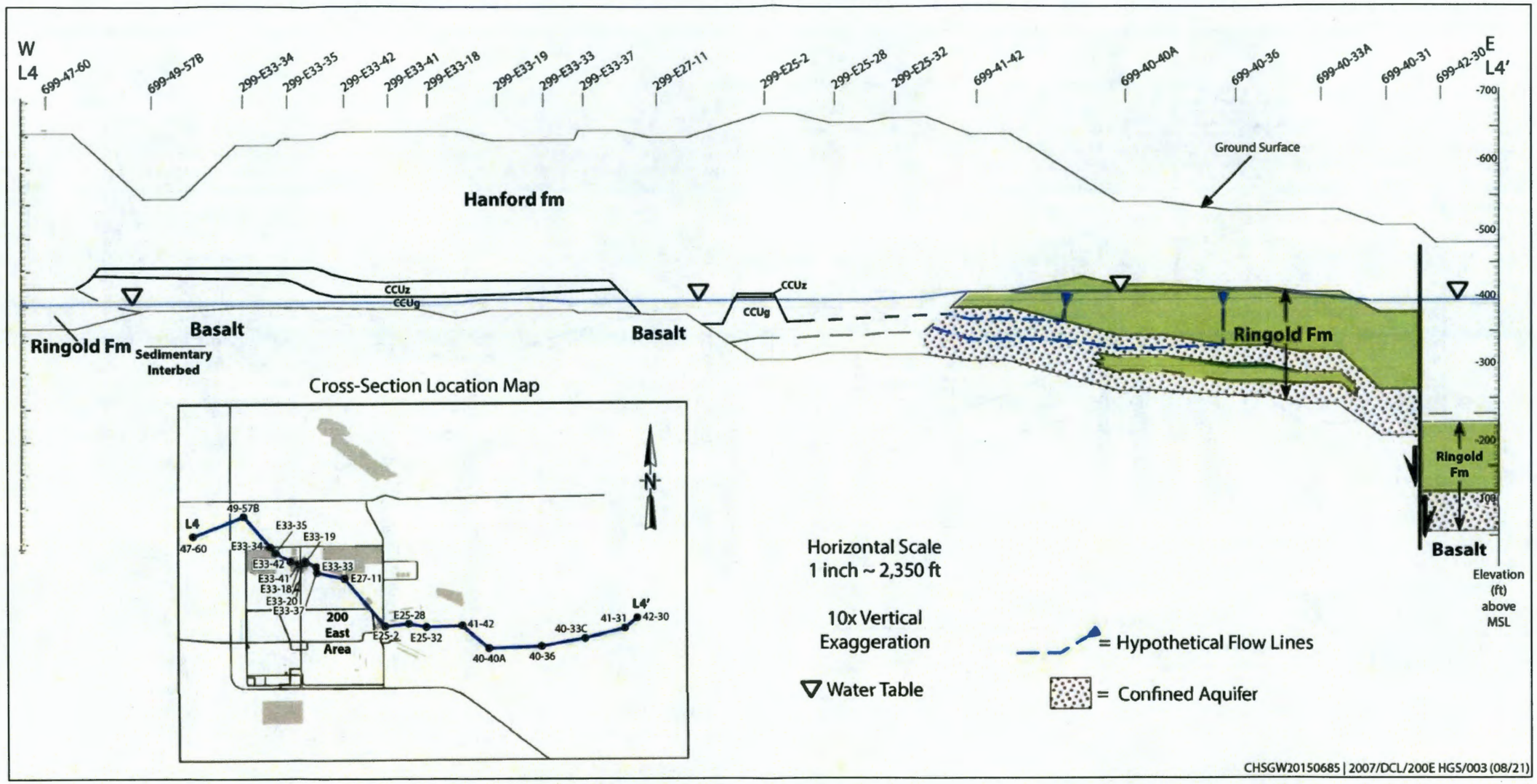
Figure 2-14 is a regional west-east cross section passing through the southern part of the western Inner Area. Well 299-W18-1 in the cross section represents LLWMA-4. These landfills are underlain by suprabasalt sediments composed of the Hanford formation, the CCU, and the Ringold Formation. The depth to the water table is 67 to 76 m (219 to 249 ft) bgs, and the aquifer thickness ranges from 64 to 69 m (210 to 226 ft) thick. The unconfined aquifer is entirely within the upper coarse gravels of the Ringold Formation, and the base of the unconfined aquifer is the Ringold Formation lower mud. A confined aquifer lies below the RLM within the Ringold Formation unit A (basal coarse unit).

Based on the groundwater annual report for 2013 (DOE/RL-2014-32), the groundwater flow beneath these landfills is generally to the east-northeast, with a gradient of approximately 0.006. The groundwater flow was initially affected to a very large degree by the interim 200-ZP-1 OU P&T system, which has extraction wells located directly to the east of the landfills and injection wells directly to the west of the landfills. The expanded 200-ZP-1 OU P&T system has a similar effect, but it is larger in magnitude than the initial system.



Source: DOE/RL-2002-39, *Standardized Stratigraphic Nomenclature for Post-Ringold-Formation Sediments Within the Central Pasco Basin.*

Figure 2-9. North-to-South Regional Western Inner Area Geologic Cross Section Showing the Cold Creek Perching Unit



Source: PNNL-12261, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington.*

Note: Well 299-E33-34 represents LLWMA-1; well 299-E27-11 represents LLWMA-2.

Figure 2-10. Schematic Regional Hydrogeologic Cross Section Passing Northwest to Southeast beneath the Northern Part of the Eastern Inner Area and Vicinity

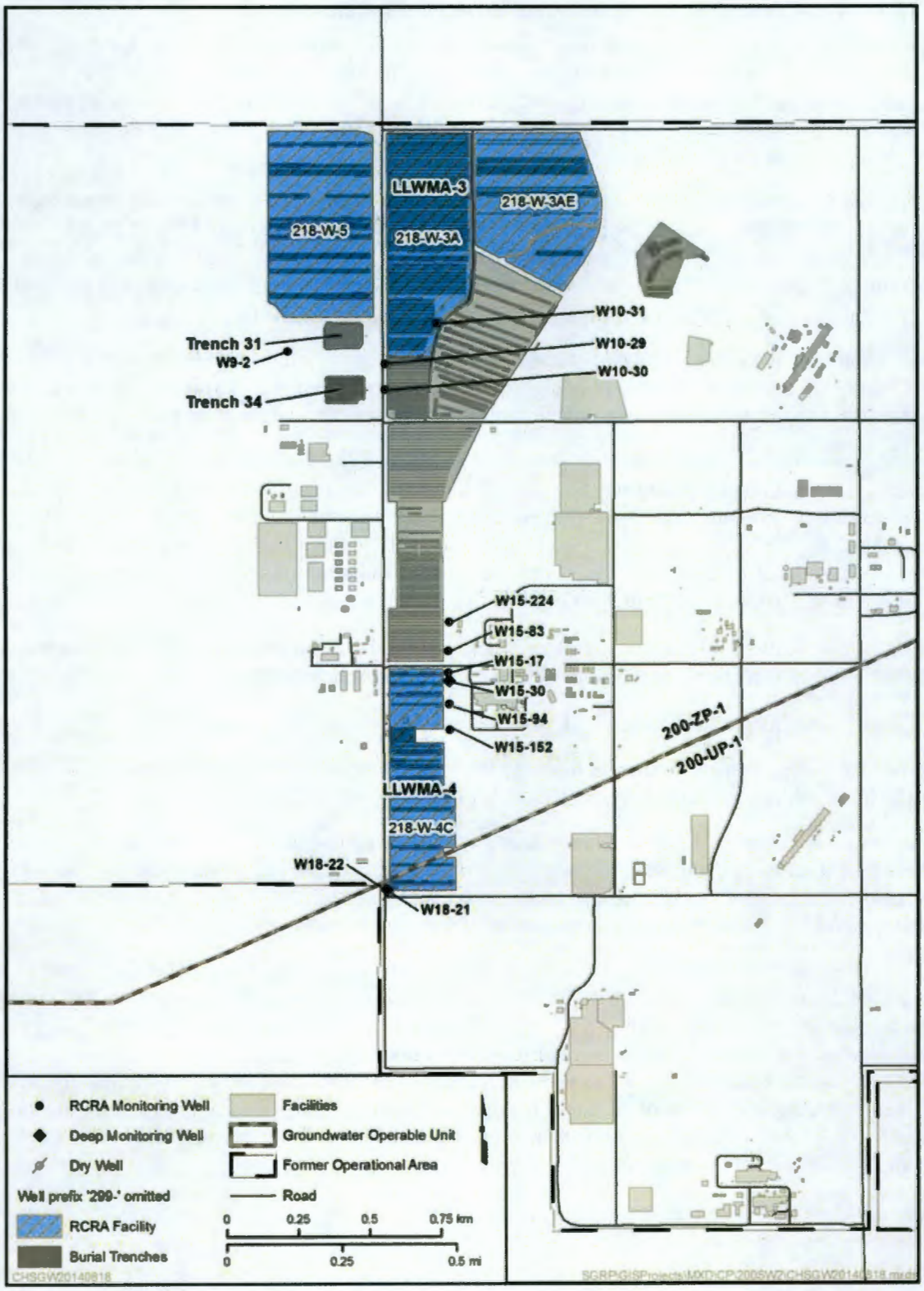


Figure 2-11. LLWMA-3 and LLWMA-4

2.5.4.5.1 Hydrogeology at Low-Level Waste Management Areas 1 and 2

The northwestern corner of the eastern Inner Area pertains to the 218-E-2, 218-E-2A, 218-E-4, 218-E-5, 218-E-5A, 218-E-9, and 218-E-10 Landfills (Figure 2-15). The following summary is from the investigations and groundwater monitoring conducted at the 218-E-10 Landfill, also known as LLWMA-1 (Figure 2-15). Wells 299-E28-26 and 299-E33-29 in Figure 2-16, and well 299-E33-34 in Figure 2-10, represent a portion of the stratigraphy beneath LLWMA-1.

The Hanford formation and Cold Creek fine-grained silt to sand facies and coarse-grained gravel facies directly underlie LLWMA-1. The depth to the water table ranges between 71 and 88 m (233 and 289 ft) bgs, and the unconfined aquifer thickness ranges between 1.7 m (5.6 ft) at the northeast corner to an estimated 15 m (49.2 ft) at the southwest corner. The unconfined aquifer is contained in the sand and gravel of the CCU_g coarse gravel (as shown in cross section Figure 2-10).

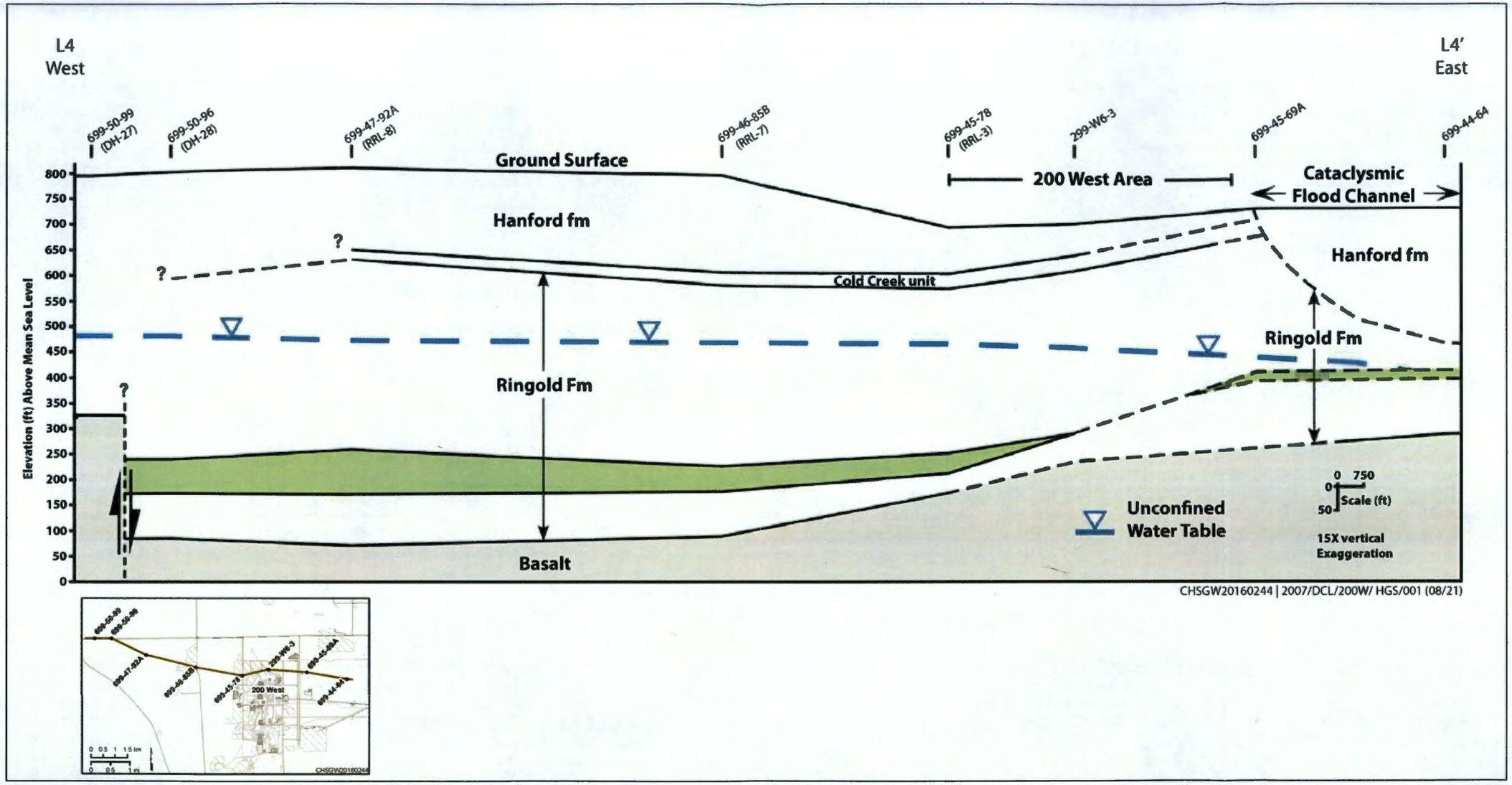
Groundwater flow in the northwest part of the 200 East Area was toward the north-northwest from the mid-1980s to 2011(primarily as a result of high-volume artificial recharge to the unconfined aquifer), but from mid-2011 to the end of 2014, the groundwater flow direction has stabilized to a south-southeast flow direction.

Formerly, the direction of groundwater flow diverged beneath the eastern Inner Area, with some water flowing toward the north through Gable Gap and some flowing southeast through the 200-PO-1 OU toward the Columbia River. This condition changed during 2011; flow is now toward the south and southeast across much of the eastern Inner Area. The change can be attributed to the following three factors (DOE/RL-2013-22, *Hanford Site Groundwater Monitoring Report for 2012*):

- Higher than normal Columbia River stage during the summer months of 2011 and 2012, which caused higher water levels to the north of the eastern Inner Area in Gable Gap
- The continued long-term decline of the water table in the eastern Inner Area
- The lack of high-volume discharges to the TEDF located east of the 200 East Area since 2010, which has contributed to the lower water levels in the eastern Inner Area

The northeastern corner of the eastern Inner Area pertains to the 218-E-8, 218-E-12A, and 218-E-12B Landfills. The following summary is from the investigations and groundwater monitoring conducted at the 218-E-12B Landfill, also known as LLWMA-2. Well 299-E34-11 in Figure 2-16 and well 299-E27-11 in Figure 2-10 represent a portion of the stratigraphy beneath LLWMA-2.

LLWMA-2 is directly underlain by only the Hanford formation in the eastern half, where solid waste has been buried. In the western half of LLWMA-2, the Hanford formation and CCU fine-grained silt to sand facies and coarse-grained gravel facies are present. The depth to the water table is 74 to 69 m (226 to 243 ft) bgs, and the aquifer thickness ranges from 0 to approximately 5.4 m (0 to 17.8 ft) at the 218-E-12B Landfill (LLWMA-2). Wells in the north portion of LLWMA-2 are all dry because the water table has dropped below the top of the basalt bedrock as shown in Figures 2-16 and 2-17. Beneath the eastern part of LLWMA-2, the unconfined aquifer is contained in the lower gravel-dominated Hanford formation, which directly overlies the basalt (Figure 2-17).



Source: PNNL-13858, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-West Area and Vicinity, Hanford Site, Washington.*

Figure 2-12. Schematic Regional Hydrogeologic Cross Section Passing West to East beneath the Southern Part of the Western Inner Area and Vicinity

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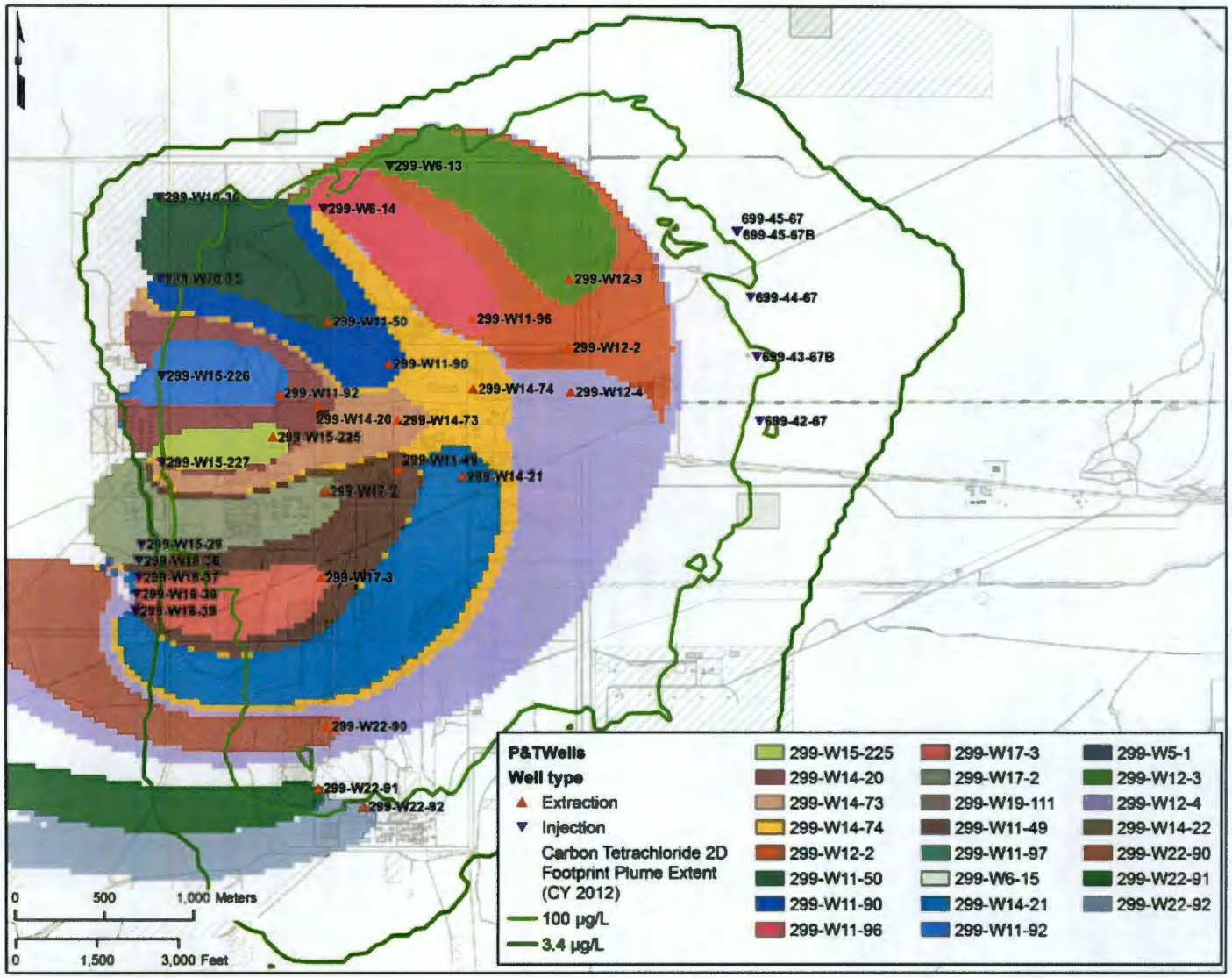


Figure 2-13. 200-ZP-1 OU P&T System Capture Zone near the 200-SW-2 OU Landfills in the Western Inner Area

Groundwater flow in the northeast portion of the 200 East Area was considered to be west between the mid-1980s to early in the new millennium based on small water table elevation differences within select wells. Currently, the high transmissivity of the aquifer sediments coupled with the very low groundwater gradient has made it impossible to determine the flow direction; however, from 2003 to mid-2011, analyses of nitrate and sulfate concentration changes in groundwater indicated a southwest flow direction. Since mid-2011, the flow direction indication in the northern part of the 200 East Area is now considered south-southeast.

In the northeastern Inner Area, the aquifer thins to zero against the basalt. Recent top of basalt characterization and well installation activities at this aquifer boundary located beneath the Liquid Effluent Retention Facility (LERF) resulted in the identification of an area containing fractured basalt flow top that could conduct groundwater to and/or from the unconfined aquifer beneath this region; the fractured flow top could extend west beneath the 218-E-12B Landfill where the basalt occurs above the water table. The fractured flow-top thickness map (Figure 2-9) and cross sections (Figures 2-14, 2-16, and 2-17) indicate the interpreted extent and thickness of this unit. Four wells installed at LERF were completed largely or entirely in this fractured flow-top material and yielded adequate water to allow for groundwater monitoring at LERF. Further evaluations of the extent of this unit and hydraulic relevance to the overlying unconfined aquifer are ongoing.

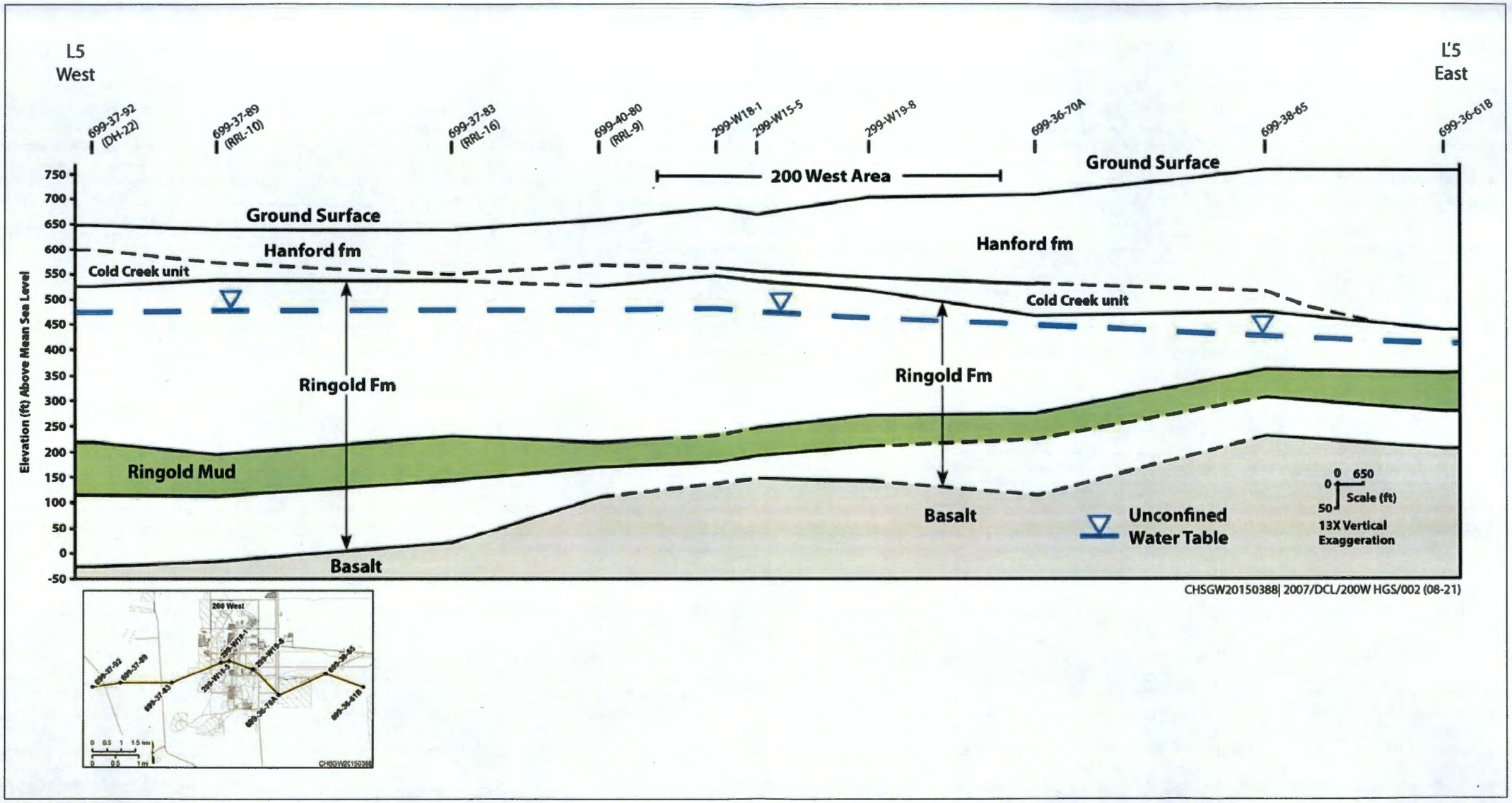
The 218-C-9 and 218-E-1 Landfills are located south of LLWMA-2, within the eastern Inner Area where the aquifer is thicker. Interpretations in this area are primarily from PNNL-12261. Figure 2-17 is a cross section showing the geology beneath these sites. Wells 299-E24-8 and 299-E27-1 represent the 218-C-9 Landfill. Well 299-E24-7 represents the 218-E-1 Landfill.

The uppermost aquifer beneath the 218-C-9 Landfill is in the sand and gravel of the Hanford formation. The base of the aquifer is either a fine-grained portion of Rwia or the basalt surface (Figure 2-17). The unconfined aquifer is approximately 22 m (72 ft) thick beneath the landfill. The flow direction is difficult to determine due to the flat water table. At nearby WMA C, the flow direction is interpreted to be toward the southwest (DOE/RL-2008-01, *Hanford Site Groundwater Monitoring for Fiscal Year 2007*).

The uppermost aquifer beneath the 218-E-1 Landfill is in the sand and gravel of the Hanford formation and perhaps Rwia (Figure 2-17). The base of the aquifer is inferred to be a fine-grained portion of Rwia at an elevation of approximately 88 m (290 ft) amsl. The aquifer is 34 m (112 ft) thick. The flow direction is difficult to determine because of the flat water table. However, at the nearby Integrated Disposal Facility (IDF), flow direction is interpreted to be toward the east or southeast (DOE/RL-2008-01).

2.6 Groundwater Operable Units

The Hanford Site is divided into 12 separate groundwater OUs, as depicted in Figure 2-18. Depending on their location, the 24 landfills overlie one of four groundwater OUs (200-ZP-1, 200-UP-1, 200-BP-5, or 200-PO-1). Groundwater contaminant plumes are attributed primarily to past operations of land-based liquid waste disposal facilities (e.g., ponds, ditches, and cribs) and other liquid waste management facilities (e.g., reverse wells, leaking underground storage tanks, and pipelines).



Source: PNNL-13858, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-West Area and Vicinity, Hanford Site, Washington.*

Figure 2-14. Schematic Regional Hydrogeologic Cross Section Passing West to East beneath the Southern Part of the Western Inner Area and Vicinity

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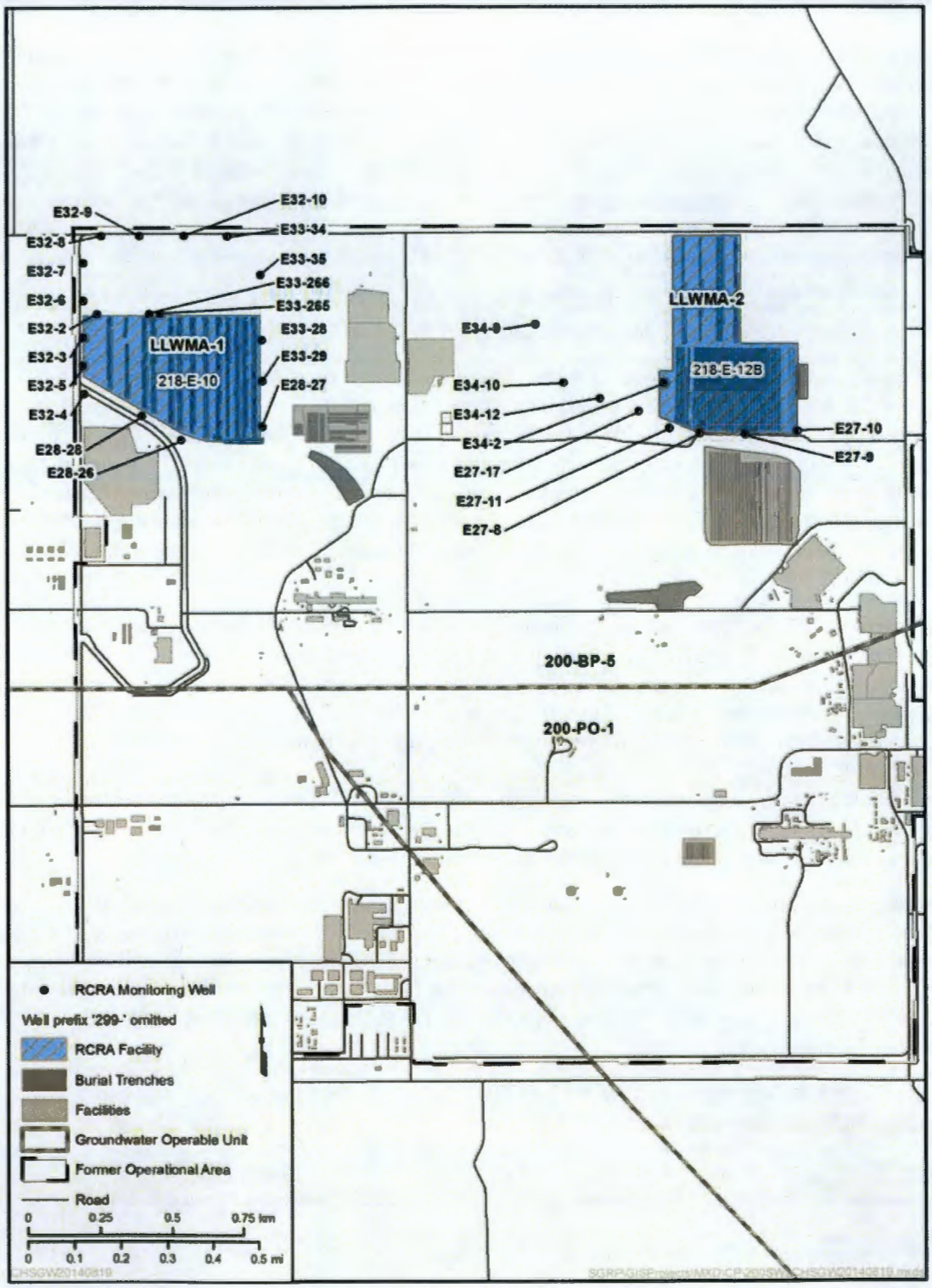


Figure 2-15. LLWMA-1 and LLWMA-2

2.6.1 200-ZP-1 Groundwater Operable Unit

The 200-ZP-1 Groundwater OU includes the northern and central parts of the western Inner Area and the western 600 Area (Figures 2-18 and 2-19). The 200-SW-2 OU landfills within this OU boundary include LLWMA-3. Groundwater is monitored to assess the performance of a P&T system for carbon tetrachloride contamination, to track other contaminant plumes, and to monitor and assess RCRA TSD units and effluent disposal from SALDS. Data from facility-specific monitoring also are integrated into CERCLA groundwater investigations. The groundwater contamination plumes of interest in this area include carbon tetrachloride, chloroform, trichloroethene, nitrate, chromium, fluoride, tritium, iodine-129, technetium-99, and uranium (Figures 2-18, 2-19, and 2-20).

The 200-ZP-1 OU ROD (EPA et al., 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington*) defines the remedy for the 200-ZP-1 OU.

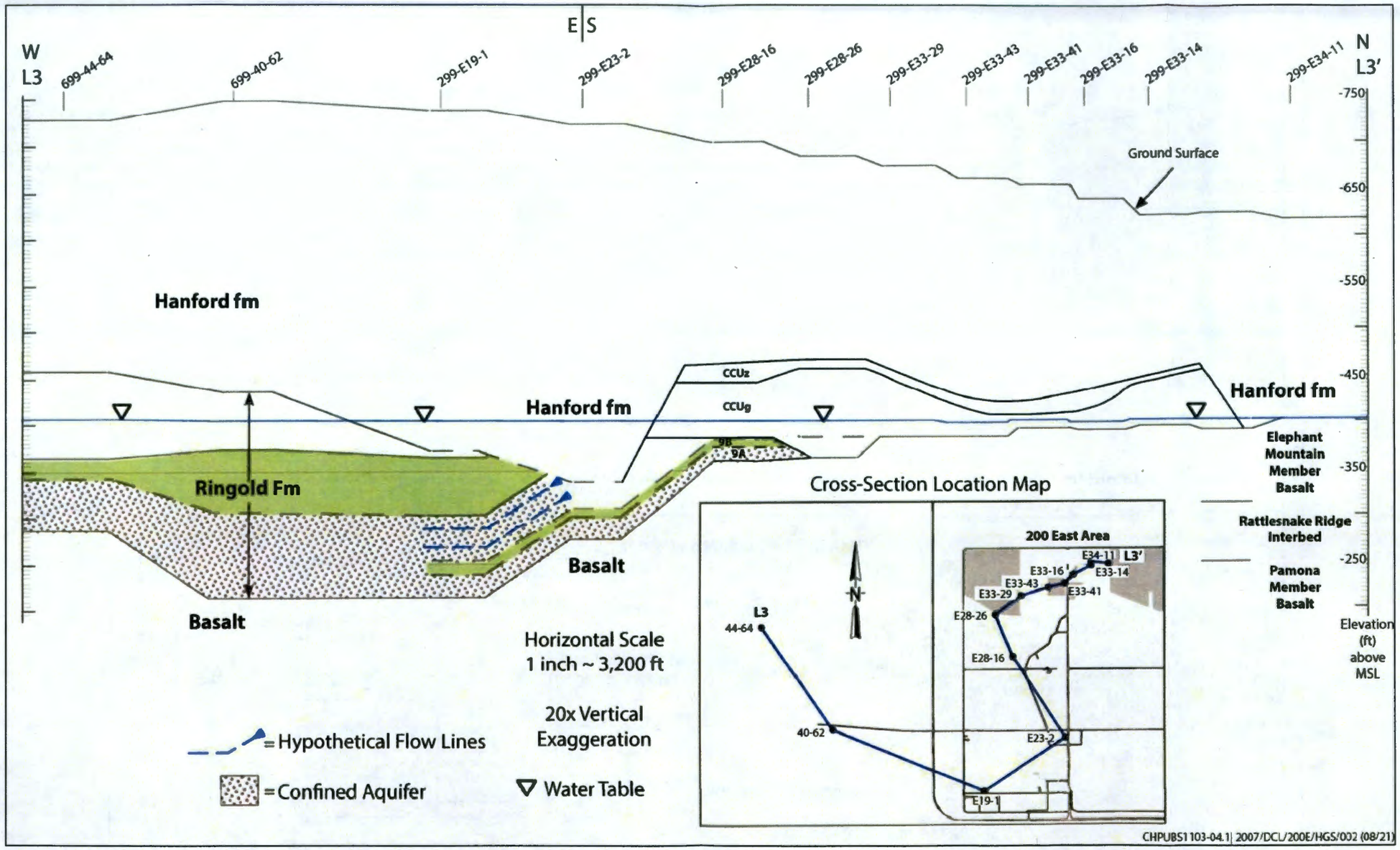
A groundwater P&T system has been designed and installed and is operating in accordance with an approved RD/RAWP. The system is designed to capture and treat contaminated groundwater to reduce the mass of carbon tetrachloride, total chromium (trivalent chromium and hexavalent chromium), nitrate, trichloroethene, iodine-129, and technetium-99 throughout the 200-ZP-1 OU by a minimum of 95 percent in 25 years. The P&T component has been implemented in combination with monitored natural attenuation (MNA) to achieve cleanup levels listed for all contaminants of concern (COCs) in 125 years. The estimated pumping rate required to reduce the mass of COCs by 95 percent in 25 years is 6,057 L/min (1,600 gpm).

