DOE/RL-2004-24
Revision 0

Feasibility Study for the 200-CW-5 Cooling Water Operable Unit

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

U.S. DEPARTMENT OF ENERGY
Richland Operations Office

P.O. Box 550
Richland, Washington 99352

DOE/RL-2004-24
Revision 0

Feasibility Study for the 200-CW-5 Cooling Water Operable Unit

Date Published
May 2011

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

A. D. Aardal 06/06/2011
Release Approval Date

Approval Page

Title *Feasibility Study for the 200-CW-5 Cooling Water Operable Unit*

Approval Briant Charboneau, Federal Project Director for Soil and Groundwater

U.S. Department of Energy, Richland Operations Office

Signature — Date: 5-16-2011

Approval Craig Cameron, Project Manager

U.S. Environmental Protection Agency

Signature — Date: 5/16/2011

This page intentionally left blank.

Executive Summary

This feasibility study (FS) addresses the waste sites of the 200-CW-5 Operable Unit (OU) that are represented by the Z-Ditches waste group. The Z-Ditches waste group is located within the Inner Area of the Hanford Site Central Plateau. This area is expected to require long term waste management activities. The Z-Ditches consist of five co-located waste sites, including three liquid waste transfer ditches, one liquid waste disposal unit, and a single-use sludge disposal site that are contaminated with similar waste constituents. This FS develops and evaluates alternatives using historical and remedial investigation (RI) data and information presented in DOE/RL-2003-11, *Remedial Investigation Report for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-SC-1 Steam Condensate Group Operable Units*[1] (RI Report), to address the risks to human health and the environment (HHE) from Z-Ditches soil contamination.

The human health baseline risk assessment (BRA), ecological risk assessment (ERA), and groundwater protection evaluation that were completed during the RI phase have been updated for this report to reflect revised guidance from the U.S. Environmental Protection Agency (EPA) regarding calculation of contaminant exposure point concentrations (EPCs) and to incorporate evaluation of the subsistence farmer and Native American exposure scenarios (the RI Report included only an industrial worker scenario). This FS also provides a comparison of nonradiological contaminants to WAC 173-340-740(3)(b), "Standard Method B Soil Cleanup Levels," and WAC 173-340-745(5)(b), "Standard Method C Industrial Soil Cleanup Levels." Results of the updated risk evaluation are summarized in Chapter 3 of this FS with supporting detail provided in Appendices B, D, and F.

The BRA conducted in the RI Report concluded that there was a potential risk to HHE based on the current and reasonably anticipated future industrial land use. Re-evaluation of EPCs based on EPA's revised guidance has resulted in revised EPCs for several radiological contaminants. The BRA was updated in accordance with EPA direction to calculate radiological health effects based on risk, not dose.

---

[1] DOE/RL-2003-11, 2004, *Remedial Investigation Report for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-SC-1 Steam Condensate Group Operable Units*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/pdwdocs/fsd0001/osti/2004/I0044981.pdf.

Because the land use for the Z-Ditches area for the foreseeable future is industrial, an industrial worker scenario, with Standard Method C industrial soil cleanup levels and consideration for protection of terrestrial plants and animals, was used to guide the development of remedial action objectives (RAOs), preliminary remediation goals (PRGs), and remedial action alternatives. Potential exposures to humans and terrestrial plants and animals were estimated to occur from ground surface to a depth of 4.6 m (15 ft) as the regulatory point of compliance for the direct contact exposure pathway. Groundwater protection PRGs were not exceeded; therefore, groundwater protection was not a primary driver in the FS; however, RAOs have been identified for protection of groundwater.

Based on the risk assessments, this FS addresses the following risk-based concerns:

- Ra-226 and Pu-239 present a potential risk to an industrial worker through the direct contact exposure pathway. The primary contributors to excess lifetime cancer risk (ELCR) are Pu-239 (64 percent contribution) and Ra-226 (31 percent contribution). The fractional contributions from Am-241 and Cs-137 are overshadowed by the large contribution from Pu-239 and Ra-226 through the external exposure route.

- Aroclor-1260 is present at concentrations above the WAC 173-340-745(5)(b), Standard Method C industrial soil cleanup level. Based on the comparison to the industrial soil cleanup level, there is a concern that human receptors exposed to soils at the Z-Ditches may be at risk for adverse health effects.

- Am-241, Cs-137, Pu-239/240, Ra-226, and Sr-90 are present at concentrations above the biota concentration guide screening levels. Based on the comparison of concentrations to ecological screening concentrations, there is a concern that wildlife and plants exposed to soils at the Z-Ditches may be at risk for adverse health effects.

- Aroclor-1254, Aroclor-1260, boron, and mercury are present at concentrations above the WAC 173-340-7493, Table 749-3, Ecological Indicator Soil Concentrations for Protection of Terrestrial Plants and Animals. Based on the comparison of concentrations to the ecological indicator soil concentrations, there is a concern that terrestrial plants and animals exposed to soils at the Z-Ditches may be at risk for adverse health effects.

The following RAOs were established to evaluate whether the remedial alternatives comply with potential applicable or relevant and appropriate requirements (ARARs) and are protective to the representative industrial worker and to ecological wildlife receptors in an industrial land use scenario:

- **RAO 1—**Prevent or mitigate unacceptable risk to human health and ecological receptors associated with radiological exposure to wastes or soil contaminated above risk-based criteria by removing the source or eliminating the pathway.
- **RAO 2—**Prevent or mitigate unacceptable risk to human and ecological receptors associated with nonradiological exposure to wastes or soil contaminated above risk-based criteria by removing the source or eliminating the pathway.
- **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, including protecting the Columbia River from adverse impacts.

The remedial alternatives (Table ES-1) were developed and evaluated for the 200-CW-5 OU Z-Ditches to protect HHE and to meet RAOs. For purposes of remedial alternative development, the Z-Ditches site was divided into three separate work areas as discussed in Section 6.2.3 (Work Areas 1, 2, and 3) based on varying site contamination conditions along the length of the ditches presenting the potential for different remedies at different locations. The reasonably foreseeable land use across this OU is industrial. Currently, there are Hanford Site controls in place that control land use activities in consideration of current site conditions. Upon selection of final cleanup actions, appropriate institutional controls (ICs) will be identified to ensure protection of HHE and the effectiveness of the selected remedial actions. These activities will be implemented through DOE/RL-2001-41, *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions*.[2]

[2] DOE/RL-2001-41, 2007, *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions*, Rev. 2, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www2.hanford.gov/arpir/?content=findpage&AKey=00099819.

Table ES-1. Remedial Alternatives Evaluated for the 200-CW-5 Operable Unit

Alternative	Description
Alternative 1—No Action	This alternative would leave waste sites in their current state, with no additional remedial activities or access restrictions. (NCP requires consideration of a No-Action Alternative).
Alternative 2—MESC/MNA/IC	Maintain the existing soil cover and monitor the site contamination conditions and establish ICs to limit access for the duration of site risk.
Alternative 3—RTD	Remove soil contaminated above risk level and dispose of low-level waste onsite at the ERDF.
Alternative 4—Barrier	Install an engineered barrier that prevents and controls exposure to hazardous substances. Includes ICs to maintain the barrier and limit access.
Alternative 5A—ISV with Barrier and RTD	In situ vitrification of contamination greater than PRGs to reduce mobility and place a barrier over in situ vitrification melts. Remove lower level radiological contamination for disposal at ERDF. Includes ICs to maintain the barrier and limit access.
Alternative 5B—ISV with Barrier	In situ vitrification of contamination greater than PRGs to reduce mobility and place a barrier. Includes ICs to maintain the barrier and limit access.

ERDF = Environmental Restoration Disposal Facility
IC = institutional controls
ISV = In Situ Vitrification
MESC/MNA = maintain existing soil cover/monitored natural attenuation
NCP = National Contingency Plan
PRG = preliminary remediation goal
RTD = removal, treatment, and disposal

The remedial alternatives were evaluated with respect to the first seven of the nine Comprehensive Environmental Response, Compensation, and Liability Act of 1980[3] (CERCLA) criteria (EPA/540/G-89/004, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, Interim Final, OSWER Directive 9355.3-01)[4] in a detailed analysis and in a comparative analysis.

Threshold Criteria

- Overall protection of HHE
- Compliance with ARARs

[3] *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 USC 9601, et seq. Available at: http://www.epa.gov/oecaagct/lcla.html#Hazardous%20Substance%20Responses.

[4] EPA/540/G-89/004, 1988, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, Interim Final, OSWER 9355.3-01, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://epa.gov/superfund/policy/remedy/pdfs/540g-89004-s.pdf.

Balancing Criteria

- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost

The two CERCLA modifying criteria (state acceptance and community acceptance) will be evaluated by EPA and the U.S. Department of Energy (DOE) through the public review process of the Proposed Plan for the 200-CW-5 and 200-PW-1/3/6 OUs and documented in a combined record of decision (ROD). The Preferred Alternative's ability to meet the criterion of community acceptance, however, can be evaluated fully only after the public review and comment period on the Proposed Plan. The Preferred Alternative will be selected by the DOE Richland Operations Office (RL), and EPA, considering the key trade-offs between the remedial alternatives identified in this FS, risk management judgments, and the cost-effectiveness of each alternative. Acceptance will be documented in a ROD.

Key findings of the FS alternative evaluations for the Z-Ditches are:

- Alternatives 1 and 2 do not meet CERCLA threshold criteria and are not considered protective for the Z-Ditches.
- Alternatives 3, 4, 5A, and 5B are protective and would comply with potential ARARs but with significant cost variability.

Table ES-2 summarizes the evaluated alternatives. Using information from this FS, the decision makers will identify a Preferred Alternative in the Proposed Plan and, following public comment, will select an alternative in a ROD. The actual range of volumes to be excavated and the incremental inventory of contamination within areas of the sites could vary in the field. Planning assumptions were made based on available information.

Table ES-2. Comparative Analysis Summary for the CW-5 OU Waste Sites

	Threshold Criteria		Balancing Criteria				
	Overall Protectiveness of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction in Toxicity, Mobility, and Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost[a] (Net Present Worth in $ Million)
No Action	No	No	Not Ranked[b]				$0
MESC/MNA/IC	No	No	Not Ranked[b]				$0
RTD	Yes	Yes	○	●	◐	◐	$58.1
Engineered Surface Barrier	Yes	Yes	◐	●	○	○	$19.6
ISV/RTD/Barrier	Yes	Yes	○	◐[c]	◐	●	$318
ISV/Barrier	Yes	Yes	◐	◐[c]	◐	●	$287

a. These cost estimates are based on the best available information for the site-specific anticipated remedial actions. The actual costs are expected to range from -30 percent to +50 percent of these estimated values. Major changes to assumed remedial action scope can result in remedial action costs outside of this range. Net present worth calculations are based on 1,000 years.

b. No Action and MESC/MNA/IC Alternatives not ranked because these alternatives do not meet the threshold criteria.

c. Rated "performs moderately well" for this criterion overall. ISV applies only to Work Area 2. No treatment of contaminants in Work Area 1 or 3.

Explanation of Evaluation Metric

● = performs less well against the criterion relative to the other alternatives with significant disadvantages or uncertainty

◐ = performs moderately well against the criterion relative to the other alternatives with some disadvantages or uncertainty

○ = performs very well against the criterion relative to the other alternatives with minor disadvantages or uncertainty

ARAR = applicable or relevant and appropriate requirement
IC = institutional controls
ISV = In Situ Vitrification
MESC/MNA = maintain existing soil cover/monitored natural attenuation
RTD = removal, treatment, and disposal

Contents

Appendices

Figures

Tables

Terms

AD	soil sampling analytical data
ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
BCA	bias-corrected accelerated bootstrap method
BCG	biota concentration guide
bgs	below ground surface
BRA	baseline risk assessment
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	Code of Federal Regulations
CLARC	Ecology 94-145, *Cleanup Levels and Risk Calculations under the Model Toxics Control Act Cleanup Regulation* (CLARC, Version 3.1)
CLT	central limit theorem
COC	contaminant of concern
COPC	contaminant of potential concern
CSM	conceptual site model
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
ELCR	excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ERA	ecological risk assessment
ERDF	Environmental Restoration Disposal Facility
ET	evapotranspiration
FS	feasibility study
FY	fiscal year
GRA	general response action
GW	groundwater
HAB	Hanford Advisory Board

HCP EIS	DOE/EIS-0222-F, *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*
HEPA	high-efficiency particulate air (filter)
HHE	human health and the environment
HMS	Hanford Meteorological Station
HQ	hazard quotient
IC	institutional control
ISV	in situ vitrification
K_d	distribution coefficient
MCL	maximum contaminant level
MESC	maintain existing soil cover
MNA	monitored natural attenuation
MTCA	Model Toxics Control Act
N/A	not applicable
NCP	National Contingency Plan
NEPA	*National Environmental Policy Act of 1969*
NPL	National Priorities List
ORP	U.S. Department of Energy, Office of River Protection
OU	operable unit
PCB	polychlorinated biphenyl
PFP	Plutonium Finishing Plant, also Z Plant facilities
PRG	preliminary remediation goal
Proposed Plan	DOE/RL-2009-117, *Proposed Plan for the 200-CW-5, 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units*
PVC	polyvinyl chloride
RAO	remedial action objective
RBC	risk-based concentration
RCRA	*Resource Conservation and Recovery Act of 1976*
RESRAD	RESidual RADioactivity (dose model)
RI	remedial investigation

RI/FS Work Plan	DOE/RL-99-66, *Steam Condensate/Cooling Water Waste Group Operable Units RI/FS Work Plan; Includes: 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 Operable Units*
RI Report	DOE/RL-2003-11, *Remedial Investigation Report for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-SC-1 Steam Condensate Group Operable Units*
RL	U.S. Department of Energy, Richland Operations Office
RLS	radionuclide logging system
RME	reasonable maximum exposure
ROD	record of decision
RTD	removal, treatment, and disposal
SLERA	screening-level ecological risk assessment
STOMP	Subsurface Transport Over Multiple Phases (code)
TMV	toxicity, mobility, or volume
Tri-Parties	U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Ecology
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TRU	Transuranic (waste) as defined in DOE G 435.1-1, *Implementation Guide for Use with DOE M 435.1-1*
TSD	treatment, storage, and disposal
UCL	upper confidence limit
UPR	unplanned release
U.S.	United States
WAC	*Washington Administrative Code*
WIDS	Waste Information Data System (database)
WIPP	Waste Isolation Pilot Plant
XS	X-ray spectroscopy
Z Plant	Plutonium Finishing Plant, also Z Plant facilities

This page intentionally left blank.

1 Introduction

The Hanford Site, managed by the U.S. Department of Energy (DOE), encompasses approximately 1,517 km^2 (586 mi^2) in the Columbia Basin of south-central 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 40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," Appendix B, "National Priorities List," (NPL) pursuant to the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA). The 200 Area NPL site consists of the 200 West Area and 200 East Area (Figure 1-1), which contain waste management facilities and inactive irradiated fuel reprocessing facilities.

The 200 Area consists of hundreds of waste sites grouped into operable units (OUs). The 200-CW-5 Z-Ditches Cooling Water Waste Group OU is the focus of this feasibility study (FS). The 200-CW-5 OU is a CERCLA past-practice OU under the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement [Ecology et al., 1989a]) having EPA as the lead regulatory agency. The 200-CW-5 OU is located in the 200 West Area of the Hanford Site's Central Plateau, as shown in Figure 1-1. The 200-CW-5 OU waste sites (Figure 1-2) primarily received cooling water, steam condensate, and chemical sewer waste waters which sometimes contained radiological and chemical contaminants from Z Plant facilities of the 200 West Area. Figure 1-3 shows current conditions at the Z-Ditches that are the subject of this FS and the amount and type of vegetation present on or around the Z-Ditches waste sites that have been backfilled and surface stabilized, and are in proximity to one another.

1.1 Operable Unit Organization

The nature and number of OUs at the Hanford Site have evolved as the Hanford Site investigation process has matured. These OUs were established using predominantly historical information based on process knowledge. The preliminary conceptual models developed from these early OUs provided both an initial prediction of the nature and extent of primary contaminants of concern (COCs) and support for the selection of and prioritization of groups.

The Tri-Party Agreement establishes major milestones for completing the waste site investigation effort (Milestone M-15-00), and completing waste site remediation of non-tank farm OUs (Milestone M-16-00) in the 200 Area (Ecology et al., 1989a). In 2002, the DOE Richland Operations Office (RL), EPA, and Washington State Department of Ecology (Ecology) (the Tri-Parties) renegotiated the 200 Area waste site cleanup milestones under the Tri-Party Agreement, further consolidating the OUs (Ecology, DOE, and EPA, 2002, *Hanford Tri-Party Agreement Modifications to 200 Area Waste Sites Cleanup Milestones, Tri-Party Agreement Change Requests and Comment and Response Document)*. The Tri-Parties agreed to combine the 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU with the 200-CW-5 OU for investigation and remedial decision-making. Remedial investigation (RI) results of these consolidated OUs are reported in DOE/RL-2003-11, 2004, *Remedial Investigation for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-SC-1 Steam Condensate Group Operable Units* (RI Report).

Based on Tri-Party Agreement modifications in 2005/2006, five 200-CW-5 OU waste sites remain within the scope of this FS. These waste sites include the 216-Z-1D Ditch, 216-Z-11 Ditch, 216-Z-19 Ditch, 216-Z-20 Tile Field, and UPR-200-W-110 Unplanned Release. These waste sites are shown in Figure 1-2. The remediation of waste sites in this OU will also address the 200-W-207 pipeline.

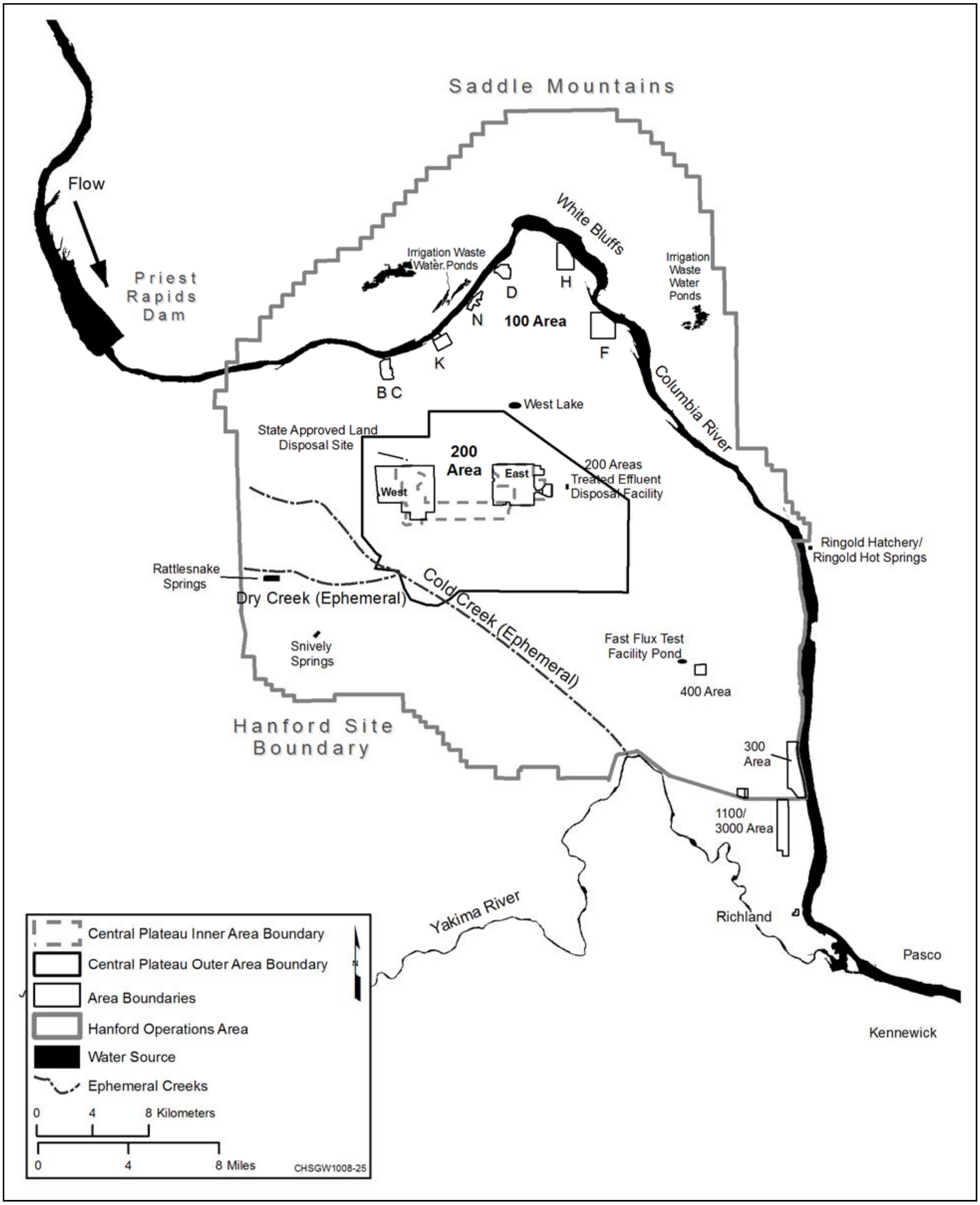


Figure 1-1. Location of the Hanford Site and the 200 Area

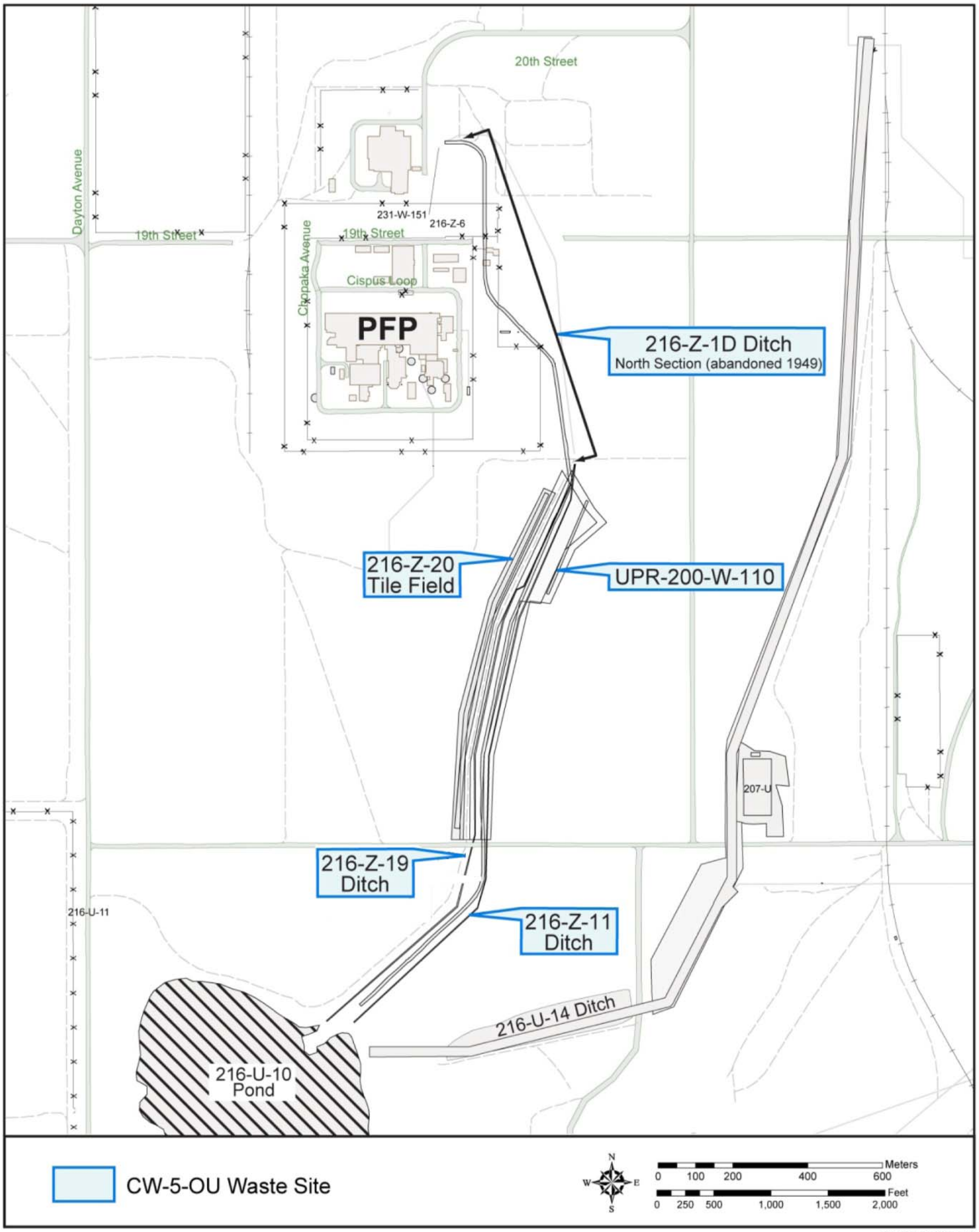


Figure 1-2. Location of the 200-CW-5 Operable Unit Waste Sites

The 200-W-207 Pipeline, which is 82.3 m (270 ft) long, was used to transfer waste to 216-Z-1D Ditch, 216-Z-11 Ditch, 216-Z-19 Ditch, and 216-Z-20 Tile Field. Detailed pipeline information is located in Appendix H of DOE-RL-2007-27, *Feasibility Study for the Plutonium/Organic-Rich Process Condensate/Process Waste Group Operable Unit: Includes the 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units*.

Figure 1-3. Photograph of the 216-Z Ditches

1.2 200-CW-5 Operable Unit Characterization

The process for characterization and remediation of waste sites at the Hanford Site is addressed in the Tri-Party Agreement. Additional changes are being made to the Tri-Party Agreement in 2010 that change the OUs in the Central Plateau to be more geographic in nature. As part of this change, the Proposed Plan for the 200-CW-5 OU will be consolidated with the Proposed Plan for the 200-PW-1/3/6 OU, which also includes plutonium contaminated soil waste sites.

To support the RI/FS process in the 200 Area, the Tri-Parties also developed a plan to provide a strategy for conducting investigations in phases and present background information, preliminary identification of potential applicable or relevant and appropriate requirements (ARARs), remedial action objectives (RAOs), preliminary identification and screening of technologies, and preliminary development and screening of potential remedial alternatives. This FS builds from information provided in this plan.

As documented in DOE/RL-99-66, *Steam Condensate/Cooling Water Waste Group Operable Units RI/FS Work Plan; Includes: 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 Operable Units* (RI/FS Work Plan), the Tri-Parties agreed that historical data were appropriate for use in the Z-Ditches characterization and that more data were needed for the 216-Z-11 Ditch. As a result, data were collected in 2002 under the 200-CW-5 OU RI/FS Work Plan to characterize the nature and vertical extent of chemical and radiological contamination and physical conditions in the vadose zone underlying the southern end of the 216-Z-11 Ditch. Initially, the 216-Z-11 Ditch had been selected as a representative site for 200-CW-5 OU. The scope of RI/FS Work Plan activities included drilling, surface and borehole geophysical surveys, and sampling and analysis of soil based on agreements reached in the supporting data quality objectives process (BHI-01294, *Data Quality Objective Summary Report for the 200-CW-5 U Pond/Z Ditches System Waste Sites*). The RI results for the 216-Z-11 Ditch were reported in the RI Report. In addition, two pipelines (231-Z and 235-5) were evaluated through Manholes 2 and Z-8 during the RI. The pipeline investigation consisted of collecting in situ gamma measurements and smear samples.

The RI Report included historical and RI analytical data used to characterize the nature and extent of contamination at the Z-Ditches, to provide contamination modeling information, and to provide the analytical basis for the baseline risk assessment (BRA). Based on RI data and the proximity of the 216-Z-1D, 216-Z-11, and 216-Z-19 Ditches, the RI Report grouped these ditches together into a single, contiguous characterization and contamination area under the term Z-Ditches. The new Z-Ditches group replaced the single 216-Z-11 Ditch as the 200-CW-5 OU representative site. However, the FS alternative evaluation process identified that because of site proximity, an excavation or barrier action for the original Z-Ditches area would encroach physically on individual site boundaries, making a separate action at these sites difficult. Consequently, this FS grouped all of the 200-CW-5 OU waste sites (216-Z-1D Ditch, 216-Z-11 Ditch, 216-Z-19 Ditch, 216-Z-20 Tile Field, and UPR-200-W-110 Unplanned Release) together, with the Z-Ditches recommended alternative being applied to all 200-CW-5 OU sites.

1.3 Purpose

The purpose of this FS is to develop and evaluate alternatives for remediation of the waste sites in the 200-CW-5 OU. This FS refines preliminary potential ARAR, RAO, and general response actions (GRAs) previously identified by the Tri-Parties. Technology screening and alternatives development initially documented by the Tri-Parties are reviewed and refined, as necessary, based on the 200-CW-5 OU RI Report and other sources of existing information. The alternatives considered provide a range of potential response actions (e.g., no action; maintain existing soil cover [MESC] with monitored natural attenuation [MNA] and institutional controls [ICs]; removal, treatment, and disposal [RTD]; barrier; in situ vitrification [ISV] with barrier and RTD; ISV with barrier) that are appropriate to address site-specific risk conditions. The alternatives are evaluated against the threshold and balancing CERCLA evaluation criteria defined in EPA/540/G-89/004, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, Interim Final, OSWER 9355.3-01. The Tri-Parties will use decision documents contained in the Administrative Record, including this FS, as the basis for selecting a recommended remedy to mitigate potential site risks to human health and the environment (HHE). Recommended remedial alternative(s) will be presented to the public for review and comment in a Proposed Plan that addresses not only the 200-CW-5 OU, but also the 200-PW-1/3/6 OU discussed in DOE/RL-2007-27.

1.4 Scope

Cleanup of the 200-CW-5 OU is a source control action that addresses contaminated soil and structures (e.g., 216-Z-20 Tile Field buried piping) of the Z-Ditches group waste sites. Other than the requirement for source control action to be protective of HHE (including protection of groundwater), the scope does not include remediation of groundwater that may be beneath these waste sites. Contaminated groundwater in the 200 West Area is being addressed by the 200-UP-1 and 200-ZP-1 groundwater OUs.

1.5 Report Organization

The essential elements of the FS process, presented in Chapter 1 through Chapter 7, are summarized as follows:

- Chapter 1 presents the purpose, scope, and regulatory framework for the FS, as well as an overview of report organization.
- Chapter 2 presents descriptions of the physical setting, waste sites, and site contamination.
- Chapter 3 summarizes the revised BRA, ecological risk assessment (ERA), and groundwater protection risk evaluation. In addition, this section describes exposure scenarios, discusses land use assumptions, and develops the overall cleanup objectives and media-specific goals for the waste sites.
- Chapter 4 refines the technologies identified for these OUs and waste sites by evaluating new information on existing technologies or relevant emerging technologies. The technologies are screened broadly for applicability to the waste sites in the FS. Screening considerations include effectiveness (likelihood of meeting RAOs for the specific contaminants present at the site), implementability relative to specific site conditions, status of technology development, and relative cost.
- Chapter 5 describes the remedial alternative development process and combines that information with site-specific data from the RI to refine the remedial alternatives for detailed and comparative analyses.
- Chapter 6 presents a detailed analysis of each remedial alternative against seven CERCLA evaluation criteria (protection of HHE; compliance with ARARs; long-term effectiveness; reduction of toxicity, mobility, or volume [TMV]; short-term effectiveness; implementability; and cost) as defined in EPA/540/G-89/004. This chapter also assesses each alternative relative to *National Environmental Policy Act of 1969* (NEPA) values, as required by DOE policy.
- Chapter 7 presents the comparative analysis of the seven remedial alternatives and identifies their relative advantages and disadvantages, based on the seven CERCLA evaluation criteria. The results of this analysis provide a basis for selecting a remedial alternative.
- Chapter 8 contains all references for the main body of the report; each appendix contains its own reference section.
- Appendix A presents an analysis of ARARs and available guidance with respect to the 200-CW-5 OU.
- Appendix B presents the human health and ecological risk evaluation tables.
- Appendix C presents the basis for the cost estimates. Detailed cost estimates are provided for each 200-CW-5 OU remedial alternative.
- Appendix D presents the risk analysis for the subsistence farmer land use as the No Action Alternative.
- Appendix E presents the site-specific data sheets that support conceptual site models (CSMs).
- Appendix F presents a quantitative Native American risk assessment.

2 Background Information

This chapter generally presents 200-CW-5 OU background information regarding how the 200-CW-5 OU was organized, how OU waste sites were characterized, characterization results, and use of the data in identifying site risk for remedial decision-making. Specifically, this chapter describes the waste for the OU liquid-waste-generating processes, site construction and operating history, the physical setting, natural and cultural resources, historical and RI characterization activities, and nature and extent of Z-Ditches contamination.

2.1 200-CW-5 Operable Unit Background and History

The 200-CW-5 OU waste sites within the scope of this FS include the 216-Z-1D Ditch, 216-Z-11 Ditch, 216-Z-19 Ditch, 216-Z-20 Tile Field, and UPR-200-W-110 Unplanned Release. The remediation of waste sites in this OU will also address the 200-W-207 pipeline. This pipeline was used to transfer waste to 216-Z-1D Ditch, 216-Z-11 Ditch, 216-Z-19 Ditch, and 216-Z-20 Tile Field. Detailed pipeline information is located in Appendix H of the 200-PW-1/3/6 FS (DOE-RL-2007-27). The 200-CW-5 OU is located within the 200 Industrial Land Use Area. This section summarizes the background and history of this OU. Although the Z-Ditches are discussed as three units, the five 200-CW-5 OU waste sites collectively will be called the Z-Ditches for subsequent FS chapters in this report.

2.1.1 200-CW-5 Operable Unit Description

The 200-CW-5 OU is a process-based OU established to address waste sites that received equipment or vessel cooling water and steam condensate liquid waste streams from Z Plant facilities in the 200 West Area. The exception was UPR-200-W-110 Unplanned Release, which did not receive effluent, but was a one-time use disposal trench for spoils from the 216-Z-1D Ditch and contained the same waste stream contaminants.

Initially, cooling water waste streams were not anticipated to be contaminated. The cooling water and steam condensate was designed to be entirely separate from contaminated process liquids. This was accomplished with physical barriers, which typically were the walls of a heating or cooling pipe coil. Steam and cooling water were circulated through coils inside process vessels to adjust the temperatures in the vessels. The spent steam was condensed with cooling water after exiting the process vessel. The condensed steam and cooling water were released to plant sewers or piping systems that discharged to ditches and ponds.

Although these cooling water streams did not contact process materials or chemicals under normal operating conditions, these streams sometimes contained low concentrations of radionuclides and/or chemicals. Over time, coils that circulated steam and cooling water inside chemical process tanks were known to develop pinholes and hairline cracks because of the corrosive chemicals and high thermal gradients in these tanks. These minor defects usually did not lead to contamination of the steam and cooling water because the pressure in the pipe coils was greater than the pressure in the process or condenser vessels. However, whenever the pressure in the coils was reduced or suspended, minor leakage through the flaws into the coils led to waste stream contamination. Other accidental releases from causes such as operator error also have contributed to contamination of the effluents discharged to the waste facilities in these OUs.

Although radionuclide inventory estimates exist, current data provide a more reliable indication of the nature and extent of Z-Ditch contamination because of the uncertain nature of the results arrived at using waste stream chemistry methods, and the absence of available inventory information for periods of time when the ditch streams were not monitored. The Z-Ditches radiological contaminant inventory is difficult to identify with certainty because contaminant inventory estimates (where available) based on historical waste stream chemistry diverge significantly from the expected inventory based on soil sampling data. However, the soil sampling data provide a more reliable indication of the nature and extent of Z-Ditch contamination. The initial waste stream inventory estimates from DOE/RL-96-81, *Waste Site Grouping for the 200 Areas Soil Investigations*, are based on limited waste stream discharge sampling collected over more than 35 years of continuous operation that identified the 216-Z-11 Ditch as the most contaminated Z-Ditch. These inventory estimates may not be accurate because they are based on waste stream chemistry that converted alpha counts to plutonium concentrations, a process that could significantly overestimate the quantity of plutonium. Conversely, periodic waste stream sampling likely would not reflect intermittent, short-term higher concentration discharge incidents and, thus, would underestimate the total plutonium released to the ditches. Also, these estimates could have overlooked inventory from periods when no discharge records exist (e.g., for 1961 through 1966 when the Space Nuclear Auxiliary Power program was operating in Z Plant producing purified Np-237 and Pu-238). Based on 1959 sampling data, the results of the Z-Ditch characterization in 1979, and information obtained in 1971 when the head end of the 216-Z-1D Ditch was mistakenly unearthed during excavation of the 216-Z-19 Ditch, WHC-EP-0707, *216-U-10 Pond and 216-Z-19 Ditch Characterization Studies*, concluded that the historical plant operations inventory estimates for the Z-Ditches likely were erroneous. WHC-EP-0707 concluded that the lower portion of the 216-Z-1D Ditch, not the 216-Z-11 Ditch, contains the majority of the Z-Ditches plutonium inventory with both the 216-Z-11 and 216-Z-19 Ditch inventories an order of magnitude lower.

2.1.2 Construction and Operations of 200-CW-5 Operable Unit Waste Sites

For purposes of this FS and for reasons discussed later in this section, the north and south sections of the 216-Z-1D Ditch, as shown in Figure 1-2, are evaluated as separate sites because they operated during different times, and contamination conditions for each section have been shown to be different.

The Z-Ditches are a series of three parallel, shallow, unlined, and open-air ditches that operated in chronological sequence from 1944 to 1981. The ditches routed cooling water and other waste waters from the Z Plant to the 216-U-10 Pond for disposal. From 1944 to 1956, the ditch system was used to convey cooling water effluents from the 231-Z Plutonium Isolation Plant where concentrated plutonium from the bismuth phosphate process at the 221-T Plant was processed from a wet nitrate form to a solid plutonium nitrate form for offsite shipment. The startup of the Z Plant in 1949 provided for additional processing steps to convert plutonium nitrate into more stable and safer forms, including oxalate, oxide, and pure metal. Additional process modifications were required to adapt the plant to handle inputs from a larger number of reactors and from new chemical separations plants (Reduction-Oxidation Plant and Plutonium-Uranium Extraction Plant). Machining of plutonium produced large quantities of scrap. After 1956 when the bismuth phosphate process was shut down, the 231-Z Plutonium Isolation Plant was converted for use on other projects, including metallurgical studies, weapons component fabrications, and reactor fuel development. The recovery of uranium and plutonium by extraction (RECUPLEX) process in the Z Plant initially was used for scrap reclamation. Later, adjacent recovery facilities such as the 236-Z Plutonium Reclamation Facility, the 232-Z Waste Incinerator Facility, and the 242-Z Waste Treatment Facility were added. These processes generated process equipment and vessel cooling water and steam condensate waste streams that, due to coil failures and occasional process upsets, sometimes were radiologically contaminated.

The collective Z-Ditches area was deactivated and stabilized in 1981 following construction of the 216-Z-20 Tile Field as the primary Z-Plant waste water disposal facility. The concrete headwalls, vegetation, and miscellaneous unsalvageable equipment were disposed into the 216-Z-19 Ditch bottom.

At this time, the previously buried 216-Z-1D and 216-Z-11 Ditches received an additional 0.15 to 0.30 m (0.5 to 1.0 ft) of clean fill.

2.1.2.1 216-Z-1D Ditch

The 216-Z-1D Ditch operated from 1944 to 1959. It was 1,295 m (4,249 ft) long and 0.6 m (2 ft) deep, with a bottom width of 1.2 m (4 ft), side slopes of 2.5:1, and a minimum grade of 0.05 percent (WHC-EP-0707). Originally, the ditch flowed from a headwall located approximately 60 m (196 ft) east of Building 231-Z. In 1949, after approximately 4 years of operations and as part of Building 234-5Z (Z Plant) construction, the north 526 m (1,725 ft) section of this ditch was abandoned, backfilled, and replaced with process sewer piping that was routed around 234-5Z facility security fencing. A new headwall was constructed approximately 457 m (1,500 ft) downstream where the new pipeline emptied into the remaining south portion of the ditch. The south portion continued to operate until 1959 and had the potential to receive cooling water waste containing constituents associated with the additional processes that occurred at the 231-Z Plutonium Isolation Plant after 1949.

The north portion of the 216-Z-1D Ditch reportedly did not contain significant contamination when it was abandoned in 1949 and, according to data gathered in 1981, is significantly less contaminated than the south portion of the 216-Z-1D Ditch. The coil failures that were a major source of cooling water waste stream contamination in later years had not yet developed, and no reports of process-upset discharges have been identified. Open ditches were routinely surveyed for radiological contamination to control the potential spread of windblown contamination. In 1981, sampling at the north end of the 216-Z-1D Ditch identified a maximum plutonium concentration of less than 70 pCi/g (RI Report [DOE/RL-2003-11]). The early plutonium purification process in the 231-Z Plutonium Isolation Plant that produced the early 216-Z-1D Ditch waste streams was a tightly controlled process due to the high value of the concentrated plutonium product being processed. At that time, process waste streams were segregated with regard to their potential to contain plutonium with major plutonium-containing waste streams being recycled directly back to 224-T Concentration Facility. The cooling water waste streams did not have a recognized potential to contain plutonium. All other secondary waste streams having a potential to contain plutonium were sent to the 231-W-151 Sump where they were analyzed, neutralized, and either recycled back to the 224-T Concentration Facility for reprocessing, or, if the plutonium was not considered recoverable, disposed to the 216-Z-4 Trench, 216-Z-5 Crib, 216-Z-6 Crib, and/or 216-Z-10 Injection/Reverse Well. Waste containing plutonium was not expected to have been disposed to the 216-Z-1D Ditch (SGW-35060, *Inventory Estimates for Liquid Discharges from the 231-Z Facility*).

2.1.2.2 216-Z-11 Ditch

The 216-Z-11 Ditch operated from 1959 to 1971 and was constructed to replace the 216-Z-1D Ditch after high plutonium contamination was discovered in the portion below the new headwall. As with the other Z-Ditches, it is presumed that the 216-Z-11 Ditch was retired due to evidence of unacceptable levels of surface contamination obtained during operations. The 216-Z-11 Ditch was excavated immediately east of and parallel to the south portion of the 216-Z-1D Ditch and was of similar length (approximately 797 m [2,615 ft] long), width (1.2 m [4 ft] at the bottom), and depth (0.6 m [2 ft] deep). Material excavated for 216-Z-11 Ditch construction was used to backfill the 216-Z-1D Ditch to grade.

2.1.2.3 216-Z-19 Ditch

In April 1971, the 216-Z-11 Ditch was retired and replaced with the 216-Z-19 Ditch. The 216-Z-19 Ditch was dug west of and parallel to the 216-Z-1D and 216-Z-11 Ditches and operated from 1971 to 1981. Excavation material was used to backfill the 216-Z-11 Ditch to grade. The 216-Z-19 Ditch was similar to that of the previous ditches, except that it was 1.2 m (4 ft) deep (DOE/RL-91-58, *Z Plant Source Aggregate Area Management Study Report*).

In 1971, during construction of the 216-Z-19 Ditch, contaminated sediments approximately 130 m (427 ft) from the 216-Z-1D Ditch were inadvertently excavated. Consequently, this portion of the ditch was shifted approximately 10.6 m (35 ft) west. The contaminated sediments were reburied in a trench dug parallel to and east of the 216-Z-11 Ditch, currently designated UPR-200-W-110 Unplanned Release and now a 200-CW-5 OU waste site.

A temporary alignment resulted in the 216-Z-19 Ditch reentering the existing 216-Z-11 Ditch to use the only culvert beneath 16th Street. In October 1971, a new culvert was installed 15 m (49 ft) to the west, and the 216-Z-19 Ditch was realigned and continued approximately 305 m (1,000 ft) to the 216-U-10 Pond.

In late March 1976, an accidental release of contamination occurred in the 216-Z-19 Ditch and efforts were made to contain the contaminants in the ditch. A series of three earthen dams were constructed at intervals along the portion of the ditch above 16th Street to raise the ditch water level above the original contaminated water line and to stop contaminated waste water from reaching the 216-U-10 Pond. A water sprinkler system was installed between the lowermost dam and the 216-U-10 Pond to control the spread of windblown contamination by preventing this portion of the ditch from drying out. Thereafter, waste water never reached the pond. In March 1978, the sprinklers were shut down and the dams were removed, but the remaining surface water infiltrated the soil column before reaching the pond. Consequently, from 1976 until 1981 when the 216-Z-19 Ditch ceased receiving effluent, waste stream contaminants were disposed to the soil column. Waste water was diverted from the 216-Z-19 Ditch to the 216-Z-20 Tile Field shortly afterward.

Deactivation and stabilization of the Z-Ditches area began in 1981, following construction of the 216-Z-20 Tile Field as the primary Z Plant waste water disposal facility. Woody vegetation in the 216-Z-19 Ditch was killed with herbicides (glyphosate and dicamba) before backfill operations were initiated. The 216-Z-19 Ditch was covered with 0.6 to 1 m (2 to 3 ft) of clean soil. The concrete headwalls, vegetation, and miscellaneous unsalvageable equipment were incorporated into the ditch bottom. At the same time, the previously buried 216-Z-1D and 216-Z-11 ditches received an additional 0.15 to 0.30 m (0.5 to 1.0 ft) of clean fill. The Z-Ditch area likely has 0.30 to 0.6 m (1 to 2 ft) of accumulated stabilizing soil cover over the ditch backfill material. The entire Z-Ditch Complex was reposted as an Underground Radioactive Materials Area.

2.1.2.4 216-Z-20 Tile Field

The 216-Z-20 Tile Field operated from 1981 to 1995. It was used to dispose of similar effluent that had previously been routed via the ditches to the 216-U-10 Pond. The 216-Z-20 Tile Field is an unlined, subsurface disposal site that is 463 by 3 m (1,519 by 10 ft) at the base of the unit with a depth of 2.9 m (9.5 ft). Three perforated polyvinyl chloride (PVC) pipes run the length of the ditch in a bed of gravel that was backfilled with clean gravel and soil. The 216-Z-20 Tile Field received cooling water, steam condensate, storm sewer runoff, and/or building and chemical drain waste from Building 234-5Z (Z Plant), 231-Z Plutonium Isolation Plant, Building 291-Z, 232-Z Waste Incinerator Facility, 236-Z Plutonium Reclamation Facility, and 2736-Z Plutonium Storage Building.

The site received effluent volume of 3.8 billion L (1 billion gal) with an effluent volume to soil-pore-volume ratio of 173:1. The estimated site inventory for plutonium is less than 1 g (0.03 oz), and inventories for cesium, americium, and strontium are estimated at 1 Ci or less. A total of 1 Ci of Am-241 and 2 Ci of Pu-239 were released to the crib in 1985 from contamination of process cooling. Further, such releases were prevented by installation of secondary coolant loops.

2.1.2.5 Construction and Operations of UPR-200-W-110

UPR-200-W-110 Unplanned Release is a narrow, one-time use disposal trench located immediately east of and parallel to the 216-Z-11 Ditch. This trench was used to dispose of spoils containing

216-Z-1D Ditch sediments and clean backfill material inadvertently excavated from the 216-Z-1D Ditch during 216-Z-19 Ditch construction in 1971. The trench is 129.5 m (425 ft) long and 4.6 m (15 ft) deep. The bottom 2 m (7 ft) of the trench was filled with the spoils material and filled to grade with clean backfill. Consequently, this site contains similar waste constituents as the other Z-Ditches. No inventory is reported for this site. This trench is within the same underground radioactive material zone as the other Z-Ditches.

2.2 200-CW-5 Operable Unit Physical Setting

The following sections briefly describe the meteorology, topography, geology, and hydrogeologic frameworks for the 200-CW-5 OU waste sites. Additional discussions are provided in PNNL-16346, *Hanford Site Groundwater Monitoring for Fiscal Year 2006*; PNNL-16623, *Hanford Site Environmental Report for Calendar Year 2006*; PNNL-6415, *Hanford Site National Environmental Policy Act (NEPA) Characterization*; RI/FS Work Plan (DOE/RL-99-66); and the RI Report.

2.2.1 Hanford Site Meteorology

The Hanford Site lies east of the Cascade Mountains and has a semi-arid climate caused by the rain shadow effect of the mountains. Climatological data are monitored at the Hanford Meteorological Station (HMS) and other locations throughout the Hanford Site. From 1946 through 2007, the recorded maximum temperature was 45 ºC (113 ºF), and the recorded minimum temperature was –30.6 ºC (–23 ºF) (PNNL-6415). The two extremes occurred during August and February, respectively. The monthly average temperature ranged from a low of –0.7 ºC (31 ºF) in January to a high of 24.7 ºC (76 ºF) in July. The annual average relative humidity is 55 percent (PNNL-6415).

Most precipitation occurs during late autumn and winter, with more than half of the annual amount occurring from November through February (PNNL-6415). Annual average precipitation is 17 cm (6.8 in.). Because this area typically receives less than 25.5 cm (10 in.) of precipitation a year, the climate is considered to be semi-arid (PNNL-6415).

The prevailing wind direction at the HMS is from the northwest during all months of the year (PNNL-6415). Monthly average wind speeds are lowest during the winter months and average about 3 m/s (6 to 7 mi/h). The highest average wind occurs during the summer and is about 4 m/s (8 to 9 mi/h). The record wind gust was 35.7 m/s (80 mi/h) in 1972.

Concerns about severe weather usually center on hurricanes, tornadoes, and thunderstorms. Washington does not experience hurricanes, and tornadoes are rare and generally small in the northwestern portion of the United States. The estimated probability of a tornado striking a point on the Hanford Site is 9.6×10^{-6}/yr. The average occurrence of thunderstorms near the HMS is 10 per year (PNNL-6415, *Hanford Site National Environmental Policy Act [NEPA] Characterization*).

2.2.2 Topography

The Hanford Site is located in the Pasco Basin on the Columbia Plateau. The 200 West Area is located on the 200 Area Central Plateau near the center of the Hanford Site. The 200 Area Central Plateau is the common reference used to describe the Cold Creek Bar – a relatively flat, prominent terrace that trends generally east to west with elevations between 198 and 230 m (650 to 755 ft) above mean sea level. The Cold Creek Bar formed during the cataclysmic flooding events of the Missoula floods, which ended approximately 13,000 years ago.

2.2.3 Geology

The Hanford Site is underlain by basalt of the Columbia River Basalt Group and a sequence of suprabasalt sediments. From oldest to youngest, the major geologic units of interest are the Elephant Mountain Basalt Member, the Ringold Formation, the Cold Creek unit (formerly, Plio-Pleistocene unit, early “Palouse” soil, caliche layer, or pre-Missoula gravels), and the Hanford formation. A generalized stratigraphic column for the 200 West Area is shown in Figure 2-1. Figure 2-2 is a geological cross section of the entire length of the Z-Ditches from the 231-Z Plutonium Isolation Plant down to the 216-U-10 Pond.

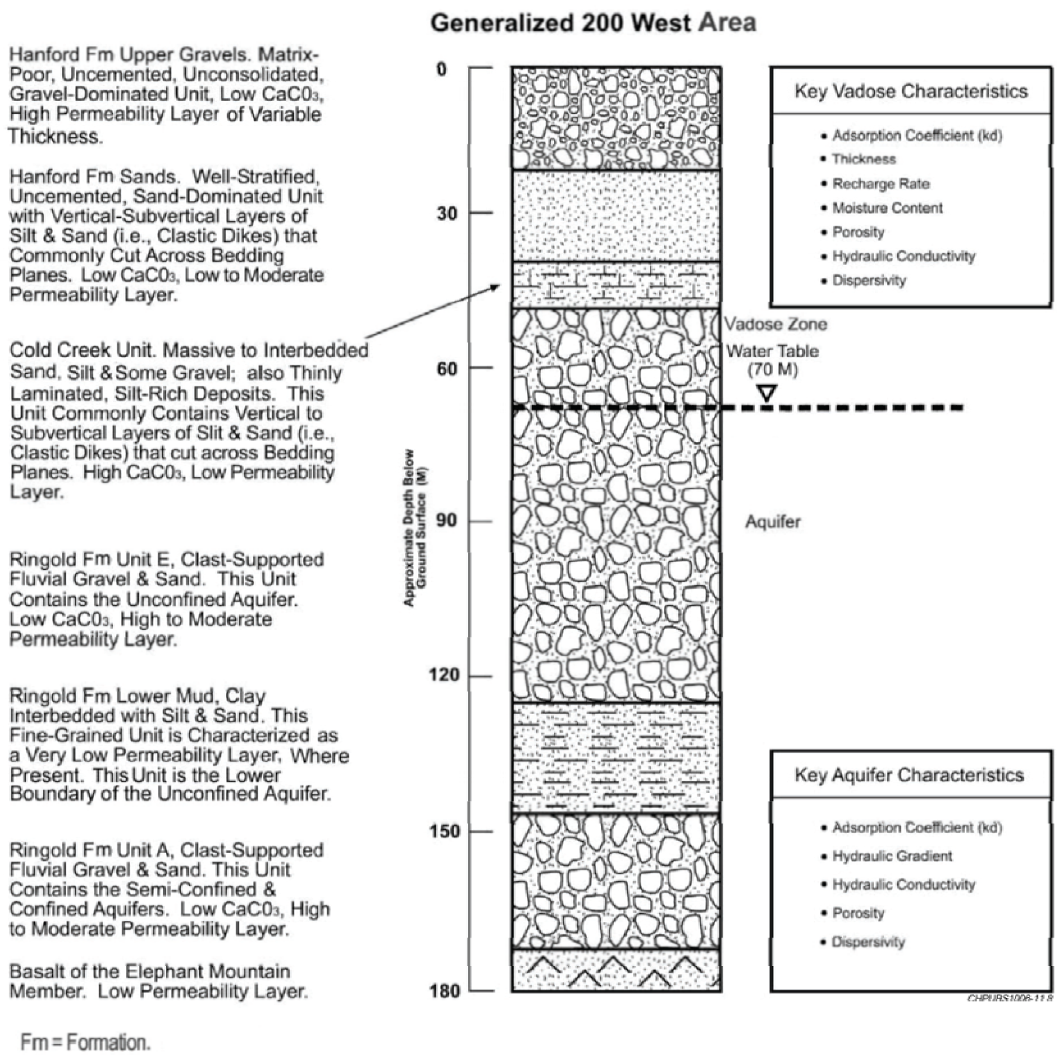


Figure 2-1. Generalized Stratigraphic Column for the 200 West Area

The Elephant Mountain Basalt Member is bedrock beneath the OUs and consists of a medium- to fine-grained tholeiitic basalt with abundant microphenocrysts of plagioclase (DOE/RW-0164, *Consultation Draft Site Characterization Plan: Reference Repository Location, Hanford Site, Washington*). Basalt is overlain by the Ringold Formation over all of the 200 West Area. The Ringold Formation consists of an interstratified sequence of unconsolidated clay, silt, sand, and granule to cobble gravel deposited by the ancestral Columbia River. The fluvial-lacustrine Ringold Formation is informally divided into several units; these are (from oldest to youngest) the fluvial gravel and sand of unit A, the buried soil horizons and lake deposits of the lower mud sequence, the fluvial sand and gravel of unit E, and the lacustrine mud of the upper Ringold unit.

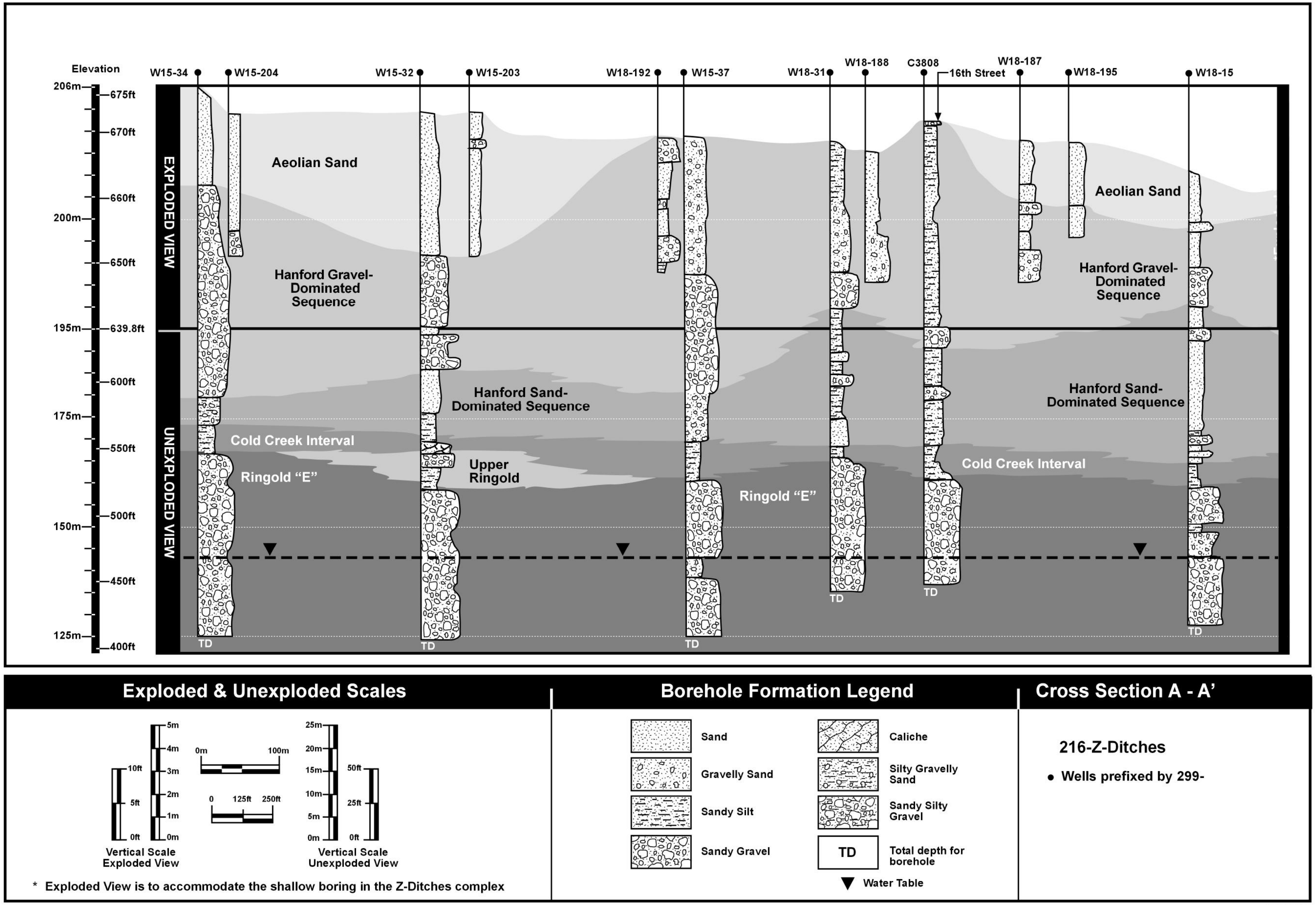


Figure 2-2. Geologic Cross Section, Z-Ditches in the 200 West Area

This page intentionally left blank.

The Cold Creek unit overlies the Ringold Formation in the 200 West Area (DOE/RL-2002-39, *Standardized Stratigraphic Nomenclature for Post-Ringold Formation Sediments Within the Central Pasco Basin*) and is divided into five lithofacies. Descriptions of the five lithofacies units, depositional environments, and association with previous site nomenclature are shown in Table 2-1 and are further described in DOE/RL-2002-39. The five lithofacies units are differentiated based on grain size, sedimentary structure, sorting, fabric, and mineralogy as follows:

1. Fine-grained, laminated to massive
2. Fine-to coarse-grained, calcium carbonate cemented
3. Coarse-grained, multilithic
4. Coarse-grained, angular, basaltic
5. Coarse-grained, round basaltic lithofacies

Table 2-1. Lithofacies of the Cold Creek Unit

Lithofacies	Environment of Deposition	Previous Site Nomenclature
Fine-grained, laminated to massive. Consists of a brown-to yellow very well sorted cohesive, compact, and massive-to laminated-and stratified-fine-grained sand and silt. It is moderately to strongly calcareous with relatively high natural background gamma activity.	Fluvial-overbank and eolian	Palouse soil, early "Palouse" soil, Hanford formation/ Plio-Pleistocene unit silt.
Fine-to coarse-grained, calcium carbonate cemented. Consists of basaltic to quartzite gravels, sands, silts, and clay that are cemented with one or more layers of secondary, pedogenic calcium carbonate.	Calcic paleosol	Highly weathered subunit of the Plio-Pleistocene unit/caliche, calcrete.
Coarse-grained, multilithic. Consists of rounded, quartzose to gneissic clast-supported pebble-to cobble-size gravel with a quartzo-feldspathic sand matrix.	Mainstream alluvium	Distantly derived subunit of the Plio-Pleistocene unit/ pre-Missoula flood gravel.
Coarse-grained, angular, basaltic. Consists of angular, clast-to matrix-supported basaltic gravel in a poorly sorted mixture of sand and silt with no stratification. Calcic paleosols may be present.	Colluvium	New facies designation for the Pasco Basin.
Coarse-grained, round basaltic lithofacies.	Sidestream alluvium	Locally derived subunit of the Plio-Pleistocene unit.

Notes:

Based on DOE/RL-2002-39, *Standardized Stratigraphic Nomenclature for Post-Ringold Formation Sediments within the Central Pasco Basin*.

The Hanford formation overlies the Cold Creek unit in the 200 West Area. The Hanford formation consists of unconsolidated gravel, sand, and silt deposited by cataclysmic floodwaters. These deposits consist of gravel- and sand-dominated facies. The gravel-dominated facies consist of cross-stratified, coarse-grained sands and granule to boulder gravel. The gravel is uncemented and matrix poor. The sand facies consist of well-stratified, fine- to coarse-grained sand and granule gravel. Silt content is variable and may be interbedded with the sand. Where the silt content is low, an open-framework texture is common. An upper and lower gravel unit and a middle sand facies are present in the study area.

The cataclysmic floodwaters that deposited sediments of the Hanford formation also locally reshaped the topography of the Pasco Basin. The floodwaters deposited a thick sand and gravel bar that constitutes the higher southern portion of the 200 Area, informally known as the 200 Area Central Plateau.

Holocene-aged deposits overlie the Hanford formation and are dominated by eolian sheets of sand that form a thin veneer across the site, except in localized areas where they are absent. Surficial deposits consist of very fine-to medium-grained sand to occasionally silty sand. Silty deposits less than 1 m (3 ft) thick also have been documented at waste sites where fine-grained windblown material has settled out through standing water over many years.

2.2.4 Hydrostratigraphy

A detailed discussion of the hydrostratigraphy in the Z-Ditches area is contained in the RI Report and is summarized in this section. The vadose zone is the unsaturated region between the ground surface and water table. Near the 200 West Area, the vadose zone thickness is 62 m (206 ft). Details of performance of the aquifer and recharge rates are contained in PNL-10285, *Estimated Recharge Rates at the Hanford Site*, and in PNL-5506, *Hanford Site Water Table Changes 1950 through 1980: Data Observations and Evaluation.* Recharge to the unconfined aquifer in the 200 Area is from artificial and natural sources.

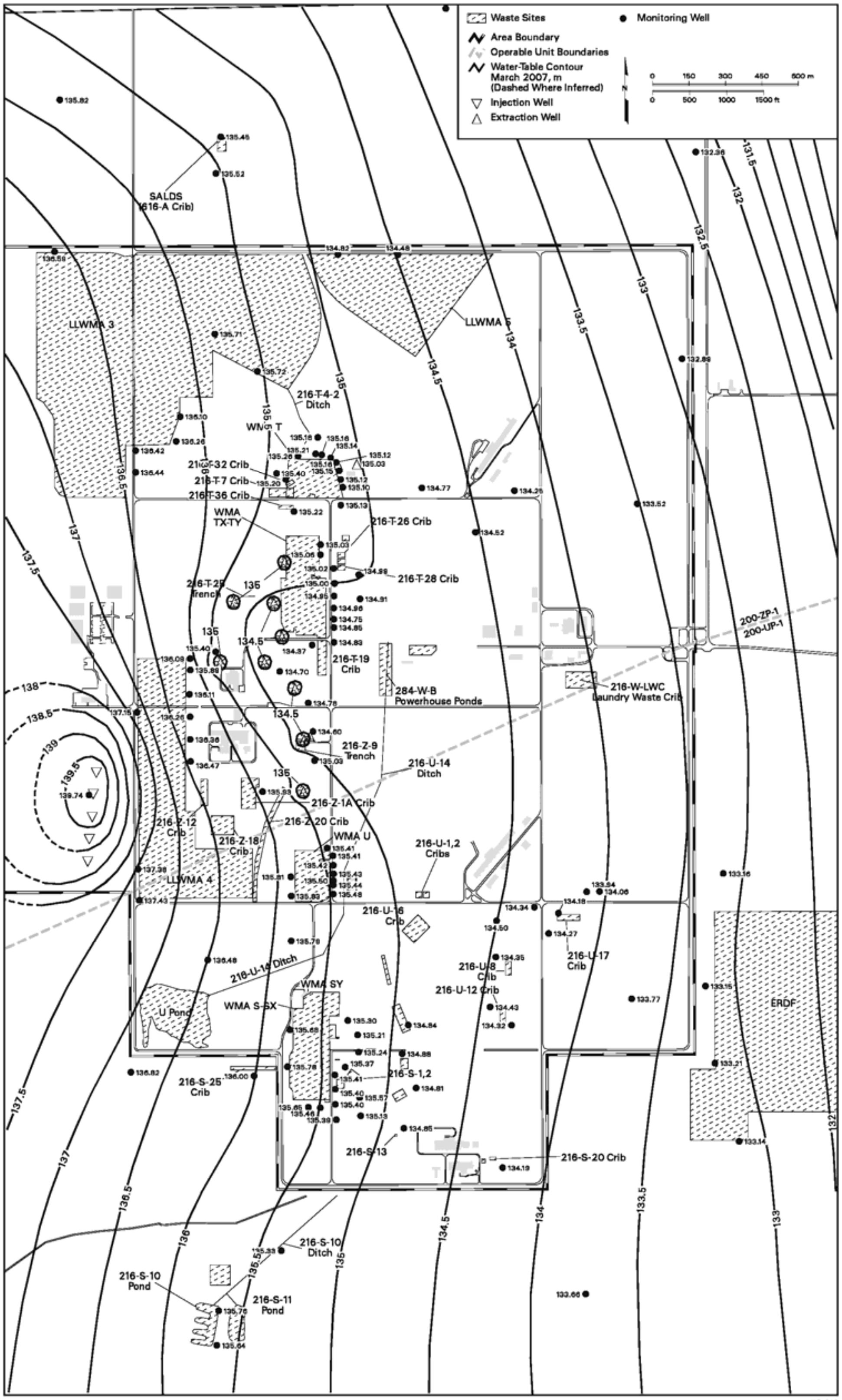
While the liquid waste disposal facilities (e.g., 216-Z-20 Tile Field) were operating, many localized areas of saturation or near saturation were created in the soil column. With the reduction of artificial recharge in the 200 Area, these locally saturated soil columns are dewatering. As the soil column dewaters, the moisture flux decreases. However, residual moisture in the vadose zone, particularly in and above fine-textured, low permeability layers, may remain held up for extended periods. This is shown by 200 Area sampling that generally confirms elevated moisture levels at such layers coupled with the presence of more mobile contaminants (if in the waste streams) that would have traveled with the moisture front. In the absence of artificial recharge, natural recharge becomes a primary driving force for contaminant movement in the vadose zone making control of natural recharge important in controlling vadose zone contaminant transport.

The unconfined aquifer in the 200 Area occurs in the Hanford formation, the Cold Creek unit, and the Ringold Formation. The groundwater in the unconfined aquifer flows from areas where the water table is higher (west of the Hanford Site) to areas where it is lower (the Columbia River) (DOE/RL-2008-01, *Hanford Site Groundwater Monitoring for Fiscal Year 2007*). In general, groundwater flow through the 200 Areas Central Plateau occurs in a predominantly easterly direction, from the 200 West Area to the 200 East Area (Figure 2-3).

Historical discharges to the ground greatly altered the groundwater flow regime. This occurred especially around the 216-U-10 (U Pond) disposal system in the 200 West Area that included the Z-Ditches and resulted in a groundwater mound developing in excess of 26 m (85 ft). As the hydraulic effects of this artificial recharge diminishes, groundwater flow has acquired, as predicted in BHI-00469, *Hanford Sitewide Groundwater Remediation Strategy-Groundwater Contaminant Predictions,* a more easterly course through the 200 Area, with some flow possibly continuing through Gable Gap.

2.3 Natural and Cultural Resources

Natural resources in the study area and vicinity include vegetation and wildlife resources. Biological and ecological information, including potential effects of implementing remedial actions and identification of sensitive habitats and species, will be used to aid in evaluating impacts to the environment from contaminants in the soils. This section also considers cultural and aesthetic resources and socioeconomics associated with activities in the 200 Area.



Source: NAVD88, 1988, *North American Vertical Datum of 1988*

Figure 2-3. Water Table Map Encompassing the 200-CW-5 Operable Unit

As discussed later in this section dealing with ecological risk, 200 Areas Central Plateau survey data were collected in 2000 and 2001 in support of Central Plateau ecological evaluations (DOE/RL-2001-54, *Central Plateau Ecological Evaluation*). These data included plant community descriptions, identification of plant and wildlife species, and avian census data. Also, at that time, designated levels of habitat under DOE/RL-96-32, *Hanford Site Biological Resources Management Plan*, including rare plant populations, were identified and mapped. No fire other than the Command 24 fire in 2000 has reached the Z-Ditches.

2.3.1 Vegetation

Vegetation in the study area is characterized by native shrub-steppe, interspersed with large areas of disturbed ground dominated by annual grasses and forbs. In the native shrub-steppe, the dominant shrub is big sagebrush (*Artemisia tridentata*). The understory is dominated by the native perennial, Sandberg's bluegrass (*Poa sandbergii*), and the introduced annual, cheatgrass (*Bromus tectorum*). Other shrubs typically present include rabbitbrush (*Chrysothamnus spp*.), spiny hopsage (*Grayia spinosa*), and antelope bitterbrush (*Purshia tridentata*). Other native bunchgrasses that also are present include Indian ricegrass (*Oryzopsis hymenoides*) and needle-and-thread grass (*Stipa comata*). Common herbaceous species include turpentine cymopteris (*Cymopteris terebinthinus*), globemallow (*Sphaeralcea munroana*), balsamroot (*Balsamorhiza careyana*), milkvetch (*Astragalus spp*.), yarrow (*Achillea millefolium*), dwarf evening primrose (*Camissonia pygmaea*), and daisy (*Erigeron spp*.).

Many of the waste disposal and storage sites in the 200 Area have been backfilled with clean soil and planted with crested or Siberian wheatgrass (*Agropyron cristatum* and *Agropyron sibericum*, respectively) to stabilize surface soil, control soil moisture, or displace more invasive deep-rooted species like Russian thistle (PNNL-6415). The soil and vegetation associated with the waste sites addressed in this FS are highly disturbed. This disturbed habitat primarily is the result of mechanical and operational disturbance. Outlying habitats also have been disturbed because of range fires, clearing, and construction activities.

2.3.2 Wildlife

The largest mammal potentially frequenting the study area is the mule deer (*Odocoileus hemionus*). Mule deer are much more common along the Columbia River; the few that forage throughout the 200 Area make up a distinct group called the Central Population (PNNL-11472, *Hanford Site Environmental Report for Calendar Year 1996*). A large elk herd (*Cervus canadensis*) currently resides on the Fitzner-Eberhardt Arid Lands Ecology Reserve. The Rattlesnake Hills herd of elk that inhabits the Hanford Site primarily occupies the Arid Lands Ecology Reserve and private lands that adjoin the reserve to the south and west and do not forage on the 200 Area Plateau where the Z-Ditches are located (PNNL-6415).

Experienced biologists reported sighting a cougar (*Felis concolor*) on the Arid Lands Ecology Reserve during the elk relocation in March 2000, supplementing anecdotal accounts of other observations of the presence of a cougar on the Hanford Site (PNNL-6415).

Other mammals common to the 200 Area are badgers (*Taxidea taxus*), coyotes (*Canis latrans*), Great Basin pocket mice (*Perognathus parvus*), northern pocket gophers (*Thomomys talpoides*), and deer mice (*Peromyscus maniculatus*). Badgers are known for their digging ability and have been suspected of excavating contaminated soil at 200 Area radioactive waste sites (BNWL-1794, *Distribution of Radioactive Jackrabbit Pellets in the Vicinity of the B-C Cribs, 200 East Area, USAEC Hanford Reservation*). The majority of badger diggings are a result of searches for food, especially for other burrowing mammals such as pocket gophers and mice. Pocket gophers, Great Basin pocket mice, and deer mice are abundant herbivores in the 200 Area. These small mammals can excavate significant amounts of soil as they construct their burrows (e.g., Hakonson et al., 1982, "Disturbance of a Low-Level Waste Burial Site Cover by Pocket Gophers"). Mammals associated with buildings and facilities include

Nuttall's cottontails (*Sylvilagus nuttallii*), house mice (*Mus musculus*), Norway rats (*Rattus norvegicus*), and various bat species.

Common bird species in the study area include the starling (*Sturnus vulgaris*), horned lark (*Eremophila alpestris*), meadowlark (*Sturnella neglecta*), western kingbird (*Tyrannus verticalis*), rock dove (*Columba livia*), black-billed magpie (*Pica pica*), and raven (*Corvus corax*). Burrowing owls (*Athene cunicularia*) commonly nest in the 200 Area in abandoned badger or coyote holes, or in open-ended stormwater pipes along roadsides in more industrialized areas. Loggerhead shrike (*Lanius ludovicianus*) and sage sparrow (*Amphispiza belli*) are common nesting species in habitats dominated by sagebrush. Long-billed curlews (*Numenius americanus*) have been observed nesting on inactive waste sites.

Reptiles common to the study area include gopher snakes (*Pituophis melanoleucus*) and sideblotched lizards (*Uta stansburiana*). Rattlesnakes (*Crotalus viridis*) also have been observed. Reptile sightings are not widespread, with only 23 observations of side-blotched lizards at 316 sites surveyed during a 2001 Ecological Compliance Assessment Project survey (DOE/RL-2001-54, Appendix B).

Three of the most common groups of insects include darkling beetles, grasshoppers, and ants. Ants have been known to burrow up to 2.7 m (9 ft) into the vadose zone and bring contaminants to the surface.

2.3.3 Species of Concern

The Hanford Site is home to a number of species of concern, but many of these are associated with the Columbia River and its shoreline, not the Central Plateau.

Several threatened, endangered, and candidate species are found on the Central Plateau. These species are detailed in Table 2-2. Fauna are managed by the Washington Department of Fish and Wildlife, and migratory birds are protected by the *Migratory Bird Treaty Act of 1918*. Species that are associated with specific localities or altitude not within the Central Plateau, or whose habit is riparian or river shore, are omitted with the exceptions of the bald eagle (*Haliaeetus leucocephalus*), the peregrine falcon (*Falco peregrinus*), and the golden eagle (Aquila chrysaetos). It should be noted that the bald and golden eagles are protected by the *Bald and Golden Eagle Protection Act of 1940*. While these species are dependent on the river corridor, they are occasionally observed on the Central Plateau. Additionally, the pygmy rabbit (*Brachylagus idahoensis*), a federal and state endangered species, has not been observed on the Central Plateau but has been seen on the Arid Lands Ecology Reserve and is included in Table 2-2.

Table 2-2. Potential Species of Concern on the Central Plateau

Common Name(s)	Scientific Name(s)	State Listing	Federal Listing
Plants			
Great Basin gilia	*Aliciella leptomeria*	T	None
Geyer's milk-vetch	*Astragalus geyeri*	T	None
Rosy pussypaws/rosy calyptridium	*Cistanthe rosea*	T	None
Desert dodder	*Cuscuta denticulata*	T	None
Loeflingia	*Loeflingia squarrosa var. squarossa*	T	None
Small-flowered evening primrose	*Camissonia minor*	S	None
Dwarf evening-primrose	*Camissonia pygmaea*	S	None
Gray cryptantha	*Cryptantha leucophaea*	S	None

Table 2-2. Potential Species of Concern on the Central Plateau

Common Name(s)	Scientific Name(s)	State Listing	Federal Listing
Piper's daisy	*Erigeron piperianus*	S	None
Suksdorf's monkey-flower	*Mimulus suksdorfii*	S	None
Coyote tobacco	*Nicotiana attenuata*	S	None
Birds			
Sage sparrow	*Amphispiza belli*	E	None
Ferruginous hawk	*Buteo regalis*	T	SC
Greater sage grouse	*Centrocercus urophasianus*	T	C
Burrowing owl	*Athene cunicularia*	C	SC
Golden eagle*	*Aquila chrysaetos*	C	None
Loggerhead shrike	*Lanius ludovicianus*	C	SC
Sage thrasher	*Oreoscoptes montanus*	C	None
Bald eagle*	*Haliaeetus leucocephalus*	S	SC
Peregrine falcon	*Falco peregrinus*	S	SC
Mammals			
Pygmy rabbit	*Brachylagus idahoensis*	E	E
Black-tailed jackrabbit	*Lepus californicus*	C	None
White-tailed jackrabbit	*Lepus townsendii*	C	None
Merriam's shrew	*Sorex merriami*	C	None
Townsend's ground squirrel	*Spermophilus townsendii*	C	SC
Washington's ground squirrel	*Spermophilus washingtoni*	C	C
Amphibians and Reptiles			
Striped whipsnake	*Masticophis taeniatus*	C	None
Northern sagebrush lizard	*Sceloporus graciosus*	C	SC

* Bald and golden eagles are protected by the *Bald and Golden Eagle Protection Act of 1940.*

Sources:

WDFW, 2009, "Species of Concern," Washington State, current through June 1, 2009

WNHIS, 2009, "Washington Natural Heritage Information System List of Known Occurrences of Rare Plants and Animals in Washington February 2009"

WNHP, 2009," List of Plants Tracked by the Washington National Heritage Program," January 2009

E = Endangered
C = Candidate
S = Sensitive
SC = Species of Concern
T = Threatened

Plant and animal species of concern, their designations, and the places of their occurrence can change over time. At this time, it is not anticipated that remediation of the 200-CW-5 OU will affect any species of concern, but incorporating the needs of these species into project planning will help to mitigate any potential effects. Especially important is avoiding, where possible, undisturbed shrub-steppe habitat because this is important to many species of concern. The undisturbed shrub-steppe in the Central Plateau was designated as Level 3 habitat in DOE/RL-96-32, which requires mitigation of any disturbance (e.g., through avoidance and minimization) and possibly rectification and compensation. Additional details on protecting Level 3 habitats and species of concern are provided in DOE/RL-96-32. In addition, site-specific environmental surveys, required before ground disturbance can occur, serve as a final check to ensure that ecological resources are adequately protected.

2.3.4 Cultural Resources

A comprehensive archaeological survey of the 200 Area found artifacts in conjunction with areas of high topographic relief and in the vicinity of sources of permanent water, but few artifacts associated with open, inland flats (PNL-7264, *Archaeological Survey of the 200 East and 200 West Areas, Hanford Site, Washington*). PNL-7264 addressed only undisturbed portions of the 200 Area, not including the highly disturbed and contaminated Z-Ditches, and did not address facilities and structures. In the 200 West Area, the only culturally sensitive area identified is the historic White Bluffs Road that crosses the northwest corner of the site. The report concluded that additional cultural resource reviews are required only for proposed projects within 100 m (328 ft) of this road. None of the waste sites associated with the OUs involved in this FS are within 100 m (328 ft) of this road (PNL-7264).

Between 1994 and 1996, RL, the Washington State Historic Preservation Office, and the Advisory Council on Historic Preservation negotiated DOE/RL-96-77, *Programmatic Agreement Among the U.S. Department of Energy, Richland Operations Office, The Advisory Council on Historic Preservation, and the Washington State Historic Preservation Office for the Maintenance, Deactivation, Alteration, and Demolition of the Built Environment on the Hanford Site, Washington*, satisfied all requirements of the *National Historic Preservation Act of 1966* for remediation of the Hanford Site by the following: (1) documenting a representative sample of 190 buildings/structures, and (2) writing a single, integrated document chronicling the unique history of the Hanford Site, its technology, and the people who worked at the Hanford Site. Section I(C) of DOE/RL-96-77 states the following:

> *"Completion of the Site-wide Treatment Plan established under this PA [Programmatic Agreement] satisfies all Section 106 requirements for identification, evaluation, and treatment necessary for all undertakings, up to and including demolition, which may affect Manhattan Project and Cold War Era properties."*

RL established a Historic Buildings Task Group, as required by Section II(A) of DOE/RL-96-77, and charged them with the responsibility "to identify, inventory, and evaluate all historic buildings and structures on the Hanford Site not evaluated previously or otherwise exempt by Stipulation III.A.1-6 of this agreement." Over a 2-year period, the Task Group met regularly and evaluated approximately 1,000 buildings and structures, making both a determination of which were contributing and which were non-contributing properties within the Hanford Site Manhattan Project and Cold War Era Historic District and which properties would be individually documented as significant buildings or as representatives of property types. Other than listing in the Hanford Site Historic Buildings database, no documentation was required for buildings/structures not selected as significant or representative (see Section II(C) of DOE/RL-96-77).

On January 15, 1998, RL issued the final version of DOE/RL-97-56, *Hanford Site Manhattan Project and Cold War Era Historic District Treatment Plan*. DOE/RL-97-56, Appendix C lists the waste sites selected for documentation on Historic Property Inventory Forms. The documented waste sites included the following:

- 216-U-10 (U Pond)
- 218-E-14 and 218-E-15 Storage Tunnels
- 218-WR; AW, T, TX, and TY Tank Farms
- 244-UR Vault
- BC Cribs
- 216-B-5 Injection/Reverse Well

No additional documentation is required for the 200-CW-5 OU waste site. However, the *National Historic Preservation Act of 1966,* Section 106, cultural resource reviews will be required for access areas (e.g., new or improved roads) and laydown areas (e.g., equipment storage) for required infrastructure for remediation of the 200-CW-5 OU.

2.3.5 Aesthetics, Visual Resources, and Noise

With the exception of Rattlesnake Mountain, land on the Hanford Site generally is flat with little relief. Rattlesnake Mountain, rising to 1,060 m (3,478 ft) above mean sea level, forms the southwestern boundary of the Hanford Site, and Gable Mountain and Gable Butte are the highest landforms on the Hanford Site itself. The view toward Rattlesnake Mountain is visually pleasing, especially in the springtime when wildflowers are in bloom. Large rolling hills are located to the west and far north. The Columbia River, flowing across the northern part of the Site and forming the eastern boundary, generally is considered scenic.

Studies at the Hanford Site on the propagation of noise have been concerned primarily with occupational noise at work sites. Environmental noise levels have not been extensively evaluated because of the remoteness of most Hanford Site activities and their isolation from receptors covered by Federal or state statutes. Most industrial facilities on the Hanford Site are located far enough away from the Site boundary that noise levels at the boundary are not measurable or are indistinguishable from background noise levels (PNNL-6415).

2.3.6 Socioeconomics

As reported in PNNL-6415, activity on the Hanford Site plays a dominant role in the socioeconomics of the Tri-Cities (i.e., the Cities of Pasco, Richland, and Kennewick, Washington) and other parts of Benton and Franklin Counties. The agricultural community also has a significant effect on the local economy. Any major changes in Hanford Site activity would potentially affect the Tri-Cities and other areas of Benton and Franklin Counties.

DOE and its contractors compose the largest single source of employment in the Tri-Cities. During fiscal year (FY) 2006, an average of 9,759 employees were employed by DOE Office of River Protection (ORP) and its prime contractor CH2M HILL Hanford Group, Inc.; DOE RL and its prime contractors Fluor Hanford, Inc., Washington Closure Hanford, LLC (WCH), and AdvanceMed Hanford; and the DOE Office of Science Pacific Northwest Site Office (PNSO) and the PNNL, which is operated by Battelle. FY 2006 year-end employment for all DOE contractors was 9,707, down from 10,135 at the end of FY 2005. In addition to these totals, Bechtel National, Inc. (BNI), which has had the responsibility to design, build, and start up waste treatment facilities for the vitrification of liquid radioactive waste since December 2000, employed 1,647 at the end of FY 2006. BNI employment peaked at 3,867 in July 2004.

The total annual average number of DOE contractor employees has declined by nearly 7,600 since FY 1994 when employment peaked at 19,200 employees, but DOE contractor employment still represents 11 percent of the total jobs in the economy. Total employment in the Richland, Kennewick, and Pasco metropolitan statistical area averaged 106,100 per month during 2006, down from 107,700 in 2005. Based on employee records as of April 2007, more than 90 percent of DOE contractor employees live in Benton and Franklin Counties. Approximately 73 percent reside in Richland, Pasco, or Kennewick. More than 36 percent are Richland residents, 11 percent are Pasco residents, and 25 percent live in Kennewick. Residents of other areas of Benton and Franklin Counties, including West Richland, Benton City, and Prosser, account for about 17 percent of total DOE contractor employment.

In addition to the Hanford Site, other key employers in the area include:

- Energy Northwest
- ConAgra/Lamb Weston
- Tyson Fresh Meats
- Wal-Mart
- AREVA NP, Inc.
- Boise Cascade Corporation Paper and Corrugated Container Divisions

Tourism and government transfer payments to retirees in the form of pension benefits also are important contributors to the local economy.

Benton County had an estimated population of 160,600 and 64,200 lived in Franklin County during 2006, totaling 224,800, an increase of more than 17 percent from the Census 2000 figure. This growth rate is faster than the State of Washington as a whole, which has grown 8.2 percent since the 2000 Census. According to the 2000 Census, population totals for Benton and Franklin Counties were 142,475 and 49,347, respectively. Both Benton and Franklin Counties also grew at a faster pace than the state during the 1990s. The population of Benton County increased 42.7 percent, up from 112,560 during 1990, and the population of Franklin County increased 71.3 percent, up from 37,473 during 1990, while the population of the State of Washington rose 21.1 percent.

Based on the 2000 census, the 80-km (50-mi) radius area surrounding the Hanford Site had a total population of 482,300 and a minority population of 178,500. The ethnic composition of the minority population is primarily Hispanic (24 percent), self-designated "other and multiple races" (63 percent), and Native American (6 percent). Asians and Pacific Islanders (4 percent) and African Americans (3 percent) make up the remainder of the population in the area. The Hispanic population resides predominantly in Franklin, Yakima, Grant, and Adams Counties. Native Americans within the 80-km (50-mi) area reside primarily on the Yakama Reservation and upstream of the Hanford Site near the town of Beverly, Washington.