In addition to the P&T system, natural attenuation processes are expected to reduce concentrations of some of the contaminants to below the cleanup levels. These natural attenuation processes include abiotic degradation, dispersion, sorption, and natural radioactive decay. Monitoring will be employed in accordance with the approved remedial design/remedial action documents to evaluate the effectiveness of the P&T system and natural attenuation processes. Fate and transport analyses conducted as part of the FS (DOE/RL-2007-28, *Feasibility Study Report for the 200-ZP-1 Groundwater Operable Unit*) indicate that the time frame necessary to reduce the remaining COC concentrations to acceptable levels through MNA will be approximately 100 years. Modeling also indicates that this portion of the plume will remain on the Central Plateau geographic area during this time frame.

Monitoring is required over the life of the action to evaluate its performance and optimize its effectiveness and shall be conducted in accordance with the approved remedial design/remedial action documents. For the MNA component, monitoring locations, POCs, and specifications will be developed as part of the RD/RA documents that will provide data on performance, including data indicating whether the key mechanisms of natural attenuation are performing in a manner that satisfies the remedy requirements and schedule.

The final CERCLA cleanup process for the 200-ZP-1 OU is described in a series of regulatory documents, including the following:

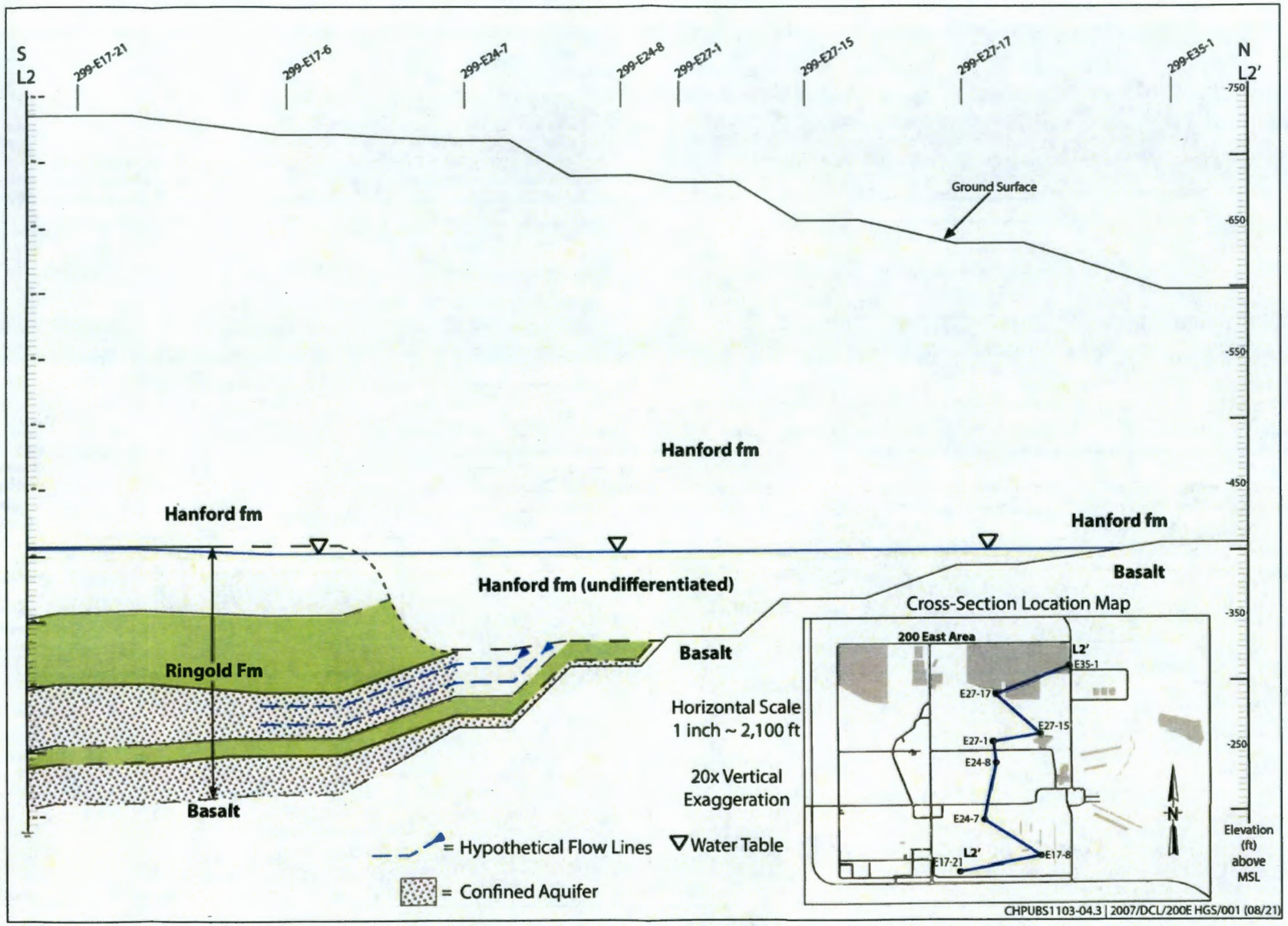
- DOE/RL-2003-55, *Remedial Investigation/Feasibility Study Work Plan for the 200-ZP-1 Groundwater Operable Unit*, prepared in fiscal year (FY) 2004 and implemented in FY 2005
- DOE/RL-2006-24, *Remedial Investigation Report for the 200-ZP-1 Groundwater Operable Unit*, published in October 2006



Source: PNNL-12261, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington.*

Note: Wells 299-E28-26 and 299-E33-29 represent LLWMA-1; well 299-E34-11 represents LLWMA-2.

Figure 2-16. Schematic Regional Hydrogeologic Cross Section Passing West to East beneath the Northwestern Portion of the Eastern Inner Area and Vicinity



Source: PNNL-12261, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington.*

Note: Well 299-E24-7 represents the vicinity of the 218-E-1 Landfill, and between wells 299-E24-8 and 299-E27-1 represents the area beneath the 218-C-9 Landfill.

Figure 2-17. Schematic Regional Hydrogeologic Cross Section Passing North to South beneath the Eastern Inner Area

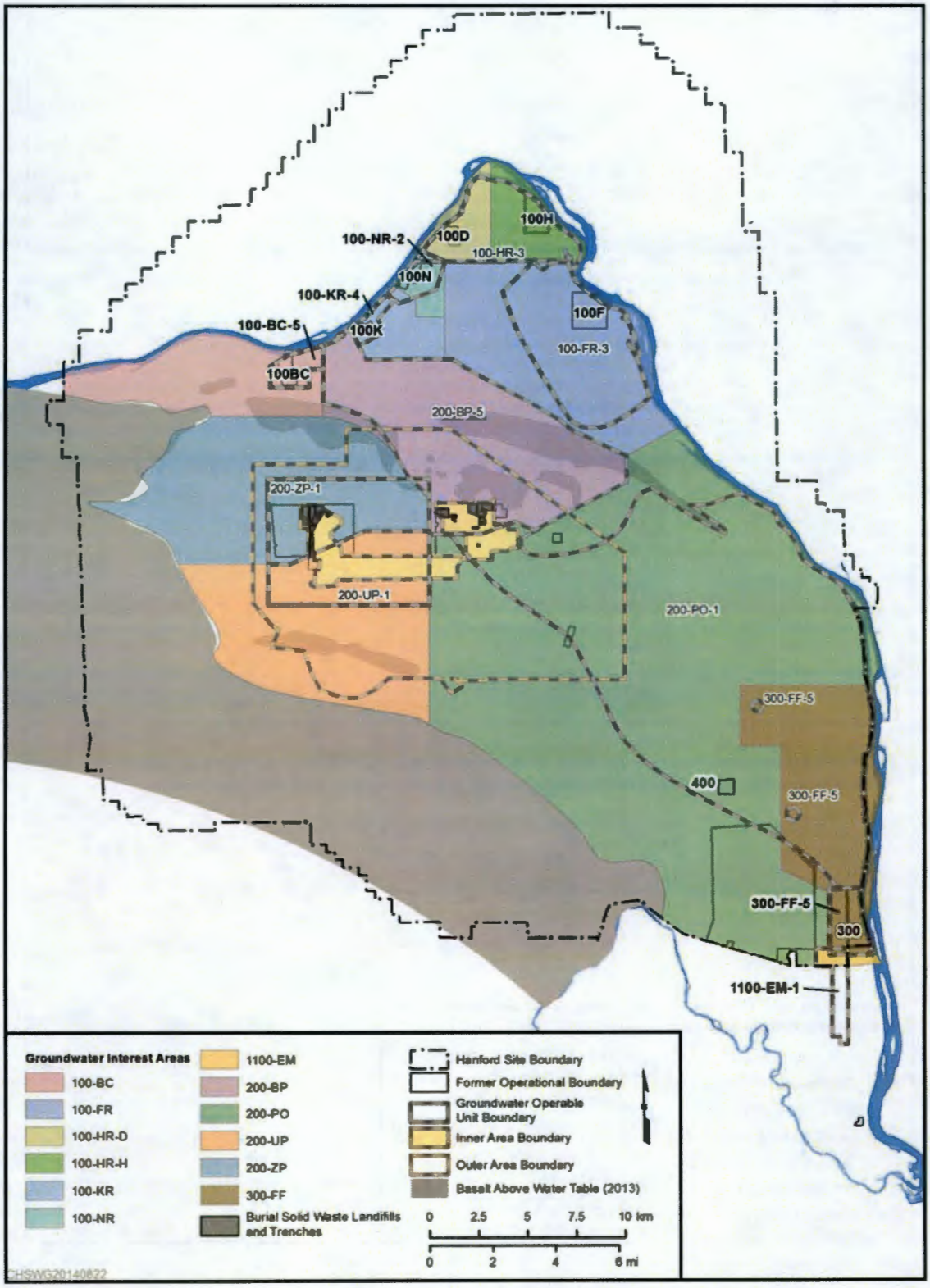


Figure 2-18. Hanford Site Groundwater OUs and Areas of Interest

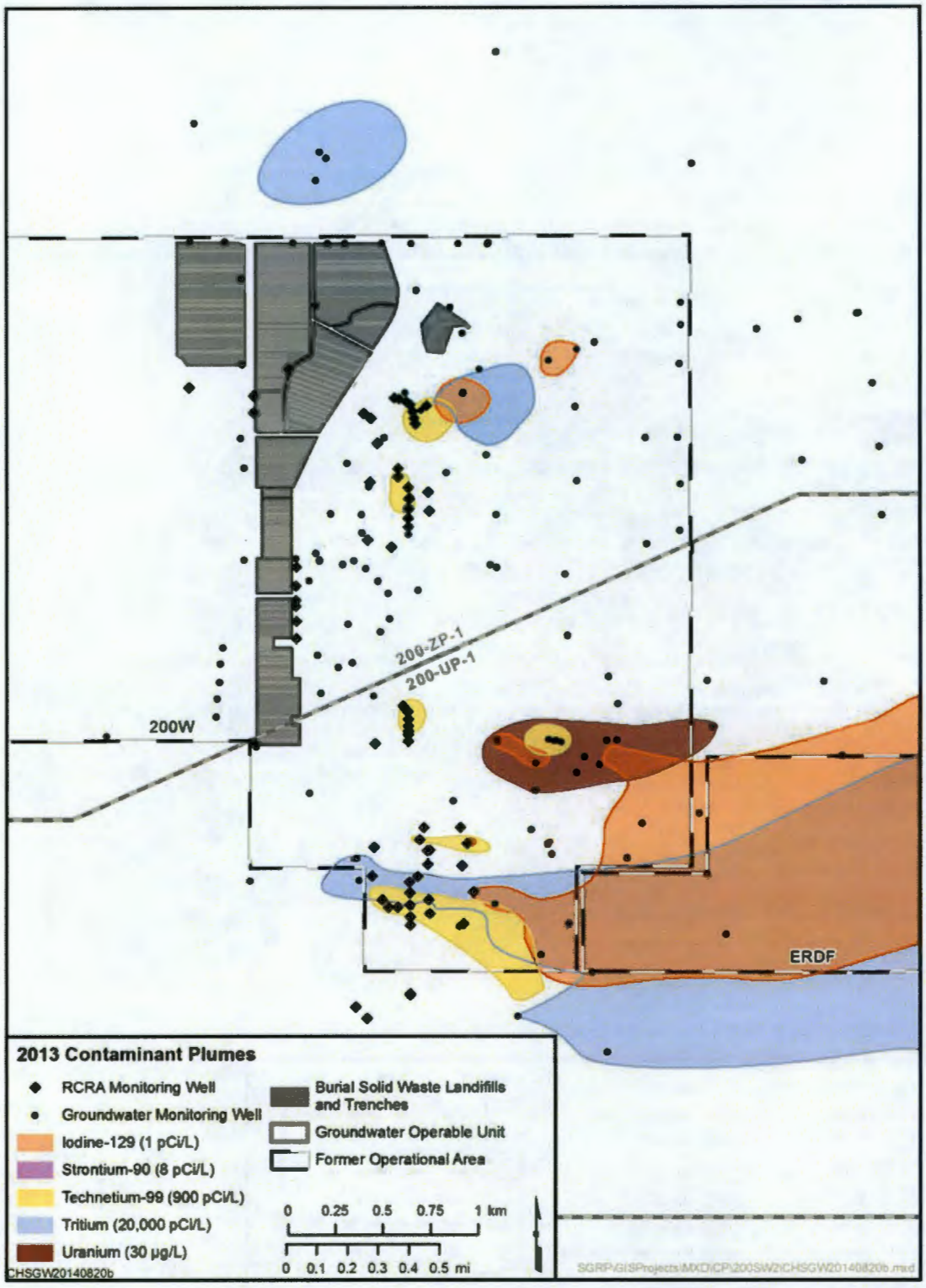


Figure 2-19. Western Inner Area Showing the Groundwater OUs and Radiological Groundwater Contamination Plumes

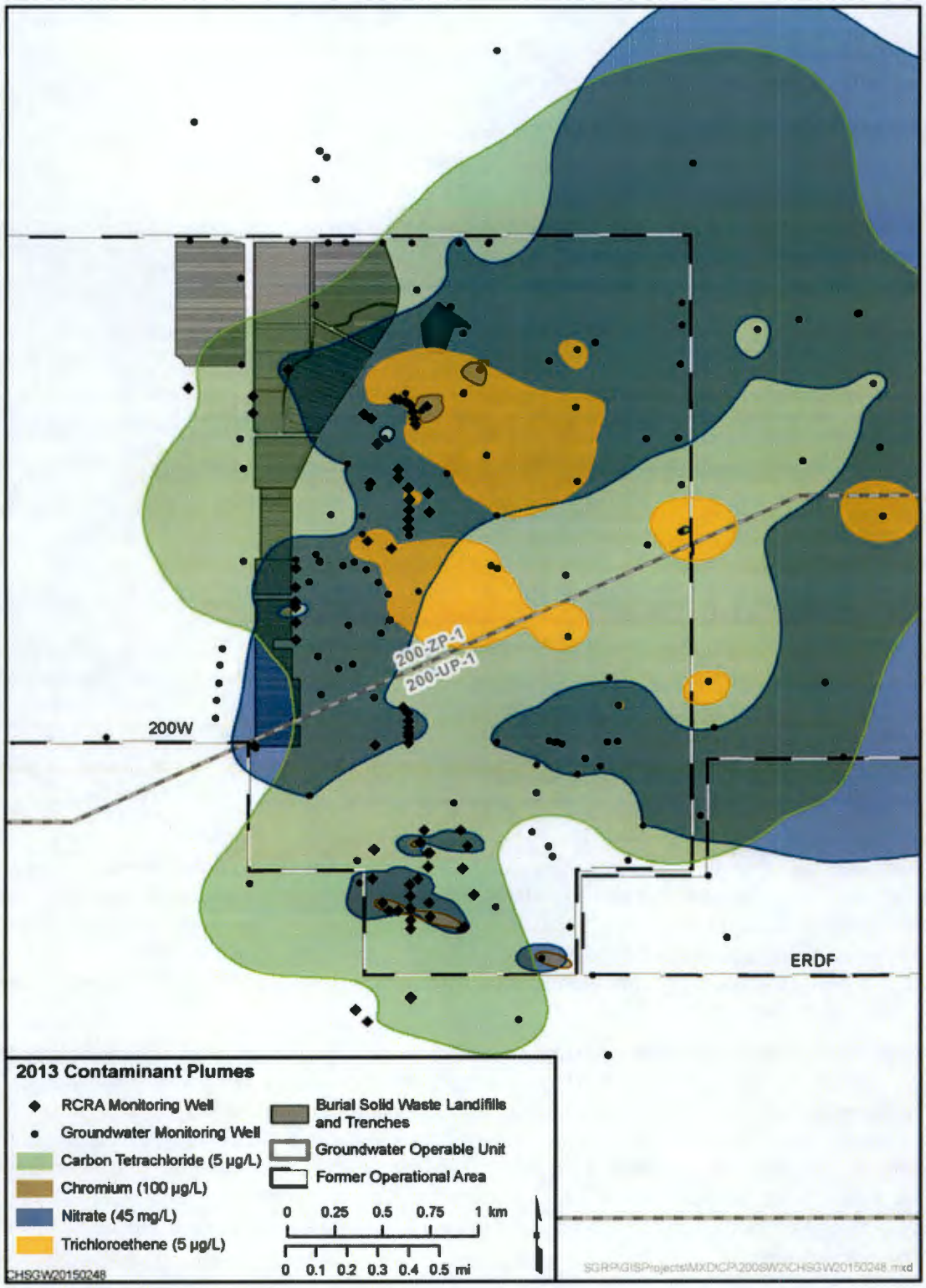


Figure 2-20. Western Inner Area Showing the Groundwater OUs and Nonradiological Groundwater Contamination Plumes

- DOE/RL-2007-28, *Feasibility Study Report for the 200-ZP-1 Groundwater Operable Unit*
- DOE/RL-2007-33, *Proposed Plan for Remediation of the 200-ZP-1 Groundwater Operable Unit*, completed in July 2008
- DOE/RL-2008-78, *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan*, for implementing all of the tasks for design, installation, and operation of the 200 West P&T (as set forth in the final ROD), completed in July 2009

The COCs include carbon tetrachloride, trichloroethene, iodine-129, technetium-99, nitrate, hexavalent chromium, total chromium, and tritium. The final remedy addresses contamination throughout the vertical extent of the aquifer.

The remedial action objectives (RAOs) identified in the ROD include returning the 200-ZP-1 OU groundwater to beneficial use, applying institutional controls to prevent use of groundwater until the cleanup levels have been attained, and protecting the Columbia River from degradation and unacceptable impacts caused by contamination from the 200-ZP-1 OU. RAOs are achieved through four remedy components:

- MNA
- Institutional controls
- Flow-path controls
- A P&T system

The final P&T network will include at least 36 injection and extraction wells. The 200-ZP-1 OU remedial action will capture and treat contaminated groundwater beneath some 200-SW-2 OU landfills.

2.6.2 200-UP-1 Groundwater Operable Unit

The 200-UP-1 Groundwater OU is located in the southern portion of the western Inner Area and adjacent portions of the surrounding 600 Area (Figures 2-18, 2-19, and 2-20). The 200-SW-2 OU solid waste landfill 218-W-4C overlies a portion of this groundwater OU.

With the exception of the Environmental Restoration Disposal Facility (ERDF), the other facilities and waste sites overlying the 200-UP-1 Groundwater OU are associated with early operation of the REDOX Plant (plutonium and uranium separation) and U Plant (uranium recovery). DOE conducts groundwater monitoring in the 200-UP-1 OU under CERCLA and under RCRA for WMAs U and S-SX and the 216-S-10 Pond and Ditch. Monitoring of radionuclides is also performed to meet *Atomic Energy Act of 1954* (AEA) requirements.

Groundwater monitoring within the 200-UP-1 Groundwater OU is performed under a sampling schedule incorporated into the RD/RAWP (DOE/RL-2013-07, *200-UP-1 Groundwater Operable Unit Remedial Design/Remedial Action Work Plan*). Technetium-99, uranium, tritium, iodine-129, nitrate, chromium, and carbon tetrachloride form extensive groundwater plumes in the area. These contaminants originated from past liquid waste disposal operations in this area except for carbon tetrachloride, which has migrated into the 200-UP-1 OU from the 200-ZP-1 OU. The contaminants chloroform, 1,4-dioxane, strontium-90, selenium-79, and trichloroethene have been found in groundwater to a limited extent and are routinely sampled in selected wells.

Within the 200-UP-1 OU, groundwater occurs as an unconfined aquifer and as confined aquifers beneath the RLM unit and between the basalt flows. The unconfined aquifer is the aquifer directly impacted by past waste disposal operations. The unconfined aquifer occurs within Rwie; its base is the fine-grained RLM (Figure 2-7).

Depths from land surface to the water table range from 64 m to 106 m (210 ft to 348 ft), with the largest depths occurring in the northeastern portion of the OU. The thickness of the unconfined aquifer varies from 70 m (230 ft) in the western portion of the OU to near zero north of the OU boundary where the top of the lower mud unit has been extrapolated to occur above the water table. The water table elevations in the western Inner Area and resultant groundwater gradients have been historically affected by large-volume wastewater discharges. Currently groundwater flow in the unconfined aquifer is toward the east within the southern western Inner Area and toward the east-northeast in the eastern portion of the OU (DOE/RL-2014-32).

An interim action ROD addressing all of the major contaminant plumes within the 200-UP-1 OU was published during September 2012 (EPA et al., 2012, *Record of Decision for Interim Remedial Action Hanford 200 Area Superfund Site 200-UP-1 Operable Unit*). This ROD superseded the prior interim action ROD issued in 1997 (EPA/ROD/R10-97/048, *Interim Remedial Action Record of Decision for the 200-UP-1 Operable Unit, Hanford Site, Benton County, Washington*). The selected remedy in the 2012 ROD consists of a combination of the following:

- Groundwater extraction and treatment for technetium-99, uranium, and chromium
- A combination of P&T system and MNA for nitrate and carbon tetrachloride
- MNA for tritium
- Hydraulic containment for iodine-129 while treatment technologies are investigated
- ICs

CERCLA activities during 2013 included continued groundwater monitoring, continued operation of a groundwater extraction system downgradient from the S-SX Tank Farms, and publication of an RD/RAWP (DOE/RL-2013-07). The third CERCLA 5-year review (DOE/RL-2011-56, *Hanford Site Third CERCLA Five-Year Review Report*) identified no issues pertaining to the 200-UP-1 OU.

2.6.3 200-BP-5 Groundwater Operable Unit

The 200-BP-5 Groundwater OU interest area addresses groundwater contaminant plumes beneath the northern half of the eastern Inner Area and adjacent portions of the surrounding 600 Area (Figures 2-18, 2-21, and 2-22). This OU underlies RCRA TSD units and RCRA and CERCLA past-practice units in the northern part of the eastern Inner Area and extends north to Gable Gap. Eleven solid waste landfills overlie the 200-BP-5 OU (218-E-2, 218-E-2A, 218-E-4, 218-E-5, 218-E-5A, 218-E-8, 218-E-9, 218-E-10, 218-E-12A, 218-E-12B, and 218-C-9 Landfills).

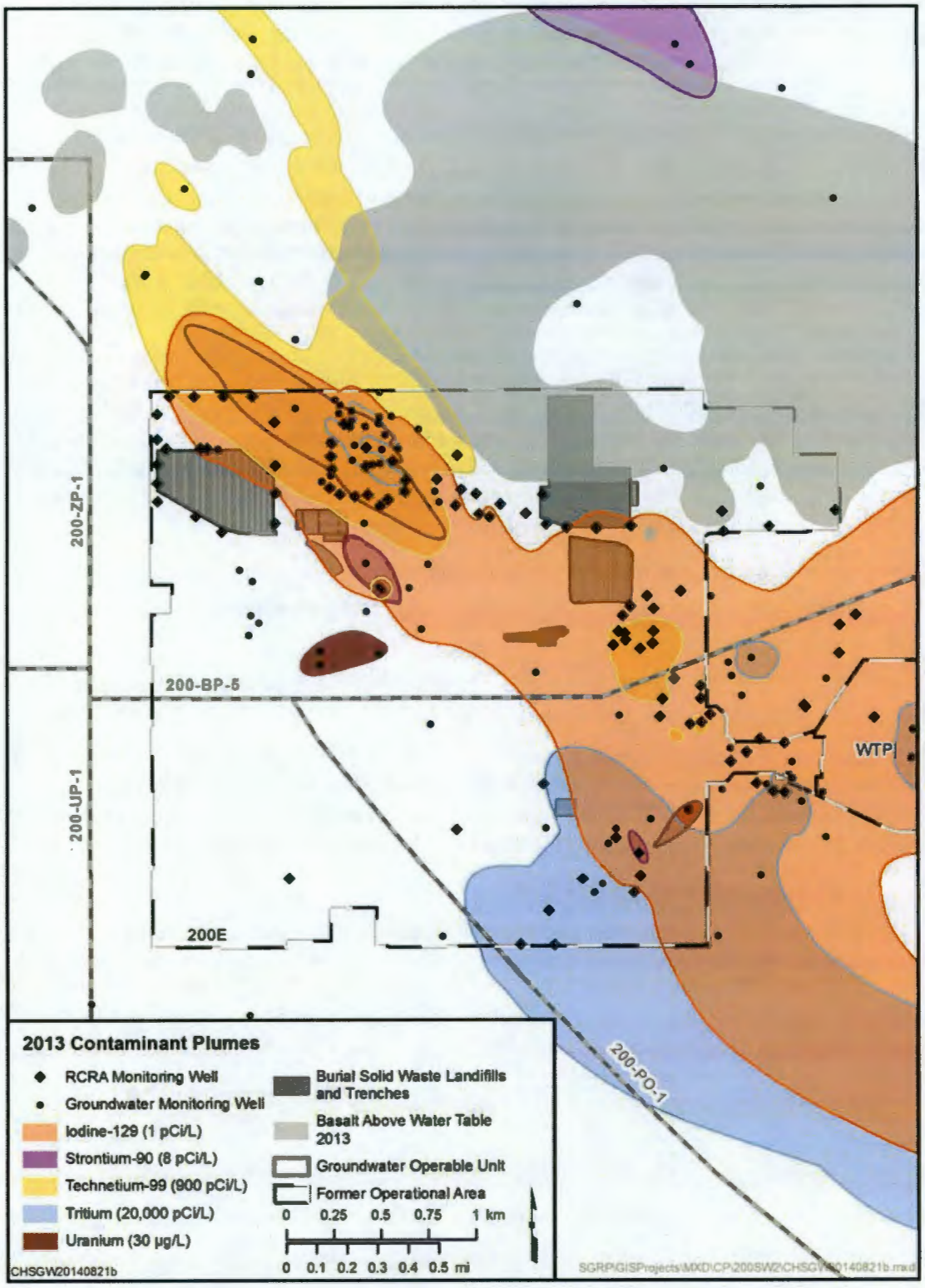


Figure 2-21. Eastern Inner Area Showing the Groundwater OUs and Radiological Groundwater Contamination Plumes

Figure 2-22. Eastern Inner Area Showing the Groundwater OUs and Nonradiological Groundwater Contamination Plumes

Technetium-99 and uranium have been identified as contaminants of potential concern (COPCs) in the 200-BP-5 OU. Perched water contamination, discussed in the previous section, has affected the groundwater in the 200-BP-5 OU beneath the B Complex area contributing to these two plumes. Other groundwater contaminants include cyanide, strontium-90, tritium, iodine-129, and nitrate. Groundwater is monitored in this OU to define the regional extent of technetium-99, uranium, and other significant contaminants across the OU, as well as the local extent of contamination associated with specific RCRA TSD units in the area. Groundwater remediation is not performed in the 200-BP-5 OU; however, a CERCLA removal action to reduce the risk of groundwater contamination is being conducted at the 200-DV-1 OU by extracting contaminated perched water above the unconfined aquifer beneath the B Complex area.

DOE/RL-2010-74, *Treatability Test Plan for the 200-BP-5 Groundwater Operable Unit*, identified the need for 15 additional wells to resolve the future impact to groundwater, improve the understanding of contaminant nature and extent within the aquifer, and refine the groundwater flow direction. Fieldwork began in 2006 and continued through 2010. Depth-discrete samples were collected at 14 existing wells within the 200-BP-5 OU. The samples were collected to evaluate the vertical extent of contamination beneath, adjacent, and downgradient of waste sites where contaminant infiltration is thought to be occurring.

The COCs defined in DOE/RL-2001-49, *Groundwater Sampling and Analysis Plan for the 200-BP-5 Operable Unit*, include nitrate, iodine-129, technetium-99, uranium, strontium-90, cyanide, cobalt-60, cesium-137, plutonium-239/240, and tritium. Routine CERCLA groundwater monitoring requirements are described in the 200-BP-5 RI/FS work plan (DOE/RL-2010-74). Two reports associated with a treatability test near WMA B/BX/BY Tank Farm were written (SGW-44329, *200-BP-5 OU Data Quality Objectives Summary Report*; DOE/RL-2010-74).

2.6.3.1 200-PO-1 Groundwater Operable Unit

The 200-PO-1 Groundwater OU interest area addresses groundwater contaminant plumes beneath the southern portion of the eastern Inner Area and a large triangular portion of the Hanford Site extending to the Hanford townsite and the Columbia River. Only one solid waste landfill (218-E-1) overlies the 200-PO-1 OU. Within the 200-PO-1 OU, tritium, nitrate, and iodine-129 are the contaminants with the largest plumes in groundwater. Other COPCs in more localized areas include strontium-90 and technetium-99. COPCs also include arsenic, chromium, manganese, vanadium, cobalt-60, cyanide, and uranium. Additional information, including a discussion of other contaminants detected in the groundwater, can be found in DOE/RL-2014-32.

2.7 Surface Water Hydrogeology

Primary surface water features associated with the Hanford Site are the Columbia and Yakima Rivers. Groundwater in the unconfined aquifer beneath the 200-SW-2 OU eventually discharges to the Columbia River east and southeast of the Central Plateau.

The Columbia River flows through the northern and eastern margins of the Hanford Site. Routine water quality monitoring of the Columbia River is conducted by DOE for radiological and nonradiological parameters. In general, the Columbia River water is characterized by a very low suspended load, a low nutrient content, and an absence of microbial contaminants (DOE/RW-0164, *Site Characterization Plan: Reference Repository Location, Hanford Site, Washington*).

About one-third of the Hanford Site is drained by the Yakima River system. Cold Creek and its tributary, Dry Creek, are ephemeral streams on the Hanford Site that are within the Yakima River drainage system. Both streams drain areas along the western portion of the Hanford Site and cross the southwestern part of

the Hanford Site toward the Yakima River. Surface flow, which may occur during spring runoff or after heavier-than-normal rain events, typically infiltrates and disappears into the surface sediments before reaching the Yakima River. Rattlesnake Springs, located on the western part of the Hanford Site, forms a small surface stream that flows for about 2.9 km (1.8 mi).

2.8 Environmental Resources

Because of the long-standing management practices of DOE, most of the land on the Hanford Site is relatively undisturbed. The Site is surrounded by agricultural and residential development. Hanford is one of the last large areas of relatively undisturbed shrub-steppe habitats in Washington State.

The ecological setting has been characterized using a compilation of data from biological inventories of plants and wildlife plus ecological characterizations from the following reports:

- The Nature Conservancy (TNC) of Washington Sitewide geographic information system-based plant community mapping for all areas outside the Hanford Site boundaries and biodiversity surveys of mammals, birds, reptiles, amphibians, insects, and plants between 1994 and 1998 in three annual reports (Pabst, 1995, *Biodiversity Inventory and Analysis of the Hanford Site, 1994 Annual Report*; Soll and Soper, 1996, *Biodiversity Inventory and Analysis of the Hanford Site, 1995 Annual Report*; Hall, 1998, *Biodiversity Inventory and Analysis of the Hanford Site, 1997 Annual Report*), and a final report in 1999 (Soll et al., 1999, *Biodiversity Inventory and Analysis of the Hanford Site, Final Report 1994-1999*)
- Central Plateau ecological data compilation (PNNL-13230, *Hanford Site Environmental Report for Calendar Year 1999*; PNNL-13331, *Population Characteristics and Seasonal Movement Patterns of the Rattlesnake Hills Elk Herd – Status Report 2000*; PNNL-13487, *Hanford Site Environmental Report for Calendar Year 2000*; and PNNL-13745, *Hanford Site Ecological Quality Profile*)
- Characterization of vegetative communities associated with the Inner Area facilities at the Hanford Site (WHC-SD-EN-TI-216, *Vegetation Communities Associated with the 100-Area and 200-Area Facilities on the Hanford Site*)
- Vascular plants of the Hanford Site (PNNL-13688, *Vascular Plants of the Hanford Site*)
- Hanford Site biological resource management plan (using TNC and other characterization reports), identifying four levels of habitat value and appropriate management strategies for the Hanford Site (DOE/RL-96-32, *Hanford Site Biological Resources Management Plan*)

The Hanford Site is characterized as a cool desert or a shrub-steppe and supports a biological community typical of this environment. The Central Plateau contains a number of plant, mammal, bird, reptile, amphibian, and insect species, as discussed in the following subsections.

2.8.1 Vegetation of the Central Plateau

The vegetation of the Central Plateau is characterized by native shrub-steppe interspersed with large areas of disturbed ground with a dominant annual grass component. The native stands are classified as an *Artemisia tridentata/Poa sandbergii - Bromus tectorum* community (PNL-2253, *Ecology of the 200 Area Plateau Waste Management Environs: A Status Report*), meaning that the dominant shrub is big sagebrush (*Artemisia tridentata*) and the understory is dominated by the native Sandberg's bluegrass (*Poa sandbergii*) and the introduced annual cheatgrass (*Bromus tectorum*). Other shrubs that are typically present include gray rabbitbrush (*Chrysothamnus nauseosus*), green rabbitbrush (*C. viscidiflorus*), spiny hopsage (*Grayia spinosa*), and occasional antelope bitterbrush (*Purshia tridentata*). Other native

bunchgrasses that are typically present include bottlebrush squirreltail (*Sitanion hystrix*), Indian ricegrass (*Achnatherum hymenoides*), needle-and-thread (*Stipa comata*), and prairie junegrass (*Koeleria cristata*). Common and important herbaceous species include turpentine cymopteris (*Cymopteris terebinthinus*), globemallow (*Sphaeralcea munroana*), balsamroot (*Balsamorhiza careyana*), several milk vetch species (*Astragalus caricinus*, *A. sclerocarpus*, *A. succumbens*), long-leaf phlox (*Phlox longifolia*), the common yarrow (*Achillea millifolium*), pale evening-primrose (*Oenothera pallida*), thread-leaf phacelia (*Phacelia linearis*), and several daisy/fleabane species (*Erigeron poliospermus*, *E. Filifolius*, and *E. pumilus*). More than 100 plant species have been documented in native stands on the Central Plateau.

Disturbed communities on the Central Plateau are primarily the result of mechanical disturbance or range fires. Mechanical disturbance, construction activities, soil borrow areas, road clearings, and fire breaks result in changes to native plant communities. Revegetation of remediated waste sites in the River Corridor (as described in DOE/RL-2011-116, *Hanford Site Revegetation Manual*) has been successful with replanting of suitable native species in the 100 Area following remediation activities. Examples are provided in annual issues of the *River Corridor Closure Contractor Revegetation and Mitigation Monitoring Report*, such as WCH-288 (2008), WCH-362 (2009), WCH-428 (2010), WCH-512 (2011), and WCH-554 (2012). The Hanford Site revegetation manual is planned to be used following future remedial actions on the Central Plateau.

The vegetation in and around the ponds and ditches in the Inner Area is significantly different from that of the surrounding dry land areas. Several tree species are present, especially cottonwood (*Populus trichocarpa*) and willows (*Salix* spp.). Wetland species also are present, including several sedges (*Carex* spp.), bulrushes (*Scirpus* spp.), cattails (*Typha latifolia* and *T. angustifolia*), and pondweeds (*Potamogeton* spp.).

2.8.2 Mammals

Although mule deer (*Odocoileus hemionus*) are much more common to riparian sites along the Columbia River, they are frequently observed foraging throughout the Central Plateau. The largest mammal living on the Central Plateau is the elk (*Cervus elaphus*). A herd of 772 elk also occurs on the Hanford Site, with a herd of 22 regularly occupying areas around the northern portion of central Hanford (HNF-54666, *Elk Monitoring Report for Calendar Year 2012*). Other mammal species common to the Central Plateau include badgers (*Taxidea taxus*), coyotes (*Canis latrans*), blacktail jackrabbits (*Lepus californicus*), Townsend ground squirrels (*Spermophilus townsendii*), Great Basin pocket mice (*Perognathus parvus*), pocket gophers (*Thomomys talpoides*), and deer mice (*Peromyscus maniculatus*). Badgers are known for their digging capability and have been implicated several times for tunneling into inactive burial grounds throughout the Central Plateau. Most badger excavations in the Central Plateau are a result of badgers searching for prey (e.g., mice and ground squirrels). Coyotes are the principal predators, consuming such prey as rodents, insects, rabbits, birds, snakes, and lizards. The Great Basin pocket mouse is the most abundant small mammal, which thrives in sandy soils and lives entirely on seeds from native and revegetated plant species. Townsend ground squirrels are not abundant in the Central Plateau, but they have been seen at several different sites.

Other small mammals that live in low numbers include the western harvest mouse (*Reithrodontomys megalotis*) and the grasshopper mouse (*Onychomys leucogaster*). Mammals associated more closely with buildings and facilities include Nuttall's cottontails (*Sylvilagus nuttallii*), house mice (*Mus musculus*), Norway rats (*Rattus norvegicus*), and some bat species. Nine bat species have been identified at the Hanford Site (HNF-53759, *Summer Bat Monitoring Report for Calendar Year 2012*). Five locations for the 2012 summer survey were within the Inner Area, some with bats observed. Mammals such as skunks

(*Mephitis mephitis*), raccoons (*Procyon lotor*), weasels (*Mustela* spp.), porcupines (*Erethizon dorsatum*), and bobcats (*Lynx rufus*) have only been observed on very few occasions.

2.8.3 Birds

More than 235 species of birds have been documented to occur at the Hanford Site (WHC-EP-0402, *Status of Birds at the Hanford Site in Southeastern Washington*). At least 100 of these species have been observed in the Inner Area. The most common passerine birds include starlings (*Sturnus vulgaris*), horned larks (*Ermophila alpestris*), meadowlarks (*Sturnella neglecta*), western kingbirds (*Tyranus verticalis*), rock doves (*Columba livia*), barn swallows (*Hirundo rustica*), cliff swallows (*Hirundo pyrrhonota*), black-billed magpies (*Pica pica*), and ravens (*Corvus corax*). Common raptors include the northern harrier (*Circus cyaneus*), American kestrel (*Falco sparvarius*), and red-tailed hawk (*Buteo jamaicensis*). Swainson's hawks (*Buteo swainsoni*) sometimes nest in the trees at some of the army bunker sites that were used in the 1940s. Golden eagles (*Aquila chrysaetos*) are observed infrequently. Burrowing owls (*Athene cunicularia*) nest at several locations throughout the Inner Area. The most common upland game birds found in the Inner Area are California quail (*Callipepla californica*) and Chukar partridge (*Alectoris chukar*); however, ring-necked pheasants (*Phasianus colchicus*) and gray partridges (*Perdix perdix*) may be found in limited numbers. The only native game bird common to the Central Plateau is the mourning dove (*Zenaida macroura*), which migrates south each fall. Other species of note that nest in undisturbed sagebrush habitats in the Central Plateau include sage sparrows (*Amphispiza belli*) and loggerhead shrikes (*Lanius ludovicianus*). Long-billed curlews (*Numenius americanus*) also use the sagebrush areas and revegetated burial grounds for nesting and foraging.

Waterfowl and aquatic birds formerly inhabited areas with running or standing water; however, these areas have been removed through stabilization and remedial action cleanup activities. No substantial bodies of open water remain in the Central Plateau.

2.8.4 Reptiles and Amphibians

Common reptiles include gopher snakes (*Pituophis melanoleucus*) and side-blotched lizards (*Uta stansburiana*). Other reptiles and amphibians that are infrequently observed include sagebrush lizards (*Sceloporus graciosus*), horned toads (*Phrynosoma douglassii*), western spadefoot toads (*Scaphiopus intermontana*), yellow-bellied racers (*Coluber constrictor*), Pacific rattlesnakes (*Crotalus viridis*), and striped whipsnakes (*Masticophis taeniatus*). Both lizards and snakes are prey items of mammalian and avian predators.

2.8.5 Insects

Hundreds of insect species inhabit the Central Plateau. Two of the most common groups of insects include several species of darkling beetles and grasshoppers. Harvester ants also are common and have been implicated in the uptake of radionuclides from some of the burial grounds in the eastern Central Plateau. The maximum documented burrowing depth of harvester ants at the Hanford Site and depth from which ants can excavate and bring up material is 270 cm (8.9 ft) (Sample et al., 2015, "Depth of the Biologically Active Zone in Upland Habitats at the Hanford Site, Washington: Implications for Remediation and Ecological Risk Management"; PNL-2774, *Characterization of the Hanford 300 Area Burial Grounds, Task IV – Biological Transport*). Insects affect the surrounding plant community and serve as the prey base for many species of birds, reptiles, and mammals.

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3 Initial Evaluation

This chapter summarizes the current understanding of site conditions for the 200-SW-2 OU landfills and the adequacy of the existing information to support remedy decisions. The descriptions for the landfills include the nature and extent of contamination. This chapter also introduces the characterization strategy developed in conjunction with DOE and Ecology over the course of several months during calendar year 2014 and the results of previous characterization activities. Finally, this chapter summarizes the elements of the preliminary risk assessment, CSMs, baseline risk analysis, COPC discussion, and PRGs.

3.1 Contaminant Sources

As discussed in Chapter 2, landfills in the 200-SW-2 OU received solid waste (e.g., bulk quantities of trash, construction debris, soiled clothing, failed equipment, and laboratory and process waste). The waste was placed into the landfills directly or packaged (e.g., in cardboard, wooden, or fiber-reinforced polyester boxes; steel drums; concrete burial vaults; or other containers). Some waste was contaminated with radionuclides, organics, and/or inorganic chemicals from various facilities (mainly from the Hanford Site 200 Areas). Relatively small amounts of waste from the 100 and 300 Areas and from offsite sources was placed in the landfills (mostly in the RCRA TSD units).

3.1.1 Historical Documentation of Contaminant Inventories

The following sources estimate an inventory of the typical radionuclides and chemicals disposed in the 200-SW-2 OU landfills:

- Hanford Environmental Information System database
- SWITS database
- WIDS database
- ARH-2762, *Input and Decayed Values of Radioactive Solid Wastes Buried in the 200 Areas Through 1971*
- DOE/RL-96-81, *Waste Site Grouping for 200 Areas Soil Investigations*
- RHO-CD-673, *Handbook 200 Areas Waste Sites*
- WHC-EP-0125-1, *Summary of Radioactive Solid Waste Received in the 200 Areas During Calendar Year 1988*
- WHC-EP-0912, *The History of the 200 Area Burial Ground Facilities*

Sources of information for 200-SW-2 OU contaminant inventories vary widely among the different landfills. An effort begun in 2004 continues to reconcile and combine sources of information to obtain data based on the best knowledge available. The following was determined:

- Nearly 147,000 historical records are available that document the contents of waste disposed at the radioactive landfills. Estimated quantities of plutonium and uranium that were disposed in the landfills are available.
- 42 percent list other radiological contaminants.
- 43 percent generally describe the waste components (e.g., plastic, wood, and paper).

- 36 percent have detailed descriptions of the waste (e.g., "failed dissolver from REDOX" or "drums of depleted uranium").
- About 29,000 records are associated with waste that is not in the scope of this work plan (i.e., RSW-TRU and MLLW disposed in lined trenches 218-W-5-T31 and 218-W-5-T34).

In addition, about 12 percent of the individual records list nonradiological contaminants that currently are, or once were, regulated as dangerous waste under WAC 173-303, "Dangerous Waste Regulations." One reason for this smaller percentage is that most waste packages with detailed records are from more recent burials and do not contain regulated constituents. Additionally, although a variety of chemical waste may have been disposed at these landfills, chemical inventories were not consistently maintained until the effective regulation date of RCRA waste at the Hanford Site (August 19, 1987).

Summary inventory information available for each landfill is included with the CSMs in Appendix D of this work plan. Appendix K provides a detailed summary of the historical documentation review.

3.1.2 Historical Documentation of Landfill Types, Landfill Configuration, and Waste Forms

The waste generators and the waste-generating processes that disposed waste at the 200-SW-2 OU landfills (200 Areas, other Hanford Site areas, and offsite facilities) varied over time. In addition, the waste generators produced different types and quantities of waste.

Before 1970, waste was designated as dry, construction, or industrial, with no segregation of materials within these major categories. Industrial waste trenches received large items, often packaged in drag-off boxes. Dry waste was disposed in trenches, in containers (e.g., cardboard boxes, drums), or unpackaged (i.e., loose debris). Construction trenches contain demolition and construction debris. Many of the trenches contain waste that may cause as low as reasonably achievable (ALARA) concerns. Waste with dose rates over 1,000 R/hr at contact has been disposed to these trenches (SWITS).

The cover requirements for landfill waste have varied over the years. Wind erosion exposed some waste that was buried shallow in earlier landfills. Shallow burial also resulted in uptake from plants whose roots penetrated into the waste packages. A number of incidents are documented where burial boxes collapsed, dispersing radioactive contamination across wide areas. Most of the collapse issues were resolved through soil compaction, removal of deep-rooted vegetation, and the addition of soil and shallow-rooted vegetation. Site maintenance programs also include the application of herbicides by licensed applicators to control deep-rooted plant growth on stabilized landfills.

Landfill summaries provided in Chapter 2 reflect the information that is readily available for the 200-SW-2 OU landfills. Process models and assessment results fill in unknown information where records are incomplete. CSMs provide known inventories. Process knowledge and historical/anecdotal information, rather than disposal records, provide insight regarding the contents of many of the older landfills. The characterization methodologies described in this work plan validate and enhance the historical information by using technologies that address the risk potential and help evaluate potential remedies.

3.1.3 Unplanned Release Sites

Eleven UPR sites (Table 2-3 in Chapter 2) are within the footprint of one of the landfills or near the landfills. All of the UPRs have been consolidated into the 200-SW-2 OU, and each was assigned to a specific landfill where the UPR occurred. The characterization strategy described in this work plan evaluates the presence of a potential risk pathway associated with the UPRs as part of the characterization for the landfill locations.

3.1.4 Former Liquid Disposal Sites

Several former liquid disposal sites (i.e., ponds and ditches) are assigned to the 200-SW-2 OU. Portions of two landfills (218-W-3AE and 218-W-2A) are located on the former T Pond and Ditch (216-T-4-1, 216-T-4-2, 216-T-4A, and 216-T-4B) locations. They intermittently received the following waste streams: cooling water from the 221-T and 224-T Buildings, steam condensate from the 221-T Building, decontamination waste from 2706-T, condenser cooling water from the 242-T Building, and waste streams by the 207-T retention basin and 200-W-163-PL.

The 216-C-9 Pond is collocated with the 218-E-9 Landfill. It received radiologically contaminated cooling water from the 201-C Semiworks Facility, which began decommissioning in 1983. In 1985, the east end of the dried pond began receiving Semiworks decommissioning solid waste. Based on advanced geophysics, the characterization proposed in this work plan includes additional characterization technologies to determine if there is a complete risk pathway associated with the former ponds and the associated landfills. If a pathway is confirmed, then (as part of the installation of the borings and pushes) samples will be collected from below the bottom of the landfill and former ponds to determine the nature of the contamination and to allow the evaluation of groundwater protection in accordance with DOE/RL-2011-50 and as described in Section 4.3 in Chapter 4 of this work plan.

3.1.5 Z Plant Burn Pit

The Z Plant burn pit, formerly located in Trench 33 of the 218-W-4C Landfill, was a disposal site for combustible nonradioactive construction and office and nonhazardous laboratory waste, including unnamed chemicals. The burn pit was excavated during construction of the 218-W-4C Landfill.

3.1.6 Nonaqueous-Phase Liquids

A small amount of sorbed, stabilized organic liquid has been disposed to the 200-SW-2 OU. One of the goals of this work plan is to determine whether these organics have migrated to the vadose zone or groundwater. All seven of the TSD unit landfills are known to contain disposed organics.

Over the last 10 years, numerous scientific studies have been conducted on the movement of nonaqueous-phase liquid (NAPL) contaminants in various subsurface environments. These studies have significantly changed the current understanding of how these contaminants move through the subsurface.

Several factors contribute to increased dense nonaqueous-phase liquid (DNAPL) penetration through vadose and saturated soils. A table that discusses these factors in a qualitative way is included in Pankow and Cherry, 1996, *Dense Chlorinated Solvents and Other DNAPLs in Groundwater: History, Behavior, and Remediation*, which also cites the following factors (nonprioritized) that facilitate penetration:

- High DNAPL density
- Low interfacial tension
- Low viscosity
- Large DNAPL volume release
- Long-duration DNAPL release
- High permeability
- Vertical and subvertical geological structure

Another important factor used to determine the behavior of a NAPL at the pore scale is the spreading coefficient. This factor is determined in a three-phase system (in order of preferential wetting of the solids: water, NAPL, air) by the interfacial tensions between the phases. When the spreading coefficient

is positive, the NAPL tends to form a film around the wetting phase and spreads readily. In unsaturated soils, this would lead to greater penetration of smaller pores by the NAPL. When the spreading coefficient is negative, the NAPL will form discrete lenses and will not move as readily over the air water interface. Additional details regarding NAPLs in the vadose zone at the Hanford Site are presented in Appendix H.

3.2 Evaluation of Existing Data

The CSMs provided in Appendix D contain summaries of existing data for each landfill. While data gaps do exist, they exist within a larger context of substantially complete information. For example, qualitative data (from anecdotal and historical sources) are associated with the oldest and smallest landfills. Although more numerous, these landfills represent only a small proportion (about 5 percent) of the total volume of waste. Good disposal records (i.e., records that show waste location, volume, container type, and radiological inventory) are available for about 63 percent of the waste volume in the 200-SW-2 OU. Roughly half of these records also contain a detailed waste content description.

Baseline geophysical data exist for many landfills. Using these data, information can be obtained to depths of 6 m (20 ft), depending on site conditions and the types of anomalies present. For example, large objects are easier to detect at depth than smaller objects. Baseline geophysical data available for many of the landfills also provide nonintrusive information on trench configuration and contents (e.g., metallic objects).

Most of the landfills have passive soil gas data with nondetect results, providing limited indications that releases have occurred and that constituent mobility related to volatilization of landfill contents has not been significant. None of the passive soil gas detections correlate to geophysical anomalies (i.e., suspected buried drums or tanks).

3.2.1 Nature and Extent of Contamination

Current knowledge regarding the nature and extent of groundwater contamination at the landfills is based on monitoring wells installed on the Central Plateau and on field sampling activities conducted as part of the Phase I-A and I-B DQO processes and the Central Plateau ecological risk assessment (ERA). Historical record reviews guided many of the sampling activities. Phase I-A activities formed the basis for Phase I-B activities. Besides historical record searches, the field sampling activities in Phases I-A and I-B used soil gas sampling, geophysics, and radiological surveys. Appendix D summarizes the results of these investigations.

The nature of the material disposed in the 200-SW-2 OU landfills was predominantly dry, sorbed onto media to reduce mobility, or a nonmobile metal. The low annual precipitation and recharge rate at the Hanford Site further reduce the likelihood for contaminant migration through infiltration. However, four landfills (218-E-12B, 218-W-3A, 218-W-4B, and 218-W-4C) did experience some episodic water events (i.e., ponding from storms and/or migration of cooling water) (e.g., 218-E-12B). The landfills may have experienced contaminant migration due to the induced hydraulic gradient caused by the ponding.

3.2.2 Previous Characterization Activities

The following subsections discuss the characterization activities that have occurred in the past as part of the 200-SW-2 OU Project or other related projects in which characterization data were collected that can be used as supplemental data for this project. Examples of these data include sampling results generated during RCRA groundwater monitoring efforts and vapor and soil sampling results generated as part of the M-91 Project.

3.2.2.1 Geophysical Investigations

Geophysical surveys were conducted at select landfills in 2005, 2006, and 2009. The purpose of the surveys was to identify trench placement (i.e., boundaries and geometry) and locate anomalies within the landfills. The SAP (Appendix A) presents a brief summary of geophysical methods, both previously used and proposed. Surface geophysics summarized in the SAP will be used at select landfills to confirm/determine landfill boundaries. The CSMs (Appendix D) summarize the results of past geophysical investigations for each landfill.

Numerous field investigations, including passive soil gas surveys, geophysics, logging of monitoring wells installed near the landfills, radiological surveys, air emission monitoring, and other investigations, have been completed on many of the landfills as part of the attempt made to characterize the contents of the landfills and to assess the potential risk associated with a potential release from the landfill.

3.2.2.2 Passive Soil Vapor Sampling

Passive soil vapor sampling of the 200-SW-2 OU landfills occurred in four stages (groups), as follows.

- **Stage 1:** Samples were collected from selected trenches in five landfills from June to July 2006.
- **Stage 2:** Passive samples were collected again from the five Stage 1 landfills in an effort to better define areas of high concentration (Stages 2 through 4 were undertaken in 2009).
- **Stage 3:** Sampling was performed at 12 landfills where geophysical investigations suggested the presence of metal objects that might contain fluid; no significant soil vapor concentrations were found.
- **Stage 4:** Sampling was performed at one landfill in an attempt to find organic vapors related to "soft" waste forms, such as personal protective equipment and rags that may have been used to absorb organic liquids.

The CSMs (Appendix D) provide results of the passive soil gas data sampling for each landfill.

3.2.3 Retrievably Stored Waste Sampling

TPA (Ecology et al., 1989a) Milestone M-091-49 requires completion of the retrieval and designation of contact-handled suspect TRU-RSW in the 218-W-4B, 218-W-3A, and 218-E-12B Landfills. In 2003, the 218-W-4C Landfill was added. Milestone M-091-49 states that DOE will sample and analyze, in accordance with the approved SAPs, the trench substrates to determine whether releases to the environment have occurred from waste containers.

As part of TRU retrieval, sampling through vent risers in the trenches was to begin before waste retrieval. The following SAPs for each landfill were developed:

- DOE/RL-2003-48, *218-W-4C Sampling and Analysis Plan*
- DOE/RL-2004-32, *218-E-12B Burial Ground Sampling and Analysis Plan*
- DOE/RL-2004-70, *218-W-4B Burial Ground Sampling and Analysis Plan*
- DOE/RL-2004-71, *218-W-3A Burial Ground Sampling and Analysis Plan*

The following three-step process is followed to complete the sampling requirements:

- Step I of the SAP occurs prior to waste retrieval. Soil vapor samples are collected passively or through existing vent risers to determine volatile organic compound (VOC) levels. Based on the location of the highest levels of VOCs detected during field screening, biased soil vapor sampling locations are selected for laboratory analysis. Samples are generally collected at the base of the trench, near the bottom of the existing vent risers. Results of Step I are used to determine biased sampling sites for Step II.
- Step II is initiated post-retrieval. Soil vapor sampling is conducted along the edges of the trench bottoms. A direct-push technology is used in order to obtain vapor samples at varying depths from the bottom of the trench. In addition to direct-push sampling in areas known to have contained retrievably stored TRU waste, biased sampling is performed using results from Step I, visual observations, organic vapor monitoring, and radiological surveys on trench floor and vadose zone soils.
- Step III sampling will assess available data and characterize substrate soils. Additional sampling may be required based on sampling results from Steps I and II.

TPA (Ecology et al., 1989a) Milestone M-091-49 requires quarterly reporting of sampling results. Appendix H summarizes the results of sampling, as documented in quarterly reports. Appendix H also contains other details, including a summary of activities performed in support of M-091-49 sampling.

The results of this sampling were inconclusive due to the limits of field instrumentation. Mean and median results were not representative of the samples collected, did not determine the possibility of the presence of contamination, and did not help focus biased samples on areas with high contamination detection levels. Nondetections were reported as "undetected" (i.e., not detected above the practical quantitation factor) rather than zero.

One of the goals of this RFI/RI is to determine the extent of contaminant migration into the vadose zone below the solid waste trenches. The 200-SW-2 OU Project may take advantage of the opportunity to gather trench samples below areas where solid waste was disposed by targeting RSW-TRU retrieval areas. Direct-push locations for soil substrate and active soil gas samples may be selected in areas of retrieved RSW-TRU if such locations become available before fieldwork commences for the 200-SW-2 OU RFI/RI. Some locations are already available and will be considered during detailed fieldwork planning.

If the 200-SW-2 OU field investigation specified by this work plan precedes post-retrieval vapor sampling under TPA Milestone M-091-49, then the vapor sampling following retrieval of RSW-TRU in the 218-W-3A, 218-W-4B, and 218-E-12B Landfills will be performed under this work plan. Post-retrieval sampling for Milestone-M-091-49 will fulfill the requirements of both the M-091 Project and the 200-SW-2 OU field investigation, regardless of which project collects the data.

3.2.4 Soil Vapor Extraction Associated with the 200-SW-2 Operable Units

From 1992 to 2010, a soil vapor extraction (SVE) system in the western Inner Area removed a total of 79,750 kg of carbon tetrachloride from the vadose zone in the 200-PW-1 OU east and north of the 218-W-4C Landfill. The three primary carbon tetrachloride disposal sites are the 216-Z-9, 216-Z-1A, and 216-Z-18 subsurface infiltration facilities.

The following subsections provide brief summaries of the SVE activities in the western Inner Area, and Appendix H provides more detailed information.

3.2.4.1 Soil Vapor Extraction from the 218-W-4B Landfill

An SVE system operated at the 218-W-4B Landfill from December 2006 through July 2007 (SGW-37111, *Performance Evaluation Report for Soil Vapor Extraction Operations at the 200-PW-1 Operable Unit Carbon Tetrachloride Site, Fiscal Year 2007*). The system detected elevated concentrations of carbon tetrachloride in Trench 7 during the environmental release investigation performed to support retrieval operations for RSW. Operators moved vapor extraction points periodically from west to east as vapor extraction operations reduced the carbon tetrachloride concentrations and as waste retrieval progressed. The SVE system was removed to allow retrieval operations for the remaining waste at the end of Trench 7.

3.2.4.2 Soil Vapor Extraction from the 218-W-4C Landfill

An SVE system operated at the 218-W-4C Landfill from November 2003 through April 2004 (WMP-26178, *Performance Evaluation Report for Soil Vapor Extraction Operations at the 200-PW-1 Carbon Tetrachloride Site, Fiscal Year 2004*). Elevated concentrations of carbon tetrachloride were detected at the east end of Trench 4. The SVE system operated 2 to 7 hr/d to remove carbon tetrachloride from the trench and minimize the potential for a release to groundwater. As the carbon tetrachloride concentrations declined, SVE operations extended to 24 hr/d in January 2004. The SVE system removed approximately 11 kg of carbon tetrachloride during FY 2004. The system was removed to allow retrieval operations at the east end of Trench 4.

3.2.5 Groundwater

The groundwater program for the 200-SW-2 OU landfills includes a network of monitoring wells that is routinely sampled, as required by WAC 173-303-400(3), "Interim Status Facility Standards," and as defined by 40 CFR 265.92(d), "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Sampling and Analysis." The network is co-sampled for AEA surveillance as directed by DOE orders. These programs define the groundwater indicator parameter monitoring for groundwater quality detection monitoring at the 200-SW-2 OU landfills. As of February 2015, none of the 200-SW-2 OU landfills posed an impact to groundwater quality. In addition, several 200-SW-2 OU monitoring wells are co-sampled for CERCLA requirements, which track the migration of plumes extending from other sources beneath the various landfills.

3.2.5.1 RCRA Treatment, Storage, and Disposal Unit Groundwater Monitoring

An overview of the regulatory basis, location, and implementation of the RCRA TSD unit groundwater monitoring for the 200-SW-2 OU is provided below.

DOE issued a final rule (10 CFR 962, "Byproduct Material") in May 1987, stating that the hazardous waste components of mixed waste are subject to RCRA regulations. In November 1987, EPA authorized Ecology to regulate these hazardous waste components within the state of Washington (51 FR 24504, "EPA Clarification of Regulatory Authority Over Radioactive Mixed Waste"). In 1996, the Washington State Attorney General determined that the effective regulation date of mixed waste in Washington State was August 19, 1987. In May 1989, DOE, EPA, and Ecology signed the TPA (Ecology et al. 1989a), which established the roles and responsibilities of the agencies involved in regulating and controlling remedial restoration of the Hanford Site, including RCRA TSD unit groundwater monitoring for the 200-SW-2 OU.

Based on their proximity, there are four 200-SW-2 OU landfill TSD unit LLWMA groupings for purposes of groundwater monitoring (Figures 3-1 and 3-2). LLWMA-3 and LLWMA-4 are located in the western Inner Area within the 200-ZP-1 Groundwater OU (Figure 3-1). LLWMA-1 and LLWMA-2 are located in the eastern Inner Area within the 200-BP-5 Groundwater OU (Figure 3-2). A small part of

LLWMA-4 is technically within the 200-UP-1 Groundwater OU. As of February 2015, the RCRA groundwater monitoring network consists of 38 wells that are monitored on an annual or semiannual basis (Table 3-1).

RCRA groundwater monitoring is implemented by WAC 173-303-400 and 40 CFR 265, Subpart F, "Groundwater Monitoring." The regulatory requirements of WAC 173-303-400 are applicable to the seven TSD unit landfills because they are located within the boundaries of the 200-SW-2 OU.

As of February 2015, the following RCRA groundwater monitoring plans identify the requirements for detection monitoring at the applicable 200-SW-2 OU landfills (Appendix F contains a copy of each):

- **LLWMA-1:** DOE/RL-2009-75, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-1*
- **LLWMA-2:** DOE/RL-2009-76, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-2*
- **LLWMA-3:** DOE/RL-2009-68, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-3*
- **LLWMA-4:** DOE/RL-2009-69, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-4*

DOE periodically revises the interim RCRA groundwater monitoring plans to reflect changing groundwater conditions. The plans are updated as needed, and a final permit status monitoring plan is expected to replace these interim plans upon agreement and completion of the conditions of *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste* (also referred to as the Hanford RCRA Permit).

The RCRA interim status regulations require semiannual comparisons of upgradient and downgradient groundwater results to determine whether the TSD units have adversely affected groundwater quality. The comparisons include four contaminant indicator parameters: pH, specific conductance, total organic carbon (TOC), and total organic halides. Although certain indicator parameters have exceeded the statistical measurements for a significant increase during the history of interim status detection monitoring, further assessment has not found evidence of a dangerous waste constituents associated with the burial grounds. Site-specific information for each of the sites follows.

In the eastern Inner Area, impact to groundwater beneath LLWMA-1 is from regional contamination defined by the 200-BP-5 OU (Figure 3-2); it is not associated with the overlying landfills. In 1999, DOE reported to Ecology the exceedance of specific conductance in well 299-E33-34. The elevated specific conductance level was determined to be from migration of BY Cribs plumes (DOE/RL-2011-118, *Hanford Site Groundwater Monitoring for 2011*). The most significant chemical contaminants identified were nitrate and cyanide (some of which may be contamination from the B-BX-BY Tank Farms and other nearby cribs). Relatively few regional chemical contaminant plumes affect the groundwater beneath LLWMA-2, located within the eastern Inner Area. Nitrate contamination has continued to exceed DWSs in several wells at LLWMA-1, but it continues to display characteristics of other source sites. Thus, subsequent elevated specific conductance levels at wells 299-E32-10 and 299-E33-34 have not and are not a cause for a change from interim status indicator evaluation groundwater monitoring. Another exceeded indicator parameter at LLWMA-1 was associated with TOC in 2012. TOC values exceeding the statistical measurements for a significant increase were localized at well 299-E33-265. The subsequent assessment found no dangerous waste constituents associated with the 218-E10 Burial Ground and directed the groundwater monitoring program to return to interim status detection monitoring as defined in DOE/RL-2009-75 (DOE/RL-2013-25, *First Determination RCRA Groundwater Quality Assessment Report for Low-Level Burial Grounds Low-Level Waste Management Area-1*).

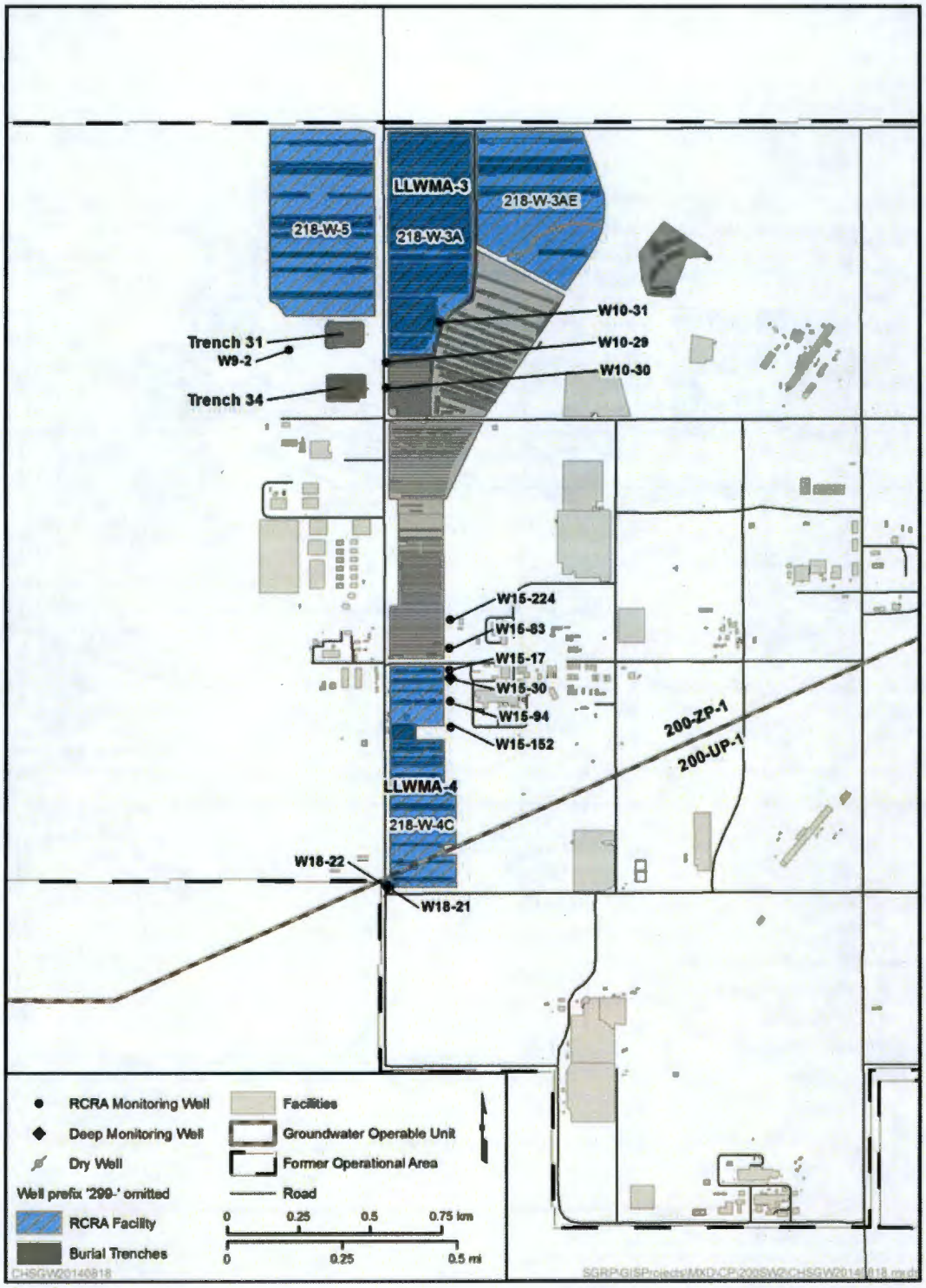

Figure 3-1. Western Inner Area RCRA TSD Unit Groundwater Network around 200-SW-2 OU Landfills

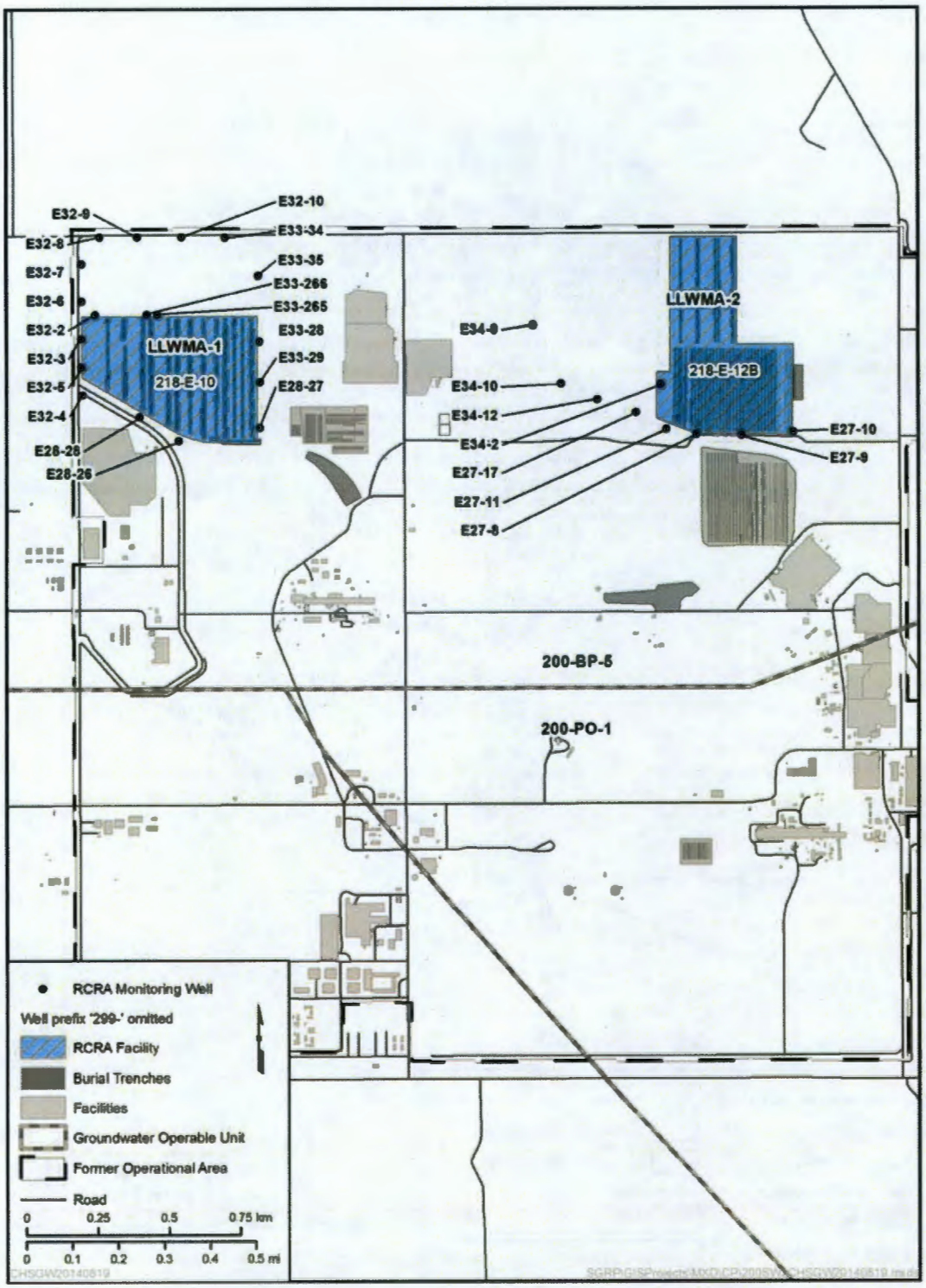

Figure 3-2. Eastern Inner Area RCRA TSD Unit Monitoring Network near 200-SW-2 OU Landfills

Table 3-1. Summary of RCRA Groundwater Monitoring Networks for the 200-SW-2 OU Landfills

LLWMA	Area	Landfill	Number of Monitoring Wells
LLWMA-1	Eastern Inner Area	218-E-10	18
LLWMA-2	Eastern Inner Area	218-E-12B	9
LLWMA-3	Western Inner Area	218-W-3A, 218-W-3AE, and 218-W-5	4
LLWMA-4	Western Inner Area	218-W-4B and 218-W-4C	7

LLWMA = low-level waste management area

At LLWMA-2, both specific conductance and TOC have exceeded statistical measurements for a significant increase. Specific conductance at wells 299-E34-9 and 299-E27-10 has been significantly greater than the other monitoring wells in the network. The elevated specific conductance at well 299-E34-9 was determined to be primarily associated with nitrate migration in the groundwater from the BY Cribs, as explained in 13-AMRP-0192, "Notification of Resource Conservation and Recovery Act Indicator Parameter Exceedance at Low-Level Waste Management Area 2," sent to Ecology on May 28, 2013. The reason that the BY Cribs were considered the source was the southeast flow direction change in 2011 and the signature of other contaminants associated with the BY Cribs. The other well associated with elevated specific conductance (299-E27-10) was also associated with elevated TOC. Because of the flow direction in this area and prior elevated levels of specific conductance and TOC at well 299-E34-7, a correlation to the assessment completed at well 299-E34-7 is representative of groundwater quality at well 299-E27-10. The assessment at well 299-E34-7 continued semiannually from 2000 to 2005 and included assessment of 40 CFR 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Appendix IX, "Ground-Water Monitoring List," dangerous waste constituents and hydrocarbons. The assessment ended in 2005 because well 299-E34-7 became sample dry due to the declining water table. PNNL-15670, *Hanford Site Groundwater Monitoring for Fiscal Year 2005*, concluded that dangerous waste constituents were not identified at well 299-E34-7. As a result, interim status detection monitoring continues at LLWMA-2.