2.4 Summary of 200-CW-5 Operable Unit Characterization

This section summarizes RI and historical data-collection activities at 200-CW-5 OU waste sites. The activities include RI sampling and analysis activities at the 216-Z-11 Ditch in 2002 and existing historical characterization activities at other Z-Ditch locations that have provided information and data used in FS evaluation processes.

2.4.1 Remedial Investigation Data-Collection Activities

The RI activities for the 200-CW-5 OU were conducted in 2002 in accordance with DOE/RL-99-66 and DOE/RL-2002-24, *200-CW-5 U Pond/Z Ditches Cooling Water Group Operable Unit Remedial Investigation Sampling and Analysis Plan*. The 200-CW-5 OU RI focused on characterization of the 216-Z-11 Ditch, which was identified for further RI characterization initially as a 200-CW-5 OU representative waste site by DOE/RL-96-81 and BHI-01294, *Data Quality Objective Summary Report for the 200-CW-5 U Pond/Z Ditches System Waste Sites*. During the 200-CW-5 OU data quality objective process, the 216-Z-11 Ditch was selected for RI evaluation to complete the contamination picture of the Z-Ditches areas because a large body of historical characterization data existed for the 216-Z-1D and 216-Z-19 Ditches but less was known about the 216-Z-11 Ditch. The 216-Z-11 Ditch waste-stream inventories, effluent volumes received, and the current level of characterization all suggested that high contaminant inventories are present in the subsurface beneath this receiving site. Consequently, the 216-Z-11 Ditch was expected to present 200-CW-5 OU worst case waste site contaminant conditions.

The RI was conducted from January to October 2002 and began with soil probe investigations to optimize placement of a single borehole at the highest anticipated contamination area of the 216-Z-11 Ditch. Soil probes were placed at transects along the 216-Z-11 Ditch and ground-penetrating radar was used to identify the location of the backfilled and parallel 216-Z-1D and 216-Z-19 Ditches for inclusion in the investigation.

Borehole C3808 was drilled at the 216-Z-11 Ditch at the location of highest contamination found by the soil probes. These efforts are summarized in CP-12134, *Borehole Summary Report for Borehole C3808 in the 216-Z-11 Ditch, 200-CW-5, U-Pond/Z-Ditches Cooling Water Operable Unit*, and were presented in the RI Report. Borehole C3808 was logged in 2002 with a small-diameter gross gamma/passive neutron tool with spectral gamma logging to depths of 4.9 m and 68.6 m (16 ft and 225 ft), respectively.

For purposes of remedial decision-making and based on RI results, the RI report grouped the 216-Z-1D (south portion), 216-Z-19, and 216-Z-11 Ditches together into a single, contiguous characterization and contamination area (Z-Ditches) thereby replacing the 216-Z-11 Ditch as the 200-CW-5 OU representative site with the collective Z-Ditches. This was done because these three ditches represent one large, contiguous contamination area that received the same waste streams; are parallel and side-by-side; sometimes shared common areas along their length; ditch boundaries have been obscured by site stabilization activities and essentially are indiscernible; and because of uncertainty associated with the exact location of boreholes relative to individual ditch locations.

2.4.2 Prior Z-Ditches Area Characterization (1959–1981)

This section identifies characterization activities at the Z-Ditches area before the 2002 RI.

2.4.2.1 216-Z-1D Ditch Sediment Sampling (1959)

A total of 90 sediment grab samples (“mud samples”) were collected from the bottom of the 216-Z-1D Ditch in 1958 and 1959 to investigate radiological surface contamination. Samples were collected on 30 m (100-ft) centers in groups of three for the entire length of the ditch. Nine of these samples were collected from the 216-Z-1D Ditch and the remaining 81 samples were collected from the “234-235” Ditch, which may be an alias for the 216-Z-1D Ditch. The samples were analyzed for total alpha activity and Pu-239. Sample locations are shown in WHC-EP-0707, and analytical results are presented in the RI Report (DOE/RL-2003-11, Appendix A, Table A-4).

2.4.2.2 216-Z-19 Ditch Sediment Sampling (1976)

Eight sediment samples were collected from the bottom of the 216-Z-19 Ditch during March and April 1976 (WHC-EP-0707). The samples were analyzed for K-40, Sr-89/90, Cs-137, Ce-139, Pu-239, Am-241, and Ra-226. Samples were collected along the entire ditch alignment. Only descriptive locations are available for these samples (e.g., “west bank head,” “U Pond inlet”). Analytical results are presented in the RI Report (DOE/RL-2003-11, Appendix A, Table A-4).

2.4.2.3 Routine Annual 216-Z-19 Ditch Sediment Sampling (1974–1979)

As part of the Rockwell Hanford Operations Environmental Surveillance Program, sediment samples were collected annually at the 216-Z-19 Ditch from 1974 through 1977 (WHC-EP-0707). One sediment sample was collected annually from 1974 to 1977, two were collected in 1978, and four were collected in 1979. Samples were analyzed for radionuclides, including Sr-90, Cs-137, Pu-239/240, and Am-241. Only descriptive locations are available for these samples. Analytical results are presented in the RI Report (DOE/RL-2003-11, Appendix A, Table A-4).

2.4.2.4 216-Z-19 Ditch Characterization Sampling (1979–1981)

In 1979, a characterization study was performed of the 216-Z-19 Ditch (and 216-U-10 Pond) to gather surface and near-surface samples from the 216-Z-19 Ditch. The 216-Z-19 Ditch was still operating at the time of the study and the portion of the ditch above 16th Street was dammed to prevent water from reaching the 216-U-10 Pond and portions containing standing water. In total, 246 samples were collected along nine transects placed over the length of the ditch, with each transect having seven sample points. The transect locations are shown in WHC-EP-0707. Vertical sample intervals generally were 5 to 10 cm (2 to 4 in.) in length, and samples were collected less than 1 m (3 ft) below the ditch bottom. Analytical results are presented in the RI Report (DOE/RL-2003-11, Appendix A, Table A-4).

Laboratory analyses were conducted at the Rockwell Laboratory (onsite) and two offsite laboratories (Eberline Services and Environmental Analysis Laboratory). Only laboratory analyses were used in the RI Report to evaluate the concentrations of the radioactive constituents. Forty-five of the 246 samples were analyzed using a developmental and unreliable analytical process (Dev Van IA) and so the results were not used. The remaining samples used for the transect investigation were analyzed for Cs-137, Pu-239/240, Pu-238, Sr-90, and Am-241. Thirteen additional separate surface grab samples were collected from the bottom of the ditch from 16th Street to the delta region entering the 216-U-10 Pond to better characterize the lower end of the ditch.

In addition, 19 boreholes were drilled near the Z-Ditches in 1980 and 1981. Two deep monitoring wells (299-W18-177 and 299-W18-178) were drilled during March and April 1980 to evaluate the vertical distribution of contaminants. Seventeen shallow exploration wells were drilled between February and April 1981 to locate and sample the backfilled 216-Z-1D and 216-Z-11 Ditches. The shallow wells included 299-W15-203 and 299-W15-204 that were drilled in the 216-Z-1D Ditch North Section to a depth of 6.1 m (20 ft) below ground surface (bgs). Seventy samples were collected from these boreholes and analyzed for Pu-238, Pu-239/240, and Am-241. As with the transect data described earlier, results from the Dev Van IA detector are not included in the data set. Consequently, a total of 66 samples were analyzed (20 from two deep boreholes and 46 from 9 shallow boreholes). The results are presented in the RI Report (DOE/RL-2003-11, Appendix A, Table A-4).

2.4.2.5 Field Screening in Support of 216-Z-20 Tile Field Construction and UPR-200-W-110 Location and Stabilization (1979-1980)

This activity included drilling of 44 boreholes to support design and construction of the 216-Z-20 Tile Field and stabilization of the UPR-200-W-110. This activity was documented in Rockwell International report RHO-HS-VS-4, *Earth Science Investigations of the 216-Z-20 Crib, the UN-216-W-20 Spoil Trench, and the Storm Sewer Pond*. This Rockwell report was not formally published but represents credible anecdotal information. Nine shallow boreholes were drilled in and around the backfilled UPR-200-W-110 Unplanned Release, at that time known as the UN-216-W-20 spoils trench, to determine the location and boundaries of the trench and to identify the extent of radiological contamination. Other boreholes were drilling near the planned 216-Z-20 Tile Field site; however, only the unplanned release (UPR) investigation data are used in the FS.

Analytical data were not generated from the UPR portion of this investigation and consequently, this information will not be used for risk assessment purposes. However, the field-screening information will be used to support discussion of a potential UPR relationship with the heavily characterized Z-Ditches.

Sediment samples were collected from groups of five or six cores taken from each of Boreholes 233 through 239 located in and around the trench. Samples were analyzed in the field using a system capable of assaying grab samples for Pu-239 and Am-241 using Si(Li) X-ray spectroscopy (XS). This screening identified the presence of Am-241 and Pu-239 in Boreholes 233 through 239.

2.5 Z-Ditches Characterization Results – Nature and Extent of Contamination

The nature and vertical extent of contamination at the Z-Ditches characterization area were identified based on 216-Z-11 Ditch 2002 RI data obtained from Borehole C3808 and existing historical data from other Z-Ditch locations, that have been identified as sufficient to support risk evaluation in the 200-CW-5 OU. Contamination is defined in this section as the presence of chemical and radiological constituents that are not essential nutrients and that present potential risk because their concentrations exceed regulatory risk-based standards or other risk-based screening levels described in later sections and detailed in the RI Report.

As discussed in Section 2.4.1, the Z-Ditches, consisting of the 216-Z-1D (south portion), 216-Z-11, and 216-Z-19 Ditches, are discussed in the FS collectively as one contiguous contamination area. The sample results listed below reflect data presented in the RI Report (DOE/RL-2003-11, Appendix A), including the Borehole C3808 sampling in 2002 (CP-12134), based on sampling activities outlined in Sections 2.4.1 and 2.4.2 of this document. Borehole C3808 samples were analyzed for limited radioisotopic analyses (10 samples for americium, plutonium, curium), as well as 12 samples for full-suite chemical (VOC, SVOC, PCB, Cr^{+6}, anions, total metals) and radiological analysis. Although some radionuclides (potassium, radium, thorium, and uranium) were detected to 12.2 m (40 ft) bgs, radionuclides were not detected above screening levels below soil depths of approximately 5.3 m (17.5 ft) bgs.

The sampling results show that contamination is consistent with the Z-Ditches contaminant distribution model reflecting that these cooling water waste streams, generally contaminated from cooling coil failures, have relatively little chemical contamination and the primary radionuclides are relatively immobile in soil. The highest concentrations are found in the areas that correspond to the ditch bottoms and the interval down to 1 to 1.8 m [3 to 6 ft] below the ditch bottom. Below this interval of high concentrations, plutonium and americium concentrations decrease with depth and there are no concentrations that exceed risk-based screening levels used in the baseline risk assessment and RI report. In general, Z-Ditch soil sampling showed americium and plutonium detections but few samples with concentrations above screening levels from the ground surface to the ditch bottom. These detections could represent contamination on the ditch sides due to water ponding or mixing during backfilling operations.

Analytical sampling at Borehole C3808 did not identify chemicals, such as acids or solvents, in soils at the borehole location at levels sufficient to mobilize contamination in the soil column.

A summary of the maximum concentrations of contaminants in the Z-Ditches in the zone from 0.6 to 5.3 m (2 to 17.5 ft) bgs is shown in Table 2-3. Ranges of concentrations expressed as maximum and minimum concentrations of contaminants can be found in Table 5-4 of the RI Report.

Radionuclide contamination in the Z-Ditches begins at a depth of about 0.6 m (2 ft) bgs. Because the ditches had a 2.5:1 slope and so were much wider at the top than the bottom, detections at backfilled ditches (shown in the RI Report) shallower than the presumed ditch bottom could indicate that the sample was taken from the ditch sides not the ditch bottom. From 0.6 to 1.2 m (2 to 4 ft) bgs, there are small amounts of Cs-137 and Sr-90 and occasionally significant quantities of Pu-239/240 (40,000 pCi/g found at the 216-Z-11 Ditch in 1981) and Am-241 (9,500 pCi/g found at the 216-Z-19 Ditch in 1979). The highest concentrations of plutonium and americium were reported in the 216-Z-19 Ditch and the 216-Z-1D Ditch from 1.2 to 5.3 m (4 to 17.5 ft) bgs. Cesium-137 also is present at high concentrations

(66,000 pCi/g) at this depth. The exception to these results is found at the north end of the 216-Z-1D Ditch where analytical sampling and geophysical logging at two locations show Pu-239/240 and Am-241 at concentrations of less than 100 pCi/g (WHC-EP-0707). Concentrations of all contaminants decrease with depth and below 5.3 m (17.5 ft) bgs, radionuclide contamination is less than 1 pCi/g.

Table 2-3. Maximum Soil Concentrations from 0.6 to 5.3 m (2 to 17.5 ft) bgs

Contaminant	Maximum Concentration	Sample Location (Ditch)	Sample Date	Sample Depth (ft bgs)[a]
Radionuclides				
Cesium-137	66,000 pCi/g[b]	216-Z-19	1976	7
Americium-241	7,870,000 pCi/g[c]	216-Z-19	1976	7
Strontium-90	216 pCi/g	216-Z-19	3/24/76	7
Plutonium-238	5,500 pCi/g	216-Z-19	5/1979	7 to 6
Plutonium-239	780,000 pCi/g	216-Z-1D	1959	8
Plutonium-239/240	13,000,000 pCi/g	216-Z-19	5/1979	4
Thorium-230	8.4 pCi/g	216-Z-11	2002	10 to 12.5
Radium-226	5,200 pCi/g	216-Z-19	4/21/76	7
Nonradionuclides[d]				
Nitrite	43 mg/kg	216-Z-11	2002	10 to 15
Total petroleum hydrocarbon	27 mg/kg	216-Z-11	2002	10 to 12.5
Aroclor-1254	52 mg/kg	216-Z-11	2002	7.5 to 10
Aroclor-1260	78 mg/kg	216-Z-11	2002	7.5 to 10
Boron	24 mg/kg	216-Z-11	2002	7.5 to 10

a. Sample depths shown are depths bgs at the time of sampling. Contamination now 1 to 0.6 m (2 ft) deeper at locations sampled before 1981 due to addition of stabilization material.

b. Decayed value for Cs-137 was used from 2003 (DOE/RL-2003-11, *Remedial Investigation for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-SC-1 Steam Condensate Group Operable Units*). Cesium-137 has a half-life of only 30 years and decayed value was used because concentrations have diminished significantly since sample collection.

c. Americium value shown is the value measured at the time of sample analysis and does not reflect radioactivity decay or Pu-241 ingrowth since then.

d. All nonradiological soil sample results from 2002 RI sampling of Borehole C3808.

Aroclor is an expired trademark.

bgs= below ground surface

The maximum Pu-239/240 concentration was reported as 13,000,000 pCi/g at the south end of the 216-Z-19 Ditch (U Pond delta). However, as described in SGW-37174, *Z-Ditches Study for the 200-CW-5 Cooling Water Operable Unit*, this concentration is orders of magnitude higher than contaminant levels generally reported for this area and appears to be a localized contamination effect and a statistical outlier.

A total of 12 samples were analyzed for Ra-226. Ra-226 was detected at a concentration of 5,200 pCi/g at the 216-Z-19 Ditch near 16th Street. Ra-226 was detected at a concentration of 5,000 pCi/g at the 216-Z-19 Ditch U Pond inlet (Delta). Both of these detections were at an original depth of 2.1 m (7 ft) bgs, and a corrected depth of 9 ft bgs after the 2 ft of stabilized material. The remaining 10 Ra-226 measurements were at concentrations ranging between 0.4 pCi/g and 1.1 pCi/g. Since these analyses were completed in March and April of 1976, it is difficult to determine the quality of these results or whether these detections are false positives because of matrix interferences with other alpha emitters.

The gross gamma and passive neutron detector logging results showed agreement with the spectral gamma logging data, both of which identified a major zone of contamination at approximately 2.9 m (9.5 ft) bgs. It should be noted that sample depths shown in Table 2-3 are depths bgs at the time of sampling. The contamination now resides approximately 0.6 m (2 ft) deeper at locations sampled before 1981 due to addition of stabilization material.

Aroclor-1254 and Aroclor-1260 are polychlorinated biphenyls (PCBs) that were reported at Borehole C3808 only at 2.3 to 3 m (7.5 to 10 ft) bgs at concentrations of 52 and 78 mg/kg, respectively. Total petroleum hydrocarbon was detected 3 to 3.8 m (10 to 12.5 ft) bgs at a concentration of 27 mg/kg but did not exceed screening levels. Molybdenum is the only inorganic metal that exceeded risk-based screening levels in soil samples from Borehole C3808. It was detected 46 to 47 m (152 to 154.5 ft) bgs at a concentration of 0.82 mg/kg. Boron was detected 2.3 to 3.0 m (7.5 to 10 ft) bgs at a maximum concentration of 24 mg/kg with all other detections at or below 1 mg/kg.

Nitrite was inaccurately reported by the RI Report at concentrations exceeding risk-based screening levels in soil samples collected from Borehole C3808. Nitrite was detected from 3 to 5.3 m (10 to 17.5 ft) bgs, ranging in concentration from 23 mg/kg to a maximum of 43 mg/kg at a depth of 3 m (10 ft). The reported nitrite concentrations exceed 4.0 mg/kg as the risk-based soil concentration considered protective of groundwater (WAC 173-340-747, "Deriving Soil Concentrations for Ground Water Protection"). However, upon further review, it was determined that the nitrate and nitrite values reported in the RI Report were inconsistent as nitrite values were much larger than nitrogen in nitrite and nitrate values. By converting all of the data to nitrogen (N) in nitrate and to N in nitrite, and then reevaluating the data, it was determined that the actual nitrite values were significantly less than originally reported with the newer values ranging from nondetect to 5.3 mg/kg. Because the maximum nitrite concentration is now essentially at the risk-based screening level (4.0 mg/kg), nitrite is no longer considered a risk to groundwater.

For this FS, the nature and extent of contamination for UPR-200-W-110 Unplanned Release is identified using field-screening data. These data will be used later in this chapter to support an understanding of the UPR-200-W-110 Unplanned Release through the heavily characterized Z-Ditches. Analytical data were not generated from the UPR investigation. This field-screening information is not considered useable for risk assessment purposes. The screening results identified the presence of Am-241 and Pu-239 in Boreholes 233 through 239. Maximum plutonium concentration of 3,300 (+1,000) pCi/g and Am-241 of 400 pCi/g, were measured in Borehole 233 located near the center and bottom of the trench at 3.8 m (12.5 ft) bgs. Screening data showed less than 1,000 pCi/g at the other UPR boreholes. The screening results confirm the presence of plutonium and americium in this UPR, but at lower concentrations than the Z-Ditches because of mixing contaminated sediments with clean backfill during the excavation and reburial activities. The screening evaluation indicates that UPR contamination is lower than the Z-Ditches area contamination.

The contamination distribution model for the Z-Ditches is presented in Figure 2-4.

200-CW-5 Cooling Water

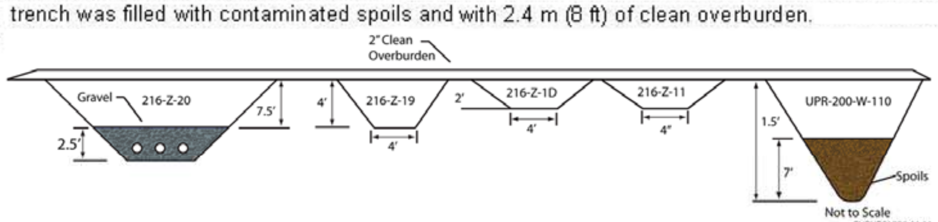
Z-Ditches (216-Z-11, 216-Z-19, 216-Z-1D), 216-Z-20 Tile Field, and UPR-200-W-110

PFP Zone

History

The 200-CW-5 OU waste sites include the Z-Ditches (216-Z-11, 216-Z-19, 216-Z-1D), 216-Z-20 Tile Field, and UPR-200-W-110. The Z-Ditches operated in chronological sequence from 1944 to 1981 primarily to transfer cooling water and stream condensate effluent waste from the Z Plant's 231-Z, 234-5Z, and 291-Z Buildings to the 216-U-10 Pond. These streams were sometimes contaminated with low levels of radionuclides (primarily Am-241, Pu-239/240, Pu-238, Cs-137, and Sr-90) generally by cooling coil failures but sometimes through process upsets. In 1949 the upper 526 m (1,725 ft) (see Plan View Area A) of the ditch was backfilled and replaced with the 200-W-125 pipeline that discharged to a new concrete outfall structure that became the northern-most waste inlet point. After a release of plutonium and americium from 231-Z in 1959, the ditch was deactivated, backfilled, and replaced by the 216-Z-11 Ditch, which operated from 1959 to 1971. The 216-Z-11 Ditch was deactivated, backfilled, and replaced with the 216-Z-19 Ditch, which operated from 1971 to 1981. In 1971, during 216-Z-19 Ditch construction, spoils were inadvertently excavated from part of the backfilled 216-Z-11 Ditch and were placed in disposal trench UN-216-W-20, later designated UPR-200-W-110. The 216-Z-19 Ditch was initially a waste transfer ditch but after 1976 was dammed to contain a radionuclide release and thereafter operated as a disposal site. In 1981, the Z-Ditches were replaced with the 216-Z-20 Tile Field disposal site. By that time the ditches were backfilled and in 1981, the entire area was stabilized by addition of 0.3 m (1 ft) of clean soil and is now an Underground Radioactive Material Area.

CONSTRUCTION: The Z-Ditches (216-Z-11, 216-Z-19, 216-Z-1D), were shallow open ditches that were approximately 842 m (2,765 ft) long (216-Z-1D Ditch was initially 1,295 m (4,250 ft) long before being shortened), 1.2 m (4 ft) wide at the bottom, and 0.6 to 1.2 m (2 to 4 ft) deep with 2.5:1 sloped sides and a 0.05% grade toward the 216-U-10 Pond. The 216-Z-20 Tile Field crib structure consisted of three 15 cm (6 in.) perforated PVC distribution pipes that were capped at the ends and placed in an excavation that was 463 m (1,519 ft) long, 3 m (10 ft) wide at the bottom. The pipes lay in a 0.8 m (2.5 ft) deep gravel bed that was backfilled with soil tograde. Four sets of risers along the length of the unit(three in a row acrossthe width of the unit) rose to aheight of 0.46 m (1.5 ft) above grade. UPR-200-W-110 is 4.6 m (15 ft) deep, 129.5 m (425 ft) long, andup to 33.5 m (100 ft) ft wide.The bottom 2.1 m (7 ft) of the trench was filled with contaminated spoils and with 2.4 m (8 ft) of clean overburden.



WASTE VOLUME: Waste Volume for Z-Ditches (216-Z-1D, 216-Z-11, 216-Z-19) and UPR 200-W-110 unknown (WIDS). Waste volume for 216-Z-20 Tile Field is 3,800,000,000 L.

DURATION (WIDS):
216-Z-1D - 1944 to 1959
216-Z-11 - 1959 to 1971
UPR-200-W-110 - 1971 (Occurence date)
216-Z-19 - 1971 to 1981
216-Z-20 - 1981 to 1995

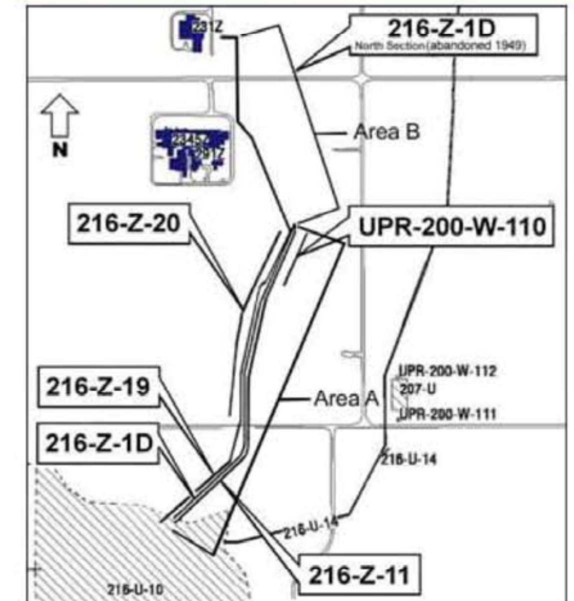
ESTIMATED DISCHARGED INVENTORY: Uncertain because contaminant inventory estimations based on waste stream chemistry during operations diverge from inventory based on soil sampling.

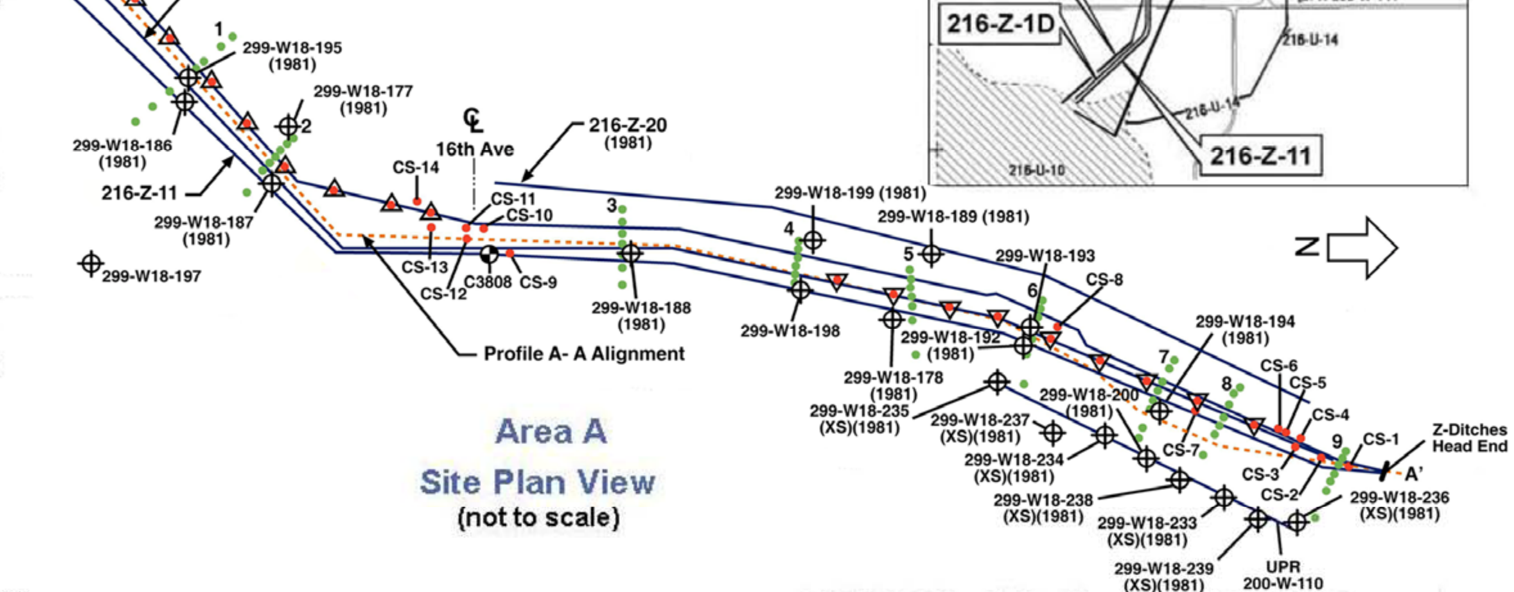
REFERENCES:
WIDS general summary reports
RHO-LD-114
DOE/RL-91-52
WHC-EP-0707
DOE/RL-2003-11
CP-12134
RHO-HS-VS-4

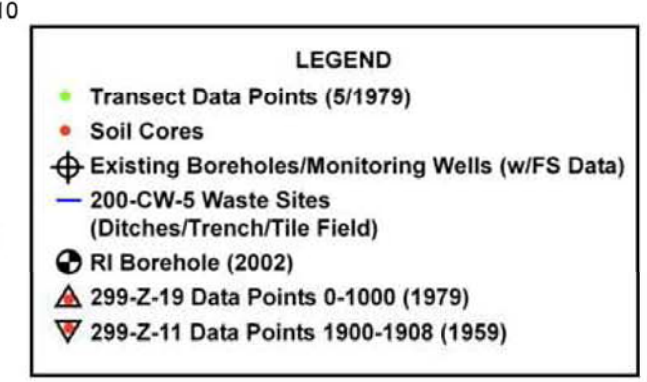
Basis of Knowledge (Data Types)

- Process History
- Soil Sampling Analytical Data (AD)
- X-ray Spectroscopy Field Screening - (XS)

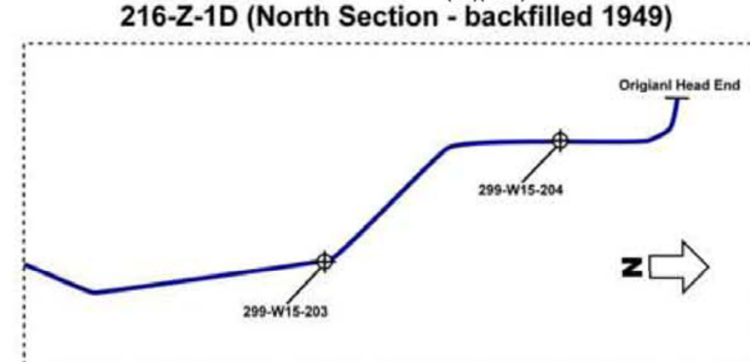
Note: All data AD unless noted otherwise.







216-Z-1D (North Section - backfilled 1949)



Area B

CHPUBS1006-11.7

Figure 2-4. Z-Ditches, 216-Z-20 Tile Field, and UPR-W-110 Unplanned Release Waste Sites Conceptual Site Model

200-CW-5
Cooling Water

Z-Ditches (216-Z-11, 216-Z-19, 216-Z-1D), 216-Z-20 Tile Field, and UPR-200-W-110

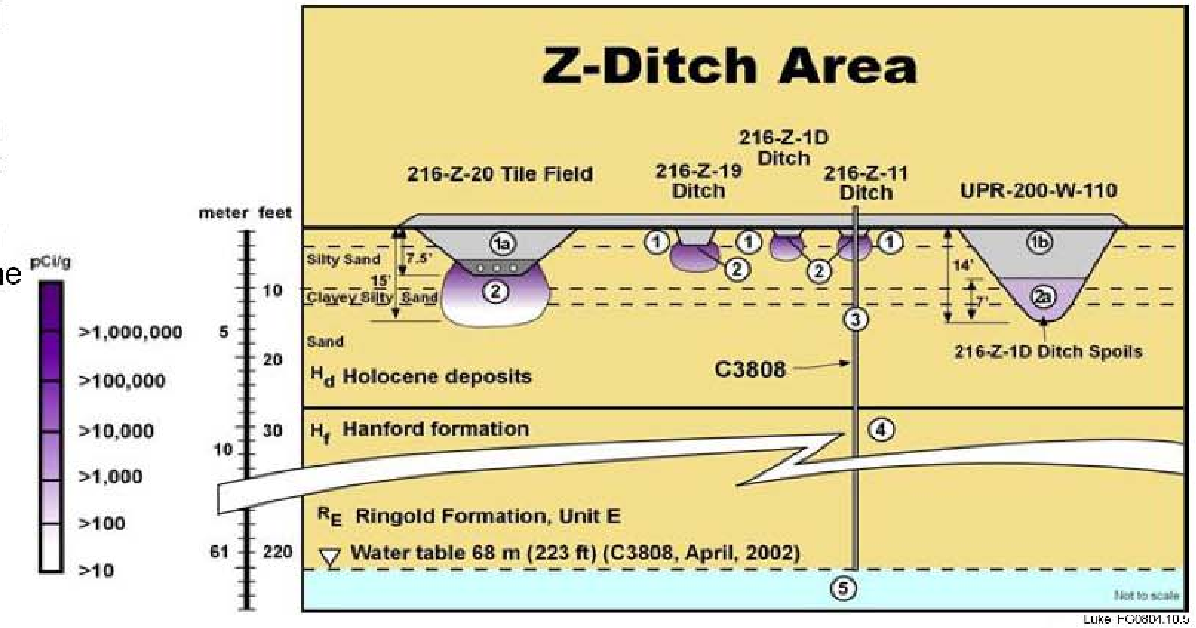
PFP Zone

Characterization Summary

From 1959 to 1981, the ditches were intermittently sampled primarily for plutonium, americium, cesium, and strontium to ensure contamination control at open ditches or to characterize retired and backfilled ditches (DOE/RL-2003-11; WHC-EP-0707). In 1959, 90 sediment samples were taken from the open 216-Z-1D Ditch. During 216-Z-19 Ditch operations (1971 to 1981), 8 ditch bottom samples were taken in 1979, 9 ditch sediment samples in 1977-79, and 201 ditch bottom and surface soil samples in 1979-80 at 9 transects that crossed the backfilled 216-Z-1D and 216-Z-11 Ditches (WHC-EP-0707). In 1980-81, 70 samples were taken from deep Borehole 299-W18-177 at the 216-Z-11 Ditch and 299-W18-178 at the 216-Z-19 DItch and from 17 shallow boreholes at the backfilled 216-Z-11 Ditches (DOE/RL-2003-11). In 1981 the north end of the 216-Z-1D Ditch was sampled at Boreholes 299-W-15-203 and -204 and material from 9 shallow boreholes installed at UPR-200-W-110 underwent in-field x-ray spectroscopy (RHO-HS-VS-4). In 1981 Boreholes 299-W18-189, -193, -194, and -195 at the 216-Z-11 Ditch and 299-W18-188 and -192 at the 216-Z-1D Ditch were sampled for plutonium and americium. In 2002, data were collected for the 200-CW-5 OU RI that included spectral gamma/passive neutron geophysical logging of 24 soil probes at 5 transects and installation, sampling, and geophysical logging of Borehole C3808. Neutron moisure logging at Borehole C3808 suggests that elevated moisure was no deeper than 21 to 34 m (70 to 110 ft) bgs (CP-12134). RI and historical sampling data show that radiological contamination is variable along the length of the ditches; the major area of contamination is centrally located north of 16th Street and south of the Z-Ditches inlet structure. The contamination is shallow (1.2 to 5.2 m [4 to 17 ft] bgs) with the maximum (americium at 7.8 million pCi/g and plutonium at 13 million pCi/g concentrations reported just below the presumed ditch bottoms (1.2 to 1.8 m [4 to 6 ft] bgs). In general, plutonium and americium concentrations decrease with depth to less than 1 pCi/g at 5.3 m (17.5 ft) bgs.

It should be noted that SGW 37174, Z Ditches Study for the 200 CW 5 Cooling Water Operable Unit, describes the 13 million pCi/g plutonium concentration as higher than contaminant levels generally reported for this area and appears to be a localized contamination effect and a statistical outlier.

Contaminant Distribution Model



Notes apply to Contaminant Distribution Model:

1. The Z-Ditches (216-Z-1D, 216-Z-11, and 216-Z-19) were open, unlined ditches that operated in chronological sequence from 1944 to 1981 transferring primarily equipment and vessel cooling water sometimes containing plutonium and americium to the 216-U-10 Pond. The north end of the 216-Z-1D Ditch was abandoned and backfilled in 1949. Significant effluent migration into the soil column is not generally expected with the waste transfer ditch model. However, from 1976 to 1981, the 216-Z-19 Ditch was dammed from the concrete outfall to 16th Street and all waste was disposed to the soil column. From 1981 to 1995 the 216-Z-20 Tile Field was used to dispose of cooling water waste that was, by that time, expected to generally contain less contamination (Note 1a). UPR-200-W-110 was a one-time use disposal trench for sediments from the backfillled 216-Z-1D Ditch (Note 1b).

2. The plutonium and americium have large distribution coefficients (K_d) and readily sorb to soils. Soil sampling did not report organics or acids in ditch soils that could mobilize contaminants in the soil column. Consequently, the maximum concentrations have been found to exist near the ditch bottoms (approximately 1.2 to 2.3 m [4 to 7.5 ft] bgs), decreasing with depth to less than 1 pCi/g beyond 5.2 m (17 ft) bgs. Contamination was found to be variable along the ditches. Contaminant migration beyond UPR-200-W-110 trench walls is not expected to have occurred (Note 2a).

3. At Borehole C3808, the wetting front moved vertically downward beneath the ditches into the Hanford Formation with gravity drainage (CP-12134). Any potential lateral spreading of liquids would mainly occur from contact with the Cold Creek unit (formerly called the Plio-Pleistocene unit) if actually reached by the moisture front.

4. Moisture logging data for Borehole C3808 suggest that elevated moisture ceases between 21.3m (70 ft) bgs and 33.5 m (110 ft) bgs. However, the moisture pathway deeper than approximately 5.2 m (17 ft) bgs was essentially non-contaminated. Because mobile contaminants were reported in Borehole C3808 at only very low concentrations, residual contamination is not expected in the vadose zone after gravity drainage.

5. Local groundwater contamination has not been attributed to Z-Ditches operations. Low contaminant concentrations in the groundwater could be attributed to older boreholes or clastic dikes that may have provided preferential pathways through the vadose one.

CHPUBS1106-11.02

Figure 2-4. Z-Ditches, 216-Z-20 Tile Field, and UPR-W-110 Unplanned Release Waste Sites Conceptual Site Model (continued)

3 Summary of Baseline Risk Assessment and Development of Remedial Action Objectives and Preliminary Remediation Goals

This chapter summarizes the BRA, defines the RAOs for the 200-CW-5 OU, and sets up PRGs. The BRA was conducted as part of the RI Report (DOE/RL-2003-11, Chapter 5) and has been updated for this FS to reflect revised guidance from EPA (EPA, 2002, *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites,* OSWER 9285.6-10) regarding calculation of contaminant exposure point concentrations (EPCs) and to incorporate evaluation of additional human exposure scenarios. The updated BRA establishes the need to take remedial actions for these sites based on hypothetical unrestricted land use (subsistence farmer) and industrial use exposure scenarios. The RAOs are media-specific or OU-specific objectives for protecting HHE. The RAOs are developed considering land use, contaminants of potential concern (COPCs), potential ARARs, and exposure pathways. The RAOs also specify remediation goals so that an appropriate range of remedial options can be developed for evaluation. This chapter describes the elements used to develop the RAOs and presents the RAOs and PRGs used to evaluate alternatives that will be finalized in the 200-CW-5 OU record of decision (ROD).

Determining the feasibility of remedial actions requires the identification of PRGs. The PRGs are criteria by which aspects of a cleanup under CERCLA are measured. They include ARARs, guidance and advisories (to be considered materials), and risk-based concentrations of radionuclides and chemicals in environmental media that have been brought forward from the human health and ecological risk assessments conducted for the 200-CW-5 OU waste sites.

3.1 Conceptual Exposure Model

This section summarizes the conceptual exposure model (CEM) for the 200-CW-5 OU waste sites (the Z-Ditches). A CEM establishes the framework for the BRA by identifying the means by which human and ecological receptors on or near the waste sites may come in contact with contaminants in environmental media. Information pertaining to contaminant sources, release mechanisms, transport media, exposure routes, and receptors is used to develop a conceptual understanding of potential risks and exposure pathways. Assumptions concerning potential receptors are based on current and anticipated future use of the land and groundwater. The CEM presented in the RI Report (DOE/RL-2003-11, Section 5.1.5) focused on potential human receptors associated with industrial land use. To evaluate the need to take remedial action in the FS, the CEM has been expanded to include potential human receptors associated with unrestricted land use (i.e., the evaluation of baseline risks in the absence of any remedial action or site controls).

3.1.1 Land and Groundwater Use

The current and reasonably anticipated future land use of the 200-CW-5 OU areas are discussed in the following subsections. Land use forms part of the basis for exposure assessment assumptions and risk characterization conclusions.

3.1.1.1 Current Land Use

All current land use activities associated with the Central Plateau are industrial in nature. The facilities located in the Central Plateau processed formerly irradiated fuel from the plutonium production reactors in the 100 Area. Most of the facilities directly associated with fuel reprocessing are now inactive and awaiting final disposition. Several waste management facilities operate in the Central Plateau, including permanent waste disposal facilities such as the Environmental Restoration Disposal Facility (ERDF), low-level radioactive waste burial grounds, and mixed-waste trenches permitted by the *Resource Conservation and Recovery Act of 1976* (RCRA). Construction of high-level waste treatment facilities in the Central Plateau began in 2002. The 200 East Area is the planned disposal location for the vitrified low-activity tank wastes. Non-Hanford Site DOE organizations and the U.S. Department of the Navy use the 200 East Area treatment, storage, and disposal (TSD) units. In addition, U.S. Ecology, Inc. operates a commercial low-level radioactive waste disposal facility on a 40-ha (100-ac) tract of land at the southwest corner of the 200 East Area that is leased to Washington State.

3.1.1.2 Anticipated Future Land Use

The reasonably anticipated future land use for the Central Plateau is industrial (DOE worker) for at least 50 years and then industrial (DOE or non-DOE worker) thereafter.

The DOE worked for several years with cooperating agencies 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, *The Future for Hanford: Uses and Cleanup, The Final Report of the Hanford Future Site Uses Working Group* (Drummond, 1992), was an early product of the efforts to develop land use assumptions. The report recognized that the Central Plateau would be used to some degree for waste management activities for the foreseeable future. Following the report, DOE issued DOE/EIS-0222-F, *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 the subsequent supplemental analysis (DOE/EIS-0222-SA-01), The HCP EIS analyzes the potential environmental impacts of alternative land use plans for the Hanford Site and considers the land use implication of ongoing and proposed activities. Under the preferred land use alternative selected in the HCP EIS ROD, the Central Plateau was designated for industrial use, defined as areas suitable and desirable for TSD of hazardous, dangerous, radioactive, and nonradioactive wastes, as well as related activities (Figure 3-1). The recent supplemental analysis reconfirmed the land use designations first proposed in the HCP EIS.

Subsequent to the HCP EIS, the Hanford Advisory Board (HAB) issued HAB Advice No. 132 (“Consensus Advice No. 132: Exposure Scenarios Task Force on the 200 Area,” Klein et al., 2002). The HAB acknowledged that some waste would remain in the Central Plateau Inner Area when cleanup is complete. The goal identified within HAB Advice No. 132 is that this Inner Area be as small as possible and not include contaminated areas outside the Central Plateau’s fenced areas. HAB Advice No. 132 further stated that waste within the Inner Area should be stored and managed to make it inaccessible to inadvertent intruding humans and biota, and that the DOE should maximize the potential for any beneficial use of the accessible areas of the Inner Area. The HAB advised that risk scenarios for the waste management areas of the Inner Area should include a reasonable maximum exposure (RME) to a worker/day user and to an intruder.

In response to HAB Advice No. 132 (Klein et al., 2002), and for the purposes of this FS, the Tri-Parties have agreed to assume the following reasonably anticipated future land use: industrial for at least 50 years, which may include TSD of hazardous, dangerous, radioactive, and nonradioactive wastes. Following that period, the 200-CW-5 OU areas are anticipated to be industrial. Starting at least 100 years after active waste management (roughly 150 years from present), the potential for inadvertent intrusion into subsurface waste may increase because knowledge of hazards may not be widely held. As long as residual contamination remains above levels that allow for unrestricted use, institutional controls (ICs) will be required.

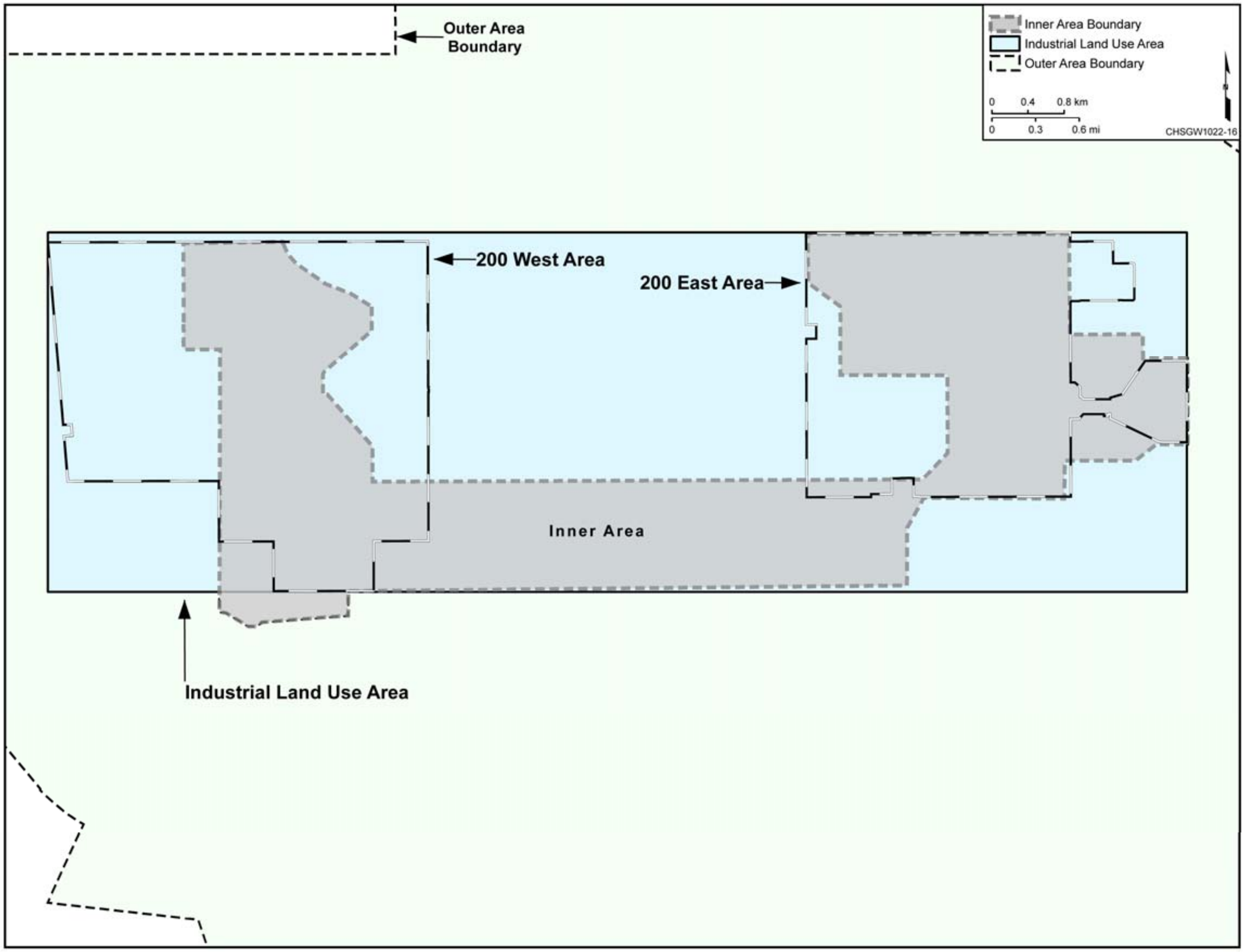


Figure 3-1. Location of the Industrial Land Use Area

3.1.1.3 Regional Land Use

Communities in the region of the Hanford Site consist of the incorporated Cities of Richland, West Richland, Kennewick, and Pasco, and numerous other smaller communities within Benton and Franklin Counties. Section 2.3.6 presents the socioeconomics of the region. No residences are located on the Hanford Site. The inhabited residences nearest to the 200 Area 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*) (Hanford NEPA).

3.1.1.4 Groundwater Use

The groundwater in the Central Plateau currently is contaminated, although not from Z-Ditches operations, and is not withdrawn for beneficial uses. Fate and transport modeling conducted in the RI Report indicates that chemical or radiological contaminants present in the Z-Ditches will not reach groundwater at levels that could adversely impact groundwater.

3.1.2 Exposure Pathways

An exposure pathway can be described as the physical course that a contaminant takes from the point of release to the receptor. Contaminant intake or exposure route is the means by which a contaminant enters a receptor. For an exposure pathway to be complete, all of the following components must be present:

- A contaminant source
- A mechanism of contaminant release and transport
- An exposure point (that is, a location where people or wildlife can come into contact with the contaminants)
- An exposure route
- A receptor or exposed population

In the absence of any one of these components, an exposure pathway is considered incomplete and, by definition, no risk or hazard exists.

3.1.3 Contaminant Sources and Release Mechanisms

The primary sources of contamination for the Z-Ditches were cooling water and steam condensate waste streams. Contaminated process liquids typically did not come into direct contact with the waste streams, because the steam and cooling water were contained inside circulating coils inside the process. The Z-Ditches waste streams are therefore generally described as containing low-level radionuclides and chemicals from noncontact cooling water and steam condensate. Minor failures (i.e., pinholes and hairline cracks) of the coils used to cool the process vessels provided a pathway for contaminated liquid to enter these waste streams. Other accidental releases, such as operator error, have led to the contamination of the effluent discharged to these Z-Ditches.

The primary release mechanisms that transport the contaminants from the source via environmental media to potential receptors, are as follows:

- Direct contact and external radiation with soil containing contaminants (receptor contact with shallow zone soil replaces release and transport)
- Infiltration, percolation, and leaching of contaminants from waste site soil to groundwater

- Generation of dust emanating from shallow zone soil to ambient air from wind or during maintenance or construction activities at the site
- Consumption of foodstuffs contaminated by uptake of soil contamination into biota, vegetation, wildlife, and livestock

3.1.4 Potentially Complete Human Exposure Pathways and Receptors

The exposure pathways for potential current and future human receptors at the Z-Ditches have been formulated based on the site conceptual model, in accordance with EPA/540/1-89/002, *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A): Interim Final*, OSWER 9285.7-02B. Based on the land use plans within the Inner Area boundary, the BRA for the RI Report in 2003 used an industrial worker scenario to characterize human health risk associated with an industrial land use (DOE/RL-2003-11, Section 5.2). The industrial worker scenario was evaluated for direct contact exposure to contamination present in the 0 to 4.6 m (15 ft) point of compliance. This assumes that contamination located within the top 4.6 m (15 ft) can be brought to the surface through excavation activities and distributed to the soil surface.

As discussed in Section 3.3 of this FS, the analytical data set for the Z-Ditches has been re-evaluated to reflect revised guidance from EPA regarding methods for calculating contaminant EPCs for risk assessment. This evaluation has resulted in revised EPCs for several of the Z-Ditches radiological COPCs. The industrial worker exposure scenario presented in the RI report was not updated using the revised EPCs; however, three additional exposure scenarios are included in this revision of the FS to reflect exposure conditions if the land use were unrestricted. These additional exposure scenarios include the subsistence farmer and two Native American exposure scenarios. The exposure scenarios in this FS include the subsistence farmer exposure scenario for presenting an assessment of baseline risks in the absence of any remedial action or site controls. Evaluation results are summarized in Section 3.5 and presented in detail in Appendix D of this FS. The point of compliance for evaluating the subsistence farmer exposure scenario is the same as the industrial worker scenario; contamination present is from the ground surface to a depth of 4.6 m (15 ft) bgs. Protection of groundwater at the Z-Ditches was evaluated in the RI Report and was based on contamination from the ground surface to the groundwater table.

Several local and regional Tribes have ancestral ties to the Hanford Reach of the Columbia River and surrounding lands, and DOE has requested that each Tribe provide an exposure scenario that reflects their traditional activities. At this time, the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) (Harris, 2008, *Application of the CTUIR Traditional Lifeways Exposure Scenario in Hanford Risk Assessments*; Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways*) and the Yakama Nation (Ridolfi, 2007, *Yakama Nation Exposure Scenario for Hanford Site Risk Assessment*) have provided scenarios. These scenarios, like the subsistence farmer scenario in the BRA, are not consistent with the anticipated future land use but are evaluated to assist interested parties in providing input on the remedial alternatives as part of the CERCLA modifying criteria. An evaluation of radiological risk for the CTUIR and Yakama Nation exposure scenarios has been performed for the Z-Ditches and the results are presented in Appendix F of this FS.

Following are brief descriptions of each exposure scenario considered for the Z-Ditches human health risk assessment.

3.1.4.1 Industrial Worker Scenario

Under reasonably anticipated future site conditions, industrial workers could potentially be exposed to radiological COPCs, in shallow zone soil (0 to 4.6 m [15 ft] bgs) from the Z-Ditches, which are distributed onto the soil surface through future excavation activities. The industrial worker exposure scenario (Appendix B) assumes that the workplace is the key source of radiological contaminant exposure and that the receptor could potentially be exposed to shallow zone soil. Potential routes of exposure associated with direct contact with soil include direct external exposure, incidental soil ingestion, and inhalation of dust generated from wind or maintenance activities. The exposure frequency for the industrial worker is 250 days per year over a duration of 25 years. The industrial worker is assumed to spend six hours per day indoors and two hours per day outdoors. This exposure scenario assumes that drinking water is obtained from a source other than the groundwater beneath the site and that food products are not grown on the site. This exposure scenario is used to calculate the preliminary remediation goals for radiological COPCs for the Z-Ditches.

Exposure to nonradiological COPCs is evaluated by comparison to WAC 173-340-745, Soil cleanup standards for industrial properties. Contamination present within the top 4.6 m (15 ft) of soil are assumed to be excavated and distributed along the soil surface for direct contact exposure. Soil cleanup levels are calculated using the equations listed in WAC 173-340-745(5)(iii)(B)(I) and (II). Potential routes of exposure to soil include incidental soil ingestion. The exposure frequency is 0.4 (146 days per year) over a duration of 20 years. The Standard Method C industrial soil cleanup levels described in WAC 173-340-745 (5)(b)(iii)(B) represent the PRGs for nonradiological COPCs for the Z-Ditches.

3.1.4.2 Construction Worker Scenario

Under reasonably anticipated future site conditions, construction workers could potentially be exposed to radiological and nonradiological COPCs, in shallow zone soil (0 to 4.6 m [15 ft] bgs) from the Z-Ditches, which are distributed onto the soil surface through future excavation activities. Construction workers involved in active soil disturbance (e.g., putting in an underground utility line or constructing a building) would be exposed to soils at depth for much shorter durations than the industrial worker.

Potential routes of exposure associated with direct contact with soil include direct external exposure, incidental soil ingestion, and inhalation of dust generated from wind or maintenance activities. The exposure frequency for the construction worker is 30 days per year over a 1 year duration. The construction worker is assumed to spend eight hours per day outdoors. This exposure scenario assumes that drinking water is obtained from a source other than the groundwater beneath the site and that food products are not grown on the site.

The construction worker exposure scenario (Appendix B) is used to calculate PRGs for radiological and nonradiological COPCs to determine the health protective levels of COPCs that could remain in place at the Z-Ditches. The PRG values determined using this exposure scenario result in a less conservative concentration (i.e., a higher concentration) than those determined using the industrial worker exposure scenario. Soil concentrations are greater for the construction worker primarily because of a shorter exposure frequency (30 days for a construction worker and 250 days for an industrial worker) and a shorter exposure duration (1 year for a construction worker and 25 years for an industrial worker).

3.1.4.3 Subsistence Farmer Scenario

The subsistence farmer scenario (Appendix D) represents the No Action Alternative in which no remediation or ICs were applied to the Z-Ditches. Inclusion of a subsistence farmer scenario (also known as the rural residential scenario) in a BRA is intended to provide a conservative estimate of risk, associated with a waste site in the absence of any remedial action or control (institutional or otherwise).

In estimating a baseline risk, the only pre-existing controls or actions that can be considered are those actions that have already been taken to reduce or eliminate contaminants as opposed to controlling or precluding exposure (EH-231-014/1292). No credit is taken for actions that simply control access to a site or limit exposure to existing contamination in developing the subsistence farmer scenario. Therefore, although the existing ICs and stabilization cover at the Z-Ditches limit current exposures, they do not reduce or eliminate contaminants from the site and are not considered in the exposure assessment for this analysis.

Based on the land uses identified in DOE/EIS-0222-F, it is unlikely that the Z-Ditches will be used for residential purposes. The subsistence farmer scenario does not represent one of the future land uses envisioned for the Central Plateau, and is not the basis for developing final remediation goals. Use of this scenario is only intended to define the No Action Alternative within the FS. The results of this analysis were used to determine whether remedial alternatives would be evaluated in the FS.

As a conservative estimate of baseline risks, it is assumed that exposure to the shallow zone soil (0 to 4.6 m [15 ft] bgs) occurs when a subsistence farmer establishes a residence on the waste site and receives exposure by direct contact with the soil and through the food chain. It is assumed that the ICs are not in place, and contamination within the top 4.6 m (15 ft) is excavated and distributed along the soil surface. The exposure frequency for the rural resident is 350 days per year over a duration of 30 years. The direct contact pathway includes potential exposure through external radiation, incidental soil ingestion, dermal contact with soil, and inhalation of ambient vapors and dust particulates. The food chain pathway includes exposure from ingestion of fruits and vegetables grown in a backyard garden and consumption of meat (beef and poultry) and milk from livestock raised in the contaminated area. Uptake of contamination into crops and livestock is solely from contamination present in soil, and includes use of groundwater contaminated by migration of contaminants in the soil beneath the waste site. The contribution of radioactive contamination in the soil to drinking water and water used for irrigation purposes is also included in the evaluation. Radioactive soil contamination represents a potential future source of exposure via the groundwater pathway through leaching and transport of the soil contamination to groundwater by infiltrating moisture. Exposure pathways associated with existing groundwater contamination beneath the Z-Ditches are not considered in the risk evaluation and will be addressed in the appropriate Central Plateau groundwater OUs.

Exposure to nonradiological COPCs is evaluated by comparison to WAC 173-340-740. Contamination present within the top 4.6 m (15 ft) of soil is assumed to be excavated and distributed along the soil surface for direct contact exposure. Soil cleanup levels are calculated using the equations listed in WAC 173-340-740(3)(iii)(B)(I) and (II). Potential routes of exposure to soil include incidental soil ingestion. It is assumed that a child is exposed to soil for 365 days per year over a duration of 6 years.

3.1.4.4 Native American Exposure Scenarios

Several local and regional tribes have ancestral ties to the Hanford Reach of the Columbia River and surrounding lands. DOE has requested that each tribe provide an exposure scenario that reflects their traditional activities. At this time, the CTUIR (Harris and Harper, 2004) and the Yakama Nation (Ridolfi, 2007) have provided exposure scenarios.

The CTUIR and Yakama Nation (Appendix F) scenarios reflect exposure conditions if the land use within the industrial area of the Central Plateau were released for traditional lifeway activities assuming the current waste site configuration of the Z-Ditches. These scenarios, like the subsistence farmer scenario in the BRA, are not consistent with the anticipated future land use but are evaluated to assist interested parties in providing input on the remedial alternatives as part of the CERCLA modifying criteria. The CTUIR and Yakama Nation exposure scenarios each include an evaluation of external gamma radiation, incidental soil ingestion, and inhalation of dust particulates for the direct contact pathway. These scenarios also include exposure from food chain pathways, including consumption of fruits and vegetables grown in a backyard garden and consumption of beef and poultry that graze on and are penned on a pasture. Milk consumption is included in the Yakama Nation exposure scenario, but is not included in the food consumption pathway for the CTUIR scenario. Exposure from the food chain pathways is solely from contamination present in soil, and includes use of groundwater contaminated by migration of contaminants in the soil beneath the waste site. Existing groundwater contamination beneath the 200-CW-5 OU is not considered in the risk evaluation and will be addressed in the appropriate Central Plateau groundwater OUs.

Additionally, the CTUIR and Yakama Nation exposure scenarios include potential exposure from consumption of wild game hunted on the Central Plateau. However, exposure from consumption of wild game is not evaluated because the area of the 200-CW-5 OU waste sites is considered too small to support foraging wild game. The CTUIR and Yakama Nation scenarios also include assumptions to estimate potential exposure from the consumption of fish and sweat lodge use. For purposes of this risk assessment, both exposure pathways are considered incomplete because fish are not immediately available and groundwater for sweat lodge use is not available. The fish consumption exposure pathway is being included by the 100 Areas and 300 Area River Corridor BRA because fish are available in these areas.

3.1.4.5 Relationship of Exposure Scenarios to Central Plateau Cleanup Completion Strategy

In September 2009, the *Central Plateau Cleanup Completion Strategy*, hereafter referred to as the Cleanup Completion Strategy (DOE/RL-2009-81), was issued to provide an outline of DOE’s vision for completion of cleanup activities across the Central Plateau. The Cleanup Completion Strategy describes DOE’s cleanup approach and provides a framework and context for DOE’s proposals for remedy selection for structures, soil, debris, and groundwater from a plateau-wide perspective. The Cleanup Completion Strategy organizes the Central Plateau cleanup into the following three major components:

- ***The Inner Area*** is approximately 10 mi^2 (26 km^2) in the middle of the Central Plateau and encompasses the region where chemical processing and waste management activities occurred.
- ***The Outer Area*** is greater than 65 mi^2 (169 km^2) and includes much of the open area on the Central Plateau where limited processing activity occurred. Cleanup levels in the Outer Area are expected to be comparable to those being used for waste sites along the Columbia River (River Corridor).
- ***Groundwater Remediation*** is necessary for approximately 80 mi^2 (208 km^2) of groundwater beneath the Hanford Site contaminated above drinking water standards because of past processing activities that occurred on the Central Plateau. Cleanup that started in 1995 is being expanded to contain contaminant plumes in the Central Plateau, remove contaminants, and restore groundwater to beneficial use.

The Cleanup Completion Strategy was provided to the regulatory community, the Tribal Nations, political leaders, the public, and Hanford Site stakeholders to promote dialogue on the Hanford Site’s future.

In accordance with CERCLA requirements, cleanup levels will be established commensurate with the potential future use to ensure protection of potential future users and ecological receptors. The following are specified in the Cleanup Completion Strategy (DOE/RL-2009-81):

- Cleanup levels for waste sites within the Inner Area will be established recognizing federal ownership and DOE accountability and control for the foreseeable future and consistent with the anticipated future land use of industrial.
- Cleanup levels for waste sites within the Outer Area will be established to enable unrestricted surface uses comparable with the River Corridor and consistent with the anticipated future land use of conservation-mining. This area will also remain under federal ownership with DOE accountability and control into the foreseeable future.

Under the new decision structure, the 200-CW-5 OU decision was retained as legacy decisions and, although they are located within the newly defined Inner Area, the Tri-Parties agreed to proceed with the remedy selection for these OUs as independent, standalone decisions. The human health exposure scenarios and corresponding environmental media cleanup levels that will be developed later for the Inner Area by the Tri-Parties may, therefore, be somewhat different than those that were used to support the 200-CW-5 OU proposed actions. One of the implications of the new Cleanup Completion Strategy (DOE/RL-2009-81) is that 200-CW-5 OU is being carried forward under the historic strategy. That is, the FS for the 200-CW-5 OU was originally prepared in 2007 using different assumptions and risk scenarios that may not be applied under the new Cleanup Completion Strategy. However, all cleanup actions that will be proposed for the Central Plateau will be protective of HHE and will meet statutory requirements for remedy selection including compliance with ARARs.

3.1.5 Potentially Complete Ecological Exposure Pathways and Receptors

The following ecological exposures potentially associated with the Z-Ditches have been considered for characterizing ecological risks:

- Potential current or future direct contact with, or ingestion of, surface soil by invertebrates (e.g., beetles)
- Uptake of contaminants in soil by vegetation
- Bioaccumulation through ingestion of soil and food items (e.g., plants, prey) consumed by wildlife that may forage at the waste sites

Ecological risks are addressed using a screening level ecological risk assessment (SLERA) approach. This approach follows guidance given in WAC 173-340-7490 “Terrestrial Ecological Evaluation Procedures” and DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*. For purposes of this FS, the standard point of compliance (0 to 4.6 m [15 ft] bgs) was used to evaluate the protection of ecological receptors. In the SLERA, analytical results in soil are compared to the available soil indicator concentrations presented in Table 749-3 of WAC 173-340-900 and Tier 1 biota concentration guides (BCGs) established in DOE-STD-1153-2002. Analytes with concentrations that exceed the published soil indicator concentration for protection of terrestrial plants and animals are identified as a contaminant of potential ecological concern, which may need to be considered in the evaluation of remedial alternatives.

3.2 Contaminants of Potential Concern

A COPC is a constituent that is identified as a potential threat to HHE and whose data are of sufficient quality for use in a quantitative BRA. Identification of COPCs is an important process because it determines the list of contaminants for which further risk evaluations will be developed. Development of COPCs in the data evaluation and risk assessment process is discussed in EPA/540/1-89/002. A detailed description of the COPC selection process conducted for the 200-CW-5 OU waste sites is presented in the RI Report (DOE/RL-2003-11, Section 5.2.2).

The factors considered in identifying the COPCs were as follows:

- Identification of detected contaminants - as a conservative measure, all chemicals that were detected at least once in any of the shallow- or deep-zone soil samples were carried to the next step in the COPC selection process. Chemicals that were not detected in any of the soil samples (i.e., zero percent frequency of detection) were not selected as COPCs.
- Frequency of detection - constituents detected in shallow- or deep-zone soil samples at a frequency of 5 percent or more were carried to the next step of the screening process. In addition, constituents

detected at a frequency of less than 5 percent, but with maximum concentrations greater than 10 times the soil risk-based concentrations (RBCs), were retained as COPCs.

- Essential nutrients - essential nutrients are those constituents considered essential for human nutrition. Recommended daily allowances are developed for essential nutrients to estimate safe and adequate daily dietary intakes (NAS, 1989, Recommended Dietary Allowances). Because calcium, magnesium, potassium, and sodium are considered to be essential nutrients and have no available toxicity factors, they were excluded from further consideration as COPCs.
- Background screening - sitewide soil background levels have been established for most metals and radiological constituents at the Hanford Site. The maximum detected concentration of each metal or radionuclide detected in shallow- or deep-zone soil was compared to the 90th percentile background value. Statewide soil background levels were used where Hanford Site background levels were not available. Because background criteria have not been developed for volatile organic compounds (VOCs), PCBs, or semivolatile organic compounds in soils at the Hanford Site, any constituent detected in these fractions was carried forward into the risk assessment.
- Availability of toxicity factors for calculating soil cleanup standards - if a toxicity value was not available from a reliable source or an appropriate surrogate could not be identified, then the contaminant was not included in the risk assessment.

A comparison of maximum detected soil concentrations to Hanford Site background cleanup levels is provided in Appendix B. Cleanup levels are from the Model Toxics Control Act Statue and Regulation, Revised 2007, and reflect recent toxicological values published by the EPA.

3.3 Exposure Point Concentrations

EPA recommends using an average concentration to represent a “reasonable estimate of the concentration likely to be contacted over time” (EPA/540/1-89/002). EPA also recommends using the 95 percent upper confidence limit (UCL) on the mean for this variable (EPA, 1992, *Supplemental Guidance to RAGS: Calculating the Concentration Term*, OSWER Publication 9285.7-081). For the direct contact exposure pathway, EPCs are calculated using concentrations directly measured in soil. For the inhalation route, modeling is performed to estimate nonradiological constituent concentrations in air from particulate or vapor emissions from soil. The EPCs associated with the Z-Ditches were calculated in the RI Report in accordance with EPA, 1992. The EPC computation procedures for the RI Report are described in Section 5.1.5.7 and Appendix E of DOE/RL-2003-11.

After the RI Report was issued, EPA revised its guidance on calculating EPCs for environmental data sets (EPA, 2002). In an effort to understand the uncertainties associated with the Z-Ditches data set, the RI data set has been re-evaluated using EPA’s revised methodology for calculating EPCs. The re-evaluation was performed by using EPA’s ProUCL 4.0 analysis tool (EPA/600/R-07/038, *ProUCL Version 4.0 User Guide*) to calculate the EPCs for the Z-Ditches COPCs. For some of the COPCs, minimum sample size requirements are not met for calculating a 95 percent UCL concentration. Therefore, the maximum detected concentration was used as the EPC for the Z-Ditches. EPA suggests the use of the maximum detected value as a default to estimate the EPC term when the 95 percent UCL exceeds the maximum value (e.g., Ra-226) or for data sets that contain fewer than five results. All of the Z-Ditches nonradiological COPC data sets are reported with fewer than five samples; therefore, no changes have been made to the EPCs for the nonradiological COPCs. In contrast, the ProUCL 4.0 evaluation has resulted in revised EPCs for several of the Z-Ditches radiological COPCs. Table 3-1 lists the EPC and the basis of the EPC value from the ProUCL 4.0 evaluation for each of the radiological COPCs.

Table 3-1. Z-Ditches Summary of Statistics and Exposure Point Concentrations

	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result (pCi/g)	Maximum Nondetected Result (pCi/g)	Minimum Detected Result (pCi/g)	Maximum Detected Result (pCi/g)	Average Concentration (pCi/g)	EPC (pCi/g)	EPC Basis
Americium-241	286	284	99%	0.19	15	0.014	7.87E+06	30,656	202,640	97.5% KM (Chebyshev) UCL*
Cesium-137	187	184	98%	0.04	0.04	0.0021	66,041	371	2,571	97.5% KM (Chebyshev) UCL*
Plutonium-238	62	54	87%	0.034	0.46	0.015	5,500	402	1,302	97.5% KM (Chebyshev) UCL*
Plutonium-239 + Plutonium-239/240	281	279	99%	0.46	0.53	0.001	7.80E+05	8,257	28,291	97.5% KM (Chebyshev) UCL*
Radium-226	12	12	100%	--	--	0.4	5,200	851	5,200	Max. Detect
Radium-228	4	2	50%	0.37	0.37	0.69	0.81	0.47	0.81	Max. Detect
Strontium-90	30	23	77%	2.5	9.6	0.28	216	19	95.18	99% KM (Chebyshev) UCL*
Thorium-228	4	1	25%	0.47	1.8	0.66	0.66	0.58	0.66	Detected Result
Thorium-230	4	3	75%	1.1	1.1	0.5	8.4	4	8.4	Max. Detect
Thorium-232	4	1	25%	0.7	1.7	0.71	0.71	0.57	0.71	Detected Result
Uranium-233/234	4	1	25%	0.68	2.5	0.36	0.36	0.75	0.36	Detected Result
Uranium-238	4	2	50%	1.1	1.2	0.44	0.77	0.59	0.77	Max. Detect

* KM (Chebyshev) UCL = UCL based on Kaplan-Meier estimates using Chebyshev inequality. Computed with ProUCL Version 4.0 (EPA/600/R-07/038).
EPA/600/R-07/38, *ProUCL Version 4.0 User Guide*.

-- = not applicable
EPC = exposure point concentration
Max = maximum
UCL = upper confidence limit

The EPC re-evaluation included a statistical outlier test to determine the presence of outliers associated with the plutonium isotope data set. Details of the outlier test are presented in SGW-37174. The outlier test indicated the presence of two potential Pu-239/240 statistical outliers, with concentrations of 1.3×10^7 pCi/g and 7.5×10^5 pCi/g, located at the inlet to the 216-U-10 Pond and near the northern headwall of the Z-Ditches, respectively.

In addition to the statistical outlier test, the spatial locations and physical properties of the two data points were examined and compared to the data points of surrounding samples. Evaluation of this comparison revealed that the concentrations recorded for the two potential outliers are several orders of magnitude greater than other samples collected in the respective sampling areas and most likely represent a localized effect. As such, these two data points do not reasonably represent a significant area of potential contamination at levels as high as those seen in the two samples. These locations should be considered to be similar in concentration to the surrounding areas with regard to general contamination levels. By removing these two outliers, there is an appreciable decrease in the fractional contribution of plutonium that more accurately reflects the overall contributions of the COPCs.

Table 3-1 represents the statistical evaluation of the data set after removal of the Pu-239/240 outlier results. For purposes of this evaluation, analytical results reported as undifferentiated Pu-239/240 were treated as entirely Pu-239 and combined with the Pu-239 analytical results. This assumption is considered reasonable because in most cases Pu-239 is the dominant isotope. Similarly, analytical results reported as undifferentiated U-233/234 were treated as entirely U-234 because in most cases U-234 is the dominant isotope.

Comparison of the Table 3-1 EPC values to the EPC values reported in the RI risk assessment (DOE/RL-2003-11, Table 5-4) results in the following differences:

- A reduction in the Pu-239 EPC from 4,460,000 pCi/g to 28,291 pCi/g
- An increase in the Am-241 EPC from 76,152 pCi/g to 202,640 pCi/g
- An increase in the Cs-137 EPC from 951 pCi/g to 2,571 pCi/g
- No change in the Ra-226 EPC (5,200 pCi/g)

3.4 Potential Applicable or Relevant and Appropriate Requirements

Appendix A identifies the potential ARARs for the 200-CW-5 OU waste sites.

3.5 Baseline Risk Assessment Summary

BRAs are conducted to evaluate whether the site presents unacceptable risk to HHE that could require remedial action without taking into account any possible controls. BRAs are also used to indicate the need for action. Data evaluated for the Z-Ditches BRA focused on the subsistence farmer and included the sample results from the shallow zone soils (0 to 4.6 m [15 ft] bgs) collected before and during the 2002 characterization effort and are presented in Appendix A of the RI Report. Risk information is used to help determine if remedial action is necessary and to support remedial alternative evaluations. The BRA conducted in the RI Report concluded there was a potential risk to HHE based on the industrial worker exposure scenario. Subsequent to the RI report, additional analysis of the RI data set was conducted as discussed in Section 3.3 to address revised guidance from EPA regarding calculation of EPCs. This FS updates the comparison to the WAC 173-340-745(5)(b), Standard Method C industrial soil cleanup levels (industrial) based on the revisions made to the 2007 Model Toxics Control Act Cleanup Regulations as described in Section 3.3 (WAC 173-340, “Model Toxics Control Act – Cleanup”). The BRA was also updated in accordance with EPA guidance to calculate radiological PRGs based on risk. This FS also provides the results of a risk assessment based on a subsistence farmer exposure scenario (Appendix D) and WAC 173-340-740(3)(b), Standard Method B soil cleanup levels for unrestricted use (Appendix B) and the results of the two Native American exposure scenarios (CTUIR and Yakama Nation, Appendix F) as discussed in Section 3.1.4. This FS also provides a comparison of EPCs to PRGs developed for the construction worker scenario (Appendix B, Table B-3) to assist the Tri-Parties in decision making. Table 3-2 presents a risk assessment summary for the Z-Ditches.

The potential for ecological risk at the Z-Ditches was identified in a SLERA as discussed in Section 3.1.5. Table 3-2 presents a summary of this assessment. DOE/RL-2007-50, *Central Plateau Ecological Risk Assessment Report* (CP ERA) was submitted to the regulatory agencies in February 2008. Based on the regulatory agency comments and the results from a subsequent review of the CP ERA report and the development of the Cleanup Completion Strategy (DOE/RL-2009-81), the Tri-Parties decided the CP ERA report will be revised and reissued as a data compilation and status report. Portions of the data presented in this report will be incorporated into updated analyses of ecological risks in the proposed BRAs supporting Central Plateau RI/FSs that will be conducted in accordance with the Cleanup Completion Strategy.

Table 3-2. Waste Site Risk Summary

Risk Element	Z-Ditches
Do the Z-Ditches meet the WAC 173-340-745(5)(b)(iii)(B) Standard Method C industrial soil cleanup levels for chemicals?[a]	
Are concentrations less than WAC 173-340-745?	No
Constituents that exceed WAC 173-340-745	Aroclor-1260
Do the Z-Ditches meet the WAC 173-340-740(3)(b) Standard Method B soil cleanup levels for chemicals?[b]	
Are concentrations less than WAC 173-340-740?	No
Constituents that exceed WAC 173-340-740	Aroclor-1254, Aroclor-1260
Do the Z-Ditches exceed the EPA upper risk threshold of 10^{-4} for radionuclides for the subsistence farmer exposure scenario?[c]	
ELCR at 0 year	9.0×10^{-1}
Primary radionuclides that contribute ELCR, 0 year	Ra-226, Am-241, Cs-137
ELCR at 150 years	9.2×10^{-1}
Primary radionuclides that contribute ELCR, 150 years	Ra-226, Am-241
ELCR at 1,000 years	4.6×10^{-1}
Primary radionuclides that contribute ELCR, 1,000 years	Ra-226, Am-241, Pu-239
Do the Z-Ditches exceed the EPA upper risk threshold of 10^{-4} for radionuclides for the industrial worker exposure scenario?[d]	
ELCR at 0 year	6.1×10^{-1}
Primary radionuclides that contribute ELCR, 0 year	Pu-239, Ra-226
ELCR at 150 years	5.7×10^{-1}
Primary radionuclides that contribute ELCR, 150 years	Pu-239, Ra-226
ELCR at 1,000 years	4.7×10^{-1}
Primary radionuclides that contribute ELCR, 1,000 years	Pu-239, Ra-226

Table 3-2. Waste Site Risk Summary

Risk Element	Z-Ditches
Do the Z-Ditches meet standards for soil concentrations protective of groundwater – chemicals?	
Are groundwater protection standards exceeded based on initial screening?	Yes[e]
Chemicals exceeding WAC 173-340-747(4)	Aroclor-1254, Aroclor-1260
Chemicals predicted to reach groundwater above WAC 173-340-720	None[f]
Groundwater protection required?	No
Do the Z-Ditches meet standards for soil concentrations protective of groundwater – radionuclides?	
Are groundwater protection standards exceeded based on initial screening?	No[g]
Radionuclides predicted to reach groundwater above MCL	None[f]
Groundwater protection required?	No
Do the Z-Ditches meet ecological screening values – chemicals?	
Are concentrations less than Table 749-3 values?	No[h]
Constituents that exceed Table 749-3 values	Aroclor-1254, Aroclor-1260, Boron, Mercury
Ecological protection required?	Yes
Do the Z-Ditches meet ecological screening values – radionuclides?	
Are concentrations less than BCGs?	No[i]
Constituents that exceed BCGs	Am-241, Cs-137, Pu-239, Pu-239/240, Ra-226, Sr-90
Ecological protection required?	Yes

a. Based on comparison of waste site soil concentrations to WAC 173-340-745(5)(b)(iii)(B), Standard Method C industrial soil cleanup levels, Table B-2 provides comparison results.

b. Based on comparison of waste site soil concentrations to WAC 173-340-740(3)(b), Standard Method B soil cleanup levels. Table B-1 provides comparison results.

c. Based on RESRAD calculation of radiological risk to a subsistence farmer assuming waste site soil contamination extends from the ground surface to 4.6 m (15 ft) bgs. RESRAD input parameters are listed in Table B-7. Calculation results are summarized in Table B-7. Details of the RESRAD evaluation are discussed in Appendix D.

d. Based on RESRAD calculation of radiological risk to an industrial worker assuming waste site soil contamination extends from the ground surface to 4.6 m (15 ft) bgs. Table B-6 lists the RESRAD input parameters. Table B-8 summarizes calculation results.

e. Initial screening based on comparison of waste site soil concentrations to soil concentrations protective of groundwater calculated in accordance with WAC 173-340-747(4), "Deriving Soil Concentrations for Groundwater Protection, Fixed Parameter Three-Phase Partitioning Model." Table B-12 provides comparison results.

f. Based on results of STOMP fate and transport modeling that indicates groundwater protection standards (federal MCLs and state cleanup levels based on WAC 173-340-720 "Groundwater Cleanup Standards") will not be exceeded within 1,000 years. Contaminants modeled with STOMP are listed in Table B-14. Details of the STOMP modeling are discussed in Chapter 4 of DOE/RL-2003-11.

g. Initial screening based on results of RESRAD soil-to-groundwater pathway calculation indicating that no radionuclides in waste site soil would reach groundwater within 1,000 years. RESRAD input parameters are listed in Table B-5. Calculation results are summarized in Table B-13. Subsequent numerical modeling with STOMP (DOE/RL-2003-11 Chapter 4) was performed to confirm the results obtained with RESRAD.

h. Based on comparison of waste site soil concentrations to soil concentrations specified in WAC 173-340-900, "Tables," Table 749-3, "Ecological Indicator Soil Concentrations (mg/kg) for Protection of Terrestrial Plants and Animals." Table B-10 provides comparison results.

Table 3-2. Waste Site Risk Summary

Risk Element	Z-Ditches
i. Based on comparison of waste site soil concentrations to soil concentrations listed in DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*, Table 6.4, "Biota Concentration Guides (BCGs) for Water and Soil (in Special Units) for Use in Terrestrial System Evaluations." Table B-11 provides comparison results.	

Notes:

This table summarizes the results of the Z-Ditches BRA and includes information from both the RI Report (DOE/RL-2003-11 Chapter 5) and a supplemental risk assessment conducted in support of the FS that updates and expands on the risk assessment presented in the RI Report. Detailed assessment results for the individual risk assessment elements shown in this table are provided in Appendix B.

Sources:

ANL, 2007, RESRAD for Windows, Version 6.4.

DOE/RL-2003-11, *Remedial Investigation for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-SC-1 Steam Condensate Group Operable Units*.

PNNL-11217, *STOMP: Subsurface Transport Over Multiple Phases: Theory Guide.*

BCG	=	biota concentration guide
ELCR	=	excess lifetime cancer risk
EPA	=	U.S. Environmental Protection Agency
MCL	=	maximum contaminant level
RESRAD	=	RESidual RADioactivity (dose model) (ANL 2007)
STOMP	=	Subsurface Transport Over Multiple Phases (fate and transport model) (PNNL-11217)

3.6 Summary of Risk-Based Concentrations for the Feasibility Study

Section 3.1 summarizes the results of the updated BRA and provides the results from evaluating the subsistence farmer scenario (an assessment of a hypothetical unrestricted land use exposure scenario) at the Z-Ditches. Based on these assessments, this FS addresses the following RBCs:

- Ra-226, Am-241, Pu-239, and Cs-137 present a potential risk to a subsistence farmer through the direct contact and food chain exposure pathways. The primary contributors to excess lifetime cancer risk (ELCR) are Ra-226 (85 percent contribution), Am-241 (12 percent contribution), and Pu-239 (1 percent contribution). Although the ELCR contribution from Pu-239 exceeds a value of 1×10^{-2}, the Pu-239 contribution relative to the overall maximum ELCR value of 9.8×10^{-1} is overshadowed by the large contributions from Ra-226 through the external exposure and plant ingestion exposure routes. It should also be noted that the Pu-239 concentrations without the outliers continue to result in an ELCR value greater than $1x10^{-4}$.

- Ra-226 and Pu-239 present a potential risk to an industrial worker through the direct contact exposure pathway. The primary contributors to ELCR are Pu-239 (64 percent contribution) and Ra-226 (31 percent contribution). The fractional contributions from Am-241 and Cs-137 are overshadowed by the large contribution from Pu-239 and Ra-226 through the external exposure route.

- Am-241, Cs-137, Pu-239/240, Ra-226, and Sr-90 are present at concentrations above the BCG screening levels. Based on the comparison of concentrations to ecological screening concentrations, there is a concern that wildlife, and plants exposed to soils at the Z-Ditches may be at risk for adverse health effects.

- Aroclor-1260 is present at concentrations above the WAC 173-340-745(5)(b), Standard Method C industrial soil cleanup level. Based on the comparison to the industrial soil cleanup level, there is a concern that human receptors exposed to soils at the Z-Ditches may be at risk for adverse health effects.
- Aroclor-1254, Aroclor-1260, boron, and mercury are present at concentrations above the WAC 173-340-7493, Table 749-3, Ecological Indicator Soil Concentrations for Protection of Terrestrial Plants and Animals. Based on the comparison of concentrations to the ecological indicator soil concentrations, there is a concern that terrestrial plants and animals exposed to soils at the Z-Ditches may be at risk for adverse health effects.
- Aroclor-1254, Aroclor-1260, and Pu-239/240 are reported at a single hot-spot location. These concentrations exceed the industrial worker direct contact exposure PRGs. Based on the comparison of concentrations from this location to ecological screening values for Aroclor-1254 and Aroclor-1260 (0.65 mg/kg), a concern exists that wildlife exposed to soils at this location may be at risk for adverse health effects.

3.7 Remedial Action Objectives

The RAOs are descriptions of what the remedial action is expected to accomplish (i.e., medium or site-specific goals for protecting HHE). RAOs are defined as specifically as possible and usually address the following variables:

- Media of interest (e.g., contaminated soil and solid waste)
- Types of contaminants (e.g., radionuclides, inorganic chemicals, and organic chemicals)
- Potential receptors (e.g., humans and wildlife including plants and invertebrates)
- Possible exposure pathways (e.g., external radiation, inhalation, and ingestion)
- Levels of residual contaminants that may remain following remediation (i.e., contaminant levels below cleanup standards or below a range of levels for different exposure routes)

The RAOs provide a basis for evaluating the capability of a specific remedial alternative to achieve compliance with potential ARARs and/or an intended level of risk protection for HHE. RAOs specific to the 200 Area for soils, solid wastes, and groundwater were initially developed in the Implementation Plan (DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*). Specific RAOs for this FS were defined based on the fate and transport of contaminants, projected land uses for the 200 Area, and the 200-CW-5 OU conceptual exposure model. The RAOs for this FS are as follows.

- RAO 1–Prevent or mitigate unacceptable risk to human health and ecological receptors associated with radiological exposure to wastes or soil contaminated above risk-based criteria by removing the source or eliminating the pathway.
- RAO 2–Prevent or mitigate unacceptable risk to human and ecological receptors associated with nonradiological exposure to wastes or soil contaminated above risk-based criteria by removing the source or eliminating the pathway.
- 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, including protecting the Columbia River from adverse impacts.

The RAOs will be finalized in the ROD for these waste sites. Achievement of the RAOs will be described in the remedial design/remedial action work plan to be prepared after the ROD is approved.

For the purposes of this FS, RAO 1 is satisfied for radiological COPCs when the following objectives are met:

- Prevent or mitigate direct contact exposure to radiological COPCs by industrial workers, in the top 4.6 m (15 ft) of the Z-Ditches, that would exceed an ELCR of 1 in 10,000.
- Prevent or mitigate direct contact exposure to radiological COPCs by terrestrial receptors (wildlife, plants, and biota) that would exceed a dose rate of 0.1 rad/day.

For purposes of this FS, RAO 2 is satisfied for nonradiological COPCs when the following objectives are met:

- Prevent or mitigate direct contact exposure to nonradiological COPCs, in the top 4.6 m (15 ft) of the Z-Ditches, that would exceed the WAC 173-340-745(5)(b), Standard Method C industrial soil cleanup level based on an ELCR of 1 in 100,000 or an individual non-cancer hazard quotient (HQ) of 1 or a total hazard index (HI) of 1.
- Prevent or mitigate direct contact exposure to nonradiological COPCs by terrestrial receptors (wildlife, plants, and biota) that would exceed an individual ecological non-cancer HQ of 1 or a total ecological HI of 1.