For the western Inner Area sites, contamination from an upgradient source defined by the 200-ZP-1 OU impacts groundwater beneath much of LLWMA-3 (Figure 3-1). This contamination includes carbon tetrachloride, chloroform, TCE, and nitrate. A 1993 groundwater assessment for LLWMA-3 (WHC-SD-EN-EV-026, *Results of Groundwater Quality Assessment Program at Low-Level Waste Management Area 3 of the Low-Level Burial Grounds*) concluded that the contamination is from other upgradient sources and that LLWMA-3 has not contributed to groundwater contamination.

Regional VOC contamination affects LLWMA-4, as well as the underlying groundwater within the capture zone of the 200 West P&T. Carbon tetrachloride is the major contaminant in the plume, but chloroform, TCE, and perchloroethene also are present. An assessment performed for LLWMA-4 in 2009 regarding TOC exceeding statistical measurements for a significant increase at well 299-W15-224 (SGW-40211, *First Determination RCRA Groundwater Quality Assessment Plan for the Low-Level Burial Grounds Low-Level Waste Management Area-4*). The results of the assessment did not find dangerous waste/dangerous waste constituents in the groundwater originating from LLWMA-4, and monitoring returned to indicator evaluation monitoring, as reported in SGW-41903, *Groundwater Quality Assessment Plan for Low-Level Waste Management Area 4*.

3.2.5.2 CERCLA Groundwater Monitoring

The following documents are current groundwater monitoring plans for the associated CERCLA OUs below the 200-SW-2 OU landfills in the western and eastern Inner Areas:

- DOE/RL-2001-49, *Groundwater Sampling and Analysis Plan for the 200-BP-5 Operable Unit*
- DOE/RL-2007-31, *Remedial Investigation/Feasibility Study Work Plan for the 200-PO-1 Groundwater Operable Unit*
- DOE/RL-2009-115, *Performance Monitoring Plan for the 200-ZP-1 Groundwater Operable Unit Remedial Action*
- DOE/RL-2013-07, *200-UP-1 Groundwater Operable Unit Remedial Design/Remedial Action Work Plan*

3.2.5.3 Western Inner Area Groundwater

Two major groundwater OUs, 200-ZP-1 and 200-UP-1 (Figure 3-3), underlie the 200-SW-2 OU landfills located in the western Inner Area. Groundwater flow in the unconfined aquifer is primarily to the east-northeast in the western Inner Area, but it is influenced by the 200 West P&T and effluent discharges to the SALDS. Historical gradients have changed based on changes and elimination of wastewater disposal to the surface or vadose zone. Several plumes within these groundwater OUs originate from known liquid releases from waste process units or regional sources. The 200-ZP-1 OU includes the northern and central portions of the western Inner Area and the western portion of the 600 Area. Twelve solid waste landfills overlie the 200-ZP-1 OU (Figure 3-3): the 218-W-1, 218-W-1A, 218-W-2, 218-W-2A, 218-W-3, 218-W-3A, 218-W-3AE, 218-W-4A, and 218-W-4B Landfills; all but the southeast corner of the 218-W-4C Landfill; and the 218-W-5 and 218-W-11 Landfills.

Groundwater is monitored to assess the performance of the 200-ZP-1 OU final ROD 200 West P&T system for remediating 200-ZP-1 OU groundwater contaminants of concern. Data from facility-specific monitoring also are integrated into CERCLA groundwater investigations. The groundwater contamination plumes of interest in this area include carbon tetrachloride, TCE, nitrate, chromium, tritium, iodine-129, technetium-99, and uranium. Chloroform, dichloromethane, and chloromethane are also monitored as degradation products of carbon tetrachloride; vinyl chloride and cis-1,2-dichloroethene are monitored as degradation products of TCE; and chloride is monitored to evaluate natural attenuation of chlorinated solvents.

Carbon tetrachloride is the primary groundwater COC. The plume originated from discharges to the Z Cribs and trenches (e.g., 216-Z-9 Trench, 216-Z-1A Tile Field, and 216-Z-18 Crib) and has moved north and east of these waste sites.

The 200-UP-1 OU interest area addresses groundwater contaminant plumes beneath the southern third of the western Inner Area and adjacent portions of the surrounding 600 Area (Figure 3-3). The primary sources of groundwater contamination in the OU are waste sites associated with operations at the REDOX Plant for plutonium/uranium separation and operation of the U Plant for uranium recovery. Technetium-99, uranium, tritium, iodine-129, nitrate, chromium (total and hexavalent), and carbon tetrachloride form extensive groundwater plumes in the area. These contaminants originated from operations in this area, except for carbon tetrachloride, which has migrated into the 200-UP-1 OU from the 200-ZP-1 OU. Only the southeast corner of the 218-W-4C Landfill overlies the 200-UP-1 OU, and there is no evidence that contamination from the waste disposed in the landfill has migrated and directly affected groundwater.

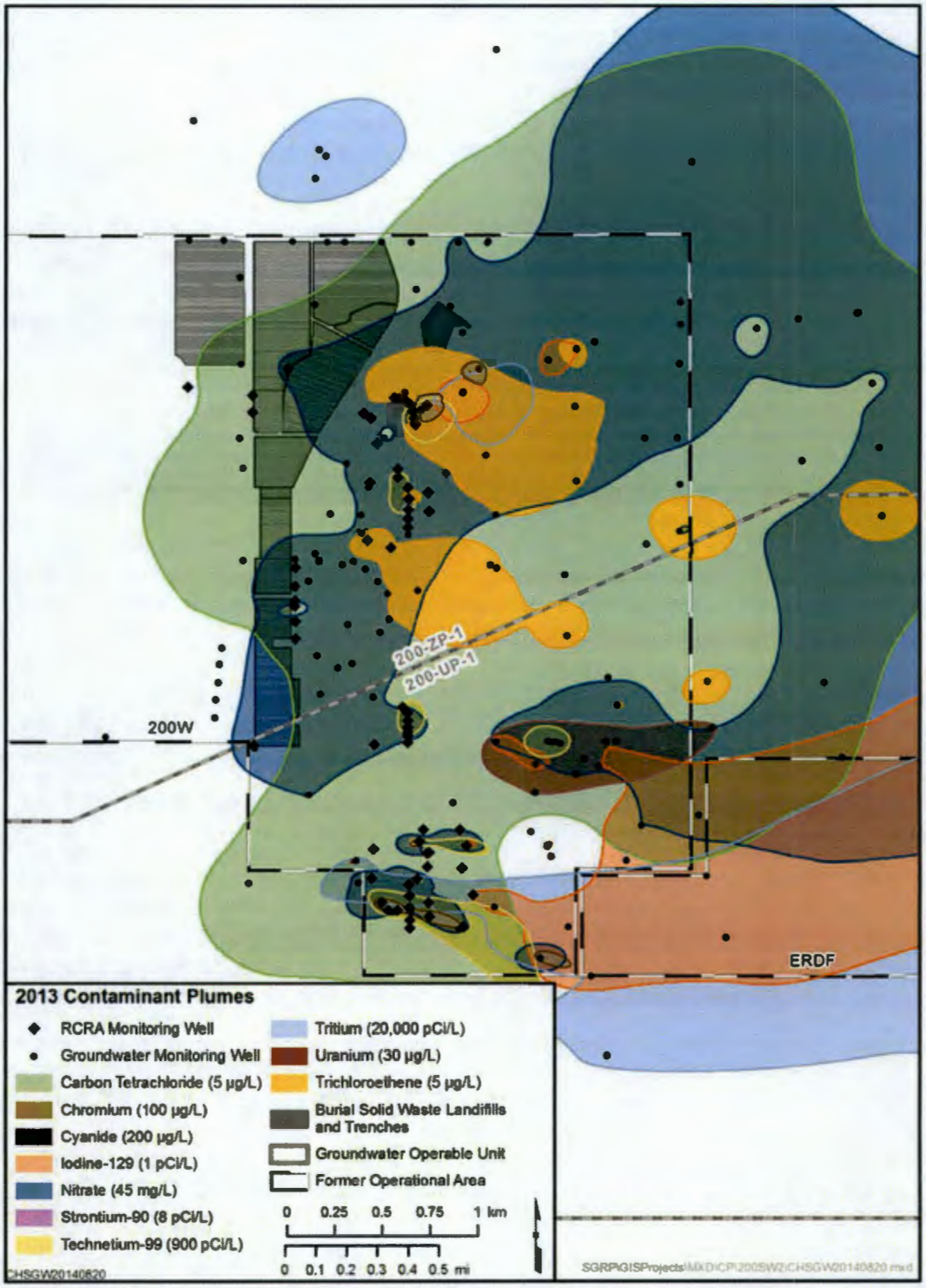

Figure 3-3. Western Inner Area Groundwater Monitoring Network and Major Known Plumes

An interim remedial action P&T system operated in the central part of the 216-U-1 and 216-U-2 Cribs to address technetium-99 and uranium plumes between 1994 and early 2011, with a 1-year shutdown in 2006 to perform a rebound study. Operations ceased in March 2011 when interim RAOs were achieved and flow rates from extraction wells were too low to justify continued pumping. A groundwater extraction system installed in 2011 remediates the high technetium-99 plume under the S-SX Tank Farms waste management area (WMA S-SX) via the 200 West P&T. In September 2012, the Tri-Parties signed the 200-UP-1 OU ROD (EPA et al., 2012).

The selected interim remedy for the 200-UP-1 OU includes a combination of groundwater extraction and treatment using P&T technology, MNA, hydraulic containment, and ICs. The process for designing the remedies in the ROD is described in DOE/RL-2013-07. The document includes the design approach for a new U Plant area P&T system, in addition to the current WMA S-SX groundwater extraction system.

3.2.5.4 Eastern Inner Area Groundwater

The 200-SW-2 OU landfills in the eastern Inner Area overlie the 200-BP-5 OU. A number of groundwater plumes exist within the OU and extend beneath both LLWMA-1 and LLWMA-2 (Figure 3-4). The plumes within the 200-BP-5 OU originated from known releases, as discussed in DOE/RL-2014-32. None of these plumes are attributed to releases originating from the landfills.

The 200-BP-5 OU addresses groundwater contaminant plumes beneath the northern half of the eastern Inner Area and adjacent portions of the surrounding 600 Area. This OU extends to Gable Gap and includes several RCRA TSD units and CERCLA past-practice units in the northern portion of the eastern Inner Area. Technetium-99 and uranium are significant COCs in the 200-BP-5 OU, although uranium has a more limited distribution area. Other contaminants include nitrate, iodine-129, cyanide, strontium-90, tritium, cesium-137, and plutonium-239/240. Groundwater is monitored in this OU to define the regional extent of technetium-99, uranium, and other significant contaminants across the OU, as well as the local extent of contamination associated with specific RCRA TSD units in the area.

Eleven 200-SW-2 OU landfills overlie the 200-BP-5 OU: 218-E-2, 218-E-2A, 218-E-4, 218-E-5, 218-E-5A, 218-E-8, 218-E-9, 218-E-10, 218-E-12A, 218-E-12B, and 218-C-9.

Nitrate, iodine-129, technetium-99, and uranium are the most extensive groundwater plumes in the 200-BP-5 OU. These contaminants emanate mainly from local sources, except for iodine-129, which predominantly migrated into the OU from the adjacent 200-PO-1 OU in the late 1980s and early 1990s. Other contaminants with smaller areal extent within the 200-BP-5 OU include cyanide, strontium-90, tritium, cesium-137, and plutonium-239/240.

Major changes occurred in 2011 for groundwater flow within the unconfined aquifer in the southern part of 200-BP-5 OU, south of Gable Mountain. The flow direction completed an 180-degree flow direction change in July 2011 due to ongoing water table declines in the eastern Inner Area and the temporal Columbia River stages. Since July 2011, the flow direction has maintained a mostly south-southeastern flow from the southern part of Gable Gap into the northwestern quarter of the eastern Inner Area. No significant changes in distribution of the 10 contaminant plumes within the 200-BP-5 OU were observed during the monitoring period from October 2012 through December 2013. Nitrate continued to be the most extensive plume in the OU during 2013. Although the contaminant distribution did not show significant change, there was some incremental degradation of water quality observed locally near selected sites. One example is significant increases in nitrate and cyanide along the western side of LLWMA-2 during the reporting period. These increases were determined to be associated with the flow direction change and subsequent migration of contaminants from the BY Cribs. Additional information is provided in DOE/RL-2014-32.

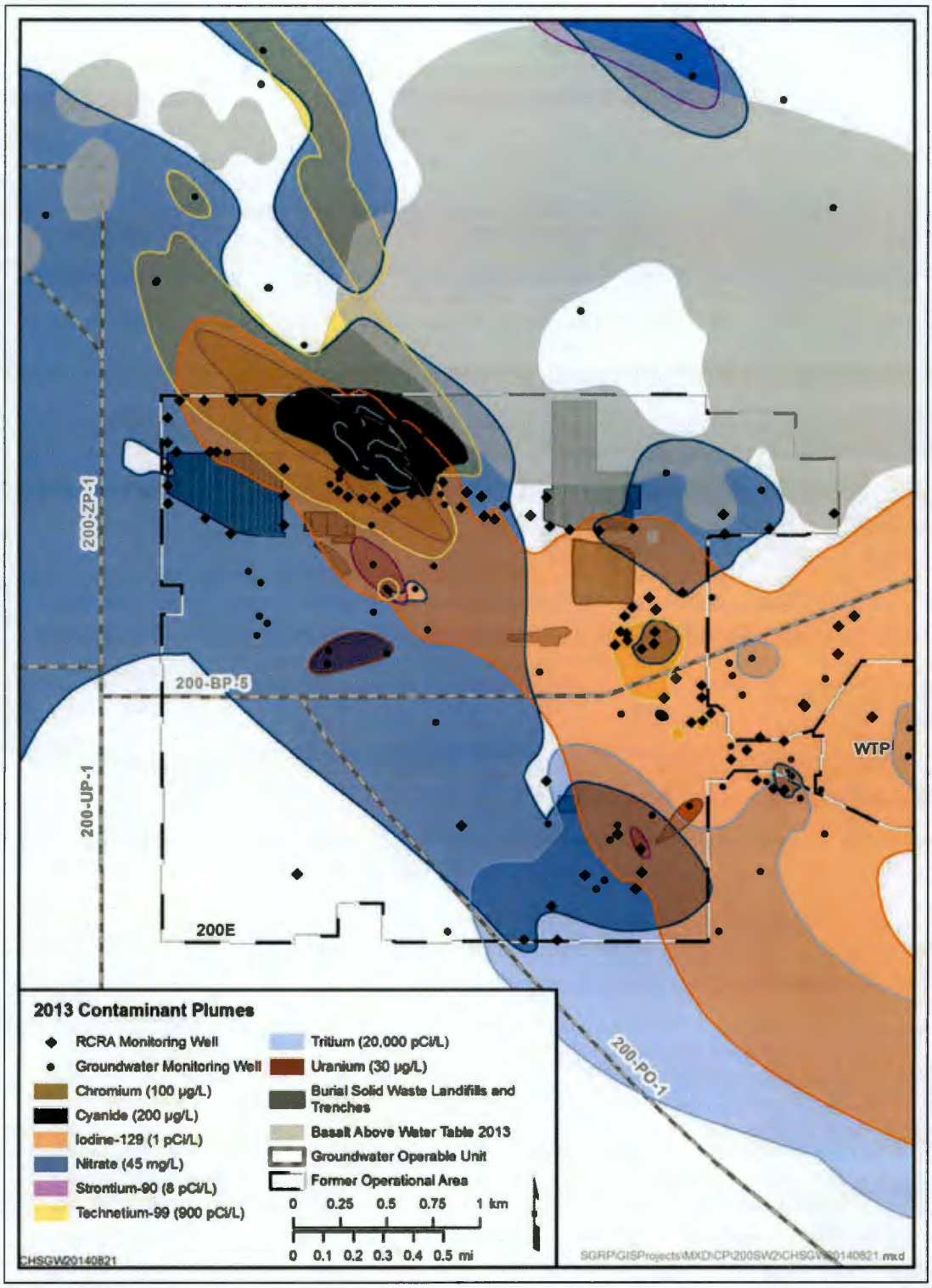

Figure 3-4. Eastern Inner Area Groundwater Monitoring Network and Major Known Plumes

The 200-PO-1 Groundwater OU interest area addresses groundwater contaminant plumes that have originated beneath the southern portion of the eastern Inner Area (Figure 3-4). Only the 218-E-1 Landfill overlies the 200-PO-1 Groundwater OU. The OU boundary extends southeastward to the Columbia River because of regional tritium and iodine-129 plumes that have migrated off the Central Plateau. Other COPCs include nitrate and, in more localized areas, strontium-90, uranium, and technetium-99.

Groundwater monitoring results continue to show that tritium and iodine-129 are the major plumes extending from the eastern Inner Area into the remainder of the 200-PO-1 Groundwater OU; and also that small, more isolated plumes (including strontium-90 and uranium) are located near the PUREX Cribs. Additionally, there is a small technetium-99 plume located near WMA A-AX. All of these groundwater contaminants continue to exceed their respective DWSs. Additional information, including a discussion of other contaminants detected in the groundwater, is contained in DOE/RL-2014-32.

3.3 Identification of Contaminants of Potential Concern

A set of radiological and organic COPCs that may be present in the 200-SW-2 OU landfills was developed based on the following documents:

- 200 Area plant operations as identified in various DQO documents for the 200 Area OUs, including the 200-CW-1, 200-CS-1, 200-CW-5, 200-LW-1, 200-LW-2, 200-MW-1, 200-PW-1, 200-PW-2, 200-PW-4, 200-TW-1, and 200-TW-2 OUs
- The ERA DQOs for the 200 Areas (WMP-20570, *Central Plateau Terrestrial Ecological Risk Assessment Data Quality Objectives Summary Report – Phase I*; WMP-25493, *Central Plateau Terrestrial Ecological Risk Assessment Data Quality Objectives Summary Report-Phase II*); WMP-29253, *Central Plateau Terrestrial Ecological Risk Assessment Data Quality Objectives Summary Report – Phase III*)
- DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*

To ensure that contaminants resulting from waste in other Hanford Site areas (e.g., 100 and 300 Areas) and offsite are represented, the COPC input list also included potential contaminants listed in the following information sources:

- Nonradiological constituents in containers with a "dangerous waste" flag set in SWITS for landfills that are within scope
- Radiological constituents listed in all containers in SWITS for in-scope landfills
- Nonradiological constituents listed in WAC 173-340-900, "Tables," Table 749-3 ("Ecological Indicator Soil Concentrations (mg/kg) for Protection of Terrestrial Plants and Animals")

The COPC input list consisted of more than 800 potential contaminants. Radionuclides were eliminated from the list if they had short half-lives, were naturally occurring, or were produced only in small quantities. Chemicals were eliminated if they were used in small quantities, were nonhazardous, or are unable to exist in conditions in the landfills (i.e., exist in a gaseous state or naturally degrade very quickly.)

Table 3-2 lists the COPCs for the 200-SW-2 OU waste sites.

Table 3-2. 200-SW-2 OU Landfills COPC List

Radionuclides					
^{241}Am	^{244}Cm	^{63}Ni	^{241}Pu	^{228}Th	^{3}H
^{14}C	^{152}Eu	^{237}Np	^{79}Se	^{230}Th	$^{233/234}U$
^{137}Cs	^{154}Eu	^{238}Pu	^{90}Sr	^{232}Th	^{235}U
^{60}Co	^{155}Eu	$^{239/240}Pu$	^{99}Tc	^{234}Th	^{238}U
^{243}Cm	^{129}I				
Metals					
Aluminum - Al	Boron – B	Lithium – Li	Silver – Ag		
Antimony – Sb	Cadmium – Cd	Manganese – Mn	Strontium – Sr		
Arsenic – As	Chromium – Cr	Mercury – Hg	Thallium – Tl		
Barium – Ba	Cobalt – Co	Molybdenum – Mo	Uranium – U		
Beryllium – Be	Copper – Cu	Nickel – Ni	Vanadium – V		
Bismuth – Bi	Lead – Pb	Selenium – Se	Zinc – Zn		
Anions					
Fluoride – F^-	Nitrate – NO_3^-	Sulfate – SO_4^{2-}	Phosphate – PO_4^{3-}		
Nitrite – NO_2^-	Chloride – Cl^-	Bromide – Br^-			
Other					
Ammonium – NH^{4+} (pH also to be measured)	Asbestos	Kerosene	Cyanide – CN^-		
Volatile Organics					
1,1,1-Trichloroethane	2-Nitropropane	cis-1,2-Dichloroethene	Tetrachloroethene		
1,1,2,2-Tetrachloroethane	4-Methyl-2-pentanone	Diethyl ether	Toluene		
1,1,1,2-Tetrachloroethane	Acetone	Ethyl acetate	trans-1,2-Dichloroethene		
1,1,2-Trichloro-1,2,2-trifluoroethane	Acetonitrile	Ethylbenzene	trans-1,3-Dichloropropene		
1,1,2-Trichloroethane	Benzene	Isobutanol	Trichloroethene		
1,1-Dichloroethene	Carbon disulfide	Methanol	Trichlorofluoromethane		
1,1-Dichloroethane	Carbon tetrachloride	Methylene chloride	Vinyl chloride		
1,2-Dichloroethane	Chlorobenzene	n-Butyl alcohol (1-butanol)	Xylenes (total)		
2-Butanone	Chloroform				

Table 3-2. 200-SW-2 OU Landfills COPC List

Semivolatile Organics			
1,2,4-Trichlorobenzene	Acenaphthene	Di-n-octylphthalate	N-nitroso-di-n-propylamine
2,4,5-Trichlorophenol	Benzo(a) anthracene	Fluoranthene	Naphthalene
2,4,6-Trichlorophenol	Benzo(a)pyrene	Hexachlorobenzene	n-Nitrosomorpholine
2,4-Dinitrotoluene	Benzo(b)fluoranthene	Hexachlorobutadiene	o-Dichlorobenzene
2-Chlorophenol	Benzo(k)fluoranthene	Di-n-butylphthalate	o-Nitrophenol
2-Ethoxyethanol	Bis(2-ethylhexyl) phthalate	Dibenz(a,h)anthracene	Pentachlorophenol
2-Methylphenol (o-cresol)	Butylbenzylphthalate	Hexachloroethane	Pyrene
3+4-Methylphenol (m+p-cresol)	Chrysene	Indeno(1,2,3-d)pyrene	Pyridine
4-Chloro-3-methylphenol (p-Chloro-m-cresol)	Cyclohexanone	Nitrobenzene	Tributyl phosphate
Pesticides			
Aldrin	Alpha-BHC	Gamma-BHC (Lindane)	Endrin
4-4'-DDT	Beta-BHC	Chlordane	Heptachlor
4-4'-DDD	Delta-BHC	Dieldrin	Heptachlor epoxide
4-4'-DDE			
Aroclors (Polychlorinated Biphenyls)			
Aroclor 1016	Aroclor 1232	Aroclor 1248	Aroclor 1260
Aroclor 1221	Aroclor 1242	Aroclor 1254	

3.4 Land and Groundwater Use

This section describes the current and future land use and groundwater use for the Inner Area, consistent with the Central Plateau cleanup completion strategy, the Inner Area cleanup principles (see Section 1.3.2 in Chapter 1), and the 200-ZP-1 OU ROD (EPA et al., 2008). Reasonably anticipated future land use for the Inner Area is industrial. It is recognized that some areas are dedicated to long-term waste management; the Tri-Parties anticipate that these waste units will be managed in perpetuity. The Tri-Parties have defined the smallest practical area on the Central Plateau for waste management as the Inner Area. Land use and groundwater use will be consistent with the 200-WA-1 and 200-EA-1 OU BRAs.

Groundwater beneath the Central Plateau is currently contaminated and undergoing active remediation; withdrawal is prohibited as a result of ICs emplaced by DOE. Under current Hanford Site use conditions, there are no complete human or ecological exposure pathways, except when groundwater discharges to the Columbia River, which is located few miles downgradient. Furthermore, regardless of land-use designations for surface soils, groundwater within the Central Plateau is not anticipated to become a future source of drinking water until cleanup criteria are met and groundwater is restored to its highest beneficial use.

3.4.1 Current Land Use

The current land-use activities in the Inner Area are industrial. Several waste management facilities continue to operate on the Central Plateau, including permanent waste disposal facilities such as the ERDF, LLBGs, and mixed waste trenches permitted by RCRA. Construction of tank waste treatment facilities on the Central Plateau began in 2002. The IDF is the planned disposal location for the vitrified low-activity tank waste. The U.S. Department of the Navy uses Trench 94, an active TSD unit in 218-E-12B. In addition, US Ecology, Inc. operates a commercial LLW disposal facility on a 40 ha (100 ac) tract of land leased to Washington State (located in the Inner Area).

3.4.2 Reasonably Anticipated Future Land Use

The reasonably anticipated future land-use designation for the portion of the Central Plateau where the 200-SW-2 OU sites are located (in the Inner Area) is industrial (exclusive).

DOE worked with cooperating agencies for several years to define land-use goals for the Hanford Site. The cooperating agencies and stakeholders included the National Park Service, Tribal Nations, the states of Washington and Oregon, local/county and city governments, economic and business development interests, environmental groups, and agricultural interests. A 1992 report (Drummond, 1992, *The Future for Hanford: Uses and Cleanup, The Final Report of the Hanford Future Site Uses Working Group*) was an early product of the efforts to develop land-use assumptions. The report recognized that the Central Plateau would be used for waste management activities for the foreseeable future. Following issuance of the report, DOE issued DOE/EIS-0222F, *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (HCP EIS) and associated ROD (64 FR 61615, "Record of Decision: Hanford Comprehensive Land-Use Plan Environmental Impact Statement (HCP EIS)") in 1999, and a supplement analysis (DOE/EIS-0222-SA-01, *Supplement Analysis: Hanford Comprehensive Land-Use Plan Environmental Impact Statement*) in 2008.

The HCP EIS (DOE/EIS-0222F) analyzed the potential environmental impacts of alternative land-use plans for the Hanford Site and considered the land-use implications of ongoing and proposed activities. Under the preferred land-use alternative selected in the HCP EIS ROD (64 FR 61615), the Central Plateau was designated for industrial exclusive use, defined as "areas suitable and desirable for management of hazardous, dangerous, radioactive, nonradioactive wastes, and related activities." The 2008 supplement analysis (DOE/EIS-0222-SA-01) reconfirmed the land-use designations in the HCP EIS and clarified that the comprehensive land-use plan will remain in effect as long as DOE retains legal control of some portion of the Hanford Site, which is expected to be longer than 50 years.

The area designated as the Central Plateau in the Drummond (1992) report and the HCP EIS (DOE/EIS-0222F) is only a portion of the area now commonly known as the Central Plateau. The current 195 km^2 (75 mi^2) area Central Plateau also encompasses a portion of the land known in previous documents as "all other areas," with a designated land use of conservation (mining). The Inner Area portion of the Central Plateau (described in Section 1.3 in Chapter 1 of this work plan) is within the area designated for industrial/industrial exclusive land use. At approximately 25 km^2 (10 mi^2), the Inner Area covers about one-half of the industrial exclusive area and is defined by DOE as the final footprint area of the Hanford Site that will be required for permanent waste management and containment of residual contamination.

3.4.3 Regional Land Use

Communities in the region of the Hanford Site consist of the incorporated cities of Richland, West Richland, Kennewick, Pasco, and numerous other smaller communities within Benton and Franklin counties. No residences are located on the Hanford Site. The inhabited residences nearest to the Central Plateau are farmhouses on land approximately 16 km (10 mi) north, across the Columbia River. The city of Richland corporate boundary is approximately 27 km (17 mi) to the south (PNNL-6415, *Hanford Site National Environmental Policy Act (NEPA) Characterization*).

3.4.4 Groundwater Use

The groundwater underlying the Central Plateau is contaminated and is not currently withdrawn for beneficial uses. Groundwater wells are routinely used on the Central Plateau to measure or monitor groundwater contaminants and groundwater conditions, and to support groundwater P&T systems. Several wells are also available to supply emergency cooling water to facilities, if needed. Groundwater beneath the Central Plateau is not anticipated to become a future source of drinking water until cleanup criteria are met. DOE's goal is to restore Central Plateau groundwater to beneficial use, unless restoration is determined to be technically impracticable.

3.5 Potential Applicable or Relevant and Appropriate Requirements

CERCLA Section 121, "Cleanup Standards" (as amended), requires, in part, that any applicable or relevant and appropriate standard, requirement, criterion, or limitation promulgated under any federal environmental law, or any more stringent state requirement promulgated pursuant to a state environmental statute, be met (or a waiver justified) for any hazardous substance, pollutant, or contaminant that will remain onsite after completion of the remedial/removal action. CERCLA guidance (EPA/540/G-89/006, *CERCLA Compliance with Other Laws Manual: Interim Final*; EPA/540/G-89/004) forms the basis for the applicable or relevant and appropriate requirement (ARAR) identification process.

The 200-SW-2 OU waste site remediation will be in accordance with a CERCLA decision document. Any remedial/removal action(s) at the individual waste sites will be required to meet ARARs. In many cases, the ARARs form the basis for the PRGs to which contaminants must be remediated to protect HHE. The ARARs also define or restrict how specific requirements of a remedial/removal alternative can be implemented based on the nature of the activity or the location of the site. This work plan describes the potential ARARs, and the potential ARARs are further defined in the FS analysis of alternatives.

3.5.1 Evaluation Process for Potential Applicable or Relevant and Appropriate Requirements

The potential ARAR evaluation prepared for this work plan was conducted in accordance with the NCP (40 CFR 300.430(f)(1)(ii)(B)(2), "Remedial Investigation/Feasibility Study and Selection of Remedy"). Under CERCLA, ARARs consist of two sets of requirements: (1) those promulgated substantive standards that would be applicable requirements if the remediation were not being conducted under authority of CERCLA (CERCLA response actions are exempt from permitting requirements by authority of Section 121(e)(1), "Permits and Enforcement"), and (2) those substantive standards that are relevant and appropriate requirements of promulgated environmental regulations.

An "applicable" requirement at the Hanford Site is an environmental requirement that DOE would have to comply with by law if the same action were being undertaken apart from CERCLA authority. All jurisdictional prerequisites of the requirement must be met in order for the requirement to be applicable, including specific application to federal agencies (through a waiver of federal sovereign immunity).

"Relevant and appropriate" requirements refer to those environmental requirements, such as cleanup standards, that address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site (40 CFR 300.400(g)(2), "General"). A requirement that is relevant and appropriate may not meet one or more jurisdictional prerequisites for applicability but it still makes sense at the site, given the circumstances of the site and the release. In evaluating the relevance and appropriateness of a requirement, the following eight comparison factors in 40 CFR 300.400(g)(2) are considered:

1. The purpose of the requirement and the purpose of the CERCLA action.
2. The medium regulated or affected by the requirement and the medium contaminated or affected at the CERCLA site.
3. The substances regulated by the requirement and the substances found at the CERCLA site.
4. The actions or activities regulated by the requirement and the remedial/removal action contemplated at the CERCLA site.
5. Any variances, waivers, or exemptions of the requirement and their availability for the circumstances at the CERCLA site.
6. The type of place regulated and the type of place affected by the release or CERCLA action.
7. The type and size of structure or facility regulated and the type and size of structure or facility affected by the release or contemplated by the CERCLA action.
8. Any consideration of use or potential use of affected resources in the requirement and the use or potential use of the affected resource at the CERCLA site.

In addition, potential ARAR evaluations determine whether the requirements fall into one of three categories: chemical-specific, location-specific, or action-specific. The definitions of the requirement categories are as follows:

- Chemical-specific requirements are usually health-based or risk-based numerical values or methodologies that when applied to site-specific conditions result in the establishment of public and worker safety levels and site cleanup levels.
- Location-specific requirements are restrictions placed on the concentration of dangerous substances or the conduct of activities solely because they occur in special geographic areas.
- Action-specific requirements are usually technology-based or activity-based requirements or limitations triggered by the remedial/removal actions performed at the site.