For purposes of this FS, RAO 3 is satisfied for nonradiological COPCs when the following objectives are met:

- Soil concentrations are less than WAC 173-340-747(4) soil concentrations for groundwater protection.
- When additional fate and transport modeling demonstrates that soil concentrations would not impact groundwater above MCLs.

RAO 3 is satisfied for radiological COPCs when additional fate and transport modeling demonstrates that soil concentrations would not impact groundwater above MCLs.

Protection of the Columbia River from contaminants in these waste sites is achieved through the groundwater protection objective; there is no surface water in the immediate vicinity of the waste sites that requires a separate remedial action objective.

3.8 Preliminary Remediation Goals

The PRGs are based on attainment of acceptable levels of human health and ecological risk. PRGs are preliminary numeric representations of the RAOs (i.e., preliminary cleanup levels) using the anticipated future land use, applicable contaminants, and relevant exposure pathways. PRGs are considered preliminary until finalized in a ROD as remedial action goals. Typically, PRGs are identified for individual hazardous substances identified as final COPCs. Final COPCs are the subset of the contaminants listed as COPCs (Appendix B) that exceed applicable standards. If multiple contaminants are present at a site, the suitability of using individual PRGs as final cleanup values protective of HHE is evaluated based on site-specific information and the potential for contaminant interaction.

Meeting these PRGs and the potential ARARs and, by extension, achieving RAOs, can be accomplished by reducing concentrations (or activities) of contaminants to remediation goal levels or by eliminating potential exposure pathways/routes. Contaminant-specific and numeric soil PRGs for direct exposure and protection of groundwater typically are presented as concentrations, which for nonradionuclides are in milligrams per kilogram (mg/kg) for soil and for radionuclides are in picocuries per gram (pCi/g). Final remedial action goals developed from the PRGs will be specified in a ROD that identifies the selected remedial alternative for the Z-Ditches.

Residual risks following completion of remediation of the waste sites must meet the 10^{-4} to 10^{-6} ELCR for radiological and carcinogenic COPCs and must be below an HI value of 1.0 for non-carcinogenic chemicals. Actual soil contaminant concentrations achieving these cleanup objectives will be presented in a remedial action report for the OU. The remedial action report will demonstrate how and where specific criteria have been applied and how the remedy protects receptors from the COPCs identified for the Z-Ditches. Table 3-3 and Table 3-4 identify nonradiological and radiological PRGs, respectively, for the Z-Ditches.

3.8.1 Direct Contact Exposure Preliminary Remediation Goals for Nonradioactive Contaminants

Development of the PRGs for direct contact exposure to nonradioactive contamination for both human and ecological receptors is described in the following subsections.

3.8.1.1 Human Exposure

For human receptors, PRGs developed for direct contact exposure to nonradioactive contamination in soils are based on risk-based standards. Risk-based standards for individual hazardous substances are established using applicable federal and state laws and risk equations. Risk-based standards for individual carcinogens in an industrial worker exposure scenario are based on an ELCR of 1 x 10^{-5} and an HQ of 1.0 for individual non-carcinogenic substances as described in WAC 173-340-745(5)(b)(iii)(B). Consistent with this approach, the methodology described for industrial properties under WAC 173-340-745(5), “Method C Industrial Soil Cleanup Levels,” is used to calculate the risk-based standards.

Risk-based standards for some contaminants are calculated to be less than area background values or practical quantitation limits. Where risk-based standards are less than area background concentrations, PRGs may be set at concentrations that are equal to the agreed upon site or area background concentrations. Area background values for selected nonradioactive contaminants in soil have been characterized for the Hanford Site (DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*). Similarly, where risk-based standards are less than practical quantitation limits, PRGs will default to the practical quantitation limits. Therefore, the PRGs for individual nonradioactive contaminants in solid waste and particulate reflect the value that is greatest among risk-based standards, area background values, or practical quantitation limits. Table 3-3 lists the nonradiological PRGs for direct contact exposure to humans for those final COPCs.

3.8.1.2 Ecological Exposure

The Z-Ditches are within the industrial area identified in the HCP and within the area designated by the ROD (64 FR 61615) as industrial. The industrial land use designation allows for continued waste management operations within the 200 Area consistent with past NEPA, CERCLA, and RCRA commitments and, among other things, will allow for the development of new waste management facilities. Sites within the industrialized portion of the 200 Area currently have limited habitat suitable for the establishment of ecological communities and food webs to support a hierarchy of terrestrial receptors. Maintenance of the industrial use will prevent future human inhabitation. However, cleanup to industrial land use standards may not continue to be protective of ecological receptors if ICs are lost. A SLERA has been used to develop soil PRGs for the protection of terrestrial organisms, including plants and soil biota.

Table 3-3. Summary of Nonradionuclide Soil Preliminary Remediation Goals for All Pathways

Constituent	Hanford Site Background[a] (mg/kg)	Direct Contact[b] (mg/kg)	Groundwater Protection[c] (mg/kg)	Terrestrial Plant and Animal Protection[d,e] (mg/kg)	Overall PRG[f] (mg/kg)
Contaminants of Potential Concern – Z-Ditches					
Aroclor-1254	--	66	0.11[g]	0.65	0.65
Aroclor-1260	--	66	0.72	0.65	0.65
Boron	NE	700,000	205	0.5	0.5
Mercury	0.33	560	0.019	0.1	0.33

a. Background concentrations are 90th percentile values of the log normal distribution of sitewide soil background data from DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*. Where the applicable PRG for a constituent is less than background, the background value is used as the PRG.

b. Direct contact values represent shallow vadose-zone concentrations that are protective of human receptors from direct contact with contaminated solids. Listed values are based on WAC 173-340-745(5) "Method C Industrial Soil Cleanup Levels" and are used to evaluate the top 4.6 m (15 ft) (WAC 173-340-745, "Soil Cleanup Standards for Industrial Properties"). These values can be obtained from the web-based *Cleanup Levels and Risk Calculations under the Model Toxics Control Act Cleanup Regulation; (CLARC), Version 3.1* tool (https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx), updated to be consistent with the new Model Toxics Control Act (WAC 173 340) rule amendments adopted by Ecology effective November 12, 2007.

c. Values represent deep vadose-zone soil concentrations that will be protective of groundwater. Values are calculated using the WAC 173-340 three-phase model for protection of drinking water (WAC 173-340-747[4], "Fixed Parameter Three-Phase Partitioning Model"). These values can be obtained from the web-based CLARC tool (https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx), updated to be consistent with the new Model Toxics Control Act (WAC 173 340) rule amendments adopted by Ecology effective November 12, 2007.

d. Ecological indicator soil concentrations for protection of terrestrial plants and animals are obtained from WAC 173-340-900, "Tables," Table 749-3.

e. Constituents with values shown are those constituents that exceed their respective ecological indicator soil concentration protective of terrestrial plants, soil biota, and wildlife as shown in Appendix B.

f. Listed values represent the most restrictive soil PRG derived from evaluation of direct contact and terrestrial plant and animal protection. Overall PRGs selected based on terrestrial wildlife protection should be interpreted in light of the discussion later in this FS.

g. This COPC exceeds soil concentrations for groundwater protection; however, subsequent STOMP modeling (PNNL-11217) indicates that this COPC would not exceed MCLs in the groundwater. Aroclor is an expired trademark.

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

PNNL-11217, *STOMP: Subsurface Transport Over Multiple Phases: Theory Guide*

WAC 173-340, "Model Toxics Control Act--Cleanup"

WAC 173-340-745, "Soil Cleanup Standards for Industrial Properties"

WAC 173-340-745(5), "Method C Industrial Soil Cleanup Levels"

WAC 173-340-747, "Deriving Soil Concentrations for Ground Water Protection"

WAC 173-340-747(4), "Fixed Parameter Three-Phase Partitioning Model"

WAC-173-340-900, "Tables"

--	=	no criteria established
CLARC	=	Ecology 94-145, *Cleanup Levels and Risk Calculations under the Model Toxics Control Act Cleanup Regulation; CLARC, Version 3.1*
PRG	=	preliminary remediation goal
STOMP	=	Subsurface Transport Over Multiple Phases (code)

Table 3-4. Summary of Radionuclide Soil Preliminary Remediation Goals

Constituent	Industrial Direct Exposure[a,b] (pCi/g)	BCG[c] (pCi/g)	Overall PRG[d,e] (pCi/g)
Am-241	940	4,000	940
Cs-137	18	20	18
Pu-239	2,900	6,000	2,900
Ra-226	4.0	50	4.0

a. Direct contact exposure values represent activities for individual radionuclides corresponding to a 10^{-4} ELCR for an industrial worker scenario. PRG values apply to the zero to 4.6 m (15 ft) bgs point of compliance as defined in WAC 173-340-740(6), "Model Toxics Control Act—Cleanup," "Unrestricted Land Use Soil Cleanup Standards," "Point of Compliance."

b. PRG values obtained from ECF-200CW5-10-0075, *Calculation of Preliminary Remediation Goals in Soil for an Industrial Worker Exposure Scenario*.

c. Concentration in soil that could result in a 0.1 rad/day dose to terrestrial wildlife.

d. Listed values represent the most restrictive PRG derived from evaluation of the direct contact exposure to humans or terrestrial plants and animals.

e. Exposure-point concentration divided by the overall PRG will provide the fraction of the overall PRG. Potential remediation should be sufficient to reduce the sum of these fractions for the site to below one.

BCG = biota concentration guide (DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*)

ELCR = excess lifetime cancer risk

PRG = preliminary remediation goal

For sites with ICs that prevent excavation of deeper soil, WAC 173-340-7490 allows a conditional point of compliance to be set at the biologically active soil zone. However, for this FS, the standard point of compliance that extends from the soil surface to a depth of 4.6 m (15 ft) was used as stated in WAC-173-340-7490(4)(b), "Standard Point of Compliance". Priority chemicals of ecological concern and their soil-screening levels are listed in WAC 173-340-900, "Tables," Table 749-3. These soil-screening levels were used in conjunction with the risk assessment to develop PRGs for the final COPCs that are protective of ecological receptors, including plants and soil biota, as indicated in Table 3-3.

3.8.2 Direct Contact Exposure Preliminary Remediation Goals for Radionuclides

The PRGs for direct contact exposure to radioactive contamination for both human and ecological receptors are described in the following subsections.

3.8.2.1 Human Exposure

Remediation goals for radioactive wastes and radioactively contaminated soils for human receptor direct contact exposures are based on EPA radionuclide soil cleanup guidance. As established by 40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," CERCLA cleanup actions generally should achieve a level of risk within the 10^{-4} to 10^{-6} ELCR for an individual. Furthermore, EPA policy has noted that the upper boundary of the risk range is not a discrete line at 10^{-4} and that a specific risk estimate around 10^{-4} may be considered acceptable, if justified based on site-specific conditions (EPA 540/R/99/006, *Radiation Risk Assessment At CERCLA Sites: Q&A*, OSWER Directive 9200.4-31P). Demonstration that the 10^{-4} to 10^{-6} residual risk-range goal has been achieved will be accomplished through final verification sampling during closeout of individual sites.

The individual PRGs for the identified final COPCs are calculated for an industrial worker direct contact exposure that corresponds to a risk threshold value of 10^{-4} ELCR and are provided in Table 3-4. For radionuclide final COPCs, PRG numerical values correspond to EPA's 10^{-4} target risk threshold and the site-specific exposure scenario selected for remedial design.

3.8.2.2 Ecological Exposure

The international community has been involved for more than 20 years in evaluating the effects of ionizing radiation on plants and animals. The International Atomic Energy Agency issued a study in 1992 (IAEA 332, *Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards*), endorsing the 1977 and 1990 International Commission on Radiological Protection report's *Recommendations of the International Commission on Radiological Protection* (ICRP-26 and ICRP-60) and stating that chronic radiation dose rates below 0.1 rad/day will not harm plant and animal populations and that radiation standards for human protection also will protect populations of nonhuman biota. The report implies that dose limits of 0.1 rad/day for animals and 1 rad/day for plants will protect populations, but additional evaluation of effects may be needed if sensitive species are present.

ORNL/TM-13141, *Effects of Ionizing Radiation on Terrestrial Plants and Animals: A Workshop Report*, presents information from a DOE-sponsored workshop held in 1995. In this report, experts in radioecology and ERA concluded that the 0.1 rad/day limit for animals and the 1 rad/day limit for plants recommended by the International Atomic Energy Agency are adequately supported by the available scientific information. However, the workshop participants concluded that guidance on implementing the limits is needed and that the existing data support application of the recommended limits for populations of terrestrial and aquatic organisms to representative rather than maximally exposed individuals.

In response to ORNL/TM-13141, DOE produced DOE-STD-1153-2002, which provides a graded approach to ERA for radionuclides and screening-level BCGs because no promulgated screening or cleanup levels are available for radionuclides. DOE-STD-1153-2002 provides a cost-effective, easy-to-implement methodology that can be used to demonstrate compliance with DOE dose limits and with findings of the International Atomic Energy Agency and National Council on Radiation Protection and Measurements regarding doses below which deleterious effects on populations of aquatic and terrestrial organisms have not been observed. The technical standard also can be used to assess ecological effects of radiological exposure when conducting ERAs.

The DOE's graded approach for evaluating radiation doses to biota consists of a three-step process that is designed to guide a user from an initial, conservative general screening to a more rigorous analysis using site-specific information (if needed) and is consistent with the eight-step EPA approach for conducting ERAs. The DOE recommends a three-step process that includes: (1) assembling radionuclide concentration data and knowledge of sources, receptors, and routes of exposure for the area to be evaluated; (2) applying a general screening methodology that provides limiting radionuclide concentration values (i.e., BCGs) in soil, sediment, and water; and (3) if needed, conducting a risk evaluation through site-specific screening, site-specific analysis, or a site-specific biota dose assessment conducted within an ecological risk framework, similar to that recommended by EPA/630/R-95/002F, *Guidelines for Ecological Risk Assessment*. Any of the steps within the graded approach may be used at any time, but the general screening methodology is usually the simplest, most cost-effective, and least time-consuming process.

The BCGs contained in DOE-STD-1153-2002 include conservative screening concentrations that are judged protective of the most sensitive terrestrial organisms, assuming a dose of 0.1 rad/day.[1] Each radionuclide-specific BCG represents the limiting radionuclide concentration in environmental media (i.e., soil, sediment, or water) that would not exceed the DOE's established or recommended dose standards for biota protection; therefore, soil concentrations that are less than the BCGs are not considered to pose a threat to terrestrial receptors.

[1] Terrestrial plant species are assumed to be protected at sites containing a dose of up to 1 rad/day (DOE-STD-1153-2002).

4 Identification and Screening of Remedial Technologies

The Implementation Plan (DOE/RL-98-28) provided an initial framework to guide the RI in the 200 Area. The plan identified and screened technologies that could be used to address contaminants in the soil and solid waste in the arid 200 Area environment.

Since this time, additional site characterization information was obtained at the 216-Z-11 Ditch as a portion of the 200-CW-5 OU RI and presented in the RI Report (DOE/RL-2003-11). Site contamination information and risks identified in the RI Report and summarized earlier in this FS were used to refine the preliminary evaluation of alternatives that will meet RAOs. A review of technologies was conducted to identify emerging technologies and to update technologies, either of which could effectively address potential site risk. If a technology was previously identified and evaluated and no modifications have been identified, the technology is mentioned only briefly in this chapter and the Implementation Plan is referenced for detailed information.

4.1 General Response Actions

The initial process of identifying viable remedial action alternatives is described in the plan as consisting of the following steps:

1. Define RAOs.
2. Identify GRAs to satisfy RAOs.
3. Identify potential technologies and process options associated with each GRA.
4. Screen process options to select a representative process for each type of technology based on effectiveness, implementability, and cost.
5. Assemble viable technologies or process options retained in Step 4 into alternatives representing a range of removal, treatment, containment, and ICs options, including no action.

Chapter 3 identified the RAOs for this FS. The Implementation Plan identified the following preliminary GRAs:

- No action
- ICs
- Containment
- RTD
- Ex situ treatment
- In situ treatment

These GRAs are intended to cover the range of response options necessary to meet the RAOs. Modifications to these GRAs were not necessary, based on the new information collected and evaluated in the RI Report. Detailed descriptions of each GRA are included in the Implementation Plan.

4.2 Screening and Identification of Technologies

This section screens and identifies viable technologies for 200-CW-5 OU remedial actions. Technology types and process options were identified and screened as described above (in accordance with CERCLA guidance) using effectiveness, implementability, and relative cost as criteria to determine the most viable options. The initial identification and screening of remedial technologies described in Appendix D of the

Implementation Plan is modified based on the information obtained from the RI and the additional risk assessment performed to support this FS. The following subsections summarize the technology screening conducted, discuss the screening of new technologies identified since the creation of the Implementation Plan, and discuss technologies that are retained for the 200-CW-5 OU. The technologies are discussed by GRA group. Table 4-1 presents a roadmap for technology selection.

Table 4-1. Technology Types and Process Options for Soil

General Response Action	Technology Type	Process Option	Retained in Implementation Plan (DOE/RL-98-28)	Retained in Feasibility Study for 200-CW-5 Operable Unit
No action	None	Not applicable	Yes	Yes
Institutional controls	Land use restrictions	Deed restrictions	Yes	Yes
	Access controls	Signs/fences	Yes	Yes
		Entry control	Yes	Yes
	Monitoring	Groundwater	Yes	Yes
		Vadose Zone	Yes	Yes
		Air	Yes	Yes
	Surface barriers	Existing soil cover	No	Yes
Containment, including ET barriers	Surface barriers	Hanford Barrier	Yes	No
		Modified RCRA and other ET Caps	Yes	Yes
		Standard RCRA Caps	No	No
		Asphalt, concrete, or cement-type cap	No	No
	Vertical barriers	Slurry walls	Yes	No
		Grout curtains	Yes	No
Removal	Excavation	Conventional	Yes	Yes
		High contamination	No	Yes
Disposal	Landfill disposal	Onsite landfill	Yes	Yes
		Offsite landfill/ repository	Yes	Yes
Ex situ treatment	Thermal treatment	Thermal desorption	Yes	No
		Vitrification	Yes	No
	Physical/chemical treatment	Vapor extraction	Yes	No
		Soil washing	Yes	No
		Mechanical separation	Yes	No
		Solidification/ stabilization	Yes	No
		Soil mixing	Yes	No

Table 4-1. Technology Types and Process Options for Soil

General Response Action	Technology Type	Process Option	Retained in Implementation Plan (DOE/RL-98-28)	Retained in Feasibility Study for 200-CW-5 Operable Unit
In situ treatment	Thermal treatment	Vitrification (Z-Ditches)	Yes	Yes
	Chemical/physical treatment	Vapor extraction	Yes	No
		Grout injection (pipelines and tanks)	Yes	Yes
		Deep soil mixing	Yes	No
		Dynamic compaction (component of barrier)	Yes	No
	Natural attenuation	Natural attenuation	Yes	Yes

Notes:

DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*

ET = evapotranspiration
RCRA = *Resource Conservation and Recovery Act of 1976*

4.2.1 Rescreening of Technologies Based on Risk Assessment Results

Because the initial screening was preliminary, and because additional site-specific risk assessment and characterization information is available, the remedial technologies presented previously were rescreened for application to the 200-CW-5 OU remedial action. The following is a brief discussion of the technology rescreening.

4.2.1.1 No Action

The National Contingency Plan (40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan") requires that a No Action Alternative be evaluated as a baseline for comparison with other alternatives. The No Action Alternative represents a situation where no restrictions, controls, or active remedial measures are applied to the site. The No Action Alternative implies a scenario of leaving the site and taking no measures to monitor or control contamination. This requires that a site does not pose an unacceptable threat to human health and the environment. The No Action Alternative was retained for 200-CW-5 OU and is carried forward in this FS.

4.2.1.2 Institutional Controls

Institutional controls are restrictions imposed on land use and/or site access to prevent or reduce public exposure to hazardous wastes or hazardous constituents at levels that exceed acceptable health risks, consisting of the following:

- Physical and/or legal barriers to prevent access to contaminants
- Monitoring of the groundwater and/or the vadose zone
- Maintaining existing soil cover

Institutional controls usually are required when contaminants remain in place at concentrations above cleanup levels; the controls likely will be a component of the remedial alternatives. Restrictions may include land use restrictions, natural resource use restrictions, well restriction areas, deed restrictions, deed notices, declaration of environmental restrictions, access controls, monitoring requirements, site-posting requirements, information distribution, notification in closure letter, restrictive covenants, and federal/state/county/local registries.

These activities are implemented at the Hanford Site through DOE/RL-2001-41, *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions*. Operations at the Hanford Site are expected to terminate in approximately 2050, and active ICs are assumed for approximately another 1,000 years following the termination of operations. Effective passive ICs will be designed to provide protection for at least 500 years, matching the period of effective ICs for ERDF, as recognized in the ERDF ROD (EPA/ROD/R10-95/100, *Declaration of the Interim Record of Decision for the Environmental Restoration Disposal Facility*).

Physical methods of controlling access to waste sites include access controls (such as signs, fences, and entry control), artificial or natural barriers, and active surveillance. Physical restrictions are effective in protecting human health by reducing potential contact with contaminated media. Site access controls also avoid adverse environmental, worker safety, and community safety impacts that arise from the potential release of contaminants associated with other remedial technologies (e.g., removal). If used alone, however, physical restrictions are not effective in achieving containment, removal, or treatment of contaminants. Physical restrictions also require ongoing monitoring and maintenance.

Legal restrictions include both administrative and real property actions intended to reduce or prevent future human exposure to contaminants remaining onsite by restricting the use of the land, including groundwater use. Land use restrictions and controls on real property development are effective in providing a degree of human health protection by minimizing the potential for contact with contaminated media. Restrictions can be imposed through land covenants, which would be enforceable by the United States and, under Washington State law, Ecology. Land use restrictions are somewhat more effective than access controls if control of a site transfers from the DOE to another party, because land use restrictions use legal and administrative mechanisms already available to the community and the State.

The disadvantages of land use restrictions are similar to those for access controls in that they also do not contain, remove, or treat contaminants. In addition, land use restrictions are not self-enforcing. Land use restrictions only can be triggered by an effective system for monitoring land use to ensure compliance with the imposed restrictions.

Sampling and environmental monitoring is an integral part of ICs and is necessary to verify that contaminants are attenuating as expected, to ensure that contaminants remain isolated, and to ensure that the remedial measures implemented are meeting performance objectives. Periodic sampling activities would include sampling of the actual contaminants and verification of overall site characteristics (geochemical, hydrogeologic, and biological properties). Environmental monitoring would be conducted to ensure that waste containment is achieved and that no further degradation of groundwater occurs. Surface radiation surveys and sampling of local biota may be necessary if contaminants remain near the surface.

Depending on the remedial action and results of sampling and monitoring, it will be necessary to maintain the existing soil cover or cap in order to ensure continued isolation of the contaminants.

Based on the results of the RI activities, no changes have been made to this technology from what appeared in the previous evaluation. The ICs technologies will be incorporated into remedial alternatives in Chapter 5 for evaluation.

4.2.1.3 Containment

Containment includes physical measures to restrict access to in-place contaminants or to reduce the migration of contaminants from their current location. Containment technologies include surface barriers (caps) and vertical barriers (slurry walls and grout walls), which are used to prevent or limit infiltration and/or intrusion into the contaminated zone.

Surface Barriers. Surface barrier technologies are applicable for groundwater, human health, and ecological protection. Several different types of surface barriers have been evaluated for use at the Hanford Site. DOE/RL-93-33, *Focused Feasibility Study of Engineered Barriers for Waste Management Units in the 200 Areas*, evaluated four conceptual barrier designs for different types of waste sites: the Hanford Barrier, the Modified *Resource Conservation and Recovery Act of 1976* (RCRA) Subtitle C Barrier, the Modified RCRA Subtitle D Barrier, and the Standard RCRA Subtitle C Barrier. Based on the results of this evaluation, the previous evaluation identified three of these engineered barriers as suitable for use at waste sites in the 200 Area:

- Hanford Barrier
- Modified RCRA Subtitle C Barrier
- Modified RCRA Subtitle D Barrier

Generally, this alternative consists of constructing surface barriers over contaminated waste sites to physically isolate the contamination; control the amount of water that infiltrates into contaminated media, which reduces or eliminates leaching of contamination to groundwater; and/or to prevent intrusion. Because groundwater risk has not been identified at the Z-Ditches, a barrier primarily would function to prevent ecological exposure as radiation attenuates. However, because of the long attenuation period for plutonium, a Z-Ditches barrier will be considered that controls water infiltration into the contamination zone.

All surface barriers considered in this FS are evapotranspiration (ET) barriers. ET barriers rely predominantly on the water-holding capacity of soil in conjunction with evaporation from the near-surface and plant transpiration to control water movement through the barrier. Precipitation infiltrates at the surface, where it is retained in the soil by absorption and adsorption until ET processes move the water back to the atmosphere. Such designs are particularly suitable for semiarid and arid climates with a low annual precipitation and relatively high ET potential. When precipitation exceeds ET, water is stored; when ET exceeds precipitation, water is released. Water balance studies at the Hanford Site have shown that vegetation and soil type control the downward movement of precipitation, and for finer grained soils with a healthy plant cover of shrubs and grasses, net recharge is close to zero (Gee et al., 1992, "Variations in Recharge at the Hanford Site"). The ET barriers can be divided into two categories: capillary barriers and monolithic (also called monofill) barriers. Figure 4-1 presents a generalized schematic of the monofill and capillary barriers.

The ET-type barriers retained in the previous technology evaluation (i.e., the Hanford Barrier, the Modified RCRA Subtitle C Barrier, and the Modified RCRA Subtitle D Barrier) are capillary barriers. Capillary barriers consist of a fine-grained soil layer overlying a relatively coarse-grained soil layer. The distinct textural interface between the two soil layers creates a capillary breach that functions to increase the water-holding capacity of the fine-grained soil and produces relatively low moisture conditions in the coarse-grained soil. Alternately, the barrier can incorporate a synthetic membrane to inhibit vertical flow of infiltrating water. The term "modified" means that the design varies in certain key respects from conventional barrier designs but is expected to be equivalent to or to exceed the performance of the conventional design. Figure 4-2 depicts a generalized conceptual schematic for the Modified RCRA Subtitle C Barrier.

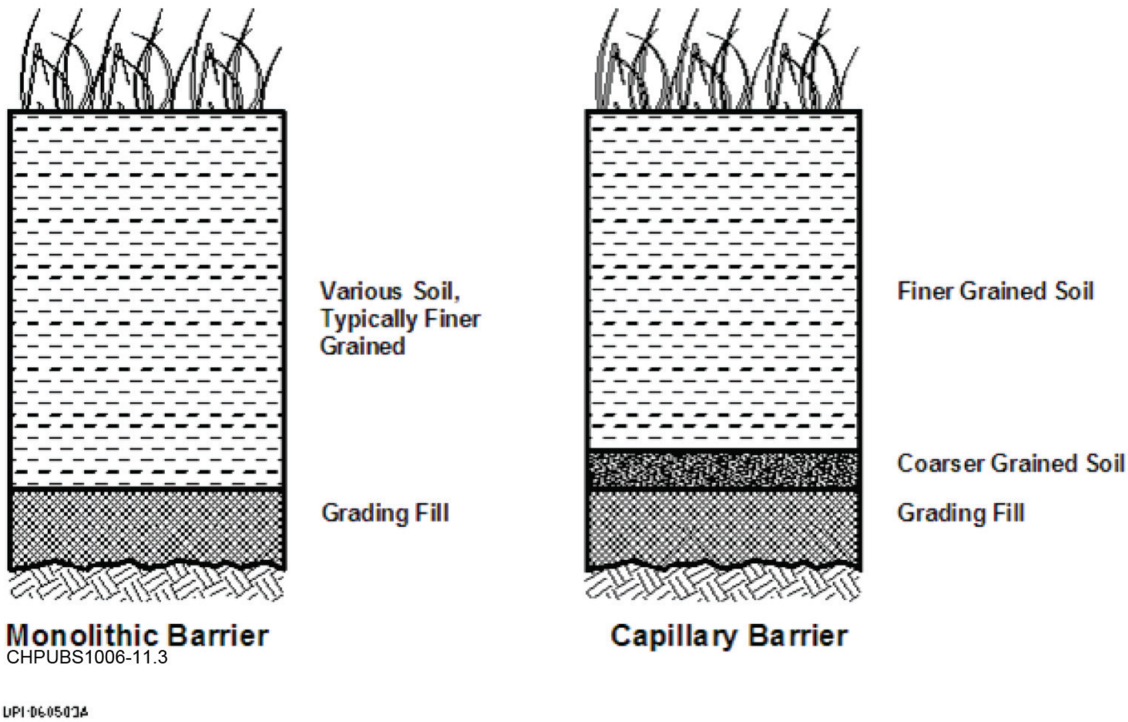
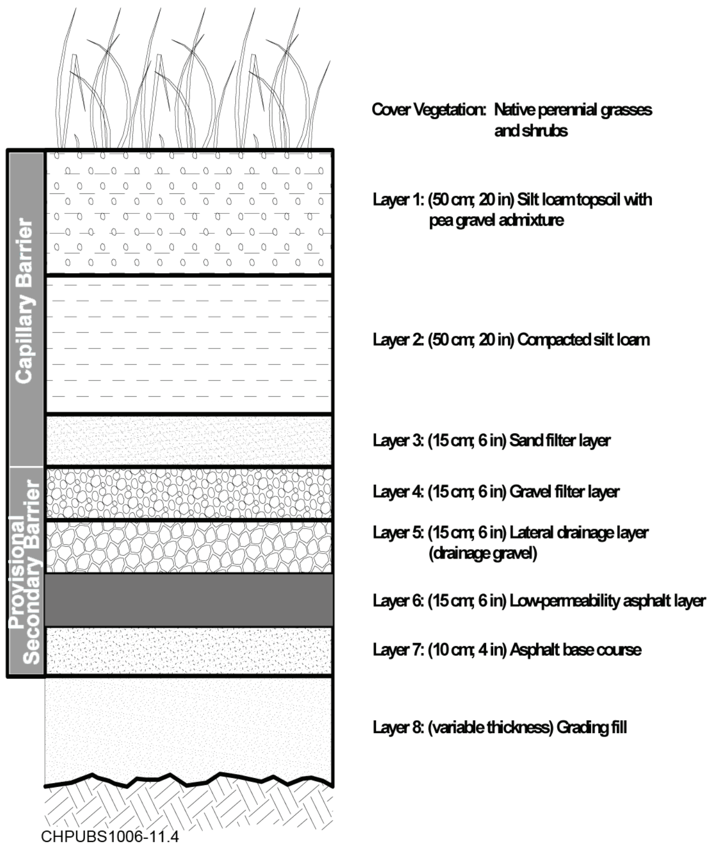


Figure 4-1. Generalized Conceptual Schematic of Evapotranspiration Barriers: Monofill Barrier and Capillary Barrier

Monolithic barriers (Figure 4-1) rely on a relatively thick single layer of fine-textured soil covered with native vegetation to control infiltration. Given the same soil type, the monolithic barrier requires additional soil thickness relative to capillary barriers for an equivalent water storage capacity. Should the thickness of the soil required for water-holding capacity exceed the rooting depth, water removal capacity diminishes.

The Hanford Barrier, the Modified RCRA Subtitle C Barrier, and the Modified RCRA Subtitle D Barrier, were designed to address various categories of contamination (e.g., plutonium at greater than 100 nCi/g, low-level, hazardous, and sanitary). These designs all include additional layers for added levels of containment. The Modified RCRA Subtitle C Barrier (Figure 4-2) design was developed for sites containing hazardous, low-level waste, or low-level mixed waste to provide long-term containment and hydrologic protection for a performance period of 500 years (DOE/RL-93-33). The Modified RCRA Subtitle C Barrier also was developed because the conventional RCRA Subtitle C cap design, aimed at areas with much higher precipitation, contains a clay component that desiccates under dry conditions and is not effective for arid climates. The design includes the components of a capillary barrier overlying a secondary barrier system using a low permeability layer. The secondary barrier layers are provisional, depending on the site-specific need for redundancy in hydrologic protection, a vapor barrier, and/or a more robust biointrusion layer.

The ET barriers are effective in semiarid and arid environments, where precipitation is limited and ET potential is high. Water-balance studies at the Hanford Site have shown that vegetation and soil type are the primary factors that control the downward movement of precipitation, and for finer-grained soils with a healthy plant cover of shrubs and grasses, estimated net recharge in the 200 East Area ranges from 1.5 to 4 mm/yr (0.06 to 0.16 in/year) (PNNL-14702, *Vadose Zone Hydrogeology Data Package for Hanford Assessments*, Table 4-15). The recharge estimate for an ET barrier is 0.1 mm/yr (0.004 in./yr) (PNNL-14702, Table 4-16).



Notes:

RCRA = *Resource Conservation and Recovery Act of 1976*

Figure 4-2. Conceptual Schematic: Capillary Modified RCRA Subtitle C Barrier

There are several barrier designs. Three of the designs were evaluated and screened out early in the process primarily based on implementability and cost. These barrier designs are the Hanford barrier and RCRA Subtitle C and Subtitle D barriers. Relative to the other technologies, the complexities in design and construction of the Hanford barrier place it last with respect to implementability and cost. The RCRA Subtitle C and Subtitle D Barriers were screened out because of implementability, cost, and uncertainty of the barriers' useful life in arid climates as a result of desiccation cracking, breakdown caused by freeze thaw cycles, and biointrusion (DOE/EM-0558, *Alternative Landfill Cover*).

For the purposes of the FS, the Modified RCRA Subtitle C barrier will be considered, and design and construction complexities can be addressed during the remedial design process.

Vertical Barriers (Slurry Walls and Grout Walls). Slurry walls and grout walls were retained in the previous evaluation. Slurry walls are formed by vertically excavating a trench that is filled with a slurry (typically a mix of soil, bentonite, and water) that forms a continuous low permeability barrier. Grout walls are formed by injecting grout, under pressure, directly into the soil matrix (permeation grouting) or in conjunction with drilling (jet grouting) at regularly spaced intervals to form a continuous low permeability wall. Using directional drilling techniques, angled grout walls can be formed beneath a waste site. This type of angled barrier is limited (more so than vertical slurry walls) by difficulties in verifying barrier continuity and by the materials used. New innovative materials have the potential for limiting radionuclide mobility through chemical reactions.

Slurry walls and grout walls have potential application in the vadose zone to limit the horizontal movement of moisture into contaminated materials or to limit the horizontal migration of contaminants. Vertical barriers can be used as a supplemental element in the design of surface caps to improve containment performance; both slurry walls and grout walls are suitable technologies for this application.

While use of slurry walls and grout walls would provide a means of limiting horizontal movement of contamination and water as part of a barrier alternative, suitability of this technology to limit vertical migration of contaminants is less certain. Because the Z-Ditches are long and narrow, installation of a horizontal grout barrier beneath this site would be difficult to construct. For these reasons, the use of slurry walls and grout walls as horizontal barriers to prevent vertical migration of contaminants is not retained in this FS.

4.2.1.4 Removal, Treatment, and Disposal

The previous evaluation identified excavation of contaminated soils (with treatment as needed to meet disposal criteria), transportation, and disposal to the appropriate disposal facility as an applicable technology for the waste sites. Excavation of material generally is accomplished using standard earth-moving equipment, such as backhoes and front-end loaders. This technology is retained for use at sites as a standalone remedial alternative and in combination with other remedial technologies, such as a barrier. As depths increase, there is more chance that the side slope requirements (generally a horizontal to vertical ratio of 1.5:1) will interfere with nearby buildings and facilities.

The levels of radiological contamination at 200-CW-5 OU waste sites may pose a significant threat to workers. Elevated levels of Am-241 and Pu-239/240 encountered during excavation and disposal activities may result in implementing remote-handled removal techniques. Whether remote or contact handled, special safety controls will be required to address the contaminant concentrations. These factors are discussed in further detail in Chapter 6. Shoring may be needed at cut intervals to reach these depths safely. Large excavations would significantly increase the time that workers are exposed to the highly contaminated zones, resulting in increased doses. In addition, large excavations to these depths would put a significant amount of contaminated material at risk for spread through airborne pathways. Costs would increase because of these augmented safety techniques.

Waste disposal is divided into two types. The first is onsite disposal of waste soils that would be designated as mixed or low-level waste. The second is temporary onsite storage of waste containing plutonium at concentrations greater than 100 nCi/g, followed by offsite disposal.

1. **Onsite disposal of low-level and mixed low-level waste**. The onsite disposal option for mixed or low-level waste is ERDF. The waste acceptance criteria for ERDF (WCH-191, *Environmental Restoration Disposal Facility Waste Acceptance Criteria*) are based on regulatory requirements (e.g., RCRA land disposal restrictions) and risk-based considerations for long-term protection of human health and the environment. If waste cannot be accepted at ERDF, then a suitable alternate disposal facility will be used; however, all contaminated soils from the 200-CW-5 OU without plutonium and americium at concentrations greater than 100 nCi/g are expected to be acceptable for disposal to the ERDF. Based on existing information, soil and/or debris removed from the waste sites do not require treatment to meet ERDF waste acceptance criteria (WCH-191). In addition, it is not

anticipated that any significant quantities of waste with plutonium and americium greater than 100 nCi/g would be generated by any of the alternatives.

2. **Disposal of waste containing plutonium at concentrations greater than 100 nCi/g**. Some waste soil containing plutonium at concentrations greater than 100 nCi/g may be generated during the Z-Ditches remediation. Repackaged soil that is determined to contain transuranic radionuclides at concentrations greater than 100 nCi/g (100,000 pCi/g), would undergo waste certification and shipment to the Waste Isolation Pilot Plant (WIPP).

The WIPP is exempt from RCRA land disposal restrictions. Consequently, specific ex situ treatment for contaminants of Z-Ditches mixed waste that would require disposal at WIPP will not be necessary.

4.2.1.5 Ex Situ Treatment

Ex situ treatment processes retained in the previous evaluation include thermal desorption, vapor extraction, mechanical separation, soil washing, ex situ vitrification, solidification/stabilization, and soil mixing.

Thermal desorption and vapor extraction technologies typically are applied to soils contaminated with light- to medium-range hydrocarbons and other organics. Thermal desorption also is effective on heavier range hydrocarbons (e.g., diesel, oil). Based on the data contained in the RI Report and the results of the risk assessment, remediation for hydrocarbons or organics other than the potential for some small quantity of PCB contamination, is not necessary. These ex situ technologies are ineffective for radionuclides and inorganic compounds and, therefore, were rejected for this FS.

The primary mechanical separation technique for solid media is sieving to segregate material according to size, but other physical properties also may be used as a basis for segregation (e.g., local discoloration of soil). The main disadvantage of this technology is that increased waste handling carries the potential of greater worker risk and the production of fugitive dust. This process has been used as a component of removal and disposal actions on the Hanford Site. Experience in the 300 Area burial grounds has proved clogging of the sieving device may be a problem. There is no apparent technical advantage to using mechanical separation for the waste sites in this FS; therefore, the technology is not retained in this FS.

Soil washing has limited effectiveness on many radionuclides, with the risk of higher exposures to workers and potentially high costs associated with the soil washing, especially if chemicals are needed to remove contaminants. Based on the results of the RI, treatment is not required to meet the ERDF or WIPP waste acceptance criteria; therefore, soil washing is not retained in this FS.

Ex situ vitrification is costly and is deemed unnecessary to dispose of waste at ERDF or WIPP. An ex situ vitrification facility (the Waste Vitrification Plant) is currently under construction on the Hanford Site; however, at the earliest it will not be available to treat waste until 2019. In addition, the costs associated with treating waste at this facility are not yet available. Therefore, ex situ vitrification is not retained in this FS.

Solidification/stabilization technologies generally are used to immobilize soil contaminants; this is assumed unnecessary for disposal to ERDF or to WIPP. Therefore, solidification/ stabilization technologies are not retained in this FS.

Soil mixing or blending as an ex situ treatment process reduces the mobility of contaminants by entraining them in the solidifying agent. It is not anticipated that ex situ treatment of this kind will be required for the contaminants in the Z-Ditches, as these contaminants are already quite immobile in soil. Therefore, soil mixing as a specified ex situ treatment is not retained in this FS. However, limited blending of soil with noncontaminated materials (e.g., kitty litter to absorb liquids) may be required to meet worker health and safety standards or to achieve a prohper waste form to meet disposal facility waste acceptance criteria. This action is incidental to remedial action activities and is not considered a standalone alternative requiring evaluation in this FS.

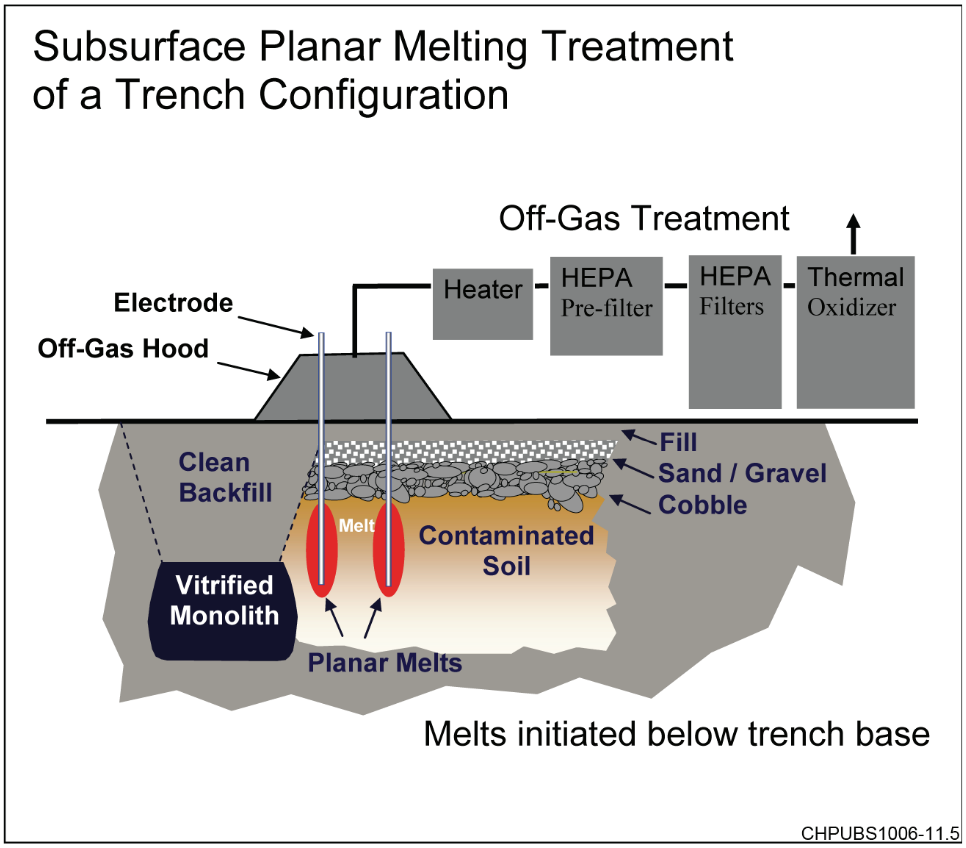
4.2.1.6 In Situ Treatment

In situ treatment technologies were retained in the previous evaluation to mitigate contaminant mobility or to treat organics in situ. The technologies are vitrification, grout injection, soil mixing, dynamic compaction, and natural attenuation.

In Situ Vitrification. The ISV process is a mobile, subsurface, in situ thermal-treatment process. ISV applies an electrical current through vertically placed electrodes to melt contaminated soil. As the soil melts, it becomes electrically conductive and continued application of power results in joule heating within the molten media between and around the electrodes. Melt temperatures attain between 1,200 and 2,000 °C (2,200 to 3,600°F), depending on the composition of the mixture. To accommodate subsidence caused by soil densification and increased thermal efficiency and radionuclide retention, clean overburden is placed over the melt zone before initiating melting. Air emissions are collected and treated locally in an offgas treatment system before discharge to the environment. This process forms a stable, vitrified glass matrix. When cooled, the matrix is durable, non-leachable, and impermeable, which destroys, removes, or immobilizes contaminants. The glass monolith forms a substantial physical barrier that inhibits both human and biological intrusion into the residual contamination (PNL-4800 Suppl. 1, *In Situ Vitrification of Transuranic Waste: An Updated Systems Evaluation and Applications Assessment*). Los Alamos National Laboratory reported that several diamond bits were required to perform sampling because of the hardness of the glass. Figure 4-3 shows a conceptual schematic of this ISV technology.

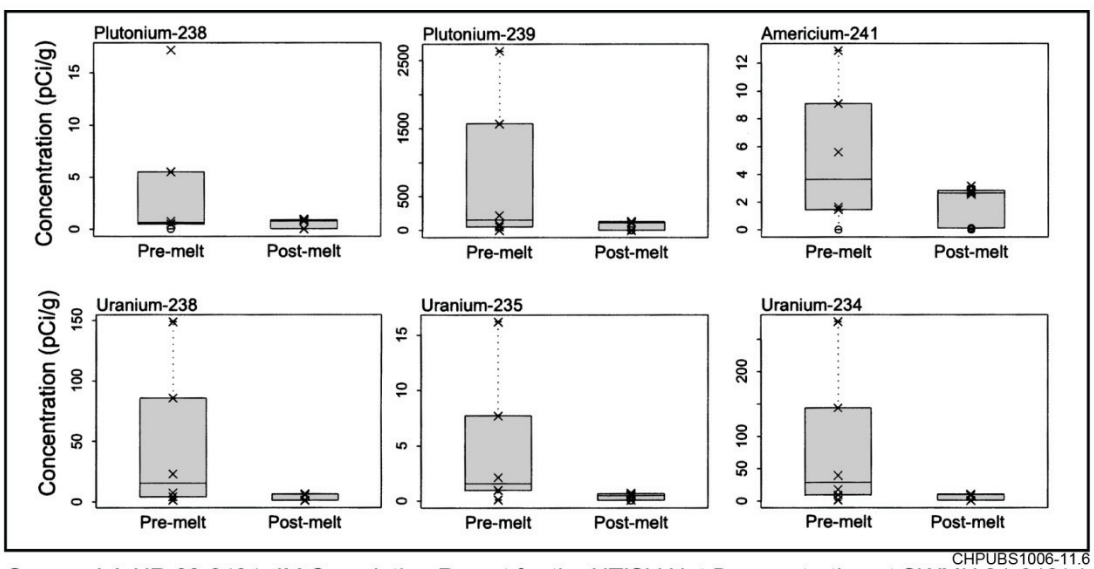
The stable mass chemically incorporates most inorganics (including heavy metals and radionuclides) homogeneously distributed throughout the melt because of the low viscosity of the molten glass and the convective flow that occurs. ISV destroys or removes organic contaminants by pyrolysis (which occurs as the temperature increases before the actual melting) and/or by chemical reactions (e.g., catalytic dechlorination reactions). The convective mixing reduces criticality potential by preventing necessary conditions, particularly for plutonium, which is not reduced to its reactive metallic state and is uniformly dispersed (not concentrated) as an oxide within the glass (LA-UR-03-6494, *IM Completion Report for the NTISV Hot Demonstration at SWMU 21-018(a)-99 (MDA V)*). Analytical data identified both a general reduction in radionuclide concentrations in post-melt glass and a uniform distribution of radionuclides because of the convective mixing. In addition, typically the melt retains greater than 99.99 percent of the plutonium (PNNL-11346, *Plutonium Dioxide Dissolution in Glass*). Figure 4-4 depicts pre- and post-melt radionuclide concentrations from the Los Alamos National Laboratory test (LA-UR-03-6494).

ISV encapsulates the highly contaminated soils and immobilizes alpha emitters, such as plutonium, so that any subsequent direct contact poses only moderate risks. Plutonium contamination immobilized in the glass was nonsmearable, was not detected in the air, and surface dose reduction is expected because of self-shielding of the vitrified mass (PNL-4800 Suppl. 1).



Note: HEPA high-efficiency particulate air (filter)

Figure 4-3. Conceptual Schematic: In Situ Vitrification



Source: LA-UR-03-6494, *IM Completion Report for the NTISV Hot Demonstration at SWMU 21-018(a)-99 (MDA V)*

Figure 4-4. Comparison of Pre- and Post- In Situ Vitrification Radionuclide Concentrations

ISV is not considered effective at depths greater than about 6.1 m (20 ft) or where individual melts must be greater than 12.2 by 12.2 m (40 by 40 ft) at the surface. ISV is not a fully matured technology and presents some implementation and performance acceptance challenges in a field environment. Some of these challenges requiring acceptable resolutions are as follows:

- Effective depth
- Assurance of acceptable glass form at the bottom of the melt
- Proper mixing of the soil
- Performance of glass for 1,000 years
- Glass formula evaluation and addition of new material
- In-process sampling analysis accuracy
- Homogeneity of glass formed
- Exposure and radiation levels at the top of the melt

A number of tests and demonstrations have been conducted to address these issues. As part of the development of the original ISV process by PNNL for DOE, a full-scale radioactive melt was completed at the 216-Z-12 Crib. The technology was demonstrated most recently by a "hot" demonstration at Los Alamos National Laboratory, reported in LA-UR-03-6494. Based on the results of in-process monitoring and sampling conducted during the hot demonstration, the technology processed the desired treatment volume, the resulting glass was both homogeneous and durable, and contaminants were not driven from the absorption bed into the surrounding tuff. Other tests (AMEC Earth & Environmental and Geomelt Richland Test Facility in 1996 and Parson's Chemical Works, Inc., site in Grand Ledge, Michigan [EPA/540/R-94/520, *Geosafe Corporation In Situ Vitrification, Innovative Technology Evaluation Report*]) showed that melting operations conducted close together would fuse without trapping unprocessed waste.

ISV may be applicable for the Z-Ditches containing high concentrations of transuranic isotopes (e.g., Pu-239/240 and Am-241) within 5.3 m (17.5 ft) of the surface. ISV has been selected at other DOE sites for processing soil contaminated with transuranic radionuclides as reported in EPA/541/R-02/100, *Record of Decision (ROD) for Waste Area Group 7, Trenches 5 and* 7 *in Melton Valley at Oak Ridge National Laboratory*. Based on the technology development to date, which shows that ISV is likely to meet requirements for long-term waste site contaminant control and stability, ISV is retained in this FS.

Grout Injection. Grout injection, commonly referred to as jet grouting or in situ grouting, is a process that entails injecting a slurry-like mixture of cements, chemical polymers, or petroleum-based waxes into contaminated media. Grouts are specially formulated to encapsulate contaminants, isolating them from the surrounding environment. As summarized in INEEL-01-00281, *Engineering Design File, Operable Unit 7-13/14 Evaluation of Soil and Buried Waste Retrieval Technologies*, in situ grouting has been approved by regulating agencies and implemented at several small-scale sites. However, in situ grouting has not been applied to large-scale sites with many radiological and chemical hazards such as the 200-CW-5 OU sites.

Grout injection, as a standalone action, is rejected for this FS because of the size and depth of the waste sites. However, the technology is applicable as a sub-element to other remedial alternatives, such as barrier placement, to fill voids in pipelines, cribs, and tanks that would remain in place under the alternative. Of the 200-CW-5 OU waste sites, grout injection immobilization treatment is applicable only to the approximately 1,392 m (4,560 ft) of 15 cm (6 in.) diameter perforated waste distribution piping of the 216-Z-20 Tile Field, if the piping is not removed.

Dynamic Compaction. Dynamic compaction is used to increase the soil density, compact the buried solid waste, and/or reduce void spaces by dropping a heavy weight onto the ground surface. Compaction can reduce the hydraulic conductivity of subsurface soils and the mobility of contaminants. Because the compactive energy attenuates with depth, dynamic compaction is limited to shallow applications, typically less than 3 m (10 ft). Chemicals and radionuclides at the sites in this FS generally extend deeper than 3 m (10 ft). For this reason, dynamic compaction is rejected in this FS as a standalone action and is not retained in the FS as a sub-element of any other alternative.

Soil Mixing. In situ deep soil mixing uses large augers (mixers) and injector head systems to inject and mix solidifying agents (cement or pozzolanic based) into contaminated soil in place. The process reduces the mobility of contaminants by entraining them in the solidifying agent. Soil mixing at depth is difficult to implement in rocky soils and the effectiveness of solidification of the contaminated soil is difficult to monitor and ensure. This technology is not suitable for use at the Z-Ditches because the contamination is shallow and does not contain chemicals that would require treatment to allow land disposal; the primary site contaminants are radionuclides (americium and plutonium) that are immobile in soils; and, because the size of the Z-Ditches area would make ensuring its effectiveness difficult. Consequently, soil mixing as in situ treatment is rejected for this FS.

Natural Attenuation. Natural attenuation is retained for this FS because it is a natural component of all of the potential alternatives. Natural attenuation is most effective on sites with nonradionuclides that readily degrade in the environment and on sites with radionuclides that have short half-lives, such as Cs-137. However, natural attenuation is a slow process at sites that have radionuclides with long half-lives (e.g., plutonium and americium) or nonradionuclides that do not degrade naturally in the environment.

4.2.2 Remedial Technologies and Process Options Retained for 200-CW-5 Operable Unit Alternative Development

Table 4-1 shows the remedial technologies and process options retained for development of remedial alternatives specific to the 200-CW-5 OU based on the technology screening identified in this chapter.

This page intentionally left blank.

5 Remedial Action Alternatives

The EPA guidance for conducting FSs under CERCLA recommends that a limited number of technologies be carried forward from the technology identification and screening activity. These technologies then are grouped into remedial alternatives to address the site-specific conditions. In Chapter 4, technologies were identified and screened based on site-specific characteristics and COPCs. In this chapter, these technologies are grouped into remedial alternatives to address site contamination problems. Several remedial alternatives are developed and described in this chapter for the 200-CW-5 OU waste sites.

5.1 Development of Alternatives

Significant efforts and evaluations have contributed to defining applicable technologies and process options that address the 200-CW-5 OU waste sites. Appendix D of the Implementation Plan (DOE/RL-98-28) provides initial information on identification and screening of remedial technologies for the 200 Area waste sites. This previous evaluation, in conjunction with the earlier (Chapter 4) technology screening, forms the basis for the development of remedial alternatives. The previous evaluation preliminarily developed remedial alternatives based on the results of the technology screening for the waste sites. Remedial alternatives identified in the Implementation Plan for the 200-CW-5 OU included the following:

- No action
- MESC/MNA/IC
- RTD (onsite disposal)
- Containment using surface barriers (barrier)
- ISV

For all alternatives, pipelines connected to the waste sites are planned to be evaluated and assessed in accordance with the information outlined in Appendix H of the 200-PW-1/3/6 FS. Evaluation of the No Action Alternative is a requirement under CERCLA. The MESC/MNA/IC alternative is retained and further developed in this FS for sites where existing remedial actions are in place or where contamination is expected to reach RAOs within a reasonable ICs period. The RTD and capping (barrier) alternatives are also retained and further developed in this FS. The ISV technology alternative is retained for consideration at the Z-Ditches in two alternatives that use ISV in combination with RTD or barrier placement. The in situ grouting or stabilization alternative, as a standalone alternative, is screened out of this FS because of implementation problems associated with the size of the waste sites and unproven effectiveness on large-scale sites having radiological and chemical hazards. However, in situ grouting or stabilization technologies are retained for inclusion as elements of other remedial actions. The following subsections further develop and describe the alternatives.

One important factor in the development of site-specific remedial alternatives is that radionuclides, heavy metals, and some inorganic compounds cannot be destroyed and therefore persist in the environment. As such, these compounds must be physically removed or treated (e.g., immobilized, contained, or chemically converted) to achieve a less-mobile or less-toxic form to meet the RAOs. However, because at the Z-Ditches heavy metals or inorganic compounds do not present unacceptable risk, the long-lived radionuclides will drive the development of remedial alternatives that provide long-term protectiveness.

5.2 Description of Alternatives

This section provides a description of the selected alternatives considered for evaluation in this FS, including the following:

- Alternative 1—No Action
- Alternative 2—MESC/MNA/IC
- Alternative 3—RTD (ERDF Disposal)
- Alternative 4—Barrier
- Alternative 5A—ISV with Barrier and RTD
- Alternative 5B—ISV with Barrier

Table 5-1 illustrates the process of identifying technology types, combining process options, and presenting the elements of each alternative.

5.2.1 Alternative 1—No Action

The "National Oil and Hazardous Substances Pollution Contingency Plan" (40 CFR 300) requires that a No Action Alternative be evaluated as a baseline for comparison with other remedial alternatives. The No Action Alternative represents a situation where no legal restrictions, access controls, or active remedial measures are applied to the site. No action implies leaving the waste site and allowing the wastes to remain in their current configuration, affected only by natural processes. No maintenance or other activities are instituted or continued. Selecting the No Action Alternative would require a waste site not to pose an unacceptable threat to human health or the environment.

Based on the waste site evaluations and the results of the risk assessment, the Z-Ditches do not meet the RAOs using the No Action Alternative.

5.2.2 Alternative 2—Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls

This alternative takes advantage of existing soil covers and the nature of the contaminants that have relatively short half-lives, in combination with ICs, to provide protection of human health and the environment. Monitoring also is an element of this alternative. For the waste sites in this OU, a soil cover exists that was placed during construction (i.e., clean backfill over the subsurface of the 216-Z-20 Tile Field) or after site retirement during backfilling or site stabilization activities. Under this alternative, these existing soil covers would be maintained to isolate the contamination and limit intrusion, thereby breaking the exposure pathway between human and ecological receptors and the contaminants. ICs, including legal and physical barriers, also would be used to prevent human intrusion into the site.

ICs involve the use of physical and legal barriers, such as fences and/or access restrictions in the form of deed restrictions, to control land and groundwater use to reduce or eliminate exposure to COPCs. ICs also can include groundwater, vadose zone, surface soil, biotic, and/or air monitoring. ICs for this alternative include periodic surveillance of the waste sites for evidence of contamination and biologic intrusion; emplacement of vegetation, herbicide application, manual removal, or other activities to control deep-rooted plants; control of deep burrowing animals; maintenance of signs and/or fencing; maintenance of the existing soil cover (including an assumed periodic addition of soil); administrative controls; and site reviews.

Table 5-1. Summary of Remedial Alternatives and Associated Components

Technology Type	Process Option	Alternative 1 No Action	Alternative 2 MESC/ MNA/IC	Alternative 3 RTD	Alternative 4 Barrier	Alternatives 5A and 5B ISV with Barrier and RTD (5A), and ISV with Barrier (5B)
No action	No action	X				
Land use restrictions	Deed restrictions		X		X	X
Access controls	Signs/fences		X		X	X
	Entry control		X		X	X
Monitoring	Groundwater		X	[c]	X	X
	Vadose zone		X		X	X
	Air		X		X	X
Surface barriers	Existing soil cover		X			X
	Barrier				X	
In situ physical treatment	Grout injection[a]				X	X
In situ thermal treatment	ISV					X
Removal	Conventional excavation			X		X[b]
	Excavation in high concentration areas			X		
Landfill disposal	Onsite landfill			X		X
Monitored natural attenuation	Offsite landfill/ repository			X		
	Monitored natural attenuation		X		X	X

a. Grout injection is limited to stabilizing buried 216-Z-20 Tile Field waste distribution piping to prepare for barrier placement under Alternatives 4 and 5B.

b. A component of Alternative 5A (ISV and RTD) only.

c. Any groundwater monitoring will be rolled into the site-wide groundwater-monitoring program for compliance monitoring.

ISV = in situ vitrification
MESC/MNA/IC = maintain existing soil cover/monitored natural attenuation/institutional controls
RTD = removal, treatment, and disposal

Contaminants remaining beneath the clean soil cover would be allowed to attenuate naturally until RAOs are met. Natural attenuation relies on natural processes to lower contaminant concentrations until cleanup levels are met. MNA would include sampling and/or environmental monitoring, consistent with EPA guidance (EPA/540/R-99/009, *Use of Monitored Natural Attenuation at Superfund RCRA Corrective Action and Underground Storage Tank Sites November 1997*, OSWER 9200.4-17P*)*, to verify that contaminants are attenuating as expected. Attenuation monitoring activities could include monitoring of the vadose zone using geophysical logging methods or groundwater monitoring to verify that natural attenuation processes are effective.

The existing network of groundwater monitoring wells in the Central Plateau is adequate for monitoring these sites, in coordination with the groundwater OUs (200-UP-1 and 200-ZP-1). If the existing network becomes unsatisfactory, additional monitoring wells can be added. If remediation activities result in the decommissioning of groundwater monitoring wells in the area of remediation, an evaluation of future monitoring needs will be conducted.

5.2.3 Alternative 3—Removal, Treatment, and Disposal

Under Alternative 3, contaminated soil would be removed, treated if required to meet receiving facility waste acceptance criteria, and disposed of at an approved facility. A generalized cross section for this alternative in Figure 5-1 shows only shallow zone contamination that could be found at the Z-Ditches.

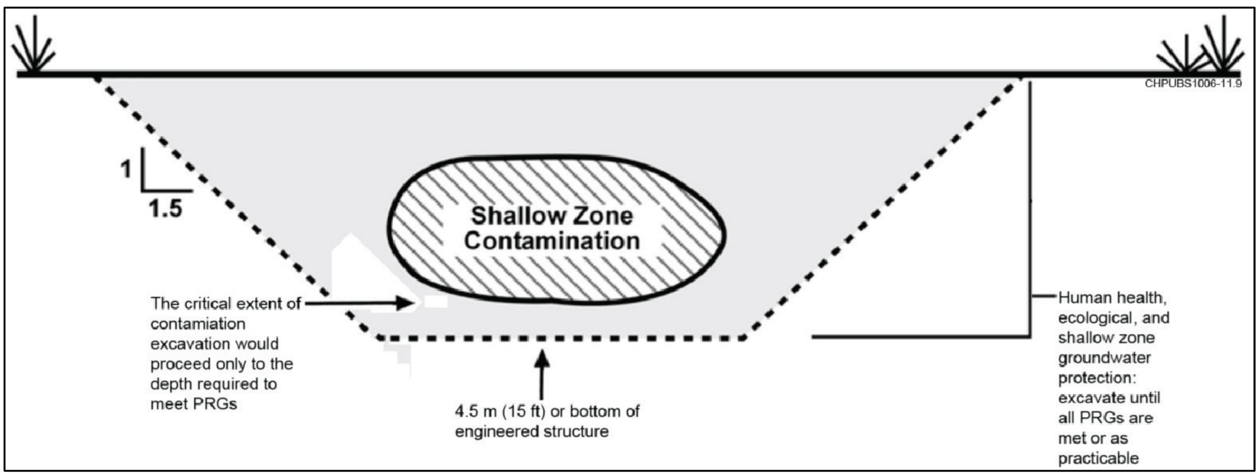


Figure 5-1. Generalized Removal, Treatment, and Disposal Alternative (Alternative 3)

The disposal facility chosen depends on the type of waste to be disposed. The majority of the waste generated under this alternative would be low-level waste that can be disposed of at the ERDF. Although there are localized areas with minor plutonium or americium above 100 nCi/g, disposal to a geologic repository is not anticipated based on the use of common excavation techniques, which are expected to achieve ERDF waste acceptance criteria (WCH-191).

Alternative 3 provides for full site RTD using excavation techniques that are not anticipated to result in soil contaminated above 100 nCi/g that needs to be segregated from lesser-contaminated soil for waste management purposes. This alternative assumes that no transuranic waste will be generated through the remediation activities and therefore assumes disposal of all waste onsite at the ERDF. It will generate low-level waste in significant quantities.

Soil and associated structures (such as tile field piping) having contaminant concentrations above the PRGs would be removed as low-level waste under this alternative using conventional excavation techniques where appropriate, or specialized excavation techniques where contamination levels require added protection. Contaminated excavated materials would be disposed of at an approved disposal facility, currently envisioned as the ERDF. Whenever possible, noncontaminated excavated soil (e.g., clean overburden) would be stockpiled in an adjacent area as backfill material. Precautions would be used to minimize the generation of onsite fugitive dust. Depending on the configuration and depth of the excavation, shoring might be used to comply with safety requirements and to reduce the quantity of excavated soil.

The excavation depth and volume of soil removed largely depend on the exceeded PRGs. At the Z-Ditches, hypothetical unrestricted land use exposure goals, human health direct contact, and ecological PRGs are exceeded. Consequently, removals generally would be conducted to a maximum of 4.6 m (15 ft) bgs consistent with the points of compliance identified in WAC 173-340-745(6)(d), "Soil Cleanup Standards for Industrial Properties–Point of Compliance," and WAC 173-340-7490(4)(b), "Terrestrial Ecological Evaluation Procedures–Point of Compliance." Based on characterization data (Chapter 2) and risk assessment results (Chapter 3), the Z-Ditches excavation depth considered protective of human health, ecological, and subsistence farmer receptors could be limited to approximately 4 m (13 ft) bgs. Because groundwater protection PRGs were not exceeded at the Z-Ditches, deep zone soils need not be removed to protect groundwater. Chapter 3 presents the risk assessment results that support the depth of excavation. Below-grade structures deeper than 4.6 m (15 ft) bgs, including some 216-Z-20 Tile Field waste distribution piping that could be deeper than 4.6 m (15 ft) bgs, were not included as part of the cost estimate evaluation. Sampling will be conducted to confirm that leaving the structures in place meets the requirements for protection of HHE, including protection of groundwater.

The remediation of soil and associated structures for this alternative would be guided by the observational approach. The observational approach is a method of planning, designing, and implementing a remedial action that relies on information (e.g., samples, field screening) collected during remediation to guide the direction and scope of the activity. Waste site data are collected to assess the extent of contamination and to make "real-time" decisions in the field. Targeted (or hot-spot) removals could be considered under this alternative where contamination is localized.

Based on existing information, soil and/or debris removed from the waste sites do not require treatment to meet ERDF waste acceptance criteria (WCH-191). However, additional activities are required to meet health and safety requirements during excavation, handling, transportation, and disposal. During common excavation procedures, higher concentration soil areas would have less contaminated soil resulting in meeting as low as reasonably achievable (ALARA) goals and reduction of worker risks at all points in the removal and disposal process. Contaminated soil and structures would be containerized (e.g., drums, burrito wraps, rolloff boxes) and transported to the ERDF, located in the 200 West Area.

After the PRGs are met, uncontaminated soil would be used to backfill the excavation. The backfill material could be found at a variety of sources, including local borrow pits and any remaining excavated material that is determined to be clean (verified as clean by meeting the PRGs). Following remediation, the site will be recontoured, resurfaced, and/or revegetated to establish natural site conditions that are consistent with industrial usage. Maintenance of the site is required until the revegetation species are sufficiently established.

5.2.4 Alternative 4—Barrier

The barrier alternative consists of constructing a surface barrier over the contaminated waste site that is designed to break the exposure pathway preventing human and ecological exposure. Although groundwater has not been shown to be at risk from Z-Ditches contaminants, the barrier will be an ET-type barrier designed to minimize infiltration. Additional elements to the barrier alternative include ICs, discussed earlier, and MNA, which is particularly important for the Z-Ditches that have elevated contamination levels that pose long-term human-health and ecological risks. Grout injection of the remaining 216-Z-20 Tile Field waste distribution piping could be a potential sub-element of this alternative. For the Z-Ditches where the contamination is shallow and long-lived, the barrier alternative would include ICs to prevent future human intrusion.

A Z-Ditches barrier would be designed to ensure contaminant isolation and control infiltration. The ET surface barriers rely on the water-holding capacity of a soil, evaporation from the near-surface, and plant transpiration to control water movement through the barrier. Monolithic and capillary ET barrier designs have been approved or planned for use in several western states (EPA, 2003, *Remediation Technology Descriptions*; DOE/RL-93-33, *Focused Feasibility Study of Engineered Barriers for Waste Management Units in the 200 Areas*) and have been shown to be equivalent to or to exceed the performance of the standard RCRA Subtitle C Barrier design.

Use of a barrier alternative would require an assessment of the lateral extent of contamination during the confirmatory and/or remedial design phases to size the cap properly to prevent exposure and infiltration. The site-specific extent of contamination can be assessed using a variety of approaches including, but not limited to, process knowledge, previous site investigations, geophysical logging, and/or soil sampling. Some degree of oversizing of the barrier beyond the footprint of the waste zone (referred to as overlap) could be necessary to deter lateral infiltration. The overlap is dependent on the barrier design used and the lateral extent of contamination. For the purposes of this FS, an overlap of 6.1 m (20 ft) is assumed based on the performance of an ET barrier. The type and availability of barrier construction materials also are design considerations. The results of the most recent investigation (BHI-01551, *Alternative Fine-Grained Soil Borrow Source Study Final Report*) will be considered during remedial design for selection of the barrier construction materials.

A surveillance and maintenance program will be necessary throughout the barrier life to maintain cap integrity and ensure continued protection. These surveillance and maintenance activities would be a portion of ICs to ensure that the cap is performing as designed. This includes performance monitoring through groundwater and vadose-zone soil monitoring, if practical. This FS assumes robust performance monitoring during the first 5 years after construction, followed by a more focused effort thereafter.

To consider this alternative as protective at the Z-Ditches, the ICs that perform barrier inspections and maintenance must be assumed to continue for the duration of unacceptable site risk. Given the long half-lives of some Z-Ditches contaminants (Am-241 and Pu-239/240), site contamination will not meet RAOs through natural attenuation for thousands of years.

If a barrier is the preferred alternative or a component of the preferred alternative, finalization of barrier design will occur as part of the remedial design process. The final design will be determined in the remedial design phase and will consider RAOs and ROD requirements, performance standards to ensure continued effective waste isolation and infiltration control, lateral extent of contamination, material availability, cost effectiveness, and current surface barrier technology information.

5.2.5 Alternatives 5A and 5B—In Situ Vitrification with Barrier and Removal, Treatment, and Disposal (5A), or In Situ Vitrification with Barrier (5B)

Under Alternatives 5A and 5B, the area of soil anticipated to have the most contamination would undergo ISV treatment, and risk from site contaminants at the remaining less contaminated Z-Ditch locations would be mitigated through removal or placement of a barrier. The ISV treatment would immobilize radionuclide contaminants in Z-Ditches soils at areas with the highest contamination in an impermeable, durable, stable, and non-leachable glass matrix. The glass waste form would mitigate human health direct contact and ecological exposure. ISV would significantly reduce radiation dose potential at the site because most of the radiological exposure at the Z-Ditches is from alpha-emitting radionuclides that are permanently bound in the glass matrix and which provide much less direct radiation dose than the gamma-emitting radionuclides. Further, the ISV convective mixing and the final glass matrix have been demonstrated to reduce exposure from gamma-emitting radionuclides.

Although the waste is treated, exposure potential from the glass matrix will remain at reduced but unspecified concentrations. Consequently, a barrier will be placed over the ISV melts to prevent exposure to the treated glass matrix and to prevent infiltration. In addition, the ISV alternative would require continuing ICs and monitoring for the duration of site risk. ICs would be used to ensure barrier integrity for waste isolation, prevent intrusion, and verify that the immobilization performance requirements are met.

The ISV treatment area would include an area of soil contamination that exists intermittently between the depths of approximately 1.83 and 3.35 m (6 and 11 ft) bgs and for a length of about 274 m (900 ft), centered along the length of the ditches. Beneath some portions of this high contamination zone, fission products, and transuranic contamination continue to a depth of approximately 5.3 m (17.5 ft) bgs. Although individual ISV melts normally are constrained to an effective area of about 12.2 by 12.2 by 6.1 m deep (40 by 40 by 20 ft), testing has shown that multiple melts can be merged to allow effective ISV treatment of wider and longer areas. Consequently, the Z-Ditches contamination is within ISV's demonstrated area of effectiveness, making ISV a potentially viable alternative. This alternative is particularly viable when compared to worker safety considerations and uncertainties associated with excavation.

Once ISV operations are concluded, the resulting matrix would be sampled to verify quality, leachability, and homogeneous mixing of contaminants, along with other performance parameters, especially between and underneath melts to verify complete melting of the contaminated soil. Sampling would be accomplished using techniques similar to those described in LA-UR-03-6494, *IM Completion Report for the NTISV Hot Demonstration at SWMU 21-018(a)-99 (MDA V)*, including use of a hollow-stem auger rig with a diamond-impregnated epoxy coring bit due to the hardness of the glass matrix. Sampling under the melt could be accomplished with conventional slant drilling. Analyses likely would be similar to the radionuclide analyses performed at Los Alamos that would address 200-CW-5 OU COPCs.

As described as follows, for Alternatives 5A and 5B, the ISV technology could be used in combination with other alternatives, such as RTD and barriers, to achieve RAOs. The ISV component of Alternatives 5A and 5B would be the same but the approach for combining alternatives to achieve RAOs and most effectively meet CERCLA criteria will depend on site-specific contaminant conditions and protectiveness requirements.

Alternative 5A would use ISV treatment, at areas of radionuclide contamination above PRGs with a barrier to prevent exposure and infiltration over the ISV melts, in conjunction with RTD of remaining contaminated soil for disposal at ERDF to meet PRGs. The ISV treatment would permanently immobilize the highest risk contaminants in an impermeable, durable, stable, and non-leachable glass matrix that would remain protective during an extended attenuation period. The ISV component would serve to eliminate the higher worker risk and costs associated with removal and disposal of the mass of long-lived, contamination associated with the bottom of the ditches. The RTD component would further reduce overall site risk by removing remaining contaminants above PRGs from the majority of the site. The RTD component would significantly reduce overall site risk by removing contaminants from locations generally containing contaminant concentrations less than PRGs, which represents the majority of the site area. ICs would be required for this alternative because contamination above PRGs, although immobilized, is left on site requiring isolation and intrusion protection.

Alternative 5B includes the same ISV treatment component as Alternative 5A but in combination with a barrier over the entire site to prevent exposure and to limit infiltration. The ISV component of Alternative 5B treats the same areas of contamination above PRGs as Alternative 5A, and protects the site in the same manner and to the same extent, as does the ISV portion of Alternative 5A. The barrier component of Alternative 5B would be similar to the barrier identified for use with other barrier alternatives and would provide the same level of protectiveness, through mitigation of the already reduced direct exposure risk from contaminants remaining in shallow soil. The actual design of the barrier would be determined through the detailed design activities. Although untreated soil with contamination above PRGs would remain in place, the overall contamination levels, and therefore the overall site risk, would be significantly reduced. ICs would be required for this alternative, because contamination remains at the site above PRGs, although immobilized and protectively capped, requiring isolation and intrusion protection.

6 Detailed Analysis of Alternatives

This chapter presents the detailed analysis of the 200-CW-5 OU remedial alternatives described in Chapter 5. The alternatives are evaluated against the first seven of the nine CERCLA evaluation criteria described in the following section to identify if they meet the criteria. As indicated later in this chapter, the last two CERCLA criteria are addressed outside the scope of this FS.

Initially, the term "Z-Ditches" referred to the portions of the 216-Z-1D, 216-Z-11, and 216-Z-19 Ditches that are approximately 838 m (2,749 ft) in length (between the headwall structure and U-Pond). These liquid waste transfer ditches are parallel, side-by-side in immediate proximity, transferred similar waste streams, and sometimes even shared flow paths. These ditches comprise one essentially contiguous, similarly contaminated area for which characterization data, risk information, and alternative cost information exist. As discussed in Chapter 2, the 216-Z-20 Tile Field and UPR-200-W-110 Unplanned Release were assigned to the Z-Ditches based on similar nature and extent of contamination. Consequently, all of the 200-CW-5 OU waste sites, including the 216-Z-20 Tile Field and UPR-200-W-110 Unplanned Release, are considered for remedial action collectively as the Z-Ditches. Substantial economies would be expected to be realized through implementation of a coordinated remedial action for all 200-CW-5 OU waste sites.

The analysis of the alternatives takes into account the nature and extent of the contaminants in the Z-Ditches and considers the assumed land use. Currently, the land use for the Z-Ditches is industrial, as stated in the ROD Amendment for the Hanford Comprehensive Land-Use Plan Environmental Impact Statement (DOE/EIS-0222-F, *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*; DOE/EIS-0222-SA-01, *Supplement Analysis, Hanford Comprehensive Land-Use Plan Environmental Impact Statement*; 73 FR 55824, "Amended Record of Decision for the Hanford Comprehensive Land-Use Plan Environmental Impact Statement"). This land use can be reasonably predicted to be the same for the next 50 years, given DOE's current commitment to vitrify waste in the tank farms, and is assumed to remain industrial for the foreseeable future and for the duration of site risk. The detailed analysis is presented by alternative and the analysis shows how each alternative meets CERCLA criteria for the Z-Ditches.

6.1 Description of Evaluation Criteria

The EPA has developed nine CERCLA evaluation criteria, defined in EPA/540/G-89/004, *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, Interim Final*, OSWER 9355.3-01, to address the statutory requirements and the technical and policy considerations important for selecting remedial alternatives. These criteria serve as the basis for conducting detailed alternative analyses in this chapter and comparative analyses of alternatives later in this FS (Chapter 7) and for subsequent alternative recommendations.

The nine CERCLA evaluation criteria are as follows:

- Overall protection of HHE
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of TMV
- Short-term effectiveness
- Implementability
- Cost

- State acceptance
- Community acceptance

The first two criteria, overall protection of HHE and compliance with ARARs, are threshold criteria. Alternatives that do not protect HHE or those that do not comply with ARARs (or do not justify a waiver) would not meet statutory requirements and are eliminated from further consideration in this FS.

For alternatives that meet threshold criteria, the next five criteria (long-term effectiveness and permanence; reduction of TMV; short-term effectiveness; implementability; and cost) are balancing criteria upon which the remedy selection is based. The CERCLA guidance for conducting an FS lists appropriate questions to be answered when evaluating an alternative against the balancing criteria (EPA/540/G-89/004). The detailed analysis process in this chapter addresses these questions, providing a consistent basis for the evaluation of each alternative.

The final two modifying criteria, state and community acceptance, will be evaluated outside the scope of this FS. The criterion of state acceptance will be addressed in the Proposed Plan. The Proposed Plan will identify the preferred remedy (or remedies) accepted by the Tri-Parties. The criterion of community acceptance will be evaluated following the issuance of the Proposed Plan for public review and comment.

In addition to the CERCLA criteria, NEPA values have been incorporated into this document. Assessment of these considerations is important for the integration of NEPA values into CERCLA documents, as required by DOE, 1994, *Secretarial Policy on the National Environmental Policy Act*, and DOE O 451.1B, *National Environmental Policy Act Compliance Program*. Potential effects on NEPA values also are discussed in this chapter.

6.1.1 Overall Protection of Human Health and the Environment

This threshold criterion determines whether adequate protection of HHE, including preservation of natural systems and biological diversity, is achieved through implementation of the remedial alternative. Protection includes reducing risk to acceptable levels, either by reducing contaminant concentrations or by eliminating potential routes for exposure, and minimizing exposure threats introduced by actions during remediation. Environmental protection includes avoiding or minimizing impacts to natural, cultural, and historical resources. This criterion also evaluates the potential for human health risks, the extent of those risks, and whether a net environmental benefit will result from implementing the remedial alternative.

This criterion is the primary objective of the remedial action program. As indicated in EPA guidance, this criterion, and the criteria for compliance with ARARs, long-term effectiveness and permanence, and short-term effectiveness, overlap (EPA/540/G-89/004). This FS used the CERCLA risk range of 1×10^{-4} to 1×10^{-6} ELCR for human health as the range of protectiveness. An HQ of one or less was applied for nonradionuclides. Alternatives were measured against these standards to determine if the alternative is protective. Ecological compliance was judged using WAC 173-340-900, "Tables," for nonradionuclides and DOE/STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota,* for radionuclides.

Protection of groundwater was measured against groundwater protection standards derived from the MCLs identified in 40 CFR 141, "National Primary Drinking Water Regulations," in fate and transport modeling reported in the RI Report (DOE/RL-2003-11), and Appendix B of this document. The groundwater protection standards are provided for radionuclides, as soil contaminant concentrations that will not result in a groundwater concentration that exceed drinking water MCLs, and for non-radionuclides that will not exceed concentrations calculated using the formulas of WAC 173-340-747.

6.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

The ARARs are any appropriate standards, criteria, or limitations under any federal environmental law or more stringent state requirement that must be either met or waived for any hazardous substance, pollutant, or contaminant that will remain at the site during or after completion of a remedial action. The ARAR identification process is based on CERCLA guidance (EPA/540/2-88/002, *Technological Approaches to Cleanup of Radiologically Contaminated Superfund Site*). Appendix A presents potential federal and state chemical-, location-, and action-specific ARARs associated with remediation of the waste sites. Each alternative is assessed for compliance against these ARARs. When an ARAR cannot be met, the lead agency can request a waiver if a solid basis exists for justifying the waiver. Several of these ARARs address the protection, restoration, or enhancement of fish and wildlife habitat and other natural, cultural, and historical resources.

6.1.3 Long-Term Effectiveness and Permanence

This criterion addresses the results of a remedial action in terms of risks that remain at the site after RAOs are met. The primary focus of this evaluation is the extent and effectiveness of the controls that could be required to manage the risk posed by treatment residuals and/or untreated wastes. The following components of the criterion are considered for each alternative:

- Magnitude of residual risk to human and ecological receptors. This factor assesses the residual risk from untreated waste or treatment residue after remedial activities are completed. The characteristics of the residual waste are considered to the degree that they remain hazardous, taking into account their volume, toxicity, mobility, and propensity to bioaccumulate.
- Adequacy and reliability of controls. This factor assesses the adequacy and suitability of controls used to manage treatment residues or untreated wastes that remain at the site. It also assesses the long-term reliability of management controls for providing continued protection from residues, and it includes an assessment of the potential need to replace the alternative's technical components.

A related consideration is the restoration time required to reestablish sustainable environmental conditions, including wildlife habitat and cultural resources, where appropriate. Residual risk to natural and cultural resources after conclusion of remedial activities also is evaluated. Current environmental conditions are assessed against the alternative's long-term and permanent solutions. The assessment considerations are based on whether lasting environmental losses would be incurred for the sake of short-term cleanup gains, including whether environmental restoration and/or mitigation options would be precluded if a remedial alternative were implemented. As long as contamination remains on the site above levels that would allow for unrestricted use or unlimited exposure, an evaluation of remedy effectiveness is required, at a minimum, every five years.

6.1.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

This criterion addresses the degree to which a remedial alternative reduces the TMV of a hazardous substance. Significant overall reduction can be achieved by destroying toxic contaminants or by reducing total mass, contaminant mobility, or total volume of contaminated media.

This criterion focuses on the following factors for each alternative:

- The treatment processes used and the materials treated
- Whether recycling, reuse, and/or waste minimization are used in the treatment process
- The type and quantity of treatment residuals that remain following treatment, and whether any special treatment actions will be needed

- Whether the alternative satisfies the statutory preference for treatment as a principal element

6.1.5 Short-Term Effectiveness

This criterion evaluates the potential effects on HHE during the construction and implementation phases of a remedial action. This criterion also considers the speed with which an alternative achieves protection. The following factors are considered for each alternative:

- Health and safety of remediation workers and reliability of protective measures taken. Specifically, this involves any risk resulting from implementation, such as fugitive dust, transportation of hazardous materials, or air quality impacts from offgas emissions.
- Physical, biological, and cultural impacts that might result from the construction and implementation of the remedial action, and whether the impacts can be controlled or mitigated.
- The amount of time for the RAOs to be met.

Short-term human health impacts are closely related to the duration of exposure to hazardous waste and the risks associated with waste removal. With greater exposure time, there is greater risk. Guidelines will be followed during implementation of the remedial action to minimize worker risks and to maintain radiation exposures ALARA.

Short-term environmental impacts are related primarily to the extent of physical disturbance of a site and its associated habitat. Risks also can be associated with the potential disturbance of sensitive species (e.g., bald eagles) because of increased human activity in the area.

6.1.6 Implementability

This criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of the required services and materials.

The following factors are considered for each alternative:

- Technical feasibility
  - The likelihood of technical difficulties in constructing and operating the alternative
  - The likelihood of delays because of technical problems
  - Uncertainties related to innovative technologies that could cause failures
- Administrative feasibility
  - Ability to coordinate activities with other offices and agencies
  - Potential for regulatory constraints to develop (e.g., as a result of uncovering buried cultural resources or encountering endangered species)
- Availability of scarce resources, services, and materials
  - Availability of adequate onsite or offsite treatment storage capacity, and disposal services, if necessary
  - Availability of necessary equipment, specialists, and provisions to ensure obtaining any additional resources, if necessary

6.1.7 Cost

This criterion considers the cost of implementing a remedial alternative, including capital costs, operations and maintenance costs, and monitoring costs for the duration of the 1,000-year period of active ICs. The cost evaluation also includes monitoring of any restoration or mitigation measures for natural, cultural, and historical resources. Appendix C presents details of the cost estimates. The input parameters used in these estimates are the best available at this time, but in many cases the data on COPCs, site locations, and site dimensions are somewhat limited, leading to potential uncertainties for all the sites evaluated in this FS. Despite these uncertainties, the cost estimates are of sufficient quality to fulfill the primary objective, which is to aid in selecting preferred remedial alternatives. Appendix C calculated time to complete remediation for the Z-Ditches area in a manner that likely would overestimate the time to complete remediation. Remedial activity timeframes were calculated for each of the Z-Ditches consecutively when, in actuality, site remedial activities at the contiguous Z-Ditches could proceed concurrently.

The cost estimates for the purposes of this study are presented in either FY 2009 constant dollars or present value terms. The present-worth costs assume a 2.8 percent discount rate (based on 2009 Office of Management and Budget information) and assume operations and maintenance for 1,000 years. The cost estimates were prepared from information available at the time of this study. The actual cost of the project will depend on additional information gained during the remedial design phase, the final scope and design of the selected remedial action, the schedule of implementation, the competitive market conditions, and other variables. However, most of these factors are not expected to have a significant effect on the relative cost differences of alternatives.

6.1.8 State Acceptance

This criterion evaluates the technical issues and concerns that Ecology, as the representative of the State of Washington, could have regarding a remedial alternative. This criterion will be addressed prior to signing the ROD.

6.1.9 Community Acceptance

This criterion evaluates the issues and concerns that the public may have regarding a remedial alternative. This criterion will be addressed following public comment on the Proposed Plan.

6.2 Detailed Analysis of Alternatives

This section presents the detailed analysis of the alternatives evaluated under an industrial land use scenario for the Z-Ditches decision unit representing the 200-CW-5 OU waste sites. To the extent practicable and to avoid FS redundancy, where a primary component of an alternative (e.g., barrier or RTD) has undergone detailed analysis against the CERCLA criteria and will be used by another alternative in a substantially similar manner, the earlier detailed analysis will be referenced. Table 6-1, presented at the end of this section, summarizes the detailed analysis of the Z-Ditches alternatives presented in the following subsections.