In summary, an environmental requirement is applicable if the specific terms or jurisdictional prerequisites of a law or regulation directly address the circumstances at the site. If not applicable, an environmental requirement may nevertheless be relevant and appropriate if (1) circumstances at the site are, based on best professional judgment, sufficiently similar to the problems or situations regulated by the requirement; and (2) the use of the requirement is well suited to the site. Only the substantive requirements (e.g., use of control/containment equipment or compliance with numerical standards) associated with ARARs apply to CERCLA onsite activities. ARARs associated with administrative requirements, such as permitting, are not applicable to CERCLA onsite activities (CERCLA Section 121(e)(1)). This CERCLA permitting exemption will extend to remedial/removal activities conducted at the 200-SW-2 OU.

CERCLA also provides for the identification of "to be considered" (TBC) information. TBC information is defined as nonpromulgated advisories or guidance issued by federal or state governments that are not legally binding and do not have the status of potential ARARs. In some circumstances, TBCs (along with ARARs) determine the remedial/removal action necessary for protection of HHE. TBC information generally complements ARARs in the determination of protectiveness at a site or in the implementation of certain actions. For example, because soil cleanup standards do not exist for all contaminants, screening levels, which would be TBCs, may be helpful in defining appropriate remedial/removal action goals.

3.5.2 Waivers from Applicable or Relevant and Appropriate Requirements

CERCLA Section 121 identifies six circumstances in which ARARs for onsite remedial/removal actions may be waived:

- The remedial/removal action selected is only a part of a total remedial/removal action (e.g., an interim action), and the final remedy will attain the ARAR upon its completion.
- Compliance with the ARAR will result in a greater risk to HHE than alternative options.
- Compliance with the ARAR is technically impracticable from an engineering perspective.
- An alternative remedial/removal action will attain an equivalent standard of performance using another method or approach.
- The ARAR is a state requirement that the state has not consistently applied (or demonstrated the intent to apply consistently) in similar circumstances.
- Compliance with the ARAR will not provide a balance between protecting HHE and the need to allocate funds for other response actions.

After remedy implementation (post-ROD), if performance monitoring data indicate that attaining the ARARs is technically impracticable from an engineering perspective, then an evaluation may be conducted to assess whether a technical impracticability (TI) waiver from one or more chemical-specific ARARs is warranted. TI waivers only apply to that portion of the groundwater contaminant plume for which restoration to ARARs is determined to be technical impracticable.

3.5.3 Potential Applicable or Relevant and Appropriate Requirements for the 200-SW-2 Operable Unit

Table 3-3 lists potential ARARs and TBCs for the 200-SW-2 OU. These ARARs and TBCs will be subject to further review and final presentation in the RI/FS report.

3.6 Conceptual Exposure Models for Fate and Transport Evaluation

This section presents a qualitative understanding of contaminant fate and transport, as well as risk to receptors for 200-SW-2 OU waste sites. A discussion of the exposure areas is also provided.

3.6.1 Exposure Pathways and Routes

The exposure pathways, exposure routes, exposure assumptions, and toxicity values that will be used for the human health exposure scenarios are described in Section 3.8.1. Human health risks will be assessed using an outdoor worker exposure scenario for the standard point of compliance (0 to 4.6 m [15 ft] bgs). For radiological contamination below 4.6 m (15 ft) bgs, direct contact risks for human health will be evaluated using a construction worker exposure scenario.

Table 3-3. Potential Federal and Washington State ARARs and TBC Materials for the 200-SW-2 OU

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
Groundwater					
***Safe Drinking Water Act of 1974* (Public Law 93-523, as amended; 42 USC 300f et seq.); 40 CFR 141, "National Primary Drinking Water Regulations"**					
40 CFR 141.61, "Maximum Contaminant Levels for Organic Contaminants" 40 CFR 141.50(b), "Maximum Contaminant Level Goals for Organic Contaminants"	Chemical	Establishes MCLs and MCLGs as criteria for groundwater and surface water that are or may be used for drinking water. The standards or goals are designed to protect human health from adverse effects of organic contaminants in the drinking water.	Groundwater underlying the 200-SW-2 OU contains contaminants that may require remediation; although groundwater is not currently used for drinking water, it is a potential drinking water source. The MCLs are used in groundwater protection calculations.	ARAR	Groundwater remediation and management activities (e.g., groundwater treatment, discharge of treated groundwater, in situ remediation of groundwater, or MNA).
40 CFR 141.62, "Maximum Contaminant Levels for Inorganic Contaminants" 40 CFR 141.51(b), "Maximum Contaminant Level Goals for Inorganic Contaminants"	Chemical	Establishes MCLs and MCLGs as criteria for groundwater and surface water that are or may be used for drinking water. The standards/goals are designed to protect human health from adverse effects of inorganic contaminants in the drinking water.	Groundwater underlying the 200-SW-2 OU contains contaminants that may require remediation; although groundwater is not currently used for drinking water, it is a potential drinking water source. The MCLs are used in groundwater protection calculations.	ARAR	Groundwater remediation and management (e.g., discharge of treated groundwater, in situ remediation of groundwater, or MNA).
40 CFR 141.66, "Maximum Contaminant Levels for Radionuclides"	Chemical	Establishes MCLs and MCLGs as criteria for groundwater and surface water that are or may be used for drinking water. The standards/goals are designed to protect human health from adverse effects of inorganic contaminants in the drinking water.	Groundwater underlying the 200-SW-2 OU contains contaminants that may require remediation; although groundwater is not currently used for drinking water, it is a potential drinking water source. The MCLs are used in groundwater protection calculations.	ARAR	Groundwater remediation and management (e.g., discharge of treated groundwater, in situ remediation of groundwater, or MNA).
"Hazardous Waste Cleanup -- Model Toxics Control Act" (RCW 70.105D, as amended); WAC 173-340, "Model Toxics Control Act—Cleanup"					
WAC 173-340-720(2), "Potable Groundwater Defined" WAC 73-340-720(4)(b)(i, iii)(A)&(B), "Method B Cleanup Levels for Potable Ground Water" WAC 173-340-720(7), "Adjustments to Cleanup Levels" WAC 173-340-720(8), "Points of Compliance" WAC 173-340-720(9)(b-f), "Compliance Monitoring"	Chemical	Groundwater cleanup levels are based on estimates of the highest beneficial use and the reasonable maximum exposure expected to occur under both current and potential future site use conditions. Method B equations (720-1 and 720-2) to calculate groundwater cleanup levels for noncarcinogens and carcinogens, respectively, only if "sufficiently protective, health-based criteria or standards have not been established under applicable state and federal laws." Groundwater cleanup levels are established at concentrations that do not directly or indirectly cause violations of surface water, sediments, soil, or air cleanup standards.	Groundwater underlying the 200-SW-2 OU contains contaminants that may require remediation; although groundwater is not currently used for drinking water, it is a potential drinking water source. The MCLs are used in groundwater protection calculations.	ARAR	Groundwater remediation and management (e.g., discharge of treated groundwater, in situ remediation of groundwater, or MNA).
"Water Well Construction" (RCW 18.104, as amended); WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"					
WAC 173-160-161, "How Shall Each Water Well Be Planned and Constructed?"	Action	Identifies well planning and construction requirements.	Groundwater monitoring and treatment wells and borings that may be installed.	ARAR	Investigative and remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.
WAC 173-160-171, "What Are the Requirements for the Location of the Well Site and Access to the Well?"	Action	Identifies the requirements for locating a well.	Groundwater monitoring and treatment wells and borings that may be installed.	ARAR	Investigative and remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.
WAC 173-160-181, "What Are the Requirements for Preserving the Natural Barriers to Ground Water Movement Between Aquifers?"	Action	Identifies the requirements for preserving natural barriers to groundwater movement between aquifers.	Groundwater monitoring and treatment wells and borings that may be installed.	ARAR	Investigative and remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.

Table 3-3. Potential Federal and Washington State ARARs and TBC Materials for the 200-SW-2 OU

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
WAC 173-160-400, "What Are the Minimum Standards for Resource Protection Wells and Geotechnical Soil Borings?"	Action	Identifies the minimum standards for resource protection wells and geotechnical soil borings.	Groundwater monitoring and treatment wells and borings that may be installed.	ARAR	Investigative and remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.
WAC 173-160-430, "What Are the Minimum Casing Standards?"	Action	Identifies the minimum casing standards.	Groundwater monitoring and treatment wells and borings that may be installed.	ARAR	Investigative and remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.
WAC 173-160-440, "What Are the Equipment Cleaning Standards?"	Action	Identifies the equipment cleaning standards.	Groundwater monitoring and treatment wells and borings that may be installed.	ARAR	Investigative and remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.
WAC 173-160-450, "What are the Well Sealing Requirements?"	Action	Identifies the well sealing requirements.	Groundwater monitoring and treatment wells and borings that may be installed.	ARAR	Investigative and remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.
WAC 173-160-460, "What is the Decommissioning Process for Resource Protection Wells?"	Action	Identifies the decommissioning process for resource protection wells.	Groundwater monitoring and treatment wells and borings that may be installed.	ARAR	Investigative and remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.
Soil and Vadose Zone					
"Hazardous Waste Cleanup -- Model Toxics Control Act" (RCW 70.105D, as amended); MTCA (WAC 173-340)					
WAC 173-340-745(5), "Soil Cleanup Standards for Industrial Properties" WAC 173-340-745(6), "Soil Cleanup Standards for Industrial Properties," "Adjustments"	Chemical	Rules set standards for degree of cleanup required by a remedial action where industrial land use represents the reasonable maximum exposure under both current and future site use conditions. Total excess cancer risk may not exceed 1×10^{-5} or a noncancer hazard index of 1 for chemical contaminants.	Soil in the 200-SW-2 OU contains contaminants that require remediation. The requirements corresponding to Method C soil cleanup levels will be used to calculate cleanup levels based on an industrial land use, which is different than the conservation/mining land use assigned to this area.	ARAR	Soil cleanup actions where concentration of hazardous substances in the soil exceed Method C cleanup levels.
WAC 173-340-440(9), "Institutional Controls," "Restrictive Covenants"	Chemical	Limits or prohibits activities that may interfere with the integrity of an interim action or cleanup action or that may result in exposure to hazardous substances at a site.	Institutional controls may be required for soil that does not meet the requirements for unlimited use and unrestricted exposure.	ARAR	Soil cleanup actions where concentration of hazardous substances in the soil exceed Method C cleanup levels.
OSWER Directive 9285.7-55, *Guidance for Developing Ecological Soil Screening Levels*	Chemical	Provides a set of risk-based soil screening levels (Eco-SSLs) for several soil contaminants that are of ecological concern for terrestrial plants and animals at hazardous waste sites. Also describes the process used to derive these levels and provides guidance for their use.	Soil in the 200-SW-2 OU contains contaminants that require remediation. Comparison to SSLs may be appropriate for defining potential COCs. The SSL comparison may also be appropriate to default to an Eco-SSL for COCs that lack corresponding published cleanup criteria in MTCA (WAC 173-340).	TBC	Soil cleanup actions to protect ecological receptors.
"Regional Screening Levels for Chemical Contaminants at Superfund Sites" (EPA, 2015a)	Chemical	Provides a set of risk-based screening levels; the regional screening levels provide tables of human health risk-based screening levels calculated using the latest toxicity values, default exposure assumptions, and physical and chemical properties. Risk-based screening levels may help determine whether levels of contamination found at CERCLA hazardous waste sites warrant further investigation or site cleanup, or whether no further investigation or action is required.	Target analytes detected in soil and vadose zone soil includes constituents that could pose risks to human health.	TBC	Assistance in the identification of areas, contaminants, and conditions that may require further remedial investigation.

Table 3-3. Potential Federal and Washington State ARARs and TBC Materials for the 200-SW-2 OU

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
WAC 173-340-747(3) through (8), "Deriving Soil Concentrations for Groundwater Protection"	Chemical	Establishes soil cleanup levels where industrial land use represents the reasonable maximum exposure under both current and future site use conditions. Cleanup standards require specification of the following: hazardous substance concentrations that protect HHE (cleanup levels), the location of the site where cleanup levels must be attained (points of compliance), and other regulatory requirements that apply to the cleanup action because of the type of action or location of the site. These requirements are specified in the applicable state and federal laws and are generally established in conjunction with the selection of a specific cleanup action.	Soil in the 200-SW-2 OU contains contaminants that require remediation.	ARAR	Soil cleanup actions where concentration of hazardous substances in the soil exceeds soil concentration for protection of groundwater.
WAC 173-340-7490, "Terrestrial Ecological Evaluation Procedures" WAC 173-340-7493, "Site-Specific Terrestrial Ecological Evaluation Procedures" WAC 173-340-7494, "Priority Contaminants of Ecological Concern"	Chemical	Defines goals and procedures for determining whether a release of hazardous substances to soil may pose a threat to the terrestrial environment. Characterizes existing or potential threats to terrestrial plants or animals exposed to hazardous substances in soil; and establishes site-specific cleanup standards for the protection of terrestrial plants and animals. Provides numeric concentrations of hazardous substances determined to persist, bioaccumulate, or are highly toxic to terrestrial ecological receptors. Concentrations listed in Table 749-2 (WAC 173-340-900, "Tables") are based on protection of wildlife for industrial and commercial land uses, and that are protective of plants and animals for other land uses.	Soil in the 200-SW-2 OU contains contaminants that require evaluation to determine whether they have the potential to cause significant adverse effects to terrestrial ecological receptors.	TBC	Soil remediation activities including containment and RTD may pose risks to terrestrial plants and animals.
Radionuclide ARAR Dose Compliance Concentrations for Superfund Sites					
OSWER Directive 9200.4-18, *Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination* EPA/540/R/99/006, *Radiation Risk Assessment at CERCLA Sites: Q&A* (OSWER Directive 9200.4-31P)	Chemical	This memorandum establishes protective cleanup levels in media for radioactive contamination at CERCLA sites. The EPA has determined that the dose limits established by the NRC in 62 FR 39058, "Radiological Criteria for License Termination" final rule (25 mrem/yr, which is equivalent to 5×10^{-4} increase lifetime risk) will not provide a protective basis for establishing PRGs under CERCLA. A dose of 15 mrem/yr effective dose (approximately equivalent to 3×10^{-4} increase in lifetime risk) is preferred as the maximum dose limit for humans. In the final guidance, EPA further clarifies that 15 mrem/yr is not a presumptive cleanup level under CERCLA. Rather, site decision makers should continue to use the CERCLA risk range when ARARs are not used to set cleanup levels. This is for several reasons, as using dose-based guidance would result in unnecessary inconsistency regarding how radiological and nonradiological (chemical) contaminants are addressed at CERCLA sites.	Soil in the 200-SW-2 OU contains radioactive contaminants that, if not remediated, could pose unacceptable risk to human health.	TBC	Development of cleanup levels of media, including air, water, soil, groundwater, and biota.
OSWER Directive 9200.4-17P, *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites*	Action	Provides the framework and appropriateness for using the MNA as a remedy component for organic and inorganic contaminants.	Soil in the 200-SW-2 OU contains contaminants that require remediation. The use of MNA as a remedy may be appropriate.	TBC	Soil remediation activities, including MNA.

Table 3-3. Potential Federal and Washington State ARARs and TBC Materials for the 200-SW-2 OU

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
Air					
"Washington Clean Air Act" (RCW 70.94, as amended): WAC 173-400, "General Regulations for Air Pollution Sources"					
WAC 173-400-040, "General Standards for Maximum Emissions"	Action	All sources and emissions units are required to meet the general emission standards unless a specific source standard is available. General standards apply to visible emissions, particulate fallout, fugitive emissions, odors, emission detrimental to health and property, sulfur dioxide, and fugitive dust.	Soil and/or groundwater remedial actions implemented in the 200-SW-2 OU have the potential to emit emission subject to these standards because hazardous contaminants detected include covered regulated hazardous air pollutants.	ARAR	Remedial actions that have the potential to release hazardous air emissions.
WAC 173-400-075(1), (3), and (6), "Emission Standards for Sources Emitting Hazardous Air Pollutants"	Action	Establishes national emission standards for hazardous air pollutants. Adopts, by reference, 40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," and appendices.	Soil and/or groundwater hazardous contaminants detected in the 200-SW-2 OU include covered regulated hazardous air pollutants.	ARAR	Actions performed at the 200-SW-2 OU that could result in the emission of hazardous air pollutants, including excavation activities implemented during the remedial action that have the potential to emit visible, particulate, fugitive, and hazardous air emissions and odors.
"Washington Clean Air Act" (RCW 70.94, as amended); WAC 173-460, "Controls for New Sources of Toxic Air Pollutants"					
WAC 173-460-060, "Control Technology Requirements" WAC 173-460-070, "Ambient Impact Requirement" WAC 173-460-150, "Table of ASIL, SQER and de minimis Emission Values"	Action	Establishes control of new sources emitting toxic air pollutants to prevent air pollution, reduce emissions to the extent reasonably possible, and maintain such levels of air quality as will protect human health and safety. Toxic air pollutants include carcinogens and noncarcinogens listed in WAC 173-460-150. Three major requirements of this regulation include (1) implementation of best available control technology for toxics, (2) quantification of toxic air pollutant emissions, and (3) health and safety protection demonstration.	Hazardous contaminants detected in soil and/or groundwater in the 200-SW-2 OU includes constituents that would constitute toxic air pollutants if released to the air.	ARAR	Groundwater and soil remediation activities such as treatment systems that have the potential to emit hazardous air emissions and that would be considered a new source.
"Washington Clean Air Act" (RCW 70.94, as amended); WAC 173-480, "Ambient Air Quality Standards and Emission Limits for Radionuclides"					
WAC 173-480-040, "Ambient Standard"	Action	Defines the maximum allowable level for radionuclides in the ambient air, which shall not cause a maximum accumulated dose equivalent of 25 mrem/yr to the whole body or 75 mrem/yr to any critical organ. However, ambient air standard under 40 CFR 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities"; and Subpart I, "National Emission Standards for Radionuclide Emissions from Federal Facilities Other Than Nuclear Regulatory Commission Licensees and Not Covered by Subpart H," are not to exceed amounts that result in an effective dose equivalent of 10 mrem/yr to any member of the public.	Hazardous contaminants detected in soil and groundwater in the 200-SW-2 OU include radionuclides that could be emitted to ambient air during remedial actions.	ARAR	Investigative and remediation activities that have the potential to emit radionuclides above maximum acceptable levels.
WAC 173-480-050(1), "General Standards for Maximum Permissible Emissions"	Action	At a minimum, all emission units shall make every reasonable effort to maintain radioactive materials in effluents to unrestricted areas ALARA. Control equipment of sites operating under ALARA shall be defined as reasonably available control technology and ALARA control technology.	The potential for fugitive and diffuse emissions due to excavation and related activities will require efforts to minimize those emissions.	ARAR	Investigative and remediation activities that have the potential to emit radionuclides above maximum acceptable levels.
WAC 173-480-060, "Emission Standards for New and Modified Emission Units"	Action	Requires that construction, installation, or establishment of a new air emission control units use best available radionuclide control technology.	Hazardous contaminants detected in soil and groundwater in the 200-SW-2 OU include radionuclides that could be emitted from air emission control units during remedial actions.	ARAR	Investigative and remediation activities that require air pollution control equipment and have the potential to emit radionuclides.

Table 3-3. Potential Federal and Washington State ARARs and TBC Materials for the 200-SW-2 OU

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
WAC 173-480-070(2), "Emission Monitoring and Compliance Procedures"	Action	Requires that radionuclide emissions shall be determined by calculating the dose to members of the public using Department of Health-approved sampling procedures at the point of maximum annual air concentration in an unrestricted area where any member of the public may be.	Hazardous contaminants detected in soil and groundwater in the 200-SW-2 OU include radionuclides that could be emitted to unrestricted areas during remedial actions.	ARAR	Investigative and remediation activities that have the potential to emit radionuclides to unrestricted areas above maximum acceptable levels.
"Nuclear Energy and Radiation" (RCW 70.98, as amended); WAC 246-247, "Radiation Protection -- Air Emissions"					
WAC 246-247-035(1)(a)(i) "Radiation Protection—Air Emissions," "National Standards Adopted by Reference for Sources of Radionuclide Emissions" (Adopts by reference, 40 CFR 61, Subpart A, "General Provisions")	Action	Requires the owner or operator of each stationary source of hazardous air pollutants subject to a national emission standard for a hazardous air pollutant to determine compliance with numerical emission limits in accordance with emission tests established in NESHAP (40 CFR 61.13, "Emission Tests and Waiver of Emission Tests"), or as otherwise specified in an individual subpart. Compliance with design, equipment, work practice, or operational standards shall be determined as specified in the individual subpart. Also, maintain and operate the source, including associated equipment for air pollution control, in a manner consistent with good air pollution control practice for minimizing emissions.	Hazardous radionuclide contaminants that would be subject to NESHAP air pollutant standards and resultant requirements have the potential to be detected in and emitted from structures, components, debris, soil, or groundwater involved in the remedial actions. Associated design, equipment, work practice, or equipment for radionuclide air pollution control may also be maintained and operated.	ARAR	Investigative and remedial actions involve stationary sources that provide a potential to emit regulated hazardous air pollutants (e.g., vapor extraction systems, decontamination stations, deactivation, demolition, or waste removal or storage activities). Associated design, equipment, work practice, or air emissions controls may be maintained and operated.
WAC 246-247-035(1)(a)(i), (ii), (iii), and (iv), "Radiation Protection—Air Emissions," "National Standards Adopted by Reference for Sources of Radionuclide Emissions" (Adopts by reference, 40 CFR 61, Subpart A, "General Provisions"; 40 CFR 61, Subpart H, "Radionuclides other than Radon"; and 40 CFR 61, Subpart I, "From Federal Facilities Other Than Nuclear Regulatory Commission Licensees and Not Covered by Subpart H")	Action	Requires the owner or operator to maintain and operate each monitoring system as specified in the applicable subpart, and in a manner consistent with good air pollution control practice for minimizing emissions. Approvals of alternatives to any monitoring requirements or procedures are obtained from the regulatory agency. Requires the owner or operator of each stationary source of hazardous air pollutants subject to a national emission standard for a hazardous air pollutant to determine compliance with numerical emission limits in accordance with emission tests established in NESHAP (40 CFR 61.13, "Emission Tests and Waiver of Emission Tests"), or as otherwise specified in an individual subpart. Compliance with design, equipment, work practice or operational standards shall be determined as specified in the individual subpart. Also, maintain and operate the source, including associated equipment for air pollution control, in a manner consistent with good air pollution control practice for minimizing emissions.	Hazardous radionuclide contaminants that would be subject to NESHAP air pollutant standards and resultant requirements have the potential to be detected in and emitted from structures, components, debris, soil, or groundwater involved in the remedial actions. The hazardous contaminants will be monitored as identified under each applicable NESHAP subpart.	ARAR	Investigative and remedial soil, air, and groundwater monitoring systems, and decontamination and stabilization of contaminated structures, treatment of sludge, and operation of exhausters and vacuums, that may produce airborne emissions of hazardous pollutants to residential areas.
WAC 246-247-040(3)-(4), "General Standards"	Action	Requires that emissions be controlled to ensure emission standards are not exceeded. Requires use of best available radionuclide control technology and as low as reasonably achievable control technology.	Hazardous contaminants detected in soil and groundwater in the 200-SW-2 OU reactor sites include radionuclides that could be emitted during remedial actions.	ARAR	Investigative and remediation activities (e.g., RTD, excavation, demolition, and ventilation).
WAC 246-247-075, "Monitoring, Testing and Quality Assurance"	Action	Establishes the monitoring, testing, and quality assurance requirements for radioactive air emissions. Emissions from nonpoint and fugitive sources of airborne radioactive material shall be measured. Measurement techniques may include, but are not limited to, sampling, calculation, smears, or other reasonable method for identifying emissions as determined by the lead agency.	Hazardous contaminants in the 200-SW-2 OU waste sites include radionuclides that could be emitted as airborne radioactive material during remedial actions.	ARAR	Investigative and remediation activities (e.g., RTD, excavation, demolition, and ventilation) that could be emitted from fugitive sources.

Table 3-3. Potential Federal and Washington State ARARs and TBC Materials for the 200-SW-2 OU

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
***Clean Air Act of 1990* and amendments; 40 CFR 60, "Standards of Performance for New Stationary Sources"; and 40 CFR 63, "National Emission Standards for Hazardous Air Pollutants for Source Categories"**					
40 CFR 60, Subpart IIII, "Standards of Performance for Stationary Compression Ignition Internal Combustion Engines" 40 CFR 60, Subpart JJJJ, "Standards of Performance for Stationary Spark Ignition Internal Combustion Engine" 40 CFR 63, Subpart ZZZZ, "National Emission Standard for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines"	Action	Establishes requirements for stationary engines.	This applies to all stationary engines.	ARAR	Anywhere a stationary engine is used at the facility.
***Clean Air Act of 1977* (42 USC 7401, et seq.); 40 CFR 61, "National Emission Standards for Hazardous Air Pollutants"**					
40 CFR 61.140, "Applicability" 40 CFR 61.145, "Standard for Demolition and Renovation"	Action	Defines regulated ACM and regulated removal and handling requirements. Specifies sampling, inspection, handling, and disposal requirements for regulated sources having the potential to emit asbestos. Specifically, no visible emissions are allowed during handling, packaging, and transport of ACM.	Encountering ACM (e.g., on pipelines, facilities, or buried asbestos) is possible during the remedial investigation phase or during remedial activities.	ARAR	Site investigation and remedial activities that include demolition or renovation and associated handling, packaging, and transportation of ACM including IDW management and disposal.
40 CFR 61.150, "Standard for Waste Disposal for Manufacturing, Fabricating, Demolition, Renovation, and Spraying Operations"	Action	Identifies requirements for the removal and disposal of asbestos from demolition and renovation activities.	Encountering ACM on pipelines, facilities, or buried asbestos is possible during the remedial investigation phase or during remedial activities.	ARAR	Site investigation and remedial activities that include demolition or renovation and associated handling, packaging, and transportation of ACM, including IDW management and disposal.
Solid Waste					
***Toxic Substances Control Act of 1976* (Pub L. 107-377, as amended; 15 USC Section 2605 et seq.); 40 CFR 761, "Polychlorinated Biphenyls Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions"**					
40 CFR 761.50(b)1, 2, 3, and 7, "Applicability," "PCB Waste" 40 CFR 761.50(c), "Applicability," "Storage for Disposal"	Action	Establishes general PCB disposal requirements for the storage and disposal of PCB wastes including liquid PCB wastes, PCB items, PCB remediation waste, PCB bulk product wastes, and PCB/radioactive wastes at concentrations greater than 50 ppm.	PCB wastes may be encountered and or generated during the remedial investigation and subsequent remediation of the 200-SW-2 OU.	ARAR	Soil excavation and remediation, equipment and debris handling and disposal, and IDW management and disposal.
40 CFR 761.60(a), "Disposal Requirements," "PCB Liquids" 40 CFR 761.60(b), "Disposal Requirements," "PCB Articles" 40 CFR 761.60(c), "Disposal Requirements," "PCB Containers"	Action	Establishes requirements applicable to the handling and disposal of PCB liquids, PCB articles, and PCB containers.	PCB liquids, articles, and/or containers may be encountered and or generated during the remedial actions for the 200-SW-2 OU.	ARAR	Equipment and debris handling, storage, and disposal; IDW management and disposal.
40 CFR 761.61, "PCB Remediation Waste"	Action	Provides cleanup and disposal options for PCB remediation waste based on the concentration at which the PCBs are found.	PCB remediation wastes may be encountered and or generated during the remedial actions for the 200-SW-2 OU.	ARAR	Soil remediation, RTD, and IDW management and disposal.

Table 3-3. Potential Federal and Washington State ARARs and TBC Materials for the 200-SW-2 OU

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
"Hazardous Waste Management" (RCW 70.105, as amended); WAC 173-303, "Dangerous Waste Regulations"					
WAC 173-303-016, "Identifying Solid Waste" WAC 173-303-017, "Recycling Processes Involving Solid Waste"	Action	Defines solid waste.	Solid waste will be generated during the 200-SW-2 OU remedial actions.	ARAR	Investigative and remediation activities will generate solid wastes, such as drums, barrels, tanks, containers, bulk wastes, debris, contaminated soil, and vadose zone soil.
WAC 173-303-070 (3), "Designation of Dangerous Waste"	Action	Establishes the method for determining if a solid waste is a dangerous waste (or an extremely hazardous waste).	Dangerous/hazardous waste may be generated during the 200-SW-2 OU remedial actions.	ARAR	Investigative and remediation (including waste treatment) activities that generate wastes (e.g., drums, barrels, tanks, containers, bulk wastes, debris, and contaminated soil).
WAC 173-303-077, "Requirements for Universal Waste"	Action	Identifies those wastes exempted from regulation under WAC 173-303-140 and WAC 173-303-170, "Requirements for Generators of Dangerous Waste," through WAC 173-303-9907, "Reserved" (excluding WAC 173-303-960, "Special Powers and Authorities of the Department"). These wastes are subject to regulation under WAC 173-303-573, "Standards for Universal Waste Management."	Universal wastes may be generated during the 200-SW-2 OU remedial actions.	ARAR	Remediation activities (disposal, storage, recycling, and onsite treatment) that manage universal wastes consistent with the requirements of the *Washington Administrative Code.*
WAC 173-303-120(3), "Recycled, Reclaimed, and Recovered Wastes" WAC 173-303-120(5), "Recycling of Used Oil"	Action	Defines the requirements for the recycling of materials that are solid and dangerous waste. Specifically, WAC 173-303-120(3) provides for the management of certain recyclable materials, including spent refrigerants, antifreeze, and lead acid batteries. WAC 173-303-120(5) provides for the recycling of used oil.	Recycled, reclaimed, and recovered wastes may be generated because vehicles and machines will be used for during the 200-SW-2 OU remedial actions.	ARAR	FS remediation recycling activities consistent with the requirements of the *Washington Administrative Code* and are not otherwise subject to CERCLA as hazardous substances.
WAC 173-303-140, "Land Disposal Restrictions"	Action	Establishes treatment requirements and disposal prohibitions for land disposal of dangerous waste and incorporates by reference WAC 173-303-140(2)(a), "Land Disposal Restrictions," and the federal land disposal restrictions of 40 CFR 268, "Land Disposal Restrictions." These are applicable to solid waste that is designated as dangerous or mixed waste in accordance with WAC 173-303-070(3),"Designation Procedures."	Onsite land disposal may be a selected remedy for the 200-SW-2 OU dangerous waste and debris.	ARAR	Investigative and remediation wastes destined for onsite land disposal at the Hanford Site.
WAC 173-303-170, "Requirements for Generators of Dangerous Waste"	Action	Establishes the requirements for dangerous waste generators. WAC 173-303-170(3) includes the substantive provisions of WAC 173-303-200, "Accumulating Dangerous Waste Onsite," by reference. WAC 173-303-200 further includes certain substantive standards from WAC 173-303-630, "Use and Management of Containers"; and WAC 173-303-640, "Tank Systems," by reference. Specifically, the substantive standards for management of dangerous or mixed waste are relevant and appropriate to the management of dangerous waste that will be generated during the remedial action.	Dangerous wastes may be generated during the remedial investigation phase and implementation of the remedial action.	ARAR	Investigative derived waste and remedial wastes (e.g., contaminated soil, vadose zone soil, groundwater, and treatment chemicals).
WAC 173-303-200, "Accumulating Dangerous Waste On-Site"	Action	Establishes the requirements for accumulating wastes onsite. WAC 173-303-200 further includes certain substantive standards from WAC 173-303-630, "Container Management"; and WAC 173-303-640, "Tank Systems," by reference.	Dangerous waste may be generated during the remedial investigation phase and implementation of the remedial actions in the 200-SW-2 OU.	ARAR	Management of dangerous waste during remedial and investigative actions.

Table 3-3. Potential Federal and Washington State ARARs and TBC Materials for the 200-SW-2 OU

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
WAC 173-303-64620, "Requirements"	Action	Establishes requirements for corrective action for releases of dangerous wastes and dangerous constituents including releases from solid waste management units.	Releases of dangerous wastes and dangerous constituents have occurred within the 200-SW-2 OU that may present a threat to HHE.	ARAR	Investigative and remediation of dangerous wastes and dangerous constituents from solid waste management units and spill sites. Corrective action can also be applied at treatment, storage, and/or disposal units whenever a release occurs.
WAC 173-303-610, "Requirements for Closure of Dangerous Waste Units"	Action	Establishes requirements for closing units that have treated, stored, or disposed dangerous waste.	Dangerous wastes may remain in the 200-SW-2 OU after closure.	ARAR	Remedial design and operation of regulated units that contain dangerous wastes and that will remain in the 200-SW-2 OU after closure.
WAC 173-303-665(6), "Dangerous Waste Regulations," "Landfills," "Closure and Post-Closure"	Action	Specifies closure and post-closure requirements for landfills.	Containment may be considered as a remedial alternative.	ARAR	Design and operation of an engineered landfill cover, including associated groundwater monitoring.
"Solid Waste Management—Reduction and Recycling" (RCW 70.95, as amended); WAC 173-350, "Solid Waste Handling Standards"					
WAC 173-350-025, "Owner Responsibilities for Solid Waste" WAC 173-350-040, "Performance Standards" WAC 173-350-300, "On-Site Storage, Collection and Transportation Standards" WAC 173-350-900, "Remedial Action"	Action	Establishes minimum functional performance standards for the proper handling and disposal of solid waste. Requirements for the proper handling of solid waste materials originating from residences, commercial, agricultural, and industrial operations, and other sources and identifies those functions necessary to ensure effective solid waste handling.	Solid, nondangerous waste will be generated during implementation of 200-SW-2 OU remedial actions.	ARAR	Investigative and remedial actions that generate solid, nondangerous waste.
Historical and Archeological Resources					
***National Historic Preservation Act of 1966* (Pub. L 89-665, as amended, 16 USC 470 et seq.)**					
36 CFR 800, "Protection of Historic Properties" 36 CFR 65, "National Historic Landmarks Program" 36 CFR 60,"National Register of Historic Places"	Location	Law and its regulations intended to preserve historical and archaeological sites in the United States. Requires federal agencies to consider the impacts of their undertaking on cultural properties through identification, evaluation, mitigation processes, and consultation with interested parties.	Cultural and historic sites have been identified within the 200-SW-2 OU.	ARAR	Investigation and remediation activities that occur in areas near cultural or historic sites. Regulations implementing Section 106 of the *National Historic Preservation Act of 1966* will be complied with.
***Native American Graves Protection and Repatriation Act of 1990* (Public Law 101-601,as amended, 25 USC 3001 et seq.) 43 CFR 10**					
43 CFR 10, "Native American Graves Protection and Repatriation Regulations"	Location	Requires that remedial actions do not cause the loss of any archaeological or historic data. This act mandates preservation of the data; it does not require protection of the actual waste site or facility.	Archaeological and historic sites have been identified within the 200-SW-2 OU.	ARAR	Investigation and remediation activities that occur in areas near archeological or historical sites.
Natural and Ecological Resources					
***Migratory Bird Treaty Act of 1918* (16 USC 703-712; Ch. 128; July 13, 1918; 40 Stat. 755), as amended.**					
50 CFR 10, "Wildlife and Fisheries," "General Provisions" 50 CFR 21, "Wildlife and Fisheries," "Migratory Bird Permits"	Location	Protects all migratory bird species and prevents "take" protected migratory birds, their young, or their eggs.	Migratory birds are present in project area.	ARAR	Remedial actions that require mitigation measures to deter nesting by migratory birds on, around, or within remedial action site and methods to identify and protect occupied birds' nests.