6.2.1 Detailed Analysis of Alternative 1—No Action

Alternative 1 is retained for detailed analysis of Z-Ditches alternatives as required by CERCLA regulations to provide a baseline description of the effects of taking no action. Although no action is taken under this alternative, it is recognized that natural attenuation, an EPA-recognized process for radionuclides, will occur at all radioactively contaminated sites, regardless of the alternative selected.

As addressed in the following subsections, the No Action Alternative fails the threshold criteria for ecological and human health (without a cover). It also is not protective of a subsistence farmer exposure scenario. Consequently, for the Z-Ditches, the No Action Alternative is screened out as a candidate 200-CW-5 OU alternative.

6.2.1.1 Overall Protection of Human Health and the Environment

For the Z-Ditches, the No Action Alternative would fail to provide overall protection of HHE under CERCLA because contaminants at concentrations result in an ELCR that exceeds the EPA upper target risk threshold of 1 x 10^{-4} for the subsistence farmer exposure scenario. Contaminant concentrations are above the DOE Standard Tier 1 biota concentration guides and ecological soil indicator concentrations when no measures are performed to prevent or mitigate exposure to human or ecological receptors. Therefore, for the Z-Ditches, this alternative fails to meet this criterion under CERCLA.

6.2.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

ARARs can be action-, chemical-, or location-specific. Because no remedial activities would take place under this alternative, action-specific ARARs would not be triggered. No location-specific ARARs have been identified for the waste sites. Chemical-specific ARARs for human health direct contact and ecological protection have been exceeded at the Z-Ditches. Because no action would be taken to control the exposure pathway, this alternative would not meet the ARARs for protection of human health and ecological receptors at the Z-Ditches. ARARs include risk-based concentrations for soil cleanup that, if exceeded, would result in 10^{-4} ELCR from direct contact and food chain exposures under the subsistence farmer scenario. Table 3-2 shows the human health risk for the Z-Ditches exceeds the acceptable risk threshold from the subsistence farmer exposure scenario.

6.2.1.3 Long-Term Effectiveness and Permanence

Long-Term Effectiveness and Permanence for Human Health. For the Z-Ditches, the No Action Alternative fails to provide long-term effectiveness and permanence for human health under the subsistence farmer scenario because contaminant concentrations are above the EPA upper risk threshold of 1 x 10^{-4} and soil concentrations exceed risk-based standards for protection of ecological receptors. For this reason, this alternative fails to meet this criterion under CERCLA.

- *Long-Term Effectiveness and Permanence for Groundwater.* Contaminants are not predicted to reach groundwater at the Z-Ditches. Therefore, Alternative 1 does provide long-term effectiveness for groundwater protection at the Z-Ditches.

- *Long-Term Effectiveness and Permanence for the Environment.* The Z-Ditches sites do not meet the standard for protection of the environment in the 0 to 4.6 m (0 to 15 ft) bgs zone.

6.2.1.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Reduction of TMV would occur at all the waste sites in the form of natural attenuation, which is the natural radioactive decay process. Radioactive decay is the only process currently available to eliminate nuclear particle emissions. Most of the contaminants identified during characterization would be influenced by the radioactive decay process. However, at the Z-Ditches the concentrations of radionuclides with long half-lives (e.g., Pu-239/240 with a half-life of 24,069 years and Am-241 with a half-life of 432 years) are high enough to require thousands of years for the radionuclides to decay to concentrations below PRG levels.

Table 6-1. Summary of 200-CW-5 Operable Unit Alternatives

Criteria	Alternative 1 No Action	Alternative 2 MESC/MNA/ICs	Alternative 3 RTD	Alternative 4 Barrier (Full Site)	Alternative 5A ISV (Work Area 2) with Barrier and RTD (Work Areas 1 and 3)	Alternative 5B ISV (Work Area 2) with Barrier (Full Site)
Threshold Criteria 1: Overall Protectiveness						
Protection of human receptors	Not protective. Source of contamination not removed: ELCR exceeds the EPA upper target risk threshold of 1 x 10^{-4} for the subsistence farmer exposure scenario.	Not protective. Source of contamination not removed. ELCR exceeds the EPA upper target risk threshold of 1 x 10^{-4} for the industrial worker exposure scenario.	Protective. Permanently removes contamination to levels protective of industrial workers.	Protective. Presence of barrier eliminates direct contact exposure pathway.	Protective. ISV reduces risk to industrial workers in Work Area 2 to less than 1 × 10^{-6} and RTD eliminates direct contact pathway at Work Areas 1 and 3.	Protective. ISV reduces risk to industrial workers in Work Area 2 to less than 1 × 10^{-6} and barrier eliminates the direct contact exposure pathway at all work areas.
Protection of ecological receptors	Not protective. Source of contamination not removed. Ecological protection thresholds are exceeded.	Not protective. Source of contamination not removed. Ecological protection thresholds are exceeded.	Protective. Permanently removes contamination to levels protective of ecological receptors.	Protective. Barrier deters intrusion of deep-rooted plants or deep-burrowing animals by eliminating exposure pathway.	Protective. Work Area 2 ISV glass matrix is impermeable to terrestrial receptors. Barrier over ISV breaks the ecological direct contact exposure pathway. RTD permanently removes contamination from Work Areas 1 and 3.	Work Area 2 ISV glass matrix impermeable to wildlife. Full site barrier breaks the ecological direct contact exposure pathway to glass matrix at Work Area 2 and prevents biological and ecological intrusion.
Groundwater Protection	No impact to groundwater identified.	No impact to groundwater identified.	No impact to groundwater identified.	No impact to groundwater identified, and barrier provides infiltration control.	No impact to groundwater identified, and barrier provides infiltration control.	No impacts to groundwater identified, and barrier provides infiltration control.
Threshold Criteria 2: Compliance with ARARS						
Chemical-specific ARAR	COPC concentrations exceed human and ecological protection standards and criteria.	COPC concentrations exceed human and ecological protection standards and criteria.	COPC concentrations removed to levels compliant with human and ecological protection standards and criteria.	Meets criteria.	Meets criteria.	Meets criteria.
Location-specific ARARs	None.	None.	None.	None.	None.	None.
Action-specific ARARs	No action; therefore, no action-specific ARARs.	No action; therefore, no action-specific ARARs.	Meets criteria.	Meets criteria.	Meets criteria.	Meets criteria.
Other criteria and guidance	None.	None.	None.	None.	None.	None.
Balancing Criteria 3: Long Term Effectiveness and Permanence Magnitude of Residual Risk						
Adequacy and reliability of alternative and controls	Not adequate because no controls over remaining contamination.		RTD requires no controls after contaminant removal.	Barrier effective while maintained. ICs for continued maintenance presumed to be viable for the duration of site risk.	RTD requires no controls at Work Areas 1 and 3 after contaminant removal. ISV reliability at Work Area 2 uncertain because ISV not proven on a large scale. Pilot demonstration necessary. Barrier over ISV melts is effective and reliable while maintained. ICs for barrier maintenance presumed viable for the duration of site risk.	ISV reliability at Work Area 2 less certain because ISV not proven on a large scale. Pilot demonstration necessary. Barrier over ISV melts and the entire site is reliable while maintained. ICs for continued maintenance presumed to be viable for the duration of site risk.
Need for 5-year review	Review required because contamination left at the waste site..	Review required because contamination left at the waste site.	Required because contamination remains above levels that would allow for unrestricted use or unlimited exposure.	Required because contamination remains at the waste site.	Required because contamination would remain at the waste site.	Required because contamination would remain at the waste site.

Table 6-1. Summary of 200-CW-5 Operable Unit Alternatives

Criteria	Alternative 1 No Action	Alternative 2 MESC/MNA/ICs	Alternative 3 RTD	Alternative 4 Barrier (Full Site)	Alternative 5A ISV (Work Area 2) with Barrier and RTD (Work Areas 1 and 3)	Alternative 5B ISV (Work Area 2) with Barrier (Full Site)
Balancing Criteria 4: Reduction of Toxicity, Mobility, or Volume Through Treatment						
Treatment process used	None. Only radionuclide natural attenuation.		None required because waste removed.	None. Only radionuclide natural attenuation.	ISV of plutonium above PRG. None required for removed waste.	ISV of plutonium above PRG and radionuclide natural attenuation at barrier.
Amount of soil treated	None.		None.	None.	29,685 m^3 (38,826 yd^3) treated.	29,685 m^3 (38,826 yd^3) treated.
Reduction of toxicity, mobility, or volume of soil	None.		None.	None.	ISV is an immobilization technology.	ISV is an immobilization technology.
Irreversible treatment	None.		None.	None.	ISV not reversible.	ISV not reversible.
Type and quantity of residuals remaining after treatment	N/A		N/A	N/A	Approximately 29,685 m^3 (38,826 yd^3) of vitrified material requiring isolation and intrusion prevention.	Approximately 29,685 m^3 (38,826 yd^3) of vitrified material requiring isolation and intrusion prevention.
Statutory preference for treatment	Does not satisfy.		Does not satisfy.	Does not satisfy.	Satisfies.	Satisfies.
Balancing Criteria 5: Short-Term Effectiveness						
Community protection	No action presents no remedy implementation risk.		Potential for accidental contamination releases during RTD but minimized by distance to potential receptors and mitigation measures.	No potential for contamination release, and general barrier industrial impacts minimized by distance to potential receptors and extensive mitigation measures.	Community protection good because ISV process occurs under hoods with offgas monitoring and control systems to prevent releases. Increased potential for accidental contamination releases during RTD minimized by distance to potential receptors and extensive mitigation measures.	Community protection good because ISV process occurs under hoods with offgas monitoring and control systems to prevent releases. No potential for contamination release, and general barrier industrial impacts minimized by distance to potential receptors and extensive mitigation measures.
Worker protection	No action; therefore, no risk to workers.		Moderate short term risk of radiological direct contact and airborne exposure from RTD of contaminated soils that is low-level waste.	Worker risk limited to industrial risks from barrier construction activities that are readily controllable.	ISV risk moderate for electrical and construction hazards but increases with multiple mobilizations and a long implementation period. High worker risk at RTD Work Areas 1 and 3 would be mitigated by stringent worker safety controls and site contamination controls.	ISV risk moderate for electrical and construction hazards but increases with multiple mobilizations over a long implementation period. Worker risk from barrier construction activities low and is reliably controllable.
Environmental impacts	No action; therefore, no impact.		Moderate environmental risk from accidental releases during RTD. Already-disturbed industrial area with minimal habitat and no sensitive species.	Minimal environmental impact. Barrier construction traffic disturbs surrounding areas but little potential for contaminant releases.	Low potential for releases due to extensive ISV process controls and equipment. Only moderate environmental risk from accidental releases during RTD because already-disturbed industrial area with minimal habitat and absence of sensitive species.	Low potential for releases due to ISV process controls and equipment. Minimal environmental impact from barrier construction that will not disturb contaminated soils or from traffic disturbances of surrounding areas.
Time until action is complete	No time required to implement.		Excavation of contaminated material and ERDF disposal as low-level waste would take 885 work days.	Barrier construction would take 1 year with ICs to continue for the foreseeable future.	ISV of Work Area 2 and RTD of Work Areas 1 and 3 would occur consecutively and take a total of 3 years and 3 months with IC for the foreseeable future.	ISV of Work Area 2 with barrier placement over Work Areas 1 and 3 would occur consecutively and require approximately 4 years with ICs for the foreseeable future.

Table 6-1. Summary of 200-CW-5 Operable Unit Alternatives

Criteria	Alternative 1 No Action	Alternative 2 MESC/MNA/ICs	Alternative 3 RTD	Alternative 4 Barrier (Full Site)	Alternative 5A ISV (Work Area 2) with Barrier and RTD (Work Areas 1 and 3)	Alternative 5B ISV (Work Area 2) with Barrier (Full Site)
Criteria 6: Implementability						
Ability to construct and operate	Technically implementable because no action.		RTD and assumed onsite disposal at ERDF of low-level waste is common and implementable with little uncertainty.	Barrier construction and operation readily implementable and technically feasible.	ISV large-scale implementability uncertain without a pilot project. RTD of low-level waste at Work Areas 1 and 3 is implementable.	ISV large-scale implementability uncertain without a pilot project. Barrier construction and operation readily implementable.
Ease of doing more action if needed	Not applicable – no action.		Additional excavation laterally or to a maximum depth of 4.6 m (15 ft) bgs implementable.	Implementable to expand barrier size during construction.	Technologically feasible to extend the melts laterally. Not implementable to change the monolithic mass once cooled. Additional excavation of Work Areas 1 and 3 to a maximum depth of 4.6 m (15 ft) bgs is implementable.	Technologically feasible to extend the melts laterally. Not implementable to change the monolithic mass once cooled. Implementable to expand barrier size during construction.
Ability to monitor effectiveness	Not applicable because no monitoring.		No monitoring required.	Barrier monitoring implementable and effective in early detection of barrier failure.	Monitoring of soil around the ISV matrix readily implementable and monitoring of the glass matrix likely implementable but uncertain due to newness of ISV. Monitoring of RTD area not required.	Monitoring of soil around the ISV matrix readily implementable and monitoring of the glass matrix likely implementable but uncertain due to newness of ISV. Barrier monitoring implementable and effective in early detection of barrier failures.
Ability to obtain approvals and coordinate with other agencies	No approvals necessary.		Meeting disposal facility (ERDF) waste acceptance criteria implementable. Other agency or facility approvals not required.	No approvals necessary.	No special approvals necessary for ISV. For RTD meeting disposal facility (ERDF or WIPP) waste acceptance criteria, implementable.	No special approvals necessary for ISV. No barrier approvals are necessary.
Availability of services and capacities	No services or capacities required.		Contractor services readily available and ERDF disposal capacity sufficient.	Contractor services readily available.	Availability of ISV construction and operations personnel uncertain. Contractors for RTD and ERDF capacity sufficient.	Availability of ISV construction and operations personnel uncertain. Contractor services readily available.
Availability of equipment, specialists, and materials	None required.		Standard excavation and material-handling equipment and containers available.	Barrier placement equipment, materials, and personnel readily available.	Availability of special ISV treatment and monitoring equipment (possibly multiple sets of probes and hoods), a robust power source, and probe operators uncertain. For RTD of low-level waste at Work Areas 1 and 3, standard excavation and material-handling equipment available.	Availability of special ISV treatment and monitoring equipment (possibly multiple sets of probes and hoods), a robust power source, and probe operators uncertain. Barrier placement equipment, materials, and personnel readily available.
Availability of technologies	None required.		Excavation technology readily available.	Barrier technology readily available.	Sufficient quantity and effectiveness of ISV technology shown for test-scale operations only. Technology will require pilot-scale demonstration. RTD technology for Work Areas 1 and 3 readily available.	Sufficient quantity and effectiveness of ISV technology shown for test-scale operations only. Technology will require pilot-scale demonstration. Barrier technology readily available.
Criteria 7: Cost						
Capital cost ($M)	$0		$60.5	$9.47	$339	$297
Non-discounted costs ($M)	$0		$60.5	$295	$622	$581
Total present-worth cost ($M)	$0		$58.1	$19.6	$318	$287

This page intentionally left blank.

In EPA/540/R-99/009, *Use of Monitored Natural Attenuation at Superfund RCRA Corrective Action and Underground Storage Tank Sites November 1997*, OSWER 9200.4-17P, the EPA acknowledges that natural attenuation can be an appropriate treatment for contaminated soil. Because of uncertainties in the science of natural attenuation processes, the EPA considers source control and performance monitoring to be fundamental components of this remedy. However, the No Action Alternative has no source control or monitoring components; therefore, because of the concentrations and the substantial length of time required for Z-Ditches radionuclides to meet PRGs through natural attenuation, this alternative fails to meet this criterion under CERCLA.

6.2.1.5 Short-Term Effectiveness

No short-term risks to humans would be associated with the No Action Alternative because remedial activities would not be conducted. Risk to other workers near the site is minimal because of protective soil covers and appropriate safety measures for work activities. However, short-term risk for the DOE site worker could exist at the Z-Ditches and this alternative takes no active measures to mitigate this risk beyond natural attenuation. Consequently, the alternative fails to meet the criterion for short-term effectiveness with regard to timely achievement of RAOs.

6.2.1.6 Implementability

The No Action Alternative could be implemented immediately and would not present any technical or administrative problems. Radionuclides at all of the waste sites addressed by this FS are currently undergoing natural attenuation.

6.2.1.7 Cost

The No Action Alternative would involve no implementation costs.

6.2.2 Detailed Analysis of Alternative 2—Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls

Under Alternative 2, existing soil covers and/or barriers would be maintained to prevent direct human and ecological exposure to contaminants remaining at the waste site and to provide protection from intrusion by human and/or biological receptors. This alternative generally is limited to sites where risk will attenuate to below RAOs in a reasonable length of time, usually associated with the 1,000-year period of active ICs, and where infiltration or intrusion controls are not required. Legal and physical barriers also would be used to prevent human access to the site. The existing soil covers and/or barriers break the exposure pathway between human and ecological receptors and the contaminants. Although the risk assessment has not identified unacceptable risk to groundwater at the Z-Ditches, because significant contamination inventory will remain in place, groundwater monitoring is included in this alternative.

The following sections present an analysis of Alternative 2 against the evaluation criteria.

6.2.2.1 Overall Protection of Human Health and the Environment

Current protective measures and existing soil cover would not provide overall protection of HHE because contaminants exceed risk thresholds for soil at depths of 0 to 4.6 m (0 to 15 ft) bgs. Contamination in shallow zone soils will remain, which presents chemical and radiological risk to ecological receptors and to an industrial worker.

The Z-Ditches exceed human health direct contact and ecological PRGs in the 0 to 4.6 m (0 to 15 ft) bgs zone. In addition, the industrial worker exposure scenario for the 200-CW-5 OU analysis performed separately for the three proximate Z-Ditches (216-Z-1D, 216-Z-11, and 216-Z-19) showed that the collective Z-Ditches area poses a threat to human health. Because of the threat posed to both human and ecological receptors, this alternative is not protective of HHE. However, ICs would be in place to prevent unauthorized access and potential exposure.

6.2.2.2 Compliance with Applicable or Relevant and Appropriate Requirements

Under Alternative 2, ARARs would not be met at the Z-Ditches. At the Z-Ditches, soil concentrations from zero to 4.6 m (15 ft) bgs are greater than the industrial worker direct contract PRGs. Thus, each site fails to comply with ARARs in at least one category.

Alternative 2 does not protect ecological receptors and does not meet ARARs. Alternatives that do not protect HHE or do not comply with ARARs would not meet statutory requirements and would be eliminated from further consideration in this FS. Therefore, Alternative 2 has been removed from further consideration or evaluation in this FS.

6.2.3 Detailed Analysis of Alternative 3—RTD

For purposes of remedial alternative development, the Z-Ditches site was divided into three separate work areas (Work Areas 1, 2, and 3) based on varying site contamination conditions along the length of the ditches presenting the potential for different remedies at different locations. Figure 6-1 shows the work areas under Alternative 3, soil and debris (e.g., buried concrete headwall structure) contaminated above PRGs would be removed from the Z-Ditches Work Areas 1, 2, and 3; treated as necessary to meet disposal facility waste acceptance criteria; and transported for disposal to an approved waste disposal facility.

The north portion of the 216-Z-1D Ditch, which was replaced by process sewer piping in 1949 (as described in Section 2.1.2.1), is believed to meet PRGs for industrial use, ecological receptors, and protection of groundwater, based on existing sampling data and process knowledge. It is assumed that no remedial action is required for the north portion of the 216-Z-1D Ditch. The north portion is assumed to contribute zero area or volume requiring active remediation. Thus, no costs are associated with implementation of the remedy. Sampling will be conducted to confirm this assumption.

Figure 6-2 shows the plutonium and americium contaminated soil expected to require removal at all three work areas. Under the RTD alternative, excavation would take place up to 4.6 m (15 ft) bgs. Figure 6-2 also shows the approximate locations of two cesium and radium exceedances. One location is at the end of the Z-Ditches and the other location is near 16th Street. These radionuclides reside in the same locations as the plutonium and americium contaminated soil and would be removed at the same time. Finally, it should be noted that that the plutonium "outliers' discussed in Sections 2.5 and 3.3 of this FS have been included on Figure 6-2.

Alternative 3 assumes that all radiologically contaminated soil would be disposed onsite at ERDF as low-level waste. This assumption is based on the use of standard excavation techniques and is also based on uncertainty associated with characterization data could have overestimated the level of contamination. Based on the Z-Ditches characterization data, soils are not anticipated to require treatment before disposal at ERDF.

This alternative generally provides a high degree of overall protection of HHE, because contaminants are removed to meet PRGs, and no unacceptable risks would remain at the Z-Ditches. Verification sampling would be conducted to determine that PRGs are met by the removal activities. Because contaminants above PRGs would be removed from the site and placed in an approved disposal facility, failure of this alternative is not likely. Risk associated with the failure of the disposal facility (i.e., ERDF) is not evaluated in this section, but instead is evaluated in disposal facility documents, including ERDF authorization basis documents.

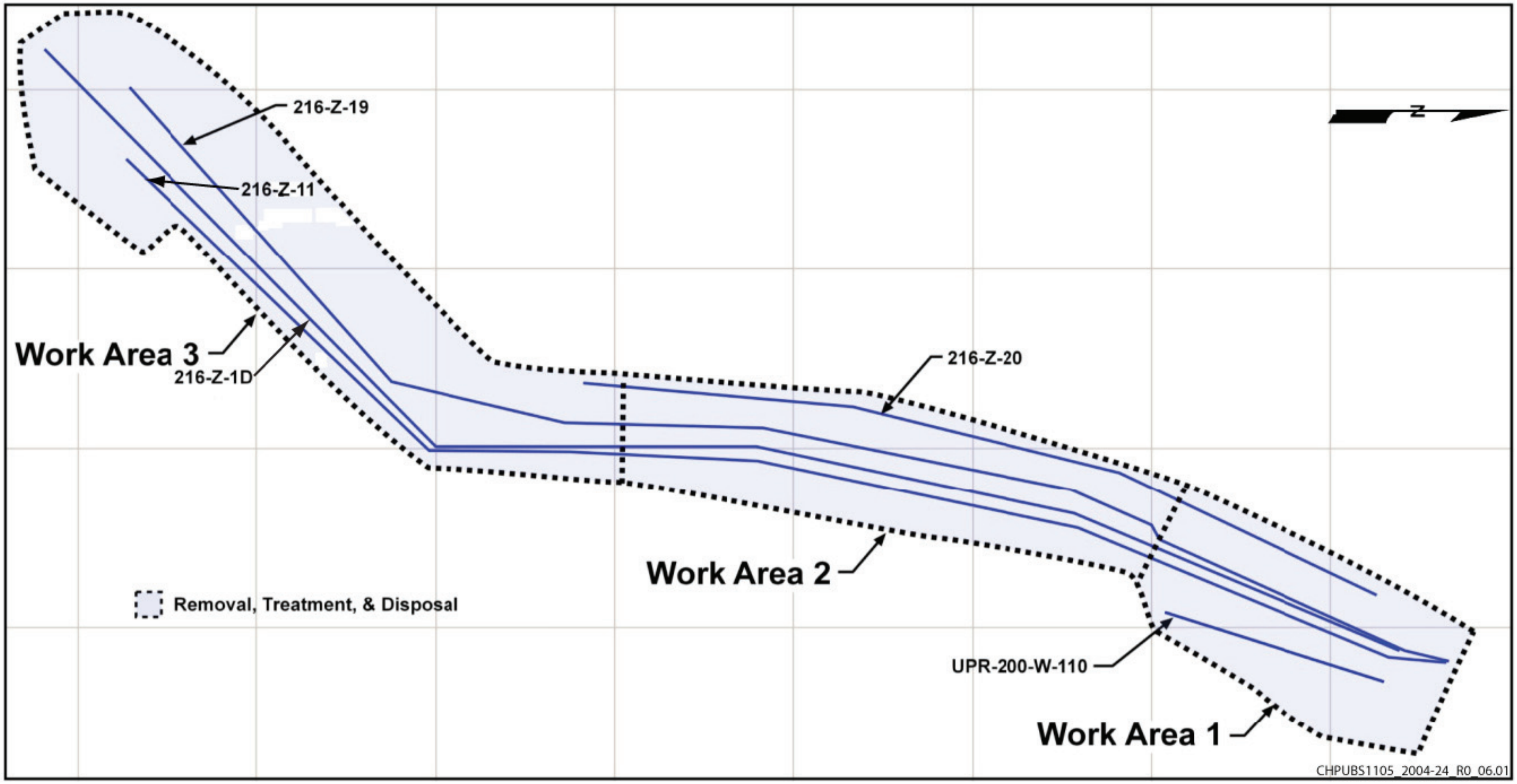


Figure 6-1. Generalized Site Configuration Under Alternative 3

The following subsections present a detailed analysis of Alternative 3 against CERCLA evaluation criteria.

6.2.3.1 Overall Protection of Human Health and the Environment

Because this alternative removes contaminants that are above PRGs, it provides overall protection of HHE in all cases. Risk analysis of the Z-Ditches area showed that contamination above PRGs occurs only in the shallow zone (0 to 4.6 m [0 to 15 ft] bgs). At the deepest point, contaminants would require removal to a depth of approximately 4 m (13 ft) bgs to eliminate potential risk to human and ecological receptors.

6.2.3.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 3 would comply with chemical-specific ARARs by removing soil and structures that exceed PRGs. Removal of all contaminants would achieve the chemical-specific ARARs discussed in Section 6.1.2 for protection of human health and ecological receptors. Action-specific ARARs, such as worker, public, and environmental exposure standards, may be exceeded under this alternative during implementation unless proper precautions are taken. Other action-specific ARARs that could be pertinent to Alternative 3 are Washington State solid and dangerous waste regulations (for management of characterization and remediation wastes and performance standards for waste left in place), *Atomic Energy Act of 1954* regulations (for performance standards for radioactive waste sites), and federal and state regulations related to air emissions. It is anticipated that these ARARs could be met. No location-specific ARARs have been identified for the waste sites addressed in this FS.

6.2.3.3 Long-Term Effectiveness and Permanence

The following sections describe the long-term effectiveness and permanence of Alternative 3 regarding HHE and groundwater protection.

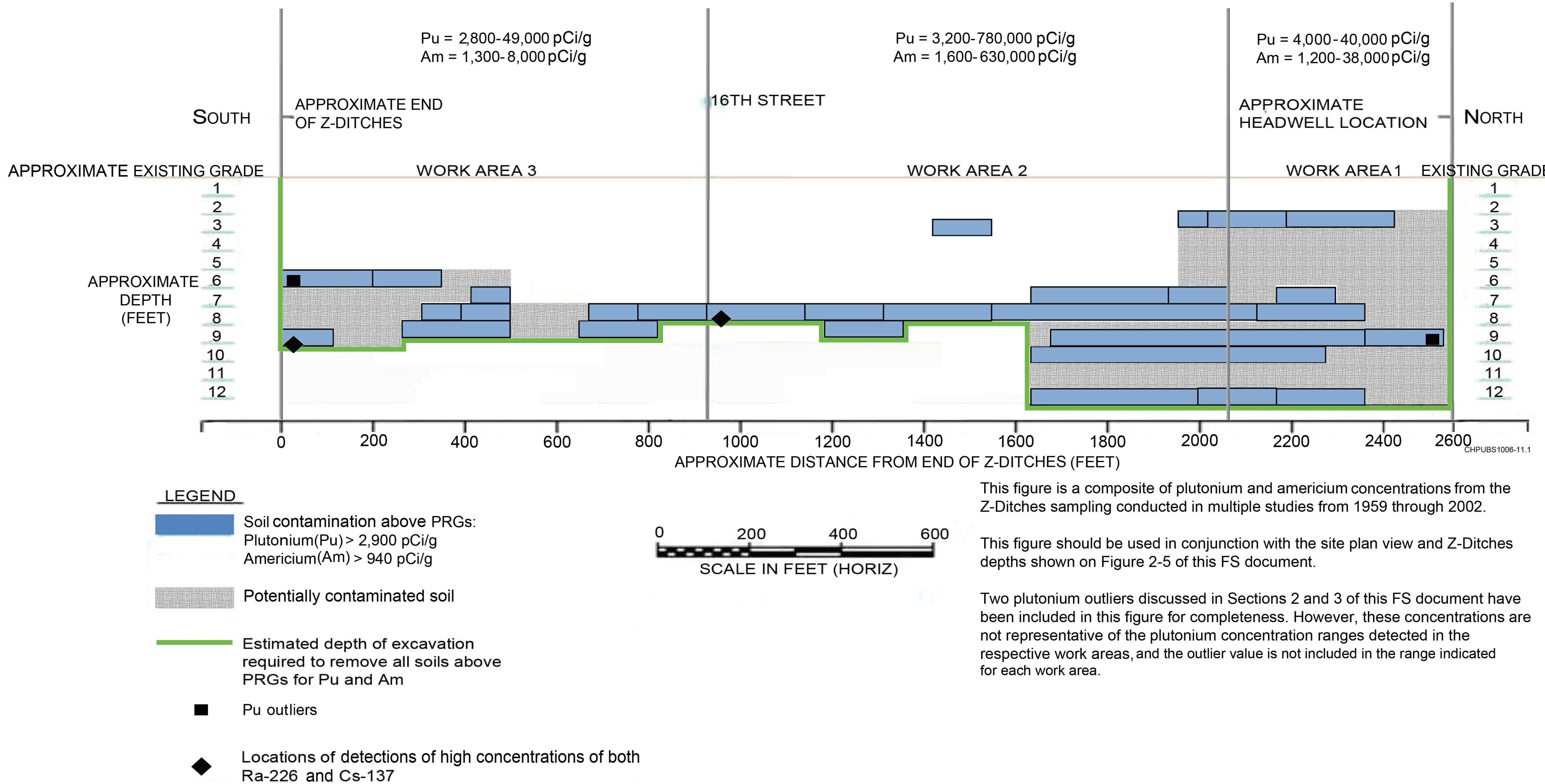
Human Health. With regard to human health, Alternative 3 would be effective and permanent in the long term for all the Z-Ditches because excavation activities would permanently remove contaminants to levels that meet human health RAOs. This alternative provides a permanent solution to the maximum extent practicable. No controls would be required that have potential to fail. All of the waste would remain onsite at ERDF. This action would transfer the long-term impact of the waste from the Z-Ditches to the disposal facility, which is designed for long-term management of buried waste.

Groundwater Protection. Because no risks to groundwater have been identified from the 200-CW-5 OU waste sites, evaluation of Alternative 3 for groundwater protectiveness is not required.

The Environment. Alternative 3 removes all contaminated Z-Ditches soil in the 0 to 4.6 m (0 to 15 ft) bgs zone to PRGs and therefore would be effective and permanent with respect to the environment and ecological receptors. Excavation and transportation of waste and structures would disturb areas beyond the waste site boundaries during the implementation period. These areas would be revegetated after disturbance, which would include control of intrusion by non-native, noxious plants until the new vegetation is established. Clean excavation material would be stockpiled for use in backfilling excavations. Additional backfill material would be obtained from existing soil borrow areas. However, any impact to the environment from borrow pit operations would be minimal.

6.2.3.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

This RTD alternative could include treatment of the removed waste to the extent necessary to meet disposal facility waste acceptance criteria, however, this is not anticipated to be required.



This figure is a composite of plutonium and americium concentrations from the Z-Ditches sampling conducted in multiple studies from 1959 through 2002.

This figure should be used in conjunction with the site plan view and Z-Ditches depths shown on Figure 2-5 of this FS document.

Two plutonium outliers discussed in Sections 2 and 3 of this FS document have been included in this figure for completeness. However, these concentrations are not representative of the plutonium concentration ranges detected in the respective work areas, and the outlier value is not included in the range indicated for each work area.

Figure 6-2. Cross Section of Z-Ditches Soil Contamination and Work Areas

This page intentionally left blank.

6.2.3.5 Short-Term Effectiveness

Under Alternative 3, waste generated during excavation of even the most contaminated Z-Ditches soil is assumed to be low-level waste that can be disposed onsite at ERDF. Short-term effects of this alternative are primarily associated with worker safety during excavation of soil and structures and waste transportation and disposal. Onsite disposal of low-level waste at ERDF provides less worker risk than offsite disposal. However, because excavation of highly contaminated Z-Ditches soil still poses a threat to workers, stringent work control measures remain important where radiological worker and environmental risks are potentially high. Unprotected workers would present a potential unacceptable risk because of the potentially high concentrations at the Z-Ditches of long-lived americium and plutonium isotopes.

Consequently, only qualified workers using appropriate safety precautions would conduct Alternative 3 excavation activities. Lessons learned from other Hanford Site excavations show that worker risk can be greatly reduced during excavation of highly contaminated soil through enhanced excavation techniques and stringent safety measures. Shielded excavation equipment for these wastes could be employed to reduce worker dose. Worker protections also could include filtered breathing air and use of water spray for dust suppression.

Impact to Environment During Remediation. Physical disruption of the waste sites during Alternative 3 excavation, increased human activity, and noise, in addition to the generation of fugitive dust, affect local biological resources. However, the waste sites are located in historically disturbed industrial areas. Potential animal intrusion and biological uptake are additional issues that will require control of open excavations and exposed contaminated soils at the end of each day. This control could be accomplished through placement of covers or fixatives. Not only are digging animals a concern, but in open trenches where cellulose was used to control dust and other airborne releases, insects such as fruit flies represent a further pathway to spread contamination. These are documented pathways at the Hanford Site. The surface area disturbed during excavation of the Z-Ditches will be 3 ha (7.4 ac). It is assumed that an additional 0.6 ha (1.5 ac) will be disturbed from activities such as staging construction activities and stockpiling clean soil, for a total disturbed area of approximately 4 ha (9.8 ac). Currently, there are no obstructions surrounding the Z-Ditches to hinder this alternative.

Transportation activities on the Central Plateau would increase as a result of bringing construction equipment to the site, transporting contaminated soils to ERDF, and bringing clean fill to the excavated sites. Because the Z-Ditches and ERDF are located within 3 km (1.8 mi.), minimal potential risk is associated with the transport of waste. These actions would cause short-term impacts. Air monitoring around the waste sites would be used to monitor potential air releases (e.g., waste or fill-material particulates) that could affect the public and the environment.

Time to Achieve the Remedial Action Objectives. Alternative 3 prevents risk to human and ecological receptors at the Z-Ditches by moving the source to an engineered disposal facility. Construction and waste excavation activities for the Z-Ditches would be expected to require approximately 885 working days to complete. Appendix C shows the timeframe used and assumes two hydraulic excavators are used, operations are conducted 40 hours per week, and ERDF would be accepting approximately 161 m^3 (211 yd^3) of waste per day from the 200-CW-5 OU remedial action. Once completed, all long-term RAOs will be met (e.g., reducing risk to human health and ecological receptors). Short-term concerns, which include preventing or reducing occupational health risks and minimizing the general disruption of wildlife habitat, will be addressed during the remedial action.

6.2.3.6 Implementability

The technology necessary to excavate low-level waste is proven and implementable. Equipment and qualified operators to perform this relatively shallow excavation [less than 4.6 m (15 ft) bgs] are readily available. Because of high radiological contamination levels, significant pre-job safety analysis would be required before implementation. Any aboveground or belowground structures (e.g., vent pipes and concrete structures) would be removed along with the waste site soil covers and contaminated soils. As a worker safety measure, every 0.3 m (1 ft) of excavation would require 0.46 m (1.5 ft) of side slope for a 1:1.5 vertical to horizontal ratio that significantly increases the amount of material excavated but is considered implementable.

To remove soils contaminated above the PRGs, the Z-Ditches excavation at some locations could be advanced up to a depth of up to 4.6 m (15 ft) bgs. To remove the COPCs at this group, approximately 143,000 m^3 (187,000 yd^3) of soil would have to be removed as waste and all would be disposed onsite at ERDF. The remaining capacity of ERDF as of February 6, 2004, was 7.65 million m^3 (10,000,000 yd^3), and disposal of this quantity of waste at ERDF is considered implementable. Disposal of low-level waste at ERDF is much more implementable than offsite disposal.

This alternative is administratively feasible because as a CERCLA action, coordination with other offices is minimal. Although CERCLA actions must meet the substantive ARAR requirements for onsite CERCLA actions (40 CFR 300.415[j]), site actions are exempted from obtaining federal, state, and local permits (CERCLA, Section 121 [e][l]). Further, cultural resources or endangered species are not present at the Z-Ditches that could present regulatory restraints or delays during the activities.

6.2.3.7 Cost

Table 6-1 summarizes the cost to implement Alternative 3 for the Z-Ditches; Appendix C provides details about the cost estimate. For the Z-Ditches excavation and disposal at ERDF, the present-worth cost is $58.1 ($60.5 non-discounted) million. Alternative 3 assumes that WIPP waste will not be generated in any significant quantities. Alternative costs include mobilizing personnel and equipment; monitoring, sampling, and analysis; excavating; disposing of the waste at ERDF; backfilling with Hanford Site resources and additional backfilling from a local stockpile; revegetating; and performing prime contractor oversight. Costs are based on the use of standard excavation equipment (e.g., hydraulic excavators, front-end loaders, tractor-trailers). The costs are based on the assumption that a subcontractor would do the work, with oversight performed by prime contractor personnel.

6.2.4 Detailed Analysis of Alternative 4—Barrier

Figure 6-3 depicts how Alternative 4 would place a barrier on the Z-Ditches to limit industrial worker and ecological direct contact exposure. The Z-Ditches COPCs are immobile, and groundwater risk was not identified. However, because of the long half-life of plutonium, infiltration prevention will be a barrier design consideration. Plutonium above PRGs is present at the central portion of the site (Work Area 2), and remaining site locations (Work Areas 1 and 3) also contain concentrations of long-lived radionuclides above PRGs. The barrier design primarily would be used to prevent human and ecological direct contact exposure. This barrier would not render site contamination inaccessible for future remedial action as technologies evolve that could alter remedial decision-making.

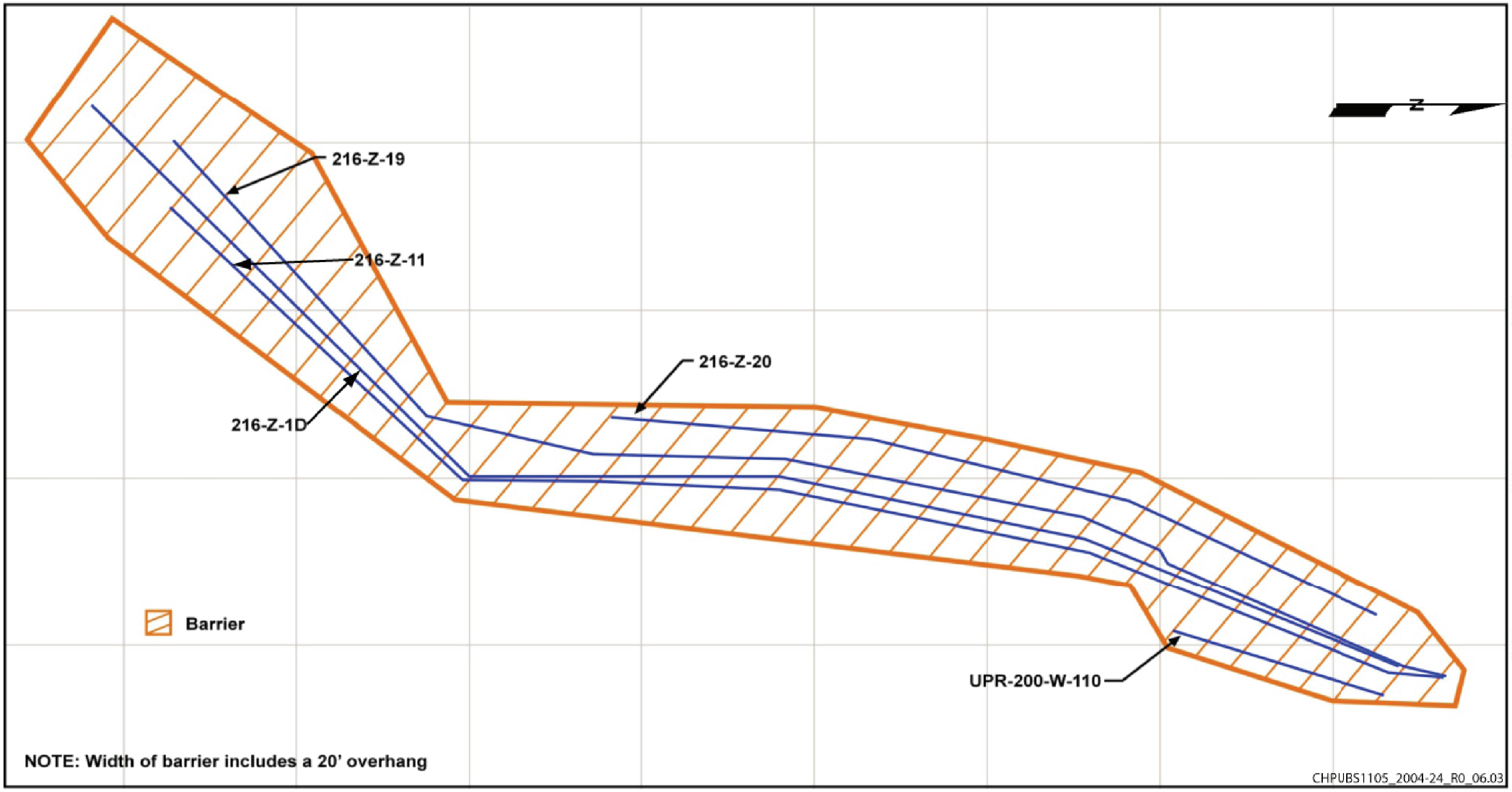


Figure 6-3. Generalized Site Configuration Under Alternative 4

The ARARs and technical guidance do not provide specific performance or technical standards for the design life of a barrier over material having radionuclides at levels similar to those that would meet NRC Class C low-level waste. However, 10 CFR 61.52, “Land Disposal Facility Operation and Disposal Site Closure,” suggests the top of the Class C low-level waste should be approximately 5 m (16 ft) below the surface, or that intrusion barriers should be designed to protect against inadvertent intrusion for at least 500 years. In addition, the barrier is planned to ensure that contamination above cleanup levels is at least 4.6 m (15 ft) below the barrier surface in accordance with WAC 173-340-7490(4)(b), “Standard Point of Compliance.” The noncontaminated soil covers over the waste sites would be incorporated into the barrier design to maximize use of existing clean cover and minimize the cost of materials and impact to visual aesthetics. The ICs will protect against inadvertent human intrusion for the duration of site risk.

The overlying ET layer will retain moisture in the upper level and inhibit moisture infiltration into the contamination zone. This lack of moisture should effectively discourage root penetration past the layer.

Institutional controls, including land use and site access restrictions to prevent intrusion, would be instituted at barrier sites until the RAOs are achieved through natural attenuation. Operations and maintenance would provide vadose zone monitoring for remedy performance and a means of identifying potential impacts to groundwater, which currently are not expected. Groundwater monitoring would be coordinated with monitoring at the appropriate groundwater OU.

The north portion of the 216-Z-1D Ditch, which was replaced by process sewer piping in 1949 (as described in Section 2.1.2.1), is believed to meet PRGs for industrial use, ecological receptors, and protection of groundwater based on existing sampling data and process knowledge. It is assumed that no remedial action is required for the north portion of the 216-Z-1D Ditch. The north portion is assumed to contribute zero area requiring active remediation, and thus no costs are associated with implementation of the remedy. Sampling will be conducted to confirm this assumption.

The following sections present a detailed analysis of the ET barrier as Alternative 4 against the evaluation criteria.

6.2.4.1 Overall Protection of Human Health and the Environment

This alternative would be protective of HHE because the barrier system would isolate contaminants and eliminate the direct contact exposure pathway for human and ecological receptors. A barrier system would provide additional distance between potential human and ecological receptors above and beyond the existing soil covers over the waste sites. The barrier alternative would include ICs to ensure barrier integrity, limit access to prevent intrusion into the contamination zone, and monitor performance to ensure continued protectiveness.

6.2.4.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 4 would comply with all ARARs for the waste sites by eliminating the direct contact exposure pathway for human and ecological receptors by emplacing a protective barrier. In addition to the barrier, ICs such as additional land use restrictions and groundwater monitoring are elements of this alternative to ensure continued protectiveness.

6.2.4.3 Long-Term Effectiveness and Permanence

The following sections identify the long-term effectiveness and permanence of Alternative 4 regarding HHE and groundwater protection.

Human Health. The barrier alternative would be protective of HHE by eliminating the direct contact exposure pathway. Chemicals and radionuclides left in place at the waste sites would be physically isolated from receptors by the existing soil covers and the barrier. Contaminants at the Z-Ditches waste site have no impact to groundwater. However, the barrier would be designed to limit infiltration.

The 5-year reviews required for sites with contaminants above PRGs would serve to monitor the effectiveness and reliability of the barriers, and adjustments and maintenance activities could be instituted to help prevent failure. Continued site management, in the form of ICs (e.g., deed restrictions, fencing, signage, monitoring of groundwater) as a required component of this alternative, would ensure continued protectiveness.

Groundwater Protection. Alternative 4 is protective of groundwater because no impact to groundwater from the Z-Ditches was identified.

The Environment. This alternative would provide protection to the environment by placing a barrier between the waste and the surface flora and fauna as mentioned previously. The barrier is protective of ecological receptors by eliminating the direct contact exposure pathway. However, the barrier and ICs would be designed to prevent the intrusion of deep-rooted plants and burrowing animals.

6.2.4.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative 4 has no engineered treatment component to reduce TMV. The barrier alternative would prevent direct contact exposure, while natural attenuation through radioactive decay reduces radioactivity levels. Natural attenuation would greatly reduce the concentrations and, therefore, the toxicity and volume of the shorter-lived cesium and strontium during the design life of the barrier. Over a much longer time period, the barrier also would keep the site protective as the toxicity and volume of the longer-lived plutonium and americium are reduced through natural attenuation.

6.2.4.5 Short-Term Effectiveness

For Alternative 4, only minimal short-term risks are expected and primarily would be associated with general construction activities at the borrow sites and placement of the barrier. Workers that are qualified (i.e., have the appropriate training and experience) and use appropriate safety precautions would conduct these activities. Risks to workers for this alternative were compared to the baseline No Action Alternative. The barrier alternative would not require excavation of contaminated soils, and buried structures (e.g., buried concrete headwall structures) are not expected that would require removal to prevent subsidence and so would minimize worker risk from exposure to contaminated material. Worker risk would be controlled through adherence to site health and safety procedures. Air monitoring would help identify potential air releases (e.g., barrier-material particulates) that could affect the public during construction of the surface barriers.

Impact to Environment During Remediation. Physical disruption of the waste sites during barrier construction, increased human activity and noise, and the generation of fugitive dust affect local biological resources and could disrupt wildlife. However, the waste sites are located in historically disturbed industrial areas already disturbed by earlier facility operations and in areas adjacent to ongoing facility operations. As such, short-term impacts to vegetation and animals at these sites would be low because these sites currently have poor wildlife habitats.

Time to Achieve the Remedial Action Objectives. Appendix C shows the time to complete design, construction, and support activities under Alternative 4. These activities could require approximately 273 field work days to complete.

6.2.4.6 Implementability

No cultural resources or endangered species exist at the site that invoke regulations that could cause accommodation delays.

Construction of the barrier would follow standard procedures that have been thoroughly field tested at the Hanford Site. The barriers likely would require repair and possibly replacement sometime during the operational timeframe. Monitoring the continued integrity of the barriers would be accomplished through visual inspection and would be supplemented with groundwater sampling. Implementation of the barrier alternative would require additional design data (e.g., GPR) and possibly confirmatory sampling, if required to supplement existing data in determining the lateral extent (overhang) of the barrier.

Barrier construction requires only standard construction materials that are readily available. Gravel, sand, and silt/loam soil used for the barriers would be transported from borrow areas located on or near the Hanford Site. Construction workers primarily would be associated with operating heavy earth-moving equipment and truck drivers and qualified workers would be readily available. Appendix C identifies the anticipated volumes of these materials. Borrow locations are being evaluated for the large silt volume necessary for construction.

Analyses of an appropriate borrow area for silt/loam soil will be the subject of a future evaluation that will include consideration of natural and cultural resources. Obtaining sufficient barrier material, especially for a multilayered barrier, could affect areas of ecological significance and is a consideration in evaluating the relative risk reduction gained by installing the barrier.

6.2.4.7 Cost

The present-worth cost to implement the ET barrier as Alternative 4 for the Z-Ditches is $19.6 ($295 non-discounted) million. Costs include stabilization of the existing site; excavation or import, transportation, and placement of barrier material; compaction of the barrier; prime contractor oversight; and confirmatory sampling. Costs are based on the use of standard equipment (e.g., hydraulic excavators, front-end loaders, dozers) and assume that a subcontractor would do the work, with oversight performed by the prime contractor. The operations and maintenance costs include site inspection/surveillance, periodic radiation site surveys of surface soil, monitoring of site vadose zone soils, biotic control, maintenance of signs and markers, cover maintenance, and site reviews. The cost of long term monitoring of contaminated groundwater, in the 200 West Area by the 200-UP-1 and 200-ZP-1 Groundwater OUs, is apportioned among the contributing source OUs, and the 200-CW-5 OU portion of this cost is included in the cost estimate for this alternative.

6.2.5 Detailed Analysis of Alternative 5A—In Situ Vitrification with Barrier and Removal, Treatment, and Disposal

Alternative 5A includes the removal of contaminated soil in Work Areas 1 and 3 to below PRGs and treatment of the most contaminated soil at Work Area 2 with an ISV process. Figure 6-4 depicts site configuration under Alternative 5A.

The analysis for the RTD component of this alternative is the same as the analysis for Alternative 5A, which also would remove soil with contaminants above PRGs from Work Areas 1 and 3. The excavation would be filled with borrow material obtained on the Hanford Site. This alternative is applicable to the Z-Ditches because of the high concentration of plutonium and americium and because the Z-Ditches configuration is shallow and narrow, which suits the ISV treatment process.

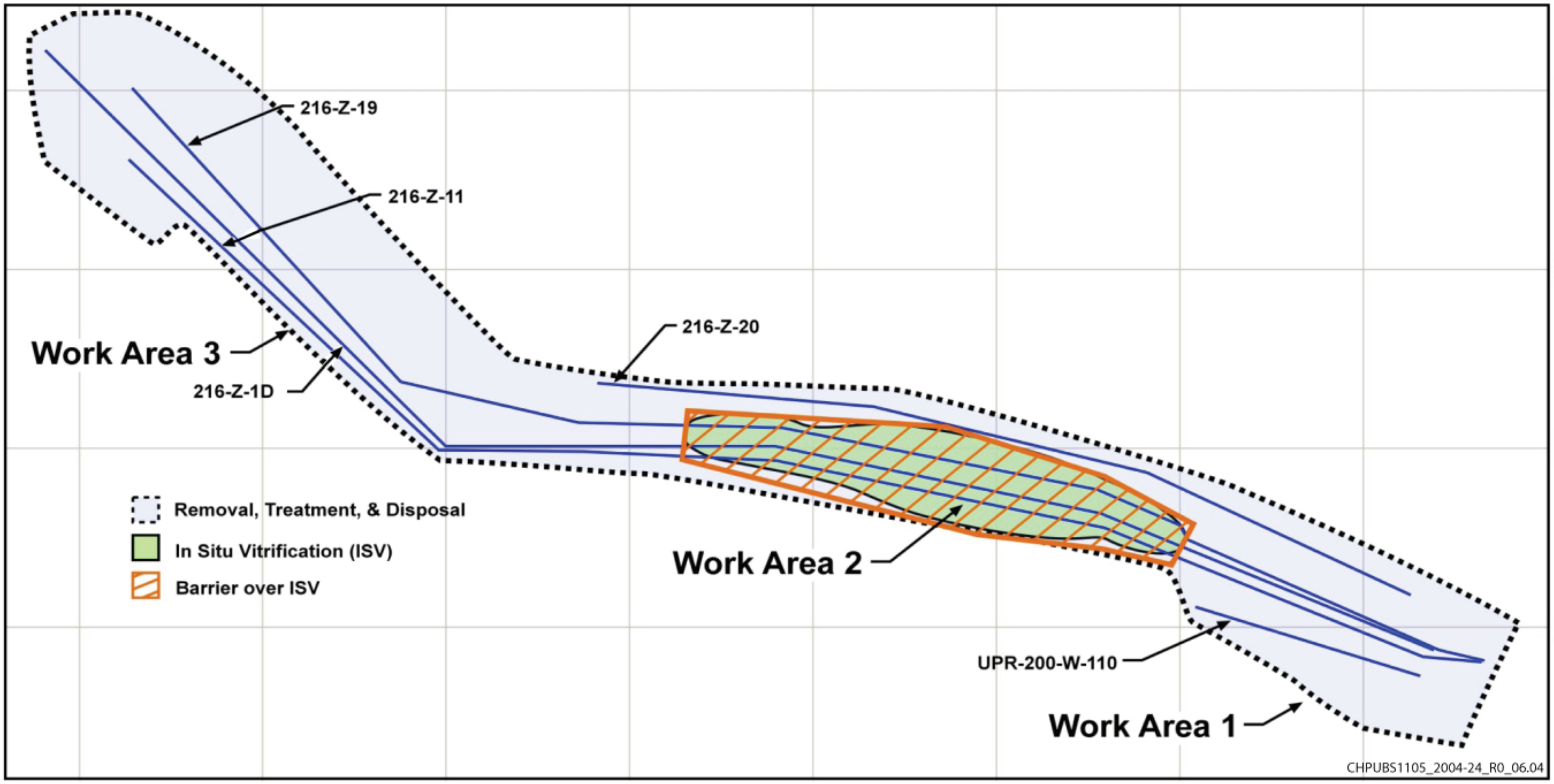


Figure 6-4. Generalized Site Configuration Under Alternative 5A

As described in Chapter 4, ISV applies an electrical current to melt contaminated soil and forms a vitrified mass that is stable and impermeable with low contaminant leachability when cooled. Tests and natural analogs have shown vitrified waste to have the long-term stability required for sites having long-lived radionuclide contamination. The stable mass chemically incorporates most inorganics (including heavy metals and radionuclides) and destroys or removes all organic contaminants. Convective mixing that occurs during the molten phase of vitrification will cause contaminant homogeneity throughout the melt matrix. Although ISV primarily is an immobilization treatment process, it also can reduce contaminant volume, accounting for 20 to 50 percent soil mass reduction. Subsidence would occur and be filled with clean material.

To prevent human and ecological direct contact exposure, a barrier similar to that in Alternative 4 would be placed over the ISV melt area as a component of this alternative. Alternative 5A would include continuing ICs and monitoring to ensure barrier integrity and performance and to prevent intrusion.

The north portion of the 216-Z-1D Ditch, which was replaced by process sewer piping in 1949 (as described in Section 2.1.2.1), is believed to meet PRGs for industrial use, ecological receptors, and protection of groundwater based on existing sampling data and process knowledge. It is assumed that no remedial action is required for the north portion of the 216-Z-1D Ditch. The north portion is assumed to contribute zero area or volume requiring active remediation. Thus, no costs are associated with implementation of the remedy. Sampling will be conducted to confirm this assumption.

The following sections present a detailed analysis of Alternative 5A against the evaluation criteria.

6.2.5.1 Overall Protection of Human Health and the Environment

Alternative 5A is considered protective of HHE and will meet RAOs for the Z-Ditches because it permanently treats the most contaminated Z-Ditch soils in place and removes contaminants to below PRGs from the remaining areas of the site. An ISV process will be used to immobilize the highest concentration alpha and gamma-emitting contaminants at Work Area 2 by binding them in a non-leachable glass matrix that also will prevent any unanticipated migration. Sampling would be performed to verify that the final waste form meets design specifications. Because the treated waste remains on the waste site, a barrier similar to that used for Alternative 4 will be placed over the ISV melt that permanently eliminates the direct contact exposure pathway and prevents infiltration until RAOs are reached in the glass matrix through natural attenuation. ICs at the ISV melt location could be required, and would include maintenance of a protective cover, land use restrictions to prevent intrusion, and monitoring. The RTD component removes the contaminants to below PRGs at Work Areas 1 and 3.

Alternative 5A generally provides an elevated degree of overall protection of HHE, because shallow-zone contaminant concentrations above the PRGs are removed and alpha and gamma-emitting contaminants in the highest area of contamination are permanently immobilized. In addition, the barrier eliminates the direct contact exposure pathway to human and ecological receptors and prevents infiltration into the contamination zone. However, of the alternatives considered in this FS, ISV is considered an innovative technology and is not technically proven for large-scale application and therefore has the greatest level of technical uncertainty.

The detailed analysis of HHE protectiveness for the Alternative 5A RTD component is the same analysis as for Alternative 3, which provides for RTD of the same locations to the same lateral and vertical extent.

6.2.5.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 5A complies with ARARs by significantly reducing site risk through ISV treatment of soil contaminated with plutonium above PRGs at Work Area 2 (which immobilizes the contaminants). Placement of a barrier over the ISV melts eliminates the direct contact exposure pathway. RTD at Work

Areas 1 and 3 permanently removes the contamination present at concentrations above PRGs. ICs associated with this alternative, including land use restrictions, will be instituted to prevent unauthorized access for the duration of site risk and will provide for continued groundwater monitoring. The Alternative 5A RTD component would comply with ARARs by removing contaminants to below PRGs at Work Areas 1 and 3 in the same manner as described for Alternative 3.

6.2.5.3 Long-Term Effectiveness and Permanence

The following sections describe the long-term effectiveness and permanence of Alternative 5A regarding HHE and groundwater protection.

Human Health. With regard to human health, Alternative 5A would be effective and permanent in the long term because ISV treatment permanently immobilizes contaminants in the glass matrix. To be effective in the long term, a barrier is assumed necessary after implementation of the alternative to eliminate the direct contact exposure pathway to the treated glass matrix and to prevent infiltration until radionuclide PRGs are met through natural attenuation.

Groundwater Protection. Alternative 5A is protective of groundwater because no impact to groundwater from the Z-Ditches was identified.

The Environment. Alternative 5A would protect the environment at Work Area 2 because ISV would permanently immobilize the contamination into a stable and impermeable glass matrix resulting in a low contaminant- leaching potential. Because of the hardness of the glass matrix, penetration by burrowing animals is not anticipated. Alternative 5A would further protect the environment by placing a barrier between the glass waste matrix and the surface flora and fauna to prevent direct contact exposure. ICs would be instituted to prevent the intrusion of deep-rooted plants and burrowing animals on the barrier.

6.2.5.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative 5A ISV is a treatment that permanently reduces contaminant mobility but to a limited degree can also reduce contaminant volume and toxicity. ISV meets the statutory preference for treatment over other less permanent waste management approaches. This alternative will immobilize contaminants in a stable and impermeable glass matrix with low contaminant leaching potential until RAOs are met through natural attenuation. ISV reduces contaminated soil volume during the vitrification process by approximately 20 to 50 percent (EPA/540/R-94/520, *Geosafe Corporation In Situ Vitrification, Innovative Technology Evaluation Report*). The barrier over the glass matrix will accommodate natural attenuation by breaking human and ecological direct contact exposure pathways during the extended natural attenuation period.

The Alternative 5A RTD component does not provide for reduction of TMV but addresses toxicity, mobility, and volume of contaminants at the site through contaminant removal.

6.2.5.5 Short-Term Effectiveness

Qualified workers using appropriate safety precautions would conduct Alternative 5A RTD and ISV (with barrier placement) activities. For Alternative 5A, short-term risks from the ISV component are expected to be moderate. The potential risks to workers from the ISV component primarily would be associated with ISV construction activities. These activities include installation and operations of high-voltage electrical lines and equipment; installation and operations of the thermally and electrically hot ISV melt probes; installation and operation of off-gas collection hoods over the melts; and transportation of make-up soil from borrow sites and soil placement over the melt locations to address subsidence and volume reduction. Worker risk would be controlled through adherence to site health and safety procedures. An offgas treatment system would be in continuous operation during ISV operations to collect, treat, and analyze airborne contaminants having a potential to impact workers before release to the environment. Air monitoring around the gas hood and treated air release points also would mitigate potential air releases that could affect workers or the public during ISV operations. Short-term risks from Alternative 5A barrier placement are associated with general construction activities such as soil addition or barrier construction. These potential risks are considered minimal and would be further minimized by the use of qualified workers using appropriate safety precautions.

Short-term effects of Alternative 5A would be associated primarily with worker safety during waste excavation (soil and structures), transportation, and disposal. Unprotected workers present a potential for unacceptable risk because of the high concentrations at the Z-Ditches of long-lived americium and plutonium isotopes. Worker radiation doses for excavation of Work Areas 1 and 3 under this alternative would be similar to dose rates encountered during Alternative 3 excavation of these areas. However, overall worker dose from Alternative 5A would be less than from Alternative 3 that excavate the entire site, including Work Area 2 that contains the highest Z-Ditches contaminant concentrations.

Impact to Environment During Remediation. Local biological resources would be affected by physical disruption of the waste sites during equipment mobilization, excavation, ISV operations, additions of clean fill to excavations and subsidence areas, barrier placement over the ISV melt, and demobilization. The increased human activity and noise and the generation of fugitive dust affect local biological resources that readily can be controlled through standard mitigation operations such as water sprays. However, the waste sites are located in historically disturbed industrial areas. Approximately 5 ha (12 ac) of surface area will be disturbed during ISV implementation.

Transportation activities on the Central Plateau would increase as a result of bringing construction equipment to the site, transporting contaminated soils to the ERDF, and bringing clean fill to the excavated sites and barrier material. Approximately 99,000 m^3 (130,000 yd^3) of radionuclide contaminated soil excavated from the Z-Ditches Work Areas 1 and 3 would be transported to ERDF. WIPP disposal is not anticipated to be required at the less contaminated Work Areas 1 and 3. Because ERDF is located within 3 km (1.8 mi), minimal environmental disturbance would be associated with the transport of waste.

Time to Achieve the Remedial Action Objectives. Based on calculations performed in Appendix C, ISV with barrier and RTD activities would be expected to require 1,865 work days to complete and to meet the RAO for preventing unacceptable risk to human and ecological receptors. This extended period of implementation is based on the assumption that ISV and associated site activities generally will be performed consecutively, not concurrently.

6.2.5.6 Implementability

Of the Z-Ditches remedial alternatives analyzed in this FS, the Alternative 5A ISV component is the least used and least proven in routine field operations. ISV has been proven effective on smaller test sites, and major concerns have been satisfactorily resolved in these tests. However, ISV is not used routinely for large-scale operations and should be considered a less proven technology. For this reason, cost estimates, schedules, and overall technical feasibility and effectiveness have a higher degree of uncertainty than is the case for other, more proven, alternatives. This alternative likely would require a pilot test project to resolve technical uncertainties.

6.2.5.7 Cost

Alternative 5A includes RTD of contaminants in Work Areas 1 and 3 and ISV treatment of soil at Work Area 2 that contains plutonium above PRGs with placement of a barrier over the ISV melt site. The present-worth cost of Alternative 5A is $318 ($622 non-discounted) million. ISV costs include mobilizing personnel and equipment; monitoring, sampling, and analysis; ISV operations; disposal of secondary waste (e.g., scrub liquid and high-efficiency particulate air [HEPA] filters); backfilling with Hanford Site resources; procuring additional backfill from a local stockpile; compacting the barrier (if a barrier is required); revegetating and stabilizing the site; and prime contractor oversight. Costs are based on the use of standard equipment (e.g., hydraulic excavators, front-end loaders, dozers) and assume that a subcontractor would do the work, with oversight performed by the prime contractor. The cost estimate assumes that the subcontractor personnel are wearing Level D personal protective equipment (e.g., coveralls, no respirators) during ISV operations. The operations and maintenance costs include site inspection/surveillance, periodic radiation site surveys of surface soil, monitoring of site vadose zone soils, biotic control, maintenance of signs and markers, cover maintenance, and site reviews. The cost of long-term monitoring of contaminated groundwater in the 200 West Area by the 200-UP-1 and 200-ZP-1 groundwater OUs is apportioned among the contributing source OUs and the 200-CW-5 OU portion of this cost is included in the cost estimate for this alternative.

6.2.6 Detailed Analysis of Alternative 5B—In Situ Vitrification with Barrier

Alternative 5B includes the ISV treatment of soil at Work Area 2 containing plutonium above PRGs, and placement of a barrier over the entire site, including over the ISV melt location. Grout injection of the remaining 216-Z-20 Tile Field waste distribution piping after barrier placement would be a potential sub-element of this alternative. The Alternative 5B ISV treatment is the same activity as performed under Alternative 5A, which underwent detailed analysis previously in this chapter and this alternative is considered applicable to the Z-Ditches for the same reasons. The Alternative 5B barrier is similar to the full site barrier presented for Alternative 4. Figure 6-5 depicts site configuration under Alternative 5B. As with Alternative 5A, because significant contamination inventory will remain in place under this alternative, ICs and monitoring would be required throughout the period of natural attenuation to ensure the barrier is maintained and remains protective and to prevent unauthorized access. The following sections present a detailed analysis of Alternative 5B against the evaluation criteria.

The north portion of the 216-Z-1D Ditch, which was replaced by process sewer piping in 1949 (as described in Section 2.1.2.1), is believed to meet PRGs for industrial use, ecological receptors, and protection of groundwater based on existing sampling data and process knowledge. It is assumed that no remedial action is required for the north portion of the 216-Z-1D Ditch. The north portion is assumed to contribute zero area or volume requiring active remediation. Thus, no costs are associated with implementation of the remedy. Sampling will be conducted to confirm this assumption.

6.2.6.1 Overall Protection of Human Health and the Environment

Alternative 5B is considered protective of HHE for the Z-Ditches. The ISV component permanently immobilizes the highest concentration alpha- and gamma-emitting contaminants at Work Area 2 in the glass matrix. The ISV has the potential to provide a high degree of overall protection of HHE because contaminants are converted to a stable form with low leachability. However, of the alternatives considered in this FS, ISV is considered an innovative technology and is not technically proven for routine, large-scale application and therefore has a high level of technical uncertainty. The Alternative 5B barrier component places a protective isolation barrier over the entire site, including the ISV melts area that eliminates the human and ecological direct contact exposure pathway until RAOs are met through natural attenuation. The Alternative 5B barrier component provides overall protection of HHE in the same manner and to the same degree as Alternative 4, which also provides for a barrier over the entire site and which underwent detailed analysis earlier in this chapter.

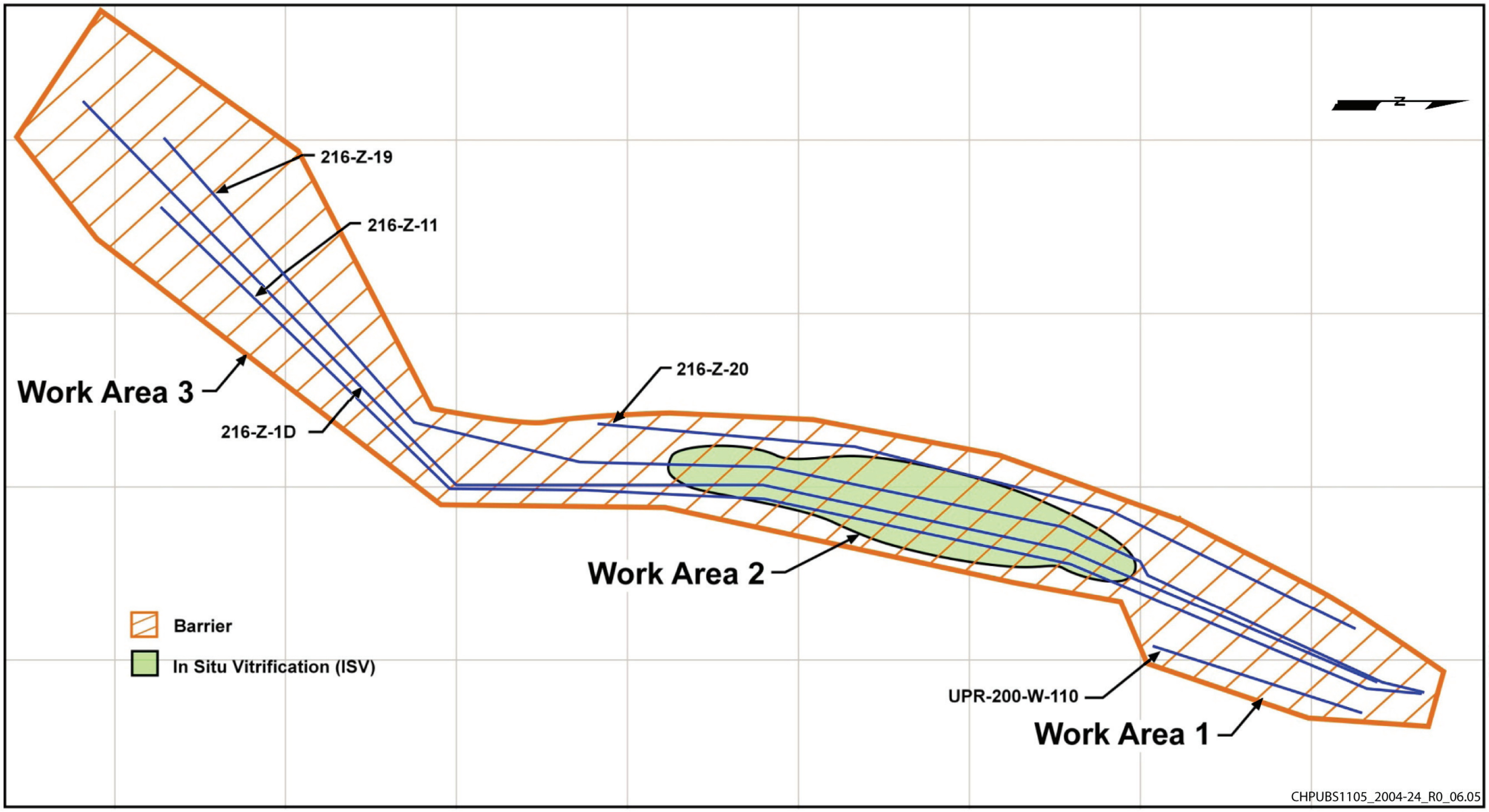


Figure 6-5. Generalized Site Configuration Under Alternative 5B

6.2.6.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 5B provides for ISV at the same location (Work Area 2) and to the same degree as Alternative 5A, which underwent detailed analysis earlier in this chapter. The detailed analysis of the CERCLA criteria for compliance with ARARs for the Alternative 5B ISV component would be the same analysis as that for the Alternative 5A ISV component.

Alternative 5B provides for a barrier at the same location (Work Areas 1 and 3) using a similar barrier to Alternative 4, which underwent detailed analysis earlier in this chapter. The detailed analysis of the CERCLA criteria for compliance with ARARs for the Alternative 5B barrier component would be the same analysis as that for the Alternative 4 barrier component.

6.2.6.3 Long-Term Effectiveness and Permanence

The CERCLA long-term effectiveness and permanence criteria pertain to analysis of the alternative for protectiveness of HHE and groundwater. The Alternative 5B ISV is the same activity at the same location (Work Area 2) and to the same degree as the previously analyzed Alternative 5A. Consequently, the detailed analysis of the CERCLA criteria for the long-term effectiveness and permanence criteria, as they pertain to protectiveness of HHE and groundwater for the Alternative 5B ISV component, would be the same analysis as performed previously in this chapter for the Alternative 5A ISV component.

The Alternative 5B barrier also provides for a barrier over the entire site as previously analyzed for Alternative 4. The detailed analysis of the CERCLA criteria for the long-term effectiveness and permanence criteria, as they pertain to protectiveness of HHE and groundwater for the Alternative 5B barrier component, would be the same analysis as that performed for Alternative 4 earlier in this chapter.

6.2.6.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative 5B permanently reduces toxicity and mobility through engineered ISV treatment that immobilizes contaminants and binds them into a stable, impermeable, and durable glass-like matrix that has low contaminant leaching potential until RAOs are met through natural attenuation. Alternative 5B provides for ISV at the same location (Work Area 2) and to the same degree as Alternative 5A, which underwent detailed analysis previously in this chapter. Consequently, the detailed analysis of the CERCLA criteria for TMV for the Alternative 5B ISV component would be the same analysis as that for the Alternative 5A ISV component.

Alternative 5B provides for a barrier over the entire site using a similar barrier as Alternative 4, which underwent detailed analysis earlier in this chapter. That analysis indicated that the Alternative 5B barrier component does not reduce contaminant TMV.

6.2.6.5 Short-Term Effectiveness

The CERCLA short-term effectiveness criteria pertain to analysis of the alternative for remediation worker risk, impacts to the environment during remediation, and time to achieve RAOs. Alternative 5B has both ISV and barrier components, which essentially are identical to activities associated with alternatives that have undergone detailed analysis for these CERCLA criteria earlier in this chapter. Analysis for remediation worker risk considered worker training, experience, relative risk from ISV and barrier activities, and risk mitigation actions. For the impacts to the environment, earlier analysis considered impacts to the local biological resources, the area of disturbance from the various remedial activities, and mitigating factors. The earlier analyses also identified the time to achieve RAOs by ISV treatment and placement of a barrier that is protective until RAOs are met.

The Alternative 5B ISV component is the same activity at the same location (Work Area 2) and to the same degree as the previously analyzed Alternative 5A. The detailed analysis of the CERCLA criteria for the short-term effectiveness for the Alternative 5B ISV component would be the same analysis as that performed earlier for the Alternative 5A ISV component.

Alternative 5B also provides for a full site barrier using a similar barrier as previously analyzed for Alternative 4. The detailed analysis of the CERCLA criteria for the short-term effectiveness for the Alternative 5B barrier component would be the same analysis as that performed earlier for the Alternative 4 barrier component.

The time to implement Alternative 5B would be approximately 1,263 workdays.

6.2.6.6 Implementability

The CERCLA short-term implementability criteria pertain to analysis of the alternative’s technical and administrative feasibility and the availability of essential materials and services to implement the alternative. Alternative 5B has both ISV and barrier components, which are essentially identical to activities associated with alternatives that have undergone detailed analysis for these CERCLA criteria earlier in this chapter. Alternative 5B ISV is the same activity at the same location (Work Area 2) and to the same degree as the previously analyzed Alternative 5A. The Alternative 5B barrier also provides for a full site barrier as previously analyzed for Alternative 4. The prior analyses considered technical feasibility with regard to the potential for delays or failure due to technical uncertainties, including the availability of essential materials and services and administrative feasibility with regard to coordination of agencies and potential regulatory constraints that could arise if cultural (archeological sites) or biological resources (endangered species) are encountered.

The detailed analysis of the CERCLA implementability criteria for the Alternative 5B ISV component would be the same as that for the Alternative 5A ISV component performed previously. The detailed analysis of the CERCLA implementability criteria for the Alternative 5B barrier component would be the same as that performed previously for the Alternative 4 barrier.

6.2.6.7 Cost

Alternative 5B includes ISV treatment of soil at Work Area 2 containing plutonium above PRGs and placement of a full site barrier. The Alternative 5B present-worth cost would be $287 ($581 non-discounted) million. Alternative 5B has both the ISV and barrier components that are essentially identical to activities associated with alternatives that have undergone detailed cost analysis earlier in this chapter. Alternative 5B ISV is the same activity at the same location (Work Area 2) and to the same degree as the previously analyzed Alternative 5A. The cost considerations for ISV included the costs of mobilizing personnel and equipment; monitoring, sampling, and analysis; ISV operations; disposal of secondary waste (e.g., scrub liquid and HEPA filters); backfilling with Hanford Site resources; procuring additional backfilling from a local stockpile; and prime contractor oversight.

The Alternative 5B barrier also provides for the same barrier over the entire site as previously analyzed for Alternative 4. The cost considerations for barrier placement included stabilization of the existing site; excavation or import, transportation, and placement of barrier material; compaction of the barrier; prime contractor oversight; and confirmatory sampling. The operations and maintenance costs include site inspection/surveillance, periodic radiation site surveys of surface soil, monitoring of site vadose zone soils, biotic control, maintenance of signs and markers, cover maintenance, and site reviews. The cost of long-term monitoring of contaminated groundwater in the 200 West Area by the 200-UP-1 and 200-ZP-1 groundwater OUs is apportioned among the contributing source OUs and the 200-CW-5 OU portion of this cost is included in the cost estimate for this alternative.

Appendix C presents details of the cost estimates. Table 6-1 summarizes the costs. The actual costs are expected to range from -30 percent to +50 percent of these estimated values. The actual range of volumes to be excavated and the incremental inventory of contamination within areas of the sites could vary significantly in the field. Planning assumptions were made based on available information.

6.3 NEPA Values

This section addresses the incorporation of the *National Environmental Policy Act of 1969* (NEPA) values into CERCLA documents. This is consistent with DOE Order 451.1B Change 1 that requires that CERCLA actions address and incorporate NEPA values such as socioeconomic, ecological, offsite, and cumulative impacts in CERCLA documents at the DOE site to the extent practicable. Alternatives to address the release or threatened release of hazardous substances have been identified and analyzed in this FS. The No Action Alternative would not mitigate the environmental impacts from the hazardous substances. All other alternatives could mitigate the impacts associated with the release or threatened release as well as provide for the remediation of the hazardous substances. Specifically, the application of the substantive environmental protection standards identified as ARARs would reduce impacts of the hazardous substances on air, surface waters, soil, groundwater, plants, and animals to levels that have been identified by regulation.

NEPA values associated with remediation are based on the detailed information presented in this FS including the area and site characteristics, COPCs, and identification and analysis of remedial actions. Applying a “sliding scale” of NEPA analysis to the 200-CW-5 OU (using DOE’s NEPA Guidance, (2nd Edition, Dec. 2004)), and considering the CERCLA ARARs, the principle resource areas of concern include the contaminants in the soils, solid and liquid radioactive and hazardous waste management, air emissions, potential adverse effects to historic and cultural resources, ecological resources, socioeconomics (including environmental justice concerns), and transportation.

For purposes of implementing the remediation alternative associated with soil removal, when soils at a site in this OU are found to be contaminated with hazardous substances in concentrations presenting a material threat to HHE, that threat will be mitigated by meeting the applicable ARAR standards as well as following current DOE policy and guidance. The net anticipated effect could be an overall positive contribution to cumulative environmental effects at the Hanford Site through removal, treatment, and disposal of such hazardous substances and COPCs into a facility that has been designed and legally authorized to safely contain such contaminants. DOE expects that the primary facility to receive contaminated soils will be the ERDF. NEPA values in the planning for the ERDF operation were explained in detail in the original ERDF NEPA Roadmap, DOE/RL-94-41 (1994), *NEPA Roadmap for the Environmental Restoration Disposal Facility Regulatory Package*, for the ERDF RI/FS (RI/FS, DOE/RL-93-99, *Remedial Investigation and Feasibility Study Report for the Environmental Restoration Disposal Facility*, Rev. 1, Oct. 1994) as described in the most recent ERDF ROD Amendment (EPA et al., 2007, *Amendment to the Record of Decision for the USDOE Hanford Environmental Restoration Disposal Facility*). The NEPA values (i.e., resource area and relevant NEPA considerations) most relevant to and potentially affected by the actions taken under this remedial action are described in Table 6-2.

In addition, DOE is including the combined effects anticipated from ongoing CERCLA and Tri-Party Agreement (Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Order*) response actions as part of the cumulative impact analysis in DOE/EIS-0391, *Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*. The aforementioned tank closure and waste management EIS includes a site-wide cumulative impact groundwater analysis. This presents the public with a separate opportunity for comment as part of that NEPA process, and is being used to inform the public concerning ongoing implementing cleanup actions on the Hanford Site.

Table 6-2. NEPA Considerations

NEPA Values	Description	Evaluation (Includes the Evaluation for Each Alternative)
Transportation	Considers impacts of the proposed action on local traffic (i.e., traffic at the Hanford Site) and traffic in the surrounding region.	Implementation of alternative remedial actions would be expected to produce short-term impacts on local traffic. For Alternatives 4, 5A, and 5B, impacts would result from hauling cover material to the waste site areas. For Alternatives 3 and 5A, impacts would result from hauling waste to ERDF and/or WIPP and hauling clean excavation fill material to the site. For these alternatives, impacts could be expected from increased traffic bringing supplies, equipment, and workers to the sites. Alternatives 5A and 5B also would include hauling ISV equipment to and from the ISV location. Transportation impacts were considered in DOE/RL-93-99, *Remedial Investigation and Feasibility Study Report for the Environmental Restoration Disposal Facility*, as part of the evaluation of short term effectiveness and implementability. NEPA values in the planning for the ERDF operation were explained in detail in DOE-RL-94-41, *NEPA Roadmap for the Environmental Restoration Disposal Facility Regulatory Package*. The impacts of transportation of TRU waste to WIPP and disposal of transuranic (TRU) waste at WIPP, although not anticipated for this remedial activity, were analyzed in DOE/EIS-0026-S-2, *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement*. See the discussion of cumulative impacts for a perspective of transportation to the ERDF.
Air Quality	Considers potential air quality concerns associated with emissions generated during the proposed action.	Airborne releases associated with Alternatives 3 and 4 would be expected to be minor with the use of appropriate work controls (e.g., sampling during favorable wind conditions, use of dust suppressants). A maximum of 143,000 m^3 (187,000 yd^3) of contaminated soil would be removed (Alternative 3, RTD). Any potential of airborne release of contaminants during alternative remedial actions would be controlled in accordance with DOE radiation control and air

Table 6-2. NEPA Considerations

NEPA Values	Description	Evaluation (Includes the Evaluation for Each Alternative)
		pollution control standards, to minimize emissions of air pollutants at the Hanford Site, and protect all communities outside the Site boundaries. Operation of trucks and other diesel-powered equipment for these alternatives would be expected, in the short-term, to introduce quantities of sulfur dioxide, nitrogen dioxide, particulates, and other pollutants to the atmosphere, typical of similar-sized construction projects. These releases would not be expected to cause any air quality standards to be exceeded and (as needed) dust generated during remedial activities would be minimized by watering or other dust-control measures. Vehicular and equipment emissions would be controlled and mitigated in compliance with the substantive standards for air quality protection that apply to the Hanford Site. Alternatives 5A and 5B include an offgas treatment system, in operation during vitrification operations. Releases from the offgas treatment system would be subject to compliance with substantive air ARARs and will be described in an air monitoring plan, which will be prepared before implementation.
Natural, Cultural, and Historical Resources	Considers impacts of the proposed action on wildlife, wildlife habitat, archeological sites and artifacts, and historically significant properties.	Impacts on ecological resources in the vicinity of the remedial actions would be mitigated in accordance with the *Hanford Site Biological Resources Management Plan* (DOE/RL-96-32) and *Hanford Site Biological Resources Mitigation Strategy* (DOE/RL-96-88), and with the applicable standards of all relevant biological species protection regulations. Because these sites have already been disturbed, and only isolated artifacts could be encountered during project activities, implementation of DOE/RL-98-10, *Hanford Cultural Resources Management Plan*, and consultation with area Tribes would help ensure appropriate mitigation to avoid or minimize any adverse cultural or historical resource effects and address any relevant concerns. Impacts to other cultural values will be minimized through implementation of DOE/RL-98-10; DOE/RL-2005-27, *Revised Mitigation Action Plan for the Environmental Restoration Disposal Facility*; and consultation with area Tribes as needed. This will help ensure appropriate mitigation to avoid or minimize any adverse effects to natural and cultural resources and address any other relevant concerns. Potential impacts to cultural and historical resources that may be encountered during the short-term construction activities associated with implementing the action would be mitigated through compliance with the appropriate substantive requirements of the *National Historic*

Table 6-2. NEPA Considerations

NEPA Values	Description	Evaluation (Includes the Evaluation for Each Alternative)
		Preservation Act of 1966 and other ARARs related to cultural preservation.
Socioeconomic Impacts	Considers impacts pertaining to employment, income, other services (e.g., water and power utilities), and the effect of implementation of the proposed action on the availability of services and materials.	The proposed action is within the scope of current RL environmental restoration activities and would have minimal impact on the current availability of services and materials. This work would be expected to be accomplished largely using employees from the existing contractor workforce. Even if the remedial activities creates additional service sector jobs, the total expected increase in employment would be expected to be less than 1% of the current employment levels. The socioeconomic impact of the project would contribute to the continuing overall positive employment and economic impacts on eastern Washington communities from Hanford Site cleanup operations.
Noise, Visual, and Aesthetic Effects	Considers increases in noise levels or impaired visual or aesthetic values during or after the proposed remedial actions.	Alternative 1 would have little to no impact on current noise, visual, or aesthetic site characteristics. Excavation activities associated with Alternatives 3 and 5A would increase noise levels and impair visual values, but the impacts would be short-term during remedial actions and ultimately would improve the aesthetics by removing site materials. Likewise, Alternative 4 would increase noise levels and impair visual values in the short-term during construction of the barrier. These alternatives also could have some long-term visual and aesthetic impacts, both positive and negative. Positive impacts would result from the removal of aboveground site structures. Negative impacts would be associated with the visibility and aesthetics of the barriers over large distances if they are not contoured to blend in with the surrounding area. Alternatives 5A and 5B ISV would increase noise levels and impair visual values, but the impacts would be short-term during remedial actions.
Environmental Justice	Considers whether the proposed response actions would have inappropriately or disproportionately high and adverse human health or environmental effects on minority or low-income populations.	Per Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,* DOE seeks to ensure that no group of people bears a disproportionate share of negative environmental consequences resulting from proposed federal actions. No impacts are associated with proposed activities associated with the 200-CW-5 OU that could reasonably be determined to affect any member of the public; therefore, they would not have the potential for high and disproportional adverse impacts on minority or low-income groups.
Cumulative Impacts (Direct and Indirect)	Considers whether the proposed action could have cumulative impacts on human health or the environment when considered together with other activities	The environmental concern of the 200-CW-5 OU is associated directly with the targeted area. Because of the temporary nature of the activities and their remote location, cumulative impacts on air quality or noise with other Hanford Site or regional

Table 6-2. NEPA Considerations

NEPA Values	Description	Evaluation (Includes the Evaluation for Each Alternative)
	locally, at the Hanford Site, or in the region.	construction and cleanup projects would be minimal. When soils at a site in this OU are found to be contaminated with hazardous substances in concentrations presenting a material threat to human health and the environment, that threat would be mitigated. The net anticipated effect could be a positive contribution to cumulative environmental effects at the Hanford Site through removal, treatment, and disposal of such hazardous substances and COPCs into a facility that has been designed and legally authorized to safely contain such contaminants, such as the ERDF. Contaminated soil removed under any alternative would meet the ERDF waste acceptable criteria as described in WCH-191, *Environmental Restoration Disposal Facility Waste Acceptance Criteria*. The volume of soil that could be generated for disposal during implementation of the remedial action is estimated to be approximately 143,000 m^3 (187,000 yd^3) over the expected duration of this action (the action is anticipated to occur over a 2.7-year period, resulting in approximately 53,500 m^3 (70,000 yd^3) per year (and attendant transportation requirements). For Alternatives 3, the projected disposal volume of 143,000 m^3 (187,000 yd^3) may necessitate ERDF expansion. ERDF is being expanded in 2010. If additional expansion is required to accommodate this volume, then ERDF cell expansion would be addressed through appropriate separate CERCLA review.
Mitigation	Considers whether or not if adverse impacts cannot be avoided, response action planning should minimize them to the extent practicable. This value identifies required mitigation activities.	Compliance with the substantive requirements of the ARARs would mitigate potential environmental impacts on the natural environment, including migratory birds, and endangered species. DOE has also established policies and procedures for the management of ecological and cultural resources when actions might affect such resources (DOE/RL-96-32, DOE/RL-96-88, and DOE/RL-98-10). Cultural resource and biological species reviews/surveys are undertaken that also provide suggested mitigation activities to ensure adverse effects associated with implementing the actions are minimized or avoided. Health and safety procedures, documented in the Health and Safety Plan, established by site contractors would mitigate risks to workers from the remedial activities.

Table 6-2. NEPA Considerations

NEPA Values	Description	Evaluation (Includes the Evaluation for Each Alternative)
Irreversible and Irretrievable Commitment of Resources	Considers the use of nonrenewable resources for the proposed response actions and the effects that resource consumption would have on future generations. (When a resource [e.g., energy minerals, water, wetland] is used or destroyed and cannot be replaced within a reasonable amount of time, its use is considered irreversible.)	Materials that would be used to backfill the waste site or construct the barrier would be taken, if needed, from the surrounding area to contour the backfill to match the surrounding area. Normal usage of resources during construction activities, such as fuel and water, would be irreversibly used. Disposal of the waste materials into the ERDF will irreversibly consume landfill space. Restoration of formerly disturbed areas to a more natural state would be expected to result in a net benefit to the ecological and visual resources within the region.

TRU = transuranic

7 Comparative Analysis of Alternatives

This chapter presents the comparative analysis of the five remedial alternatives analyzed for the Z-Ditches of the 200-CW-5 OU. This analysis will identify the relative advantages and disadvantages based on the detailed analysis of each alternative against the seven CERCLA evaluation criteria as presented in Chapter 6. The results of this analysis provide a basis for selecting a remedial alternative for the Z-Ditches. The remedial alternatives compared are as follows:

- Alternative 1—No Action
- Alternative 3—RTD
- Alternative 4—Barrier
- Alternative 5A—ISV with Barrier and RTD
- Alternative 5B—ISV with Barrier

Table 7-1 shows the CERCLA criteria and considerations for ranking each alternative.

Table 7-1. Alternative Ranking Considerations for CERCLA Criteria

CERCLA Criteria	Alternative Evaluation
Overall protection of HHE	Alternatives were ranked using residual risk and uncertainty as guiding standards.
Compliance with ARARs	Alternatives were ranked using the standard that if all ARARs are met, then alternatives are equal.
Long-term effectiveness and permanence	Alternatives were ranked with useful life of alternative and danger to public and environment as guiding standards.
Reduction in TMV	If treatment is applied, the alternative is ranked higher than if no treatment is applied. Otherwise, alternatives are ranked equally.
Short-term effectiveness	Alternatives were ranked primarily for the ability to prevent exposure to workers and the environment, with secondary ranking for time to meet RAOs.
Implementability	Alternatives with proven technology ranked higher than unproven technologies. Secondary consideration is availability of resources to support remedial action.
Cost	Alternatives were ranked from lowest to highest cost.

ARAR = applicable or relevant and appropriate requirement
HHE = human health and the environment
RAO = remedial action objective
TMV = toxicity, mobility, or volume

7.1 Overall Protection of Human Health and the Environment

Alternative 3 provides the greatest protection of HHE because contaminants are removed from the site to meet cleanup levels. Alternative 5A provides greater protection to HHE than the remaining alternatives, but less than Alternative 3, because it leaves waste in the ground. Alternative 5B provides a slight improvement over Alternative 4 because of the encapsulation and immobilization of the contaminants with concentrations greater than PRGs at the site; however, it leaves the residual risk left in place.

Alternative 4 is ranked next because of the isolation of waste at the site. Alternative 1 fails to protect HHE.

7.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternatives 3, 4, 5A, and 5B meet the ARARS identified and are ranked equally. Alternative 1 does not comply with ARARs for the Z-Ditches and is ranked last.

7.3 Long-Term Effectiveness and Permanence

Alternative 3 provides the greatest long-term effectiveness and permanence because it removes contaminants at concentrations above PRGs from the site. Alternative 5A is next best because it provides greater long-term effectiveness and permanence than the remaining alternatives; however, it leaves waste in the ground. Alternative 5B provides slightly better protection than Alternative 4 because of the encapsulation of contaminants with concentrations greater than PRGs at the site, but leaves the residual risk in place. Alternative 4 is ranked next because all contamination remains at the waste site, but it is isolated with a barrier. Alternative 1 fails to protect HHE and presents the largest danger to the public at the site.

7.4 Reduction in Toxicity, Mobility, or Volume through Treatment

Alternative 5A and 5B rank moderately well for reduction in toxicity, mobility, and volume through treatment because it treats contaminated material (i.e., PCBs) using vitrification to reduce mobility. ISV provides only a marginal difference in reducing the mobility of plutonium and americium. In addition, these constituents are not mobile under existing or anticipated conditions. In addition, the barrier would be placed over the area where ISV was applied to provide additional protection of human health and the environment. Alternative 5A treats contaminated material and removes the remaining contamination to meet cleanup levels. Alternative 5B meets the criteria for treatment but leaves waste in place. The remaining alternatives are ranked equally because no reduction in TMV is achieved.

7.5 Short-Term Effectiveness

Alternative 4 ranks highest because it provides much lower potential for worker and environmental exposure to contaminants and lower overall risk than alternatives that excavate contaminated material. Alternative 5B is ranked next because contaminated material is not excavated, but moderate worker risk is associated with the long ISV implementation timeframe and working with thermally and electrically hot equipment. Alternative 5A has similar potential worker and environmental short-term risks associated with excavation of low-level waste from Work Areas 1 and 3 and is ranked equally. Alternative 3 is ranked equally because it provides only slightly more risk because it excavates the entire site, although under this alternative the waste is presumed to be low-level.

7.6 Implementability

Alternative 4 is the most implementable alternative because the barrier option is a proven technology that has a low potential for delays arising from technical or administrative difficulties. All of the material, equipment, and personnel necessary to implement an Alternative 4 barrier are readily available. Alternative 3 ranks moderately well and would require excavation of contaminated material and an appropriate disposal facility with sufficient disposal capacity such as ERDF which is currently available. Alternatives 5A and 5B rank lowest because of the unproven nature of ISV at a large-scale site, such as the Z-Ditches. ISV has been proven effective on smaller test sites, and major concerns have been satisfactorily resolved in these tests, but ISV is not used routinely for large-scale operations and should be considered a less-proven technology. For this reason, cost estimates, schedules, and overall technical feasibility and effectiveness have a higher degree of uncertainty than is the case for other, more proven alternatives. Alternatives relying on ISV likely would require a pilot test project to resolve technical uncertainties.

7.7 Cost

The detailed information regarding implementation cost for each alternative is presented in Chapter 6 and Appendix C. Although only Alternatives 3, 4, 5A, and 5B meet threshold criteria, the present net value costs of all alternatives are presented as follows (in millions of dollars):

- Alternative 1 has no cost, but does not address current risks, meet RAOs, or meet threshold criteria, and is not a remedial alternative candidate for the Z-Ditches.
- Alternative 4, at $19.6 ($295 non-discounted), can meet overall protectiveness goals by installing a barrier over the entire site. The barrier would have less implementation cost uncertainty than any other viable alternative. This alternative mitigates site risk by breaking the exposure pathway at the entire site, while minimizing worker risk and potential spread of contaminants associated with excavation of greater than PRG-contaminated soils. Because waste is left in place at concentrations above PRGs, long-term controls are required until PRGs are met, the cost of which can be uncertain. Engineered barriers would operate in conjunction with long-term ICs to help ensure barrier performance and integrity and to prevent intrusion until RAOs are met through natural attenuation.
- Alternative 3, at $58.1 ($60.5 non-discounted), provides full site RTD that is more expensive than the barrier placement of Alternative 4. Because contamination is not left at the waste site above PRGs, uncertainties associated with costs of long-term site monitoring are not incurred. Although high contamination levels exist in some site soils that could require special worker safety requirements and site contamination controls, RTD under this alternative is assumed to generate only low-level waste that can be disposed onsite at ERDF.
- Alternative 5B, at $287 ($581 non-discounted), with ISV treatment and engineered barrier components, is the second most costly alternative. Both the ISV and barrier components leave waste at the site, although in a protective manner, until RAOs are met through natural attenuation. The Alternative 6B ISV cost estimate carries uncertainties associated with implementation of this innovative and relatively untried technology, making accurate cost predictions and determination of overall effectiveness less certain. The barrier component leaves contaminated soil in place, which avoids much of the cost and uncertainty associated with excavation of soil with concentrations greater than PRGs, but incurs the uncertainties associated with the cost of long-term site monitoring.
- Alternative 5A, at $318 ($622 non-discounted), with ISV treatment and RTD components, is the most costly alternative. The ISV component of this alternative has the same cost and uncertainties as the ISV component of Alternative 5B.

Table 7-2 summarizes the evaluated alternatives. Using information from this FS, the decision makers will identify a Preferred Alternative in the PP. Based on previous HAB and stakeholder input, and including any upcoming public comment, an alternative will be selected in a ROD.

Table 7-2. Comparative Analysis Summary for the 200-CW-5 Operable Unit Waste Sites

	Threshold Criteria		Balancing Criteria				
	Overall Protectiveness of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction in Toxicity, Mobility, and Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost[a] (Net Present Worth in $ Million)
No Action	No	No	Not Ranked[b]				$0
MESC/MNA/IC	No	No	Not Ranked[b]				$0
RTD	Yes	Yes	○	●	◐	◐	$58.1
Engineered Surface Barrier	Yes	Yes	◐	●	○	○	$19.6
ISV/RTD/Barrier	Yes	Yes	○	◐[c]	◐	●	$318
ISV/Barrier	Yes	Yes	◐	◐[c]	◐	●	$287

a. These cost estimates are based on the best available information for the site-specific anticipated remedial actions. The actual costs are expected to range from -30 percent to +50 percent of these estimated values. Major changes to assumed remedial action scope can result in remedial action costs outside of this range. Net present worth calculations are based on 1,000 years.

b. No Action and MESC/MNA/IC Alternatives not ranked because these alternatives do not meet the threshold criteria.

c. Rated "performs moderately well" for this criterion overall. ISV applies only to Work Area 2. No treatment of contaminants in Work Area 1 or 3.

Explanation of Evaluation Metric

● = Performs less well against the criterion relative to the other alternatives with significant disadvantages or uncertainty.

◐ = Performs moderately well against the criterion relative to the other alternatives with some disadvantages or uncertainty.

○ = Performs very well against the criterion relative to the other alternatives with minor disadvantages or uncertainty.

ARAR = applicable or relevant and appropriate requirement
IC = institutional controls
ISV = In Situ Vitrification
MESC/MNA = maintain existing soil cover/monitored natural attenuation
RTD = removal, treatment, and disposal

7.8 CERCLA and RCRA Corrective Action

The Tri-Party Agreement (Ecology et al., 1989a) governs integration and coordination of CERCLA and RCRA at Hanford. At the Hanford Site, the Tri-Party Agreement requires that CERCLA remedial actions and RCRA corrective action requirements be satisfied with one process. Key language specific to past-practice unit cleanup includes the following:

- Article IV, Paragraph 17, which cites the Tri-Parties intent "to integrate DOE's CERCLA response obligations and RCRA corrective action obligations which relate to the release(s) of hazardous substances, hazardous wastes, pollutants and contaminants" covered by Ecology et al. (1989a)

- Article XIV, which applies to the performance of both CERCLA remedial action and RCRA corrective action
- Article XXIII, which acknowledges the potential for overlap between CERCLA and RCRA cleanup
- Article XXIV, which specifies the approach for regulatory oversight

Section 5.4 of the *Hanford Federal Facility Agreement and Consent Order Action Plan* (Tri-Party Agreement Action Plan [Ecology, et al., 1989b]) addresses the rationale and approach for past-practice cleanup. Two key objectives are to (1) ensure that only one past-practice program will be applied at each OU, and (2) that the process selected be sufficiently comprehensive to satisfy the technical requirements of both statutory authorities and the respective regulations.

Therefore, in accordance with the Tri-Party Agreement, Parts Three and Four, and the Tri-Party Agreement Action Plan, Sections 5.4, 5.6, and 7.0, past-practice cleanup (remediation) is intended to satisfy both CERCLA remedial action and RCRA corrective action requirements. In addition to fulfilling CERCLA requirements, the preferred remedial action will fulfill DOE's corrective action obligations under RCW 70.105, "Hazardous Waste Management," for the units identified herein. The Tri-Parties agree that the selected preferred alternative will be sufficiently comprehensive to satisfy the technical requirements of both statutory authorities and the respective regulations.

The DOE's corrective action obligation for work performed under CERCLA is addressed in the RCRA Hanford Facility Permit (*Hanford Facility Resource Conservation and Recovery Act Permit, Dangerous Waste Portion, Revision 8, for the Treatment, Storage, and Disposal of Dangerous Waste* [WA7890008967]), Condition II.Y.2.a. Specifically, Condition II.Y.2.a provides that DOE corrective action obligations be met through adherence to the Tri-Party Agreement (Ecology et al., 1989a) and the resulting ROD, subject to the reservations and requirements of Condition II.Y.2.a.i through Condition II.Y.2.a.iv.

This page intentionally left blank.

8 References

10 CFR 61.52, "Licensing Requirements for Land Disposal of Radioactive Waste," "Land Disposal Facility Operation and Disposal Site Closure," *Code of Federal Regulations*. Available at: http://edocket.access.gpo.gov/cfr_2009/janqtr/10cfr61.52.htm.

40 CFR 141, "National Primary Drinking Water Regulations," *Code of Federal Regulations*. Available at: http://www.access.gpo.gov/nara/cfr/waisidx_08/40cfr141_08.html.

40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," Appendix B, "National Priorities List," *Code of Federal Regulations*. Available at: http://edocket.access.gpo.gov/cfr_2009/julqtr/40cfr300AppB.htm.

40 CFR 1502.16, "Environmental Impact Statement," "Environmental Consequences," *Code of Federal Regulations*. Available at: http://edocket.access.gpo.gov/cfr_2008/julqtr/40cfr1502.16.htm.

64 FR 61615, "Record of Decision: Hanford Comprehensive Land-Use Plan Environmental Impact Statement (HCP EIS)," *Federal Register*, Vol. 64, No. 218, pp. 61615-61625, November 12, 1999. Available at: http://www.epa.gov/EPA-IMPACT/1999/November/Day-12/i29325.htm.

73 FR 55824, "Amended Record of Decision for the Hanford Comprehensive Land-Use Plan Environmental Impact Statement," *Federal Register*, Vol. 73, No. 188, pp. 55824-55826, September 26, 2008. Available at: http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=2008_register&docid=55825.pdf.

Albright, W.H., C.H. Benson, G.W. Gee, T. Abichou, A.C. Roesler, and S.A. Rock, 2003, "Examining the Alternatives," *Civil Engineering*, Vol. 73, No. 5, May.

ANL/EAD-4, 2001, *User's Manual for RESRAD, Version 6*, Argonne National Laboratory, Environmental Assessment Division, Argonne, Illinois. Available at: http://web.ead.anl.gov/resrad/documents/resrad6.pdf.

Bald and Golden Eagle Protection Act of 1940, 16 USC 668-668d, et seq. Available at: http://www.fws.gov/migratorybirds/mbpermits/regulations/BGEPA.PDF.

BHI-00469, 1997, *Hanford Sitewide Groundwater Remediation Strategy – Groundwater Contaminant Predictions*, Rev. 1, Bechtel Hanford Company, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D197301490.

BHI-01294, 1999, *Data Quality Objective Summary Report for the 200-CW-5 U Pond/Z Ditches System Waste Sites*, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

BHI-01551, 2002, *Alternative Fine-Grained Soil Borrow Source Study Final Report*, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

BNWL-1794, 1973, *Distribution of Radioactive Jackrabbit Pellets in the Vicinity of the B-C Cribs, 200 East Area, USAEC Hanford Reservation*, Battelle Northwest Laboratories, Richland, Washington.

Census, 2000, U.S. Bureau of the Census, U.S. Department of Commerce, Washington, D.C. Available at: http://www.census.gov.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 USC 9601, et seq. Available at: http://uscode.house.gov/download/pls/42C103.txt.

CP-12134, 2002, *Borehole Summary Report for Borehole C3808 in the 216-Z-11 Ditch, 200-CW-5 U-Pond/Z-Ditches Cooling Water Operable Unit*, Rev. 0, Fluor Hanford, Inc., Richland, Washington.

DOE G 435.1-1, 1999, *Implementation Guide for Use with DOE M 435.1-1*, U.S. Department of Energy, Washington, D.C. Available at: http://www.directives.doe.gov/cgi-bin/explcgi?4??+%3Cin%3E+series;maxdocs=300;APP=onixdoe;collection=neword,newguide,newmanual,newpolicy,newnotice;UP=current.html;INTERFACE=1WINDOW.

DOE O 451.1B Chg 1, *National Environmental Policy Act Compliance Program*, U.S. Department of Energy, Washington, D.C. Available at: http://www.directives.doe.gov/cgi-bin/explhcgi?qry1741107269;doe-248.

DOE, 1994, *Secretarial Policy on the National Environmental Policy Act* (memorandum from H. R. O'Leary, Secretary of Energy, for Secretarial Officers and Heads of Field Elements), U.S. Department of Energy, Washington, D.C., June 13. Available at: http://gc.energy.gov/NEPA/nepa_documents/TOOLS/GUIDANCE/Volume2/1-6b-secpolicy.html.

DOE/EIS-0026-S-2, 1997, *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement*, U.S. Department of Energy, Carlsbad Area Office, Carlsbad, New Mexico.

DOE/EIS-0222-F, 1999, *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*, U.S. Department of Energy, Washington, D.C. Available at:
http://www5.hanford.gov/arpir/?content=findpage&AKey=D199158842.
http://www5.hanford.gov/arpir/?content=findpage&AKey=D199158843.
http://www5.hanford.gov/arpir/?content=findpage&AKey=D199158844.
http://www5.hanford.gov/arpir/?content=findpage&AKey=D199158845.
http://www5.hanford.gov/arpir/?content=findpage&AKey=D199158846.
http://www5.hanford.gov/arpir/?content=findpage&AKey=D199158847.

DOE/EIS-0222-SA-01, 2008, *Supplement Analysis, Hanford Comprehensive Land-Use Plan Environmental Impact Statement*, Draft, U.S. Department of Energy, Washington, D.C. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=DA06917281.

DOE/EIS-0391, 2009, *Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*, U.S. Department of Energy, Richland, Washington. Available at: http://www2.hanford.gov/arpir/?content=findpage&AKey=0912180376. http://www2.hanford.gov/arpir/?content=findpage&AKey=0912180377. http://www2.hanford.gov/arpir/?content=findpage&AKey=0912180378. http://www2.hanford.gov/arpir/?content=findpage&AKey=0912180379. http://www2.hanford.gov/arpir/?content=findpage&AKey=0912180380. http://www2.hanford.gov/arpir/?content=findpage&AKey=0912180381. http://www2.hanford.gov/arpir/?content=findpage&AKey=0912180382. http://www2.hanford.gov/arpir/?content=findpage&AKey=0912180383. http://www2.hanford.gov/arpir/?content=findpage&AKey=0912180384. http://www2.hanford.gov/arpir/?content=findpage&AKey=0912180385. http://www2.hanford.gov/arpir/?content=findpage&AKey=0912180386. http://www2.hanford.gov/arpir/?content=findpage&AKey=0912180387. http://www2.hanford.gov/arpir/?content=findpage&AKey=0912180388. http://www2.hanford.gov/arpir/?content=findpage&AKey=0912180389. http://www2.hanford.gov/arpir/?content=findpage&AKey=0912180390. http://www2.hanford.gov/arpir/?content=findpage&AKey=0912180391. http://www2.hanford.gov/arpir/?content=findpage&AKey=0912180392. http://www2.hanford.gov/arpir/?content=findpage&AKey=0912180393. http://www2.hanford.gov/arpir/?content=findpage&AKey=0912180394. http://www2.hanford.gov/arpir/?content=findpage&AKey=0912180395. http://www2.hanford.gov/arpir/?content=findpage&AKey=0912180396. http://www2.hanford.gov/arpir/?content=findpage&AKey=0912180397. http://www2.hanford.gov/arpir/?content=findpage&AKey=0912180398. http://www2.hanford.gov/arpir/?content=findpage&AKey=0912180373. http://www2.hanford.gov/arpir/?content=findpage&AKey=0912180374. http://www2.hanford.gov/arpir/?content=findpage&AKey=0912180375.

DOE/EM-0558, 2000, *Alternative Landfill Cover*, Innovative Technology Summary Report OST/TMS ID 10, U.S. Department of Energy, Office of Environmental Management, Office of Science and Technology, Washington, D.C. Available at: http://costperformance.org/pdf/Sandia_Cap.pdf.

DOE/RL-91-52, 1992, *U Plant Source Aggregate Area Management Study Report*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D196110688.

DOE/RL-91-58, 1992, *Z Plant Source Aggregate Area Management Study Report*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D196124396.

DOE/RL-92-24, 1994, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*, Rev. 2, 2 vols., U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www2.hanford.gov/arpir/?content=detail&AKey=D196078863. http://www2.hanford.gov/arpir/?content=detail&AKey=D196078869.

DOE/RL-93-33, 1996, *Focused Feasibility Study of Engineered Barriers for Waste Management Units in the 200 Areas*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D197226618.

DOE/RL-93-99, 1994, *Remedial Investigation and Feasibility Study Report for the Environmental Restoration Disposal Facility*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D196061256.

DOE/RL-94-41, 1994, *NEPA Roadmap for the Environmental Restoration Disposal Facility Regulatory Package*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D196074918.

DOE/RL-96-12, 1996, *Hanford Site Background; Part 2, Soil Background for Radionuclides*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www2.hanford.gov/arpir/?content=findpage&AKey=D1808987.

DOE/RL-96-32, 1996, *Hanford Site Biological Resources Management Plan,* Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www.pnl.gov/ecomon/Docs/brmap/BRMAP.html.

DOE/RL-96-77, 1996, *Programmatic Agreement Among the U.S. Department of Energy, Richland Operations Office, The Advisory Council on Historic Preservation, and the Washington State Historic Preservation Office for the Maintenance, Deactivation, Alteration, and Demolition of the Built Environment on the Hanford Site, Washington*, Rev. 0, Enclosure to letter 96-EAP-154, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=DA06717578.

DOE/RL-96-81, 1997, *Waste Site Grouping for 200 Areas Soil Investigations,* Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D197197143.

DOE/RL-96-88, 2003, *Hanford Site Biological Resources Mitigation Strategy*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www.pnl.gov/ecomon/Docs/BRMiS.pdf.

DOE/RL-97-56, 1998, *Hanford Site Manhattan Project and Cold War Era Historic District Treatment Plan*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-98-10, 2003, *Hanford Cultural Resources Management Plan*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-98-28, 1999, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D199153696.

DOE/RL-99-07, 2000, *200-CW-1 Operable Unit RI/FS Work Plan and 216-B-3 RCRA TSD Unit Sampling Plan*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www2.hanford.gov/arpir/?content=findpage&AKey=D8434692.

DOE/RL-99-11, 1999, *200-BP-1 Prototype Barrier Treatability Test Report*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D199157937.

DOE/RL-99-66, 2004, *Steam Condensate/Cooling Water Waste Group Operable Units RI/FS Work Plan; Includes: 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 Operable Units*, Rev. 1, Re-issue, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www2.hanford.gov/arpir/?content=findpage&AKey=D5962949.

DOE/RL-2000-62, 2003, *Hanford 2012—Accelerating Cleanup and Shrinking the Site*, Rev. 2, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2001-41, 2007, *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions*, Rev. 2, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=00099819.

DOE/RL-2001-54, 2005, *Central Plateau Ecological Evaluation*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2002-24, 2002, *200-CW-5 U Pond/Z Ditches Cooling Water Group Operable Unit Remedial Investigation Sampling and Analysis Plan*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D9043135.

DOE/RL-2002-39, 2002, *Standardized Stratigraphic Nomenclature for Post-Ringold Formation Sediments Within the Central Pasco Basin*, Rev. 0, U.S. Department of Energy, Richland, Washington.

DOE/RL-2003-11, 2004, *Remedial Investigation for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-SC-1 Steam Condensate Group Operable Units*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/pdwdocs/fsd0001/osti/2004/I0044981.pdf.

DOE/RL-2005-27, 2005, *Revised Mitigation Action Plan for the Environmental Restoration Disposal Facility*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2009-117, 2008, *Proposed Plan for the 200-CW-5 Cooling Water Operable Unit*, Draft B, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www2.hanford.gov/arpir/?content=findpage&AKey=0808050320.

DOE/RL-2007-27, 2009, *Feasibility Study for the Plutonium/Organic-Rich Process Condensate/Process Waste Group Operable Unit: Includes the 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units,* Draft B, REISSUE, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=0904240166.

DOE/RL-2007-50, 2008, *Central Plateau Terrestrial Ecological Risk Assessment Report*, Draft A REISSUE, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www2.hanford.gov/arpir/?content=findpage&AKey=DA06834859.

DOE/RL-2008-01, 2008, *Hanford Site Groundwater Monitoring for Fiscal Year 2007*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=00098824.

DOE/RL-2009-81, 2009, *Central Plateau Cleanup Completion Strategy*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www2.hanford.gov/arpir/?content=findpage&AKey=1002180676.

DOE/RL-2009-10, 2010, *Hanford Site Cleanup Completion Framework*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=1008190506.

DOE/RW-0164, 1988, *Consultation Draft Site Characterization Plan: Reference Repository Location, Hanford Site, Washington*, Vols. 1-9, U.S. Department of Energy, Washington, D.C. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D196007701.
http://www5.hanford.gov/arpir/?content=findpage&AKey=D196007769.
http://www5.hanford.gov/arpir/?content=findpage&AKey=D196007788.
http://www5.hanford.gov/arpir/?content=findpage&AKey=D196007871.
http://www5.hanford.gov/arpir/?content=findpage&AKey=D196007870.
http://www5.hanford.gov/arpir/?content=findpage&AKey=D196007876.
http://www5.hanford.gov/arpir/?content=findpage&AKey=D196007901.
http://www5.hanford.gov/arpir/?content=findpage&AKey=D196007935.
http://www5.hanford.gov/arpir/?content=findpage&AKey=D196027182.

DOE-STD-1153-2002, 2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*, DOE Technical Standard, U.S. Department of Energy, Washington, D.C. Available at http://www.hss.energy.gov/NuclearSafety/techstds/standard/std1153/1153.htm.

Drummond, M.E., 1992, *The Future for Hanford: Uses and Cleanup, The Final Report of the Hanford Future Site Uses Working Group*, Richland, Washington.

ECF-200CW5-10-0075, 2010, *Calculation of Preliminary Remediation Goals in Soil for an Industrial Worker Exposure Scenario*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

Ecology 94-145, 2001, *Cleanup Levels and Risk Calculations under the Model Toxics Control Act Cleanup Regulation; CLARC, Version 3.1*, Washington State Department of Ecology, Olympia, Washington.

Ecology, DOE, and EPA, 2002, *Hanford Tri-Party Agreement Modifications to 200 Area Waste Sites Cleanup Milestones, Tri-Party Agreement Change Requests and Comment and Response Document*, Change Number M-13-02-1, June 2002, Washington State Department of Ecology, U.S. Department of Energy, and U.S. Environmental Protection Agency, Olympia, Washington.

Ecology, EPA, and DOE, 1989a, *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.

Ecology, EPA, and DOE, 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan*, 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=82.

EPA, Ecology, and DOE, 2007, *Amendment to the Record of Decision for the USDOE Hanford Environmental Restoration Disposal Facility*, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=DA04316406.

EPA, Ecology, and DOE, 2010, *Proposed Changes to the Tri-Party Agreement for Central Plateau Cleanup Work*, Fact Sheet, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington. Available at: http://www.hanford.gov/files.cfm/TPA_CP_Fact_Sheet_FINAL_4-26.pdf.

EH-231-014/1292, 1992, *Use of Institutional Controls in a CERCLA Baseline Risk Assessment*, CERCLA Information Brief, U.S. Department of Energy, Office of Environmental Guidance, Washington, D.C. Available at: http://homer.ornl.gov/nuclearsafety/env/guidance/cercla/base.pdf.

Endangered Species Act of 1973, 16 USC 1531, et seq. Available at: http://www4.law.cornell.edu/uscode/16/ch35.html.

EPA, 1992, *Supplemental Guidance to RAGS: Calculating the Concentration Term*, OSWER Publication 9285.7-081, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.deq.state.or.us/lq/pubs/forms/tanks/UCLsEPASupGuidance.pdf.

EPA, 2002, *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites*, OSWER 9285.6-10, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://epa.gov/oswer/riskassessment/pdf/ucl.pdf.

EPA, 2003, *Remediation Technology Descriptions*, "Alternative Landfill Cover Project Profiles," Office of Solid Waste and Emergency Response, Technology Innovation Program, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.clu-in.org/products/altcovers/usersearch/lf_details.cfm?Project_ID=64.

EPA/540/1-89/002, 1989, *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A): Interim Final,* OSWER 9285.7-02B, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://epa.gov/swerrims/riskassessment/ragsa/pdf/rags-vol1-pta_complete.pdf.

EPA/540/2-88/002, 1988, *Technological Approaches to Cleanup of Radiologically Contaminated Superfund Sites*, U.S. Environmental Protection Agency, Washington, D.C.

EPA/540/G-89/004, 1988, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, Interim Final, OSWER 9355.3-01, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://epa.gov/superfund/policy/remedy/pdfs/540g-89004-s.pdf.

EPA/540/R-94/520, 1995, *Geosafe Corporation In Situ Vitrification, Innovative Technology Evaluation Report*, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, Ohio. Available at: http://www.epa.gov/nrmrl/lrpcd/site/reports/540r94520/540r94520.pdf.

EPA 540/R/99/006, 1999, *Radiation Risk Assessment At CERCLA Sites: Q&A*, Directive 9200.4-31P, Office of Emergency and Remedial Response, Office of Radiation and Indoor Air, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/oerrpage/superfund/resources/radiation/pdf/riskq&a1.pdf.

EPA/540/R-99/009, 1999, *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites*, OSWER 9200.4-17P, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/OUST/directiv/d9200417.pdf.

EPA/541/R-02/100, 2002, *Record of Decision (ROD) for Waste Area Group 7, Trenches 5 and 7 in Melton Valley at Oak Ridge National Laboratory*, U.S. Environmental Protection Agency, Washington, D.C.

EPA/600/R-07/038, 2007, *ProUCL Version 4.0 User Guide*, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/esd/tsc/images/proucl4user.pdf.

EPA/630/R-95/002F, 1998, *Guidelines for Ecological Risk Assessment*, U.S. Environmental Protection Agency, Risk Assessment Forum, Washington, D.C. Available at: http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=12460.

EPA/ROD/R10-95/100, 1995, *Declaration of the Interim Record of Decision for the Environmental Restoration Disposal Facility*, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington. Available at: http://www.epa.gov/superfund/sites/rods/fulltext/r1095100.pdf.

Executive Order 12898, 1994, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, William J. Clinton, February 11. Available at: http://www.epa.gov/fedrgstr/eo/eo12898.htm.

Gee, G.W., M.J. Fayer, M.L. Rockhold, and M.D. Campbell, 1992, "Variations in Recharge at the Hanford Site," *Northwest Science*, Vol. 66, pp. 237-250.

Hakonson, T.E., J.L. Martinez, and G.C. White, 1982, "Disturbance of a Low-Level Waste Burial Site Cover by Pocket Gophers," *Health Physics*, 42:868-871.

Hanford Site Historic Buildings, Hanford Site database.

Harris, S., 2008, *Application of the CTUIR Traditional Lifeways Exposure Scenario in Hanford Risk Assessments*, Department of Science and Engineering, Confederated Tribes of the Umatilla Indian Reservation, Pendleton, Oregon.

Harris, S. and B. Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways*, Department of Natural Resources, Confederated Tribes of Umatilla Indian Reservation, Pendleton, Oregon.

Harris, Stuart G. and Barbara L. Harper, 1997, "A Native American Exposure Scenario," *Risk Analysis*, Vol. 17, No. 6, pp. 789-795.

IAEA 332, 1992, *Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards*, Technical Report Series No. 332, International Atomic Energy Agency, Vienna, Austria.

ICRP-26, 1977, *Recommendations of the International Commission on Radiological Protection*, International Commission on Radiological Protection, Pergamon Press, New York.

ICRP-60, 1990, *Recommendations of the International Commission on Radiological Protection*, International Commission on Radiological Protection, Pergamon Press, New York.

INEEL-01-00281, 2001, *Engineering Design File, Operable Unit 7-13/14 Evaluation of Soil and Buried Waste Retrieval Technologies*, Rev. A, Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho.

Klein, K.A., D.R. Einan, and M.A. Wilson, 2002, "Consensus Advice #132: Exposure Scenarios Task Force on the 200 Area" (letter to Mr. Todd Martin, Hanford Advisory Board, from Keith A. Klein, U.S. Department of Energy; David R. Einan, U.S. Environmental Protection Agency; and Michael A. Wilson, State of Washington, Department of Ecology, 02-HAB-0006), Richland, Washington, July 11. Available at: http://www.hanford.gov/hanford/files/HAB_resp-132.pdf.

LA-UR-03-6494, 2003, *IM Completion Report for the NTISV Hot Demonstration at SWMU 21-018(a)-99 (MDA V),* Los Alamos National Laboratory, Los Alamos, New Mexico.

Migratory Bird Treaty Act of 1918, 16 USC 703, et seq. Available at: http://www.animallaw.info/statutes/stusmba.htm.

NAS, 1989, *Recommended Dietary Allowances* 10th Ed., National Academy of Science, Washington, D.C. Available at: http://www.nap.edu/catalog.php?record_id=1349#toc.

National Environmental Policy Act of 1969, 42 USC 4321, et seq. Available at: http://www.fhwa.dot.gov/environment/nepatxt.htm.

National Historic Preservation Act of 1966, 16 USC 470, et seq. Available at: http://www.law.cornell.edu/uscode/16/470.html.

NAVD88, 1988, *North American Vertical Datum of 1988*, National Geodetic Survey, Federal Geodetic Control Committee, Silver Spring, Maryland.

ORNL/TM-13141, 1995, *Effects of Ionizing Radiation on Terrestrial Plants and Animals: A Workshop Report*, Oak Ridge National Laboratory, Oak Ridge, Tennessee. Available at: http://www.esd.ornl.gov/programs/ecorisk/documents/tm13141.pdf.

PNL-4800 Suppl. 1, 1987, *In Situ Vitrification of Transuranic Waste: An Updated Systems Evaluation and Applications Assessment,* Pacific Northwest Laboratory, Richland, Washington. Available at: http://www.osti.gov/energycitations/product.biblio.jsp?query_id=18&page=0&osti_id=6757179.

PNL-5506, 1986, *Hanford Site Water Table Changes 1950 through 1980: Data Observations and Evaluation*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://www.osti.gov/energycitations/product.biblio.jsp?osti_id=5887785.

PNL-7264, 1990, *Archaeological Survey of the 200 East and 200 West Areas, Hanford Site*, *Washington,* Pacific Northwest Laboratory, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D197182656.

PNL-10285, 1995, *Estimated Recharge Rates at the Hanford Site,* Pacific Northwest Laboratory, Richland, Washington. Available at: http://www.osti.gov/energycitations/servlets/purl/10122247-XORHkt/webviewable/10122247.pdf.

PNNL-6415, 2005, *Hanford Site National Environmental Policy Act (NEPA) Characterization,* Rev. 17, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-6415Rev17.pdf.

PNNL-11217, 1996, *STOMP: Subsurface Transport Over Multiple Phases: Theory Guide*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.osti.gov/energycitations/servlets/purl/658243-GK2oSr/webviewable/658243.pdf.

PNNL-11346, 1996, *Plutonium Dioxide Dissolution in Glass*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.osti.gov/energycitations/servlets/purl/416955-wggQnx/webviewable/416955.pdf.

PNNL-11472, 1997, *Hanford Site Environmental Report for Calendar Year 1996*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://hanford-site.pnl.gov/envreport/1996/PNNL-11472_1996.pdf.

PNNL-13033, 1999, *Recharge Data Package for the Immobilized Low-Activity Waste 2001 Performance Assessment*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-13033.pdf.

PNNL-13788, 2002, *Hanford Site Groundwater Monitoring for Fiscal Year 2001*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-13788.pdf.

PNNL-14702, 2006, *Vadose Zone Hydrogeology Data Package for Hanford Assessments*, Rev. 1, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14702rev1.pdf.

PNNL-14960, 2005, *200-BP-1 Prototype Hanford Barrier Annual Monitoring Report for Fiscal Year 2004*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14960.pdf.

PNNL-16346, 2007, *Hanford Site Groundwater Monitoring for Fiscal Year 2006*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-16346.pdf.

PNNL-16623, 2007, *Hanford Site Environmental Report for Calendar Year 2006*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://hanford-site.pnl.gov/envreport/2006/pnnl_16623.pdf.

RCW 70.105, "Hazardous Waste Management," *Revised Code of Washington*, Olympia, Washington. Available at: http://apps.leg.wa.gov/RCW/default.aspx?cite=70.105.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq. Available at: http://www.epa.gov/epawaste/inforesources/online/index.htm.

RHO-HS-VS-4, unpublished (1982), *Earth Science Investigations of the 216-Z-20 Crib, the UN-216-W-20 Spoil Trench, and the Storm Sewer Pond*, Draft, Rockwell Hanford Operations, Richland, Washington.

RHO-LD-114, 1981, *Existing Data On the 216-Z Liquid Waste Sites*, Rockwell Hanford Operations, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D196055124.

Ridolfi, 2007, *Yakama Nation Exposure Scenario for Hanford Site Risk Assessment*, prepared for the Yakama Nation, Ridolfi Inc., Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=DA06587583.

SGW-35060, 2007, *Inventory Estimates for Liquid Discharges from the 231-Z Facility*, Rev. 0, Fluor Hanford, Inc., Richland, Washington.

SGW-37174, 2008, *Z-Ditches Study for the 200-CW-5 Cooling Water Operable Unit*, Rev. 0, Fluor Hanford, Inc., Richland, Washington.

WA7890008967, 2007, *Hanford Facility Resource Conservation and Recovery Act Permit, Dangerous Waste Portion, Revision 8C, for the Treatment, Storage, and Disposal of Dangerous Waste*, as amended, Washington State Department of Ecology, Richland, Washington. Available at: http://www.ecy.wa.gov/programs/nwp/piarchive12_07.htm#Hanfords_Site-wide_Permit.

WAC 173-340, "Model Toxics Control Act—Cleanup," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-340.

173-340-720, "Groundwater Cleanup Standards." Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-340-720.

173-340-740, "Unrestricted Land Use Soil Cleanup Standards." Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-340-740.

173-340-740(3), "Method B Soil Cleanup Levels for Unrestricted Land Use."

173-340-740(6), "Point of Compliance."

173-340-745, "Soil Cleanup Standards for Industrial Properties." Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-340-745.

173-340-745(5), "Method C Industrial Soil Cleanup Levels."

173-340-747, "Deriving Soil Concentrations for Ground Water Protection." Available at: http://apps.leg.wa.gov/wac/default.aspx?cite=173-340-747.

173-340-747(4), "Fixed Parameter Three-Phase Partitioning Model."

173-340-7490, "Terrestrial Ecological Evaluation Procedures." Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-340-7490.

173-340-7490(3)(b), "Goal."

173-340-7490(4), "Point of Compliance."

173-340-7490(4)(b), "Standard Point of Compliance."

173-340-7493, "Site-Specific Terrestrial Ecological Evaluation Procedures." Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-340-7493.

173-340-900, "Tables." Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-340-900.

Waste Information Data System Report, Hanford Site database.

WCH-191, 2008, *Environmental Restoration Disposal Facility Waste Acceptance Criteria*, Washington Closure Hanford, Richland, Washington. Available at: (http://www.wch-rcc.com/pgs/readroom/WCH/wch191.pdf.

WDFW, 2009, "Species of Concern" Washington State, current through June 1, 2009, Washington Department of Fish and Wildlife website. Available at: http://wdfw.wa.gov/conservation/endangered/.

WHC-EP-0707, 1994, *216-U-10 Pond and 216-Z-19 Ditch Characterization Studies*, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

WNHIS, 2009, "Washington Natural Heritage Information System List of Known Occurrences of Rare Plants and Animals in Washington February 2009," Washington Natural Heritage Information System, Washington State Department of Natural Resources, Olympia, Washington. Available at: http://www.psrc.org/assets/2098/apph.pdf.

WNHP, 2009, "List of Plants Tracked by the Washington Natural Heritage Program," Washington Natural Heritage Program, Washington State Department of Natural Resources, Olympia, Washington. Available at: http://www1.dnr.wa.gov/nhp/refdesk/lists/plantrnk.html.

WNHP, 2008, "Washington Rare Plant Species by County," Washington Natural Heritage Program, Washington Department of Natural Resources, Olympia, Washington. Available at: http://www1.dnr.wa.gov/nhp/refdesk/lists/plantsxco/countyindex.html.

Appendix A

Potential Applicable or Relevant and Appropriate Requirements

Terms

ALARA	as low as reasonably achievable
ARAR	Applicable or Relevant and Appropriate Requirement
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
HHE	human health and the environment
OU	operable unit
PCB	polychlorinated biphenyl
RCRA	*Resource Conservation and Recovery Act of 1976*
TBC	to be considered
TSCA	*Toxic Substances Control Act of 1976*
WAC	*Washington Administrative Code*

A1 Identification of Potential Applicable or Relevant and Appropriate Requirements for the 200-CW-5 Operable Unit

This appendix identifies and evaluates potential applicable or relevant and appropriate requirements (ARARs) for waste site remediation in the 200-CW-5 Operable Unit (OU). The potential ARARs identified in this appendix have been used to form the basis for the levels to which contaminants must be remediated to protect human health and the environment (HHE). The *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) provides for the identification of to be considered (TBC) non-promulgated advisories, criteria, guidance, or proposed standards that may be consulted to interpret remediation goals when ARARs do not exist or are insufficient. Independent of the TBC and ARARs identification process at the Hanford Site, the U.S. Department of Energy (DOE) has to consider the requirements of DOE directives.

Because the waste sites in the 200-CW-5 OU will be remediated under a CERCLA decision document, remedial and corrective actions at the sites will be required to meet ARARs. This appendix identifies and evaluates potential ARARs for these sites. Final ARARs for remediation will be established in the record of decision based on the selected remedy. In many cases, the ARARs form the basis for the preliminary remediation goals to which contaminants must be remediated to protect HHE. In other cases, the ARARs define or restrict how specific remedial measures can be implemented.

The ARARs identification process is based on CERCLA guidance (EPA/540/G-89/006, *CERCLA Compliance with Other Laws Manual: Interim Final*, and EPA/540/G-89/004, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, Interim Final, OSWER 9355.3-01). Section 121 of CERCLA 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 on site after completion of remedial action.

An "applicable" requirement is a requirement that a private party would have to comply with by law if the same action was being undertaken apart from CERCLA authority. All jurisdictional prerequisites of the requirement must be met for the requirement to be applicable.

"Relevant and appropriate" requirements refer to cleanup standards that address problems or situations sufficiently similar to those encountered at the CERCLA site which have a use that is well suited to the particular site (40 CFR 300.5, "National Oil and Hazardous Substances Pollution Contingency Plan," "Definitions"). An ARAR may not meet one or more jurisdictional prerequisites for applicability but still may make sense at the site, given the circumstances of the site and the release. In evaluating the relevance and appropriateness of a requirement, the eight comparison factors in 40 CFR 300.400(g)(2), "General," "Identification of Applicable or Relevant and Appropriate Requirements," 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 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 ARARs were evaluated to determine if they fall into one of three categories: chemical-specific, location-specific, or action-specific. These categories are defined as follows:

- Chemical-specific requirements are usually health- 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- or activity-based requirements or limitations triggered by the remedial actions performed at the site.

In summary, a requirement is applicable if the specific terms or jurisdictional prerequisites of the law or regulations directly address the circumstances at a site. If not applicable, a 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 requirement's use is well suited to the site. Only the substantive requirements (e.g., use of control/containment equipment, compliance with numerical standards) associated with ARARs apply to CERCLA on-site activities. ARARs associated with administrative requirements, such as permitting, are not applicable to CERCLA on-site activities (CERCLA, Section 121[e][1]). In general, this CERCLA permitting exemption will be extended to all remedial and corrective action activities conducted at the 200-CW-5 OU.

TBC information is nonpromulgated advisories or guidance issued by federal or state governments that is not legally binding and does not have the status of potential ARARs. In some circumstances, TBCs will be considered along with ARARs in determining the remedial action necessary for protection of HHE. The TBCs complement the ARARs in determining protectiveness at a site or implementation of certain actions. For example, because soil cleanup standards do not exist for all contaminants, health advisories, which would be TBCs, may be helpful in defining appropriate remedial action goals.

A1.1 Waivers from Applicable or Relevant and Appropriate Requirements

The U.S. Environmental Protection Agency (EPA) may waive ARARs and select a remedial action that does not attain the same level of site cleanup as that identified by the ARARs. Section 121 of 42 USC 103, *Superfund Amendments and Reauthorization Act of 1986*, identifies the following six circumstances in which the EPA may waive ARARs for on-site remedial actions:

- The remedial action selected is only a part of a total remedial action (such as 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 action will attain an equivalent standard of performance with 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.
- In the case of Section 104 (Superfund-financed remedial actions), compliance with the ARAR will not provide a balance between protecting HHE and the availability of Superfund money for response at other facilities.

No waivers are being requested for the 200-CW-5 OU.

A1.2 Potential Applicable or Relevant and Appropriate Requirements Applicable to Remedial Actions for Waste Sites in the 200-CW-5 Operable Unit

Potential federal and state ARARs are presented in Tables A-1 and A-2, respectively. The chemical-specific ARARs likely to be most relevant to remediation of the 200-CW-5 OU are elements of the Washington State regulations that implement WAC 173-340, "Model Toxics Control Act—Cleanup," specifically associated with developing risk-based concentrations for cleanup (WAC 173-340-745, "Soil Cleanup Standards for Industrial Properties"). The requirements of WAC 173-340-745 help establish soil cleanup standards for nonradioactive contaminants at waste sites. The state air emission standards are likely to be important in identifying air emission limits and control requirements for any remedial actions that produce air emissions. *Resource Conservation and Recovery Act of 1976* (RCRA) land-disposal restrictions will be important standards during the management of wastes generated during remedial actions.

Action-specific ARARs that could be pertinent to remediation are state solid and dangerous waste regulations (for management of characterization and remediation of wastes and performance standards for waste left in place) and *Atomic Energy Act of 1954* regulations (for performance standards for radioactive waste sites). For radionuclides, all management is governed by DOE O 435.1, *Radioactive Waste Management*. DOE O 435.1 applies, independent of the CERCLA ARARs, and cannot be waived through the CERCLA process. However, certain requirements of DOE O 435.1 can be met onsite under CERCLA through implementation of CERCLA requirements.

During remediation, a variety of waste streams may be generated under the proposed remedial action alternatives. It is anticipated that most of the waste will be designated as low-level waste. However, quantities of dangerous or mixed waste and waste contaminated with polychlorinated biphenyl (PCB) also could be generated. The great majority of the waste will be in a solid form. Waste management will be conducted in accordance with an approved waste management plan.

The identification, storage, treatment, and disposal of hazardous waste, and the hazardous component of mixed waste generated during the remedial action, would be subject to the substantive provisions of RCRA. In the State of Washington, RCRA is implemented through WAC 173-303, "Dangerous Waste Regulations," which is an EPA-authorized state RCRA program. The substantive portions of the dangerous waste standards for generation and storage would apply to the management of any dangerous or mixed waste generated during this remedial action. Treatment standards for dangerous or mixed waste that is subject to RCRA land-disposal restrictions are specified in WAC 173-303-140, "Land Disposal Restrictions," which incorporates 40 CFR 268, "Land Disposal Restrictions," by reference.

The *Toxic Substances Control Act of 1976* (TSCA) and regulations of 40 CFR 761, "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions," govern the management and disposal of PCB wastes. The TSCA regulations contain specific provisions for PCB waste, including PCB waste that contains a radioactive component. PCBs are also considered underlying hazardous constituents under RCRA and thus could be subject to WAC 173-303 and 40 CFR 268 requirements for wastes that also designate as hazardous or mixed wastes.

Removal and disposal of asbestos and asbestos-containing material are regulated under 42 USC 7401, *Clean Air Act of 1990*, and 40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," Subpart M, "National Emission Standards for Asbestos." These regulations provide for special precautions to prevent environmental releases or exposure to personnel of airborne emissions of asbestos fibers during remedial actions. Packaging requirements are identified in 40 CFR 61.52, "Emission Standard." Asbestos and asbestos-containing material would be removed, packaged as appropriate, and disposed of in the Environmental Restoration Disposal Facility (ERDF).

Waste designated as low-level waste that meets ERDF acceptance criteria is assumed to be disposed of at ERDF, which is engineered to meet appropriate performance standards of 10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Waste." In addition, waste designated as dangerous or mixed waste would be treated as appropriate to meet land-disposal restrictions and ERDF acceptance criteria, and would be disposed of at ERDF. ERDF is engineered to meet minimum technical requirements for landfills under WAC 173-303-665, "Landfills." Applicable packaging and pre-transportation requirements for dangerous or mixed waste generated at the 200-CW-5 OU would be identified and implemented before any waste is removed from the contamination area. Alternate disposal locations may be considered when the remedial action occurs, if a suitable and cost-effective location is identified. Any potential alternate disposal location will be evaluated by the EPA to ensure that it is adequately protective of HHE.

Waste designated as PCB remediation waste likely would be disposed of at ERDF, depending on whether it is low-level waste and meets the waste acceptance criteria. PCB waste that does not meet ERDF waste acceptance criteria would be retained at a PCB storage area that meets the requirements for TSCA storage and would be transported for future treatment (if necessary) and disposal at an appropriate disposal facility.

CERCLA Section 104(d)(4) states that where two or more noncontiguous facilities are reasonably related on the basis of geography, or on the basis of the threat or potential threat to the public health or welfare or the environment, the facilities can be treated as one for purposes of CERCLA response actions. Consistent with this, the 200-CW-5 OU and ERDF would be considered onsite for purposes of Section 104 of CERCLA, and waste may be transferred between the facilities without requiring a permit.

All alternative actions will be performed in compliance with the waste management ARARs. Waste streams will be evaluated, designated, and managed in compliance with the ARAR requirements. Before disposal, waste will be managed in a protective manner to prevent releases to the environment or unnecessary exposure to personnel.

The proposed remedial action alternatives have the potential to generate airborne emissions of both radioactive and criteria/toxic pollutants.

The RCW 70.94, "Public Health and Safety," "Washington Clean Air Act," requires regulation of radioactive air pollutants. The state implementing regulation WAC 173-480, "Ambient Air Quality Standards and Emission Limits for Radionuclides," sets standards that are as stringent or more so than the federal standards under the federal *Clean Air Act of 1990* and Amendments, and under the federal implementing regulation, 40 CFR 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities." The state standards protect the public by establishing exposure standards applicable to even the maximally exposed public individual, be that individual real or hypothetical. To that end, the standards address any member of the public, at the point of maximum annual air concentration in an unrestricted area where any member of the public may be. Radionuclide airborne emissions from the facility are not to exceed amounts that would cause an exposure to any said member of the public of greater than 10 mrem/yr effective dose equivalent. The state implementing regulation WAC 246-247, "Radiation Protection—Air Emissions," which adopts the WAC 173-480 standards, and requires verification of compliance with the 10 mrem/yr standard, would be applicable to the remedial action.

WAC 246-247 further addresses emission sources emitting radioactive airborne emissions by requiring monitoring of such sources. Such monitoring requires physical measurement of the effluent or ambient air. The substantive provisions of WAC 246-247 that require monitoring of radioactive airborne emissions would be applicable to the remedial action.

The above state-implementing regulations further address control of radioactive airborne emissions where economically and technologically feasible (WAC 246-247-040(3) and -040(4), "General Standards," and associated definitions). To address the substantive aspect of these requirements, best or reasonably achieved control technology will be addressed by ensuring that applicable emission control technologies (those successfully operated in similar applications) will be used when economically and technologically feasible (i.e., based on cost/benefit). If it is determined that there are substantive aspects of the requirement for control of radioactive airborne emissions, then controls will be administered as appropriate using reasonable and effective methods.

The federal implementing regulations also contain requirements for managing asbestos material associated with demolition and waste disposal (40 CFR 61, Subpart M).

Table A-1. Identification of Potential Federal ARARs and TBC for the Remedial Action Sites

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions," 40 CFR 761			
"Applicability," Specific Subsections: 40 CFR 761.50(b)(1) 40 CFR 761.50(b)(2) 40 CFR 761.50(b)(3) 40 CFR 761.50(b)(4) 40 CFR 761.50(b)(7) 40 CFR 761.50(c)	ARAR	These regulations establish standards for the storage and disposal of PCB wastes.	The substantive requirements of these regulations are applicable to the storage and disposal of PCB wastes (e.g., liquids, items, remediation waste, and bulk product waste) at ≥50 ppm. The specific subsections identified from 40 CFR 761.50(b) reference the specific sections for the management of PCB waste type. The disposal requirements for radioactive PCB waste are addressed in 40 CFR 761.50(b)(7). This is a chemical-specific requirement.
Archeological and Historic Preservation Act (1960), 16 USC 469a-1 through 469a-(2)d	ARAR	Requires that remedial actions at 200-CW-5 OU waste sites do not cause the loss of any archaeological or historic data. This act mandates preservation of the data and does not require protection of the actual waste site or facility.	Archeological and historic sites have been identified within the 200 Area; therefore, the substantive requirements of this act are applicable to actions that might disturb these sites. This is a location-specific requirement.
National Historic Preservation Act of 1966, 16 USC 470, Section 106	ARAR	Requires federal agencies to consider the impacts of their undertaking on cultural properties through identification, evaluation and mitigation processes, and consultation with interested parties.	Cultural and historic sites have been identified within the 200 Area; therefore, the substantive requirements of this act are applicable to actions that might disturb these types of sites. This is a location-specific requirement.
Native American Graves Protection and Repatriation Act of 1990, 25 USC 3001, et seq.	ARAR	Establishes federal agency responsibility for discovery of human remains, associated and unassociated funerary objects, sacred objects, and items of cultural patrimony.	Substantive requirements of this act are applicable if remains and sacred objects are found during remediation and will require Native American Tribal consultation in the event of discovery. This is a location-specific requirement.
Endangered Species Act of 1973, 16 USC 1531 et seq., subsection 16 USC 1536(c)	ARAR	Prohibits actions by federal agencies that are likely to jeopardize the continued existence of listed species or to result in the destruction or adverse modification or critical habitat. If remediation is within critical habitat or buffer zones surrounding threatened or endangered species, mitigation measures must be taken to protect the resource.	Substantive requirements of this act are applicable if threatened or endangered species are identified in areas where remedial actions will occur. This is a location-specific requirement.

Note: Regulations pursuant to the *Resource Conservation and Recovery Act of 1976* and implemented through WAC 173-303, "Dangerous Waste Regulations" (see Table A-2).

Table A-2. Identification of Potential State ARARs and TBC for the Remedial Action Sites

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
		"Dangerous Waste Regulations," WAC 173-303	
"Identifying Solid Waste," WAC 173-303-016	ARAR	Identifies those materials that are and are not solid wastes.	Substantive requirements of these regulations are applicable, because these define how to determine which materials are subject to the designation regulations. Specifically, materials that are generated for removal from the CERCLA site during the remedial action would be subject to the procedures for identification of solid waste to ensure proper management. This is an action-specific requirement.
"Recycling Processes Involving Solid Waste," WAC 173-303-017	ARAR	Identifies materials that are and are not solid wastes when recycled.	Substantive requirements of these regulations are applicable, because these define how to determine which materials are subject to the designation regulations. Specifically, materials that are generated for removal from the CERCLA site during the remedial action would be subject to the procedures for identification of solid waste to ensure proper management. This is an action-specific requirement.
"Designation of Dangerous Waste," "Designation Procedures," WAC 173-303-070(3)	ARAR	Establishes the method for determining whether a solid waste is, or is not, a dangerous waste or an extremely hazardous waste.	Substantive requirements of these regulations are applicable to materials encountered during the remedial action. Specifically, solid waste that is generated for removal from the CERCLA site during this remedial action would be subject to the dangerous waste designation procedures to ensure proper management. This is an action-specific requirement.
"Excluded Categories of Waste," WAC 173-303-071	ARAR	Describes those categories of wastes that are excluded from the requirements of WAC 173-303 (excluding WAC 173-303-050, "Department of Ecology Cleanup Authority").	The conditions of this requirement are applicable to remedial actions in the 200-CW-5 OU, should wastes identified in WAC 173-303-071 be encountered. This is an action-specific requirement.

Table A-2. Identification of Potential State ARARs and TBC for the Remedial Action Sites

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Conditional Exclusion of Special Wastes," WAC 173-303-073	ARAR	Establishes the conditional exclusion and the management requirements of special wastes, as defined in WAC 173-303-040, "Definitions."	Substantive requirements of these regulations are applicable to materials encountered during the remedial action. Specifically, the substantive standards for management of special waste are applicable to the interim management of certain waste that will be generated during the remedial action. This is an action-specific requirement.
"Requirements for Universal Waste," WAC 173-303-077	ARAR	Identifies those wastes exempted from regulation under WAC 173-303-140, "Land Disposal Restrictions," and WAC 173-303-170 through 173-303-9907 (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."	Substantive requirements of these regulations are applicable to materials encountered during the remedial action. Specifically, the substantive standards for management of universal waste are applicable to the interim management of certain waste that will be generated during the remedial action. This is an action-specific requirement.
"Recycled, Reclaimed, and Recovered Wastes," WAC 173-303-120 Specific Subsections: WAC 173-303-120(3) WAC 173-303-120(5)	ARAR	These regulations define the requirements for recycling 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.	Substantive requirements of these regulations are applicable to certain materials that might be encountered during the remedial action. Recyclable materials that are exempt from regulation as dangerous waste and that are not otherwise subject to CERCLA as hazardous substances can be recycled and/or conditionally excluded from certain dangerous waste requirements. This is an action-specific requirement.

Table A-2. Identification of Potential State ARARs and TBC for the Remedial Action Sites

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Land Disposal Restrictions," "Land Disposal Restrictions and Prohibitions," WAC 173-303-140(4)	ARAR	This regulation establishes state standards for land disposal of dangerous waste and incorporates, by reference, federal land-disposal restrictions of 40 CFR 268, "Land Disposal Restrictions," that are applicable to solid waste that is designated as dangerous or mixed waste in accordance with WAC 173-303-070(3).	The substantive requirements of this regulation are applicable to materials encountered during the remedial action. Specifically, dangerous/mixed waste that is generated and removed from the CERCLA site during the remedial action for off-site (as defined by CERCLA) land disposal would be subject to the identification of applicable land-disposal restrictions at the point of generation of the waste. The actual off-site treatment of such waste would not be an ARAR to this remedial action, but instead would be subject to all applicable laws and regulations. This is an action-specific requirement.
"Requirements for Generators of Dangerous Waste," WAC 173-303-170	ARAR	Establishes the requirements for dangerous waste generators.	Substantive requirements of these regulations are applicable to materials encountered during the remedial action. Specifically, the substantive standards for management of dangerous/mixed waste are applicable to the interim management of certain waste that will be generated during the remedial action. For purposes of this remedial action, WAC 173-303-170(3) includes the substantive provisions of WAC 173-303-200, "Accumulating Dangerous Waste On-Site," by reference. WAC 173-303-200 further includes certain substantive standards from WAC 173-303-630, "Use and Management of Containers," and 173-303-640, "Tank Systems," by reference. This is an action-specific requirement.
"Requirements," WAC 173-303-64620(4)	ARAR	Requires corrective action to be "consistent with" specified sections in WAC 173-340.	The substantive portions of this regulations establishes the minimum requirements for *Washington State Hazardous Waste Management Act of 1976* (RCW 70.105) corrective action,

Table A-2. Identification of Potential State ARARs and TBC for the Remedial Action Sites

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Model Toxics Control Act—Cleanup," WAC 173-340 (as amended October 2007)			
"Ground Water Cleanup Standards," "Adjustments to Cleanup Levels," "Adjustments to Applicable State and Federal Laws" WAC 173-340-720(7)(b)	ARAR	Permits an adjustment of an existing state or federal cleanup standard downward so that the total excess cancer risk does not exceed 1 x 10^{-5} and the hazard index does not exceed 1.	The groundwater beneath the 200-PW-1/3/6 OUs is not currently used for drinking water. However, Central Plateau groundwater may be considered a potential drinking water source and, because the groundwater discharges to the Columbia River (which is used for drinking water), the substantive requirements in WAC 173-340-720(7)(b) are relevant and appropriate. This requirement is chemical-specific.
"Soil Cleanup Standards for Industrial Properties," "Method C Industrial Soil Cleanup Levels," Standard Method C Industrial Soil Cleanup Levels," WAC 173-340-745(5)(b)	ARAR	Establishes the process and methods used to evaluate direct contact risk to human health and the environment and to develop cleanup standards for soil and other environmental media.	Soil in the 200-PW-1/3/6 OU contains contaminants that require remediation. The substantive requirements of the specified subsections are pertinent to developing cleanup standards for the selected remedy for the 200-PW-1/3/6 OU. This is a chemical-specific requirement.
"Deriving Soil Concentrations for Ground Water Protection," "Overview of Methods," WAC 173-340-747(3)	ARAR	Establishes the process and methods used to evaluate soil concentration that may cause an impact to human health and the environment through the groundwater and to develop cleanup standards for soil and other environmental media.	Soil in the 200-PW-1/3/6 OU contains contaminants that require remediation. The substantive requirements of the specified subsections are pertinent to developing cleanup standards for the selected remedy for the 200-PW-1/3/6 OU. This is a chemical-specific requirement.
"Site-Specific Terrestrial Ecological Evaluation Procedures," "Selection of Appropriate Terrestrial Ecological Evaluation Methods," WAC 173-340-7493(3)	ARAR	Establishes the process and methods used to evaluate soil concentration that may cause an impact to terrestrial ecology and to develop cleanup standards for soil and other environmental media.	Soil in the 200-PW-1/3/6 OU contains contaminants that require remediation. The substantive requirements of the specified subsections are pertinent to developing cleanup standards for the selected remedy for the 200-PW-1/3/6 OU. This is a chemical-specific requirement.

Table A-2. Identification of Potential State ARARs and TBC for the Remedial Action Sites

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Minimum Standards for Construction and Maintenance of Wells," WAC 173-160			
"How Shall Each Water Well Be Planned and Constructed?" WAC 173-160-161	ARAR	Identifies well planning and construction requirements.	The substantive requirements of this regulation are applicable to actions that include construction of wells used for groundwater extraction, monitoring, or injection of treated groundwater or wastes. The requirements of WAC 173-160-161 through 173-160-381 (excluding 173-160-211, 173-160-251, 173-160-261, 173-160-361), 173-160-400, 173-160-420, 173-303-430, 173-160-440, 173-160-450, and 173-160-460 are applicable to groundwater well construction, monitoring, or injection of treated groundwater or wastes in the 200-CW-5 OU. This is an action-specific requirement.
"What Are the Requirements for the Location of the Well Site and Access to the Well?" WAC 173-160-171	ARAR	Identifies the requirements for locating a well.	
"What Are the Requirements for Preserving the Natural Barriers to Ground Water Movement Between Aquifers?" WAC 173-160-181	ARAR	Identifies the requirements for preserving natural barriers to groundwater movement between aquifers.	
"What Are the Design and Construction Requirements for Completing Wells?" WAC 173-160-191	ARAR	Identifies the design and construction requirements for completing wells.	
"What Are the Casing and Liner Requirements?" WAC 173-160-201	ARAR	Identifies the casing and liner requirements for water supply wells.	
"What Are the Standards for Sealing Materials?" WAC 173-160-221	ARAR	Identifies the requirements for sealing materials.	
"What Are the Standards for Surface Seals?" WAC 173-160-231	ARAR	Identifies the requirements for surface seals on water wells.	
"What Are the Requirements for Formation Sealing?" WAC 173-160-241	ARAR	Identifies the requirements for formation sealing.	

Table A-2. Identification of Potential State ARARs and TBC for the Remedial Action Sites

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"What Are the Special Sealing Standards for Driven Wells, Jetted Wells, and Dewatering Wells?" WAC 173-160-271	ARAR	Identifies the special sealing standards for driven wells, jetted wells, and dewatering wells.	
"What Are the Construction Standards for Artificial Gravel-Packed Wells?" WAC 173-160-281	ARAR	Identifies the construction standards for artificial gravel-packed wells.	
"What Are the Standards for the Upper Terminal of Water Wells?" WAC 173-160-291	ARAR	Identifies the standards for the upper terminal of water wells.	
"What Are the Requirements for Temporary Capping?" WAC 173-160-301	ARAR	Identifies the requirements for the temporary surface barrier.	
"What Are the Well Tagging Requirements?" WAC 173-160-311	ARAR	Identifies the requirements for well tagging.	
"How Do I Test a Well?" WAC 173-160-321	ARAR	Identifies the standards for testing a well.	
"How Do I Make Sure My Equipment and the Water Well Are Free of Contaminants?" WAC 173-160-331	ARAR	Identifies the method for keeping equipment and the water well free of contaminants.	
"How Do I Ensure the Quality of Drilling Water?" WAC 173-160-341	ARAR	Identifies the method for ensuring the quality of the well water.	
"What Are the Standards for Pump Installation?" WAC 173-160-351	ARAR	Identifies the standards for the installation of a pump.	

Table A-2. Identification of Potential State ARARs and TBC for the Remedial Action Sites

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"What Are the Standards for Chemical Conditioning?" WAC 173-160-371	ARAR	Identifies the standard for chemical conditioning.	
"What Are the Standards for Decommissioning a Well?" WAC 173-160-381	ARAR	Identifies the standard for decommissioning a well.	
"What Are the Minimum Standards for Resource Protection Wells and Geotechnical Soil Borings? WAC 173-160-400	ARAR	Identifies the minimum standards for resource protection wells and geotechnical soil borings.	
"What Are the General Construction Requirements for Resource Protection Wells?" WAC 173-160-420	ARAR	Identifies the general construction requirements for resource protection wells.	
"What Are the Minimum Casing Standards?" WAC 173-160-430	ARAR	Identifies the minimum casing standards.	
"What Are the Equipment Cleaning Standards?" WAC 173-160-440	ARAR	Identifies the equipment cleaning standards.	
"What Are the Well Sealing Requirements?" WAC 173-160-450	ARAR	Identifies the well sealing requirements.	
"What Is the Decommissioning Process for Resource Protection Wells?" WAC 173-160-460	ARAR	Identifies the decommissioning process for resource protection wells.	

Table A-2. Identification of Potential State ARARs and TBC for the Remedial Action Sites

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Radiation Protection—Air Emissions," WAC 246-247			
"National Standards Adopted by Reference for Sources of Radionuclide Emissions," WAC 246-247-035(1)(a)(ii)	ARAR	This regulation establishes requirements of 40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," Subpart H, "National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities," by reference. Radionuclide airborne emissions from the facility shall be controlled so as not to exceed amounts that would cause an exposure to any member of the public of greater than 10 mrem/yr effective dose equivalent.	Substantive requirements of this standard are applicable because this remedial action may include activities such as excavation, decontamination and stabilization of contaminated areas and equipment, and operation of exhausters and vacuums, each of which may provide airborne emissions of radioactive particulates to unrestricted areas. As a result, requirements limiting emissions apply. This is a risk-based standard for the purposes of protecting human health and the environment. This is an action-specific requirement.
"General Standards," WAC 246-247-040(3) WAC 246-247-040(4)	ARAR	Emissions shall be controlled to ensure that emission standards are not exceeded.	Substantive requirements of this standard are applicable because fugitive, diffuse, and point source emissions of radionuclides to the ambient air may result from activities such as excavation of contaminated soils and operation of exhauster and vacuums, performed during the remedial action. This standard exists to ensure compliance with emission standards. This is an action-specific requirement.

Table A-2. Identification of Potential State ARARs and TBC for the Remedial Action Sites

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Monitoring, Testing, and Quality Assurance," WAC 246-247-075(1) WAC 246-247-075(2) WAC 246-247-075(4)	ARAR	Establishes the monitoring, testing, and quality assurance requirements for radioactive air emissions from major sources. Effluent flow rate measurements shall be made and the effluent stream shall be directly monitored continuously with an in-line detector or representative samples of the effluent stream shall be withdrawn continuously from the sampling site following the specified guidance. The requirements for continuous sampling are applicable to batch processes when the unit is in operation. Periodic sampling (grab samples) may be used only with lead agency prior approval. Such approval may be granted in cases where continuous sampling is not practical and radionuclide emission rates are relatively constant. In such cases, grab samples shall be collected with sufficient frequency to provide a representative sample of the emissions. When it is impractical to measure the effluent flow rate at a source in accordance with the requirements or to monitor or sample an effluent stream at a source in accordance with the site selection and sample extraction requirements, the facility owner or operator may use alternative effluent flow rate measurement procedures or site selection and sample extraction procedures as approved by the lead agency. 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.	Substantive requirements of this standard are applicable because fugitive and nonpoint source emissions of radionuclides to the ambient air may result from activities such as excavation of contaminated soils and operation of exhauster and vacuums, performed during the remedial action. This standard exists to ensure compliance with emission standards. This is an action-specific requirement.
"Monitoring, Testing, and Quality Assurance," WAC 246-247-075(3)	ARAR	Methods to implement periodic confirmatory monitoring for minor sources may include estimating the emissions or other methods approved by the lead agency.	Fugitive and diffuse emissions from the excavation and related activities will require periodic confirmatory measurements to verify low emissions and are applicable. This is an action-specific requirement.

Table A-2. Identification of Potential State ARARs and TBC for the Remedial Action Sites

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Monitoring, Testing, and Quality Assurance," WAC 246-247-075(8)	ARAR	Facility (site) emissions resulting from nonpoint and fugitive sources of airborne radioactive material shall be measured. Measurement techniques may include ambient air measurements, or in-line radiation detector or withdrawal of representative samples from the effluent stream, or other methods as determined by the lead agency.	Fugitive and diffuse emissions of airborne radioactive material due to excavation and related activities will require measurement and are applicable. This is an action-specific requirement.
"General Standards," WAC 246-247-040(4) and "Ambient Air Quality Standards and Emission Limits for Radionuclides," "General Standards for Maximum Permissible Emissions," WAC 173-480-050(1)	ARAR	At a minimum, all emission units shall make every reasonable effort to maintain radioactive materials in effluents to unrestricted areas ALARA. Control equipment of facilities operating under ALARA shall be defined as reasonably available control technology and as low as reasonably achievable control technology.	The potential for fugitive and diffuse emissions due to excavation and related activities will require efforts to minimize those emissions and are applicable. This is an action-specific requirement.
"Emission Monitoring and Compliance Procedures," WAC 173-480-070(2)	ARAR	Compliance with the public dose standard shall be determined by calculating exposure at the point of maximum annual air concentration in an unrestricted area where any member of the public may be.	Fugitive and diffuse emissions resulting from excavation and related activities will require assessment and reporting and are applicable. This is an action-specific requirement.
"General Regulations for Air Pollution Sources," WAC 173-400			
"General Standards for Maximum Emissions," WAC 173-400-040	ARAR	Requires all sources of air contaminants to meet standards for visible emissions, fallout, fugitive emissions, odors, emissions detrimental to persons or property, sulfur dioxide, concealment and masking, and fugitive dust. Requires use of reasonably available control technology.	Substantive requirements are applicable to the selected remedy. The remedy likely will include or result in various sources of air contaminant emissions (e.g., construction and demolition debris, blowing dust or particulate) that will need to be controlled in accordance with these requirements. This is an action-specific requirement.

Table A-2. Identification of Potential State ARARs and TBC for the Remedial Action Sites

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Emission Standards for Combustion and Incineration Units," WAC 173-400-050 "Emission Standards for General Process Units," WAC 173-400-060 "Emission Standards for Certain Source Categories," WAC 173-400-070 "Emission Standards for Sources Emitting Hazardous Air Pollutants," WAC 173-400-075	ARAR	Requires specifically identified types of emission sources to meet additional standards beyond the general emission standards imposed by WAC 173-400-040. Incorporates the applicable federal requirements from 40 CFR 60, "Standards of Performance for New Stationary Sources," and 40 CFR 63, "National Emission Standards for Hazardous Air Pollutants for Source Categories." Requires use of either reasonably available control technology, best available control technology or maximum achievable control technology, depending on the specific type of emission source.	The substantive requirements are applicable to the selected remedy. The remedy may include or result in one or more defined types of emission sources that would need to be controlled in accordance with these requirements. This is an action-specific requirement.
"Requirements for New Sources in Attainable or Unclassifiable Areas," WAC 173-400-113	ARAR	Incorporates by reference the applicable federal requirements from 40 CFR 60, 40 CFR 61, and 40 CFR 63 (maximum achievable control technology). Requires controls to minimize the release of air contaminants resulting from new or modified sources of regulated criteria and toxic air emissions. Emissions are to be minimized through application of best available control technology.	The Hanford Site is located in an area that is currently designated as being in attainment for all criteria air pollutants. The substantive requirements are applicable to the selected remedy. The remedy may include or result in one or more defined types of emission sources that would need to be controlled in accordance with these requirements. Selected remedy may include or result in the emission of regulated pollutants that would need to be controlled in accordance with these requirements. This is an action-specific requirement.

Table A-2. Identification of Potential State ARARs and TBC for the Remedial Action Sites

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Controls for New Sources of Toxic Air Pollutants," WAC 173-460			
"Applicability," WAC 173-460-030 "Control Technology Requirements," WAC 173-460-060 "Ambient Impact Requirement," WAC 173-460-070 "First Tier Review," WAC 173-460-080 "Table of ASIL, SQER and De Minimis Emission Values," WAC 173-460-150 "Class B Toxic Air Pollutants and Acceptable Source Impact Levels," WAC 173-460-160	ARAR	Requires best available control technology for regulated emissions of toxic air pollutants and demonstration that emissions of toxic air pollutants will not endanger human health or safety.	The substantive requirements are applicable to the selected remedy. The remedy may include or result in the emission of regulated toxic air pollutants that would need to be controlled in accordance with these requirements. This is an action-specific requirement.

A2 References

10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Waste," *Code of Federal Regulations*. Available at: http://www.access.gpo.gov/nara/cfr/waisidx_09/10cfr61_09.html.

40 CFR 60, "Standards of Performance for New Stationary Sources," *Code of Federal Regulations*. Available at: http://www.access.gpo.gov/nara/cfr/waisidx_08/40cfr60_08.html.

40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," *Code of Federal Regulations*. Available at: http://www.access.gpo.gov/nara/cfr/waisidx_08/40cfr61_08.html.

61.52, "Emission Standard." Available at: http://edocket.access.gpo.gov/cfr_2009/julqtr/40cfr61.52.htm.

Subpart H, "National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities." Available at: http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=b82e7384296a8862ac89f0477bac61d4&rgn=div6&view=text&node=40:8.0.1.1.1.8&idno=40.

Subpart M, "National Emission Standards for Asbestos." Available at: http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr;sid=b3a0328bdaef71e61a0bb4104545332d;rgn=div6;view=text;node=40%3A8.0.1.1.1.13;idno=40;cc=ecfr.

40 CFR 63, "National Emission Standards for Hazardous Air Pollutants for Source Categories," *Code of Federal Regulations*. Available at: http://www.access.gpo.gov/nara/cfr/waisidx_08/40cfr63_08.html.

40 CFR 268, "Land Disposal Restrictions," *Code of Federal Regulations*. Available at: http://www.access.gpo.gov/nara/cfr/waisidx_08/40cfr268_08.html.

40 CFR 300.5, "National Oil and Hazardous Substances Pollution Contingency Plan," "Definitions, *Code of Federal Regulations*." Available at: http://edocket.access.gpo.gov/cfr_2009/julqtr/40cfr300.5.htm.

40 CFR 300.400(g)(2), "National Oil and Hazardous Substances Pollution Contingency Plan," "General," "Identification of Applicable or Relevant and Appropriate Requirements." Available at: http://edocket.access.gpo.gov/cfr_2009/julqtr/40cfr300.400.htm.

40 CFR 761, "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions," *Code of Federal Regulations*. Available at: http://www.access.gpo.gov/nara/cfr/waisidx_08/40cfr761_08.html.

40 CFR 761.50(b), "Applicability," "PCB Waste." Available at: http://edocket.access.gpo.gov/cfr_2009/julqtr/40cfr761.50.htm.

40 CFR 761.50(c), "Applicability," "Storage for Disposal." Available at: http://edocket.access.gpo.gov/cfr_2009/julqtr/40cfr761.50.htm.

Archeological and Historic Preservation Act (1960), 16 USC 469-469c. Available at: http://www.nps.gov/history/local-law/FHPL_ArchHistPres.pdf.

Atomic Energy Act of 1954, 42 USC 2011, et seq. Available at: http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0980/ml022200075-vol1.pdf.

Clean Air Act of 1990, 42 USC 7401, et seq., Pub. L. 101-549. Available at: http://www.epa.gov/air/caa/.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 USC 9601, et seq. Available at: http://uscode.house.gov/download/pls/42C103.txt.

DOE O 435.1 Chg 1, *Radioactive Waste Management*, as amended, U.S. Department of Energy, Washington, D.C. Available at: https://www.directives.doe.gov/directives/current-directives/435.1-BOrder-c1/view.

Endangered Species Act of 1973, 16 USC 1531, et seq. Available at: http://www.fws.gov/endangered/pdfs/ESAall.pdf.

EPA/540/G-89/004, 1988, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, Interim Final, OSWER 9355.3-01, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://epa.gov/superfund/policy/remedy/pdfs/540g-89004-s.pdf.

EPA/540/G-89/006, 1988, *CERCLA Compliance with Other Laws Manual: Interim Final*, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/superfund/resources/remedy/pdf/540g-89006-s.pdf.

National Historic Preservation Act of 1966, 16 USC 470, et seq. Available at: http://www.achp.gov/NHPA.pdf.

Native American Graves Protection and Repatriation Act of 1990, 25 USC 3001, et seq. Available at: http://www.nps.gov/history/local-law/FHPL_NAGPRA.pdf.

RCW 70.94, "Public Health and Safety," "Washington Clean Air Act," *Revised Code of Washington*, as amended, Washington State, Olympia, Washington. Available at: http://apps.leg.wa.gov/RCW/default.aspx?cite=70.94.

RCW 70.105, "Hazardous Waste Management," *Revised Code of Washington*, Olympia, Washington. Available at: http://apps.leg.wa.gov/RCW/default.aspx?cite=70.105.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq. Available at: http://www.epa.gov/epawaste/inforesources/online/index.htm.

Superfund Amendments and Reauthorization Act of 1986, 42 USC 103, et seq. Available at: http://www.epa.gov/superfund/policy/sara.htm.

Toxic Substances Control Act of 1976, 15 USC 2601, et seq. Available at: http://frwebgate.access.gpo.gov/cgi-bin/usc.cgi?ACTION=BROWSE&TITLE=15USCC53.

WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-160.

173-160-161, "How Shall Each Water Well Be Planned and Constructed?" Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-160-161.

173-160-171, "What Are the Requirements for the Location of the Well Site and Access to the Well?" Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-160-171.

173-160-181, "What Are the Requirements for Preserving the Natural Barriers to Ground Water Movement Between Aquifers?" Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-160-181.

173-160-191, "What Are the Design and Construction Requirements for Completing Wells?" Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-160-191.

173-160-201, "What Are the Casing and Liner Requirements?" Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-160-201.

173-160-221, "What Are the Standards for Sealing Materials?" Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-160-221.

173-160-231, "What Are the Standards for Surface Seals?" Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-160-231.

173-160-241, "What Are the Requirements for Formation Sealing?" Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-160-241.

173-160-271, "What Are the Special Sealing Standards for Driven Wells, Jetted Wells, and Dewatering Wells?" Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-160-271.

173-160-281, "What Are the Construction Standards for Artificial Gravel-Packed Wells?" Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-160-281.

173-160-291, "What Are the Standards for the Upper Terminal of Water Wells?" Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-160-291.

173-160-301, "What Are the Requirements for Temporary Capping?" Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-160-301.

173-160-311, "What Are the Well Tagging Requirements?" Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-160-311.

173-160-321, "How Do I Test a Well?" Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-160-321.

173-160-331, "How Do I Make Sure My Equipment and the Water Well Are Free of Contaminants?" Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-160-331.

173-160-341, "How Do I Ensure the Quality of Drilling Water?" Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-160-341.

173-160-351, "What Are the Standards for Pump Installation?" Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-160-351.

173-160-371, "What Are the Standards for Chemical Conditioning?" Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-160-371.

173-160-381, "What Are the Standards for Decommissioning a Well?" Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-160-381.

173-160-400, “What Are the Minimum Standards for Resource Protection Wells and Geotechnical Soil Borings?” Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-160-400.

173-160-420, “What Are the General Construction Requirements for Resource Protection Wells?” Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-160-420.

173-160-430, “What Are the Minimum Casing Standards?” Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-160-430.

173-160-440, “What Are the Equipment Cleaning Standards?” Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-160-440.

173-160-450, “What Are the Well Sealing Requirements?” Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-160-450.

173-160-460, “What Is the Decommissioning Process for Resource Protection Wells?” Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-160-460.

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

173-303-016, “Identifying Solid Waste.” Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303-016.

173-303-017, “Recycling Processes Involving Solid Waste.” Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303-016.

173-303-040, “Definitions.” Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303-040.

173-303-050, “Department of Ecology Cleanup Authority.” Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303-050.

173-303-070(3), “Designation of Dangerous Waste,” “Designation Procedures.” Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303-070.

173-303-071, “Excluded Categories of Waste.” Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303-071.

173-303-073, “Conditional Exclusion of Special Wastes.” Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303-073.

173-303-077, “Requirements for Universal Waste.” Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303-077.

173-303-120, “Recycled, Reclaimed, and Recovered Wastes.” Available at: http://apps.leg.wa.gov/wac/default.aspx?cite=173-303-120.

173-303-120(3) and -120(5).

173-303-140, “Land Disposal Restrictions.” Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303-140.

173-303-140(4), “Land Disposal Restrictions and Prohibitions.”

173-303-170, "Requirements for Generators of Dangerous Waste." Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303-170.

173-303-200, "Accumulating Dangerous Waste On-Site." Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303-200.

173-303-573, "Standards for Universal Waste Management." Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303-573.

173-303-630, "Use and Management of Containers." Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303-630.

173-303-640, "Tank Systems." Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303-640.

173-303-665, "Landfills." Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303-665.

173-303-960, "Special Powers and Authorities of the Department." Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303-960.

73-303-64620, "Requirements." Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303-64620.

WAC 173-340, "Model Toxics Control Act—Cleanup," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-340.

173-340-720(7)(b), "Ground Water Cleanup Standards," "Adjustments to Cleanup Levels," "Adjustments to Applicable State and Federal Laws." Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-340-720.

173-340-745, "Soil Cleanup Standards for Industrial Properties." Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-340-745.

173-340-745(5)(b), "Method C Industrial Soil Cleanup Levels," "Standard Method C Industrial Soil Cleanup Levels."

173-340-747, "Deriving Soil Concentrations for Ground Water Protection," "Overview of Methods." Available at: http://apps.leg.wa.gov/wac/default.aspx?cite=173-340-747.

173-340-7493(3), "Site-Specific Terrestrial Ecological Evaluation Procedures," "Selection of Appropriate Terrestrial Ecological Evaluation Methods." Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-340-7493.

WAC 173-400, "General Regulations for Air Pollution Sources," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-400.

173-400-040, "General Standards for Maximum Emissions." Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-400-040.

173-400-050, "Emission Standards for Combustion and Incineration Units." Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-400-050.

173-400-060, "Emission Standards for General Process Units." Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-400-060.

173-400-070, "Emission Standards for Certain Source Categories." Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-400-070.

173-400-075, "Emission Standards for Sources Emitting Hazardous Air Pollutants." Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-400-075.

173-400-113, "Requirements for New Sources in Attainable or Unclassifiable Areas." Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-400-113.

WAC 173-460, "Controls for New Sources of Toxic Air Pollutants," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-460.

173-460-030, "Applicability." Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-460-030.

173-460-060, "Control Technology Requirements." Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-460-060.

173-460-070, "Ambient Impact Requirement." Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-460-070.

173-460-080, "First Tier Review." Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-460-080.

173-460-150, "Table of ASIL, SQER and De Minimis Emission Values." Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-460-150.

173-460-160, "Class B Toxic Air Pollutants and Acceptable Source Impact Levels."

WAC 173-480, "Ambient Air Quality Standards and Emission Limits for Radionuclides," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-480.

173-480-050(1), "General Standards for Maximum Permissible Emissions." Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-480-050.

173-480-070(2), "Emission Monitoring and Compliance Procedures." Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-480-070.

WAC 246-247, "Radiation Protection—Air Emissions," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=246-247.

246-247-035(1)(a)(ii), "National Standards Adopted by Reference for Sources of Radionuclide Emissions." Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=246-247-035.

246-247-040(3) and -040(4), "General Standards." Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=246-247-040.

246-247-075(1), -075(2), -075(3), -075(4), and -075(8), "Monitoring, Testing, and Quality Assurance." Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=246-247-075.