Table 3-3. Potential Federal and Washington State ARARs and TBC Materials for the 200-SW-2 OU

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
Endangered Species Act of 1973, as amended (16 USC 1541-1544), specifically Sections 7 and 9(a). 50 CFR 17, "Wildlife and Fisheries," "Endangered and Threatened Wildlife and Plants" (listings, prohibitions) 50 CFR 402, "Interagency Cooperation—Endangered Species Act of 1973, as Amended" 50 CFR 222 through 50 CFR 224, "Wildlife and Fisheries," "General Endangered and Threatened Marine Species," "Threatened Marine and Anadromous Species," "Endangered Marine Anadromous Species" (endangered and threatened marine species) 50 CFR 226.212, "Wildlife and Fisheries," "Designated Critical Habitat," "Critical Habitat for 15 Distinct Population Segments (DPSs) of Salmon and Steelhead (*Oncorhynchus* spp.) in Washington, Oregon and Idaho" (critical habitat for Northwest salmon and steelhead)	Location	Prohibits actions by federal agencies that are likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of habitat critical to them. Mitigation measures must be applied to actions that occur within critical habitats or surrounding buffer zones of listed species, in order to protect the resource.	There are no identified federal endangered and/or threatened species found within the 200-SW-2 OU. This regulation will apply if any endangered and/or threatened species are identified.	ARAR	Remedial actions and investigation activities that occur within critical habitats or designated buffer zones of federally listed species.
Land Use and Exposure Scenarios					
DOE/EIS-0222F, *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*	Location	Establishes the future land-use projections for the Central Plateau.	Land use in the Central Plateau is designated as an industrial exclusive zone.	TBC	

ACM = asbestos-containing material
ALARA = as low as reasonably achievable
ARAR = applicable or relevant and appropriate requirement
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
COC = contaminant of concern
Eco-SSL = ecological screening level
EPA = U.S. Environmental Protection Agency
HHE = human health and the environment
IDW = investigation-derived waste
MCL = maximum contaminant level
MCLG = maximum contaminant level goal
MNA = monitored natural attenuation
MTCA = "Model Toxics Control Act–Cleanup" (WAC 173-340)
NESHAP = National Emission Standards for Hazardous Air Pollutants
NRC = U.S. Nuclear Regulatory Commission
OU = operable unit
PCB = polychlorinated biphenyl
ppm = parts per million
PRG = preliminary remediation goal
RTD = removal, treatment, and disposal
TBC = to be considered

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Ecological risks will be assessed for terrestrial receptors on the Central Plateau, as described in Section 3.8.2. The ecological receptors, exposure pathways, exposure parameters, and toxicity reference values that will be used to conduct the assessment are also described in Section 3.8.2.

A conditional point of compliance may be proposed for soil depth to evaluate ecological receptors and an alternate point of compliance for human health (direct contact). These conditional and alternative points of compliance would represent the biologically active zone and would be evaluated as an alternative in the FS.

3.6.2 Contaminant Fate and Transport

The groundwater protection modeling approach will be based on the process defined in the graded approach document (DOE/RL-2011-50). The modeling approach is detailed in Section 3.8.3.

3.7 Conceptual Site Models

Landfill-specific operational information was gathered during the historical records research and from previous investigations for the 200-SW-2 OU landfills to update the CSMs. Landfill-specific CSMs are presented in Appendix D.

The preliminary CSMs were developed to support remedial decision-making processes. The CSMs further acknowledge that the trench backfill material (in combination with the buried waste) most likely experiences higher precipitation-infiltration rates (i.e., recharge) than undisturbed, vegetated soils located adjacent to the landfills (PNL-10285, *Estimated Recharge Rates at the Hanford Site*). It is also recognized that, following precipitation events, topographic low areas could receive moisture runoff from adjacent areas of higher elevation. Although not easily depicted by the current CSMs included in this work plan, waste may settle, and this settling may cause localized topographic lows (commonly referred to as "sink holes" in inspection documentation). These topographic lows, in turn, may accentuate precipitation infiltration. At this time, contaminant fate and transport associated with topographic lows have not been characterized. While VOC contaminant migration beneath the landfill trenches has been characterized at LLWMA-4 at 9.8 m (32 ft) below the surface, at shallower depths the actual nature and extent are not well understood because of the limited vadose zone sampling in these areas (SGW-37027, *Burial Ground Sampling and Analysis Results for October – December 2007*).

3.8 Preliminary Baseline Risk Assessment

The purposes of a BRA are to assess potential risks associated with residual contamination at a site under baseline conditions (i.e., no further action), identify key radionuclide and chemical contributors to risk, identify key exposure pathways, and determine if there is a need to take an action to reduce risks. Clay, 1991, "Role of Baseline Risk Assessment in Superfund Remedy Selection Decisions" (OSWER Directive 9355.0-30), provides clarification of the role of the BRA in developing Superfund remedial alternatives and supporting risk management decisions. This directive states that the BRA is part of the RI. It further states the following:

> *The baseline risk assessment should "characterize the current and potential threats to human health and the environment that may be posed by contaminants migrating to groundwater or surface water, releasing to air, leaching through soil, remaining in the soil, and bioaccumulating in the food chain" ([NCP] Section 300.430[d][4]). The primary purpose of the baseline risk assessment is to provide risk managers with an understanding of the actual and potential risks to human health and the environment posed by the site and any uncertainties associated with the assessment. This information*

may be useful in determining whether a current or potential threat to human health or the environment exists that warrants remedial action.

A traditional risk characterization for human health direct contact or ecological risks is not being planned because of the heterogeneous nature of the waste in the landfills and the large area over which the landfills are located. Rather, the proposed characterization described in this work plan identifies the presence of complete risk pathways for all of the landfills (via direct contact to groundwater, or through vapor intrusion) with additional emphasis placed on those landfills that potentially pose a greater risk if a release occurs. For example, the 218-W-2 and 218-W-4A Landfills have the highest inventories of plutonium and uranium, respectively.

For the UPRs and former liquid disposal sites, a two-step process is proposed in this work plan. In the first step, information is gathered using nonintrusive techniques. Based on the findings in step one and other available information, additional data can be collected based on the DQO process to allow direct contact and ecological risks to be characterized in the RI and alternatives developed and evaluated in the FS.

Risk pathways, if present, will be evaluated during the FS to determine an appropriate technology for eliminating the pathway. For example, the FS will evaluate an alternative where a barrier is placed to eliminate the pathway for human health direct contact and ecological receptors.

The following sections describe the general methodology for conducting the BRA for the locations where quantitative risk characterization will be needed.

3.8.1 Human Health Risk Assessment Approach

The basis for human health risk assessment (HHRA) methods and parameters are drawn from EPA/540/1-89/002, *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final* (also known as Risk Assessment Guidance for Superfund [RAGS]).

3.8.1.1 Definition of Human Health Exposure Scenario

Human health risks in the Inner Area will be assessed using the outdoor worker exposure scenario for chemicals and radionuclides within the standard point of compliance (0 to 4.6 m [15 ft] bgs). For radiological contamination below 4.6 m (15 ft) bgs, direct contact risks for human health will be evaluated using a construction worker scenario. The basis for the outdoor worker and construction worker scenarios and source of equations used to calculate cancer risks and noncancer hazards will be drawn from EPA Regional Screening Level guidance (EPA, 2015a, *Regional Screening Levels for Chemical Contaminants at Superfund Sites*) for chemicals and from EPA radionuclide PRG guidance (EPA, 2015b, *Preliminary Remediation Goals for Radionuclides*) for radionuclides. Key assumptions are as follows:

- Exposure pathways selected for the outdoor worker and construction worker scenarios are based on the assumption that direct contact exposure is potentially complete to contaminants in soil.

Exposure Pathways – Chemicals	**Exposure Pathways – Radionuclides**
• Incidental soil ingestion	• Incidental soil ingestion
• Inhalation of dust and volatiles	• Inhalation of dust
• Dermal contact with soil	• Direct (external) exposure

- Groundwater protection is also evaluated as detailed in Section 3.8.3 of this work plan.
- Exposure point concentrations (EPCs) for soil will include the standard point of compliance (i.e., 0 to 4.6 m [15 ft] bgs), based on the MTCA WAC 173-340-740(6). It may include an alternative point of compliance proposed by DOE in the CMS/FS.

Table 3-4 defines the exposure parameters for the outdoor worker scenario for chemicals and radionuclides. The exposure parameters listed in Table 3-4 reflect the guidance updates published by EPA in 2014.

Table 3-4. Summary of Outdoor Worker Scenario Exposure Parameters

Exposure Parameter	Symbol	Units	Radiological		Chemicals	
			Value	Source	Value	Source
Excess lifetime cancer risk	Risk	unit-less	Isotope-specific	Calculated	Analyte-specific	Calculated
Hazard index	HI	unit-less	N/A	N/A	Analyte-specific	Calculated
Chronic daily intake	CDI	mg/kg-day, pCi, mg/m^3, or $\mu g/m^3$	Isotope-specific	Calculated	Analyte-specific	Calculated
Soil concentration	Cs	mg/kg or pCi/g	Isotope-specific	Measured value	Analyte-specific	Measured value
Averaging time – carcinogens	ATc	days	N/A	—	25,550	Default; EPA/540/1-89/002
Averaging time – noncarcinogens	ATnc	days	N/A	—	9,125	Default; EPA/540/1-89/002
Body weight – adult	BW_a	kg	N/A	—	80	EPA/600/R-090-052F, Table 8-3
Exposure frequency	EFow	days/yr	225	OSWER 9355.4-24 (Exhibit 1-2)	225	OSWER 9355.4-24 (Exhibit 1-2)
Exposure duration	EDow	year	25	OSWER Directive 9285.6-03 (p. 15)	25	OSWER Directive 9285.6-03 (p. 15)
Exposure time	ETow	hr/day	8	OSWER Directive 9200.1-120, Attachment 1	8	OSWER Directive 9200.1-120, Attachment 1
Soil ingestion rate	IRSow	mg/day	100	OSWER Directive 9285.6-03 (p. 15)	100	OSWER Directive 9285.6-03 (p. 15)
Unit correction factor 1	CF1	g/mg	0.001	Calculated	N/A	N/A
Unit correction factor 2	CF2	kg/mg	N/A	N/A	0.000001	Calculated
Unit correction factor 3	CF3	yr/day	0.00274	Calculated	N/A	N/A
Unit correction factor 4	CF4	g/kg	1,000	Calculated	N/A	N/A
Unit correction factor 5	CF5	day/hr	0.0417	Calculated	0.0417	Calculated

Table 3-4. Summary of Outdoor Worker Scenario Exposure Parameters

Exposure Parameter	Symbol	Units	Radiological		Chemicals	
			Value	Source	Value	Source
Unit correction factor 6	CF6	µg/mg	N/A	N/A	1,000	Calculated
Area correction factor	ACF	unit-less	Isotope-specific	Eckerman, 2007	N/A	N/A
Gamma shielding factor	GSF	unit-less	1	EPA/540-R-00-007	N/A	N/A
Dermal absorption fraction	ABS_d	unit-less	N/A	N/A	Analyte-specific	EPA/540/R/99/005
Skin surface area	SA_{ow}	cm^2	N/A	N/A	3,527	Attachment 1 of OSWER Directive 9200.1-120
Soil adherence factor	AF_{ow}	mg/cm^2-day	N/A	N/A	0.12	Attachment 1 of OSWER Directive 9200.1-120
Gastrointestinal absorption factor	ABS_{GI}	unit-less	N/A	N/A	Analyte-specific	EPA/540/R/99/005
Inhalation rate – adult	INH_a	m^3/day	20	OSWER Directive 9285.6-03	N/A	N/A
Particulate emission factor	PEF	m^3/kg	7.30E+10	OSWER 9355.4-24	7.30E+10	OSWER 9355.4-24
Volatilization factor	VF	m^3/kg	N/A	N/A	Analyte-specific	EPA*
Carcinogenic slope factor for soil ingestion	SF_{si}	risk/pCi	Isotope-specific	EPA*	N/A	N/A
Carcinogenic slope factor for external exposure	SF_x	risk/year per pCi/g	Isotope-specific	EPA*	N/A	N/A
Carcinogenic slope factor for inhalation	SF_{inh}	risk/pCi	Isotope-specific	EPA*	N/A	N/A
Oral carcinogenic slope factor	SF_o	$(mg/kg\text{-}day)^{-1}$	N/A	N/A	Analyte-specific	EPA*
Oral reference dose	RfD_o	(mg/kg-day)	N/A	N/A	Analyte-specific	EPA*
Unit risk factor	IUR	$(\mu g/m^3)^{-1}$	N/A	N/A	Analyte-specific	EPA*
Reference concentration	RfC	mg/m^3	N/A	N/A	Analyte-specific	EPA*

Table 3-4. Summary of Outdoor Worker Scenario Exposure Parameters

Exposure Parameter	Symbol	Units	Radiological		Chemicals	
			Value	Source	Value	Source
Decay constant	λ	unit-less	0.693	EPA/540-R-00-007	N/A	N/A
Time	Tow	years	25	OSWER Directive 9285.6-03	N/A	N/A

Sources:

Eckerman, 2007, *Ratios of Dose Rates for Contaminated Slabs.*

EPA/540/1-89/002, *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*

EPA/540-R-00-007, 2000, *Soil Screening Guidance for Radionuclides: User's Guide*, OSWER 9355.4-16A.

EPA/540/R/99/005, 2004, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment): Final*, OSWER 9285.7-02EP.

EPA/600/R-090-052F, 2011, *Exposure Factors Handbook: 2011 Edition.*

OSWER 9355.4-24, *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites.*

OSWER Directive 9200.1-120, *Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default E*
OSWER Directive 9285.6-03, 1991, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual Supplemental Guidance, Standard Default Exposure Factors, Interim Final Exposure Factors.*

* Values will be obtained from the sources described in Section 3.8.1.5, "Toxicity Assessment."

EPA = U.S. Environmental Protection Agency

N/A = not applicable

Although only the outdoor worker scenario exposure parameters are provided in Table 3-4, cleanup levels for direct contact with chemicals in soil, structures (including pipelines), and debris will be developed using the assumptions from the MTCA (WAC 173-340-745, "Soil Cleanup Standards for Industrial Properties"), as described in Section 3.8.1.8.

The exposure parameters for the construction worker scenario for radionuclides are defined in Table 3-5. The exposure parameter listed in Table 3-5 reflect the guidance updates published by EPA in 2014. MTCA Method C is described in Section 3.8.1.8 of this work plan.

Table 3-5. Summary of Construction Worker Scenario Exposure Parameters

Exposure Parameter	Symbol	Units	Value	Source
Excess lifetime cancer risk	Risk	unit-less	Isotope-specific	Calculated
Chronic daily intake	CDI	pCi	Isotope-specific	Calculated
Soil concentration	C_s	pCi/g	Isotope-specific	Measured value
Exposure frequency – construction worker	EFcw	days/yr	30	Site-specific assumption (5 days/week for 6 weeks); DOE/RL-2007-27; Rev. 0; Section A3.3.1
Exposure duration – construction worker	EDcw	year	1	OSWER 9355.4-24, Exhibit 5-1

Table 3-5. Summary of Construction Worker Scenario Exposure Parameters

Exposure Parameter	Symbol	Units	Value	Source
Exposure time – construction worker	ET_{cw}	hr/day	8	Site-specific assumption, 8 hours per 24-hour day
Soil ingestion rate – construction worker	IRS_{cw}	mg/day	330	OSWER 9355.4-24 (Exhibit 5-1)
Inhalation rate – construction worker	INH_{cw}	m^3/day	60	EPA/600/P-95/002Fa (page 5-11), based on a rate of 2.5 m^3/hr for 24 hours
Unit correction factor 1	CF1	g/mg	0.001	1 g = 1,000 mg
Unit correction factor 2	CF2	day/hr	0.0417	1 day = 24 hours
Unit correction factor 3	CF3	g/kg	1,000	1,000 g = 1 kg
Unit correction factor 4	CF4	year/day	0.00274	1 year = 365 days
Area correction factor – soil volume	$ACF_{ext\text{-}sv}$	unit-less	Isotope-specific	ORNL, 2014
Gamma shielding factor	GSF	unit-less	1	EPA/540-R-00-007
Subchronic particulate emission factor	PEF_{sc}	m^3/kg	1.28×10^{-6}	OSWER 9355.4-24
Carcinogenic slope factor for soil ingestion	SF_{si}	risk/pCi	Isotope-specific	EPA*
Carcinogenic slope factor for external exposure	SF_x	risk/year per pCi	Isotope-specific	EPA*
Carcinogenic slope factor for inhalation	SF_{inh}	risk/pCi	Isotope-specific	EPA*
Decay constant	λ	unit-less	0.693	EPA/540-R-00-007
Time – construction worker	t_{cw}	years	1	OSWER 9355.4-24, Exhibit 5-1

Sources:

DOE/RL-2007-27, *Hanford Facility Annual Dangerous Waste Report Calendar Year 2006.*

EPA/540-R-00-007, *Soil Screening Guidance for Radionuclides: User's Guide*, OSWER 9355.4-16A.

EPA/600/P-95/002Fa, *Exposure Factors Handbook, Update to Exposure Factors Handbook EPA/600/8-89/043 – May 1989, Volume I – General Factors.*

OSWER 9355.4-24, *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites.*

ORNL/TM-2013/00, *Area Correction Factors for Contaminated Soil for Use in Risk and Dose Assessment Models.*

Table 3-5. Summary of Construction Worker Scenario Exposure Parameters

Exposure Parameter	Symbol	Units	Value	Source

* Values will be obtained from the sources described in Section 3.8.1.5, "Toxicity Assessment."

EPA = U.S. Environmental Protection Agency

In addition, the BRA will present risk characterization results for the two Native American (Tribal) scenarios. Exposure assumptions for these scenarios are based on information provided in exposure scenario documents developed by the CTUIR (Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways*; Harris, 2008, *Application of the CTUIR Traditional Lifeways Exposure Scenario in Hanford Risk Assessments*) and the Yakama Nation (Ridolfi, 2007, *Yakama Nation Exposure Scenario for Hanford Site Risk Assessment, Richland, Washington*).

3.8.1.2 Basis for Action

For protection of human health (direct contact), the CERCLA-defined basis for action for radionuclides is 1 in 10,000 cumulative excess lifetime cancer risk. The basis for action for chemicals is based on the EPA Regional Screening Levels calculation at 1 in 100,000 for cancer risks or a hazard index of 1.0 for noncancer hazards.[1] Ecological risk and groundwater protection will also be considered to establish a basis for action.

3.8.1.3 Identification of Contaminants of Potential Concern

For protection of human health (direct contact), a COPC is defined as an analyte suspected of being associated with site-related activities that represent a potential threat to human health and for which data are of sufficient quality for use in a quantitative HHRA. The quantitative HHRA will initially evaluate a broad list of contaminants (radionuclides and chemicals). The characterization strategy for each OU will be used to identify the list of contaminants. Identification of COPCs will take into consideration existing site characterization data, process knowledge, and inventory estimates.

The risk characterization will discuss elevated soil background concentrations and their contribution to site risks, as well as naturally occurring elements that are not CERCLA hazardous substances, pollutants, and contaminants. The contribution from naturally occurring metals and radioisotopes, as well as widespread anthropogenic radioisotopes, will be evaluated in accordance with EPA 540-R-01-003, *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites* (OSWER 9285.7-41).

The approach used for evaluating soil background will be the same as the approach used in the BRA in the River Corridor OUs. Table 3-6 provides a summary of the 90th percentile and maximum Hanford Site soil background concentrations.

[1] Using the EPA Regional Screening Levels to establish the basis for action for chemicals will typically result in a more conservative cumulative cancer risk and noncancer hazard index than the MTCA Method C (WAC 173-340-708(5)) because the RSL concentrations are lower than the MTCA Method C direct contact cleanup levels for most chemicals. The only exception is that the MTCA Method C inhalation cleanup levels for VOCs are generally lower than their corresponding RSL concentrations. However, VOCs are no longer present in the shallow vadose zone of the Central Plateau; disposal occurred several decades ago and complete volatilization has occurred.

Table 3-6. Hanford Site Soil Background Concentrations

Analyte Name	Analyte Class	Units	90th Percentile Background Value	Maximum Background Value	Source of Background Value
Anthropogenic Radionuclides*					
Cesium-137	RAD	pCi/g	1.1	1.6	DOE/RL-96-12
Cobalt-60	RAD	pCi/g	0.0084	0.039	DOE/RL-96-12
Europium-154	RAD	pCi/g	0.033	0.079	DOE/RL-96-12
Europium-155	RAD	pCi/g	0.054	0.098	DOE/RL-96-12
Gross beta	RAD	pCi/g	23	25	DOE/RL-96-12
Plutonium-238	RAD	pCi/g	0.0038	0.019	DOE/RL-96-12
Plutonium-239/240	RAD	pCi/g	0.025	0.033	DOE/RL-96-12
Radium-228	RAD	pCi/g	1.8	2.3	DOE/RL-96-12
Strontium-90	RAD	pCi/g	0.18	0.37	DOE/RL-96-12
Thorium-228	RAD	pCi/g	1.4	1.6	DOE/RL-96-12
Total beta radiostrontium	RAD	pCi/g	0.18	0.37	DOE/RL-96-12
Naturally Occurring Radionuclides					
Potassium-40	RAD	pCi/g	17	20	DOE/RL-96-12
Radium-226	RAD	pCi/g	0.82	1.2	DOE/RL-96-12
Thorium-232	RAD	pCi/g	1.3	1.6	DOE/RL-96-12
Uranium-233/234	RAD	pCi/g	1.1	1.5	DOE/RL-96-12
Uranium-234	RAD	pCi/g	1.1	1.5	DOE/RL-96-12
Uranium-235	RAD	pCi/g	0.11	0.39	DOE/RL-96-12
Uranium-238	RAD	pCi/g	1.1	1.2	DOE/RL-96-12
Metals					
Aluminum	METAL	mg/kg	11,800	28,800	DOE/RL-92-24, Volume 1
Antimony	METAL	mg/kg	0.13	0.385	ECF-HANFORD-11-0038
Arsenic	METAL	mg/kg	6.47	27.7	DOE/RL-92-24, Volume 1
Barium	METAL	mg/kg	132	480	DOE/RL-92-24, Volume 1
Beryllium	METAL	mg/kg	1.51	10	DOE/RL-92-24, Volume 1
Boron	METAL	mg/kg	3.89	5.86	ECF-HANFORD-11-0038
Cadmium	METAL	mg/kg	0.563	2.98	ECF-HANFORD-11-0038

Table 3-6. Hanford Site Soil Background Concentrations

Analyte Name	Analyte Class	Units	90th Percentile Background Value	Maximum Background Value	Source of Background Value
Calcium	METAL	mg/kg	17,200	105,000	DOE/RL-92-24, Volume 1
Chromium	METAL	mg/kg	18.5	320	DOE/RL-92-24, Volume 1
Cobalt	METAL	mg/kg	15.7	110	DOE/RL-92-24, Volume 1
Copper	METAL	mg/kg	22	61	DOE/RL-92-24, Volume 1
Iron	METAL	mg/kg	32,600	68,100	DOE/RL-92-24, Volume 1
Lead	METAL	mg/kg	10.2	74.1	DOE/RL-92-24, Volume 1
Lithium	METAL	mg/kg	13.3	19.2	ECF-HANFORD-11-0038
Magnesium	METAL	mg/kg	7,060	32,300	DOE/RL-92-24, Volume 1
Manganese	METAL	mg/kg	512	1,110	DOE/RL-92-24, Volume 1
Mercury	METAL	mg/kg	0.013	0.029	ECF-HANFORD-11-0038
Molybdenum	METAL	mg/kg	0.47	3.17	ECF-HANFORD-11-0038
Nickel	METAL	mg/kg	19.1	200	DOE/RL-92-24, Volume 1
Potassium	METAL	mg/kg	2,150	7,900	DOE/RL-92-24, Volume 1
Selenium	METAL	mg/kg	0.78	0.84	ECF-HANFORD-11-0038
Silver	METAL	mg/kg	0.167	0.273	ECF-HANFORD-11-0038
Sodium	METAL	mg/kg	690	6.06E+03	DOE/RL-92-24, Volume 1
Thallium	METAL	mg/kg	0.185	0.523	ECF-HANFORD-11-0038
Uranium	METAL	mg/kg	3.21	4.04	Isotopic Activity Conversion based on DOE/RL-96-12 values
Vanadium	METAL	mg/kg	85.1	140	DOE/RL-92-24, Volume 1
Zinc	METAL	mg/kg	67.8	366	DOE/RL-92-24, Volume 1
Anions					
Ammonia	ANIONS	mg/kg	9.23	26.4	DOE/RL-92-24, Volume 1
Chloride	ANIONS	mg/kg	100	1,480	DOE/RL-92-24, Volume 1
Fluoride	ANIONS	mg/kg	2.81	73.3	DOE/RL-92-24, Volume 1
Nitrate	ANIONS	mg/kg	52	906	DOE/RL-92-24, Volume 1
Phosphate	ANIONS	mg/kg	0.785	225	DOE/RL-92-24, Volume 1
Sulfate	ANIONS	mg/kg	237	12,600	DOE/RL-92-24, Volume 1

Table 3-6. Hanford Site Soil Background Concentrations

Analyte Name	Analyte Class	Units	90th Percentile Background Value	Maximum Background Value	Source of Background Value

Sources:

ECF-HANFORD-11-0038, *Soil Background for Interim Use at the Hanford Site.*

DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes.*

DOE/RL-96-12, 1996, *Hanford Site Background: Part 2, Soil Background for Radionuclides.*

* Background values listed for anthropogenic radionuclides are only for shallow soils (less than 4.6 m [15 ft] below ground surface). A background value of zero applies to soil concentrations collected from deeper soils.

Analytes that are not related to Hanford Site waste or will not contribute significantly to human health risks are not carried into a quantitative risk assessment. The analytes include (1) radionuclides with a half-life less than 3 years; (2) essential nutrients; (3) soil physical property measurements; and (4) background or naturally occurring radionuclides such as potassium-40, thorium-232 and daughters, and radium-226 and daughters. This approach is the same used for the River Corridor OUs.

Applicable quantitative risks will not be assessed for analytes without appropriate toxicity values. Rather, analytes without toxicity values will be discussed qualitatively as part of the risk characterization.

3.8.1.4 Exposure Assessment

The exposure assessment will address (1) methods for developing EPCs in soil, and (2) methods for calculating concentrations in air from EPCs in soil using EPA screening models.

Development of Exposure Point Concentrations in Soil

Spatial exposure areas will be defined, and sampling and analytical data will be grouped for calculating EPCs considering factors such as the nature and extent of contamination and process knowledge. Depths in soil will be identified for grouping samples based on the characterization strategy. In general, soil samples collected from small waste sites will be grouped into a single exposure area, while soil samples from large waste sites (e.g., ponds) may be separated into more than one exposure area.

EPA's ProUCL software, version 5.1 or later, shall be used to calculate EPCs. The highest "suggested UCL to use" provided in the ProUCL output file shall be used as the EPC unless software provides a warning indicating that the "recommended UCL exceeds maximum observations". When this warning is provided, or when ProUCL cannot calculate a UCL value or does not provide a "suggested UCL to use", the maximum observed concentration will be used as the EPC.

Development of Exposure Point Concentrations in Air from Soil

Particulate emission factors for wind-blown dust and volatilization factors for VOCs (when appropriate) will be calculated in accordance with EPA guidance (OSWER 9355.4-24, *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*).

3.8.1.5 Toxicity Assessment

The toxicity criteria used for the human health cancer risk and noncancer hazard calculations will be obtained from the sources described in the following subsections.

Toxicity Values for Nonradionuclides

For nonradionuclides, the analyte-specific toxicity values are determined using the recommended reference hierarchy as described in Cook, 2003, "Human Health Toxicity Values in Superfund Risk Assessments" (OSWER Directive 9285.7-53). The hierarchy is the same as that used in the BRAs for the River Corridor OUs:

- Tier 1 – EPA Integrated Risk Information System (IRIS)
- Tier 2 – EPA Provisional Peer Reviewed Toxicity Values (PPRTVs)
- Tier 3 – Other Toxicity Values

Tier 1 – IRIS. The preferred source of toxicity data is the EPA IRIS database. Expert toxicologists at EPA have derived the values in this database, and the values have been thoroughly reviewed and validated both within and outside of EPA. If a toxicity value is available in IRIS, that value will be used in preference to values published in Tier 2 and Tier 3 sources.

Tier 2 – PPRTVs. If a toxicity value is not available in IRIS, the next source is the EPA PPRTVs. This source includes toxicity values developed by the Office of Research and Development/National Center for Environmental Assessment (NCEA)/Superfund Health Risk Technical Support Center. This database is available to the public (available at: http://hhpprtv.ornl.gov), and is also accessible to EPA risk assessors via the EPA intranet. These values are also published at the EPA Regional Screening Levels website (EPA, 2015a). Tier 2 values are used in preference to Tier 3 values.

Tier 3 – Other Toxicity Values. Tier 3 includes additional EPA and non-EPA sources of toxicity information, including the following:

- The California EPA Toxicity Criteria Database (available at: http://oehha.ca.gov/tcdb/index.asp), provides toxicity values that are peer reviewed and address both carcinogenic and noncarcinogenic effects
- The Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Levels for Hazard Substances, which are peer-reviewed estimates of the daily human exposure to hazardous substances that is likely to be without appreciable risk of adverse noncarcinogenic health effects over a specified duration of exposure
- Toxicity values in EPA 540-R-97-036 (1997), *Health Effects Assessment Summary Tables (HEAST), FY 1997 Update*

When Tier 1, Tier 2, or Tier 3 toxicity values are not available for an analyte, the toxicity values from the NCEA are used. The NCEA toxicity values can be included because the Tier 3 values can include additional EPA and non-EPA sources of toxicity information. The NCEA values can be found in the Risk Assessment Information System (ORNL, 2015).

Toxicity Values for Radionuclides

The cancer slope factors for radionuclides will be obtained from EPA 540-R-97-036 (2001), *Health Effects Assessment Summary Tables: FY 1997 Update*, April 16, 2001 Update: Radionuclide Toxicity (update of former Table 4), "Radionuclide Table: Radionuclide Carcinogenicity – Slope Factors". These values are the same as used in the BRA in the River Corridor OUs.

3.8.1.6 Risk Characterization

Risk estimates will be presented by exposure area and soil depth. The BRA will also discuss risk estimates relative to Hanford Site background levels. The risk characterization identifies the COPCs that are risk drivers.

3.8.1.7 Discussion of Uncertainties

Uncertainties in the HHRA calculations or conclusions will be specifically discussed in uncertainty sections in the RFI/CMS/RI/FS document. The discussions will identify whether risks from soil contaminants are likely overstated or understated.

3.8.1.8 Methods for Calculating Human Health Cleanup Levels

Cleanup levels for direct contact with radionuclides in soil, structures (including pipelines), and debris will be developed using parameters for the outdoor worker scenario identified in Table 3-4, as well as the toxicity values identified in Section 3.8.1.5. The outdoor worker PRGs will be used to represent reasonable maximum exposure for the industrial worker exposure to contaminated soil. For pipelines, structures, and debris, the outdoor worker two-dimensional external exposure will be used to represent reasonable maximum exposure. The two-dimensional method was developed to evaluate risks from exposure to structures with surface radioactive contamination. In this method, the outdoor worker is exposed to radioactively contaminated dust settled on finite slabs. The only pathway considered is external exposure to ionizing radiation (EPA, 2015c, *Surfaces Preliminary Remediation Goals for Radionuclides*). Table 3-4 provides the exposure parameters that will be used. PRGs corresponding to a 10^{-4} acceptable cancer risk level will be used for radionuclides. The methodology used to calculate soil PRGs for radionuclides is consistent with the methodology used for the BRAs for the River Corridor OUs.

Cleanup levels for direct contact with chemicals in soil, structures (including pipelines), and debris will be developed using the assumptions from the MTCA (WAC 173-340-745) Equations 745-1 and 745-2, along with toxicity values identified in Section 3.8.1.5. PRGs will be developed based on a 10^{-5} acceptable cancer risk level or a noncancer hazard quotient of 1. MTCA equations will be used to calculate PRGs based on direct contact (soil ingestion) and, where relevant, the PRG value will be based on the inhalation exposure pathway when it is lower than soil ingestion. The cumulative cancer risk threshold for chemicals is also 10^{-5}, so adjustment to cleanup levels based on cumulative risk may be relevant. Adjustments for multiple contaminants having similar modes of action or multiple pathways of exposure will be made where appropriate.

3.8.2 Ecological Risk Assessment Approach

The ERA approach will follow EPA guidance and the terrestrial ecological evaluation procedures developed by Ecology (MTCA). The ERAs will include, as appropriate, explanations of how the methodology conforms to guidance and requirements identified in MTCA. The ERA approach is the same as that used in the BRAs in the River Corridor OUs.

3.8.2.1 Identification of Contaminants of Potential Concern

COPCs will be identified using the same process developed for the HHRA (Section 3.8.1.3) but will consider ecological pathways and screening levels.

3.8.2.2 Conceptual Site Model for Ecological Exposure

The CSM for ecological exposure pathways will include the elements described by EPA/540-R-97-006, *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments: Interim Final*. Though not specifically referred to as a CSM, these same elements are also part of the simplified terrestrial ecological evaluation procedures (WAC 173-340-7492, "Simplified Terrestrial Ecological Evaluation Procedures") and site-specific terrestrial ecological evaluation procedures under MTCA. Previously developed evaluations will be used, including the conceptual model of ecological exposure pathways and receptors developed for the Tier 1 and Tier 2 ecological PRGs (CHPRC-00784, *Tier 1 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site*; CHPRC-01311, *Tier 2 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site*).

3.8.2.3 Evaluation of Biointrusion

The ERA will include a discussion of the soil depth to which ecological receptors are exposed. This discussion will use the analysis presented in CHPRC-00651, *Evaluation of Biointrusion Depths at the Hanford Site for Protection of Ecological Receptors*. If an alternative point of compliance for soil depth is proposed, both the standard point of compliance and the alternative point of compliance will be presented as remedial action alternatives in the FSs (and CMSs, as applicable).

3.8.2.4 Exposure Assessment

The exposure assessment will use exposure parameters, representative species, and transfer factors found in CHPRC-01311 and CHPRC-00784, which have been evaluated and used in ERAs in the River Corridor OUs. Estimation of EPCs in soil will use the same data and parallel the methods as presented for the HHRA.

3.8.2.5 Effects Assessment

The effects assessment will be the same as that used for the River Corridor OU BRAs. The assessment will use wildlife toxicity reference values developed in CHPRC-01311 and CHPRC-00784. The same soil thresholds protective of wildlife that were developed from these toxicity reference values will be used for wildlife in the Central Plateau. Effects values for terrestrial plants and invertebrates will be the soil threshold concentrations presented in ECF-HANFORD-11-0158, *Tier 2 Terrestrial Plant and Invertebrate Preliminary Remediation Goals (PRGs) for Nonradionuclides for Use at the Hanford Site*; and CHPRC-00784.

3.8.2.6 Risk Characterization

Ecological risk characterization will use standard methods and approaches that already used along the River Corridor, including the following:

- Calculation of ecological hazard quotients
- Evaluation of risk relative to established background levels to aid in identifying risk drivers
- Methods for characterizing risks when a scientific management decision point (SMDP) is reached

The SMDP is reached when exposures are higher than an ecological hazard quotient of 1 (i.e., an EPC is higher than a PRG). The potential for population-level risks to wildlife and community-level risks to plants and invertebrates will be evaluated and a risk management decision will be made using the SMDP. The River Corridor OU BRAs used the same approach. The SMDP will consider the following:

- Spatial characteristics of the remediated waste site (area and depth of the waste site)
- Proximity and size of other waste sites and unaffected habitat
- Extent of site characterization (sample density and characterization of lateral extent of contamination)
- Data quality (presence of qualifiers and adequacy of detection limits)
- Frequency that risk-based thresholds are exceeded and the location(s) of those exceedances
- Chemical-specific properties of each COC (potential to biomagnify and persistence)
- Ecological receptor-specific details
- Feeding guild is affected (plants, insects, or omnivorous, herbivorous, insectivorous, or carnivorous wildlife)
- Proportion of receptors affected
- Likelihood of population-level or community-level effects
- Home range of the receptors at risk relative to the area exceeding PRG
- Evaluation of PRGs (level of confidence, basis, and relation to other PRGs such as those for human health or groundwater protection)

During preparation of the ERA, risk assessors will evaluate potential risks to populations of mammals and birds, as well as to communities of plants and invertebrates, and will propose conclusions through the SMDP. Risk managers from DOE and the regulatory agencies will review and concur with, or revise, the SMDP conclusions.