Appendix B

Tables for the Baseline Human Health, Screening-Level Ecological, and Groundwater Protection Risk Assessments

Terms

FS	feasibility study
RESRAD	RESidual RADioactivity (dose model)
RI	remedial investigation

B1 Introduction

This appendix contains tables that support the discussion of risk in Chapter 3.0 of the feasibility study (FS), which summarizes the detailed risk assessment presentation in the remedial investigation (RI). Table B-1 through Table B-15 are a key subset of those in DOE/RL-2003-11, *Remedial Investigation for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-SC-1 Steam Condensate Group Operable Units*. DOE/RL-2003-11 documents performance of the human health, screening-level ecological, and groundwater protection risk assessments for waste sites of the 200-CW-5 Operable Unit within the scope of this FS. In a few cases, most notably the RESidual RADioactivity (RESRAD) analyses, this appendix uses updated information not used in the RI reports.

In addition to the information described above, the construction worker exposure scenario is used to calculate PRGs for radiological and nonradiological COPCs to determine the health protective levels of COPCs that could remain in place at the Z-Ditches. The PRG values determined using this exposure scenario result in a less conservative concentration (i.e., a higher concentration) than those determined using the industrial worker exposure scenario. Soil concentrations are greater for the construction worker primarily because of a shorter exposure frequency (30 days for a construction worker and 250 days for an industrial worker) and a shorter exposure duration (1 year for a construction worker and 25 years for an industrial worker). This comparison is shown in Table B-3.

B2 References

10 CFR 835, "Occupational Radiation Protection," *Code of Federal Regulations*. Available at: http://www.access.gpo.gov/nara/cfr/waisidx_09/10cfr835_09.html.

40 CFR 141, "National Primary Drinking Water Regulations," *Code of Federal Regulations*. Available at: http://www.access.gpo.gov/nara/cfr/waisidx_08/40cfr141_08.html.

ANL, 2007, *RESRAD for Windows*, Version 6.4, Environmental Assessment Division, Argonne National Laboratory, Argonne, Illinois. Available at: http://web.ead.anl.gov/resrad/register2/.

ANL/EAD-4, 2001, *User's Manual for RESRAD Version 6*, Argonne National Laboratory, Environmental Assessment Division, Argonne, Illinois. Available at: http://web.ead.anl.gov/resrad/documents/resrad6.pdf.

BHI-01177, 1998, *Borehole Summary Report for the 216-B-2-2 Ditch*, Rev. 0, Bechtel Hanford, Inc., Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D198215959.

CCN 070578, 1999, "Estimation of the Soil-Specific Exponential Parameter(b)" (letter to J.D. Fancher, CH2M HILL, Inc., from W.J. McMahon), Bechtel Hanford, Inc., Richland, Washington, June 30.

DOE/ORP-2005-01, 2006, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site*, Rev. 0, U.S. Department of Energy, Office of River Protection, Richland, Washington. Available at: http://www.hanford.gov/orp/uploadfiles/CHG_Performance_Assessment.pdf.

DOE/RL-90-07, 1992, *Remedial Investigation/Feasibility Study Work Plan for the 100-BC-1 Operable Unit, Hanford Site, Richland, Washington*, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D196104396.

DOE/RL-92-24, 2001, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*, Rev. 4, 2 vols., U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at:
http://www2.hanford.gov/arpir/?content=findpage&AKey=0096062.
http://www2.hanford.gov/arpir/?content=findpage&AKey=0096061.

DOE/RL-99-66, 2004, *Steam Condensate/Cooling Water Waste Group Operable Units RI/FS Work Plan; Includes: 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 Operable Units*, Rev. 1, Re-issue, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www2.hanford.gov/arpir/?content=findpage&AKey=D5962949.

DOE/RL-2003-11, 2004, *Remedial Investigation for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-SC-1 Steam Condensate Group Operable Units*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-STD-1153-2002, 2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*, DOE Technical Standard, U.S. Department of Energy, Washington, D.C. Available at: http://www.eh.doe.gov/techstds/standard/std1153/1153.htm.

ECF-200PW1/3/6-10-0278, 2010, *Calculation of Nonradiological WAC 173-340-745 Industrial Soil Cleanup Level*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

ECF-200PW1/3/6-10-0309, 2010, *Calculation of WAC 173-340-740 Method B Soil Cleanup Levels for Unrestricted Land Use*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

ECF-200PW136-10-0337, 2010, *Calculation of Nonradiological WAC 173-340-747, Soil Concentrations Protective of Groundwater Using Fixed Parameter Three-Phase Model*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

Ecology 94-145, 2001, *Cleanup Levels and Risk Calculations under the Model Toxics Control Act Cleanup Regulation; CLARC, Version 3.1*, Washington State Department of Ecology, Olympia, Washington. Available at:
http://www.ecy.wa.gov/programs/tcp/tools/toolmain.html.

EPA/540/R-92/003, 1991, *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals): Interim*, Publication 9285.7-01B, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://epa.gov/swerrims/riskassessment/ragsb/pdf/contents.pdf.

EPA/540/R-96/018, 1996, *Soil Screening Guidance: Users Guide*, Publication 9355.4-23, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/superfund/health/conmedia/soil/index.htm.

EPA/600/R-07/038, 2007, *ProUCL Version 4.0 User Guide*, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/esd/tsc/images/proucl4user.pdf.

EPA, 1991, *Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual Supplemental Guidance "Standard Default Exposure Factors" Interim Final*, OSWER Directive 9285.6-03, Office of Emergency and Remedial Response Toxics Integration Branch, U.S. Environmental Protection Agency, Washington D.C. Available at: http://www.epa.gov/oswer/riskassessment/pdf/OSWERdirective9285.6-03.pdf.

EPA, 1999, *Radiation Risk Assessment At CERCLA Sites: Q & A*, OSWER Directive 9200.4-31P, EPA/540/R/99/006, Office of Emergency and Remedial Response and Office of Radiation and Indoor Air, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/superfund/health/contaminants/radiation/pdfs/riskqa.pdf.

EPA, 2000, *Soil Screening Guidance for Radionuclides: User's Guide*, EPA/540-R-00-007, OSWER 9355.4-16A, Office of Radiation and Indoor Air, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/superfund/health/contaminants/radiation/radssg.htm.

PNNL-11800, 1998, *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.osti.gov/energycitations/servlets/purl/594543-mUGcOH/webviewable/594543.pdf.

PNNL-12034, 2000, *STOMP, Subsurface Transport Over Multiple Phases, Version 2.0, User's Guide*, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-14702, 2006, *Vadose Zone Hydrogeology Data Package for Hanford Assessments*, Rev. 1, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14702rev1.pdf.

PNNL-15160, 2005, *Hanford Site Climatological Summary 2004 with Historical Data*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-15160.pdf.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq. Available at: http://www.epa.gov/epawaste/inforesources/online/index.htm.

WAC 173-340-740(3)(b), "Model Toxics Control Act—Cleanup," "Unrestricted Land Use Soil Cleanup Standards," "Method B Soil Cleanup Levels for Unrestricted Land Use," "Standard Method B Soil Cleanup Levels," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-340-740.

WAC 173-340-745(5)(b), "Model Toxics Control Act—Cleanup," "Soil Cleanup Standards for Industrial Properties," "Method C Industrial Soil Cleanup Levels," "Standard Method C Industrial Soil Cleanup Levels," *Washington Administrative Code*, , Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-340-745.

WAC 173-340-747, "Model Toxics Control Act—Cleanup," "Deriving Soil Concentrations for Ground Water Protection," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/wac/default.aspx?cite=173-340-747.

WAC 173-340-750(3)(b), "Model Toxics Control Act—Cleanup," "Cleanup Standards to Protect Air Quality," "Method B Air Cleanup Levels," "Standard Method B Air Cleanup Levels," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-340-750.

WAC 173-340-750(4)(b), “Model Toxics Control Act—Cleanup,” “Cleanup Standards to Protect Air Quality,” “Method C Air Cleanup Levels,” “Standard Method C Air Cleanup Levels,” *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-340-750.

WAC 173-340-7493, “Model Toxics Control Act—Cleanup,” “Site-Specific Terrestrial Ecological Evaluation Procedures,” *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-340-7493.

WDOH/320-015, 1997, *Hanford Guidance for Radiological Cleanup*, Rev. 1, Washington State Department of Health, Olympia, Washington. Available at: http://www.doh.wa.gov/ehp/rp/environmental/cleanup.pdf.

WHC-EP-0883, 1995, *Variability and Scaling of Hydraulic Properties for 200 Area Soils, Hanford Site*, Westinghouse Hanford Company, Richland, Washington. Available at: http://www.osti.gov/bridge/servlets/purl/188564-WXbGAs/webviewable/188564.pdf.

WHC-SD-EN-SE-004, 1993, *Site Characterization Report: Results of Detailed Evaluation of the Suitability of the Site Proposed for Disposal of 200 Areas Treated Effluent*, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Waste Information Data System Report, Hanford Site database.

Table B-1. Comparison of Z-Ditch Shallow Zone Maximum Concentrations to WAC 173-340-740(3)(b), Standard Method B Soil Cleanup Levels

Constituent Name	CAS Number	Constituent Class	Units	Number of Results	Number of Detects	Frequency of Detection	Minimum Nondetected	Maximum Nondetected	Minimum Detected	Maximum Detected	Background Value[a]	Screening Value	Screening Value Source[b]	COPC Flag	Rationale Contaminant Deletion or Selection[c]
Arsenic	7440-38-2	Metal	mg/kg	4	3	75	19.3	19.3	3.7	6.2	6.5	0.67	WAC 173-340-740(3)	No	BCK
Barium	7440-39-3	Metal	mg/kg	4	4	100	--	--	0.77	87.8	132	16,000	WAC 173-340-740(3)	No	BSL
Beryllium	7440-41-7	Metal	mg/kg	4	3	75	0.965	0.965	0.22	0.25	1.5	160	WAC 173-340-740(3)	No	BSL
Boron	7440-42-8	Metal	mg/kg	4	4	100	--	--	0.77	23.8	NE	16,000	WAC 173-340-740(3)	No	BSL
Cadmium	7440-43-9	Metal	mg/kg	4	1	25	0.03	0.965	0.05	0.05	1.0	80	WAC 173-340-740(3)	No	BSL
Chromium	7440-47-3	Metal	mg/kg	4	4	100	--	--	8.7	10.5	19	120,000	WAC 173-340-740(3)	No	BSL
Copper	7440-50-8	Metal	mg/kg	4	4	100	--	--	13.5	30.4	22	3,200	WAC 173-340-740(3)	No	BSL
Hexavalent Chromium	18540-29-9	Metal	mg/kg	3	1	33.33	0.43	0.46	0.54	0.54	NE	240	WAC 173-340-740(3)	No	BSL
Lead	7439-92-1	Metal	mg/kg	4	3	75	19.3	19.3	5.8	7.1	10	250	WAC 173-340-740(2)	No	BSL
Lithium	7439-93-2	Metal	mg/kg	1	1	100	--	--	0.63	0.63	NE	160	WAC 173-340-740(3)	No	BSL
Magnesium	7439-95-4	Metal	mg/kg	4	4	100	--	--	4200	4760	7,060	NA	NA	No	NUT
Manganese	7439-96-5	Metal	mg/kg	4	4	100	--	--	333	365	512	11,200	WAC 173-340-740(3)	No	BSL
Mercury	7439-97-6	Metal	mg/kg	4	2	50	0.02	0.02	0.08	0.658	0.33	13	WAC 173-340-740(3)	No	BSL
Molybdenum	7439-98-7	Metal	mg/kg	4	3	75	9.65	9.65	0.63	0.77	2,800	400	WAC 173-340-740(3)	No	BSL
Nickel	7440-02-0	Metal	mg/kg	4	4	100	--	--	9.7	10.9	19	1,600	WAC 173-340-740(3)	No	BSL
Silver	7440-22-4	Metal	mg/kg	4	1	25	0.05	1.93	0.69	0.69	0.73	400	WAC 173-340-740(3)	No	BSL
Vanadium	7440-62-2	Metal	mg/kg	4	4	100	--	--	49.8	57.6	85	400	WAC 173-340-740(3)	No	BSL
Zinc	7440-66-6	Metal	mg/kg	4	4	100	--	--	45	63.4	68	24,000	WAC 173-340-740(3)	No	BSL
Aroclor-1254	11097-69-1	pest/PCB	mg/kg	4	1	25	0.036	0.038	52	52	NE	0.50	WAC 173-340-740(3)	Yes	ASL
Aroclor-1260	11096-82-5	Pest/PCB	mg/kg	4	1	25	0.036	0.038	77.6	77.6	NE	0.50	WAC 173-340-740(3)	Yes	ASL
Bis(2-ethylhexyl) phthalate	117-81-7	SVOC	mg/kg	3	1	33.33	0.33	0.36	0.042	0.042	NE	71	WAC 173-340-740(3)	No	BSL
Total Petroleum Hydrocarbons	TPH	TPH	mg/kg	1	1	100	--	--	26.6	26.6	NE	NA	NA	No	TOX
Acetone	67-64-1	VOC	mg/kg	3	3	100	--	--	0.004	0.014	NE	72,000	WAC 173-340-740(3)	No	BSL
Methylene Chloride	75-09-2	VOC	mg/kg	3	2	66.67	0.006	0.006	0.005	0.008	NE	133	WAC 173-340-740(3)	No	BSL
Ammonia	7664-41-7	Wetchem	mg/kg	3	2	66.67	3.53	3.53	5.11	8.15	9.2	NA	NA	No	BCK
Fluoride	16984-48-8	Wetchem	mg/kg	3	2	66.67	1.3	1.3	1.5	1.7	2.8	4,800	WAC 173-340-740(3)	No	BSL
Nitrate	14797-55-8	Wetchem	mg/kg	3	3	100	--	--	24.2	42.7	52	128,000	WAC 173-340-740(3)	No	BSL
Nitrite	14797-65-0	Wetchem	mg/kg	2	2	100	--	--	33	42.7	NE	8,000	WAC 173-340-740(3)	No	BSL
Nitrogen in Nitrite and Nitrate	NO2+NO3-N	Wetchem	mg/kg	3	3	100	--	--	5.3	7.7	NE	28,928	WAC 173-340-740(3)	No	BSL
Sulfate	14808-79-8	Wetchem	mg/kg	3	3	100	--	--	4.2	28.6	237	NA	NA	No	BCK

Table B-1. Comparison of Z-Ditch Shallow Zone Maximum Concentrations to WAC 173-340-740(3)(b), Standard Method B Soil Cleanup Levels

Constituent Name	CAS Number	Constituent Class	Units	Number of Results	Number of Detects	Frequency of Detection	Minimum Nondetected	Maximum Nondetected	Minimum Detected	Maximum Detected	Background Value[a]	Screening Value	Screening Value Source[b]	COPC Flag	Rationale Contaminant Deletion or Selection[c]

a. Background is assumed to be zero for volatile and semi-volatile organic compounds. Nonradionuclide background values were taken from DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*.

b. ECF-200PW1/3/6-10-0309, *Calculation of WAC 173-340-740 Method B Soil Cleanup Levels for Unrestricted Land Use.*

c. Rationale codes: Selection reason: ASL = above screening level
Deletion reason: BCK = near or below background levels
BSL = below screening level
TOX = constituent does not have published toxilogical information, addressed as an uncertainty
NUT = essential nutrient

WAC 173-340-740(3)(b), "Model Toxics Control Act--Cleanup," "Unrestricted Land Use Soil Cleanup Standards," "Method B Soil Cleanup Levels for Unrestricted Land Use," "Standard Method B Soil Cleanup Levels."

-- = contaminant has 100% detection frequency

CAS = Chemical Abstract Services

NA = not applicable

NE = not established

Table B-2. Comparison of Z-Ditch Shallow Zone Maximum Concentrations to WAC 173-340-745(5)(b), Standard Method C Industrial Soil Cleanup Levels

Constituent Name	CAS Number	Constituent Class	Units	Number of Results	Number of Detects	Frequency of Detection	Minimum Nondetected	Maximum Nondetected	Minimum Detected	Maximum Detected	Background Value[a]	Screening Value	Screening Value Source[b]	COPC Flag	Rationale Contaminant Deletion or Selection[c]
Arsenic	7440-38-2	Metal	mg/kg	4	3	75	19.3	19.3	3.7	6.2	6.5	88	WAC 173-340-745(5)	No	BSL
Barium	7440-39-3	Metal	mg/kg	4	4	100	--	--	0.77	87.8	132	700,000	WAC 173-340-745(5)	No	BSL
Beryllium	7440-41-7	Metal	mg/kg	4	3	75	0.965	0.965	0.22	0.25	1.5	7,000	WAC 173-340-745(5)	No	BSL
Boron	7440-42-8	Metal	mg/kg	4	4	100	--	--	0.77	23.8	NE	700,000	WAC 173-340-745(5)	No	BSL
Cadmium	7440-43-9	Metal	mg/kg	4	1	25	0.03	0.965	0.05	0.05	1.0	3,500	WAC 173-340-745(5)	No	BSL
Chromium	7440-47-3	Metal	mg/kg	4	4	100	--	--	8.7	10.5	19	5.25E+06	WAC 173-340-745(5)	No	BSL
Copper	7440-50-8	Metal	mg/kg	4	4	100	--	--	13.5	30.4	22	140,000	WAC 173-340-745(5)	No	BSL
Hexavalent Chromium	18540-29-9	Metal	mg/kg	3	1	33.33	0.43	0.46	0.54	0.54	NE	10,500	WAC 173-340-745(5)	No	BSL
Lead	7439-92-1	Metal	mg/kg	4	3	75	19.3	19.3	5.8	7.1	10	1,000	WAC 173-340-745(3)	No	BSL
Lithium	7439-93-2	Metal	mg/kg	1	1	100	--	--	0.63	0.63	NE	7,000	WAC 173-340-745(5)	No	BSL
Magnesium	7439-95-4	Metal	mg/kg	4	4	100	--	--	4200	4760	7,060	NA	NA	No	NUT
Manganese	7439-96-5	Metal	mg/kg	4	4	100	--	--	333	365	512	490,000	WAC 173-340-745(5)	No	BSL
Mercury	7439-97-6	Metal	mg/kg	4	2	50	0.02	0.02	0.08	0.658	0.33	560	WAC 173-340-745(5)	No	BSL
Molybdenum	7439-98-7	Metal	mg/kg	4	3	75	9.65	9.65	0.63	0.77	2,800	17,500	WAC 173-340-745(5)	No	BSL
Nickel	7440-02-0	Metal	mg/kg	4	4	100	--	--	9.7	10.9	19	70,000	WAC 173-340-745(5)	No	BSL
Silver	7440-22-4	Metal	mg/kg	4	1	25	0.05	1.93	0.69	0.69	0.73	17,500	WAC 173-340-745(5)	No	BSL
Vanadium	7440-62-2	Metal	mg/kg	4	4	100	--	--	49.8	57.6	85	245	WAC 173-340-745(5)	No	BSL
Zinc	7440-66-6	Metal	mg/kg	4	4	100	--	--	45	63.4	68	1.05E+06	WAC 173-340-745(5)	No	BSL
Aroclor-1254	11097-69-1	Pest/PCB	mg/kg	4	1	25	0.036	0.038	52	52	NE	66	WAC 173-340-745(5)	No	BSL
Aroclor-1260	11096-82-5	Pest/PCB	mg/kg	4	1	25	0.036	0.038	77.6	77.6	NE	66	WAC 173-340-745(5)	Yes	ASL
Bis(2-ethylhexyl) phthalate	117-81-7	SVOC	mg/kg	3	1	33.33	0.33	0.36	0.042	0.042	NE	9,375	WAC 173-340-745(5)	No	BSL
Total Petroleum Hydrocarbons	TPH	TPH	mg/kg	1	1	100	--	--	26.6	26.6	NE	NA	NA	No	TOX
Acetone	67-64-1	VOC	mg/kg	3	3	100	--	--	0.004	0.014	NE	3.15E+06	WAC 173-340-745(5)	No	BSL
Methylene Chloride	75-09-2	VOC	mg/kg	3	2	66.67	0.006	0.006	0.005	0.008	NE	17,500	WAC 173-340-745(5)	No	BSL
Ammonia	7664-41-7	Wetchem	mg/kg	3	2	66.67	3.53	3.53	5.11	8.15	9.2	NA	NA	No	BCK
Fluoride	16984-48-8	Wetchem	mg/kg	3	2	66.67	1.3	1.3	1.5	1.7	2.8	210,000	WAC 173-340-745(5)	No	BSL
Nitrate	14797-55-8	Wetchem	mg/kg	3	3	100	--	--	24.2	42.7	52	5.60E+06	WAC 173-340-745(5)	No	BSL
Nitrite	14797-65-0	Wetchem	mg/kg	2	2	100	--	--	33	42.7	NE	350,000	WAC 173-340-745(5)	No	BSL

Table B-2. Comparison of Z-Ditch Shallow Zone Maximum Concentrations to WAC 173-340-745(5)(b), Standard Method C Industrial Soil Cleanup Levels

Constituent Name	CAS Number	Constituent Class	Units	Number of Results	Number of Detects	Frequency of Detection	Minimum Nondetected	Maximum Nondetected	Minimum Detected	Maximum Detected	Background Value[a]	Screening Value	Screening Value Source[b]	COPC Flag	Rationale Contaminant Deletion or Selection[c]
Nitrogen in Nitrite and Nitrate	NO2+NO3-N	Wetchem	mg/kg	3	3	100	--	--	5.3	7.7	NE	1.27E+06	WAC 173-340-745(5)	No	BSL
Sulfate	14808-79-8	Wetchem	mg/kg	3	3	100	--	--	4.2	28.6	237	NA	NA	No	BCK

a. Background is assumed to be zero for volatile and semi-volatile organic compounds. Nonradionuclide background values were taken from DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*.

b. ECF-200PW1/3/6-10-0278, *Calculation of Nonradiological WAC 173-340-745 Industrial Soil Cleanup Levels.*

c. Rationale codes: Selection reason: ASL = above screening level
Deletion reason: BCK = near or below background levels
BSL = below screening level
TOX = constituent does not have published toxilogical information, addressed as an uncertainty
NUT = essential nutrient

WAC 173-340-745(5)(b), "Model Toxics Control Act—Cleanup," "Soil Cleanup Standards for Industrial Properties," "Method C Industrial Soil Cleanup Levels," "Standard Method C Industrial Soil Cleanup Levels."

-- = contaminant has 100% detection frequency

CAS = Chemical Abstract Services

NA = not applicable

NE = not established

Table B-3. Comparison of Z-Ditch Shallow Zone Maximum Concentrations to Construction Worker Preliminary Remediation Goals

Constituent Name	CAS Number	Constituent Class	Units	Number of Results	Number of Detects	Frequency of Detection	Minimum Nondetected	Maximum Nondetected	Minimum Detected	Maximum Detected	Exposure Point Concentration	Background Value[a,b]	PRG	PRG Source[c,d]	Rationale Contaminant Deletion or Selection[e]
Arsenic	7440-38-2	Metal	mg/Kg	4	3	75	19.3	19.3	3.7	6.2	--	6.5	105	ECF-200MW1-10-0043	BSL
Barium	7440-39-3	Metal	mg/Kg	4	4	100	--	--	0.77	87.8	--	132	54,300	ECF-200MW1-10-0043	BSL
Beryllium	7440-41-7	Metal	mg/Kg	4	3	75	0.965	0.965	0.22	0.25	--	1.5	1,650	ECF-200MW1-10-0043	BSL
Boron	7440-42-8	Metal	mg/Kg	4	4	100	--	--	0.77	23.8	--	NE	426,000	ECF-200MW1-10-0043	BSL
Cadmium	7440-43-9	Metal	mg/Kg	4	1	25	0.03	0.965	0.05	0.05	--	1.0	795	ECF-200MW1-10-0043	BSL
Chromium	7440-47-3	Metal	mg/Kg	4	4	100	--	--	8.7	10.5	--	19	3.87E+06	ECF-200MW1-10-0043	BSL
Copper	7440-50-8	Metal	mg/Kg	4	4	100	--	--	13.5	30.4	--	22	103,000	ECF-200MW1-10-0043	BSL
Hexavalent Chromium	18540-29-9	Metal	mg/Kg	3	1	33.33	0.43	0.46	0.54	0.54	--	NE	101	ECF-200MW1-10-0043	BSL
Lead	7439-92-1	Metal	mg/Kg	4	3	75	19.3	19.3	5.8	7.1	--	10	--	--	BCK
Lithium	7439-93-2	Metal	mg/Kg	1	1	100	--	--	0.63	0.63	--	NE	5,160	ECF-200MW1-10-0043	BSL
Magnesium	7439-95-4	Metal	mg/Kg	4	4	100	--	--	4200	4760	--	7,060	--	--	NUT
Manganese	7439-96-5	Metal	mg/Kg	4	4	100	--	--	333	365	--	512	5,970	ECF-200MW1-10-0043	BSL
Mercury	7439-97-6	Metal	mg/Kg	4	2	50	0.02	0.02	0.08	0.658	--	0.33	19.6	ECF-200MW1-10-0043	BSL
Molybdenum	7439-98-7	Metal	mg/Kg	4	3	75	9.65	9.65	0.63	0.77	--	2,800	12,900	ECF-200MW1-10-0043	BSL
Nickel	7440-02-0	Metal	mg/Kg	4	4	100	--	--	9.7	10.9	--	19	9,010	ECF-200MW1-10-0043	BSL
Silver	7440-22-4	Metal	mg/Kg	4	1	25	0.05	1.93	0.69	0.69	--	0.73	12,900	ECF-200MW1-10-0043	BSL
Vanadium	7440-62-2	Metal	mg/Kg	4	4	100	--	--	49.8	57.6	--	85	12,900	ECF-200MW1-10-0043	BSL
Zinc	7440-66-6	Metal	mg/Kg	4	4	100	--	--	45	63.4	--	68	774,000	ECF-200MW1-10-0043	BSL
Aroclor-1254	11097-69-1	Pest/PCB	mg/Kg	4	1	25	0.036	0.038	52	52	--	NE	36.3	ECF-200MW1-10-0043	ASL
Aroclor-1260	11096-82-5	Pest/PCB	mg/Kg	4	1	25	0.036	0.038	77.6	77.6	--	NE	63.3	ECF-200MW1-10-0043	ASL
Americium-241	14596-10-2	RAD	pCi/g	286	284	99	0.19	15	0.014	7.87E+06	202,640	NE	30,300	ECF-200MW1-10-0046	ASL
Cesium-137	10045-97-3	RAD	pCi/g	187	184	98	0.04	0.04	0.0021	66,041	2,571	1.05	1,550	ECF-200MW1-10-0046	ASL
Plutonium-238	13981-16-3	RAD	pCi/g	62	54	87	0.034	0.46	0.015	5,500	1,302	3.78E-03	1,417	ECF-200MW1-10-0046	BSL
Plutonium-239 + Plutonium-239/240	PU-239/240	RAD	pCi/g	281	279	99	0.46	0.53	0.001	7.80E+05	28,291	2.48E-02	33,500	ECF-200MW1-10-0046	BSL
Radium-226	13982-63-3	RAD	pCi/g	12	12	100	--	--	0.4	5,200	5,200	0.815	445	ECF-200MW1-10-0046	ASL
Radium-228	15262-20-1	RAD	pCi/g	4	2	50	0.37	0.37	0.69	0.81	0.81	1.32	515	ECF-200MW1-10-0046	BSL
Strontium-90	15262-20-1	RAD	pCi/g	30	23	77	2.5	9.6	0.28	216	95.18	0.178	123,000	ECF-200MW1-10-0046	BSL
Thorium-228	14274-82-9	RAD	pCi/g	4	1	25	0.47	1.8	0.66	0.66	0.66	1.32	587	ECF-200MW1-10-0046	BSL
Thorium-230	14269-63-7	RAD	pCi/g	4	3	75	1.1	1.1	0.5	8.4	8.4	1.1	1,270	ECF-200MW1-10-0046	BSL

Table B-3. Comparison of Z-Ditch Shallow Zone Maximum Concentrations to Construction Worker Preliminary Remediation Goals

Constituent Name	CAS Number	Constituent Class	Units	Number of Results	Number of Detects	Frequency of Detection	Minimum Nondetected	Maximum Nondetected	Minimum Detected	Maximum Detected	Exposure Point Concentration	Background Value[a,b]	PRG	PRG Source[c,d]	Rationale Contaminant Deletion or Selection[e]
Thorium-232	TH-232	RAD	pCi/g	4	1	25	0.7	1.7	0.71	0.71	0.71	1.32	308	ECF-200MW1-10-0046	BSL
Uranium-233/234	U-233/234	RAD	pCi/g	4	1	25	0.68	2.5	0.36	0.36	0.36	1.1	111,000	ECF-200MW1-10-0046	BSL
Uranium-238	U-238	RAD	pCi/g	4	2	50	1.1	1.2	0.44	0.77	0.77	1.06	28,500	ECF-200MW1-10-0046	BSL
Bis(2-ethylhexyl) phthalate	117-81-7	SVOC	mg/Kg	3	1	33.33	0.33	0.36	0.042	0.042	--	NE	9,900	ECF-200MW1-10-0043	BSL
Total Petroleum Hydrocarbons	TPH	TPH	mg/Kg	1	1	100	--	--	26.6	26.6	--	NE	--	--	TOX
Acetone	67-64-1	VOC	mg/Kg	3	3	100	--	--	0.004	0.014	--	NE	681,000	ECF-200MW1-10-0043	BSL
Methylene Chloride	75-09-2	VOC	mg/Kg	3	2	66.67	0.006	0.006	0.005	0.008	--	NE	733	ECF-200MW1-10-0043	BSL
Ammonia	7664-41-7	Wetchem	mg/Kg	3	2	66.67	3.53	3.53	5.11	8.15	--	9.2	--	--	BCK
Fluoride	16984-48-8	Wetchem	mg/Kg	3	2	66.67	1.3	1.3	1.5	1.7	--	2.8	141,000	ECF-200MW1-10-0043	BSL
Nitrate	14797-55-8	Wetchem	mg/Kg	3	3	100	--	--	24.2	42.7	--	52	4.13E+06	ECF-200MW1-10-0043	BSL
Nitrite	14797-65-0	Wetchem	mg/Kg	2	2	100	--	--	33	42.7	--	NE	258,000	ECF-200MW1-10-0043	BSL
Nitrogen in Nitrite and Nitrate	NO2+NO3-N	Wetchem	mg/Kg	3	3	100	--	--	5.3	7.7	--	NE	945,000	ECF-200MW1-10-0043	BSL
Sulfate	14808-79-8	Wetchem	mg/Kg	3	3	100	--	--	4.2	28.6	--	237	--	--	BCK

a. Background is assumed to be zero for volatile and semi-volatile organic compounds. Nonradionuclide background values were taken from DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*.

b. Radionuclide background values were taken from DOE/RL-96-12, Hanford Site Background: Part 2, Soil Background for Radionuclides.

c. ECF-200MW1-10-0043, *Calculation of Nonradiological Preliminary Remediation goals in Soil for a Construction Worker (Authorized User) Exposure Scenario.*

d. ECF-200MW1-10-0046, *Calculation of Radiological Preliminary Remediation goals in Soil for a Construction Worker (Authorized User) Exposure Scenario*

e. Rationale codes: Selection reason: ASL = above screening level
Deletion reason: BCK = near or below background levels
BSL = below screening level
TOX = constituent does not have published toxilogical information, addressed as an uncertainty
NUT = essential nutrient

-- = not applicable
CAS = Chemical Abstract Services
NA = not applicable
NE = not established
PRG = preliminary remediation goal

Table B-4. Comparison of Z-Ditch Shallow Zone Maximum Concentrations to WAC 173-340-750(3)(b), Standard Method B Air Cleanup Levels

Constituent Name	CAS Number	Constituent Class	Units	Number of Results	Number of Detects	Frequency of Detection	Minimum Nondetected	Maximum Nondetected	Minimum Detected	Maximum Detected	PEF or VF (m^3/kg)[a]	Max Air Concentration (mg/m^3)[b]	WAC 173-340-750(3) Method B CUL (mg/m^3)	Is Maximum [Air] > Industrial CUL?
Arsenic	7440-38-2	Metal	mg/kg	4	3	75	19.3	19.3	3.7	6.2	1.32E+09	4.70E-09	5.83E-06	No
Barium	7440-39-3	Metal	mg/kg	4	4	100	--	--	0.77	87.8	1.32E+09	6.65E-08	0.32	No
Beryllium	7440-41-7	Metal	mg/kg	4	3	75	0.965	0.965	0.22	0.25	1.32E+09	1.89E-10	0.0032	No
Boron	7440-42-8	Metal	mg/kg	4	4	100	--	--	0.77	23.8	1.32E+09	1.80E-08	0.32	No
Cadmium	7440-43-9	Metal	mg/kg	4	1	25	0.03	0.965	0.05	0.05	1.32E+09	3.79E-11	0.0016	No
Chromium	7440-47-3	Metal	mg/kg	4	4	100	--	--	8.7	10.5	1.32E+09	7.95E-09	2.4	No
Copper	7440-50-8	Metal	mg/kg	4	4	100	--	--	13.5	30.4	1.32E+09	2.30E-08	0.064	No
Hexavalent Chromium	18540-29-9	Metal	mg/kg	3	1	33.33	0.43	0.46	0.54	0.54	1.32E+09	4.09E-10	0.0048	No
Lead	7439-92-1	Metal	mg/kg	4	3	75	19.3	19.3	5.8	7.1	1.32E+09	5.38E-09	--	--
Lithium	7439-93-2	Metal	mg/kg	1	1	100	--	--	0.63	0.63	1.32E+09	4.77E-10	0.0032	No
Magnesium	7439-95-4	Metal	mg/kg	4	4	100	--	--	4200	4760	1.32E+09	3.61E-06	--	--
Manganese	7439-96-5	Metal	mg/kg	4	4	100	--	--	333	365	1.32E+09	2.77E-07	0.22	No
Mercury	7439-97-6	Metal	mg/kg	4	2	50	0.02	0.02	0.08	0.658	1.32E+09	4.98E-10	2.56E-04	No
Molybdenum	7439-98-7	Metal	mg/kg	4	3	75	9.65	9.65	0.63	0.77	1.32E+09	5.83E-10	0.0080	No
Nickel	7440-02-0	Metal	mg/kg	4	4	100	--	--	9.7	10.9	1.32E+09	8.26E-09	0.032	No
Silver	7440-22-4	Metal	mg/kg	4	1	25	0.05	1.93	0.69	0.69	1.32E+09	5.23E-10	0.0080	No
Vanadium	7440-62-2	Metal	mg/kg	4	4	100	--	--	49.8	57.6	1.32E+09	4.36E-08	0.0080	No
Zinc	7440-66-6	Metal	mg/kg	4	4	100	--	--	45	63.4	1.32E+09	4.80E-08	0.48	No
Aroclor-1254	11097-69-1	Pest/PCB	mg/kg	4	1	25	0.036	0.038	52	52	1.32E+09	3.94E-08	4.38E-06	No
Aroclor-1260	11096-82-5	Pest/PCB	mg/kg	4	1	25	0.036	0.038	77.6	77.6	1.32E+09	5.88E-08	4.38E-06	No
Bis(2-ethylhexyl) phthalate	117-81-7	SVOC	mg/kg	3	1	33.33	0.33	0.36	0.042	0.042	1.32E+09	3.18E-11	6.25E-04	No
Total Petroleum Hydrocarbons	TPH	TPH	mg/kg	1	1	100	--	--	26.6	26.6	1.32E+09	2.02E-08	--	--
Acetone	67-64-1	VOC	mg/kg	3	3	100	--	--	0.004	0.014	12,554	1.12E-06	1.4	No
Methylene Chloride	75-09-2	VOC	mg/kg	3	2	66.67	0.006	0.006	0.005	0.008	2,425	3.30E-06	0.0012	No
Ammonia	7664-41-7	Wetchem	mg/kg	3	2	66.67	3.53	3.53	5.11	8.15	1.32E+09	6.17E-09	--	--
Fluoride	16984-48-8	Wetchem	mg/kg	3	2	66.67	1.3	1.3	1.5	1.7	1.32E+09	1.29E-09	0.096	No
Nitrate	14797-55-8	Wetchem	mg/kg	3	3	100	--	--	24.2	42.7	1.32E+09	3.23E-08	2.6	No
Nitrite	14797-65-0	Wetchem	mg/kg	2	2	100	--	--	33	42.7	1.32E+09	3.23E-08	0.16	No
Nitrogen in Nitrite and Nitrate	NO2+NO3-N	Wetchem	mg/kg	3	3	100	--	--	5.3	7.7	1.32E+09	5.83E-09	0.58	No
Sulfate	14808-79-8	Wetchem	mg/kg	3	3	100	--	--	4.2	28.6	1.32E+09	2.17E-08	--	--

Table B-4. Comparison of Z-Ditch Shallow Zone Maximum Concentrations to WAC 173-340-750(3)(b), Standard Method B Air Cleanup Levels

Constituent Name	CAS Number	Constituent Class	Units	Number of Results	Number of Detects	Frequency of Detection	Minimum Nondetected	Maximum Nondetected	Minimum Detected	Maximum Detected	PEF or VF (m^3/kg)[a]	Max Air Concentration (mg/m^3)[b]	WAC 173-340-750(3) Method B CUL (mg/m^3)	Is Maximum [Air] > Industrial CUL?

WAC 170-340-750(3)(b), "Model Toxics Control Act—Cleanup," "Cleanup Standards to Protect Air Quality," "Method B Air Cleanup Levels," "Standard Method B Air Cleanup Levels."

Ammonia, sulfate, manganese, and total petroleum hydrocarbons do not have available toxicological information.

a. EPA-540/R-96/018, *Soil Screening Guidance: User's Guide*, Publication 9355.4-23.

b. Maximum detected result divided by PEF or VF, as appropriate.

-- = Not Available

CAS = Chemical Abstract Services

PEF = Particulate Emission Factor

VF = Volatilization Factor

Table B-5. Comparison of Z-Ditch Shallow Zone Maximum Concentrations to WAC 173-340-750(4)(b), Standard Method C Air Cleanup Levels

Constituent Name	CAS Number	Constituent Class	Units	Number of Results	Number of Detects	Frequency of Detection	Minimum Nondetected	Maximum Nondetected	Minimum Detected	Maximum Detected	PEF or VF (m^3/kg) [a]	Max Air Concentration (mg/m^3) [b]	WAC 173-340-750(4) Method C CUL (mg/m^3)	Is Maximum [Air] > Industrial CUL?
Arsenic	7440-38-2	Metal	mg/kg	4	3	75	19.3	19.3	3.7	6.2	1.32E+09	4.70E-09	5.83E-05	No
Barium	7440-39-3	Metal	mg/kg	4	4	100	--	--	0.77	87.8	1.32E+09	6.65E-08	0.70	No
Beryllium	7440-41-7	Metal	mg/kg	4	3	75	0.965	0.965	0.22	0.25	1.32E+09	1.89E-10	0.0070	No
Boron	7440-42-8	Metal	mg/kg	4	4	100	--	--	0.77	23.8	1.32E+09	1.80E-08	0.70	No
Cadmium	7440-43-9	Metal	mg/kg	4	1	25	0.03	0.965	0.05	0.05	1.32E+09	3.79E-11	0.0035	No
Chromium	7440-47-3	Metal	mg/kg	4	4	100	--	--	8.7	10.5	1.32E+09	7.95E-09	5.3	No
Copper	7440-50-8	Metal	mg/kg	4	4	100	--	--	13.5	30.4	1.32E+09	2.30E-08	0.14	No
Hexavalent Chromium	18540-29-9	Metal	mg/kg	3	1	33.33	0.43	0.46	0.54	0.54	1.32E+09	4.09E-10	0.011	No
Lead	7439-92-1	Metal	mg/kg	4	3	75	19.3	19.3	5.8	7.1	1.32E+09	5.38E-09	--	--
Lithium	7439-93-2	Metal	mg/kg	1	1	100	--	--	0.63	0.63	1.32E+09	4.77E-10	0.0070	No
Magnesium	7439-95-4	Metal	mg/kg	4	4	100	--	--	4200	4760	1.32E+09	3.61E-06	--	--
Manganese	7439-96-5	Metal	mg/kg	4	4	100	--	--	333	365	1.32E+09	2.77E-07	0.49	No
Mercury	7439-97-6	Metal	mg/kg	4	2	50	0.02	0.02	0.08	0.658	1.32E+09	4.98E-10	5.60E-04	No
Molybdenum	7439-98-7	Metal	mg/kg	4	3	75	9.65	9.65	0.63	0.77	1.32E+09	5.83E-10	0.018	No
Nickel	7440-02-0	Metal	mg/kg	4	4	100	--	--	9.7	10.9	1.32E+09	8.26E-09	0.070	No
Silver	7440-22-4	Metal	mg/kg	4	1	25	0.05	1.93	0.69	0.69	1.32E+09	5.23E-10	0.018	No
Vanadium	7440-62-2	Metal	mg/kg	4	4	100	--	--	49.8	57.6	1.32E+09	4.36E-08	0.018	No
Zinc	7440-66-6	Metal	mg/kg	4	4	100	--	--	45	63.4	1.32E+09	4.80E-08	1.1	No
Aroclor-1254	11097-69-1	Pest/PCB	mg/kg	4	1	25	0.036	0.038	52	52	1.32E+09	3.94E-08	4.38E-05	No
Aroclor-1260	11096-82-5	Pest/PCB	mg/kg	4	1	25	0.036	0.038	77.6	77.6	1.32E+09	5.88E-08	4.38E-05	No
Bis(2-ethylhexyl) phthalate	117-81-7	SVOC	mg/kg	3	1	33.33	0.33	0.36	0.042	0.042	1.32E+09	3.18E-11	0.0063	No
Total Petroleum Hydrocarbons	TPH	TPH	mg/kg	1	1	100	--	--	26.6	26.6	1.32E+09	2.02E-08	--	--
Acetone	67-64-1	VOC	mg/kg	3	3	100	--	--	0.004	0.014	125,554	1.12E-07	3.2	No
Methylene Chloride	75-09-2	VOC	mg/kg	3	2	66.67	0.006	0.006	0.005	0.008	2,425	3.30E-06	0.012	No
Ammonia	7664-41-7	Wetchem	mg/kg	3	2	66.67	3.53	3.53	5.11	8.15	1.32E+09	6.17E-09	--	--
Fluoride	16984-48-8	Wetchem	mg/kg	3	2	66.67	1.3	1.3	1.5	1.7	1.32E+09	1.29E-09	0.21	No
Nitrate	14797-55-8	Wetchem	mg/kg	3	3	100	--	--	24.2	42.7	1.32E+09	3.23E-08	5.6	No
Nitrite	14797-65-0	Wetchem	mg/kg	2	2	100	--	--	33	42.7	1.32E+09	3.23E-08	0.35	No
Nitrogen in Nitrite and Nitrate	NO2+NO3-N	Wetchem	mg/kg	3	3	100	--	--	5.3	7.7	1.32E+09	5.83E-09	1.2656	No
Sulfate	14808-79-8	Wetchem	mg/kg	3	3	100	--	--	4.2	28.6	1.32E+09	2.17E-08	--	--

Table B-5. Comparison of Z-Ditch Shallow Zone Maximum Concentrations to WAC 173-340-750(4)(b), Standard Method C Air Cleanup Levels

Constituent Name	CAS Number	Constituent Class	Units	Number of Results	Number of Detects	Frequency of Detection	Minimum Nondetected	Maximum Nondetected	Minimum Detected	Maximum Detected	PEF or VF (m^3/kg) [a]	Max Air Concentration (mg/m^3) [b]	WAC 173-340-750(4) Method C CUL (mg/m^3)	Is Maximum [Air] > Industrial CUL?

WAC 170-340-750(4)(b), "Model Toxics Control Act—Cleanup," "Cleanup Standards to Protect Air Quality, "Method C Air Cleanup Levels," "Standard Method C Air Cleanup Levels."

Ammonia, sulfate, manganese, and total petroleum hydrocarbons do not have available toxicological information.

a. EPA-540/R-96/018, *Soil Screening Guidance: User's Guide*, Publication 9355.4-23.

b. Maximum detected result divided by PEF or VF, as appropriate.

-- = Not Available

CAS = Chemical Abstract Services

PEF = Particulate Emission Factor

VF = Volatilization Factor

Table B-6. Parameters Used for RESRAD Analysis of Groundwater Protection

Description	Parameter	Units	Z-Ditches	Rationale and Citation
Exposure pathways	External gamma Inhalation Plant ingestion Meat ingestion Milk ingestion Aquatic foods Drinking water Soil ingestion Radon	--	Suppressed Suppressed Suppressed Suppressed Suppressed Suppressed Active Suppressed Suppressed	Based on 200-CW-5 Operable Unit Work Plan (DOE/RL-99-66) conceptual exposure model and refinement of the model as part of the RI
R011 – CZ	Area of CZ	m^2	972	Site-specific areas from WIDS
	Thickness of CZ (no cover GWP)	m	6	Represents actual thickness of contamination based on RI results
	Length parallel to aquifer flow	m	9	--
	Radiation dose limit (industrial scenario)	mrem/yr	15	10 CFR 835
	Elapsed time since waste placement	yr	0	Environmental samples were collected in 1999
Exposure point concentration	--	pCi/g	Chemical-specific	All data are decayed to 2002
R013 – cover and CZ hydrological data	Cover depth (groundwater protection)	m	0	No cover
	Cover material density (cover, industrial, direct contact)	g/cm^3	NA	--
	Cover erosion rate (cover, industrial, direct contact)	m/yr	NA	RESRAD default
	Density of CZ	g/cm^3	1.8	Site-specific values based on RI results
	CZ erosion rate	m/yr	0.001	RESRAD default
	CZ total porosity	unitless	0.33	Site-specific values based on physical property samples from RI and WHC-EP-0883

Table B-6. Parameters Used for RESRAD Analysis of Groundwater Protection

Description	Parameter	Units	Z-Ditches	Rationale and Citation
	CZ field capacity	unitless	0.2	Site-specific values based on physical property samples from RI and WHC-EP-0883
	CZ hydraulic conductivity	m/yr	22	WHC-SD-EN-SE-004
	CZ b parameter	unitless	4.05	RESRAD Table E.2 (ANL/EAD-4); CCN 070578
	Average annual wind speed	m/sec	3.4	--
	Evapotranspiration coefficient	unitless	0.656	DOE/RL-2003-11
	Precipitation	m/yr	0.16	Based on 16 cm (6.3 in.) average annual rainfall (DOE/RL-90-07)
	Irrigation rate (groundwater protection)	m/yr	0.76	--
	Irrigation mode	--	Overhead	RESRAD default
	Runoff coefficient (groundwater protection)	unitless	0.2	RESRAD default
	Watershed area for nearby stream or pond (groundwater protection)	m^2	1.00×10^6	RESRAD default
	Accuracy for water/soil computations (groundwater protection)	unitless	0.001	RESRAD default
R014 – SZ hydrological data	Density of SZ	g/cm^3	2.23	Site-specific value based on RI results and BHI-01177
	SZ total porosity	unitless	0.158	Site-specific values based on physical property samples from RI and WHC-EP-0883
	SZ effective porosity	unitless	0.158	Site-specific values based on physical property samples from RI and WHC-EP-0883
	SZ field capacity	unitless	0.04	Site-specific values based on physical property samples from RI and WHC-EP-0883
	SZ hydraulic conductivity	m/yr	5519	WHC-SD-EN-SE-004

Table B-6. Parameters Used for RESRAD Analysis of Groundwater Protection

Description	Parameter	Units	Z-Ditches	Rationale and Citation
	SZ parameter	unitless	4.05	RESRAD Table E.2 (ANL/EAD-4); CCN 070578
	Water table drop rate	m/yr	0.001	RESRAD default
	Well pump intake depth below water table	m	4.6	Typical RCRA well screen length
	ND or mass-balance	--	ND	RESRAD default
	Well pumping rate	m^3/yr	250	RESRAD default
R015 – Uncontaminated and unsaturated strata hydrological data	Number of unsaturated strata	--	3	Site-specific
	Thickness - Strata 1 (groundwater protection)	m	4	Site-specific values based on RI results and current water table elevation data
	Thickness - Strata 2 (groundwater protection)	m	30	Site-specific values based on RI results and current water table elevation data
	Thickness - Strata 3 (groundwater protection)	m	23.2	Site-specific values based on RI results and current water table elevation data
	Soil density - Strata 1 (groundwater protection)	g/cm^3	1.98	Hanford formation gravel-dominated sequence
	Soil density - Strata 2 (groundwater protection)	g/cm^3	1.5	Hanford formation sand-dominated sequence and Cold Creek unit
	Soil density - Strata 3 (groundwater protection)	g/cm^3	2.23	Ringold Unit E silty sandy gravel
	Total porosity/effective porosity - Strata 1 (groundwater protection)	unitless	0.253	Site-specific value based on RI results and BHI-01177
	Total porosity/effective porosity - Strata 2 (groundwater protection)	unitless	0.435	Site-specific values based on physical property samples from RI and WHC-EP-0883
	Total porosity/effective porosity - Strata 3 (groundwater protection)	unitless	0.158	Site-specific values based on physical property samples from RI and WHC-EP-0883

Table B-6. Parameters Used for RESRAD Analysis of Groundwater Protection

Description	Parameter	Units	Z-Ditches	Rationale and Citation
	Field capacity (groundwater protection)	unitless	0.04	Site-specific values based on physical property samples from RI and WHC-EP-0883
	Soil-specific parameter (groundwater protection)	unitless	4.05	RESRAD Table E.2 (ANL/EAD-4); CCN 070578
	Hydraulic conductivity - Strata 1 (groundwater protection)	m/yr	757	--
	Hydraulic conductivity - Strata 2 (groundwater protection)	m/yr	138	--
	Hydraulic conductivity - Strata 3 (groundwater protection)	m/yr	552	WHC-SD-EN-SE-004
R016 – Distribution coefficients and leach rates for individual radionuclides	Distribution coefficients for contaminated zone, uncontaminated zone, and SZ	mL/g	Am-241: 300 Co-60: 1200 Cs-137: 1500 Cm-244: 100 Eu-152/154/155: 300 H-3: 0 Na-22: 10 Ni-63: 300 Np-237: 15 Pu-238/239/240: 200 Ra-226/228: 20 Sr-90: 20 Tc-99: 0 Th-228/230/232: 1000 U-232/234/235/238: 3 Sb-125: 0 Se-79: 0	PNNL-11800

Table B-6. Parameters Used for RESRAD Analysis of Groundwater Protection

Description	Parameter	Units	Z-Ditches	Rationale and Citation
R017 – Inhalation and external gamma	Saturated leach rate	L/yr	0	RESRAD default
	Inhalation rate	m^3/yr	NA	RESRAD default
	Mass loading for inhalation	g/m^3	NA	RESRAD default
	Exposure duration	year	30	WAC 173-340-750 and EPA/540/R-92/003
	Inhalation shielding factor	unitless	NA	RESRAD default
	External gamma shielding factor	unitless	NA	RESRAD default
	Indoor time fraction (industrial scenario)	unitless	NA	RESRAD default
	Outdoor time fraction (industrial scenario)	unitless	NA	RESRAD default
	Shape factor	unitless	NA	RESRAD default
R018 – Ingestion pathway data, dietary parameters	Soil ingestion	g/yr	NA	RESRAD default
	Drinking water intake	L/yr	730	Assumes drinking a volume of 2 L/day
	Drinking water contamination fraction	unitless	1	Assumes that all of the water is contaminated groundwater

Table B-6. Parameters Used for RESRAD Analysis of Groundwater Protection

Description	Parameter	Units	Z-Ditches	Rationale and Citation
R019 – Ingestion pathway data, non-dietary parameters	Depth of soil mixing layer	m	NA	RESRAD default
	Groundwater fractional use – drinking water	unitless	1	Assumes that all of the water used is groundwater

10 CFR 835, "Occupational Radiation Protection."

ANL/EAD-4, *User's Manual for RESRAD Version 6*.

BHI-01177, *Borehole Summary Report for the 216-B-2-2 Ditch*.

CCN 070578, "Estimation of the Soil-Specific Exponential Parameter(b)."

DOE/RL-90-07, *Remedial Investigation/Feasibility Study Work Plan for the 100-BC-1 Operable Unit, Hanford Site, Richland, Washington*.

DOE/RL-99-66, *Steam Condensate/Cooling Water Waste Group Operable Units RI/FS Work Plan; Includes: 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 Operable Units*.

DOE/RL-2003-11, *Remedial Investigation for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-SC-1 Steam Condensate Group Operable Units*.

EPA/540/R-92/003, *Risk Assessment Guidance for Superfund: Volume I -- Human Health Evaluation Manual (Part B. Development of Risk-Based Preliminary Remediation Goals), Interim*, Publication 9285.7-01B.

PNNL-11800, *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq.

WAC 173-340-750, "Cleanup Standards to Protect Air Quality."

WDOH/320-015, *Hanford Guidance for Radiological Cleanup*.

WHC-EP-0883, *Variability and Scaling of Hydraulic Properties for 200 Area Soils, Hanford Site*.

WHC-SD-EN-SE-004, *Site Characterization Report: Results of Detailed Evaluation of the Suitability of the Site Proposed for Disposal of 200 Areas Treated Effluent*.

-- = not available
CZ = contaminated zone
GWP = groundwater protection
NA = not applicable
ND = nondispersion
RCRA = *Resource Conservation and Recovery Act of 1976*
RESRAD = RESidual RADioactivity (dose model)
RI = remedial investigation
SZ = saturated zone
WIDS = Waste Information Data System database

Table B-7. Parameters Used for RESRAD Analysis of the Industrial Worker Exposure Scenario

Description	Parameter	Units	Z-Ditches	Rationale and Citation
Exposure Pathways	External gamma Inhalation Plant ingestion Meat ingestion Milk ingestion Aquatic foods Drinking water Soil ingestion Radon	NA	Active Active Suppressed Suppressed Suppressed Suppressed Suppressed Active Suppressed	
R011 – Contaminated Zone (CZ)	Area of CZ	m^2	972	Site-specific area from WIDS
	Thickness of CZ	m	6	Value represents actual thickness of contamination based on remedial investigation (RI) results (DOE/RL-2003-11)
	Length parallel to aquifer flow	m	9	Site-specific
	Radiation dose limit (industrial scenario)	mrem/yr	15	40 CFR 141; EPA, 1999
	Elapsed time since waste placement	yr	0	RESRAD default
Exposure Point Concentrations (EPCs)	EPCs	pCi/g	Contaminant-specific	
R013 – Cover and CZ Hydrological Data	Cover depth	m	0	Assumes contamination extends to the ground surface (i.e., not credit taken for pre-existing controls, including existing 1 m-thick stabilization cover)
	Cover material density	g/cm^3	1.5	Site-specific
	Cover erosion rate	m/yr	0.00001	Value selected prevents appreciable erosion of the cover over the simulation period
	Density of CZ	g/cm^3	1.8	Site-specific value based on RI results
	CZ erosion rate	m/yr	0.00001	Value selected prevents appreciable erosion of the contaminated zone over the simulation period (only relevant if cover depth becomes zero through erosion)

Table B-7. Parameters Used for RESRAD Analysis of the Industrial Worker Exposure Scenario

Description	Parameter	Units	Z-Ditches	Rationale and Citation
R013 – Cover and CZ Hydrological Data	CZ total porosity	unitless	0.33	Site-specific value based on physical property samples from RI and WHC-EP-0883
	CZ field capacity	unitless	0.2	Site-specific value based on physical property samples from RI and WHC-EP-0883
	CZ hydraulic conductivity	m/yr	22	WHC-SD-EN-SE-004
	CZ b parameter	unitless	4.05	CCN 070578; ANL/EAD-4 (Table E.2)
	Evapotranspiration coefficient	unitless	0.751	Calculated based on Equation E.4 in ANL/EAD-4: I = (1 - Ce)[(1-Cr)Pr + Irr] Rearranging for Ce (evapotranspiration coefficient): Ce = 1 - [I/(1-Cr)Pr + Irr] I = meteoric water infiltration rate = 0.044 m/yr (44 mm/yr) from Table 4.15 in PNNL-14702 (estimated recharge rate for southern 200 W Area and ERDF, no vegetation) - assumes existing stabilization cover is maintained vegetation free throughout simulation period Cr = runoff coefficient = 0 (conservatively assumes all precipitation penetrates the topsoil) Pr = precipitation rate = 0.177 m/yr (177 mm/yr) (PNNL-15160, Table 4.1) Irr = irrigation rate = 0 Ce = 1 - (0.044 m/yr/0.177 m/yr) = 0.751 (dimensionless)
	Wind speed	m/s	3.4	Based on annual average prevailing wind speed of 7.6 mph (3.4 m/s) measured at Hanford Meteorology Station (PNNL-15160, Table 5.1)
	Precipitation	m/yr	0.177	Based on normal annual precipitation of 6.98 in. (0.177 mm) measured at Hanford Meteorology Station (PNNL-15160, Table 4.1)
	Irrigation rate	m/yr	0	Industrial worker scenario assumes no irrigation

Table B-7. Parameters Used for RESRAD Analysis of the Industrial Worker Exposure Scenario

Description	Parameter	Units	Z-Ditches	Rationale and Citation
R013 – Cover and CZ Hydrological Data	Irrigation mode	Overhead or ditch	NA	NA
	Runoff coefficient	unitless	0	Value selected conservatively assumes all precipitation penetrates the topsoil
	Watershed area for nearby stream or pond	m^2	NA	NA
	Accuracy for water/soil computations	unitless	NA	NA
R014 – Saturated Zone (SZ) Hydrological Data	Density of SZ	g/cm^3	NA	NA
	SZ total porosity	unitless	NA	NA
	SZ effective porosity	unitless	NA	NA
	SZ field capacity	unitless	NA	NA
	SZ hydraulic conductivity	m/yr	NA	NA
	SZ b parameter	unitless	NA	NA
	Water table drop rate	m/yr	NA	NA
	Well pump intake depth below water table	m	NA	NA
	Model for water transport	Non-dispersion (ND) or mass-balance	ND	RESRAD default
	Well pumping rate	m^3/yr	NA	NA

Table B-7. Parameters Used for RESRAD Analysis of the Industrial Worker Exposure Scenario

Description	Parameter	Units	Z-Ditches	Rationale and Citation
R015 – Uncontaminated and Unsaturated Strata Hydrological Data	Number of unsaturated strata	NA	NA	NA
	Thickness (layer 1)	m	NA	NA
	Thickness (layer 2)	m	NA	NA
	Thickness (layer 3)	m	NA	NA
	Soil density (layer 1)	g/cm^3	NA	NA
	Soil density (layer 2)	g/cm^3	NA	NA
	Soil density (layer 3)	g/cm^3	NA	NA
	Total porosity/effective porosity (layer 1)	unitless	NA	NA
	Total porosity/effective porosity (layer 2)	unitless	NA	NA
	Total porosity/effective porosity (layer 3)	unitless	NA	NA
	Field capacity (layer 1)	unitless	NA	NA
	Field capacity (layer 2)	unitless	NA	NA
	Field capacity (layer 3)	unitless	NA	NA
	Hydraulic conductivity (layer 1)	m/yr	NA	NA
	Hydraulic conductivity (layer 2)	m/yr	NA	NA
	Hydraulic conductivity (layer 3)	m/yr	NA	NA
	Soil-specific b parameter (layer 1)	unitless	NA	NA
	Soil-specific b parameter (layer 2)	unitless	NA	NA
	Soil-specific b parameter (layer 3)	unitless	NA	NA

Table B-7. Parameters Used for RESRAD Analysis of the Industrial Worker Exposure Scenario

Description	Parameter	Units	Z-Ditches	Rationale and Citation
R016 – Distribution Coefficients and Leach Rates for Individual Radionuclides	Distribution coefficients (Kd) for contaminated zone, uncontaminated zone, and SZ	cm3/g	Parent nuclides: Am-241: 300 Cs-137: 2,000 Pu-238: 600 Pu-239: 600 Ra-226: 20 Ra-228: 20 Sr-90: 22 Th-228: 1,000 Th-230: 1,000 Th-232: 1,000 U-234: 0.8 U-238: 0.8 Daughters: Ac-227: 300 Pb-210: 6,000 Np-237: 10 Pa-231: 15 Th-229: 1,000 U-233: 0.8 U-235: 0.8	Values for Cs, Pu, Sr, Np, and U are best estimate values for sand dominated sediment from PNNL-14702 (Table 4.11, Waste Chemistry/Source Category 4: Low Organic/Low Salt/Near Neutral, Intermediate Impact - Sand) Values for Am, Ac, Pb, Pa, Ra, and Th are best estimate values from PNNL-11800 (Table E.10, Source-Zone Category F, Low Organic/Low Salts/Near Neutral) Values shown are assigned to all RESRAD layers (contaminated zone, uncontaminated zone, and saturated zone); No gravel correction is applied
	Solubility limit	mol/L	0	RESRAD default
	Leach rate	yr^{-1}	0	RESRAD default
R017 – Inhalation and External Gamma	Inhalation rate	m^3/yr	7,300	Average annual air intake based on a daily inhalation rate of 20 m^3/day (365 days/yr). A daily rate of 20 m^3/day is assumed to be representative of a reasonably conservative inhalation rate for total (indoor plus outdoor) exposures at home and in the workplace (EPA 1991)
	Mass loading for inhalation	g/m^3	0.0001	WDOH/320-015 (Appendix B)
	Exposure duration	year	25	EPA (1991)
	Indoor dust filtration factor	unitless	0.4	RESRAD default
	External gamma shielding factor	unitless	0.4	EPA (2000, Equation 4)

Table B-7. Parameters Used for RESRAD Analysis of the Industrial Worker Exposure Scenario

Description	Parameter	Units	Z-Ditches	Rationale and Citation
R017 – Inhalation and External Gamma	Indoor time fraction	unitless	0.17	Fraction of the year spent onsite indoors. Assumes 6 hr/day, 250 days/yr (1,500 hr/8,760 hr)
	Outdoor time fraction	unitless	0.057	Fraction of the year spent onsite outdoors. Assumes 2 hr/day, 250 days/yr (500 hr/8,760 hr)
	Shape factor	Not Applicable	Circular	RESRAD default
R018 – Ingestion Pathway Data, Dietary Parameters	Fruit, vegetable, and grain consumption	kg/yr	NA	NA
	Leafy vegetable consumption	kg/yr	NA	NA
	Milk consumption	L/yr	NA	NA
	Meat and poultry consumption	kg/yr	NA	NA
	Fish consumption	kg/yr	NA	NA
	Other seafood consumption	kg/yr	NA	NA
	Soil ingestion intake	g/yr	12.5	Based on a soil ingestion rate of 50 mg/day (250 days/yr) (EPA, 1991)
	Drinking water intake	L/yr	NA	NA
	Drinking water contamination fraction	unitless	NA	NA
	Household water contamination fraction	unitless	NA	NA
	Livestock water contamination fraction	unitless	NA	NA
	Irrigation water contamination fraction	unitless	NA	NA
	Aquatic food contamination fraction	unitless	NA	NA
	Plant food contamination fraction	unitless	NA	NA

Table B-7. Parameters Used for RESRAD Analysis of the Industrial Worker Exposure Scenario

Description	Parameter	Units	Z-Ditches	Rationale and Citation
R018 – Ingestion Pathway Data, Dietary Parameters	Meat contamination fraction	unitless	NA	NA
	Milk contamination fraction	unitless	NA	NA
R019 – Ingestion Pathway Data, Nondietary Parameters	Livestock fodder intake for meat	kg/d	NA	NA
	Livestock fodder intake for milk	kg/d	NA	NA
	Livestock water intake for meat	L/d	NA	NA
	Livestock water intake for milk	L/d	NA	NA
	Livestock intake of soil	kg/d	NA	NA
	Mass loading for foliar deposition	g/m^3	NA	NA
	Depth of soil mixing layer	m	0.15	RESRAD default
	Depth of roots	m	NA	NA
R020 – Groundwater Usage	Groundwater fractional usage – drinking water	unitless	NA	NA
	Groundwater fractional usage – household usage	unitless	NA	NA
	Groundwater fractional usage – livestock water	unitless	NA	NA
	Groundwater fractional usage – irrigation	unitless	NA	NA
R021 – Radon	Not used	NA	NA	NA

Table B-7. Parameters Used for RESRAD Analysis of the Industrial Worker Exposure Scenario

Description	Parameter	Units	Z-Ditches	Rationale and Citation

40 CFR 141, "National Primary Drinking Water Regulations."

ANL, 2007, *RESRAD for Windows*, Version 6.4.

ANL/EAD-4, *User's Manual for RESRAD Version 6*.

CCN 070578, “Estimation of the Soil-Specific Exponential Parameter(b).”

DOE/RL-2003-11, *Remedial Investigation Report for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-SC-1 Steam Condensate Group Operable Units*.

EPA, 1991, *Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual Supplemental Guidance, “Standard Default Exposure Factors” (Interim Final)*, OSWER Directive 9285.6-03.

EPA, 1999, *Radiation Risk Assessment At CERCLA Sites: Q & A*, OSWER Directive No. 9200.4-31P, EPA 540/R/99/006.

EPA, 2000, *Soil Screening Guidance for Radionuclides: User’s Guide*, EPA/540-R-00-007, OSWER Directive No. 9355.4-16A.

PNNL-11800, *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*.

PNNL-14702, *Vadose Zone Hydrology Data Package for Hanford Assessments*.

PNNL-15160, *Hanford Site Climatological Summary 2004 With Historical Data*.

WDOH/320-015, *Hanford Guidance for Radiological Cleanup*.

WHC-EP-0883, *Variability and Scaling of Hydraulic Properties for 200 Area Soils*.

WHC-SD-EN-SE-004, *Site Characterization Report: Results of Detailed Evaluation of the Suitability of the Site Proposed for Disposal of 200 Areas Treated Effluent*.

NA = not applicable
CZ = contaminated zone
ND = nondispersion
RCRA = *Resource Conservation and Recovery Act of 1976*
RESRAD = RESidual RADioactivity (dose model) (ANL, 2007)
RI = remedial investigation
SZ = saturated zone
WIDS = Waste Information Data System database

Table B-8. Parameters Used for RESRAD Analysis of the Subsistence Farmer Exposure Scenario

Description	Parameter	Units	Z-Ditches	Rationale and Citation
Exposure Pathways	External gamma	NA	Active	
	Inhalation		Active	
	Plant ingestion		Suppressed	
	Meat ingestion		Suppressed	
	Milk ingestion		Suppressed	
	Aquatic foods		Suppressed	
	Drinking water		Suppressed	
	Soil ingestion		Active	
	Radon		Suppressed	
R011 – Contaminated Zone (CZ)	Area of CZ	m^2	972	Site-specific area from WIDS
	Thickness of CZ	m	7	Assumes contamination extends to the ground surface (i.e., no credit taken for pre-existing controls, including existing 1 m-thick stabilization cover). Value represents sum of contaminated zone (6 m) and stabilization cover (1 m) thicknesses based on remedial investigation (RI) results (DOE/RL-2003-11)
	Length parallel to aquifer flow	m	9	Site-specific
	Radiation dose limit (industrial scenario)	mrem/yr	15	40 CFR 141; EPA, 1999
	Elapsed time since waste placement	yr	0	RESRAD default
Exposure Point Concentrations (EPCs)	EPCs	pCi/g	Contaminant-specific	
R013 – Cover and CZ Hydrological Data	Cover depth	m	0	Assumes contamination extends to the ground surface (i.e., not credit taken for pre-existing controls, including existing 1 m-thick stabilization cover)
	Cover material density	g/cm^3	NA	NA
	Cover erosion rate	m/yr	NA	NA

Table B-8. Parameters Used for RESRAD Analysis of the Subsistence Farmer Exposure Scenario

Description	Parameter	Units	Z-Ditches	Rationale and Citation
R013 – Cover and CZ Hydrological Data	Density of CZ	g/cm^3	1.8	Site-specific value based on RI results
	CZ erosion rate	m/yr	0.00001	Value selected prevents appreciable erosion of the contaminated zone over the simulation period
	CZ total porosity	unitless	0.33	Site-specific value based on physical property samples from RI and WHC-EP-0883
	CZ field capacity	unitless	0.2	Site-specific value based on physical property samples from RI and WHC-EP-0883
	CZ hydraulic conductivity	m/yr	22	WHC-SD-EN-SE-004.
	CZ b parameter	unitless	4.05	• CCN 070578; ANL/EAD-4 (Table E.2)
	Evapotranspiration coefficient	unitless	0.91	WDOH/320-015 (Appendix B)
	Wind speed	m/s	3.4	Based on annual average prevailing wind speed of 7.6 mph (3.4 m/s) measured at Hanford Meteorology Station (PNNL-15160, Table 5.1)
	Precipitation	m/yr	0.177	Based on normal annual precipitation of 6.98 in. (0.177 mm) measured at Hanford Meteorology Station (PNNL-15160, Table 4.1)
	Irrigation rate	m/yr	0.76	WDOH/320-015 (Appendix B)
	Irrigation mode	Overhead or Ditch	Overhead	RESRAD default
	Runoff coefficient	unitless	0	Value selected conservatively assumes all precipitation penetrates the topsoil
	Watershed area for nearby stream or pond	m^2	1.00E+06	RESRAD default
	Accuracy for water/soil computations	unitless	0.001	RESRAD default

Table B-8. Parameters Used for RESRAD Analysis of the Subsistence Farmer Exposure Scenario

Description	Parameter	Units	Z-Ditches	Rationale and Citation
R014 – Saturated Zone (SZ) Hydrological Data	Density of SZ	g/cm^3	2.23	Site-specific value based on RI results and BHI-01177
	SZ total porosity	unitless	0.158	Site-specific value based on physical property samples from RI and WHC-EP-0883
	SZ effective porosity	unitless	0.158	Site-specific value based on physical property samples from RI and WHC-EP-0883
	SZ field capacity	unitless	0.04	Site-specific value based on physical property samples from RI and WHC-EP-0883
	SZ hydraulic conductivity	m/yr	5,519	WHC-SD-EN-SE-004
	SZ hydraulic gradient	unitless	0.0005	DOE/ORP-2005-01 (Table 3-14, reference case value for 200 West Area unconfined aquifer)
	SZ b parameter	unitless	4.05	CCN 070578; ANL/EAD-4 (Table E.2)
	Water table drop rate	m/yr	0.0001	Value selected results in little change in the depth of groundwater over the simulation period
	Well pump intake depth below water table	m	4.6	WDOH/320-015 (Appendix B)
	Model for water transport	Non-dispersion (ND) or mass-balance	ND	RESRAD default
	Well pumping rate	m^3/yr	250	RESRAD default
R015 – Uncontaminated and Unsaturated Strata Hydrological Data	Number of unsaturated strata	NA	3	Site-specific
	Thickness (layer 1)	m	4	Site-specific value based on RI results and current water table elevation data
	Thickness (layer 2)	m	30	Site-specific value based on RI results and current water table elevation data
	Thickness (layer 3)	m	23.2	Site-specific value based on RI results and current water table elevation data

Table B-8. Parameters Used for RESRAD Analysis of the Subsistence Farmer Exposure Scenario

Description	Parameter	Units	Z-Ditches	Rationale and Citation
R015 – Uncontaminated and Unsaturated Strata Hydrological Data	Soil density (layer 1)	g/cm^3	1.98	Hanford formation gravel-dominated sequence
	Soil density (layer 2)	g/cm^3	1.5	Hanford formation sand-dominated sequence and Cold Creek unit
	Soil density (layer 3)	g/cm^3	2.23	Ringold Unit E silty sandy gravel
	Total porosity/effective porosity (layer 1)	unitless	0.253	Site-specific value based on RI results and BHI-01177
	Total porosity/effective porosity (layer 2)	unitless	0.435	Site-specific value based on physical property samples from RI and WHC-EP-0883
	Total porosity/effective porosity (layer 3)	unitless	0.158	Site-specific value based on physical property samples from RI and WHC-EP-0883
	Field capacity (layer 1)	unitless	0.04	Site-specific value based on physical property samples from RI and WHC-EP-0883
	Field capacity (layer 2)	unitless	0.04	Site-specific value based on physical property samples from RI and WHC-EP-0883
	Field capacity (layer 3)	unitless	0.04	Site-specific value based on physical property samples from RI and WHC-EP-0883
	Hydraulic conductivity (layer 1)	m/yr	757	WHC-SD-EN-SE-004
	Hydraulic conductivity (layer 2)	m/yr	138	WHC-SD-EN-SE-004
	Hydraulic conductivity (layer 3)	m/yr	552	WHC-SD-EN-SE-004
	Soil-specific b parameter (layer 1)	unitless	4.05	CCN 070578; ANL/EAD-4 (Table E.2)
	Soil-specific b parameter (layer 2)	unitless	4.05	CCN 070578; ANL/EAD-4 (Table E.2)
	Soil-specific b parameter (layer 3)	unitless	4.05	CCN 070578; ANL/EAD-4 (Table E.2)

Table B-8. Parameters Used for RESRAD Analysis of the Subsistence Farmer Exposure Scenario

Description	Parameter	Units	Z-Ditches	Rationale and Citation
R016 – Distribution Coefficients and Leach Rates for Individual Radionuclides	Distribution coefficients (Kd) for contaminated zone, uncontaminated zone, and SZ	cm^3/g	Parent nuclides: Am-241: 300 Cs-137: 2,000 Pu-238: 600 Pu-239: 600 Ra-226: 20 Ra-228: 20 Sr-90: 22 Th-228: 1,000 Th-230: 1,000 Th-232: 1,000 U-234: 0.8 U-238: 0.8 Daughters: Ac-227: 300 Pb-210: 6,000 Np-237: 10 Pa-231: 15 Th-229: 1,000 U-233: 0.8 U-235: 0.8	Values for Cs, Pu, Sr, Np, and U are best estimate values for sand dominated sediment from PNNL-14702 (Table 4.11, Waste Chemistry/Source Category 4: Low Organic/Low Salt/Near Neutral, Intermediate Impact-Sand) Values for Am, Ac, Pb, Pa, Ra, and Th are best estimate values from PNNL-11800 (Table E.10, Source-Zone Category F, Low Organic/Low Salts/Near Neutral) Values shown are assigned to all RESRAD layers (contaminated zone, uncontaminated zone, and saturated zone). No gravel correction is applied
	Solubility limit	mol/L	0	RESRAD default.
	Leach rate	yr^{-1}	0	RESRAD default.
R017 – Inhalation and External Gamma	Inhalation rate	m^3/yr	7,300	Average annual air intake based on a daily inhalation rate of 20 m^3/day (365 days/yr). A daily rate of 20 m^3/day is assumed to be representative of a reasonably conservative inhalation rate for total (indoor plus outdoor) exposures at home and in the workplace (EPA, 1991)
	Mass loading for inhalation	g/m^3	0.0001	WDOH/320-015 (Appendix B)
	Exposure duration	year	30	EPA, 1991
	Indoor dust filtration factor	unitless	0.4	RESRAD default
	External gamma shielding factor	unitless	0.4	EPA, 2000, Equation 4

Table B-8. Parameters Used for RESRAD Analysis of the Subsistence Farmer Exposure Scenario

Description	Parameter	Units	Z-Ditches	Rationale and Citation
R017 – Inhalation and External Gamma	Indoor time fraction	unitless	0.6	Fraction of the year spent onsite indoors. Assumes 15 hr/day, 350 days/yr (5,250 h r / 8,760 hr)
	Outdoor time fraction	unitless	0.12	Fraction of the year spent onsite outdoors. Assumes 3 hr/day, 350 days/yr (1,050 h r / 8,760 hr)
	Shape factor	NA	Circular	RESRAD default
R018 – Ingestion Pathway Data, Dietary Parameters	Fruit, vegetable, and grain consumption	kg/yr	110	WDOH/320-015 (Appendix B)
	Leafy vegetable consumption	kg/yr	2.7	WDOH/320-015 (Appendix B)
	Milk consumption	L/yr	100	WDOH/320-015 (Appendix B)
	Meat and poultry consumption	kg/yr	36	WDOH/320-015 (Appendix B)
	Fish consumption	kg/yr	NA	The consumption of fish is considered an incomplete exposure pathway for Hanford Site operable units located on the Central Plateau
	Other seafood consumption	kg/yr	NA	The consumption of seafood is considered an incomplete exposure pathway for Hanford Site operable units
	Soil ingestion intake	g/yr	35	Based on a soil ingestion rate of 100 mg/day (350 days/yr) (EPA, 1991)
	Drinking water intake	L/yr	700	Based on a drinking water ingestion rate of 2 L/day (350 days/yr) (EPA, 1991)
	Drinking water contamination fraction	unitless	1	RESRAD default
	Household water contamination fraction	unitless	1	RESRAD default
	Livestock water contamination fraction	unitless	1	RESRAD default
	Irrigation water contamination fraction	unitless	1	RESRAD default

Table B-8. Parameters Used for RESRAD Analysis of the Subsistence Farmer Exposure Scenario

Description	Parameter	Units	Z-Ditches	Rationale and Citation
R018 – Ingestion Pathway Data, Dietary Parameters	Aquatic food contamination fraction	unitless	NA	NA
	Plant food contamination fraction	unitless	-1	RESRAD default
	Meat contamination fraction	unitless	-1	RESRAD default
	Milk contamination fraction	unitless	-1	RESRAD default
R019 – Ingestion Pathway Data, Nondietary Parameters	Livestock fodder intake for meat	kg/d	68	RESRAD default
	Livestock fodder intake for milk	kg/d	55	RESRAD default
	Livestock water intake for meat	L/d	50	RESRAD default
	Livestock water intake for milk	L/d	160	RESRAD default
	Livestock intake of soil	kg/d	0.5	RESRAD default
	Mass loading for foliar deposition	g/m^3	0.0001	RESRAD default
	Depth of soil mixing layer	m	0.15	RESRAD default
	Depth of roots	m	0.9	NA
R020 – Groundwater Usage	Groundwater fractional usage – drinking water	unitless	1	RESRAD default
	Groundwater fractional usage – household usage	unitless	1	RESRAD default
	Groundwater fractional usage – livestock water	unitless	1	RESRAD default
	Groundwater fractional usage – irrigation	unitless	1	RESRAD default
R021 – Radon	Not used	NA	NA	Not applicable

Table B-8. Parameters Used for RESRAD Analysis of the Subsistence Farmer Exposure Scenario

Description	Parameter	Units	Z-Ditches	Rationale and Citation

40 CFR 141, "National Primary Drinking Water Regulations."

ANL, 2007, *RESRAD for Windows*, Version 6.4.

ANL/EAD-4, *User's Manual for RESRAD Version 6*

CCN 070578, “Estimation of the Soil-Specific Exponential Parameter(b).”

DOE/ORP-2005-01, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site*.

DOE/RL-2003-11, *Remedial Investigation Report for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-SC-1 Steam Condensate Group Operable Units*.

EPA, 1991, *Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual Supplemental Guidance, “Standard Default Exposure Factors” (Interim Final)*, OSWER Directive 9285.6-03.

EPA, 1999, *Radiation Risk Assessment at CERCLA Sites: Q & A*, OSWER Directive No. 9200.4-31P, EPA 540/R/99/006.

EPA, 2000, *Soil Screening Guidance for Radionuclides: User’s Guide*, EPA/540-R-00-007, OSWER Directive No. 9355.4-16A.

PNNL-11800, *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*.

PNNL-14702, *Vadose Zone Hydrology Data Package for Hanford Assessments*.

PNNL-15160, *Hanford Site Climatological Summary 2004 With Historical Data*.

WDOH/320-015, *Hanford Guidance for Radiological Cleanup*.

WHC-EP-0883, *Variability and Scaling of Hydraulic Properties for 200 Area Soils*.

WHC-SD-EN-SE-004, *Site Characterization Report: Results of Detailed Evaluation of the Suitability of the Site Proposed for Disposal of 200 Areas Treated Effluent*.

NA = not applicable
CZ = contaminated zone
ND = nondispersion
RCRA = *Resource Conservation and Recovery Act of 1976*
RESRAD = RESidual RADioactivity (dose model) (ANL, 2007)
RI = remedial investigation
SZ = saturated zone
WIDS = Waste Information Data System database

Table B-9. RESRAD Risk Results – Unrestricted Land Use – Subsistence Farmer Scenario

Scenario	Total Risk (ELCR)	Years	Primary Radionuclide	Percentage (%) of Total Risk	Primary Pathway
Subsistence Farmer			**Z-Ditches**		
	8.98×10^{-1}	2008	Radium-226	47	Ground
			Americium-241	6	
			Cesium-137	5	
			Radium-226	3	Plant
			Americium-241	5	
			Americium-241	2	Soil
	9.02×10^{-1}	2009	Radium-226	47	Ground
			Americium-241	6	
			Cesium-137	5	
			Radium-226	31	Plant
			Americium-241	5	
			Americium-241	2	Soil
	9.80×10^{-1}	2058	Radium-226	41	Ground
			Americium-241	5	
			Cesium-137	1	
			Radium-226	42	Plant
			Americium-241	4	
			Americium-241	2	Soil
			Radium-226	1	
	9.25×10^{-1}	2158	Radium-226	41	Ground
			Americium-241	5	
			Radium-226	45	Plant
			Americium-241	4	
			Americium-241	2	Soil
			Radium-226	1	
	6.91×10^{-1}	2508	Radium-226	42	Ground
			Americium-241	4	
			Radium-226	47	Plant
			Americium-241	3	
			Plutonium-239	1	

Table B-9. RESRAD Risk Results – Unrestricted Land Use – Subsistence Farmer Scenario

Scenario	Total Risk (ELCR)	Years	Primary Radionuclide	Percentage (%) of Total Risk	Primary Pathway
	6.91×10^{-1}	2508	Radium-226	2	Soil
			Americium-241	1	
	4.63×10^{-1}	3008	Radium-226	42	Ground
			Americium-241	2	
			Radium-226	48	Plant
			Plutonium-239	2	
			Americium-241	2	
			Radium-226	2	Soil

ELCR = excess lifetime cancer risk

Table B-10. RESRAD Risk Results – Industrial Land Use-Industrial Worker Scenario

Total Risk (ELCR)	Year	Primary Radionuclide	Percentage (%) of Total Risk	Primary Pathway
		Z-Ditches		
6.04×10^{-1}	2003	Plutonium-239	64.4	Ground
		Radium-226	30.9	
6.04×10^{-1}	2004	Plutonium-239	64.4	Ground
		Radium-226	30.9	
5.91×10^{-1}	2053	Plutonium-239	65.6	Ground
		Radium-226	30.6	
5.73×10^{-1}	2153	Plutonium-239	67.3	Ground
		Radium-226	29.5	
5.26×10^{-1}	2503	Plutonium-239	72.0	Ground
		Radium-226	25.2	
4.73×10^{-1}	3003	Plutonium-239	77.8	Ground
		Radium-226	19.7	

ELCR = excess lifetime cancer risk

Table B-11. Comparison of Z-Ditch Shallow Zone Maximum Concentrations to WAC 173-340-7493, Table 749-3, Ecological Indicator Soil Concentrations for Protection of Terrestrial Plants and Animals

Constituent Name	CAS Number	Constituent Class	Units	Number of Results	Number of Detects	Frequency of Detection	Minimum Nondetected	Maximum Nondetected	Minimum Detected	Maximum Detected	Background Value[a]	Is [max] > background ?	Screening Value	Is [max] > Screening Value?	Screening Value Source[b]	COPC Flag	Rationale Contaminant Deletion or Selection[c]
Arsenic	7440-38-2	Metal	mg/kg	4	3	75	19.3	19.3	3.7	6.2	6.5	No	7	No	WAC 173-340-7493	No	BSL
Barium	7440-39-3	Metal	mg/kg	4	4	100	--	--	0.77	87.8	132	No	102	No	WAC 173-340-7493	No	BSL
Beryllium	7440-41-7	Metal	mg/kg	4	3	75	0.965	0.965	0.22	0.25	1.5	No	10	No	WAC 173-340-7493	No	BSL
Boron	7440-42-8	Metal	mg/kg	4	4	100	--	--	0.77	23.8	NE	NA	0.5	Yes	WAC 173-340-7493	Yes	ASL
Cadmium	7440-43-9	Metal	mg/kg	4	1	25	0.03	0.965	0.05	0.05	1.0	No	4	No	WAC 173-340-7493	No	BSL
Chromium	7440-47-3	Metal	mg/kg	4	4	100	--	--	8.7	10.5	19	No	42	No	WAC 173-340-7493	No	BSL
Copper	7440-50-8	Metal	mg/kg	4	4	100	--	--	13.5	30.4	22	Yes	50	No	WAC 173-340-7493	No	BSL
Hexavalent Chromium	18540-29-9	Metal	mg/kg	3	1	33.33	0.43	0.46	0.54	0.54	NE	NA	NA	NA	NA	No	TOX
Lead	7439-92-1	Metal	mg/kg	4	3	75	19.3	19.3	5.8	7.1	10	No	50	No	WAC 173-340-7493	No	BSL
Lithium	7439-93-2	Metal	mg/kg	1	1	100	--	--	0.63	0.63	NE	NA	35	No	WAC 173-340-7493	No	BSL
Magnesium	7439-95-4	Metal	mg/kg	4	4	100	--	--	4200	4760	7,060	No	NA	NA	NA	No	BCK
Manganese	7439-96-5	Metal	mg/kg	4	4	100	--	--	333	365	512	No	1,100	No	WAC 173-340-7493	No	BSL
Mercury	7439-97-6	Metal	mg/kg	4	2	50	0.02	0.02	0.08	0.658	0.33	Yes	0.1	Yes	WAC 173-340-7493	Yes	ASL
Molybdenum	7439-98-7	Metal	mg/kg	4	3	75	9.65	9.65	0.63	0.77	2,800	No	2	No	WAC 173-340-7493	No	BSL
Nickel	7440-02-0	Metal	mg/kg	4	4	100	--	--	9.7	10.9	19	No	30	No	WAC 173-340-7493	No	BSL
Silver	7440-22-4	Metal	mg/kg	4	1	25	0.05	1.93	0.69	0.69	0.73	No	2	No	WAC 173-340-7493	No	BSL
Vanadium	7440-62-2	Metal	mg/kg	4	4	100	--	--	49.8	57.6	85	No	2	Yes	WAC 173-340-7493	No	BCK
Zinc	7440-66-6	Metal	mg/kg	4	4	100	--	--	45	63.4	68	No	86	No	WAC 173-340-7493	No	BSL
Aroclor-1254	11097-69-1	Pest/PCB	mg/kg	4	1	25	0.036	0.038	52	52	NE	NA	0.65	Yes	WAC 173-340-7493	Yes	ASL
Aroclor-1260	11096-82-5	Pest/PCB	mg/kg	4	1	25	0.036	0.038	77.6	77.6	NE	NA	0.65	Yes	WAC 173-340-7493	Yes	ASL
Bis(2-ethylhexyl) phthalate	117-81-7	SVOC	mg/kg	3	1	33.33	0.33	0.36	0.042	0.042	NE	NA	NA	NA	NA	No	TOX
Total petroleum hydrocarbons	TPH	TPH	mg/kg	1	1	100	--	--	26.6	26.6	NE	NA	NA	NA	NA	No	TOX
Acetone	67-64-1	VOC	mg/kg	3	3	100	--	--	0.004	0.014	NE	NA	NA	NA	NA	No	TOX
Methylene chloride	75-09-2	VOC	mg/kg	3	2	66.67	0.006	0.006	0.005	0.008	NE	NA	NA	NA	NA	No	TOX
Ammonia	7664-41-7	Wetchem	mg/kg	3	2	66.67	3.53	3.53	5.11	8.15	9.2	No	NA	NA	NA	No	BCK
Fluoride	16984-48-8	Wetchem	mg/kg	3	2	66.67	1.3	1.3	1.5	1.7	2.8	No	200	No	WAC 173-340-7493	No	BSL
Nitrate	14797-55-8	Wetchem	mg/kg	3	3	100	--	--	24.2	42.7	52	No	NA	NA	NA	No	BCK

Table B-11. Comparison of Z-Ditch Shallow Zone Maximum Concentrations to WAC 173-340-7493, Table 749-3, Ecological Indicator Soil Concentrations for Protection of Terrestrial Plants and Animals

Constituent Name	CAS Number	Constituent Class	Units	Number of Results	Number of Detects	Frequency of Detection	Minimum Nondetected	Maximum Nondetected	Minimum Detected	Maximum Detected	Background Value[a]	Is [max] > background ?	Screening Value	Is [max] > Screening Value?	Screening Value Source[b]	COPC Flag	Rationale Contaminant Deletion or Selection[c]
Nitrite	14797-65-0	Wetchem	mg/kg	2	2	100	--	--	33	42.7	NE	NA	NA	NA	NA	No	TOX
Nitrogen in Nitrite and Nitrate	NO2+NO3-N	Wetchem	mg/kg	3	3	100	--	--	5.3	7.7	NE	NA	NA	NA	NA	No	TOX
Sulfate	14808-79-8	Wetchem	mg/kg	3	3	100	--	--	4.2	28.6	237	*No*	NA	*NA*	NA	No	BCK

a. Background is assumed to be zero for volatile and semi-volatile organic compounds. Nonradionuclide background values were taken from DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*.

b. WAC 173-340-7493, "Model Toxics Control Act—Cleanup," "Site-Specific Terrestrial Ecological Evaluation Procedures," EPA Regional Screening Values, Table 749-3.

c. Rationale codes: Selection reason: ASL = above screening level
Deletion reason: BCK = near or below background levels
BSL = below screening level
TOX = constituent does not have published toxilogical information, addressed as an uncertainty
NUT = essential nutrient

-- = contaminant has 100% detection frequency

CAS = Chemical Abstract Services

NA = not applicable

NE = not established

Table B-12. Comparison of Shallow-Zone Soil Exposure-Point Concentrations to Background and to Ecological Screening Values for Radionuclides

Constituent Name	Number of Samples	Number of Detects	Frequency of Detection (%)	Exposure-Point Concentration (pCi/g)	90th Percentile Background Concentration (pCi/g)	Exceeds Background?	BCG[a] (pCi/g)	COEC?	Justification
Z-Ditches[b]									
Americium-241	286	284	99	202,640	N/A	U	4,000	Yes	Exceeds BCGs
Cesium-137	187	184	98	2,571	0.919	Yes	20	Yes	Exceeds BCGs
Plutonium-238	62	54	87	1,302	0.0047	Yes	5,400	No	Below BCGs
Plutonium-239 + Plutonium-239/240	281	279	99	28,291	0.0192	Yes	6,000	Yes	Exceeds BCGs
Radium-226	12	12	100	5,200	0.815	Yes	50	Yes	Exceeds BCGs
Radium-228	4	2	50	0.81	N/A	U	40	No	Below BCG
Strontium-90	30	23	77	95.18	0.167	Yes	20	Yes	Requires further evaluation
Thorium-228	4	1	25	0.66	N/A	U	530	No	Below BCG
Thorium-230	4	3	75	8.4	1.1	Yes	9,980	No	Below BCG
Thorium-232	4	1	25	0.71	1.32	No	2,000	No	Below background
Uranium-233/234	4	1	25	0.36	1.1	No	5,000	No	Below background
Uranium-238	4	2	50	0.77	1.1	No	5,000	No	Below background

Table B-12. Comparison of Shallow-Zone Soil Exposure-Point Concentrations to Background and to Ecological Screening Values for Radionuclides

Constituent Name	Number of Samples	Number of Detects	Frequency of Detection (%)	Exposure-Point Concentration (pCi/g)	90th Percentile Background Concentration (pCi/g)	Exceeds Background?	BCG[a] (pCi/g)	COEC?	Justification

a. DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*, Table 6.4.

b. Constituent statistics and analytical results based on re-evaluation of the 200-CW-5 operable unit radionuclide data set using EPA's ProUCL 4.0 analysis tool (EPA/600/R-07/038, *ProUCL Version 4.0 User Guide*). The evaluation included a statistical outlier test to determine the presence of outliers associated with the plutonium isotope data set. The outlier test indicated the presence of two potential Pu-239/240 statistical outliers, with concentrations of 1.3×10^7 pCi/g and 7.5×10^5 pCi/g. Statistical evaluation of the data set after removal of these outliers yielded the Pu-239/240 results shown in this table.

BCG = biota concentration guide
COEC = contaminant of ecological concern
N/A = not available
U = undetermined

Table B-13. Comparison of Z-Ditch Deep Zone Maximum Concentrations to WAC 173-340-747 Soil Concentrations for the Protection of Groundwater

	CAS Number	Constituent Class	Units	Number of Results	Number of Detects	Frequency of Detection	Minimum Nondetected	Maximum Nondetected	Minimum Detected	Maximum Detected	Background Value[a]	Is [max] > Background ?	Screening Value	Is [max] > Screening Value?	Screening Value Source[b]	COPC Flag	Rationale Contaminant Deletion or Selection[c]
Arsenic	7440-38-2	Metal	mg/kg	12	11	92	19.3	19.3	0.57	6.8	6.5	No	0.034	Yes	WAC 173-340-747	No	BCK
Barium	7440-39-3	Metal	mg/kg	12	12	100	--	--	0.21	117	132.0	No	1648	No	WAC 173-340-747	No	BSL
Beryllium	7440-41-7	Metal	mg/kg	12	11	92	0.965	0.965	0.14	0.84	1.5	No	63	No	WAC 173-340-747	No	BSL
Boron	7440-42-8	Metal	mg/kg	12	11	92	0.15	0.15	0.21	23.8	NE	NA	205	No	WAC 173-340-747	No	BSL
Cadmium	7440-43-9	Metal	mg/kg	12	3	25	0.02	0.965	0.05	0.2	1.0	No	7.5	No	WAC 173-340-747	No	BSL
Chromium	7440-47-3	Metal	mg/kg	12	12	100	--	--	5.5	19.4	18.5	Yes	2000	No	WAC 173-340-747	No	BSL
Copper	7440-50-8	Metal	mg/kg	12	12	100	--	--	8.6	30.4	22.0	Yes	284	No	WAC 173-340-747	No	BSL
Hexavalent Chromium	18540-29-9	Metal	mg/kg	11	4	36	0.41	0.46	0.46	1.9	NE	NA	18	No	WAC 173-340-747	No	BSL
Lead	7439-92-1	Metal	mg/kg	12	11	92	19.3	19.3	2	7.1	10.2	No	3000	No	WAC 173-340-747	No	BSL
Lithium	7439-93-2	Metal	mg/kg	1	1	100	--	--	0.63	0.63	NE	NA	192	No	WAC 173-340-747	No	BSL
Magnesium	7439-95-4	Metal	mg/kg	12	12	100	--	--	2360	5430	7060.0	No	NA	NA	WAC 173-340-747	No	NUT
Manganese	7439-96-5	Metal	mg/kg	12	12	100	--	--	217	397	512.0	No	65	Yes	WAC 173-340-747	No	BCK
Mercury	7439-97-6	Metal	mg/kg	12	2	17	0.02	0.02	0.08	0.658	0.3	Yes	2.1	No	WAC 173-340-747	No	BSL
Molybdenum	7439-98-7	Metal	mg/kg	12	11	92	9.65	9.65	0.56	0.82	2800.0	No	32	No	WAC 173-340-747	No	BSL
Nickel	7440-02-0	Metal	mg/kg	12	12	100	--	--	7.1	15.2	19.1	No	130	No	WAC 173-340-747	No	BSL
Silver	7440-22-4	Metal	mg/kg	12	2	17	0.04	1.93	0.06	0.69	0.7	No	14	No	WAC 173-340-747	No	BSL
Vanadium	7440-62-2	Metal	mg/kg	12	12	100	--	--	19.6	78.9	85.1	No	1600	No	WAC 173-340-747	No	BSL
Zinc	7440-66-6	Metal	mg/kg	12	12	100	--	--	21.8	63.4	67.8	No	5971	No	WAC 173-340-747	No	BSL
Aroclor-1254	11097-69-1	Pest/PCB	mg/kg	12	1	8	0.033	0.038	52	52	NE	NA	0.11	Yes	WAC 173-340-747	Yes	ASL
Aroclor-1260	11096-82-5	Pest/PCB	mg/kg	12	1	8	0.033	0.038	77.6	77.6	NE	NA	0.72	Yes	WAC 173-340-747	Yes	ASL
Bis(2-ethylhexyl) phthalate	117-81-7	SVOC	mg/kg	11	4	36	0.33	0.36	0.042	0.059	NE	NA	13	No	WAC 173-340-747	No	BSL
Total Petroleum Hydrocarbons	TPH	TPH	mg/kg	1	1	100	--	--	26.6	26.6	NE	NA	NA	NA	WAC 173-340-747	No	TOX
Acetone	67-64-1	VOC	mg/kg	11	11	100	--	--	0.004	0.031	NE	NA	29	No	WAC 173-340-747	No	BSL
Methylene chloride	75-09-2	VOC	mg/kg	11	10	91	0.006	0.006	0.002	0.012	NE	NA	0.022	No	WAC 173-340-747	No	BSL
Ammonia	7664-41-7	Wetchem	mg/kg	11	8	73	3.04	3.53	3.28	84.5	9.2	Yes	NA	NA	WAC 173-340-747	No	TOX
Fluoride	16984-48-8	Wetchem	mg/kg	11	2	18	1.3	1.4	1.5	1.7	2.8	No	1442	No	WAC 173-340-747	No	BSL
Nitrate	14797-55-8	Wetchem	mg/kg	11	7	64	1.28	1.38	2.38	42.7	52.0	No	102	No	WAC 173-340-747	No	BSL
Nitrite	14797-65-0	Wetchem	mg/kg	3	3	100	--	--	23	42.7	NE	NA	6.4	Yes	WAC 173-340-747	Yes	ASL
Nitrogen in Nitrite and	NO2+NO3-N	Wetchem	mg/kg	11	7	64	0.2	0.22	0.7	7.7	NE	NA	23.052	No	WAC 173-340-747	No	BSL

Table B-13. Comparison of Z-Ditch Deep Zone Maximum Concentrations to WAC 173-340-747 Soil Concentrations for the Protection of Groundwater

	CAS Number	Constituent Class	Units	Number of Results	Number of Detects	Frequency of Detection	Minimum Nondetected	Maximum Nondetected	Minimum Detected	Maximum Detected	Background Value[a]	Is [max] > Background ?	Screening Value	Is [max] > Screening Value?	Screening Value Source[b]	COPC Flag	Rationale Contaminant Deletion or Selection[c]
Nitrate																	
Sulfate	14808-79-8	Wetchem	mg/kg	11	11	100	--	--	2.2	28.7	237.0	No	1000	No	WAC 173-340-747	No	BSL

a. Background is assumed to be zero for volatile and semi-volatile organic compounds. Nonradionuclide background values were taken from DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*.

b. ECF-200PW136-10-0337, *Calculation of Nonradiological WAC 173-340-747, Soil Concentrations Protective of Groundwater Using Fixed Parameter Three-Phase Model.*

c. Rationale codes:
Selection reason: ASL = above screening level.
Deletion reason: BCK = near or below background levels
BSL = below screening level
TOX = constituent does not have published toxilogical information, addressed as an uncertainty
NUT = essential nutrient

WAC 173-340-747, "Model Toxics Control Act—Cleanup," "Deriving Soil Concentrations for Ground Water Protection."

-- = contaminant has 100% detection frequency

CAS = Chemical Abstract Services

NA = not applicable

NE = not established

Table B-14. RESRAD Risk Results for Groundwater Protection

Scenario	Total Risk	Time (Years)	Primary Radionuclide	Percentage of Total Risk	Primary Pathway
Groundwater Protection, No Cover	Z-Ditches				
	0.0	0	--	--	Drinking water
	0.0	1	--	--	Drinking water
	0.0	50	--	--	Drinking water
	0.0	150	--	--	Drinking water
	0.0	200	--	--	Drinking water
	0.0	300	--	--	Drinking water
	0.0	400	--	--	Drinking water
	0.0	500	--	--	Drinking water
	0.0	1,000	--	--	Drinking water

RESRAD calculation assumed no soil cover.

RESRAD = RESidual RADioactivity (ANL/EAD-4, *User's Manual for RESRAD Version 6*)

Table B-15. Z-Ditches Contaminants Modeled with STOMP

Americium-241	Strontium-90
Cesium-137	Thorium-230
Plutonium-239	Aroclor-1254
Plutonium-239/240	Aroclor-1260

From DOE/RL-2003-11, *Remedial Investigation for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-SC-1 Steam Condensate Group Operable Units*.

Aroclor is an expired trademark.

STOMP = PNNL-12034, *STOMP, Subsurface Transport Over Multiple Phases, Version 2.0, User's Guide*.

This page intentionally left blank.

Appendix C

Cost Estimate Backup

Terms

CHPRC	CH2M HILL Plateau Remediation Company
ERDF	Environmental Restoration Disposal Facility
FP	fixed price
FS	feasibility study
IC	institutional control
ISV	in situ vitrification
NEPA	*National Environmental Policy Act of 1969*
O&M	Operations and Maintenance
OMB	Office of Management and Budget
QA	quality assurance
RCT	radiological control technician
RTD	removal, treatment, and disposal

C1 Introduction

The cost estimates for the feasibility study (FS) are developed in accordance with guidance specified in EPA 540-R-00-002, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, OSWER 9355.0-75*. The cost estimates provide a discriminator for deciding between similar protective and implemental alternatives for a specific waste site. Therefore, the costs are relational, not absolute, costs for the evaluation of the alternatives. Cost estimates for the alternatives are developed using the MAESTRO[1] Estimator cost models developed by the CH2M HILL Plateau Remediation Company (CHPRC) Project Controls and Estimating department.

The estimates have been based on actual pricing information derived from historical experience. The units used may have been factored/adjusted by the estimator and/or task lead, as appropriate, to reflect influences by the contract, work site, or other identified special conditions. Historical information from similar Hanford Site planning and construction well-drilling activities has been applied to this estimate.

The costs are presented in present-net-worth values. The present-net-worth value method is used to evaluate costs that occur during different time periods and allows for cost comparisons of alternatives based on a single cost number for each alternative. The present-net-worth value represents the dollars that would need to be set aside today to ensure that funds would be available in the future as they are needed to execute the remedial alternative.

Present-net-worth costs are estimated using the real discount rate published in Appendix C of Office of Management and Budget (OMB) Circular No. A-94, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*, effective through January 2008. Programs with durations longer than 30 years use the 30-year interest rate of 2.7 percent. Present-net-worth costs are discussed for each alternative in the following subsections. The period of analysis for the present-net-worth cost is 1000 years.

EPA 540-R-00-002 recommends including the nondiscounted costs in the FS. Nondiscounted constant dollar costs demonstrate the impact of a discount rate on the total present value cost. The nondiscounted costs are calculated for 1000-year duration and are presented for comparison purposes only.

This FS does not evaluate the economies associated with implementing multiple sites or groups with a common alternative or aggregated remediation. They will be considered in the future as part of long-range planning and through the post-record-of-decision activities, such as remedial design. Potential areas of cost sharing to reduce overall remediation costs include the following:

- Remediating all waste sites with a common preferred alternative at the same time
- Sharing mobilization/demobilization costs
- Sharing surveillance and maintenance costs
- Sharing barrier performance monitoring costs

C2 Basis of Estimates

The remedial alternatives are discussed in detail in Chapters 5.0 and 6.0 of this FS. This appendix summarizes the alternatives described in the FS and provides backup information and assumptions used in developing the cost estimates for the remedial alternatives.

---

[1] MAESTRO is a copyright of Schwaab Technology Solutions, Inc., Newman Lake, Washington.

Table C-1 provides an overview of the site information used for the cost estimates. Table C-2 provides a breakdown of capital costs for each alternative. Table C-3 provides a summary of the costs for the alternatives.

C2.1 Global Assumptions

C2.1.1 Labor

Fixed price (FP) construction craft labor rates are those listed in Appendix A of the *Site Stabilization Agreement for All Construction Work for the U.S. Department of Energy at the Hanford Site* (commonly known as the Hanford Site Stabilization Agreement). The Hanford Site Stabilization Agreement rates include base wage, fringe benefits, and other compensation as negotiated between CHPRC and the National Building and Construction Trades Department American Federation of Labor-Congress of Industrial Organizations. Other factors to cover additional costs for Workman's Compensation, *Federal Insurance Contributions Act*, and state and federal unemployment insurance to develop a fully burdened rate by craft have been incorporated. The labor rates used are for 2009.

CHPRC labor rates for management, engineering, safety oversight, and technical support are based on the CHPRC approved planning rates for fiscal year 2009.

C2.1.2 Markups

C2.1.2.1 Direct Cost Factors

Sales tax has been applied to all materials and equipment purchases at 8.3 percent.

Construction consumables are estimated at 3.5 percent of FP direct craft labor costs to allow for small tools, tape, plastics, gloves, etc.

General supervisor factor of 3 percent has been applied to FP craft labor hours.

General requirements factor of 5 percent has been applied to cover incidental labor for hauling personnel and materials along with other miscellaneous labor.

C2.1.2.2 Indirect Cost Factors

FP contractor overhead, profit, bond, and insurance costs have been applied at 26.5 percent on FP labor, materials, and equipment.

CHPRC general and administrative of 14.77 percent has been applied to all CHPRC labor, material, and equipment. General and administrative also is applied to the FP contractor costs.

Table C-1. Site Information and Quantities

Description	Remediation	Contaminated Soil Area Dimensions (feet)			Contaminated Soil Volumes (cy)		Clean Soil Volumes (cy)		ISV	Barrier				Notes
		Length	Width	Depth (bgs)	ERDF	TRU (WIPP)	Clean Excavated	Back Fill	Depth (bgs)	Length	Width	Acres	Barrier Type	
Alternative 3														
Work Area 1	RTD	610	239	varies	54351	0	8164	54351						Assume excavation depth adequate to remove all ERDF contaminated soil.
Work Area 2	RTD	1020	175	varies	56677	0	28767	56677						
Work Area 3	RTD	1042	160	varies	75923	0	17580	75923						
Alternative 4														
Work Area 1	Modified ET Barrier	610	239							715	344	5.6	Modified ET Barrier	
Work Area 2	Modified ET Barrier	1020	175							1125	280	7.2		
Work Area 3	Modified ET Barrier	1042	160							1147	265	7.0		
Alternative 5A														
Work Area 1	RTD/Barrier	610	239	varies	54351	0	8164	54351		715	344	5.6	Modified ET Barrier	Assume excavation depth adequate to remove all ERDF contaminated soil.
Work Area 2	ISV	1020	175	varies					20					Assume 20 foot depth.
Work Area 2 - 216-Z-20	RTD	1020	10	12	1134	0	12693	1134						216-Z-20 only.
Work Area 2	Modified ET Barrier	1020	175							1125	280	7.2	Modified ET Barrier	
Work Area 3	RTD/Barrier	1042	160	varies	75923	0	17580	75923		1147	265	7.0	Modified ET Barrier	Assume excavation depth adequate to remove all ERDF contaminated soil.
Alternative 5B														
Work Area 1	Modified ET Barrier	610	239							715	344	5.6	Modified ET Barrier	
Work Area 2	ISV	1020	175	varies	0	0	0	0	20					Assume 20 foot depth.
Work Area 2	Modified ET Barrier	1020	175							1125	280	7.2	Modified ET Barrier	
Work Area 3	Modified ET Barrier	1042	160							1147	265	7.0	Modified ET Barrier	

Notes:

ERDF = Environmental Restoration Disposal Facility

ISV = in situ vitrification

RTD = removal, treatment, and disposal

TRU = Radioactive waste as defined in DOE G 435.1-1, *Implementation Guide for Use with DOE M 435.1-1*

WIPP = Waste Isolation Pilot Plant

Table C-2. Capital-Cost Breakdown All Alternatives OU 200-CW-5, Hanford Site, Richland, Washington – Z Ditch

	Alternative 3	Alternative 4	Alternative 5A	Alternative 5B
	RTD Work Areas 1, 2, & 3	Barrier (ET-Monofill) & IC All Work Areas	ISV & Barrier (ET-Monofill) Work Area 2 , RTD Work Areas 1 & 3 and IC All Work Areas	ISV & Barrier (ET-Monofill) Area 2, Barrier (ET-Monofill) Work Areas 1 & 3 and IC All Work Areas
Mobilization/ Demobilization	$1,356,188	$555,280	$3,424,229	$2,659,576
Monitoring & Sampling	$3,350,828	$17,508	$2,550,872	$48,624
Site Work	$3,818,419	$509,971	$3,380,961	$892,417
Soil Excavation	$42,502,137	$0	$29,894,858	$0
Treatment	$0	$0	$263,564,458	$263,564,458
Cap	$0	$5,941,162	$5,941,162	$5,941,162
Construction Staff	$3,716,276	$994,911	$3,720,926	$1,197,949
Project Management	$2,298,533	$745,657	$7,234,322	$5,690,434
Sub Total	$57,042,381	$8,764,489	$319,711,788	$279,994,620
Remedial Design*	$3,422,543	$701,159	$19,182,707	$16,911,223
Total Project	$60,464,924	$9,465,648	$338,894,495	$296,905,843
Duration of Field Work (Days)	885	273	1865	1263
Area to be Maintained After Completion of Work (Ac)	0	19.9	19.9	19.9

Notes:

Remedial Design Capital Costs are based on EPA 540-R-00-002, Exhibit 5-8.

For projects with construction costs from $500K to $2M – Remedial design is planned at 12% of construction costs.

For projects with construction costs from $2M to $10M – Remedial design is planned at 8% of construction costs.

For projects with construction costs greater than $10M – Remedial design is planned at 6% of construction costs.

For Alt 2 the Remedial Design is planned at $20,000.

ET = Evapotranspiration

IC = institutional control

ISV = in situ vitrification

O&M = operations and maintenance

RTD = removal, treatment, and disposal

Table C-3. Site Summary for 200 CW-5 - Capital Cost, Periodic Costs, Non-Discounted Cost and Present Worth Cost 1,000-Year Duration 200-CW-5 Feasibility Cost Study

Site	Alternative	Work Scope Description	Total Capital Cost	Non-Disounted Annual & Periodic Cost	Non-Discounted Cost	Total Present Worth Cost
Z Ditch	Alternative 3	Remove and Dispose - All Work Areas; No Long-Term IC/O&M	$60,464,924	$0	$60,464,924	$58,121,992
Z Ditch	Alternative 4	Modified ET Monofill Barrier - All Work Areas; 1,000-Year Long-Term IC/O&M	$9,465,648	$285,134,087	$294,599,735	$19,603,737
Z Ditch	Alternative 5A	Remove and Dispose with Modified ET Monofill Barrier - Work Areas 1, 3, and 216-Z-20 Ditch; In situ Vitrification with Modified ET Monofill Barrier - Work Area 2; 1,000-Year Long-Term IC/O&M	$338,894,495	$283,432,759	$622,327,254	$318,044,237
Z Ditch	Alternative 5B	Modified ET Monofill Barrier - All Work Areas; In situ Vitrification with Modified ET Monofill Barrier -Work Area 2; 1,000-Year Long-Term IC/O&M	$296,905,843	$283,999,271	$580,905,114	$287,287,401

Notes:

ET = evapotranspiration
IC = institutional control
MNA = monitored natural attenuation
MESC = maintain existing soil cover
O&M = operations and maintenance

This page intentionally left blank.

C2.1.3 General Assumptions

CHPRC cost estimating templates for site remediation are used as the basis for each waste-site cost estimate.

- Construction labor, material, and equipment units are estimated based on standard commercial estimating resources and databases: Means, 2001, *ECHOS Environmental Remediation Cost Data – Unit Price*; Means, 2009, *Heavy Construction Cost Data*; Richardson, 2001, *Process Plant Construction Estimating Standards*; and the Equipment Watch *Rental Rate Blue Book for Construction Equipment*. The units may have been factored or adjusted by the estimator as appropriate to reflect influences by contract, work site, or other identified project or special conditions.
- Quotes from local commercial sources are used for materials that need to be acquired for the construction of barriers or temporary improvements.
- Equipment rates are based on 21 working days per month.
- Equipment operation is based on one shift of 8 hours per day.
- Workweek equals 5 days per week.
- Work stoppages or shutdowns caused by inclement weather are not factored into the estimates or planning schedules for this study.
- Work delays or stoppages caused by waiting for laboratory results or approval for backfilling waste-site excavations are not factored into the estimates or planning schedules for this study.
- The cost estimates include costs for design, work plan preparation, or any other preparation costs normally associated with activities occurring before field mobilization.
- Remedial design capital costs are based on EPA 540-R-00-002, Exhibit 5-8. The following guide is used in this study.
  - For projects with construction costs less than $100,000 – remedial design is planned at 20 percent of construction costs.
  - For projects with construction costs from $100,000 to $500,000 – remedial design is planned at 15 percent of construction costs.
  - For projects with construction costs from $500,000 to $2 million – remedial design is planned at 12 percent of construction costs.
  - For projects with construction costs from $2 million to $10 million – remedial design is planned at 8 percent of construction costs.
  - For projects with construction costs greater than $10 million – remedial design is planned at 6 percent of construction costs.
- Escalation has not been included in the calculations. All costs are present day (fiscal year 2008).
- Contingency rates are based on EPA 540-R-00-002, Section 5.4.

- All borrow source materials are assumed to come from an on-site source. During the remedial design, the actual borrow source location will be identified and will comply with all *National Environmental Policy Act of 1969* (NEPA) requirements.

C2.1.4 Long-Term Groundwater-Monitoring Costs

Each alternative, except the No Action Alternative, includes annual inspections and maintenance costs for periodic groundwater monitoring. The cost associated with periodic groundwater monitoring is distributed equally over applicable closure zones. The following is a description of the periodic groundwater costs.

Periodic groundwater sampling will be performed in each closure zone located at the facility. Each closure zone will contain three monitoring wells that will be sampled during the periodic sampling event. The present-worth cost for the periodic groundwater-monitoring program will be the same for each closure zone. That cost then will be divided equally among the sites within that closure zone. A summary of the facility closure zones associated with this FS is presented as follows.

Closure Zone	Number of Sites in Each Closure Zone
Plutonium Finishing Plant	40

Based on historical information from similar Hanford Site planning, the cost to install a compliant monitoring well is approximately $180,000 per well. It is assumed that this cost includes all required labor and material.

- Cost to install wells (3 wells) = $180,000/well × 3 wells
  = $540,000

Maintenance will be performed on each of the wells every 5 years during the 150-year active monitoring period. In addition, each of the wells will be replaced once every 30 years.

- Maintenance costs (3 wells) = $5,000/well × 3 wells
  = $15,000 every 5 years

- Replacement costs (3 wells) = $180,000/well × 3 wells
  = $540,000 every 30 years

During each sampling event, three groundwater samples will be collected for analysis. The analyses and cost per analysis are listed below.

- Am-241 = $125/sample × 3 samples/event = $375/event
- Pu-238, -239, -240, -241 = $300/sample × 3 samples/event = $900/event
- Volatile organic compounds = $85/sample × 3 samples/event = $255/event
- Tc-99 = $150/sample × 3 samples/event = $450/event

Total analytical cost per sampling event is $1,980.

The labor cost of doing all the paperwork, labeling, monitoring, and delivery to the laboratory is approximately $300 per well sampled.

- Total labor cost = $300/well × 3 wells
  = $900/sampling event

Total cost to collect and analyze samples per sampling event is $2,880.

Sampling events will occur at the following frequencies:

Year 1 through 30 years (life)	Semiannually (two sampling events)

The present-worth cost to conduct a periodic groundwater-monitoring program for each closure zone for 30 years was calculated.

The present-worth cost for a long-term groundwater-monitoring program is $680,153.

As a comparison, the nondiscounted present-worth cost for a long-term groundwater-monitoring program was calculated to compare the effect of a discount rate on the total project cost.

Present-worth nondiscounted costs for a long-term groundwater-monitoring program is $4,129,200.

The present-worth cost, on a per-site basis, will be added to the calculated costs. The long-term groundwater-monitoring cost per site for the Plutonium Finishing Plant closure zone is shown below. The nondiscounted long-term groundwater-monitoring cost per site is presented in parentheses.

Closure Zone	Number of Sites in Each Closure Zone	Cost per Site
Plutonium Finishing Plant	40	$17,004 ($103,230)

This cost will be added into the costs for the Alternatives 2, 4, 5A, and 5B.

C2.2 No Action Alternative

The No Action Alternative represents a situation where no legal restrictions, access controls, or active remedial measures are applied to the waste site. Taking no action implies leaving the waste site and allowing the waste to remain in its current configuration, affected only by natural processes. No maintenance or institutional controls (ICs) are included in this alternative.

Because the No Action Alternative assumes no further actions will be taken at a waste site, costs are assumed to be zero.

C2.3 Institutional Controls

Institutional Controls, which can have one-time or recurring costs (capital, annual operations and maintenance [O&M], or periodic), are non-engineering or legal/administrative measures to reduce or minimize the potential for exposure to site contamination or hazards by limiting or restricting site access.

Examples include IC plans, restrictive covenants, property easements, zoning, deed notices, advisories, groundwater use restrictions, and site information databases. An IC plan would describe the controls for a site and the way in which they would be implemented. A site information database would provide a system for managing data necessary to characterize the current nature and extent of contamination. ICs are project-specific costs that can be an important component of a remedial alternative and, as such, generally should be estimated separately from other costs, usually on a sub-element basis. ICs may need to be updated or maintained, either annually or periodically.

The IC cost model used for this alternative was developed by the CHPRC Project Controls and Estimating department. The duration for ICs only considers the initial, “year-one” period. The annual/periodic activities were based on a 1,000-year duration.

The primary annual/periodic costs associated with this alternative are surveillance and cover maintenance, monitored natural attenuation, and long-term groundwater monitoring. The costs for these annual/periodic activities were estimated based on the area of the individual waste sites or groups. Table C-3 provides the summary of the capital cost and present-net-worth value estimates.

The unit cost for surveillance and maintenance was assumed to be the same as the current unit cost for surveillance and maintenance activities conducted annually on the waste sites. The unit cost accounts for such activities as site radiation surveys, and repair of the existing soil cover on the sites where it is present. Because the existing soil cover is maintained annually, costs for replacing all or large portions of the existing cover at specified intervals (i.e., every 20 years) are considered unnecessary.

The costs associated with natural attenuation monitoring are divided into three components: radiological surveys of surface soils, spectral gamma logging of vadose-zone boreholes, and groundwater monitoring. The costs to perform radiological surveys of surface soils at waste sites are assumed to be similar to those for current survey practices at the sites and are included in the surveillance and maintenance costs.

Vadose-zone monitoring costs assume spectral gamma logging of one borehole per waste site to a 15 m (50 ft) depth once every 5 years for a 1,000-year duration. This monitoring is considered for sites with high concentrations of contaminants in the shallow zone or near the bottom of crib and trench structures. It also assumes that the service life of vadose-zone boreholes is 30 years. Costs are included for logging and periodic replacement of these boreholes for a 1,000-year duration.

Groundwater-monitoring costs are described in detail in Section C2.1.4.

General Assumptions

The general assumptions for this alternative are as follows:

- Costs were calculated based on the specific area of the site. The calculated costs are presented in Tables C-2 and C-3.
- The same-sized construction crews will be used for all sites.
- Fencing and monuments/signs for ICs and fencing maintenance are included.
- MESC/IC operations do not meet the CERCLA threshold criteria as a stand-alone alternative, therefore, a stand alone cost estimate has not been prepared. The ICs components are included in the individual alternatives. ICs consists of seven general activities: implementation of ICs, site inspection and surveillance, existing cover maintenance, natural attenuation monitoring, reporting, site reviews, and groundwater and vadose-zone monitoring.
- The prices that make up the cost estimate were obtained from one of the following sources:
  - Means, 2009
  - Experience on similar projects

C2.4 Removal, Treatment, and Disposal

The Z-Ditch site is excavated to the required depth and contaminated material is removed to the Environmental Restoration Disposal Facility (ERDF) for disposal. Excavation quantities are different for each of the Z-Ditch work areas. Alternative 3 use removal, treatment, and disposal (RTD) for the full length of the Z-Ditch; Alternative 5A uses RTD of Work Areas 1 and 3. The cost summary showing the total capital and present-worth estimated costs for the alternatives having RTD as a primary component are shown in Table C-3.

C2.4.1 General Assumptions

The general assumptions for this alternative are as follows:

- Fieldwork such as mobilization/demobilization, excavation, backfill, revegetation, and some of the post-construction work will be contracted to an FP contractor. The project management, radiological control technician (RCT) support, sampling, and safety oversight will be performed by CHPRC. The waste disposal work involved with hauling from the site to ERDF and ERDF dumping cost/fees will be performed by the environmental restoration contractor responsible for ERDF.
- Mobilization and startup include site training; mobilization of equipment and personnel; installation of temporary construction fences; construction of staging/container storage areas and access roads; and setting up office, change, and storage trailers with utilities, temporary survey buildings, and decontamination areas.
- The excavation sites will have contaminated waste removed. The sides of the excavation will be sloped at 1.5:1 to the bottom of the excavation. During the removal process, heavy equipment will be kept out of the excavation site.
- For excavation sites, overburden will be removed with a 1.5 to 2.3 m^3 (2- to 3-yd^3) excavator and two haul trucks. The soil will be stockpiled near the waste site. A highway truck with a water tank trailer is used to control dust during this activity. The production rate for one crew is 111.6 m^3/h (146 yd^3/h).
- Contaminated waste will be excavated using a 1.5 to 2.3 m^3 (2- to 3-yd^3) hydraulic crawler excavator. The contaminated soil will be directly placed into lined ERDF containers and hauled from the excavation site. A highway truck with a water tank trailer is used to control dust during this activity. Crew labor consists of one operator, one laborer, and one truck driver. The production rate for one crew is 45.9 m^3/h (60 yd^3/h).
- Air sampling will be performed during the excavation of contaminated soil. A minimum of two samples will be taken per day. The planning cost per sample is $544. The sampling crew consists of one sampler and one RCT.

Soil samples will be taken of the overburden, from ERDF containers, and for verification at the completion of the excavation. The soil-sampling costs are based on the contaminants expected to be found at the sites and are as follows.

- Noncontaminated soil sampling
  - Maximum of six samples or one sample per cubic yard, whichever is less
  - Quality assurance (QA) sample required: 1
  - Planning cost per sample: $1,319
  - The soil being sampled is the overburden that is uncontaminated and will not be removed from the site
- Sampling required for waste going to ERDF
  - One sample required for every 70 containers
  - Minimum of six samples per site

- QA samples required: a minimum of 1 sample or 5 percent of total ERDF samples, whichever is greater
- Planning cost per sample: $473

- Pre-verification process sampling
  - One sample required per 2,500 m^2 (50 × 50 m) (26,899 ft^2 [82 × 82 ft])
  - Minimum of six samples per site
  - QA samples required: a minimum of 2 samples or 5 percent of total the samples, whichever is greater
  - Planning cost per sample: $2,329
  - These samples are the preliminary samples needed to see if all of the required waste has been removed from a site being excavated.
  - This process is expected to happen twice during the excavation process.
  - If the samples show that the site has met the requirement, then the verification process will start
- Verification process sampling
  - One sample required per 625 m^2 (25 × 25 m) (6,724 ft^2 [82 × 82 ft])
  - Minimum of six samples per site
  - QA samples required: a minimum of 2 or 5 percent of total the samples, whichever is greater
  - Planning cost per sample: $9,784
  - These samples are the final samples needed to see if all of the required waste has been removed from a site being excavated
  - This process happens once during the excavation process
- Sampling crews
  - Verification sampling – 1 hour for each sample taken by a crew consisting of one CHPRC RCT and a sampler technician
  - Other sampling (air, ERDF, noncontaminated) – 2 hours for each sample taken by a crew consisting of one CHPRC RCT and a sampler technician
- The ERDF container handling and loading process starts with a site haul truck picking up an empty container at the staging area. The container is moved to a preparation area where laborers install a bed liner. The haul truck and container proceed to the loading area. After loading, the liner is sealed and the container is secured by laborers. The container is moved to the survey building where RCTs inspect and survey the container and truck for contamination. From there, the haul truck and container continue to be driven to the storage area and the container is unloaded from the truck at the storage area. Three trucks are required to support each contaminated excavation crew.

CHPRC RCT support for excavation of uncontaminated soil occurs in parallel with, and the duration is the same as, the excavation activities. There are 2 hours of RCT time per each hour of excavation. The costs shown in the estimate are based on crew hours. One RCT is stationed at the excavator and one at the stockpile site.

CHPRC RCT support for excavation of contaminated waste occurs in parallel with, and the duration is the same as, the excavation activities. There are 5 hours of RCT time per each hour of excavation. The costs shown in the estimate are based on crew hours. There is one RCT stationed at the excavator, three RCTs survey the waste container at the survey building, and one RCT is monitoring the site.

- ERDF disposal fee, transportation, and handling costs are estimated at $55 per ton. An environmental restoration contractor driver and truck/trailer will move a loaded container to ERDF and place an empty container in the staging area. The estimated costs include the rental of the containers used. For planning purposes, the capacity of an ERDF container is 9.9 m^3 (13 yd^3) of contaminated waste.
- Backfilling consists of three different operations.
  - The moving of the stockpiled overburden back to the excavation site will require one crew. The equipment used by a crew is one 3.8 m^3 (5-yd^3) loader and two haul trucks. Labor is one operator and two truck drivers. The production rate for one crew is 210.3 m^3/h (275 yd^3/h).
  - The moving of borrow material to the excavation site typically is performed by one crew hauling from an onsite pit source. The equipment used by a crew is one 3.8 m^3 (5-yd^3) loader, four 12.2 m^3 (16-yd^3) end dump trucks with 12.2 m^3 (16-yd^3) trailers, and one 4,000-gal water truck. Labor is one operator and five truck drivers. The production rate for one crew is 141.4 m^3/h (185 yd^3/h).
  - Spreading and compaction of the backfill at the site is performed by one crew. The equipment used per crew is one 300-hp dozer and one 4,000-gal water truck. Labor consists of one operator, one truck driver, and one laborer. The production rate for one crew is 141.4 m^3/h (185 yd^3/h).
- Revegetation of the waste site includes planting native dry-land grass using tractors with seed drills and hand broadcasting, hand-planting sagebrush seedlings, and irrigation for four times in the spring or early summer. All disturbed areas, such as around the waste site, stockpile, staging areas, and access roads, will be replanted.
- The CHPRC Project Management team consists of a part-time project manager, with a full-time field supervisor and part-time engineering support. QA, Radiological Control, and Safety also provide oversight along with other support for contract management and project controls. Total hours for this staff are planned at 22.5 hours per day. The duration of this work is based on total project duration.
- The FP contractor field supervisory team consists of a full-time construction manager and field supervisor, along with part-time QA, construction safety, and clerical support. Two pickup trucks are included in the cost. Total hours for this staff are planned at 21 hours per day. The duration of this work is based on total project duration.
- Demobilization includes demobilization of equipment and personnel, removing temporary construction fences, construction of staging/container storage areas, access roads, office/change/storage trailers, temporary survey buildings, and decontamination areas.

C2.5 Barriers

Alternative 4 includes a barrier constructed over the ditches. Alternative 5A provides for a barrier over Work Area 2 (in situ vitrification [ISV] area) after RTD of Work Areas 1 and 3. Alternative 5B provides for a barrier over the entire site, including Work Area 2 (ISV area). For planning purposes, the side overlap for all barriers will be 6 m (20 ft) for all exterior sides. The cost summary showing the total capital and present-worth estimated costs for the alternatives having a barrier as a component are shown in Table C-3.

Figure C-1 shows details of the assumed barrier design.

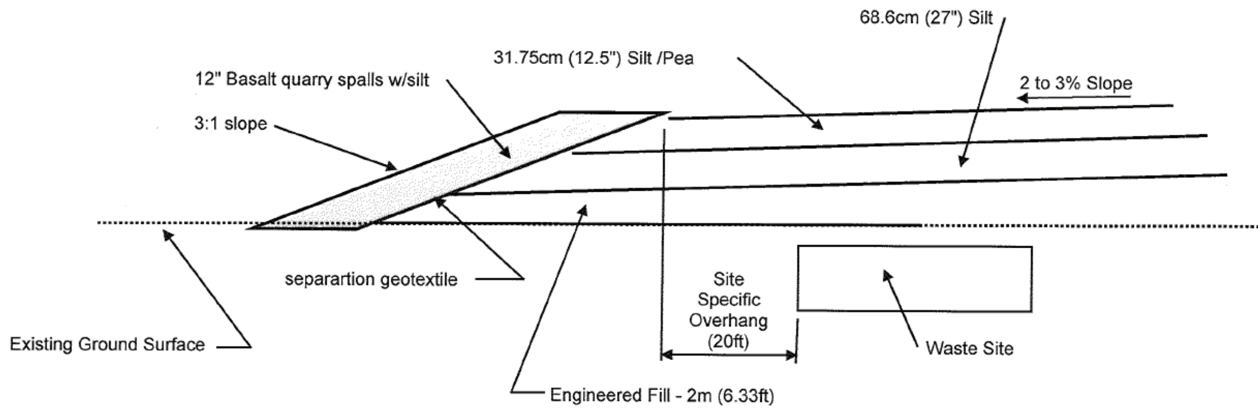


Figure C-1. Details of the Assumed Barrier Design

C2.5.1 General Assumptions

The general assumptions for this alternative are as follows:

- All borrowed source materials are assumed to come from an onsite source. During the remedial design, the actual borrowed source location will be identified and will comply with all NEPA requirements.
- Fieldwork such as mobilization/demobilization, borrow site excavation, barrier fill, revegetation, and some of the post-construction work will be contracted to an FP contractor. Project management, RCT support, sampling, and Safety oversight will be performed by CHPRC.
- Mobilization and startup include site training, mobilization of equipment and personnel, installation of temporary construction fences, construction of access roads, and setting up offices and storage trailers with utilities. Air sampling will be performed during the construction of the first layer of the barrier. A minimum of two samples will be taken per day. The planning cost per sample is $549. The sampling crew consists of one sampler and one RCT.
- Revegetation of the waste-site barrier includes planting native dry-land grass using tractors with seed drills and hand broadcasting, hand-planting sagebrush seedlings, and irrigation for four times in the spring or early summer. All disturbed areas, such as around the barrier, stockpile, staging areas, and access roads, will be replanted.

- The CHPRC Project Management team consists of a part-time project manager, with a full-time field supervisor and part-time engineering support. QA, Radiological Control, and Safety also provide oversight along with other support for contract management and project controls. Total hours for this staff are planned at 22.5 hours per day. The duration of this work is based on total project duration.
- The FP contractor field supervisory team consists of a full-time construction manager and field supervisor, along with part-time QA, construction safety, and clerical support. Two pickup trucks are included in the cost. Total hours for this staff are planned at 21 hours per day. The duration of this work is based on total project duration.
- Demobilization will include demobilization of equipment and personnel, and removal of temporary construction fences, access roads, and office/storage trailers.
- There are two onsite sources for the fill materials to construct the three soil/fill layers. The source for engineered fill is located at Pit 30 approximately halfway between the 200 East and 200 West Areas. This pit is assumed to have the sufficient quantity for this project. The source for the silt required for Layers 1 and 2 is located at Area C about 3.2 km (2 mi) south of the 200 West Area.
- The pea gravel and fractured basalt will be supplied by offsite vendors or from commercial gravel pits. These materials are delivered to the waste site by the vendor.
- All barrier sites are considered to have settled and are compacted enough to support construction of a barrier without further settling. Dynamic compaction is not used to pre-compact the site.
- The barrier sites are considered level and will not require additional pre-leveling before the start of construction.

The evapotranspiration monofill barrier will consist of the following three different layers:

- The bottom layer will be constructed of 2 m (6.33 ft) of engineered fill. The construction of the engineered fill requires the excavation of suitable borrow from an onsite pit source. The estimated time to complete the fill is based on the production rate of a 5-yd^3 loader excavating at the pit. All material is screened with a grizzly mounted on a surge bin to remove 10 cm (4 in.) or larger rocks. Five 12.2 m^3 (16-yd^3) end dump trucks with 12.2 m^3 (16-yd^3) trailers are needed to keep up with the loader. One 4,000-gal water truck provides dust control at the pit. The production rate for this work is 141.4 m^3/h (185 yd^3/h). The spreading and compaction equipment used at the barrier is a 250- to 300-hp dozer with a U-blade to spread fill, and two 12-ton vibratory tandem rollers. A 4,000-gal water truck provides dust control.
- To produce a smooth surface to prevent low areas, the surface of engineered fill is fine graded. Work involves a 5-yd^3 loader, 12-ton vibratory single drum roller, a laser-leveling equipped dozer, and a water truck. The production rate is 2,500 yd^2/h to fine grade the fill surface area. One laborer supports the grader operator as a grade checker. Two engineer technicians set up the grade and elevation control.
- The second layer will be constructed of 68.6 cm (27 in.) of silt fill. The construction of this layer involves excavating and hauling the silt from the onsite pit to the barrier. This layer is 51 cm (20 in.) deep. The estimated time to complete the fill is based on the production rate of a 5-yd^3 loader excavating at the pit. Five 12.2 m^3 (16-yd^3) end dump trucks with 12.2 m^3 (16-yd^3) trailers are needed to keep up with the loader. One 4,000-gal water truck provides dust control at the pit. The production rate for this work is 141.4 m^3/h (185 yd^3/h). At the barrier, the silt is spread with two 90- to 120-hp

low-ground-pressure dozers. The silt is scarified to prevent overcompaction. A truck with a 4,000 gal water trailer provides dust control at the barrier.

- The top layer will be constructed of 31.75 cm (12.5 in.) of silt/pea gravel fill. This layer requires a fill material consisting of silt with 15 percent pea gravel added by weight. The silt is excavated with a 4 to 5 yd^3 loader and hauled from the site silt source by two dump trucks to a process area near the pit. Pea gravel will be provided from a commercial source. The supplier will haul and stockpile the gravel at the silt process area. A 4 to 5 yd^3 loader and a pug mill with belt loader are used to mix the silt and gravel. The hauling from the process area is the same as described for the second layer. Spreading also is the same as the second layer. The side slopes of the barrier will be covered with 1 ft-deep fractured basalt with silt to fill in the void spaces in the rock.

- The side slopes of the barrier will be fine graded before placing fractured basalt. The work involves a 100 to 150 hp dozer with laser controls, a 4 to 5 yd^3 loader, one 12 ton vibratory single drum roller, and a water tanker. The production rate is 2,500 yd^2/h for the engineered fill surface area. One laborer supports the dozer operator and the water truck driver. Two engineer technicians set up the grade and elevation control.

- A geotextile is placed on the side slopes. This item of work covers the placement of needle-punched 120 mil polypropylene geotextile on the side slopes. The production rate is 300 yd^2/h. Three laborers place and splice the fabric. One operator with a 2.5 yd^3 loader and a teamster with a flatbed truck support the work.

- The top layer of the side slopes is covered with 12 in. deep fractured basalt with silt. The fractured basalt is from a commercial source and is delivered to the site by the supplier. The silt is from the onsite pit and is hauled to the barrier. The equipment used to spread the basalt is a 5 yd^3 loader, 300 hp dozer with rippers, and 1/4-time 4,000 gal water truck. Two equipment operators and 1/4-time truck driver operate the equipment. One laborer supports the operators as a grade checker and helps place fractured basalt. The placement of the silt involves excavating at the pit, hauling to the barrier, and spreading on the fractured basalt. This work occurs at the same time as the placement of the fractured basalt to ensure that the silt is worked into the basalt. The excavation and hauling from the pit uses one 5 yd^3 loader and three 12.2 m^3 (16 yd^3) end dump trucks with 12.2 m^3 (16 yd^3) trailers. The placement and mixing with the basalt use one 5 yd^3 loader. A 4,000 gal water truck is used for dust control. Two operators, four truck drivers, and one laborer operate the equipment and support the work. The production rate for this work is 70 yd^3/h.

- Instrumentation is not included for either of the barrier designs.

- After completion of the barrier construction work, a 1.2 m (4 ft) steel post with chain fence will be built around the site. The fence location is at the toe of the barrier slope.

- Surveillance and maintenance costs for the Barrier Alternative include barrier performance monitoring and repair costs. For purposes of this FS, all sites will assume annual repairs to the cap (replacement of 15.2 cm [24 in.] of topsoil layer and revegetation over 10 percent of the barrier area). This is considered a conservative estimate because the barrier has been designed to require minimal maintenance, particularly after vegetation has been established.

- During the construction of the barrier, compaction testing will be performed on the different layers. The bottom and sand layers will require that a minimum level of compaction has been reached. The top two layers will be tested to ensure that the fill does not become overcompacted.

C2.6 In Situ Vitrification

The ISV process will be used by Alternatives 5A and 5B to vitrify contaminated soils in Work Area 2 beneath the ditch, reducing the risk posed by direct contact with the material, and impeding intrusion into the residual untreated contaminants. The exact number and configuration of melts, and the components and configuration of the offgas treatment system, would be determined in the remedial design phase. Treatability testing will most likely be necessary to support design. For Alternative 5A, RTD as described above will be used at Work Areas 1 and 3 and a barrier will be placed over the ISV melts of Work Area 2 to clean up contaminated soil. For Alternative 5B, a barrier will be placed over the entire site upon completion of the ISV process. The cost summary showing the total capital and present-worth estimated costs for the alternatives having ISV as a primary component are shown in Table C-3.

C2.6.1 General Assumptions

The general assumptions for the ISV alternative are as follows:

- Fieldwork such as mobilization/demobilization, ISV, excavation, backfill, revegetation, and some of the post-construction work will be contracted to an FP contractor. The project management, RCT support, sampling, and safety oversight will be performed by CHPRC. The waste disposal work involved with hauling from the site to ERDF and ERDF dumping cost/fees will be performed by the environmental restoration contractor responsible for ERDF.
- Mobilization and startup include site training; mobilization of equipment and personnel; installation of temporary construction fences; installation of electrical power lines to feed site; construction of staging/container storage areas and access roads; and setting up office, change, and storage trailers with utilities, temporary survey buildings, and decontamination areas.
- A layer of clean fill would be placed on top of the base soils to provide a working surface for placement of the electrodes and injection of conductive material between the electrodes.
- Melts, including off-gas treatment, are assumed to cost $1,775/ton, based on DOE, 2004, *Screening-Level Evaluation of Remedial Alternatives for Pit 9 TRU Waste at Los Alamos National Laboratory*, which has been adjusted to fiscal year 2009 and for location. Additional information came from discussions with AMEC, Earth and Environmental Inc.
- The melts would result in a contiguous block of glass at the waste site.
- The melting operation would be a continuous operation for the duration of the ISV work. The planning for this work requires two sets of melting equipment. One set will be in operation while the other set will be in the process of being moved and set up for the next melt.
- Backfilling of the waste site will be required after the melts to match the surrounding ground surface. This work will start 6 months after the last melt has been completed to give the site adequate time to cool.
- Backfilling consists of two different operations.
  - The moving of borrow material to the excavation site typically is performed by one crew hauling from an onsite pit source. The equipment used by a crew is one 3.8 m^3 (5-yd^3) loader, five 12.2 m^3 (16-yd^3) end dump trucks with 12.2 m^3 (16-yd^3) trailers, and one 4,000-gal water truck. Labor is one operator and six truck drivers. The production rate for one crew is 141.4 m^3 (185 yd^3/h).

   - One crew will spread and compact the backfill at the ISV site. The equipment used per crew is one 300 hp dozer and one 4,000 gal water truck. Labor consists of one operator, one truck driver, and one laborer. The production rate for one crew is 141.4 m^3 (185 yd^3/h).

- Revegetation of the waste site will occur during the construction of the barrier. All disturbed areas, such as around the waste site, stockpile, staging areas, and access roads, will be replanted.

- The CHPRC Project Management team consists of a part-time project manager, with a full-time field supervisor and part-time engineering support. QA, Radiological Control, and Safety also provide oversight along with other support for contract management and project controls. Total hours for this staff are planned at 22.5 hours per day. The duration of this work is based on total project duration.

- The FP contractor field supervisory team consists of a full-time construction manager and field supervisor, along with part-time QA, construction safety, and clerical support. Two pickup trucks are included in the cost. Total hours for this staff are planned at 21 hours per day. The duration of this work is based on duration of the RTD work for Work Areas 1 and 3 and the final site work need to complete Work Area 2. The FP contractor field supervisory team for the ISV portion of the project is included in the unit cost of the ISV work.

- Demobilization includes demobilization of equipment and personnel, removing temporary construction fences, electrical power lines to feed site, construction of staging/container storage areas, access roads, office/change/storage trailers, temporary survey buildings, and decontamination areas.

The cost estimate does not include the following items:

- Additional site characterization to support design
- Treatability studies
- Management/disposal of secondary waste streams from the offgas system
- Post-cooling evaluation of melt (seismics and soil sampling)

Tables C-2 and C-3 show the cost summary for the total capital and present-worth estimated costs.

C3 References

DOE, 2004, *Screening-Level Evaluation of Remedial Alternatives for Pit 9 TRU Waste at Los Alamos National Laboratory*, Office of Environmental Management Technical Assistance Project #22, Draft Technical Solutions Report, U.S. Department of Energy, Washington, D.C.

EPA 540-R-00-002, 2000, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, OSWER 9355.0-75, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://epa.gov/superfund/policy/remedy/sfremedy/rifs/costest.htm.

Federal Insurance Contributions Act (FICA, The Social Security Act of 1935), 26 USC 21, et seq. Available at: http://www.law.cornell.edu/uscode/26/usc_sup_01_26_10_C_20_21.html.

Means, R.S., 2001, *ECHOS Environmental Remediation Cost Data – Unit Price*, 7th Annual Edition, Robert S. Means Company, Kingston, Massachusetts.

Means, R.S., 2009, *Heavy Construction Cost Data, 23*rd Annual Edition, Robert S. Means Company, Kingston, Massachusetts.

National Environmental Policy Act of 1969, 42 USC 4321, et seq. Available at: http://www.fhwa.dot.gov/environment/nepatxt.htm.

OMB Circular No. A-94, 1992, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*, as revised, Office of Management and Budget, Washington, D.C. Available at: http://www.whitehouse.gov/omb/circulars_a094/.

Richardson, 2001, *Process Plant Construction Estimating Standards*, Richardson Engineering Services, Inc., Mesa, Arizona.

Rental Rate Blue Book for Construction Equipment, 2008, Equipment Watch, San Jose, California.

Site Stabilization Agreement for All Construction Work for the U.S. Department of Energy at the Hanford Site, 1984, as amended, commonly known as the Hanford Site Stabilization Agreement (original title, Site Stabilization Agreement, Hanford Site, between J. A. Jones Construction Services Company and Morrison-Knudsen Company, Inc., and the Building and Construction Trades Department of the AFL-CIO and its affiliated international unions, and the International Brotherhood of Teamsters, Chauffeurs, Warehousemen, and Helpers of America). Available at: http://www.hanford.gov/pmm/page.cfm/HSSA.

This page intentionally left blank.

Appendix D

RESRAD Analysis of a Subsistence Farmer Exposure Scenario for the 200-CW-5 Operable Unit

Terms

bgs	below ground surface
BRA	baseline risk assessment
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
COPC	contaminant of potential concern
DOE	U.S. Department of Energy
ELCR	excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
FS	feasibility study
IC	institutional control
K_d	distribution coefficient
OU	operable unit
RESRAD	RESidual RADioactivity
RI	remedial investigation
RME	reasonable maximum exposure
UCL	upper confidence limit

D1 Introduction

This appendix provides an analysis of potential risk to human health from exposure to radioactive contaminants in the 200-CW-5 Operable Unit (OU). Results of this analysis are intended to supplement the baseline risk assessment (BRA) presented in the 200-CW-5 OU remedial investigation (RI) report (DOE/RL-2003-11). Time-dependent excess lifetime cancer risk (ELCR) is calculated for a subsistence farmer exposure scenario over a 1,000-year simulation period using the RESidual RADioactivity (RESRAD) computer code (*RESRAD for Windows, Version 6.4* [ANL, 2007]). The scope of the analysis is limited to the 216-Z-1 D, 216-Z-11, and 216-Z-19 Ditches, collectively referred to as the Z-Ditches. The Z-Ditches are assigned to the 200-CW-5 OU and have been grouped into one contiguous contamination area for purposes of remedial decision making.

Because the Z-Ditches are located on the Central Plateau within the industrial land-use boundary, the BRA presented in the 200-CW-5 OU RI report (DOE/RL-2003-11) used an industrial land-use scenario to represent current and reasonably anticipated future land use for the Central Plateau. Radioactive contamination was addressed based on RESRAD analysis of industrial worker direct-contact exposure to shallow-zone soil. Two separate waste site configuration cases were analyzed, current, and worst case. The current configuration case accounted for the shielding effects of the existing stabilization cover over the Z-Ditches; the worst case configuration took no credit for cover material protective effects.

To provide a consistent basis for determining whether remedial action is necessary at these waste sites, the U.S. Department of Energy (DOE) has begun including a subsistence farmer exposure scenario in BRAs for these sites. The subsistence farmer scenario represents the risk to evaluate the "no action alternative" in which DOE could leave the site, essentially making it available for completely unrestricted use. The only pre-existing controls or actions that can be considered are those actions that have already been taken to reduce or eliminate contaminants as opposed to controlling or precluding exposure (EH-231-014/1292). No credit can be taken for actions that simply control access to a site or limit exposure to existing contamination. The existing institutional controls (ICs) and stabilization cover at the Z-Ditches limit current and future exposures but do not actually reduce or eliminate contaminants from the site and are therefore not considered in the exposure assessment for this analysis.

D2 Exposure Scenario Description

The subsistence farmer scenario does not represent one of the future land uses envisioned for the Central Plateau and generally is not the basis for developing final remediation goals. Use of this scenario is intended to define the risk used to evaluate the "no action" alternative within the feasibility study (FS). The results of this analysis can be used as the basis for taking remedial action and can be used in evaluation of remedial alternatives to identify areas where ICs or other remedial actions may need to be implemented.

The subsistence farmer scenario represents an individual exposed to radiological contaminants from direct contact with soil and through the food chain pathway. Exposure estimates are based on an assumed exposure frequency of 350 days/yr over a 30-year exposure duration. The exposure assumptions and RESRAD modeling input parameters used for the analysis are provided in Table D-1. The table lists the value used for each parameter, the rationale for its use, and a reference to the source for the value.

Table D-1. Z-Ditches Summary of RESRAD Input Parameters for the Subsistence Farmer Exposure Scenario

Description	Parameter	Units	Subsistence Farmer Scenario	Rationale and Citation
Exposure Pathways	External gamma: Inhalation: Plant ingestion: Meat ingestion: Milk ingestion: Aquatic foods: Drinking water: Soil ingestion: Radon:	Not applicable	Active Active Active Active Active Suppressed Active Active Suppressed	Assumes site is available for unrestricted use and is occupied by a subsistence farmer.
R011 – Contaminated Zone (CZ)	Area of CZ	m^2	972	Site-specific area from (WIDS).
	Thickness of CZ	m	7	Assumes contamination extends to the ground surface (i.e., no credit taken for pre-existing controls, including 1 m-thick stabilization cover). Value represents sum of contaminated zone (6 m) and stabilization cover (1 m) thicknesses based on remedial investigation (RI) results (DOE/RL-2003-11).
	Length parallel to aquifer flow	m	9	Site-specific.
	Radiation dose limit (industrial scenario)	mrem/year	15	40 CFR 141; EPA 540/R/99/006.
	Elapsed time since waste placement	year	0	RESRAD default.
Exposure Point Concentrations (EPCs)	EPCs	pCi/g	Contaminant-specific	Based on statistical analysis of the RI analytical data set.
R013 – Cover and CZ Hydrological Data	Cover depth	m	0	Assumes contamination extends to the ground surface (i.e., no credit taken for pre-existing controls, including 1 m – thick stabilization cover).
	Cover material density	g/cm^3	NA	Not applicable.
	Cover erosion rate	m/year	NA	Not applicable.
	Density of CZ	g/cm^3	1.8	Site-specific value based on RI results.

Table D-1. Z-Ditches Summary of RESRAD Input Parameters for the Subsistence Farmer Exposure Scenario

Description	Parameter	Units	Subsistence Farmer Scenario	Rationale and Citation
R013 – Cover and CZ Hydrological Data	CZ erosion rate	m/year	0.00001	Value selected prevents appreciable erosion of the contaminated zone over the simulation period.
	CZ total porosity	unitless	0.33	Site-specific value based on physical property samples from RI and WHC-EP-0883.
	CZ field capacity	unitless	0.2	Site-specific value based on physical property samples from RI and WHC-EP-0883.
	CZ hydraulic conductivity	m/year	22	WHC-SD-EN-SE-004.
	CZ b parameter	unitless	4.05	CCN 070578; ANL/EAD-4 (Table E.2).
	Evapotranspiration coefficient	unitless	0.91	WDOH/320-015 (Appendix B).
	Wind speed	m/s	3.4	Based on annual average prevailing wind speed of 7.6 mph (3.4 m/s) measured at Hanford Meteorology Station (PNNL-15160, Table 5.1)
	Precipitation	m/year	0.177	Based on normal annual precipitation of 6.98 in. (0.177 mm) measured at Hanford Meteorology Station (PNNL-15160, Table 4.1).
	Irrigation rate	m/year	0.76	WDOH/320-015 (Appendix B).
	Irrigation mode	Overhead or Ditch	Overhead	RESRAD default.
	Runoff coefficient	unitless	0	Value selected conservatively assumes all precipitation penetrates the topsoil.
	Watershed area for nearby stream or pond	m^2	1.00E+06	RESRAD default.
	Accuracy for water/soil computations	unitless	0.001	RESRAD default.

Table D-1. Z-Ditches Summary of RESRAD Input Parameters for the Subsistence Farmer Exposure Scenario

Description	Parameter	Units	Subsistence Farmer Scenario	Rationale and Citation
R014 – Saturated Zone (SZ) Hydrological Data	Density of SZ	g/cm^3	2.23	Site-specific value based on RI results and BHI-01177.
	SZ total porosity	unitless	0.158	Site-specific value based on physical property samples from RI and WHC-EP-0883.
	SZ effective porosity	unitless	0.158	Site-specific value based on physical property samples from RI and WHC-EP-0883.
	SZ field capacity	unitless	0.04	Site-specific value based on physical property samples from RI and WHC-EP-0883.
	SZ hydraulic conductivity	m/year	5,519	WHC-SD-EN-SE-004.
	SZ hydraulic gradient	unitless	0.0005	DOE/ORP-2005-01 (Table 3-14, reference case value for 200 West Area unconfined aquifer).
	SZ b parameter	unitless	4.05	CCN 070578; ANL/EAD-4 (Table E.2).
	Water table drop rate	m/year	0.0001	Value selected results in little change in the depth to groundwater over the simulation period.
	Well pump intake depth below water table	m	4.6	WDOH/320-015 (Appendix B).
	Model for water transport	Nondispersion (ND) or mass-balance	ND	RESRAD default.
	Well pumping rate	m^3/year	250	RESRAD default.
R015 – Uncontaminated and Unsaturated Strata Hydrological Data	Number of unsaturated strata	Not applicable	3	Site-specific.
	Thickness (layer 1)	m	4	Site-specific value based on RI results and current water table elevation data.
	Thickness (layer 2)	m	30	Site-specific value based on RI results and current water table elevation data.
	Thickness (layer 3)	m	23.2	Site-specific value based on RI results and current water table elevation data.
	Soil density (layer 1)	g/cm^3	1.98	Hanford formation gravel-dominated sequence.

Table D-1. Z-Ditches Summary of RESRAD Input Parameters for the Subsistence Farmer Exposure Scenario

Description	Parameter	Units	Subsistence Farmer Scenario	Rationale and Citation
R015 – Uncontaminated and Unsaturated Strata Hydrological Data	Soil density (layer 2)	g/cm^3	1.5	Hanford formation sand-dominated sequence and Cold Creek unit.
	Soil density (layer 3)	g/cm^3	2.23	Ringold Unit E silty sandy gravel.
	Total porosity/ effective porosity (layer 1)	unitless	0.253	Site-specific value based on RI results and BHI-01177.
	Total porosity/ effective porosity (layer 2)	unitless	0.435	Site-specific value based on physical property samples from RI and WHC-EP-0883.
	Total porosity/ effective porosity (layer 3)	unitless	0.158	Site-specific value based on physical property samples from RI and WHC-EP-0883.
	Field capacity (layer 1)	unitless	0.04	Site-specific value based on physical property samples from RI and WHC-EP-0883.
	Field capacity (layer 2)	unitless	0.04	Site-specific value based on physical property samples from RI and WHC-EP-0883.
	Field Capacity (layer 3)	unitless	0.04	Site-specific value based on physical property samples from RI and WHC-EP-0883.
	Hydraulic conductivity (layer 1)	m/year	757	WHC-SD-EN-SE-004.
	Hydraulic conductivity (layer 2)	m/year	138	WHC-SD-EN-SE-004.
	Hydraulic conductivity (layer 3)	m/year	552	WHC-SD-EN-SE-004.
	Soil-specific b parameter (layer 1)	unitless	4.05	CCN 070578; ANL/EAD-4 (Table E.2).
	Soil-specific b parameter (layer 2)	unitless	4.05	CCN 070578; ANL/EAD-4 (Table E.2).
	Soil-specific b parameter (layer 3)	unitless	4.05	CCN 070578; ANL/EAD-4 (Table E.2).

Table D-1. Z-Ditches Summary of RESRAD Input Parameters for the Subsistence Farmer Exposure Scenario

Description	Parameter	Units	Subsistence Farmer Scenario	Rationale and Citation
R016 – Distribution Coefficients and Leach Rates for Individual Radionuclides	Distribution coefficients (Kd) for contaminated zone, uncontaminated zone, and saturated zone	cm^3/g	Contaminant-specific	Best-estimate values from PNNL-14702 and PNNL-11800.
	Saturated leach rate	yr-1	0	RESRAD default.
	Saturated solubility	mol/L	0	RESRAD default.
R017 – Inhalation and External Gamma	Inhalation rate	m^3/year	7,300	Average annual air intake based on a daily inhalation rate of 20 m3/day (365 days/yr). A daily rate of 20 m3/day is assumed to be representative of a reasonably conservative inhalation rate for total (indoor plus outdoor) exposures at home and in the workplace (EPA, 1991).
	Mass loading for inhalation	g/m^3	0.0001	WDOH/320-015 (Appendix B).
	Exposure duration	year	30	EPA, 1991.
	Indoor dust filtration factor	unitless	0.4	RESRAD default.
	External gamma shielding factor	unitless	0.4	EPA/540-R-00-007 (Equation 4).
	Indoor time fraction	unitless	0.6	Fraction of the year spent onsite indoors. Assumes 15 hr/day, 350 days/yr (5,250 hr/8,760 hr).
	Outdoor time fraction	unitless	0.12	Fraction of the year spent onsite outdoors. Assumes 3 hr/day, 350 days/yr (1,050 hr/8,760 hr).
	Shape factor	Not applicable	Circular	RESRAD default.
R018 – Ingestion Pathway Data, Dietary Parameters	Leafy vegetable consumption	kg/yr	2.7	WDOH/320-015 (Appendix B).
	Fruit, vegetable, and grain consumption	kg/yr	110	WDOH/320-015 (Appendix B).
	Milk consumption	L/yr	100	WDOH/320-015 (Appendix B).

Table D-1. Z-Ditches Summary of RESRAD Input Parameters for the Subsistence Farmer Exposure Scenario

Description	Parameter	Units	Subsistence Farmer Scenario	Rationale and Citation
R018 – Ingestion Pathway Data, Dietary Parameters	Meat and poultry consumption	kg/yr	36	WDOH/320-015 (Appendix B).
	Fish consumption	kg/yr	Not applicable	The consumption of fish is considered an incomplete exposure pathway for waste site operable units within the Central Plateau.
	Other seafood consumption	kg/yr	Not applicable	The consumption of seafood is considered an incomplete exposure pathway for waste site operable units within the Central Plateau.
	Soil ingestion intake	g/yr	35	Based on a soil ingestion rate of 100 mg/day (350 days/yr).
	Drinking water intake	L/yr	700	Based on a drinking water ingestion rate of 2 L/day (350 days/yr).
	Drinking water contamination fraction	unitless	1	RESRAD default.
	Household water contamination fraction	unitless	Not applicable	Used in RESRAD only for computation of radon exposure.
	Livestock water contamination fraction	unitless	1	RESRAD default.
	Irrigation water contamination fraction	unitless	1	RESRAD default.
	Aquatic food contamination fraction	unitless	Not applicable	Consumption of aquatic food is considered an incomplete exposure pathway.
	Plant food contamination fraction	unitless	-1	RESRAD default.
	Meat contamination fraction	unitless	-1	RESRAD default.
	Milk contamination fraction	unitless	-1	RESRAD default.

Table D-1. Z-Ditches Summary of RESRAD Input Parameters for the Subsistence Farmer Exposure Scenario

Description	Parameter	Units	Subsistence Farmer Scenario	Rationale and Citation
R019 – Ingestion Pathway Data, Nondietary	Livestock fodder intake for meat	kg/d	68	RESRAD default.
	Livestock fodder intake for milk	kg/d	55	RESRAD default.
	Livestock water intake for meat	L/d	50	RESRAD default.
	Livestock water intake for milk	L/d	160	RESRAD default.
	Livestock intake of soil	kg/d	0.5	RESRAD default.
	Mass loading for foliar deposition	g/m^3	0.0001	RESRAD default.
	Depth of soil mixing layer	m	0.15	RESRAD default.
	Depth of roots	m	0.9	RESRAD default.
R020 – Groundwater Usage	Groundwater fractional usage – drinking water	unitless	1	RESRAD default.
	Groundwater fractional usage – household usage	unitless	Not applicable	Used in RESRAD only for computation of radon exposure.
	Groundwater fractional usage – livestock water	unitless	1	RESRAD default.
	Groundwater fractional usage – irrigation	unitless	1	RESRAD default.
	Groundwater fractional usage – irrigation	unitless	1	RESRAD default.

Notes:

40 CFR 141, "National Primary Drinking Water Regulations."

ANL/EAD-4, *User's Manual for RESRAD, Version 6*.

ANL 2007, RESRAD for Windows, Version 6.4.

BHI-01177, *Borehole Summary Report for the 216-B-2-2 Ditch*.

CCN 070578, "Estimation of the Soil-Specific Exponential Parameter(b)."

DOE/ORP-2005-01, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site*.

DOE/RL-2003-11, *Remedial Investigation for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-SC-1 Steam Condensate Group Operable Units*.

Table D-1. Z-Ditches Summary of RESRAD Input Parameters for the Subsistence Farmer Exposure Scenario

Description	Parameter	Units	Subsistence Farmer Scenario	Rationale and Citation

EPA, 1991, *Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual Supplemental Guidance "Standard Default Exposure Factors" Interim Final.*

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

EPA 540/R/99/006, *Radiation Risk Assessment At CERCLA Sites: Q & A*.

PNNL-11800, *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*.

PNNL-14702, *Vadose Zone Hydrology Data Package for Hanford Assessments.*

PNNL-15160, *Hanford Site Climatological Summary 2004 with Historical Data.*

WDOH/320-015, *Hanford Guidance for Radiological Cleanup*.

WHC-EP-0883, *Variability and Scaling of Hydraulic Properties for 200 Area Soils, Hanford Site*.

WHC-SD-EN-SE-004, *Site Characterization Report: Results of Detailed Evaluation of the Suitability of the Site Proposed for Disposal of 200 Areas Treated Effluent*.

CZ = contaminated zone
ND = nondispersion
RESRAD = RESidual RADioactivity (dose model) (ANL 2007)
RI = remedial investigation
SZ = saturated zone
WIDS = Waste Information Data System database

The direct contact pathway includes exposure through external radiation, incidental soil ingestion, and inhalation of dust particulates. An external gamma-shielding factor of 0.4, an incidental soil ingestion rate of 100 mg/day, and an inhalation rate of 20 m^3/day are assumed.

The food chain pathway includes exposure from ingestion of fruits and vegetables grown in a backyard garden and consumption of meat and milk from livestock that graze on and are penned on a rural pasture. Consumption rates of 2.7 kg/yr of leafy vegetables; 110 kg/yr of fruits, vegetables, and grains; 100 L/yr of milk; and 36 kg/yr of meat and poultry are assumed.

The scenario assumes that radionuclides residing in soil from the ground surface to the groundwater table are the source of contamination for all exposure pathways. Exposure through the food chain is contributed from uptake of radionuclides that are currently in the soil and includes use of groundwater potentially contaminated by migration of contamination through the vadose zone. The analysis does not consider groundwater that is currently contaminated beneath the 200-CW-5 OU. Drinking water ingestion and irrigation water use are activated in the RESRAD exposure analysis and it is assumed that all drinking water, irrigation water, and livestock water is obtained from an on-site well that is suitable for domestic use. A drinking water ingestion rate of 2 L/day is assumed.

D3 RESRAD Analysis Methodology

Time-dependent ELCR is calculated using the RESRAD computer code (ANL 2007) implemented in accordance with guidance provided in *User's Manual for RESRAD Version 6* (ANL/EAD-4). Maximum ELCR is computed over a 1,000-year simulation period and for comparative purposes ELCR estimates are also computed for the following exposure times:

- 0 year represents current waste-site conditions.
- 50 years is the estimated time that DOE will have an on-site presence.
- 150 years is the estimated time that ICs are assumed to be effective.
- 500 years is the estimated time that passive ICs are assumed to be effective.
- 1,000 years is the estimated time frame that peak radiation dose and risk estimates should fall within.
- The year in which the upper ELCR regulatory threshold value of 10^{-4} is achieved.

D4 Exposure Scenario Input Values

The site-specific parameter set developed for analysis of the subsistence farmer scenario at the Z-Ditches is presented in Table D-1. The parameters used to represent the Z-Ditches hydrostratigraphic conceptual model (i.e., physical, meteorological, and hydrological parameters associated with the contaminated zone, unsaturated strata, and saturated zone) are generally consistent with those used in the RI BRA (DOE/RL-2003-11, Section 5.2, Table 5-20). Several parameters (e.g., annual precipitation) have been updated in the present analysis for consistency with more recently published information sources.

D4.1 Contaminated Zone

For purposes of assessing industrial direct-contact soil exposure, the RI BRA defined the point of compliance for shallow zone soils as zero to 4.6 m (15 ft) below ground surface (bgs), . The RESRAD contaminated zone thickness parameter was assigned an input value of 4.6 m (15 ft) and the exposure point concentrations (EPCs) within the contaminated zone were represented by concentrations directly measured in shallow-zone soil (generally 4.6 m [15 ft] or less). For the worst case (no cover) calculation, contaminants were conservatively assumed to be distributed evenly from the surface to a depth of 4.6 m (15 ft) bgs. For the current configuration calculation, a 1 m (3 ft) thick cover was assumed to be in place over a 4.6 m (15 ft) thick contaminated zone.

The point of compliance for the present analysis is from the surface to the groundwater table. Available characterization data for the Z-Ditches (DOE/RL-2003-11, Section 3.2.1) indicate the highest concentrations of radionuclide contamination occur within the interval from 1.5 to 5.3 m (4.9 to 17 ft) bgs. Contaminant concentrations decrease with depth and are generally less than 1 pCi/g at depths of more than 6 m (20 ft) bgs. For purposes of this analysis, a conservative input value of 7 m (23 ft) is assigned to the RESRAD contaminated zone thickness parameter. No credit is taken for the existing 1 m (3 ft) thick cover over the ditches and an input value of zero is assigned to the RESRAD cover thickness parameter. Contaminants are conservatively assumed to be distributed evenly from the surface to a depth of 7 m (23 ft) bgs.

A summary of the main contaminated-zone parameters for the Z-Ditches BRA exposure scenarios is provided in Table D-2.

D4.2 Exposure Point Concentrations

The contaminants of potential concern (COPCs) for this analysis are consistent with the Z-Ditches radionuclide COPCs identified in the RI BRA (DOE/RL-2003-11, Section 5.2.2). RESRAD requires an EPC for each COPC. For the RI BRA, EPCs were developed in accordance with EPA guidance in effect at that time (EPA, 1992) based on analytical data from soil samples collected within the Z-Ditches. EPCs were calculated as the 95 percent upper confidence limit (UCL) on the mean soil concentration except for radionuclides where the calculated 95 percent UCL was greater than the maximum detected concentration. In those cases, the maximum concentration was used in place of the 95 percent UCL. The EPC statistical calculation procedure used for the RI BRA is described in Appendix E of the RI report (DOE/RL-2003-11).

Table D-2. Contaminated-Zone Parameter Summary for Z-Ditches Baseline Risk Assessment Exposure Scenarios

Parameter	Industrial Worker (Industrial Land Use) Scenario	Subsistence farmer (Unrestricted Use) Scenario
Point of compliance	Zero to 4.6 m (15 ft) bgs.	Zero to groundwater table.
Cover depth	0 m (0 ft).	0.
Contamination zone thickness	0 to 6 m (20 ft) bgs.	0 to 7 m (23 ft) bgs.
Exposure point concentration	Uniform distribution from 1 to 6 m (3 to 20 ft) bgs. Best statistical estimate of an upper bound on the mean soil concentrations (EPA/600/R-07/038).	Uniform distribution from zero to 7 m (23 ft) bgs. Best statistical estimate of an upper bound on the mean soil concentrations (EPA/600/R-07/038).

Notes:
EPA 2002, *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites*.
EPA/600/R-07/038, *ProUCL Version 4.0 User Guide*.
bgs = below ground surface

Subsequent to the RI report, EPA modified its guidance on calculating EPCs for environmental data sets (EPA, 2002). In an effort to understand the uncertainties associated with the Z-Ditches plutonium isotope data set, the RI data set has been re-evaluated using EPA's revised methodology for calculating EPCs. Results of this supplemental plutonium evaluation are presented in *Z-Ditches Study for the 200-CW-5 Cooling Water Operable Unit* (SGW-37174). The evaluation was performed using EPA's ProUCL 4.0 analysis tool (EPA/600/R-07/038). ProUCL 4.0 contains statistical methods to address data sets both with and without nondetects. The Z-Ditches data set has nondetects. Laboratory analytical results for the plutonium isotopes (Pu-238, Pu-239, Pu-239/240) were combined in the SGW-37174 evaluation to provide an aggregate total plutonium EPC. The evaluation included a statistical test to determine the presence of outliers associated with the plutonium isotope data set. Results of the outlier test indicated the presence of two potential Pu-239/240 statistical outliers, with concentrations of 1.3×10^7 pCi/g and 7.5×10^5 pCi/g, located at the inlet to the 216-U-10 Pond and near the northern headwall of the Z-Ditches, respectively. Removal of these two data set outliers from the EPC calculation yielded an aggregate plutonium EPC of 17,451 pCi/g. By comparison, the Pu-239 EPC used for the RI risk assessment was 4,460,000 pCi/g (DOE/RL-2003-11, Table 5-4).

Additional ProUCL 4.0 analysis was performed for the present analysis to apply EPA's revised EPC calculation methodology to all radionuclide COPCs identified at the Z-Ditches. Results of the evaluation are presented in Table D-3. For this evaluation, the plutonium isotopes are analyzed individually in

ProUCL rather than in aggregate to support RESRAD calculation of isotope-specific risk contributions. Laboratory analytical results reported as undifferentiated Pu-239/240 are treated as entirely Pu-239 and combined with the Pu-239 analytical results. This assumption is considered reasonable because in most cases Pu-239 is the dominant isotope. For purposes of this analysis, the two Pu-239/240 data set outliers identified in SGW-37174 are removed from the EPC calculation. Laboratory analytical results reported as undifferentiated U-233/234 are treated as entirely U-234 because in most cases U-234 is the dominant isotope.

Table D-3 identifies the basis for the EPC value assigned to each COPC included in the analysis. The first preference was to assign the recommended UCL value as reported in the ProUCL output. For radionuclides where the recommended UCL was greater than the maximum detected concentration, or where the number of detections was too small to allow calculation of a valid UCL, the maximum detected concentration was used in place of the calculated UCL. Comparison of the Table D-3 values with the values reported in the RI risk assessment (DOE/RL-2003-11, Table 5-4) results in the following differences:

- A reduction in the Pu-239 EPC from 4,460,000 pCi/g to 28,291 pCi/g
- An increase in the Am-241 EPC from 76,152 pCi/g to 202,640 pCi/g
- An increase in the Cs-137 EPC from 951 pCi/g to 2,571 pCi/g
- No change in the Ra-226 EPC (5,200 pCi/g)

D4.3 Distribution Coefficients

In addition to EPCs, RESRAD requires a distribution coefficient (K_d) for each COPC and daughter product. The K_ds assigned for this analysis are listed in Table D-4. Radionuclides shown as daughter products are automatically included by the RESRAD code (with initial EPCs of zero pCi/g) when the parent radionuclide (COPC) is selected. K_d values for the RI risk assessment (DOE/RL-2003-11, Table 5-20) were taken from PNNL-11800. K_d values for the present analysis are taken preferentially from a more recent data source (PNNL-14702) and then from PNNL-11800 for isotopes not addressed in PNNL-14702.

K_d values for cesium, plutonium, strontium, neptunium, and uranium are best estimate values for sand dominated sediment from PNNL-14702 (Table 4.11, Waste Chemistry/Source Category 4: Low Organic/Low Salt/Near Neutral, Intermediate Impact - Sand). The values for these isotopes do not differ significantly from the PNNL-11800 values used for the RI risk assessment. PNNL-14702 does not provide K_d values for americium, actinium, lead, protactinium, radium, and thorium. Consistent with the RI risk assessment, K_d values assigned to these isotopes are best estimate values from PNNL-11800 (Table E.10, Source-Zone Category F, Low Organic/Low Salts/Near Neutral).

The Waste Chemistry/Source Category 4 values from PNNL-14702 and Source-Zone Category F values from PNNL-11800 were selected because these categories best represent the type of waste that was disposed of to the Z-Ditches. For consistency with the RI risk assessment, the K_d values shown in Table D-4 are assigned to all RESRAD layers (contaminated zone, uncontaminated zone, and saturated zone). No gravel correction is applied for this analysis.

Table D-3. Z-Ditches Summary of Statistics and Exposure Point Concentrations

Constituent	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result (pCi/g)	Maximum Nondetected Result (pCi/g)	Minimum Detected Result (pCi/g)	Maximum Detected Result (pCi/g)	Average Concentration (pCi/g)	EPC (pCi/g)	EPC Basis
Americium-241	286	284	99%	0.19	15	0.014	7.87E+06	30,656	202,640	97.5% KM (Chebyshev) UCL
Cesium-137	187	184	98%	0.04	0.04	0.0021	66,041	371	2,571	97.5% KM (Chebyshev) UCL
Plutonium-238	62	54	87%	0.034	0.46	0.015	5,500	402	1,302	97.5% KM (Chebyshev) UCL
Plutonium-239 + Plutonium-239/240	281	279	99%	0.46	0.53	0.001	7.80E+05	8,257	28,291	97.5% KM (Chebyshev) UCL
Radium-226	12	12	100%	--	--	0.40	5,200	851	5,200	Max Detect
Radium-228	4	2	50%	0.37	0.37	0.69	0.81	0.47	0.81	Max Detect
Strontium-90	30	23	77%	2.5	9.6	0.28	216	19	95.18	99% KM (Chebyshev) UCL
Thorium-228	4	1	25%	0.47	1.8	0.66	0.66	0.58	0.66	Detected Result
Thorium-230	4	3	75%	1.1	1.1	0.50	8.4	4.0	8.4	Max Detect
Thorium-232	4	1	25%	0.7	1.7	0.71	0.71	0.57	0.71	Detected Result
Uranium-233/234	4	1	25%	0.68	2.5	0.36	0.36	0.75	0.36	Detected Result
Uranium-238	4	2	50%	1.1	1.2	0.44	0.77	0.59	0.77	Max Detect

Table D-3. Z-Ditches Summary of Statistics and Exposure Point Concentrations

Constituent	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result (pCi/g)	Maximum Nondetected Result (pCi/g)	Minimum Detected Result (pCi/g)	Maximum Detected Result (pCi/g)	Average Concentration (pCi/g)	EPC (pCi/g)	EPC Basis

Notes:

EPA/600/R-07/038, *ProUCL Version 4.0 User Guide*.

-- = not applicable

EPC = exposure point concentration

UCL = upper confidence limit

KM (Chebyshev) = UCL based on Kaplan-Meier estimates using Chebyshev inequality. Computed with ProUCL Version 4.0 (EPA/600/R-07/038).

D5 Risk Analysis Results

The RESRAD analysis results are provided in Table D-5, Table D-6, Figure D-1, and Figure D-2. Table D-5 provides a summary of the results, while Table D-6 provides a detailed breakdown of radionuclide- and pathway-specific ELCR contributions. Figure D-1 and Figure D-2 display time-dependent changes in ELCR values for the primary contributing pathways and radionuclides.