3.8.2.7 Methods for Calculating Ecological Cleanup Levels

PRGs have been developed for individual feeding guilds (for birds and mammals), for plants, and for invertebrates. PRGs for chemicals are based on the lowest observed affect exposure levels presented in CHPRC-01311 and CHPRC-00784 for birds and mammals and in ECF-HANFORD-11-0158 for plants and invertebrates.

PRGs for radionuclides are developed using the methods presented in DOE-STD-1153-2002, *Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*, using as a protective threshold a dose limit of 0.1 rad/d for birds and mammals and 1.0 rad/d for plants and invertebrates.

3.8.3 Evaluation of Groundwater Protection

The evaluation of groundwater protection will be based on DOE/RL-2011-50, which will form the basis for all groundwater evaluations on the Central Plateau. The development of soil screening levels (SSLs) and PRGs for groundwater protection will be based on protecting groundwater directly below each waste site. Cumulative impacts from all waste sites and other sources within the Central Plateau will also be evaluated. The evaluation will be supported by the updated CSM developed using information

obtained as part of work plan efforts. The CSM update and evaluation will also incorporate science and technology elements described in Sections 4.4, 4.6, and 5.3 and Appendix B, as appropriate.

The use of Subsurface Transport Over Multiple Phases (STOMP) (PNNL-12030, *STOMP: Subsurface Transport Over Multiple Phases Version 2.0: Theory Guide*) as the fate and transport model for groundwater protection evaluations is established in DOE/RL-2011-50. To facilitate the modeling approach for the Central Plateau, five hydrogeologic provinces were identified in DOE/RL-2011-50, based on vadose zone hydrogeologic similarity. The characteristics, thickness, and vertical distribution of the vadose zone sediments of the five provinces are provided in DOE/RL-2011-50. Other parameter values used for the groundwater protection evaluation include ranges of distribution coefficient (K_d) values and net infiltration rates.

The K_d values identified for the River Corridor (DOE/RL-2010-95) will be used for evaluating groundwater protection for waste sites on the Central Plateau (including those within the 200-SW-2 OU). Because DOE/RL-2010-95 did not identify a K_d value for uranium, a K_d value of zero will be used for all waste sites, unless site-specific information is available.

Long-term net infiltration rates will be defined as documented in DOE/RL-2011-50. To summarize, 4 mm/yr will be used as the long-term infiltration rate for two scenarios based on two future end states:

- **Native land-cover scenario:** Assumes revegetation with native plants that will mature within about 30 years of remediation and vegetation.
- **Evapotranspiration barrier scenario:** Assumes installation of an evapotranspiration barrier at the waste site(s). After the barrier is installed, the effective infiltration rate will be reduced to 0.5 mm/yr. The barrier will be assumed to have a design life of 500 years. After that, net infiltration rates will return to the natural land cover rate of 4 mm/yr.

To establish compliance of the groundwater protection evaluation approach with the requirements of WAC 173-340-747(8), a single crosswalk for applicable waste sites across the Central Plateau will be developed. This crosswalk will follow the structure documented in DOE/RL-2010-95. Following this development, and within each of the OUs, each risk assessment will identify unique application aspects for waste sites and will demonstrate how *Washington Administrative Code* requirements are met.

3.8.3.1 Basis for Calculation of Screening Levels and Preliminary Remediation Goals

The evaluation of the groundwater protection approach involves evaluating the potential for groundwater contamination from a given waste site (with known or assumed waste geometry) or the calculation of SSLs or PRGs. The SSLs and PRGs are soil and vadose zone concentrations that would not impact groundwater above pre-defined levels. Consistent with Figure 3-1 in DOE/RL-2011-50, the SSLs will be used to identify COPCs and the PRGs will be used to set cleanup levels.

For the SSL calculation, these soil concentrations would not impact groundwater concentrations above the lowest value from the following:

- Chemicals; concentrations calculated for the EPA tap water scenario based on carcinogenic effects calculated at a target risk level of 1×10^{-6}, as applicable
- Radionuclides; concentrations calculated for the EPA tap water scenario based on carcinogenic effects calculated at a target risk level of 1×10^{-5}
- Concentrations calculated for the EPA tap water scenario based on noncarcinogenic effects calculated at a hazard quotient value of 0.1, as applicable

The groundwater protection PRGs would be calculated as concentrations that would not impact groundwater concentrations above the lowest value from the following:

- The federal and state maximum contaminant level (MCL) values, where available
- EPA screening levels for radionuclides for which no MCL is available; the groundwater cleanup level is calculated using the tap water scenario at an individual target risk level of 1×10^{-4}
- MTCA Method B cleanup level for groundwater based on carcinogenic effects calculated at a target risk level of 1×10^{-6}, as applicable, with downward adjustment to maintain cumulative risk below 1×10^{-5} for multiple contaminants in accordance with WAC 173-340-708(5) and (6), "Human Health Risk Assessment Procedures"
- MTCA Method B cleanup level for groundwater based on noncarcinogenic effects calculated at a hazard quotient value of 1, as applicable, with downward adjustment to maintain a total hazard index of 1 for multiple contaminants in accordance with WAC 173-340-708(5) and (6)

3.8.3.2 Evaluation of Cumulative Impacts and Approach for Evaluation of Alternative Point of Compliance

An alternative can be developed in the FS (and CMS, as applicable) that considers an alternative point of compliance in groundwater. The detailed evaluation of this alternative will consider the evaluation of cumulative impacts, taking into consideration the upgradient groundwater contamination through the same comprehensive approach used in PNNL-11800, *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*, and the cumulative impact analysis conducted for DOE/EIS-0391. The following considerations will be defined for this evaluation:

- The alternative point of compliance process will define a model domain (in space and time) that covers all the source waste sites within the boundary, as well as existing groundwater contamination. An example of this boundary is shown in Figure 3-5. This proposed boundary encompasses all of the liquid effluent disposal sites and the existing concentrated groundwater contamination areas within the Central Plateau. The actual boundary will be determined through the RI/FS process (and RFI/CMS, as applicable) for source OUs. The evaluation will be conducted for 1,000 years.
- Inventory estimates for waste sites will include measurements for surface soils and the vadose zone, as well as the following sources:
  - **Liquid disposal sites:** Soil Inventory Model (SIM) mean values (PNNL-16940, *Hanford Soil Inventory Model (SIM) Rev. 2 Software Documentation – Requirements, Design, and Limitations*) will be used for the base case. Ranges of effluent volumes and associated contaminant concentrations provided by SIM will be used to evaluate the uncertainties.
  - **Solid waste disposal sites:** Inventory estimates will be developed based on available information and available characterization measurements.
  - **Tank farms sources:** Data will be obtained from the most recent leak assessment reports and tank waste and ancillary equipment inventory estimates.

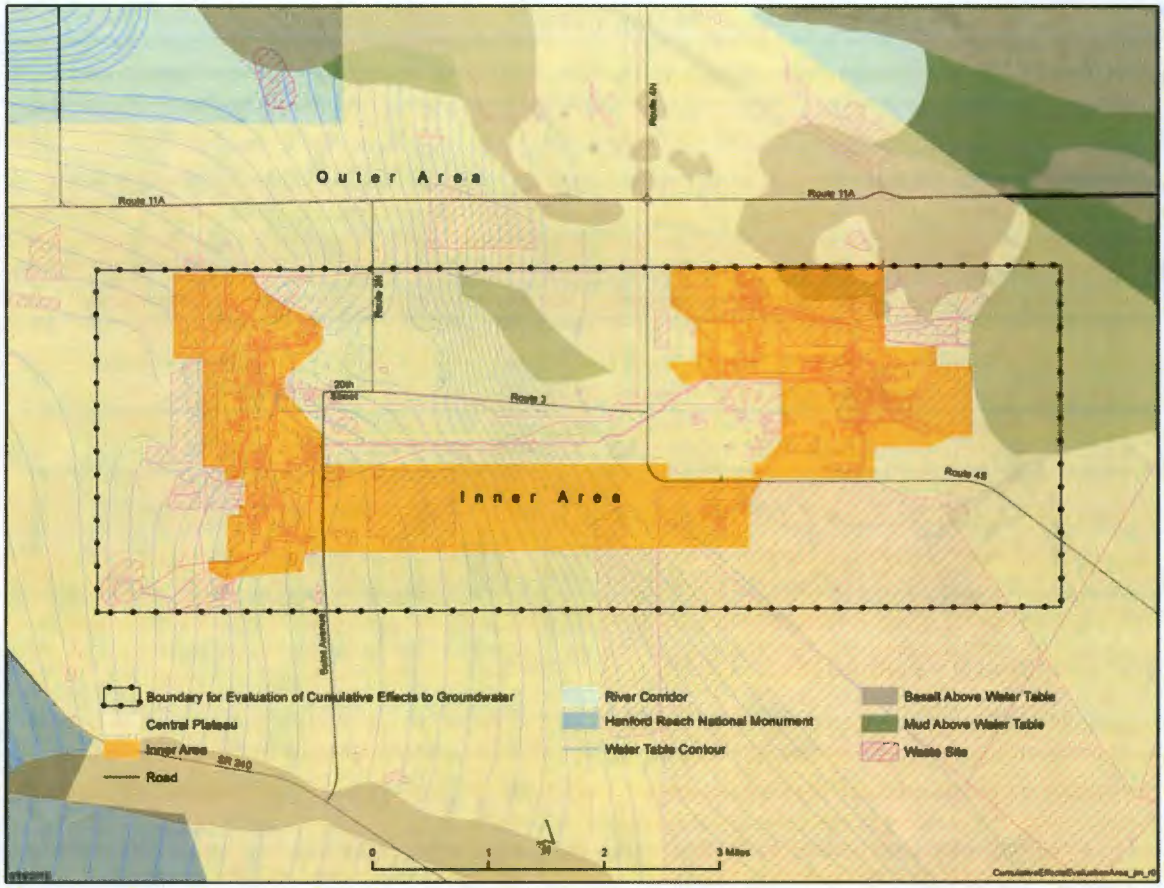

Figure 3-5. Boundary Proposed for the Evaluation of Alternative Point of Compliance for Groundwater Protection

A range of end-state conditions for waste sites and groundwater will be evaluated using the same approach documented in PNNL-14027, *An Initial Assessment of Hanford Impact Performed with the System Assessment Capability*. The conditions will be updated to reflect the current decisions and response actions that have already been implemented for the groundwater contamination on the Central Plateau, including perched water removal.

Cumulative impacts from waste sites, tank farms, and other sources in the Central Plateau will be assessed and documented in a single primary TPA (Ecology et al., 1989a) document. This document will be prepared following approval of the first work plan and prior to completion of the first RI/FS (and RFI/CMS, as applicable) for the source OUs within the Central Plateau. Following issuance of this document, each RI report for source OUs will reference this application document, evaluate any necessary updates based on new information or updated elements of the CSMs, and evaluate how the conclusions can change. Similarly, the composite analysis (required under DOE O 435.1 Chg 1, *Radioactive Waste Management*) will reference the same application document, evaluate any necessary changes, and demonstrate the performance metrics required under this DOE order.

3.9 Preliminary Remedial Action Objectives

The NCP (40 CFR 300.430(e)(2)(i)) states that RAOs be developed specifying contaminants and media of concern, potential exposure pathways, and remediation goals. For assessing data adequacy, this section includes an initial identification of RAOs. The RAOs will be refined as needed (based on the BRA) and used during the detailed analysis of alternatives conducted in the FS. The RAOs will be finalized and documented in the ROD.

The following RAOs are preliminary descriptions of what the remedial action is expected to accomplish. RAOs also are used to evaluate the various remedial alternatives and long-term protectiveness.

- **RAO #1:** Prevent or mitigate unacceptable risk to human health and ecological receptors associated with radiological exposure to waste or soil contaminated above risk-based criteria.
- **RAO #2:** Prevent or mitigate unacceptable risk to human and ecological receptors associated with chemical exposure to waste or soil contaminated above risk-based criteria for human health or soil contaminant levels on a population or community level for ecological receptors.
- **RAO #3:** Control the sources of potential groundwater contamination to support the Central Plateau groundwater goal of restoring and protecting the beneficial uses of groundwater.

3.10 Preliminary Remediation Goals

For human health direct contact, PRGs will be developed as described in Section 3.8.1.8. Section 3.8.2.7 describes ecological PRGs. For groundwater protection, development of PRGs will be based on the process defined in DOE/RL-2011-50. Section 3.8.3 provides the implementation details for this approach.

3.11 Preliminary Remedial Technologies and Process Options

According to EPA/540/G-89/004, "technology types" are defined as "general categories of technologies" (e.g., in situ grouting, vapor extraction, or capping) and technology process options are "specific processes within each technology type." A wide span of technology types and process options are evaluated, which refer to general categories of technologies and specific process options within each technology type, respectively. For example, technology types could include ex situ treatment processing or disposal. The process options for ex situ treatment processing could include either soil washing or ex situ thermal desorption, while the process options for disposal could include backfill with treated soil or onsite landfill at ERDF.

Process knowledge of the waste types, COPCs, and the CERCLA criteria will be used as evaluation matrices to tabulate a list of candidate technologies. The screening process will consider the physical specifications, OU process history, and operational logistics of each waste site type; however, the screening process will focus primarily on waste streams, COPCs, and extent of impact for sites where historical analytical data are available.

The preliminary candidate technologies to be considered during the CMS/FS process for vadose zone remediation are presented in Table 3-7 and will be evaluated for each landfill. Preliminary remedial technologies will be screened in the CMS/FS for effectiveness, implementability, relative capital costs, relative operation and maintenance costs, and sustainability. For the purpose of the CMS/FS, effectiveness refers to the ability of the process option to perform as part of a comprehensive remediation plan to meet RAOs under the conditions and limitations present at the site. Implementability refers to the relative degree of difficulty anticipated in implementing a particular process option under regulatory, technical, and schedule constraints posed by the site. An outline of the relationship between RAOs,

general response actions, remedial technology types, and process options is presented in EPA/540/G-89/004.

The RI/FS report will include a final determination regarding which technologies will be retained. In accordance with EPA and NCP (40 CFR 300) guidance, technologies and process options are categorized as follows: (1) general response actions, (2) remedial technology, and (3) process options. Technologies that are not retained during the RFI/CMS/RI/FS report evaluation will be identified and a thorough explanation will be provided in an appendix to the report. The results of the landfill-type categorization process will facilitate selection of appropriate technologies that are applicable for each waste site.

The preliminary list of technologies will be described in further detail in the RFI/CMS/RI/FS report using technology fact sheets. The fact sheets, in general, will include the following:

- High-level concepts of the technology
- Conceptual graphic depicting the technology
- Simplified exposure model showing how the technology reduces or removes risk to receptors
- Typical implementation steps

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Table 3-7. Preliminary Identification of Remedial Technologies for Vadose Zone Area Remediation of the 200-SW-2 OU

General Response Actions	Remedial Technology	Process Option	COPC Applicability[a]	Depth Range[b]	Description
Natural attenuation	MNA	MNA	Radionuclides with reasonable half-lives. Select organic compounds and metals.	Shallow/deep	Contaminants in the vadose zone are allowed to attenuate over time from natural biological processes, chemical processes, radioactive decay, and/or flushing from surface water infiltration. Rates of flushing must be low enough that groundwater standards are not exceeded. Involves ongoing monitoring to verify attenuation processes are occurring. Contingency measures are developed if attenuation is not adequate to control the risks. Typically combined with other technologies that manage the source areas and mitigate exposure. Fully mature technology.
Removal	Excavations	Standard excavations	All	Shallow	Shallow soil in identified source areas is removed using conventional construction equipment. Excavation limited to approximately 6 m (20 ft) bgs. Excavated soil is segregated (automated or laboratory-based) to determine disposal or treatment requirements.
		Deep excavations	All	Deep	Deep excavation with sloping and/or benching is a fully mature technology. Significant laybacks or a combination of innovative and mature technologies is required for deep excavations. Excavated soil is segregated (automated or laboratory based) to determine disposal or treatment requirements.
Disposal	Disposal	Backfill treated soil	All	Shallow/deep	Excavation and ex situ treatment followed by onsite disposal (backfill). Fully mature technology.
		Onsite landfill	All	Shallow/deep	Disposal of excavated soil at the Environmental Restoration Disposal Facility. Treatment performed at the facility as required to meet land disposal restrictions. Fully mature technology.
		Offsite landfill	All	Shallow/deep	Disposal of excavated soil at offsite landfills. Fully mature technology.
		Offsite repository (Waste Isolation Pilot Plant)	TRU waste	Shallow/deep	TRU waste is soil and debris containing alpha-emitting TRU radionuclides with half-lives greater than 20 years at concentrations greater than or equal to 100 nCi/g at the time of assay. TRU radionuclides include elements with atomic numbers greater than -92 (e.g., neptunium, plutonium, americium, and curium). TRU waste must be packaged and shipped to the Waste Isolation Pilot Plant in Carlsbad, New Mexico.
Containment	Surface barriers	Maintain existing soil cover	All	Shallow/deep	The existing soil cover on a waste site is maintained and/or augmented as needed to provide protection from intrusion by biological receptors. Existing soil covers include soil stabilization covers and clean overburden.
		Hanford barrier	All	Shallow/deep	A prototype, nine-layer earthen barrier with a total thickness of 4.5 m (11.8 ft). Constructed over a waste site at Hanford in 1994 to provide long-term protection of radioactive waste in a semiarid environment. Designed to be impermeable to prevent surface water infiltration through the vadose zone and limit contaminant leaching to groundwater. Will also prevent direct contact to contaminants via biological intrusion.
		Modified RCRA Subtitle C and/or D barrier	All	Shallow/deep	Modified RCRA Subtitle C barriers are designed for hazardous waste, Category 3 and Category 1 (mixed) low-level waste. Modified RCRA Subtitle D barriers are designed for nonradiological and nonhazardous solid waste or Category 1 low-level waste where hazardous constituents are not present. Various modifications to a RCRA C barrier designed to be site-specific. Number of layers can vary from four to seven. Modified RCRA D barriers are composed of approximately four layers with a relative thickness of 0.9 m (2.9 ft). Barriers are generally designed to be impermeable to prevent surface water infiltration through the vadose zone and limit contaminant leaching to groundwater. May also prevent direct contact to contaminants.
		Asphalt/concrete cap	All	Shallow/deep	Asphalt/concrete caps consist of asphalt and aggregate that is placed to form a surface barrier between waste area and the environment. This technology is well established. Asphalt/concrete caps are simple to construct. Typically used in the short term (75 years) to promote drainage, prevent infiltration into possible sources, and prevent exposure to contaminated soil.
		Vegetative cap (evapotranspiration cap)	All	Shallow/deep	Capillary barrier, which consists of a fine-grained soil layer overlying a relatively coarse-grained soil layer. The distinct textural interface in capillary evapotranspiration barriers between the fine and coarse soil layers creates a capillary break, which functionally increases the water-holding capacity of the fine-grained soil over that associated with unimpeded vertical drainage. Water will not flow into the coarse layer until the water content approaches saturation in the fine-grained soil layer. If the textural interface is sloped, water will move laterally in the fine soil layer above the interface, providing an additional mechanism for water removal.
	Horizontal subsurface barriers	Jet grouting, soil freezing	All	Shallow/deep	Barriers placed beneath the contaminated zone to limit further migration. Jet grouting is the injection of a grout mixture at very high pressures and velocities into the pore space of the soil or rock through small orifices located in the drill pipe above the drill bit. Soil freezing involves placement of cooling media distribution systems into the subsurface to freeze the soil pore water below the contamination. Frozen soil barriers (or cryogenic barriers) are constructed by freezing.

Source: DOE/RL-2001-41, *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions and RCRA Corrective Actions.*

a. Indicates the contaminants that can be addressed by a technology based on geochemical properties. A COPC applicability of "All" indicates implementation of a technology is not dependent on the nature of a chemical.

b. Depth range is based on practical limitations of implementing the given technology. "Shallow" is less than or equal to 4.6 m (15 ft) bgs; "deep" is greater than 4.6 m (15 ft) bgs.

bgs = below ground surface
COPC = contaminant of potential concern
RCRA = *Resource Conservation and Recovery Act of 1976*
TRU = transuranic
MNA = monitored natural attenuation

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4 Remedial Investigation/RCRA Facility Investigation and Feasibility Study/Corrective Measures Study Data Needs

This chapter presents the data needs based on the initial evaluations described in Chapter 3. The field and analytical tasks necessary to fulfill the identified data needs are presented in Chapter 5.

The initial assessment of data needs was conducted via the DQO process (Appendix J). This chapter describes the data needs and examines additional data needs associated with meeting the work plan objectives and supporting the FS/CMS. If during the RFI/CMS/RI/FS process additional data needs are identified to support development of remedial alternatives, a supplemental DQO and SAP will be developed.

4.1 Strategy for Defining Data Needs

Data gathering occurs at various stages in the RFI/CMS/RI/FS, remedial design, and remedial action process:

- **Decision stage:** Data are collected during the RFI/CMS/RI/FS to support the following actions:
  - Identify contaminant sources.
  - Identify landfills that have sufficient data to satisfy some or all the principal study questions (PSQs).
  - Evaluate the nature and extent of contaminants in environmental media.
  - Evaluate potential risks to HHE.
  - Determine the need for action through the BRA.
  - As appropriate, support remedy treatability testing and the development and evaluation of remedial action alternatives to mitigate unacceptable risks.
  - Support establishing performance metrics for vadose zone remedies that will support remedy alternative development.
- **Remedial design stage:** Additional field data may be collected to support remedial design. For example, additional data may be collected to refine quantification of natural attenuation, to refine targets for remedy actions in order to obtain performance goals, or to evaluate appropriate sequencing of remedy elements as for an adaptive approach.
- **Remedy implementation stage:** Additional confirmation or verification data may be obtained to support remedy implementation, transition between stages of a remedy, and/or remedy optimization. Data collection and monitoring during remedy implementation may be progressive and tied to the stages of remediation. Monitoring implementation builds on the CSM established during the decision and remedial design stages and can be tailored to focus on diagnostic elements of the contaminant system as remediation progresses from initial implementation and performance assessments toward longer term management.
- **Remedy completion stage:** Data may be collected during this stage to verify that the remedy has been effective and mitigated the identified risk for the landfills, and that the remedial action is complete.

This work plan presents an evaluation of available data to determine data needs. Information concerning the nature and extent of contamination at waste sites was assessed to determine whether sufficient data exist to evaluate risks and consequently develop an appropriate remedial decision. Based on the data collected during the RI/RFI, treatability tests may be conducted for 200-SW-2 OU contaminant mitigation technologies, contained precipitation, or liquids in the landfill that contributed to contaminant infiltration.

4.2 Data Quality Objectives Evaluation

The approach to identifying the data needs relies on the DQOs (Appendix J). The rationale for the proposed characterization is to address the data needs and is based on many factors, including the following:

- Landfill type, size, contents (based on historical records), and years of operation
- Collocated sites and proximity to other landfills (including Green Islands)
- Trench configuration (used and unused portions)
- Previous investigations (TRU excavations, soil gas sampling, and surface radiation)
- Proposed TRU excavations

Based on these factors, the PSQs and decision rules are shown in Table 4-1.

Table 4-1. 200-SW-2 OU PSQs and Decision Rules

Principal Study Question	Decision Rule
1 What data are required to support evaluation of risk, pathways, and development of remedial action alternatives?	If the design of the RFI/CMS/RI/FS characterization approach was sufficient to support evaluation of risk, pathways, and development of remedial action alternatives, then perform the evaluation of risk and select the appropriate alternative; otherwise, additional data will need to be collected.
2 Were enough data collected to support the RFI/CMS/RI/FS and selection of remedial action alternatives?	If enough data were collected to support the RFI/CMS/RI/FS and select remedial action alternatives, then select the appropriate alternative; otherwise, additional data will need to be collected.
3 Were enough data collected to evaluate whether buried waste presents a long-term effect on HHE?	If enough data were collected to evaluate whether buried waste presents a long-term effect on HHE, then select the appropriate alternative; otherwise, additional data will need to be collected.

HHE = human health and the environment
RCRA = *Resource Conservation and Recovery Act of 1976*
RFI/CMS/RI/FS = RCRA field investigation/corrective measures study/remedial investigation/feasibility study

4.3 Data Needs

A combination of intrusive and nonintrusive methods was identified to collect information regarding the nature and extent of landfill contaminants and potential risks to HHE (i.e., relevant risk pathways), support treatability testing, and support remedial action alternative development. The proposed characterization tasks for each landfill and the PSQs they satisfy are described in the SAP (Appendix A, Table A-9) and are related to their specific data needs as described in the CSM in Appendix D.

4.4 Characterization

The proposed characterization described in this work plan was developed in collaboration with Ecology and DOE-RL through multiple workshops. During those workshops, the proposed characterization for each landfill, UPR, and liquid disposal site were discussed.

4.4.1 Landfills

As part of developing the characterization plan, the landfill characteristics were discussed (e.g., inventory/contents, type, location, size, history of use, collocated waste sites). Based on this information and collaborative effort, the characterization strategy for each landfill that is presented in this work plan was developed. After the proposed characterization for each landfill was developed, a more global view of the proposed characterization was undertaken. As part of the global view, the landfill-specific characterization was plotted on plates for the western and eastern Inner Areas so the proposed characterization for each of the landfills could be evaluated against the characterization being proposed at adjacent landfills. The overall characterization plan was then adjusted, as needed, to ensure that all areas of the landfills received some level of characterization and that the landfills that have a greater risk potential (i.e., high uranium or plutonium content or hydraulic driving force) receive additional characterization.

4.4.2 Unplanned Releases

The proposed characterization for the UPRs will be completed in two steps. The first nonintrusive step consists of aerial radiation surveys, baseline geophysics, MASW geophysics, and passive soil gas sampling. The second step of the characterization consists of one or more intrusive sampling techniques including ERT and STS geophysics, horizontal borings, direct pushes, active soil gas sampling, and test pits. The collected data from these steps will be evaluated along with existing information to determine a basis for action and remedy evaluation.

4.4.3 Liquid Disposal Sites

The proposed characterization for the liquid disposal sites (e.g., former ponds) will be completed in two steps. The first nonintrusive step consists of the aerial radiation survey, baseline geophysics, MASW geophysics, and passive soil gas sampling. The second step of the characterization consists of one or more intrusive sampling techniques including ERT and STS geophysics, horizontal borings, direct pushes, active soil gas sampling, and test pits. The collected data from these steps will be evaluated along with existing information to determine a basis for action and remedy evaluation.

4.4.4 Characterization Activities

The characterization activities proposed to address 200-SW-2 OU data needs include the following.

- **Aerial radiological surveys:** A wide-area radiological survey map of the eastern and western portions of the Inner Area will be made to provide additional information about near-surface radioactive (beta and gamma) contamination. This characterization task satisfies PSQ 1 and PSQ 2. The aerial radiological survey will be done to measure radiation emissions from the ground surface in the area of the landfills and will be used to evaluate the potential for direct human and ecological exposure. The survey will use a grid spacing of 30.5 m (100 ft) and will be conducted at an elevation of 15 m (50 ft) above the ground surface using fixed-wing aircraft or a helicopter. Additional information regarding the aerial radiological survey is presented in the SAP (Appendix A).

- **Baseline geophysical investigations:** Baseline geophysical investigations will be performed at landfills that have not been investigated previously or where the trench locations are suspect. This characterization task satisfies PSQ 1 and PSQ 2. These investigations can provide data regarding waste trench location and configuration, existence of potential anomalies, and metallic objects beneath the surface. The baseline geophysical methods include ground-penetrating radar, electromagnetic induction, and total magnetic field. The data will support selecting locations for passive soil gas samples and potentially adjusting the locations of the direct pushes and horizontal borings proposed.

- **Passive and active soil gas sampling:** Passive soil gas sampling will be performed on landfills where geophysical anomalies (i.e., barrels and tanks) were identified during the baseline geophysical investigation and in the area of the Green Islands. Additional locations may be selected based on a review of the landfill records. For landfills where there have been no previous investigations, it is assumed that one passive soil gas sample per acre will be collected.

  - The soil gas samples will be used to identify release mechanisms (e.g., VOCs from barrels and tanks containing organic compounds). This characterization task satisfies PSQ 1 and PSQ 2. Additional information regarding active and passive soil gas sampling is presented in the SAP (Appendix A).

  - Active soil gas sampling locations will be based on the results of the passive soil gas sampling. Active soil gas samples will be collected in areas where "hits" of passive soil gas greater than 1,000 ng were measured. Prior to collecting the active soil gas sample, additional passive soil gas samples will be collected in a "T" pattern at 15 m (50 ft) intervals (up to 61 m [200 ft]) in four directions to confirm the location of the highest passive soil gas hit.

- **Advanced geophysical investigations:** Advanced geophysical investigations are proposed for some landfills. This characterization task satisfies PSQ 1 and PSQ 2. These investigations could identify preferential pathways for landfill contaminants in the vadose zone to reach groundwater. The proposed methodologies include multi-channel analysis of surface waves (MASW), surface-to-surface (STS) electrical resistivity, and electrical resistivity tomography (ERT). The MASW method will be used to look for preferential pathways below the landfill. The STS and ERT will be used to look for fluid (i.e., liquid contamination) in the vadose zone below the landfills.

  The rationale for the landfills that were selected for advanced geophysics includes the following:

  - Evaluate historical liquid infiltration and the potential for preferential pathways (ponding, episodic water, or disposal of large quantities of water [i.e., T Ponds and the 216-C-9 Pond]). In the case of the ponds, liquid infiltration may have occurred *before* the area was used as a landfill. However, contamination could be present in the vadose zone below the landfills.

  - Develop a better understanding of the vadose zone below landfills with relatively few records.

Landfills showing evidence of higher potential risk will receive more intensive study. The vadose zone will be thoroughly investigated to determine moisture levels and the degrees of mobile contaminant spread, with special emphasis placed on those landfills over former pond sites.

The MASW method will be done at the same time that the baseline geophysical investigations are performed. The STS method will follow the MASW, and the ERT will be done last. The locations for the STS and ERT will be based on the results of the MASW.

The proposed locations of the direct pushes and the horizontal borings may change based on the MASW results. In other words, if preferential pathways are identified from the MASW data, then a direct-push or horizontal boring may be relocated so samples from the potential pathway can be collected. Additional direct-push samples may also be added. The landfills to be investigated using these methods are identified in the SAP (Appendix A).

- **Direct-push samples and horizontal borings:** The direct pushes and horizontal borings could identify release and transport media to the vadose zone adjacent to and below select landfills. This characterization task satisfies PSQ 1 and PSQ 2. Samples collected from the direct pushes and horizontal borings will be analyzed for COCs.

Direct pushes will be conducted between the trenches so waste will not be sampled or disturbed, but they will extend to below the bottom of the trenches. The proposed locations of the pushes ensure that all of the landfill areas have at least one push. Additional pushes are proposed in areas with a history of hydraulic driving force (i.e., T Ponds, 216-C-9, or episodic ponding), areas with a higher potential for historic releases (the former Z Plant burn pit), and areas adjacent to Green Islands. As part of the selection of the locations, historical information and professional judgment were used. The proposed locations described in the SAP may be changed based on soil gas and geophysical data.

Direct-push soil samples will be collected at 1.5 m (5 ft) intervals and will be completed 18 m (60 ft) bgs (all trenches are less than 9 m [30 ft] deep). Samples will be collected as the probe is driven. Sample results will provide information on contamination beneath and adjacent to the landfills and will also support geophysical data interpretation. Additional information regarding the direct-push sampling is presented in the SAP (Appendix A).

Horizontal borings are proposed to be installed in specific areas beneath select landfills to investigate the vadose zone for releases. Samples will be collected under the center of each trench that the horizontal boring passes under. In addition, the borings may be equipped with instrumentation so monitoring can be done in the future. Additional information regarding the horizontal borings is presented in the SAP (Appendix A).

The rationale for select direct-push and horizontal boring locations includes the following:

- They are based on trench density, landfill type, and Green Islands. The proposed locations are tentative and will be confirmed based on the geophysics and soil gas sampling results. It is noted that the locations of the horizontal borings as shown in this work plan were determined collaboratively in a series of workshops with Ecology and DOE-RL. As part of selecting the locations, historical information and professional judgment were used.
- They ensure wide areal coverage of the landfills. For example, more pushes and borings are proposed for the 218-E-12B Landfill because it is relatively large. Conversely, smaller landfills have fewer proposed pushes and/or borings.
- Five pushes are proposed for the 218-E-1 Landfill because it is isolated and has few records.
- The horizontal boring lengths are limited to 152 to 183 m (500 to 600 ft) and will require a pit for the drill rig, so a "clean" area is required adjacent to the trenches.
- Some of the horizontal borings are in areas of high-density trench locations to obtain as much data as possible from areas that may have had potential releases (e.g., under the trenches).

- A relatively large number of direct pushes are proposed in the 218-W-4A Landfill because it has the most uranium disposed of any of the landfills and the fourth highest quantity of plutonium. Similarly, the 218-W-2A Landfill has a relatively high number of pushes and a horizontal boring because it has the largest quantity of disposed plutonium. The reasoning behind this approach is that if there have been releases of uranium or plutonium from any of the 200-SW-2 OU landfills; it is likely to have occurred from 218-W-2A or 218-W-4A because they have the greatest quantities of disposed uranium and plutonium. If releases are detected under the 218-W-4A or 218-W-2A Landfill, then investigations under other landfills with high uranium and/or plutonium amounts disposed may be merited.
- A horizontal boring under the 218-W-2A Landfill is tentatively proposed because it is the former T Ponds location. The T Ponds may have provided a driving force that transported mobile contaminants that are not necessarily from the landfill waste into the vadose zone below the landfill.
- A direct push is tentatively proposed in the area of the former Z Plant burn pit, which is collocated in the 218-W-4C Landfill.

- **Test pit excavations:** Focused and random test pits will be excavated in select landfills to confirm waste burial records. This characterization task satisfies PSQ 1, PSQ 2, and PSQ 3. The 200-SW-2 OU landfills will have test pits *unless* they meet one or more of the following characteristics:
  - Highly radioactive waste is recorded in any part of the landfill (for greater than 120 R/hr at burial; this primarily applies to TSD landfills).
  - Waste is mainly packaged in large boxes (test pits not needed because waste would not be visible).
  - Photographic history demonstrates good correlation with records (test pits not needed).
  - Good burial records exist (test pits not needed).

  In each landfill selected for test pits, one focused and one random pit will be excavated. The method for selecting the pit locations and the specific locations for each are described in the SAP (Appendix A). In general, the focused locations are based on historical process knowledge, and it is anticipated that these excavations will confirm the locations of the recorded landfill contents. The random locations are based on random coordinates selected using the random number generator in Microsoft® Excel®[1]. Additional information regarding the test pits is provided in the SAP (Appendix A).

Limited excavations are planned in 15 landfills in accordance with the Hanford Advisory Board (HAB) recommendation that an "observational approach" be adopted where additional information about landfill waste is needed.

- **Multi-detector probe:** The multi-detector probe will be used to investigate the level of radioactive (beta and gamma) contamination in the caissons. This characterization task satisfies PSQ 1, PSQ 2, and PSQ 3. Additional information regarding multi-detector probes is presented in the SAP (Appendix A).

[1] Microsoft® and Excel® are registered trademarks of Microsoft Corporation in the United States and/or other countries.

4.5 Treatability Studies

Under CERCLA, treatability studies are an important component of the RI/FS process and the remedial design/remedial action process. These studies provide site-specific data that aid in the screening, selection, and implementation of potential remedial actions. Treatability studies also provide performance and cost information that is needed to evaluate remedial alternatives.

At this point in the work plan development, no treatability studies are anticipated for the 200-SW-2 OU. As appropriate, the candidates for treatability testing under the work plan will be selected based on a review of previous Hanford Site technology screenings and from results of recent technology development efforts.

4.6 Innovative Investigation Techniques

Three of the investigation techniques proposed for use at the 200-SW-2 OU landfills have a limited history of deployment at the Hanford Site: horizontal borings, downhole ERT, and MASW. A fourth technique is deriving concentrations from passive soil gas by scaling the passive data with the simultaneous collection of active soil gas samples. Future innovative techniques, if any, will be evaluated to determine if they have significant advantages over currently employed techniques before they are used at the 200-SW-2 OU.

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5 Remedial Investigation/Feasibility Study and RCRA Facility Investigation/Corrective Measures Study Tasks

This chapter describes the 12 tasks that will be completed during the RFI/CMS/RI/FS process. These descriptions incorporate the RFI/RI site characterization field and analytical tasks necessary to fulfill the data needs presented in Chapter 4, data evaluation methods, analysis of remedial alternatives, reporting, and the preliminary determination of tasks to be conducted after completion of the RFI/CMS/RI/FS.

5.1 Task 1 – Project Planning

Project planning for the 200-SW-2 OU RFI/CMS/RI/FS was initiated in 2003. A series of meetings were held with Ecology, EPA, DOE-RL, Pacific Northwest National Laboratory (PNNL), HAB members, representatives from Tribal Nations, and CH2M HILL Plateau Remediation Company (CHPRC) and its predecessor contractors and subcontractors (200-SW-2 OU project) to develop the expectations for the 200-SW-2 OU work plan and to facilitate integration of project needs and data. These meetings began in 2003 and have continued until 2015.

The RFI/CMS/RI/FS activities for the 200-SW-2 OU will be coordinated with those of the M-091-49 RSW-TRU retrieval project. Planning activities for the 200-SW-2 OU have produced the following types of documents:

- CSMs, which are the initial evaluations of existing data used in Chapter 3 of this work plan and are presented in Appendix D. Each CSM contains background information summarizing waste disposal history, waste site area, trench configuration, description of solid waste forms, photographs of disposals, a list of items disposed, estimated waste constituent inventory, results of previous investigations, and a cross section of the landfill depicting the waste and disposal trenches.
- DQO summary reports for prior geophysical and soil vapor investigations (e.g., D&D-27257, *Data Quality Objectives Summary Report for Nonintrusive Characterization of Bin 3A and Bin 3B Waste Sites in the 200-SW-2 Operable Unit*; SGW-33253, *Data Quality Objectives Summary Report for Phase I-B Characterization of the 200-SW-2 Operable Unit Landfills*).
- The DQO summary report for 200-SW-2 OU waste sites (Appendix J of this work plan), which was developed to identify data needs described in Chapter 4 of this work plan.
- Summary reports of the results of previous soil gas and geophysical studies of the 200-SW-2 OU (e.g., SGW-32683, *Results from Passive Organic-Vapor Sampling in Selected 200-SW-2 Operable Unit Landfills (218-W-3A, 218-W-3AE, 218-W-4B, 218-W-4C, and 218-W-5), June-July 2006*; SGW-48278, *Investigation of Unused Landfill Areas: 218-W-4C, 218-W-6, 218-E-10, and 218-E-12B*).
- This RFI/CMS/RI/FS work plan, which identifies the scope and objectives of the planned work.
- SAPs that describe the collection of measurements and observations identified outside the scope of this work plan (e.g., D&D-28283, *Sampling and Analysis Instruction for Nonintrusive Characterization of Bin 3A and Bin 3B Waste Sites in the 200-SW-2 Operable Unit*).
- SAPs that describe the collection of measurements and observations to fill data needs identified in Chapter 4 of this work plan. Each SAP consists of a field sampling plan and quality assurance project plan (QAPjP) that provide specific details of data collection.

- A summary report of methodology used to develop CSMs (SGW-34462, *Application of the Hanford Site Feature, Event, and Process Methodology to Support Development of Conceptual Site Models for the 200-SW-2 Operable Unit Landfills*).
- A project schedule that defines project activity sequences and identifies delivery of enforceable milestone documents (Chapter 6 of this work plan).
- HAB advice received for the 200-SW-2 OU.
- Input from public involvement meetings for the 200-SW-2 OU held in Richland, Seattle, Hood River, and Portland.

5.2 Task 2 – Community Relations

A public involvement plan (DOE et al., 2012, *Hanford Federal Facility Agreement and Consent Order Hanford Public Involvement Plan*) and the NCP (40 CFR 300) outline stakeholder and public involvement opportunities. Community involvement during the RFI/RI activities will be consistent with the Hanford Public Involvement Plan (DOE et al., 2012) and will comply with the NCP. The project will use existing public, stakeholder, and area tribes involvement mechanisms and approaches.

Decision making will be guided by the following four key values, consistent with HAB advice:

1. *Minimize impacts on human and environmental health.*
2. *Protect worker safety.*
3. *Conduct an effective and cost-efficient cleanup.*
4. *Guarantee public participation and transparency.*

5.2.1 Tribal Consultation

Interactions between the area tribes and DOE-RL are facilitated through the DOE-RL Tribal Program Manager or the DOE-RL Cultural Resources Program Manager. DOE-RL interacts primarily with the Confederated Tribes and Bands of the Yakama Nation, the Confederated Tribes of the Umatilla Indian Reservation, the Nez Perce Tribe, and the Wanapum Band of Indians. Tribal consultation is in accordance with DOE O 144.1, *Department of Energy American Indian Tribal Government Interactions and Policy*. DOE-RL consults and communicates regularly with tribal program staff as well as offers tribal consultation to tribal governments and will consult with a tribal government upon its request. DOE-RL conducts regularly scheduled and ad hoc meetings with tribes based on tribal interest and needed tribal input and involvement. DOE-RL will continue to work with area tribes to ensure ongoing communication and involvement in the Inner Area decision-making process. EPA also has a government-to-government responsibility and will coordinate with DOE-RL on consultation with the tribes.

This effort will include timely notice to area tribes on decisions that might affect their rights and/or resources in the early stages of the decision-making process.

5.2.2 Stakeholder Involvement

Stakeholders are individuals who are affected by, or have an interest in, Hanford Site issues. Hanford Site stakeholders include the Hanford Natural Resource Trustees; local governments; local and regional businesses; the Hanford Site work force; local, regional, and national environmental groups; and local and regional public health organizations.

The HAB is a site-specific advisory board chartered under the *Federal Advisory Committee Act of 1972*. The HAB advises the Tri-Parties on cleanup issues. The HAB's River and Plateau Committee addresses River Corridor and Central Plateau issues and meets approximately 10 times each year. Based on the

timing of the development of significant work plan components, periodic updates will be provided to the River and Plateau Committee.

The River and Plateau Committee provides an ongoing opportunity for informal stakeholder feedback on work plan components and evolving project activities. The committee decides if an issue should be brought to the full HAB, which then determines whether formal advice should be issued.

5.2.3 Public Involvement

Public input was considered in the proposed RFI/RI characterization for the landfills. Public involvement, in accordance with this plan, will continue in the public comment period for the Proposed Plan.

5.3 Task 3 – Field Investigations and Analytical Tasks

Field investigations and analytical tasks will be conducted for the 200-SW-2 OU RFI/CMS/RI/FS to supplement existing data. The field investigation and data analysis activities will address the data needs defined in Chapter 4. The data needs were identified through the DQO process that was completed for the 200-SW-2 OU waste sites (Appendix J).

The scope of the field investigations is described the SAP (Appendix A). The SAP provides the QAPjP and the field sampling plan for the characterization activities.

The sampling activities designed to fill specific data gap with respect to the CSM for each landfill is summarized in the SAP (Appendix A, Table A-7). The SAP describes the types of analyses to be performed; the samples to be analyzed; and the precision, accuracy, representativeness, completeness, and comparability parameters used to obtain a sufficient representation of conditions at the site.

Other field-related activities include procurement of investigation contractors, mobilization and demobilization of equipment (including equipment decontamination), and management of investigation-derived waste (IDW). Generally, the order of the work will proceed per the following steps, with each step building on the outcome of the previous steps:

1. **Review and catalog existing data:** Compile and organize historical information by landfill.
2. **Perform aerial radiological surveys:** Look for near-surface radioactive hot spots identified by fly-overs of the Central Plateau.
3. **Fill data gaps from earlier investigations:** Collect baseline geophysics and passive soil gas data from those landfills where none currently exists. Baseline geophysics is needed to determine trench boundaries and to detect large objects.
4. **Perform advanced geophysics:** Collect MASW seismic and STS electrical resistivity results and identify the locations for the ERT boreholes.
5. **Conduct intrusive investigations and install wells:** Mobilize horizontal drilling, direct push, and sampling equipment. Collect active soil gas samples from landfills with previous passive soil gas detections. Collect direct-push samples and install downhole ERT electrodes. Install horizontal borehole and time domain reflectometry leak detection equipment. Random and focused test pits will be excavated per the SAP.
6. **Manage investigation-derived waste:** Manage IDW per DOE/RL-2011-41, *Hanford Site Strategy for Management of Investigation Derived Waste*. Manage waste generated during characterization activities in accordance with an approved waste control plan. This includes unused samples, test pit excavated waste, and offsite laboratory waste.

5.4 Task 4 – Sample Analysis/Data Validation

The SAP for the 200-SW-2 OU (Appendix A) identifies the target analytes, analytical methods, and analytical performance requirements for analysis of collected samples. The data obtained will be reviewed, verified, and validated in accordance with the QAPjP in the SAP.

The criteria for verification include, but are not limited to, review for completeness (i.e., samples were analyzed as requested), use of the correct analytical methods/procedures, transcription errors, correct application of dilution factors, appropriate reporting of dry weight versus wet weight, and correct application of conversion factors. Laboratory personnel may perform data verification.

Data validation will be performed to ensure that the data quality goals established during the RFI/CMS/RI/FS planning phase have been achieved. Data validation will be based on EPA functional guidelines. The criteria for data validation are based on a graded approach. The primary contractor has defined five levels of validation: Levels A through E. Level A is the lowest level and is the same as verification. Level E is a 100 percent review of all data (e.g., calibration data and calculations of representative samples from the data set). The level of data validation is specified in the QAPjP in the SAP. Data validation may be performed by the Sample Management and Reporting organization and/or by a party independent of both the data collector and the data user.

The determination of data usability will be conducted and documented in data quality assessment (DQA) reports. Data validation will be documented in data validation reports and included in the project file.

5.5 Task 5 – Data Evaluation

The measurement and observation data collected during the field activities described in the SAP for the 200-SW-2 OU will be evaluated, reduced, and presented in tabular and graphic format for subsequent use in the risk assessment, fate and transport evaluation, and for preparation of RFI/CMS/RI/FS reports. The data review and validation results in the DQA report will be used to qualify the data to confirm that only data of known and acceptable quality are used in subsequent data analyses.

The preliminary CSMs developed to support preparation of this work plan will be refined and updated through analysis, interpretation, and evaluation of data collected in accordance with the SAP for the 200-SW-2 OU and from other pertinent projects, as applicable. For each landfill or group of landfills, a data summary will be prepared describing information that will be used to evaluate site risk, assess potential threats to groundwater, and develop and evaluate remedial alternatives. The results of the evaluation will be reported in the RFI/RI report.

5.6 Task 6 – Assessment of Risk

The BRA will be conducted as part of the RFI/RI process to assess potential risks to human and ecological receptors from direct contact with soil, and potential risks to groundwater from contaminants in the vadose zone. The BRA will determine if there is a need to take remedial action to reduce risks to acceptable levels. Cleanup levels (i.e., PRGs) will also be developed as part of this task.

Due to the scope of the 200-SW-2 OU and its proximity to other OUs, a groundwater cumulative impacts evaluation (CIE) for source units and existing groundwater contamination will be conducted and documented in accordance with an approach document. This CIE approach document will be produced to gain regulatory agency concurrence on the evaluation approach. The CIE will be defined as follows: "Effects on the environment that result from the proposed action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes such other actions" (40 CFR 1508.7, "Terminology and Index," "Cumulative Impact"). The objectives of the long-term

groundwater impacts analysis are to (1) present a comprehensive evaluation to allow an informed decision making process, and (2) provide a context for comparison of the alternatives evaluated in the feasibility studies (conducted under CERCLA) for the source OUs. This analysis will also fulfill the requirements specified in WAC 173-340-747(8), "Deriving Soil Concentrations for Ground Water Protection," which states: "If detectable concentrations of hazardous substances are present in upgradient groundwater, then the dilution factor may need to be adjusted downward in proportion to the background (upgradient) concentration." The cumulative impacts evaluation will integrate understanding of contributions from all waste sites, potential sources, and existing groundwater contamination for sound decision making. Similar to the composite analysis required for low-level waste disposal facilities, this evaluation can also be used as a planning tool intended to provide a reasonable expectation that remedial actions and waste disposal activities will not result in the need for future corrective or remedial actions to ensure protection of public health and the environment (DOE M 435.1-1 Admin Chg 2, *Radioactive Waste Management Manual*).

5.7 Task 7 – Treatability Studies

No treatability studies are planned. The need for treatability studies will be revisited as the RFI/RI proceeds. To the extent that treatability studies are deemed necessary, the intent is to implement them early, as part of the RFI/RI, to assist remedial alternative evaluations for the FS/CMS.

5.8 Task 8 – Field Summary Reports

As the field investigations (and possibly treatability studies) are completed, field summary reports will be prepared to summarize the activities performed and the information collected in the field. The reports will include survey data for borehole locations, the number and types of samples collected, inventory of IDW containers, geological logs, field screening results, and geophysical logging results. The field summary reports support the preparation of the RFI/CMS/RI/FS reports.

5.9 Task 9 – Remedial Alternative Development and Screening

A range of potential remediation technologies has been developed and evaluated to support earlier versions of this work plan and associated activities. Supporting technologies (Table 5-1) were developed from resources including a technology pre-screening document (PNNL-16105, *Technology Survey to Support Revision to the Remedial Investigation/Feasibility Study Work Plan for the 200-SW-2 Operable Unit at the U.S. Department of Energy's Hanford Site*), the Collaborative Agreement (CCN 0064527, "200-SW-1 and 200-SW-2 Collaborative Workshops, Agreement, Completion Matrix, and Supporting Documentation, Final Product"), and the follow-up path forward (CCN 0073214, "Path Forward: 200-SW-1/2 RI/FS Work Plan Development"), which identified likely response scenarios applicable to the 200-SW-2 OU. The pre-screening of characterization technologies considered activities at the 618-10/618-11 Solid Waste Burial Grounds, other Hanford Site projects, and other DOE Complex sites. Remediation and characterization technology experts from PNNL, Idaho National Laboratory, and Oak Ridge National Laboratory provided technical review and input to the technology screening activities.

Table 5-1. Potential General Responses and Supporting Technologies

Potential General Response Scenario	Supporting Technologies
Surface and subsurface barriers	Arid climate engineered barrier
	Asphalt, concrete, cement-type cap
	RCRA cap
	Slurry walls
	Grout curtains
	Dynamic compaction
Removal, treatment, and disposal for all or portions of an individual landfill	Conventional
	Remote processes
	Stabilization and retrieval
	Soil vacuum
	Vitrification
	In-container vitrification
	Mechanical separation
	Solidification/stabilization
	Automated segregation based on radiation
In situ solidification and stabilization for all or portions of an individual landfill	Vitrification
	Grout injection
	Soil mixing
In situ solidification and stabilization	Grout injection
	Supersaturated grouts
	Soil desiccation
	Reactive gases
	Nanoparticles
Contaminant extraction	Soil flushing
	Electrokinetics
Natural attenuation	Monitored natural attenuation

RCRA = *Resource Conservation and Recovery Act of 1976*

Pairings of response scenarios and pre-screened technologies will be evaluated for possible incorporation into remedial alternatives. Two categories of general response actions have been identified for the 200-SW-2 OU: removal (RTD) and in-place remedies (natural attenuation, stabilization, and caps/barriers). A No Action alternative also will be considered. The following text describes these general responses:

- **No Action:** This alternative is required by the NCP (40 CFR 300) as a baseline for comparison with other remedial alternatives. No action implies allowing the waste to remain in the current configuration, thus being affected only by natural processes. No maintenance or other activities would be instituted or continued. Selecting the No Action alternative would require that a waste site poses no unacceptable risk or threat to HHE.

- **Removal, treatment, and disposal:** Remedial alternatives will be evaluated that may involve different combinations of RTD actions. Consideration of radionuclide composition and activity, remediation worker exposure hazards, and available disposal pathways will have a significant influence on remedy selection. Removal activities would involve excavation of buried waste and contaminated soil. The treatment of the excavated material may include in situ or ex situ operations.

- **Monitored natural attenuation, institutional controls, and maintain existing soil cover:** Under this alternative, an existing soil cover placed on a waste site would be maintained and/or augmented (i.e., adding additional cover material or native vegetation) as needed to provide protection from intrusion by biological receptors, along with institutional controls, such as legal controls (e.g., deed restrictions and excavation permits) and physical barriers (e.g., fencing) that would mitigate contaminant exposure. Radioactive contaminants remaining beneath the clean soil cover would be allowed to decay in place (i.e., to attenuate naturally), thereby reducing risk until remediation goals are met.

  MNA relies on natural processes to lower contaminant concentrations until cleanup levels are met. MNA would include sampling and/or environmental monitoring, consistent with EPA/540/R/99/006, *Radiation Risk Assessment at CERCLA Sites: Q & A*, to verify that contaminants are attenuating as expected and to ensure that contaminants remain isolated (e.g., will not lead to degradation of groundwater or be released to air or biota). Attenuation monitoring activities could include monitoring the vadose zone using geophysical logging methods to verify that natural attenuation processes (e.g., radiological decay) are effective for radioactive contaminants.

- **Capping/barriers:** Capping consists of constructing a surface barrier over contaminated waste sites to control the amount of water that infiltrates into contaminated media to reduce or eliminate leaching and migration of contamination to groundwater. In addition to their hydrological performance, barriers also may function as physical barriers to prevent intrusion by human and ecological receptors, limit wind and water erosion, and shield radiation. Institutional controls are required to prevent intrusion to the capped area and to prevent activities that might alter the effectiveness of the cap. Institutional controls (including legal, administrative, or physical controls such as deed restrictions, excavation permits, and fencing) are required to minimize the potential for inadvertent human exposure to contamination. Performance monitoring is associated with this alternative to ensure that the cap is performing as expected and groundwater is protected.

These general responses will be further developed by assembling combinations of the pre-screened supporting technologies (and the media to which they would be applied) into detailed alternatives. This process consists of the following six steps:

1. Develop RAOs specifying the contaminants and media of interest, exposure pathways, and PRGs. This provides a framework for consideration of treatment and containment technologies and alternatives. The PRGs are developed based on the ARARs, other available information, and site-specific risk-related factors.

2. Evaluate general response actions for each medium of interest defining containment, treatment, excavation, pumping, or other actions, singly or in combination, which may be taken to satisfy the RAOs for the site.

3. Identify volumes or areas of media to which general response actions might be applied, taking into account the requirements for protectiveness as identified in the RAOs and the chemical and physical characterization of the site.

4. Identify technologies applicable to each general response action to eliminate those that cannot be implemented technically at the site; identify treatability study candidates.

5. Identify and evaluate technology process options to select a representative process for each technology type retained for consideration.

6. Assemble the selected representative technologies into alternatives representing a range of treatment and containment combinations.

5.10 Task 10 – Detailed Analysis of Alternatives

R-CPP unit remedial alternative actions that passed screening (Section 5.9) will be evaluated against the CERCLA criteria and the Washington State corrective action requirements shown in Table 5-2. As illustrated in the table, the CERCLA criteria and the Washington State corrective action requirements are functionally equivalent. The TSD units may be clean closed or closed as a landfill in accordance with WAC 173-303-610(2), "Closure and Post-Closure." Alternatively, where releases from TSD units have likely commingled with collocated R-CPP unit releases, DOE-RL may petition the Ecology Director to replace all or part of the closure requirements (except WAC 173-303-610(2)(a)) with alternative requirements per WAC 173-303-610(1)(e). Alternative requirements, which are provided in Table 5-2 will be recommended based on results from remedial technology investigation activities, as appropriate. Alternative requirements will be approved by the Director by incorporating the closure plan containing the alternative requirements into the Permit.

The evaluation of alternatives will be consistent with HAB advice stating that the best solution at the 200-SW-2 OU landfills would likely be some combination of targeted retrieval, combined with vadose zone monitoring and remediation, and capping. The RFI/CMS/RI/FS work plan acknowledges that those methods should be considered in FS evaluations.

Once the remedial alternatives and TSD unit alternative closure requirements have been fully described and individually assessed against the applicable requirements and standards in Table 5-2, a comparative analysis will be conducted to evaluate the relative performance of the remedial alternatives and alternative closure requirements in relation to each specific evaluation requirement and standard. The RFI/CMS/RI/FS report will summarize the results of the detailed analysis, which will provide the basis for identifying the preferred remedial action/corrective action alternative and alternative closure requirements for each of the 200-SW-2 OU waste units.

Table 5-2. TSD Unit Closure Requirements and R-CPP Unit Remedial Alternative Evaluation Requirements and Standards

CERCLA Criteria[a]	Washington State Corrective Action Requirements[b]	Washington State TSD Unit Alternative Closure Requirements[c]
Threshold criteria: • Overall protection of human health and the environment • Compliance with ARARs	Threshold requirements: • Protect human health and the environment • Comply with cleanup standards • Comply with applicable state and federal law • Provide for compliance monitoring	Closure performance standards (WAC 173-303-610(2)(a)): • Minimizes the need for further maintenance • Controls, minimizes or eliminates to the extent necessary to protect human health and the environment, post-closure escape of dangerous waste, dangerous constituents, leachate, contaminated runoff, or dangerous waste decomposition products to the ground, surface water, groundwater or the atmosphere • Returns the land to appearance and use of surrounding land areas to the degree possible given the nature of the previous dangerous waste activity
Reducing criteria: • Long-term effectiveness and permanence • Reductions in toxicity, mobility, or volume through treatment • Short-term effectiveness • Implementability • Cost	Other requirements: • Use permanent solutions to the maximum extent practicable • Provide for a reasonable restoration time frame • Consider public concerns	Alternative closure requirements (WAC 173-303-610(1)(e)): • Ecology Director may, in an enforceable document, replace all or part of the closure and post-closure requirements (except for those in WAC 173-303-610(2)(a)) with alternative requirements when he or she determines: • A TSD unit is situated among other R-CPP units • A release to soil has occurred • Both the TSD unit and one or more R-CPP units are likely to have contributed to the release
Modifying criteria: • State/support agency acceptance • Community acceptance		

a. 40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan."

b. WAC 173-303-64620, "Dangerous Waste Regulations," "Requirements." These are the corrective action requirements.

c. WAC 173-303-610(2)(a) and (1)(e), "Dangerous Waste Regulations," "Closure and Post-Closure."

ARAR = applicable or relevant and appropriate requirement

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

RCRA = *Resource Conservation and Recovery Act of 1976*

R-CPP = RCRA-CERCLA past practice

TSD = treatment, storage, and disposal

WAC = *Washington Administrative Code*

5.11 Task 11 – RCRA Facility Investigation/Corrective Measures Study and Remedial Investigation/Feasibility Study Report

The RCRA RFI/CMS and CERCLA RI/FS will be combined into a single RFI/CMS/RI/FS report for the 200-SW-2 OU (Figure 1-5). The combined RFI/CMS/RI/FS report will provide details that support the closure decisions. This information will be included in the closure plan that will be in the Permit. As necessary, the RFI/CMS/RI/FS report will also include technical information that may be used to justify using alternative requirements for closure of TSD units (WAC 173-303-610(1)(e)). This information will be included in the closure plan for the specific TSD unit. The RFI/CMS/RI/FS report will consider all information available at the time of report preparation, including pertinent information from activities conducted outside of the work plan. The major elements and respective volumes of the RFI/CMS/RI/FS report include the following:

- **Volume I (RFI/RI):**
  - RAOs
  - Study area investigations and physical characteristics
  - Contamination nature and extent
  - Contaminant fate and transport
  - Human health (soil and groundwater protection) and ecological risk assessment (Section 5.6 of this document)
  - Treatability study results, if available (Section 5.7 of this document)
  - Early action summary
  - Basis for action determination
- **Volume II (CMS/FS):**
  - Refined RAOs
  - General response actions and remedial technology screening process
  - Individual and comparative alternative analysis (Section 5.10 of this document)

5.12 Task 12 – Post-RCRA Facility Investigation/Corrective Measures Study and Remedial Investigation/Feasibility Study Support

Post-RFI/CMS/RI/FS activities (including development of a PCAD/PP, closure plan or closure/post-closure plan preparation or modification, draft Permit modification, CAD/ROD, and Permit modification) are depicted in Figures 1-2 and 1-3 (Chapter 1) and described in the following subsections.

5.12.1 Proposed Corrective Action Decision/Proposed Plan, Closure Plan, and Draft Permit Modification

The PCAD/PP will be prepared using information from the RFI/CMS/RI/FS report and will identify the preferred remedial alternative(s). It is the intent of Ecology that the closure plan(s) or closure/post-closure plan(s) will also be prepared or modified using information from the RFI/CMS/RI/FS report. After the

closure plan or closure/post-closure plan has been completed, DOE-RL will submit the closure plan or closure/post-closure plan to Ecology as a modification to the Permit. Ecology will process the draft Permit modification in accordance with WAC 173-303. If the Permit modification contains a request for alternative requirements, finalization of the permit modification will also communicate the Ecology Director's approval of the alternative requirements for the specific TSD unit under WAC 173-303-610(1)(e).

The PCAD/PP and draft Permit modification, thus prepared, should be made available in parallel to the public so they may participate in the selection of a remedial alternative and closure action. Following the public review and comment period, responsiveness summaries presenting significant comments and any new relevant information received during the public comment period will be prepared for the PCAD/PP and draft Permit modification, respectively. The PCAD/PP responsiveness summary will be incorporated into the CAD/ROD. The draft Permit modification responsiveness summary will be included in the issuance of the modification.

5.12.2 Corrective Action Decision/Record of Decision and Permit Modification with Treatment, Storage, and Disposal Unit Closure Plan

Following the public comment period, supporting agency comments, and community acceptance criterion assessment, the CAD/ROD will document the selected remedial action/corrective action for each 200-SW-2 OU past-practice unit (Figures 1-2 and 1-3). The CAD/ROD will be as follows:

- A legally enforceable document that certifies the remedy selection process was performed in accordance with CERCLA and, to the extent practicable, in accordance with the NCP (40 CFR 300).[1]
- A legally enforceable document for RCRA corrective action.
- A document that includes closure information that is incorporated into a Permit modification or revision of the Hanford Facility RCRA Permit to satisfy TSD unit closure plan requirements.
- A substantive summary of the technical rationale and background information contained in the CERCLA Administrative Record file.[1]
- A technical document that provides information necessary for determining the conceptual engineering components and remedy costs and that outlines the RAOs and cleanup levels for the selected remedy.[1]
- A key communication tool for the public that explains the contamination problems the remedy seeks to address and the rationale for its selection.[1]

5.12.3 Post-Record of Decision and Corrective Action Decision Activities

Post-CAD/ROD activities include the following (see Figures 1-2 and 1-3):

- CERCLA remedial action/RCRA corrective action activities:
  - Completing a CMI and RD/RA work plan
  - Implementing the remedy
  - Developing and implementing a monitoring program (as needed)

[1] EPA 540-R-98-031, *A Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents.*

- Completing an RA report
- Issuing a certificate of completion (Ecology)

- RCRA TSD unit closure activities:
  - Implementing the closure plan
  - Submitting a certification of closure
  - Developing and implementing a post-closure care plan (as needed)
  - Submitting certification of completion of post-closure care (as needed)

6 Project Schedule

The estimated project schedule is shown in Figure 6-1. The schedule will be evaluated to identify efficiencies, will serve as the baseline for the work planning process, and will be used to measure the progress of implementing this work plan.

The schedule includes TPA milestones, field activities, and activity durations. Any revisions to the project schedule will be in accordance with Section 11.4 of the TPA (Ecology et al., 1989a).

Task Name	Start Date	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023
Conduct Site Characterization	Sep-18							
Initiate 200-SW-2 OU characterization field work **(TPA Milestone P-015-93C)**	Sep-18							
Prepare and Submit Cumulative Impacts Evaluation Approach, Draft A	Oct-16							
Prepare and Approve Cumulative Impacts Evaluation Approach, Rev. 0	Apr-18							
Prepare Cumulative Impacts Evaluation (SW-2)	Jul-18							
Prepare and Issue RFI/RI Report, Draft A	Oct-18							
Prepare and Issue CMS/FS Report, Draft A	Nov-21							
Prepare and Issue Corrective Action Decision/Proposed Plan, Draft A	Nov-21							
Submit 200-SW-2 OU RFI/CMS/RI/FS Report and PCAD/PP **(TPA Milestone P-015-93B)**	Jan-23							

Notes:
1. TPA Milestones are proposed in the tentative agreement.
2. TPA Milestone P-015-93C "Initiate characterization field work for the 200-SW-2 Operable Unit landfills in accordance with the schedule in the approved RI/FS/RFI/CMS Work Plan", due 9/30/2018
3. TPA Milestone P-015-93B "Submit RCRA Facility Investigation/Corrective Measures Study & Remedial Investigation/Feasibility Study Report and proposed Corrective Action Decision/Proposed Plan for the 200-SW-2 OU to Ecology", due 1/31/2023
4. Conduct site characterization includes field investigations and analytical tasks, sample analysis and data validation, data evaluation and field summary reports.
5. Schedules were developed using the review and approval durations established in the TPA, if these durations are exceeded the schedule will experience a day for day slip.

Figure 6-1. 200-SW-2 OU Estimated Project Schedule

7 Project Management

This chapter discusses the project organization, project coordination, change control, and dispute resolution processes. Change control processes are used to document and achieve approval for changes that arise during execution of the RFI/CMS/RI/FS. Problems are resolved at the lowest possible level, with higher levels of project oversight engaged to resolve the issues.

7.1 Project Organization

DOE-RL is the lead agency responsible for investigation and cleanup of the Central Plateau. The DOE-RL contractor implements the investigation and cleanup for DOE-RL and is responsible for planning, coordinating, and executing RFI/CMS/RI/FS activities. The lead regulatory agency (Ecology) authorizes the work scope in accordance with the TPA (Ecology et al., 1989a) and oversees the work for regulatory compliance. Figure 7-1 presents the project organization structure for cleanup of the 200-SW-2 OU.

7.1.1 U.S. Department of Energy, Richland Operations Office Project Organization

The DOE-RL Soil and Groundwater Division is responsible for remedy implementation of the 200-SW-2 OU. The federal project director for the Soil and Groundwater Division reports to the assistant manager for the River and Plateau.

The DOE-RL Contracting Officer is responsible for authorizing the Central Plateau remediation contractor to perform the RFI/CMS/RI/FS tasks for the 200-SW-2 OU.

The federal project director is responsible for obtaining lead regulatory agency approval of the work plan and SAPs, which authorize the RFI/CMS/RI/FS activities under the TPA (Ecology et al., 1989a). The federal project director also assigns the 200-SW-2 OU DOE-RL Technical Lead, who performs the role of the Project Manager identified in Section 4.1 of the TPA. The DOE-RL Technical Lead is responsible for managing the project, day-to-day oversight of contractors performing the RFI/CMS/RI/FS activities, maintaining regulatory compliance necessary for completion of the milestones, and for providing technical input to DOE-RL federal project directors.

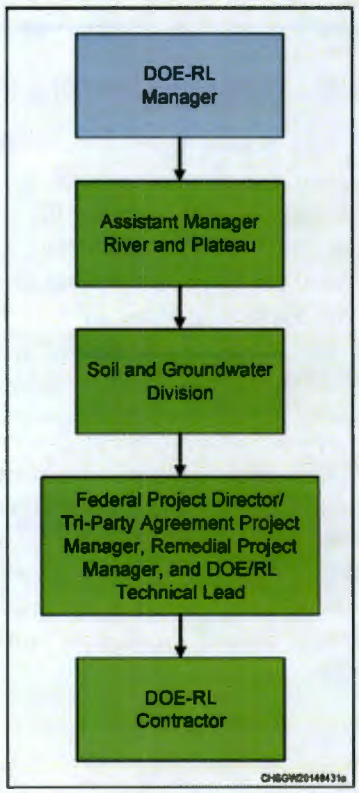

Figure 7-1. 200-SW-2 OU Project Organization

7.1.2 Regulatory Agency Oversight Organization

Ecology is the lead regulatory agency for the 200-SW-2 OU. Ecology has assigned a project manager who is responsible for overseeing various RFI/CMS/RI/FS activities. The project manager is responsible for working with DOE-RL to resolve issues and approve the documents in accordance with Article XIV through Article XVI of the TPA (Ecology et al., 1989a).

As a participating agency, EPA regulatory responsibilities include providing assistance if requested by the lead regulatory agency (Ecology), approving the final remedy, approving completion of construction, and proposing sites for deletion from the NPL (40 CFR 300, Appendix B).

7.1.3 Contractor Organization

The RFI/CMS/RI/FS activities are being conducted by CHPRC under DE-AC06-08RL14788, *CH2M HILL Plateau Remediation Company Plateau Remediation Contract*. CHPRC is responsible for integrating and executing the full scope of RFI/CMS/RI/FS activities on the Central Plateau.

7.1.4 Integration Teams

The DOE-RL/Office of River Protection Groundwater/Vadose Zone Executive Council was formed in 2006 to integrate Hanford Site groundwater, vadose zone, and risk assessment/modeling activities. The Executive Council may periodically charter integrated project teams on specific topics of interest as necessary to provide a forum for multiple projects and contractors with related activities to focus on day-to-day coordination issues and opportunities (e.g., field sampling, data communication, and data interpretation). There are no current integrated project teams for 200-SW-2 OU activities.

7.2 Project Coordination, Decision Making, and Documentation

Coordination among Ecology, EPA, the lead agency (DOE), and the contractors is essential for successful execution of the RFI/CMS/RI/FS. Consensus from the regulatory agency project managers may be documented in meeting minutes of 200 Area unit managers' meetings.

7.3 Change Control and Dispute Resolution

The work plan represents the Tri Parties' assessment of the 200-SW-2 OU data needs at the end of the systematic planning process. As new information becomes available, changes to the work scope may be required. These changes will be made to the work plan and/or to the SAP, depending on the nature of the change in accordance with Section 9.3 of the TPA Action Plan (Ecology et al., 1989b). Changes that affect the TPA (Ecology et al., 1989a) are documented using change control forms in accordance with Section 12 of the TPA Action Plan. The class or level of the change (i.e., signatory, executive management, or project management) is noted and the description, justification, and impact of the change are documented.

Dispute resolution is handled in accordance with Article XVI of the TPA (Ecology et al., 1989a). The Tri-Parties are to make reasonable attempts to resolve all disputes informally at the project manager level. Disputes that cannot be resolved informally are submitted in writing to, and resolved by, the Interagency Management Integration Team at the executive manager level. If resolution is not achieved at this level, the dispute is forwarded to higher levels of management. To promote dispute avoidance, potential problems will be identified early in the RFI/CMS/RI/FS process, and associated contingency/variance plans will be developed.

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