Table D-4. Radionuclide-Specific Distribution Coefficients (K_d)

Radionuclide	K_d (cm^3/g)	Reference
Americium-241	300	PNNL-11800
Cesium-137	2000	PNNL-14702
Plutonium-238	600	PNNL-14702
Plutonium-239	600	PNNL-14702
Radium-226	20	PNNL-11800
Radium-228	20	PNNL-11800
Strontium-90	22	PNNL-14702
Thorium-228	1000	PNNL-11800
Thorium-230	1000	PNNL-11800
Thorium-232	1000	PNNL-11800
Uranium-234	0.8	PNNL-14702
Uranium-238	0.8	PNNL-14702
Daughter Radionuclides		
Actinium-227	300	PNNL-11800
Lead-210	6000	PNNL-11800
Neptunium-237	10	PNNL-14702
Protactinium-231	15	PNNL-11800
Thorium-229	1000	PNNL-11800
Uranium-233	0.8	PNNL-14702
Uranium-234	0.8	PNNL-14702
Uranium-235	0.8	PNNL-14702

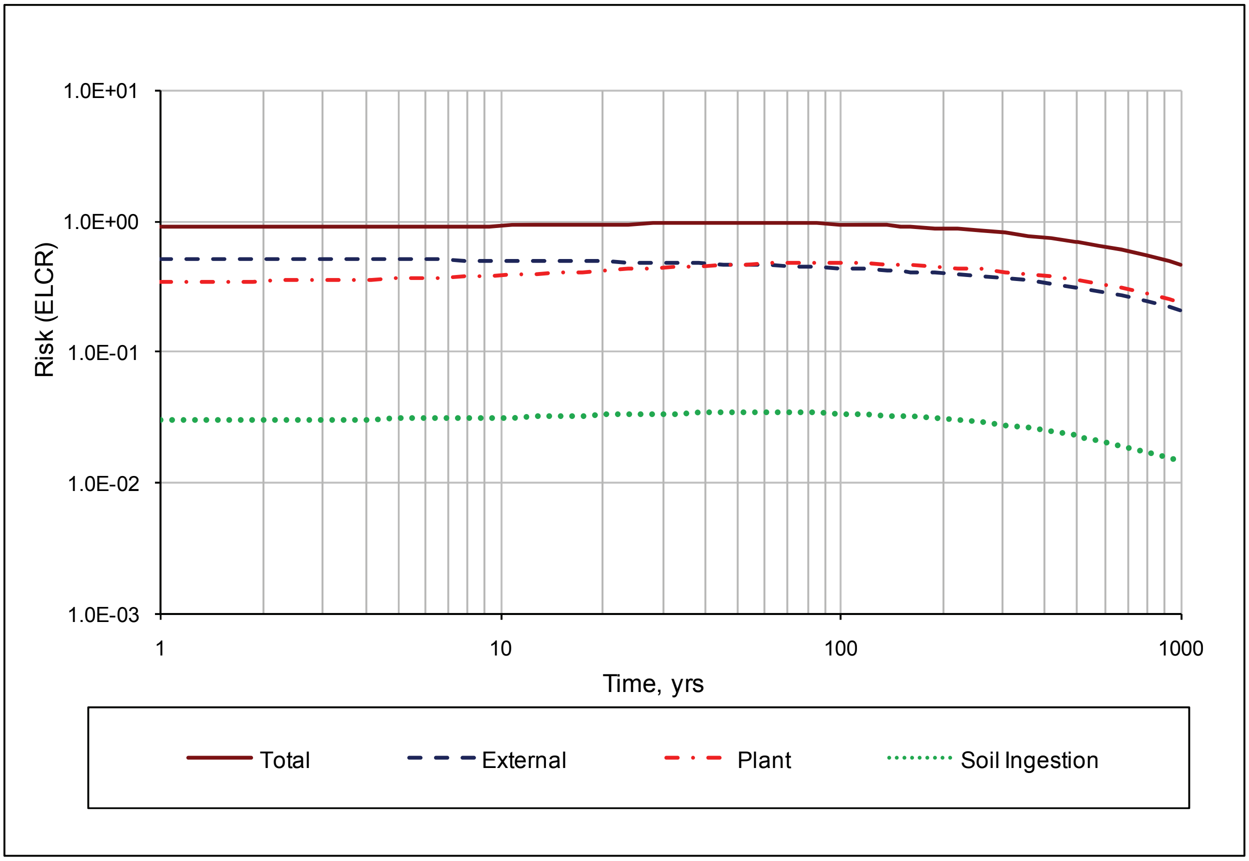
Notes:
PNNL-11800, *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*
PNNL-14702, *Vadose Zone Hydrology Data Package for Hanford Assessments*

Table D-5. Z-Ditches Radiological Cancer Risk Summary for the Subsistence Farmer Exposure Scenario

Total ELCR	Time (Years)	Primary Radionuclides	Percentage of Total ELCR	Pathway
8.98E-01	0	Ra-226	47%	External
		Am-241	6%	
		Cs-237	5%	
		Ra-226	31%	Plant
		Am-241	5%	
		Am-241	2%	Soil Ingestion
9.80E-01	50	Ra-226	41%	External
		Am-241	5%	
		Cs-237	1%	
		Ra-226	42%	Plant
		Am-241	4%	
		Am-241	2%	Soil Ingestion
		Ra-226	1%	
9.25E-01	150	Ra-226	41%	External
		Am-241	5%	
		Ra-226	45%	Plant
		Am-241	4%	
		Am-241	2%	Soil Ingestion
		Ra-226	1%	
6.91E-01	500	Ra-226	42%	External
		Am-241	4%	
		Ra-226	47%	Plant
		Am-241	3%	
		Pu-239	1%	
		Ra-226	2%	Soil Ingestion
		Am-241	1%	
4.63E-01	1000	Ra-226	42%	External
		Am-241	2%	
		Ra-226	48%	Plant
		Am-241	2%	
		Pu-239	2%	
		Ra-226	2%	Soil Ingestion

Notes:

ELCR = excess lifetime cancer risk

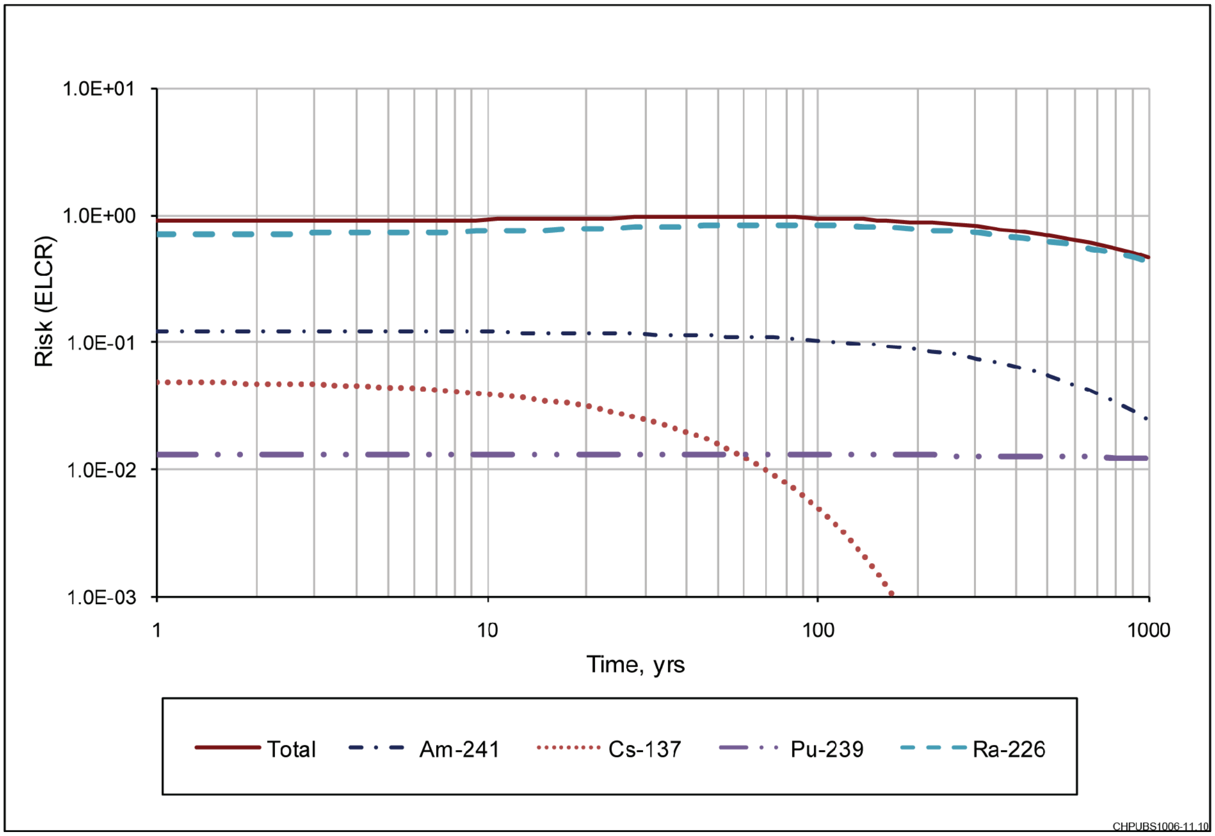


Notes:

ELCR = excess lifetime cancer risk

Figure D-1. RESRAD Analysis for the Subsistence Farmer Exposure Scenario at the Z-Ditches – Risk Contributions Over Time for Dominant Exposure Pathways

The maximum ELCR occurs at 50 years from the present time at a value very close to one, indicting 100 percent probability. The primary contributors to the maximum ELCR are Ra-226 from external radiation exposure (41 percent) and plant consumption (42 percent); Am-241 from external radiation exposure (5 percent), plant consumption (4 percent), and soil ingestion (1 percent); and Cs-137 from external radiation exposure (1 percent). Another primary contributor to risk at 50 years is from ingrowth of lead-210, a radiological decay product of radium-226. The lead-210 exposure contributions arise primarily through the plant ingestion pathway. The contributions reported in Table D-5 from plant ingestion represent the sum of contributions from parent radium-226 and daughter lead-210. After 50 years the total ELCR begins to fall very gradually, reaching a value of about 5×10^{-1} at the end of the assessment period. After 1,000 years, the primary contributors to the total ELCR are Ra-226 from external radiation exposure (42 percent), plant consumption (48 percent), and soil ingestion (2 percent); Am-241 from external radiation exposure (2 percent) and plant consumption (2 percent); and Pu-239 from plant consumption (2 percent).



Notes:

ELCR = excess lifetime cancer risk

Figure D-2. RESRAD Analysis for the Subsistence Farmer Exposure Scenario at the Z-Ditches – Risk Contributions Over Time for Dominant Radionuclides

Based on RESRAD calculations, the total ELCR is projected to remain above EPA's target risk threshold of 1×10^{-4} for at least 100,000 years (RESRAD's maximum calculation time). The ELCR contribution from Am-241, which has a half-life of 432 years, is projected to remain above the 1×10^{-4} risk threshold for approximately 4,500 years. The ELCR contribution from Ra-226, which has a half-life of 1,600 years, is projected to remain above the 1×10^{-4} risk threshold for approximately 10,000 years. And the ELCR contribution from Pu-239, which has a half-life of 24,065 years, is projected to remain above the 1×10^{-4} risk threshold for at least 100,000 years.

Analysis results indicate that over the 1,000-year simulation period there are no exposure contributions from water-dependent pathways (i.e., use of groundwater for drinking water, crop irrigation, and livestock water). The RESRAD calculations indicate that leaching would not cause radionuclides in the soil beneath the Z-Ditches to reach the water table during the 1,000-year simulation period.

Table D-6. Z-Ditches Pathway-Specific Radiological Cancer Risk for the Subsistence Farmer Exposure Scenario

Time (Year)	Radio-nuclide	Contribution to Total All Pathways ELCR													
		External		Inhalation		Plant		Meat		Milk		Soil Ingestion		All Pathways	
		ELCR	Fraction of Total	ELCR	Fraction of Total	ELCR	Fraction of Total	ELCR	Fraction of Total	ELCR	Fraction of Total	ELCR	Fraction of Total	ELCR	Fraction of Total
0	Am-241	5.42E-02	0.0604	5.79E-03	0.0064	4.36E-02	0.0485	3.95E-05	0	4.29E-06	0	1.95E-02	0.0217	1.23E-01	0.137
	Cs-137	4.52E-02	0.0503	1.61E-07	0	4.56E-03	0.0051	3.52E-04	0.0004	2.18E-04	0.0002	5.10E-05	0.0001	5.04E-02	0.0561
	Pu-238	8.76E-07	0	4.70E-05	0.0001	3.22E-04	0.0004	5.84E-07	0	1.61E-08	0	1.44E-04	0.0002	5.15E-04	0.0006
	Pu-239	5.58E-05	0.0001	1.21E-03	0.0013	8.09E-03	0.009	1.47E-05	0	3.98E-07	0	3.62E-03	0.004	1.30E-02	0.0145
	Ra-226	4.22E-01	0.4699	1.56E-04	0.0002	2.77E-01	0.3084	7.64E-04	0.0009	1.33E-03	0.0015	6.51E-03	0.0072	7.08E-01	0.788
	Ra-228	2.57E-05	0	3.14E-08	0	2.07E-05	0	5.33E-08	0	1.23E-07	0	2.96E-07	0	4.69E-05	0.0001
	Sr-90	1.28E-05	0	2.28E-08	0	3.18E-03	0.0035	5.67E-05	0.0001	3.20E-05	0	4.75E-06	0	3.29E-03	0.0037
	Th-228	4.57E-06	0	6.79E-09	0	4.22E-08	0	7.65E-11	0	1.04E-11	0	1.89E-08	0	4.64E-06	0
	Th-230	4.52E-06	0	2.23E-07	0	4.25E-06	0	1.01E-08	0	1.35E-08	0	7.89E-07	0	9.80E-06	0
	Th-232	5.70E-05	0.0001	9.24E-08	0	4.92E-05	0.0001	1.24E-07	0	2.88E-07	0	7.56E-07	0	1.07E-04	0.0001
	U-234	8.32E-10	0	6.98E-09	0	1.27E-07	0	3.69E-10	0	1.72E-09	0	2.27E-08	0	1.59E-07	0
	U-238	7.61E-07	0	1.27E-08	0	3.43E-07	0	9.98E-10	0	4.65E-09	0	6.13E-08	0	1.18E-06	0
	Total	5.22E-01	0.5807	7.20E-03	0.008	3.37E-01	0.3749	1.23E-03	0.0014	1.59E-03	0.0018	2.98E-02	0.0332	8.98E-01	1
50	Am-241	5.00E-02	0.051	5.34E-03	0.0054	4.02E-02	0.041	3.65E-05	0	3.96E-06	0	1.80E-02	0.0183	1.14E-01	0.1158
	Cs-137	1.42E-02	0.0145	5.08E-08	0	1.44E-03	0.0015	1.11E-04	0.0001	6.88E-05	0.0001	1.61E-05	0	1.59E-02	0.0162
	Pu-238	5.90E-07	0	3.16E-05	0	2.17E-04	0.0002	3.94E-07	0	1.15E-08	0	9.69E-05	0.0001	3.46E-04	0.0004
	Pu-239	5.57E-05	0.0001	1.21E-03	0.0012	8.07E-03	0.0082	1.46E-05	0	3.97E-07	0	3.61E-03	0.0037	1.30E-02	0.0132
	Ra-226	4.06E-01	0.4146	2.12E-04	0.0002	4.14E-01	0.4223	1.18E-03	0.0012	1.69E-03	0.0017	1.29E-02	0.0131	8.36E-01	0.8532
	Ra-228	8.09E-08	0	1.04E-10	0	4.93E-08	0	1.27E-10	0	2.91E-10	0	7.83E-10	0	1.32E-07	0
	Sr-90	3.83E-06	0	6.83E-09	0	9.54E-04	0.001	1.70E-05	0	9.59E-06	0	1.42E-06	0	9.86E-04	0.001

Table D-6. Z-Ditches Pathway-Specific Radiological Cancer Risk for the Subsistence Farmer Exposure Scenario

Time (Year)	Radio-nuclide	Contribution to Total All Pathways ELCR													
		External		Inhalation		Plant		Meat		Milk		Soil Ingestion		All Pathways	
		ELCR	Fraction of Total	ELCR	Fraction of Total	ELCR	Fraction of Total	ELCR	Fraction of Total	ELCR	Fraction of Total	ELCR	Fraction of Total	ELCR	Fraction of Total
50	Th-228	6.20E-14	0	9.21E-17	0	5.72E-16	0	1.04E-18	0	1.41E-19	0	2.56E-16	0	6.29E-14	0
	Th-230	1.90E-05	0	2.30E-07	0	1.70E-05	0	4.61E-08	0	6.83E-08	0	1.16E-06	0	3.75E-05	0
	Th-232	8.42E-05	0.0001	1.27E-07	0	6.72E-05	0.0001	1.70E-07	0	3.95E-07	0	1.03E-06	0	1.53E-04	0.0002
	U-234	7.74E-10	0	4.83E-09	0	8.80E-08	0	2.56E-10	0	1.19E-09	0	1.57E-08	0	1.11E-07	0
	U-238	5.27E-07	0	8.79E-09	0	2.37E-07	0	6.91E-10	0	3.22E-09	0	4.24E-08	0	8.19E-07	0
	Total	4.71E-01	0.4803	6.79E-03	0.0069	4.65E-01	0.4743	1.36E-03	0.0014	1.78E-03	0.0018	3.45E-02	0.0352	9.80E-01	1
150	Am-241	4.25E-02	0.046	4.54E-03	0.0049	3.42E-02	0.037	3.11E-05	0	3.36E-06	0	1.53E-02	0.0165	9.65E-02	0.1044
	Cs-137	1.41E-03	0.0015	5.04E-09	0	1.42E-04	0.0002	1.10E-05	0	6.82E-06	0	1.59E-06	0	1.57E-03	0.0017
	Pu-238	2.68E-07	0	1.43E-05	0	9.84E-05	0.0001	1.79E-07	0	5.76E-09	0	4.40E-05	0	1.57E-04	0.0002
	Pu-239	5.55E-05	0.0001	1.20E-03	0.0013	8.04E-03	0.0087	1.46E-05	0	3.96E-07	0	3.59E-03	0.0039	1.29E-02	0.014
	Ra-226	3.76E-01	0.4072	2.12E-04	0.0002	4.20E-01	0.4542	1.20E-03	0.0013	1.67E-03	0.0018	1.35E-02	0.0146	8.13E-01	0.8794
	Ra-228	4.55E-13	0	5.86E-16	0	2.77E-13	0	7.13E-16	0	1.64E-15	0	4.41E-15	0	7.40E-13	0
	Sr-90	3.44E-07	0	6.13E-10	0	8.56E-05	0.0001	1.52E-06	0	8.61E-07	0	1.28E-07	0	8.85E-05	0.0001
	Th-228	8.56E-30	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	8.56E-30	0
	Th-230	4.63E-05	0.0001	2.45E-07	0	4.67E-05	0.0001	1.31E-07	0	1.88E-07	0	2.11E-06	0	9.57E-05	0.0001
	Th-232	8.43E-05	0.0001	1.27E-07	0	6.72E-05	0.0001	1.70E-07	0	3.95E-07	0	1.03E-06	0	1.53E-04	0.0002
	U-234	1.31E-09	0	2.33E-09	0	4.31E-08	0	1.25E-10	0	5.76E-10	0	7.59E-09	0	5.51E-08	0
	U-238	2.53E-07	0	4.22E-09	0	1.14E-07	0	3.32E-10	0	1.55E-09	0	2.04E-08	0	3.93E-07	0
	Total	4.21E-01	0.4549	5.97E-03	0.0065	4.63E-01	0.5004	1.26E-03	0.0014	1.68E-03	0.0018	3.24E-02	0.0351	9.25E-01	1

Table D-6. Z-Ditches Pathway-Specific Radiological Cancer Risk for the Subsistence Farmer Exposure Scenario

Time (Year)	Radio-nuclide	Contribution to Total All Pathways ELCR													
		External		Inhalation		Plant		Meat		Milk		Soil Ingestion		All Pathways	
		ELCR	Fraction of Total	ELCR	Fraction of Total	ELCR	Fraction of Total	ELCR	Fraction of Total	ELCR	Fraction of Total	ELCR	Fraction of Total	ELCR	Fraction of Total
500	Am-241	2.42E-02	0.035	2.57E-03	0.0037	1.94E-02	0.028	1.77E-05	0	1.91E-06	0	8.64E-03	0.0125	5.48E-02	0.0793
	Cs-137	4.34E-07	0	1.55E-12	0	4.38E-08	0	3.38E-09	0	2.10E-09	0	4.89E-10	0	4.83E-07	0
	Pu-238	2.16E-08	0	9.00E-07	0	6.19E-06	0	1.12E-08	0	5.24E-10	0	2.76E-06	0	9.88E-06	0
	Pu-239	5.47E-05	0.0001	1.19E-03	0.0017	7.93E-03	0.0115	1.44E-05	0	3.90E-07	0	3.54E-03	0.0051	1.27E-02	0.0184
	Ra-226	2.88E-01	0.4165	1.63E-04	0.0002	3.23E-01	0.4667	9.25E-04	0.0013	1.28E-03	0.0019	1.04E-02	0.0151	6.23E-01	0.9017
	Ra-228	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0
	Sr-90	7.45E-11	0	1.33E-13	0	1.86E-08	0	3.30E-10	0	1.87E-10	0	2.77E-11	0	1.92E-08	0
	Th-228	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0
	Th-230	1.27E-04	0.0002	2.89E-07	0	1.37E-04	0.0002	3.89E-07	0	5.46E-07	0	5.01E-06	0	2.70E-04	0.0004
	Th-232	8.41E-05	0.0001	1.27E-07	0	6.71E-05	0.0001	1.70E-07	0	3.94E-07	0	1.03E-06	0	1.53E-04	0.0002
	U-234	5.13E-09	0	1.91E-10	0	8.68E-09	0	2.49E-11	0	6.55E-11	0	7.82E-10	0	1.49E-08	0
	U-238	1.93E-08	0	3.23E-10	0	8.72E-09	0	2.54E-11	0	1.18E-10	0	1.56E-09	0	3.01E-08	0
	Total	3.12E-01	0.4519	3.92E-03	0.0057	3.50E-01	0.5065	9.57E-04	0.0014	1.29E-03	0.0019	2.26E-02	0.0327	6.91E-01	1
1,000	Am-241	1.08E-02	0.0234	1.14E-03	0.0025	8.64E-03	0.0187	7.97E-06	0	8.46E-07	0	3.83E-03	0.0083	2.45E-02	0.0529
	Cs-137	4.16E-12	0	1.49E-17	0	4.20E-13	0	3.24E-14	0	2.01E-14	0	4.69E-15	0	4.64E-12	0
	Pu-238	1.17E-08	0	1.73E-08	0	1.31E-07	0	2.52E-10	0	6.41E-11	0	5.33E-08	0	2.14E-07	0
	Pu-239	5.37E-05	0.0001	1.16E-03	0.0025	7.77E-03	0.0168	1.41E-05	0	3.83E-07	0	3.47E-03	0.0075	1.25E-02	0.027
	Ra-226	1.96E-01	0.4244	1.11E-04	0.0002	2.20E-01	0.4756	6.30E-04	0.0014	8.74E-04	0.0019	7.10E-03	0.0154	4.25E-01	0.9189
	Ra-228	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0
	Sr-90	4.34E-16	0	7.74E-19	0	1.08E-13	0	1.93E-15	0	1.09E-15	0	1.61E-16	0	1.12E-13	0

Table D-6. Z-Ditches Pathway-Specific Radiological Cancer Risk for the Subsistence Farmer Exposure Scenario

Time (Year)	Radio-nuclide	Contribution to Total All Pathways ELCR													
		External		Inhalation		Plant		Meat		Milk		Soil Ingestion		All Pathways	
		ELCR	Fraction of Total	ELCR	Fraction of Total	ELCR	Fraction of Total	ELCR	Fraction of Total	ELCR	Fraction of Total	ELCR	Fraction of Total	ELCR	Fraction of Total
1,000	Th-228	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0
	Th-230	2.09E-04	0.0005	3.34E-07	0	2.29E-04	0.0005	6.54E-07	0	9.13E-07	0	7.99E-06	0	4.48E-04	0.001
	Th-232	8.38E-05	0.0002	1.26E-07	0	6.68E-05	0.0001	1.70E-07	0	3.92E-07	0	1.03E-06	0	1.52E-04	0.0003
	U-234	9.90E-09	0	2.14E-11	0	1.09E-08	0	3.11E-11	0	4.42E-11	0	3.95E-10	0	2.13E-08	0
	U-238	4.98E-10	0	8.22E-12	0	2.29E-10	0	6.68E-13	0	3.04E-12	0	3.99E-11	0	7.79E-10	0
	Total	2.08E-01	0.4486	2.41E-03	0.0052	2.37E-01	0.5117	6.53E-04	0.0014	8.77E-04	0.0019	1.44E-02	0.0312	4.63E-01	1

Notes:

ELCR = excess lifetime cancer risk

D6 Uncertainty Assessment

The uncertainties associated with the subsistence farmer scenario are largely the same as those identified and discussed in the 200-CW-5 OU BRA for the industrial scenario (DOE/RL-2003-11, Section 5.2.6). In general, the exposure assumptions for the subsistence farmer scenario are intended to be conservative and to yield an overestimate of true radiological risk.

Uncertainties Associated with the Exposure Point Concentration. There are uncertainties associated with the use of maximum detected concentrations as the exposure point concentration. In particular, the maximum detected concentration for Ra-226 is used as the EPC rather than the 95 percent UCL on the mean. The maximum concentration was selected as the EPC because the computed 95 percent UCL value exceeded the maximum detected concentration due to the small number of samples (12 total observations). Use of the maximum concentration may overstate total health risks because samples were collected based on a biased sample design (where contamination was expected to be encountered).

Uncertainties Associated with the Groundwater Exposure Pathway. This risk assessment addresses potential exposures and resulting health risks from contaminants that currently reside in the soil and does not include existing contamination in the groundwater underlying the 200-CW-5 OU. The absence of the groundwater pathway understates potential health risks. However, health risks from potential exposure to groundwater beneath the 200-CW-5 OU will be evaluated in the 200-ZP-1 and 200-UP-1 groundwater OUs and presented in the RI/FS documents.

D7 References

40 CFR 141, "National Primary Drinking Water Regulations," *Code of Federal Regulations*. Available at: http://www.access.gpo.gov/nara/cfr/waisidx_08/40cfr141_08.html.

ANL, 2007, *RESRAD for Windows*, Version 6.4, Environmental Assessment Division, Argonne National Laboratory, Argonne, Illinois. Available at: http://web.ead.anl.gov/resrad/register2/.

ANL/EAD-4, 2001, *User's Manual for RESRAD, Version 6*, Environmental Assessment Division, Argonne National Laboratory, Argonne, Illinois. Available at: http://web.ead.anl.gov/resrad/documents/resrad6.pdf.

BHI-01177, 1998, *Borehole Summary Report for the 216-B-2-2 Ditch*, Rev. 0, Bechtel Hanford, Inc., Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D198215959.

CCN 070578, 1999, "Estimation of the Soil-Specific Exponential Parameter(b)," (letter to J.D. Fancher, CH2M HILL, Inc., from W.J. McMahon), Bechtel Hanford, Inc., Richland, Washington, June 30.

DOE/ORP-2005-01, 2006, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site*, Rev. 0, U.S. Department of Energy, Office of River Protection, Richland, Washington. Available at: http://www.hanford.gov/orp/uploadfiles/CHG_Performance_Assessment.pdf.

DOE/RL-2003-11, 2004, *Remedial Investigation for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-SC-1 Steam Condensate Group Operable Units*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

EH-231-014/1292, 1992, *Use of Institutional Controls in a CERCLA Baseline Risk Assessment,* CERCLA Information Brief, U.S. Department of Energy, Office of Environmental Guidance, Washington, D.C. Available at: http://homer.ornl.gov/nuclearsafety/env/guidance/cercla/base.pdf.

EPA, 1991, *Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual Supplemental Guidance "Standard Default Exposure Factors" Interim Final*, OSWER Directive 9285.6-03, Office of Emergency and Remedial Response Toxics Integration Branch, U.S. Environmental Protection Agency, Washington D.C. Available at: http://www.epa.gov/oswer/riskassessment/pdf/OSWERdirective9285.6-03.pdf.

EPA, 1992, *Supplemental Guidance to RAGS: Calculating the Concentration Term*, OSWER Publication 9285.7-081, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.deq.state.or.us/lq/pubs/forms/tanks/UCLsEPASupGuidance.pdf.

EPA, 2002, *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites*, OSWER 9285.6-10, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://epa.gov/oswer/riskassessment/pdf/ucl.pdf.

EPA/540-R-00-007, 2000, *Soil Screening Guidance for Radionuclides: User's Guide*, OSWER Directive No. 9355.4-16A, Office of Radiation and Indoor Air, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/superfund/health/contaminants/radiation/radssg.htm.

EPA 540/R/99/006, 1999, *Radiation Risk Assessment At CERCLA Sites: Q & A*, OSWER Directive 9200.4-31P, Office of Emergency and Remedial Response, Office of Radiation and Indoor Air, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/superfund/health/contaminants/radiation/pdfs/riskqa.pdf.

EPA/600/R-07/038, 2007, *ProUCL Version 4.0 User Guide*, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/esd/tsc/images/proucl4user.pdf.

PNNL-11800, 1998, *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.osti.gov/energycitations/servlets/purl/594543-mUGcOH/webviewable/594543.pdf.

PNNL-14702, 2006, *Vadose Zone Hydrology Data Package for Hanford Assessments*, Rev. 1, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14702rev1.pdf.

PNNL-15160, 2005, *Hanford Site Climatological Summary 2004 with Historical Data*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-15160.pdf.

SGW-37174, *Z-Ditches Study for the 200-CW-5 Cooling Water Operable Unit*, Rev. 0, Fluor Hanford, Inc., Richland, Washington.

WDOH/320-015, 1997, *Hanford Guidance for Radiological Cleanup,* Rev. 1, Washington State Department of Health, Olympia, Washington. Available at: http://www.doh.wa.gov/ehp/rp/environmental/cleanup.pdf.

WHC-EP-0883, 1995, *Variability and Scaling of Hydraulic Properties for 200 Area Soils, Hanford Site*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: http://www.osti.gov/bridge/servlets/purl/188564-WXbGAs/webviewable/188564.pdf.

WHC-SD-EN-SE-004, 1993, *Site Characterization Report: Results of Detailed Evaluation of the Suitability of the Site Proposed for Disposal of 200 Areas Treated Effluent*, Westinghouse Hanford Company, Richland, Washington.

This page intentionally left blank.

Appendix E

Z-Ditches Summary Data Sheets

Terms

CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
DOE	Department of Energy
OU	operable unit
SIM	*Hanford Soil Inventory Model, Rev. 1*, RPP-26744, Rev. 0
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., 1989)

E1 Introduction

During renegotiation of *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al., 1989) M-15 milestones in 2005 and 2006 (Chapter 1.0 of the main text), the Tri-Parties (U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Ecology) undertook a supplemental data quality objectives process to support completion of remedial investigation/feasibility study processes for Central Plateau operable units (OUs). The purpose of the data quality objective process was to identify supplemental data that would fill remedial investigation data gaps and allow completion of remedial decision making. For the 200-CW-5 OU waste sites within the scope of this feasibility study (Chapter 2.0 of the main text), the Tri-Parties agreed that existing data are sufficient for *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) decision making (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*, Vol. I, Appendix C). Summary sheets have been prepared for the 200-CW-5 OU waste sites to support the Tri-Parties' understanding of the existing data. The data sheets provide key information to better define the nature and extent of contamination reflected in the contaminant distribution model for each waste site and to help refine the overall conceptual site model (Chapter 2.0 of the main text) to aid the feasibility study evaluation process.

The data summary sheets are a compilation of available information on the following key elements used in refinement of the conceptual site model for each 200-CW-5 OU waste site:

- Site identification
- Site location
- Type of site
- Site construction
- Operating history
- Effluent volume discharged
- Period of operation
- Inventory information
- Vicinity waste sites
- Characterization summary
- Data
- References

The data summaries prepared for the supplemental data quality objectives used the most recent version of RPP-26744, *Hanford Soil Inventory Model, Rev. 1* (SIM), to represent the contaminant inventory at each waste site. The SIM was developed between 1999 and 2005 to project inventory estimates for all major Hanford Site 200 Area waste-disposal sites and unplanned release sites in support of a Pacific Northwest National Laboratory effort to develop site-wide inventory estimates for historical Hanford Site operations. SIM provides inventory estimates for almost 300 waste disposal and unplanned release sites. SIM is an extension of the Hanford-Defined Waste Model, a previous activity undertaken to develop inventory estimates for materials stored in the Hanford Site's single- and double-shell tanks. In both the SIM and the Hanford-Defined Waste models, inventory estimates were developed by combining best estimates of waste compositions with waste volume discharge data. SIM inventory estimates are sensitive to the "waste composition" estimates. In the early 2000 time period when SIM input data were being compiled for Z Plant waste sites, little chemical process data were available for historical Z Plant operations.

Thus, this limited amount of Z Plant chemical processing information was used to project a similar waste composition for plant effluents being discharged to the Z Cribs. However, information uncovered since the completion of SIM leads to a better understanding of the complexity of Z Plant liquid waste discharges and leads to the conclusion that much of the SIM inventory estimate data for Z Plant waste sites has a high level of uncertainty.

Significant information about the Z Plant operations comes from recent documents associated with current decommissioning and decontamination activities. The Z Plant complex facilities have been associated with many facets of plutonium processing and component fabrication. Over the more than 50 years of Z Plant operational history, these activities changed to meet the critical needs at that point in time. As chemical processes changed so did waste-stream compositions and processing facilities. Thus, documentation needed for facility decommissioning and decontamination activities also provides considerable insight into waste-stream compositions. Information gleaned from Z Plant decommissioning and decontamination documentation will be extremely valuable in any future revisions of SIM. In the mean time, SIM inventory estimates for Z Plant waste sites will not be used in site remediation decisions. Inventory estimates for Z Plant waste sites will be based on historical and site characterization information. Sources of inventory information for Z Plant waste sites in the 200-CW-5 OU are documented in the data summary tables in this appendix.

E2 Summary Data Sheets

Summary data sheets that provide the bases for the conceptual models for the 200-CW-5 OU waste sites are provided as Tables E-1 through E-5.

Table E-1. Summary Data Sheet, Data-Needs Priority Summary for the 216-Z-11 Ditch (200-CW-5 Operable Unit)

Background						
Site Identification	216-Z-11 Ditch					
Site Location	200 West Area, Plutonium Finishing Plant zone					
Type of Site	CERCLA Past-Practice – Ditch					
Operating History	The 216-Z-11 Ditch is a backfilled, surface-stabilized ditch that ran from the east side of the 234-5Z Building southward to the 216-U-10 Pond. The ditch is currently co-located within a large, posted Underground Radioactive Material area that also includes the 216-Z-1D and 216-Z-19 Ditches. When active, the unit was a long narrow ditch with 2.5:1 sloped sides and a 0.05% grade. The 216-Z-11 Ditch was installed to replace the 216-Z-1D Ditch. The 216-Z-11 Ditch received liquid waste from Plutonium Finishing Plant process sewer, and the 291-Z and 231-Z Buildings until the ditch was deactivated in 1971. The 216-Z-11 Ditch was replaced by the 216-Z-19 Ditch. During the 1960s, a special Space Nuclear Auxiliary Power program was operating in Z Plant. The program isolated Pu-238 and released an unknown amount of Pu-239/240 to the 216-Z-11 Ditch as waste. Structures associated with this unit include the remnants of the 216-Z-1D and 216-Z-19 Ditches, UPR-200-W-110, the 216-U-10 Pond, and the culvert beneath 16th Street. Upon retirement in 1971, the ditch was backfilled to grade. The Z Plant effluent was rerouted to the 216-Z-19 Ditch. Additional backfill material was added to the 216-Z-11 Ditch when the 216-Z-19 Ditch was deactivated and backfilled in 1981.					
Vicinity Waste Sites	Z-Ditches Waste Group					
Current Status	Retired, Backfilled, and Stabilized					
Potential Remedial Alternatives						
	No Action	**MESC/MNA/IC**	**Removal, Treatment, and Disposal**	**Barrier**	**In Situ Treatment, Remove, Treat, Disposal, and Barrier**	**In Situ Treatment and Barrier**
X for Viable Alternatives	No (data indicate significant contamination at site)	X	X	X	X	X

(Other: None)

Data Evaluation and Gaps Analysis			
Data	**Known's**	**Data Uncertainties**	**Are supplemental data required to support decision making?**
C3808 299-W18-178 299-W18-188 299-W18-198 299-W18-199 C3816 C3817 C3818 C3819 C3820 C3821 C3825 C3834 C3835 C3836 299-W18-192 299-W18-193 299-W18-194 C3810 C3811 C3812 C3813 C3814 C3815	Soil data taken from Borehole C3808 showed a barium concentration around 80,000 µg/kg from 1.5 to 31 m (5 to 102 ft) below ground surface, and a peak concentration of 117,000 µg/kg at 61 m (200 ft). Chromium concentrations around 10,000 µg/kg were detected from 3 to 4.5 m (10 to 14.8 ft). There were two depths where chromium concentrations were higher. At 31 m (102 ft), the concentration was 18,500 µg/kg, and at 61 m (200 ft), the concentration was 19,400 µg/kg. Manganese was detected from 1.5 to 4.5 m (5 to 14.8 ft) at a concentration around 350,000 µg/kg. The chromium concentration at 16 m (52.5 ft) was 397,000 µg/kg and tapered off to 217,000 µg/kg at 68 m (223 ft). Nitrate was detected at 4.5 m (14.8 ft) with a concentration of 47,500 µg/kg. Vanadium was detected from 1.5 to 7.6 m (5 to 25 ft) above 50,000 µg/kg. At 16 m (52.5 ft), the concentration was 78,900 µg/kg. The concentration remained above 30,000 µg/kg until 68 m (223 ft). Plutonium-239/240 was detected in the soil at 3 and 3.8 m (10 and 12.5 ft) at a concentration of 2,780 pCi/g and 4,840 pCi/g respectively. At 4.5 m (14.8 ft), the concentration dropped to 67.7 pCi/g at 5.3 m (17.4 ft). Americium-241 was detected at 3 and 3.8 m (10 and 12.5 ft) at a concentration of 649 and 919 pCi/g, respectively. Spectral gamma logging of Borehole C3808 showed plutonium from 0.8 to 3 m (2.5 to 10 ft) with a zone of high plutonium concentration at the 2.9 m (9.5-ft) level in a layer approximately 7.6 cm (3 in.) thick. 299-W18-178 No manmade radionuclides were detected above minimum detection limits in this borehole.	None	Early agreement that supplemental data are not required.
References/Bibliography	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 USC 9601, et seq. CP-12134, Borehole Summary Report for Borehole C3808 in the 216-Z-11 Ditch, 200-CW-5, U-Pond/Z-Ditches Cooling Water Operable Unit.		
Proposed Activities	Removal, treatment, and disposal of site to remove low-level waste and placement of an isolation and intrusion barrier over remaining area of suspect TRU waste.		

Notes:
MESC/MNA/IC = maintain existing soil cover, monitored natural attenuation, and institutional controls
TRU = radioactive waste as defined in DOE G 435.1-1, Implementation Guide for Use with DOE M 435.1-1

Table E-2. Summary Data Sheet, Data-Needs Priority Summary for the 216-Z-1D Ditch (200-CW-5 Operable Unit)

Background	
Site Identification	216-Z-1D Ditch
Site Location	200 West Area, Plutonium Finishing Plant zone
Type of Site	CERCLA Past-Practice – Ditch
Operating History	The 216-Z-1D Ditch is a backfilled, surface-stabilized unit that runs from a point east of the 231-Z Building, curving southward to the 216-U-10 Pond. In 1949, the northern portion of the ditch was backfilled. A portion of the covered ditch is located inside the Plutonium Finishing Plant security fence. The backfilled portion of the ditch was replaced with an underground pipeline (see site code 200-W-125 [WIDS]) for 231-Z Building effluent. The southern portion of the ditch is co-located within a large Underground Radioactive Material area that also includes the 216-Z-11 and 216-Z-19 Ditches. The 216-Z-1D Ditch was used to transfer liquid waste from the 231-Z, 234-5Z, and 291-Z Buildings to the 216-U-10 Pond. The 216-Z-1D Ditch is associated with the 200-W-125 Pipeline, the 216-Z-11 and 216-Z-19 Ditches; the pipeline at the north end of the ditch; the stabilized 216-U-10 Pond; and the 231-Z Building outfall. The site was excavated in 1944. In 1949, the upper 526 m (1,725 ft) of the ditch was backfilled and replaced with a pipeline (200-W-125). After a release of plutonium and americium from the 231-Z Building occurred in 1959, the open portion of the ditch (a long, shallow channel with 2.5:1 sloped sides and a grade of 0.05%) from the pipeline southward to the 216-U-10 Pond (measuring 611 m [2,005 ft]) was backfilled. The ditch was replaced with a new ditch known as the 216-Z-11 Ditch. Documentation is unclear regarding whether the new ditch could have used 203 m (655 ft) of the original 216-Z-1D Ditch excavation near the outlet to the 216-U-10 Pond during some portion of 216-Z-11 Ditch operations.
Vicinity Waste Sites	Z-Ditches Waste Group
Current Status	Retired, Backfilled, Stabilized

Potential Remedial Alternatives

	No Action	MESC/MNA/IC	Removal/Treat/Disposal	Barrier	In Situ Treatment, Remove, Treat, Disposal, and Barrier	In Situ Treatment and Barrier	Other
X for Viable Alternatives	No	X	X	X	X	X	None

Data Evaluation and Gaps Analysis

Data	Knowns	Data Uncertainties	Are supplemental data required to support decision making?
	In 1959, the 216-Z-1D Ditch was sampled along its entire length starting at the inlet, in 30.5 m (100-ft) intervals, for total alpha and plutonium content in the mud found in the bottom of the ditch. The results from the mud sampling showed an average plutonium concentration of 6×10^5 pCi/g. The highest concentration found was 2.71×10^7 pCi/g of total alpha at 244 m (800 ft) from the entrance to the ditch.	None	Early agreement that supplemental data are not required.
References/Bibliography	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 USC 9601, et seq." Waste Information Data System database WHC-EP-0707, 216-U-10 Pond and 216-Z-19 Ditch Characterization Studies		
Proposed Activities	Partial removal, treatment, and disposal of site to remove low-level waste and placement of an isolation and intrusion barrier over remaining area of suspect TRU waste.		

Notes:

MESC/MNA/IC = maintain existing soil cover, monitored natural attenuation, and institutional controls

TRU = Radioactive waste as defined in DOE G 435.1-1, Implementation Guide for Use with DOE M 435.1-1

WIDS = Waste Information Data System database

Table E-3. Summary Data Sheet, Data-Needs Priority Summary for the 216-Z-19 Ditch (200-CW-5 Operable Unit)

Background							
Site Identification	216-Z-19 Ditch						
Site Location	200 West Area, Plutonium Finishing Plant zone						
Type of Site	CERCLA Past-Practice – Ditch						
Operating History	The 216-Z-19 Ditch is a backfilled, surface-stabilized site. The ditch is currently co-located within a large Underground Radioactive Material area that also includes the 216-Z-1D and 216-Z-11 Ditches. The 216-Z-19 Ditch operated as a waste disposal/transfer line for various Plutonium Finishing Plant facilities. The ditch received effluent from the 234-5Z Building, the 291-Z Stack, and the 231-Z Buildings. The ditch was fed by three underground process sewer pipelines that entered the head end of the ditch. The ditch was deactivated and backfilled when discharges transferred to the 216-Z-20 Tile Field. Structures associated with this site include the remnants of the 216-Z-1D and the 216-Z-11 Ditches, the 216-U-10 Pond, the storm water and process sewer outfalls from the Plutonium Finishing Plant, and the pipeline from the 231-Z Building. The head end of the ditch reused the first 37 m (120 ft) of land previously containing 216-Z-1D and the 216-Z-11 Ditches. The next 130 m (425 ft) of the 216-Z-19 Ditch mistakenly was excavated through a section of the contaminated (backfilled) 216-Z-1D Ditch. When the mistake was noticed, the ditch was turned west and followed a new route, parallel to the backfilled 216-Z-1D Ditch. The south end of the 216-Z-19 Ditch originally turned east and connected to the 216-Z-11 Ditch culvert that passed under 16th Street to empty into the 216-U-10 Pond. Later, a new culvert was added under 16th Street and the 216-Z-19 Ditch was directed to the new culvert.						
Vicinity Waste Sites	Z-Ditches Waste Group						
Current Status	Retired, Backfilled, Stabilized						
Potential Remedial Alternatives							
	No Action	**MESC/MNA/IC**	**Removal/Treat/Disposal**	**Barrier**	**In Situ Treatment, Remove, Treat, Disposal, and Barrier**	**In Situ Treatment and Barrier**	**Other**
X for Viable Alternatives	No (data indicate significant contamination at site)	X	X	X	X	X	None
Data Evaluation and Gaps Analysis							
Data	**Knowns**			**Data Uncertainties**	**Are supplemental data required to support decision making?**		
C3810 C3811 C3812 299-W18-193 299-W18-194 C3813 C3814 C3815 C3816 C3817 C3818	In 1979, a series of nine transects with seven sample points each were used at the 216-Z-19 Ditch to characterize the extent of plutonium and americium contamination. The results generally showed that the center of the ditch was the most highly contaminated. The highest Pu-239 concentration found was 97,800 pCi/g in the 0 to 5 cm (0 to 2 in.) depth range. The maximum Am-241 concentration was 29,000 pCi/g.			None	Early agreement that supplemental data are not required.		
References/Bibliography	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 USC 9601, et seq. WHC-EP-0707, *216-U-10 Pond and 216-Z-19 Ditch Characterization Studies*						
Proposed Activities	Partial removal, treatment, and disposal of site to remove low-level waste and placement of an isolation and intrusion barrier over remaining area of suspect TRU waste.						

Notes:

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

MESC/MNA/IC = maintain existing soil cover, monitored natural attenuation, and institutional controls

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

Table E-4. Summary Data Sheet, Data-Needs Priority Summary for the 216-Z-20 Tile Field (200-CW-5 Operable Unit)

Background		
Site Identification	216-Z-20 Tile Field	
Site Location	200 West Area; Northwest of the U Tank Farm. Parallel to and West of the 216-Z-19 Ditch.	
Type of Site	Tile Field	
Site Construction	The 216-Z-20 Tile Field is rectangular, 462.99 by 3.05 m (1,519 by 10 ft) at the bottom, and 2.91 m (9.56 ft) deep with a 1:2 side slope. The ditch is divided into North, South 1, and South 2 segments. The tile field structure has varied depths of 2.7 to 8.8 m (9 to 29 ft) below ground surface. Three 15 cm (6-in.) perforated polyvinyl chloride distribution pipes run the length of the tile field to the south end, where the pipes are capped. A set of risers (three in a row across the width of the unit) rose to a height of 0.46 m (1.5 ft) above grade at four locations along the length of the unit. The unit was filled with gravel and backfilled over with soil. Construction information is available in the following historical references: WIDS, H-2-92061, and WHC-EP-0674.	
Operating History	The 216-Z-20 Tile Field was built to receive effluent from the Plutonium Finishing Plant facilities and the 231-Z Building It was built to replace the 216-Z-19 Ditch. Construction of the 216-Z-20 Tile Field allowed the radioactively contaminated 216-Z-19 Ditch and 216-U-10 Pond to be decommissioned. The 216-Z-20 Tile Field is a liquid waste site that was used from 1981 to 1995 to receive cooling water, steam condensate, storm sewer, building drains, Hanford Engineering and Development Laboratory Radioactive Acid Digestion Test Unit cooling water, and chemical drains waste from the 234-5Z Building; cooling water stream condensate and laboratory drains from the 231-Z Building and miscellaneous drains waste from 291-Z, 232-Z, and 236-Z Buildings. The unit also received wastes from 2736-Z Building.	
Effluent Volume Discharged	3,800,000,000 L (1,003,853,793 gal) (WIDS)	
Period of Operation	1981 to 1995	
Estimated Discharged Inventory For Representative Site 216-Z-11 Ditch	**Inventory information is Available in DOE/RL-99-66**	
	Constituent	**Inventory**
	Am-241	0.492 Ci
	Plutonium	8,100 g
Vicinity Waste Sites	Z-Ditches waste group	
Characterization Summary	This site received ~4,200 ML of Z Complex chemical sewer waste, Z Complex cooling water, and plutonium recovery waste. The majority of the waste disposed is considered to be chemical sewer and cooling water. The annual volumes can be found in the following documents: RHO-HS-VS-4 RHO-HS-SR-81-3 RHO-HS-SR-82-3-4Q-LIQ-P RHO-HS-SR-83-3-4Q-LIQ-P RHO-HS-SR-84-3-4Q-LIQ-P RHO-HS-SR-85-3-4Q-LIQ-P RHO-HS-SR-86-3-4Q-LIQ-P WHC-EP-0141 WHC-EP-0141-1 WHC-EP-0141-2 WHC-EP-0527 WHC-EP-0527-1 WHC-EP-0527-2 WHC-EP-0527-3 WHC-EP-0527-4 WHC-EP-0527-5 The plutonium recovery waste contribution is estimated using waste-stream concentration and site inventory information regarding Pu-239 and is represented by an asymmetric triangular distribution with a maximum of 500 L (132 gal) (RPP-26744).	

Table E-4. Summary Data Sheet, Data-Needs Priority Summary for the 216-Z-20 Tile Field (200-CW-5 Operable Unit)

Data	
Spectral Gamma Logging System Logs (2003)	The data source for the Spectral Gamma Logging System logs is Stoller Log Data Reports.
299-W18-017 (265 ft) (2003)	Cesium-137 was detected at 8.2 m (27 ft) with a concentration near the MDL (0.2 pCi/g). Cesium-137 also was detected at 46 m (15 ft) on the repeat log with a concentration near the MDL.
299-W18-18 (265 ft) (2003)	Cesium-137 was detected at 6.1 m (20 ft) with a concentration near the MDL (0.2 pCi/g). Cesium-137 also was detected at 2.1 m (7 ft) on the repeat log with a concentration near the MDL. An increase of 6 pCi/g in apparent K-40 concentrations occurs at approximately 21.3 m (70 ft), which represents the transition from the coarse-grained sediments of the Hanford H_1 to the finer-grained sediments of the Hanford H_2. The concentration of natural U-238 is above 2.0 pCi/g near 29.3 m (96 ft), which is anomalously high within the Hanford formation.
299-W18-20 (250 ft) (2003)	Cesium-137 was detected at 4.3, 8.8, 12.5, and 13.7 m (14, 29, 41, and 45 ft) with a concentration near the MDL (0.2 pCi/g). Cesium-137 also was detected at 4 m (13 ft) on the repeat log with a concentration near the MDL. Increases of 5 pCi/g in apparent K-40 concentrations and 0.4 pCi/g in Th-232 and U-238 concentrations occur at approximately 27.1 m (89 ft), which represents the transition from the coarse-grained sediments of the Hanford H_1 to the finer-grained sediments of the Hanford H_2.
Analyses of Borehole Samples from the 216-Z-11 Ditch	The 216-Z-20 Tile Field is analogous to the 216-Z-11 Ditch. Boreholes were drilled in the 216-Z-11 Ditch. The major zone of contamination in the boreholes was detected from about 0.9 to 3.7 m (3 to 12 ft) below ground surface. The maximum soil contaminant concentrations were 40,000 pCi/g for Pu-239/240, 3389 pCi/g for Pu-238, and 3094 pCi/g for Am-241. Contaminant concentrations decreased to less than 1 pCi/g for all contaminants at 6 m (20 ft). (DOE/RL-2003-11, Section 3.2.1.5, page 3-7)
Remedial Investigation (2005-2007)	The 216-Z-20 Tile Field was investigated as being analogous to the 216-Z-11 Ditch in DOE/RL-2003-11.

References/Bibliography

BHI-00174, *U Plant Aggregate Area Management Study Technical Baseline Report* BHI-01294, *Data Quality Objective Summary Report for the 200-CW-5 U Pond/Z Ditches System Waste Sites* DOE/RL-91-52, *U Plant Source Aggregate Area Management Study Report* DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program* DOE/RL-99-66, *Steam Condensate/Cooling Water Waste Group Operable Units RI/FS Work Plan; Includes: 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 Operable Units* DOE/RL-2003-11, *Remedial Investigation for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-SC-1 Steam Condensate Group Operable Units* H-2-92061, *Tile Field to Replace Z-19 Ditch* RPP-26744, *Hanford Soil Inventory Model, Rev. 1* Stoller Log Data Reports (http://www.hanford.gov/cp/gpp/data/vzcp/vzcp.cfm) *Waste Information Data System* database	RHO-HS-SR-81-3, *Radioactive Liquid Wastes Discharged to Ground in the 200 Areas During 1981* RHO-HS-SR-82-3-4Q-LIQ-P, *Radioactive Liquid Wastes Discharged to Ground in the 200 Areas During 1982* RHO-HS-SR-83-3-4Q-LIQ-P, *Radioactive Liquid Wastes Discharged to Ground in the 200 Areas During 1983* RHO-HS-SR-84-3-4Q-LIQ-P, *Radioactive Liquid Wastes Discharged to Ground in the 200 Areas During 1984* RHO-HS-SR-85-3-4Q-LIQ-P, *Radioactive Liquid Wastes Discharged to Ground in the 200 Areas During 1985* RHO-HS-SR-86-3-4Q-LIQ-P, *Radioactive Liquid Wastes Discharged to Ground in the 200 Areas During 1986*	WHC-EP-0141, *Westinghouse Hanford Company Effluent Releases and Solid Waste Management Report for 1987: 200/600/1100 Areas* WHC-EP-0141-1, *Westinghouse Hanford Company Effluent Discharges and Solid Waste Management Report for Calendar Year 1988: 200/600 Areas* WHC-EP-0141-2, *Westinghouse Hanford Company Effluent Discharges and Solid Waste Management Report for Calendar Year 1989, 200/600 Area* WHC-EP-0527, *Environmental Releases for Calendar Year 1990* WHC-EP-0527-1, *Environmental Releases for Calendar Year 1991* WHC-EP-0527-2, *Environmental Releases for Calendar Year 1992* WHC-EP-0527-3, *Environmental Releases for Calendar Year 1993* WHC-EP-0527-4, *Environmental Releases for Calendar Year 1994* WHC-EP-0527-5, *Environmental Releases for Calendar Year 1995* WHC-EP-0674, *Groundwater Impact Assessment Report for the 216-Z-20 Crib, 200 West Area* WHC-EP-0707, *216-U-10 Pond and 216-Z-19 Ditch Characterization Studies*

Proposed Activities	In accordance with proposed Alternative 5A, remove, treat, and dispose of low-level waste at the 2126-Z-20 Tile Field portion of the Z-Ditches.

Notes:

H_1 = Hanford formation gravel-dominated facies

H_2 = Hanford formation sand-dominated facies

MDL = minimum detection level

WIDS = Waste Information Data System database

Table E-5. Summary Data Sheet, Data-Needs Summary for UPR-200-W-110 (200-CW-5 Operable Unit)

Background	
Site Identification	UPR-200-W-110
Site Location	This site is east of and parallel to the north end of the 216-Z-19 and 216-Z-11 Ditches in the 200 West Area.
Type of Site	Unplanned release/trench
Site Construction	The trench is 129.5 m (425 ft) long, 30.5 m (100 ft) wide, and 4.6 (15 ft) deep. It has been backfilled within an "Underground Radioactive Material" zone. The area was surface stabilized in 1982. The area is marked with concrete posts and an intermittent light chain.
Operating History	Disposal trench used only once in 1971.
Effluent Volume Discharged	Unknown
Duration	1971 (occurrence date)
Inventory Information	Unknown, but bounded by the inventory information for the 216-Z-1D Ditch.
Vicinity Waste Sites	216-Z-1 Ditch, 216-Z-11 Ditch, and 216-Z-19 Ditch
Characterization Summary	Characterization boreholes were drilled in 1982 to assess the hydrology, geology, and radioactive contaminants at the 216-Z-1, 216-Z-11 and 216-Z-19 Ditches; the 216-Z-20 Tile Field; and the UPR-200-W-110 site. Approximately 200 samples were collected and analyzed for radiological contaminants. At the time of stabilization (1982), the boundaries of the spoil trench were delineated based on sediment conditions encountered during drilling of shallow boreholes, radiological measurements of sediment samples collected during drilling operations, and vegetation growing in and around the spoil trench area. Nine boreholes were drilled at the site to investigate the sediment conditions and to collect sediment samples for radiological analyses. Five boreholes encountered sediments with normal moisture conditions (damp) that were penetrated at a slow to moderate rate (during drilling). Four other boreholes were drier and the penetration rate during drilling was faster. These sediments were judged to be disturbed by human intrusion. During radiological analyses, five boreholes contained detectable contaminated sediments. Positive radionuclide values were not detected from sediments in the remaining four boreholes. Vegetation growing in and around the site was inspected to aid in determining the spoil trench boundaries. At the time of the study (RHO-HS-VS-4), the spoil trench was about 10 years old and was not expected to have a less developed plant community than the surrounding area.
Data	
Field Survey Using X-Ray Spectroscopy (1982)	Sample-to-detector analysis.
299-W18-233	Data indicated Pu-239 at 3 to 5 nCi/g in the spoils deposition area at 3.8 m (12.5 ft) below ground surface.
References/Bibliography	RHO-HS-VS-4, *Earth Science Investigation of the 216-Z-20 Crib; The UN-216-W-20 Soil Trench & the Storm Sewer Pond* RPP-26744, *Hanford Soil Inventory Model, Rev. 1* *Waste Information Data System* database
Proposed Activities	In accordance with proposed Alternative 5A, remove, treat, and dispose of low-level waste at the UPR-200-W-110 portion of the Z-Ditches.

E3 References

BHI-00174, 1995, *U Plant Aggregate Area Management Study Technical Baseline Report*, Rev. 00, Bechtel Hanford, Inc., Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D198038132.

BHI-01294, 1999, *Data Quality Objective Summary Report for the 200-CW-5 U Pond/Z Ditches System Waste Sites*, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 USC 9601, et seq. Available at: http://uscode.house.gov/download/pls/42C103.txt.

CP-12134, 2002, *Borehole Summary Report for Borehole C3808 in the 216-Z-11 Ditch, 200-CW-5, U-Pond/Z-Ditches Cooling Water Operable Unit*, Rev. 0, Fluor Hanford, Inc., Richland, Washington.

DOE G 435.1-1, 1999, *Implementation Guide for Use with DOE M 435.1-1,* U.S. Department of Energy, Washington, D.C. Available at: http://www.directives.doe.gov/cgi-bin/explcgi?4??+%3Cin%3E+series;maxdocs=300;APP=onixdoe;collection=neword,newguide,newmanual,newpolicy,newnotice;UP=current.html;INTERFACE=1WINDOW.

DOE/RL-91-52, 1992, *U Plant Source Aggregate Area Management Study Report*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D196110688.

DOE/RL-98-28, 1999, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D199153696.

DOE/RL-99-66, 2004, *Steam Condensate/Cooling Water Waste Group Operable Units RI/FS Work Plan; Includes: 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 Operable Units*, Rev. 1, Re-issue, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www2.hanford.gov/arpir/?content=findpage&AKey=D5962949.

DOE/RL-2003-11, 2004, *Remedial Investigation for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-SC-1 Steam Condensate Group Operable Units*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2007-02, 2007, *Supplemental Remedial Investigation/Feasibility Study Work Plan for the 200 Areas Central Plateau Operable Units: Volume I: Work Plan and Appendices*, Rev. 0, Vol. I, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www2.hanford.gov/arpir/?content=findpage&AKey=00099914.

H-2-92061, *Tile Field to Replace Z-19 Ditch*, Hanford Site Drawing.

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=91&parent=0.

RHO-HS-SR-81-3, 1982, *Radioactive Liquid Wastes Discharged to Ground in the 200 Areas During 1981*, Rockwell Hanford Operations, Richland, Washington.

RHO-HS-SR-82-3-4Q-LIQ-P, 1983, *Radioactive Liquid Wastes Discharged to Ground in the 200 Areas During 1982*, Rockwell Hanford Operations, Richland, Washington.

RHO-HS-SR-83-3-4Q-LIQ-P, 1984, *Radioactive Liquid Wastes Discharged to Ground in the 200 Areas During 1983*, Rockwell Hanford Operations, Richland, Washington.

RHO-HS-SR-84-3-4Q-LIQ-P, 1985, *Radioactive Liquid Wastes Discharged to Ground in the 200 Areas During 1984*, Rockwell Hanford Operations, Richland, Washington.

RHO-HS-SR-85-3-4Q-LIQ-P, 1986, *Radioactive Liquid Wastes Discharged to Ground in the 200 Areas During 1985*, Rockwell Hanford Operations, Richland, Washington.

RHO-HS-SR-86-3-4Q-LIQ-P, 1987, *Radioactive Liquid Wastes Discharged to Ground in the 200 Areas During 1986*, Rockwell Hanford Operations, Richland, Washington.

RHO-HS-VS-4, unpublished, *Earth Science Investigation of the 216-Z-20 Crib; The UN-216-W-20 Soil Trench & the Storm Sewer Pond*, Rockwell Hanford Operations, Richland, Washington.

RPP-26744, 2005, *Hanford Soil Inventory Model*, *Rev. 1*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

Stoller Log Data Reports. Available at: http://www.hanford.gov/cp/gpp/data/vzcp/vzcp.cfm.

Waste Information Data System Report, Hanford Site database.

WHC-EP-0141, 1988, *Westinghouse Hanford Company Effluent Releases and Solid Waste Management Report for 1987: 200/600/1100 Areas*, Westinghouse Hanford Company, Richland, Washington.

WHC-EP-0141-1, 1989, *Westinghouse Hanford Company Effluent Discharges and Solid Waste Management Report for Calendar Year 1988: 200/600 Areas*, Westinghouse Hanford Company, Richland, Washington.

WHC-EP-0141-2, 1990, *Westinghouse Hanford Company Effluent Discharges and Solid Waste Management Report for Calendar Year 1989, 200/600 Area*, Westinghouse Hanford Company, Richland, Washington.

WHC-EP-0527, 1992, *Environmental Releases for Calendar Year 1990*, Westinghouse Hanford Company, Richland, Washington.

WHC-EP-0527-1, 1992, *Environmental Releases for Calendar Year 1991*, Westinghouse Hanford Company, Richland, Washington.

WHC-EP-0527-2, 1993, *Environmental Releases for Calendar Year 1992*, Westinghouse Hanford Company, Richland, Washington.

WHC-EP-0527-3, 1994, *Environmental Releases for Calendar Year 1993*, Westinghouse Hanford Company, Richland, Washington.

WHC-EP-0527-4, 1995, *Environmental Releases for Calendar Year 1994*, Westinghouse Hanford Company, Richland, Washington.

WHC-EP-0527-5, 1996, *Environmental Releases for Calendar Year 1995*, Westinghouse Hanford Company, Richland, Washington.

WHC-EP-0674, 1993, *Groundwater Impact Assessment Report for the 216-Z-20 Crib, 200 West Area*, Westinghouse Hanford Company, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D196107877.

WHC-EP-0707, 1994, *216-U-10 Pond and 216-Z-19 Ditch Characterization Studies*, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Appendix F

RESRAD Analysis of Native American Exposure Scenarios for the 200-CW-5 Operable Unit

Contents

Figures

Tables

Terms

COPC	contaminant of potential concern
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
CZ	contaminated zone
DOE	U.S. Department of Energy
ELCR	excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
FS	feasibility study
ND	nondispersion
OU	Operable Unit
RESRAD	RESidual RADioactivity
RI	remedial investigation
SZ	saturated zone
UCL	upper confidence limit
WIDS	Waste Information Data System database

F1 Introduction

This appendix provides an analysis of the potential risk to human health from exposure to radioactive contaminants in the 200-CW-5 Operable Unit (OU). This evaluation supplements the human health risk information presented in the 200-CW-5 OU remedial investigation (RI) report (DOE/RL-2003-11) and feasibility study (FS) (DOE/RL-2004-24). Time-dependent excess lifetime cancer risk (ELCR) is calculated for two currently available tribal land-use scenarios using the RESidual RADioactivity (RESRAD) computer code (*RESRAD*, Version 6.5 [ANL, 2009]). The scope of the analysis is limited to the 216-Z-1 D, 216-Z-11, and 216-Z-19 Ditches, collectively referred to as the Z-Ditches. The Z-Ditches are assigned to the 200-CW-5 OU and have been grouped into one contiguous contamination area for purposes of remedial decision making.

The Z-Ditches are located on the Central Plateau within the industrial land-use boundary. Two available Native American exposure scenarios (Confederated Tribes of the Umatilla Indian Reservation [CTUIR] and Yakama Nation) are evaluated to reflect exposure conditions if the land use within the industrial area of the Central Plateau were released for traditional lifeway activities. Two separate waste site configuration cases were analyzed, baseline conditions and the current site configuration case. The baseline conditions case assumes that contamination is uniformly distributed within the top 7 m (23 ft) of soil. The baseline condition case, does not take credit for interim actions that have been taken at the Z Ditches (i.e. the presence of the surface stabilization cover). The current configuration case accounted for the shielding effects of the existing stabilization cover over the Z-Ditches. It is assumed that traditional lifeway activities does not include the drilling a well to use groundwater for domestic or ceremonial purposes.

F2 Exposure Scenario Descriptions

Several local and regional tribes have ancestral ties to the Hanford Reach of the Columbia River. The U.S. Department of Energy (DOE) has requested that each Tribe provide an exposure scenario that reflects their traditional activities. At this time, the CTUIR (Harris, 2008; Harris and Harper, 2004) and Yakama Nation (Ridolfi, 2007) have provided scenarios.

Evaluation of both scenarios is performed using the two site configurations described above (baseline and current site configuration). Each scenario is evaluated assuming that radionuclides residing in soil from the ground surface to the groundwater table are the source of contamination for all exposure pathways.

Both the CTUIR and Yakama Nation exposure scenarios represent an individual exposed to radiological contaminants from direct contact with soil and through the food chain pathway. Exposure estimates are based on an assumed exposure frequency of 365 days/yr over a 70-year exposure duration. The direct contact pathway includes exposure through external radiation, incidental soil ingestion, and inhalation of dust particulates. The food chain pathway includes exposure from ingestion of fruits and vegetables grown in a backyard garden and consumption of beef and poultry that graze on and are penned on a rural pasture. Milk consumption is included in the Yakama Nation scenario (Ridolfi, 2007) but not the CTUIR scenario (Harris, 2008; Harris and Harper, 2004). Both exposure scenarios include exposure assumptions to represent consumption of wild game hunted and foods gathered on the Central Plateau. However, exposure from consumption of wild game is not included in this evaluation because the area of the Z-Ditches (approximately 1,000 m^2 [0.25 acres]) is considered too small to support foraging wild game.

Exposure through the food chain pathway is contributed from uptake of radionuclides that are currently in the soil and includes use of groundwater potentially contaminated by migration of contamination through the vadose zone. It does not consider groundwater that is currently contaminated beneath the 200-CW-5 OU. Drinking water ingestion and irrigation water use are activated in the RESRAD exposure analysis and it is assumed that 100 percent of drinking water, irrigation water, and livestock water is obtained from an on-site well that is suitable for domestic use.

Both the CTUIR and Yakama Nation exposure scenarios also include exposure assumptions for estimating potential exposure from the consumption of fish and sweat lodge use. For purposes of this risk assessment, both exposure pathways are considered incomplete and are not evaluated. The fish consumption exposure pathway is being included by the 100 Area and 300 Area River Corridor Baseline Risk Assessment. The sweat lodge exposure pathway is not included because only contamination associated with the source area is addressed in this risk assessment.

F3 RESRAD Analysis Methodology

Time-dependent ELCR is calculated using the RESRAD computer code (ANL, 2009) implemented in accordance with guidance provided in *User's Manual for RESRAD Version 6* (ANL/EAD-4). Maximum ELCR is computed for both the CTUIR and Yakama Nation exposure scenarios over a 1,000-year simulation period. For comparative purposes, ELCR estimates are discussed relative to the following exposure times.

- 0 year represents current waste-site conditions.
- 50 years is the estimated time that DOE will have an on-site presence.
- 150 years is the estimated time that ICs are assumed to be effective.
- 500 years is the estimated time that passive ICs are assumed to be effective.
- 1,000 years is the estimated period that peak radiation dose and risk estimates should fall within.
- The year in which the upper ELCR regulatory threshold value of 10^{-4} is achieved.

F4 Exposure Scenario Input Values

RESRAD requires a complete set of site- and scenario-specific input parameters for each exposure scenario. Table F-1 summarizes the input parameters corresponding to the CTUIR and Yakama Nation scenarios at the Z-Ditches. This table lists the value used for each input parameter, the rationale for its use, and a reference to the source for the value.

The RESRAD input parameters used to represent the Z-Ditches hydrostratigraphic conceptual model (i.e., physical, meteorological, and hydrological parameters associated with the uncontaminated cover, contaminated zone, unsaturated strata, and saturated zone) are consistent with those used for RESRAD analysis of the hypothetical rural residential scenario at the Z-Ditches, as presented in Appendix D. They are also generally consistent with the parameters used for the RI baseline risk assessment (DOE/RL-2003-11, Section 5.2, Table 5-20), although several parameters (e.g., annual precipitation) have been updated for consistency with more recently published information sources.

F4.1 Cover Erosion Rate

A key departure from the RI baseline risk assessment is the assumption of a cover erosion rate of 0.00001 m/yr for the current configuration case for the tribal scenarios. The cover erosion rate assumed for the RI baseline risk assessment (the RESRAD default of 0.001 m/yr) is considered unrealistically high for a relatively flat, arid site. The value used in the present analysis (0.00001 m/yr) is considered more representative of sites on the Hanford Site Central Plateau than the RESRAD default value (0.001 m/yr) and is consistent with the value used in recent Hanford Site risk assessments.

Table F-1. Z-Ditches Summary of RESRAD Input Parameters for Native American Exposure Scenarios

Description	Parameter	Units	CTUIR Scenario	Yakama Nation Scenario	Rationale and Citation
Exposure Pathways	External gamma: Inhalation: Plant ingestion: Meat ingestion: Milk ingestion: Aquatic foods: Drinking water: Soil ingestion: Radon:	Not applicable	Active Active Active Active Suppressed Suppressed Active Active Suppressed	Active Active Active Active Active Suppressed Active Active Suppressed	
R011-Contaminated Zone (CZ)	Area of CZ	m^2	972	972	Site-specific area from (WIDS)
	Thickness of CZ	m	6	6	Represents actual thickness of contamination based on RI results. This input parameter used for the current configuration case.
			7	7	Assumes contamination is uniformly distributed from zero to 7 m (23 ft) bgs. The contaminated zone represents the sum of contaminated zone thickness (6 m; 20 ft) plus the stabilization cover thickness (1 m; 3ft) based on remedial investigation (RI) results (DOE/RL-2003-11) The contaminated zone thickness is considered a conservative estimate, as WAC 173-340-740 (6) defines the point of compliance as zero to 4.6 m (15 ft). The top 4.6 m (15 ft) represents a reasonable estimate of the depth of soil that could be excavated and distributed at the soil surface because of site development activities. This input parameter is used for the baseline conditions case.
	Length parallel to aquifer flow	m	9	9	Site-specific
	Radiation dose limit (industrial scenario)	mrem/year	15	15	40 CFR 141; EPA 540/R/99/006
	Elapsed time since waste placement	year	0	0	RESRAD default

Table F-1. Z-Ditches Summary of RESRAD Input Parameters for Native American Exposure Scenarios

Description	Parameter	Units	CTUIR Scenario	Yakama Nation Scenario	Rationale and Citation
Exposure Point Concentrations (EPCs)	EPCs	pCi/g	Contaminant-specific	Contaminant-specific	Based on statistical analysis of the RI analytical data set
R013-Cover and CZ Hydrological Data	Cover depth	m	1	1	This input parameter is used for the current site configuration case
			0	0	This parameter is used for the baseline conditions case.
	Cover material density	g/cm^3	1.5	1.5	Site-specific value based on RI results
			NA	NA	Not Applicable
	Cover erosion rate	m/year	0.00001	0.00001	Value selected prevents appreciable erosion of the cover over the simulation period
			NA	NA	Not Applicable
	Density of CZ	g/cm^3	1.8	1.8	Site-specific value based on RI results
	CZ erosion rate	m/year	0.00001	0.00001	Value selected prevents appreciable erosion of the contaminated zone over the simulation period (only relevant if cover depth becomes zero through erosion).
	CZ total porosity	unitless	0.33	0.33	Site-specific value based on physical property samples from RI and WHC-EP-0883
	CZ field capacity	unitless	0.2	0.2	Site-specific value based on physical property samples from RI and WHC-EP-0883
	CZ hydraulic conductivity	m/year	22	22	WHC-SD-EN-SE-004
	CZ b parameter	unitless	4.05	4.05	CCN 070578; ANL/EAD-4 (Table E.2)
	Evapotranspiration coefficient	unitless	0.91	0.91	WDOH/320-015 (Appendix B)

Table F-1. Z-Ditches Summary of RESRAD Input Parameters for Native American Exposure Scenarios

Description	Parameter	Units	CTUIR Scenario	Yakama Nation Scenario	Rationale and Citation
R013-Cover and CZ Hydrological Data	Wind speed	m/s	3.4	3.4	Based on annual average prevailing wind speed of 7.6 mph (3.4 m/s) measured at Hanford Meteorology Station (PNNL-15160, Table 5.1)
	Precipitation	m/year	0.177	0.177	Based on normal annual precipitation of 6.98 in. (0.177 mm) measured at Hanford Meteorology Station (PNNL-15160, Table 4.1)
	Irrigation rate	m/year	0.76	0.76	WDOH/320-015 (Appendix B)
	Irrigation mode	Overhead or Ditch	Overhead	Overhead	RESRAD default
	Runoff coefficient	unitless	0	0	Value selected conservatively assumes all precipitation penetrates into the subsurface
	Watershed area for nearby stream or pond	m^2	1.00E+06	1.00E+06	RESRAD default
	Accuracy for water/soil computations	unitless	0.001	0.001	RESRAD default
R014 – Saturated Zone (SZ) Hydrological Data	Density of SZ	g/cm^3	2.23	2.23	Site-specific value based on RI results and BHI-01177
	SZ total porosity	unitless	0.158	0.158	Site-specific value based on physical property samples from RI and WHC-EP-0883
	SZ effective porosity	unitless	0.158	0.158	Site-specific value based on physical property samples from RI and WHC-EP-0883
	SZ field capacity	unitless	0.04	0.04	Site-specific value based on physical property samples from RI and WHC-EP-0883
	SZ hydraulic conductivity	m/year	5,519	5,519	WHC-SD-EN-SE-004
	SZ hydraulic gradient	unitless	0.0005	0.0005	DOE/ORP-2005-01 (Table 3-14, reference case value for 200 West Area unconfined aquifer)
	SZ b parameter	unitless	4.05	4.05	CCN 070578; ANL/EAD-4 (Table E.2)

Table F-1. Z-Ditches Summary of RESRAD Input Parameters for Native American Exposure Scenarios

Description	Parameter	Units	CTUIR Scenario	Yakama Nation Scenario	Rationale and Citation
R014 – Saturated Zone (SZ) Hydrological Data	Water table drop rate	m/year	0.0001	0.0001	Value selected results in little change in the depth of groundwater over the simulation period
	Well pump intake depth below water table	m	4.6	4.6	WDOH/320-015 (Appendix B)
	Model for water transport	ND or mass-balance	ND	ND	RESRAD default
	Well pumping rate	m^3/year	250	250	RESRAD default
R015 – Uncontaminated and Unsaturated Strata Hydrological Data	Number of unsaturated strata	Not applicable	3	3	Site-specific
	Thickness (layer 1)	m	4	4	Site-specific value based on RI results and current water table elevation data
	Thickness (layer 2)	m	30	30	Site-specific value based on RI results and current water table elevation data
	Thickness (layer 3)	m	23.2	23.2	Site-specific value based on RI results and current water table elevation data
	Soil density (layer 1)	g/cm^3	1.98	1.98	Hanford formation gravel-dominated sequence
	Soil density (layer 2)	g/cm^3	1.5	1.5	Hanford formation sand-dominated sequence and Cold Creek unit
	Soil density (layer 3)	g/cm^3	2.23	2.23	Ringold Unit E silty sandy gravel
	Total porosity/ effective porosity (layer 1)	unitless	0.253	0.253	Site-specific value based on RI results and BHI-01177
	Total porosity/ effective porosity (layer 2)	unitless	0.435	0.435	Site-specific value based on physical property samples from RI and WHC-EP-0883
	Total porosity/ effective porosity (layer 3)	unitless	0.158	0.158	Site-specific value based on physical property samples from RI and WHC-EP-0883
	Field capacity (layer 1)	unitless	0.04	0.04	Site-specific value based on physical property samples from RI and WHC-EP-0883

Table F-1. Z-Ditches Summary of RESRAD Input Parameters for Native American Exposure Scenarios

Description	Parameter	Units	CTUIR Scenario	Yakama Nation Scenario	Rationale and Citation
R015 – Uncontaminated and Unsaturated Strata Hydrological Data	Field capacity (layer 2)	unitless	0.04	0.04	Site-specific value based on physical property samples from RI and WHC-EP-0883
	Field Capacity (layer 3)	unitless	0.04	0.04	Site-specific value based on physical property samples from RI and WHC-EP-0883
	Hydraulic conductivity (layer 1)	m/year	757	757	WHC-SD-EN-SE-004
	Hydraulic conductivity (layer 2)	m/year	138	138	WHC-SD-EN-SE-004
	Hydraulic conductivity (layer 3)	m/year	552	552	WHC-SD-EN-SE-004
	Soil-specific b parameter (layer 1)	unitless	4.05	4.05	CCN 070578; ANL/EAD-4 (Table E.2)
	Soil-specific b parameter (layer 2)	unitless	4.05	4.05	CCN 070578; ANL/EAD-4 (Table E.2)
	Soil-specific b parameter (layer 3)	unitless	4.05	4.05	CCN 070578; ANL/EAD-4 (Table E.2)
R016 - Distribution Coefficients and Leach Rates for Individual Radionuclides	Distribution coefficients (Kd) for contaminated zone, uncontaminated zone, and saturated zone	cm^3/g	Contaminant-specific	Contaminant-specific	Best-estimate values from PNNL-14702 and PNNL-11800
	Saturated leach rate	yr^{-1}	0	0	RESRAD default
	Saturated solubility	mol/L	0	0	RESRAD default

Table F-1. Z-Ditches Summary of RESRAD Input Parameters for Native American Exposure Scenarios

Description	Parameter	Units	CTUIR Scenario	Yakama Nation Scenario	Rationale and Citation
R017 - Inhalation and External Gamma	Inhalation rate	m^3/year	9,125	9,490	CTUIR scenario assumes a rate of 25 m^3/day (365 days/yr) (Harris, 2008). Yakama Nation scenario assumes a rate of 26 m^3/day (365 days/yr) (Ridolfi, 2007).
	Mass loading for inhalation	g/m^3	0.0001	0.0001	WDOH/320-015 (Appendix B)
	Exposure duration	year	70	70	EPA (1991), Harris (2008), Harper and Harris (2004), and Ridolfi (2007)
	Indoor dust filtration factor	unitless	0.4	0.4	RESRAD default
	External gamma shielding factor	unitless	0.4	0.4	EPA/540-R-00-007 (2000, Equation 4)
	Indoor time fraction	unitless	0.5	0.5	Fraction of the year spent onsite indoors. Both CTUIR and Yakama Nation scenarios assume 12 hr/day indoors, 365 days/yr (4,380 hr/8,760 hr).
	Outdoor time fraction	unitless	0.25	0.25	Fraction of the year spent onsite outdoors. Both CTUIR and Yakama Nation scenarios assume 6 hr/day outdoors, 365 days/yr (2,190 hr/8,760 hr).
	Shape factor	Not applicable	Circular	Circular	RESRAD default
R018 – Ingestion Pathway Data, Dietary Parameters	Leafy vegetable consumption	kg/yr	100	100	For the CTUIR scenario, Harris (2008, Figure 1) provides a value of 613 g/day (224 kg/yr) summed across categories of bulbs, other vegetation, greens, tea, medicines, spices, roots, and tubers. For the Yakama Nation scenario, Ridolfi (2007, Table 7) provides a value of 1,118 g/day (408 kg/yr) summed across categories of wild roots, stalks/leaves, and vegetables. A maximum value of 100 kg/yr can be input into the RESRAD code; the remaining portion (124 or 308 kg/yr, respectively) is assigned to “fruit, vegetable, and grain consumption.”

Table F-1. Z-Ditches Summary of RESRAD Input Parameters for Native American Exposure Scenarios

Description	Parameter	Units	CTUIR Scenario	Yakama Nation Scenario	Rationale and Citation
R018 – Ingestion Pathway Data, Dietary Parameters	Fruit, vegetable, and grain consumption	kg/yr	184	417	For the CTUIR scenario, Harris (2008, Figure 1) provides a value of 164 g/day (60 kg/yr) summed across categories of berries, fruits, honey, sweeteners, seeds, nuts, and grain. It also includes 124 kg/yr from "leafy vegetable consumption." For the Yakama Nation scenario, Ridolfi (2007, Table 7) provides a value of 299 g/day (109 kg/yr) summed across categories of fruits and wild berries. This also includes 308 kg/yr from "leafy vegetable consumption."
	Milk consumption	L/yr	Not applicable	438	No value for CTUIR scenario given in Harris (2008) or Harper and Harris (2004). For Yakama Nation scenario, Ridolfi (2007, Table 7) provides rate of 1.2 L/day (365 day/yr).
	Meat and poultry consumption	kg/yr	68.3	154	CTUIR scenario assumes game, fowl, and egg consumption (187 g/day) is from penned livestock rather than game. Yakama Nation scenario assumes 60 percent of combined rate for game and meat (704 g/day) is from penned livestock.
	Fish consumption	kg/yr	Not applicable	Not applicable	The consumption of fish is considered an incomplete exposure pathway for waste site operable units within the Central Plateau.
	Other seafood consumption	kg/yr	Not applicable	Not applicable	The consumption of seafood is considered an incomplete exposure pathway for waste site operable units within the Central Plateau.
	Soil ingestion intake	g/yr	146	73	CTUIR scenario is based on 400 mg/day (365 days/yr) (Harris, 2008; Harris and Harper, 2004). Yakama Nation scenario is based on 200 mg/day (365 days/yr) (Ridolfi, 2007).
	Drinking water intake	L/yr	1,460	1,460	Both CTUIR and Yakama Nation scenarios are based on 4 L/day (365 days/yr) (Harris, 2008; Harris and Harper, 2004; Ridolfi, 2007).

Table F-1. Z-Ditches Summary of RESRAD Input Parameters for Native American Exposure Scenarios

Description	Parameter	Units	CTUIR Scenario	Yakama Nation Scenario	Rationale and Citation
R018 – Ingestion Pathway Data, Dietary Parameters	Drinking water contamination fraction	unitless	1	1	RESRAD default
	Household water contamination fraction	unitless	Not applicable	Not applicable	Used in RESRAD only for computation of radon exposure
	Livestock water contamination fraction	unitless	1	1	RESRAD default
	Irrigation water contamination fraction	unitless	1	1	RESRAD default
	Aquatic food contamination fraction	unitless	Not applicable	Not applicable	Consumption of aquatic food is considered an incomplete exposure pathway.
	Plant food contamination fraction	unitless	-1	-1	RESRAD default
	Meat contamination fraction	unitless	-1	-1	RESRAD default
	Milk contamination fraction	unitless	-1	-1	RESRAD default
R019 – Ingestion Pathway Data, Nondietary	Livestock fodder intake for meat	kg/d	68	68	RESRAD default
	Livestock fodder intake for milk	kg/d	Not Applicable	55	RESRAD default
	Livestock water intake for meat	L/d	50	50	RESRAD default
	Livestock water intake for milk	L/d	Not Applicable	160	RESRAD default
	Livestock intake of soil	kg/d	0.5	0.5	RESRAD default
	Mass loading for foliar deposition	g/m^3	0.0001	0.0001	RESRAD default

Table F-1. Z-Ditches Summary of RESRAD Input Parameters for Native American Exposure Scenarios

Description	Parameter	Units	CTUIR Scenario	Yakama Nation Scenario	Rationale and Citation
R019 – Ingestion Pathway Data, Nondietary	Depth of soil mixing layer	m	0.15	0.15	RESRAD default
	Depth of roots	m	0.9	0.9	RESRAD default
R020 – Groundwater Usage	Groundwater fractional usage – drinking water	unitless	1	1	RESRAD default
	Groundwater fractional usage – household usage	unitless	Not applicable	Not applicable	Used in RESRAD only for computation of radon exposure
	Groundwater fractional usage – livestock water	unitless	1	1	RESRAD default
	Groundwater fractional usage –irrigation	unitless	1	1	RESRAD default
	Groundwater fractional usage –irrigation	unitless	1	1	RESRAD default

Notes:

40 CFR 141, “National Primary Drinking Water Regulations.”

ANL/EAD-4, *User’s Manual for RESRAD Version 6*.

ANL, 2009, *RESRAD*, Version 6.5.

BHI-01177, *Borehole Summary Report for the 216-B-2-2 Ditch*.

CCN 070578, “Estimation of the Soil-Specific Exponential Parameter(b).”

DOE/ORP-2005-01, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site*.

DOE/RL-2003-11, *Remedial Investigation for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-SC-1 Steam Condensate Group Operable Units*.

EPA, 1991, *Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual* Supplemental Guidance *“Standard Default Exposure Factors” Interim Final.*

EPA/540-R-00-007, *Soil Screening Guidance for Radionuclides: User’s Guide*.

EPA 540/R/99/006, *Radiation Risk Assessment At CERCLA Sites: Q & A*.

Harris, 2008, *Application of the CTUIR Traditional Lifeways Exposure Scenario in Hanford Risk Assessments*.

Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways*.

Table F-1. Z-Ditches Summary of RESRAD Input Parameters for Native American Exposure Scenarios

Description	Parameter	Units	CTUIR Scenario	Yakama Nation Scenario	Rationale and Citation

PNNL-11800, *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*.

PNNL-14702, *Vadose Zone Hydrology Data Package for Hanford Assessments.*

PNNL-15160, *Hanford Site Climatological Summary 2004 with Historical Data.*

Ridolfi, 2007, "Yakama Nation Exposure Scenario for Hanford Site Risk Assessment."

WDOH/320-015, *Hanford Guidance for Radiological Cleanup*.

WHC-EP-0883, *Variability and Scaling of Hydraulic Properties for 200 Area Soils, Hanford Site*.

WHC-SD-EN-SE-004, *Site Characterization Report: Results of Detailed Evaluation of the Suitability of the Site Proposed for Disposal of 200 Areas Treated Effluent*.

F4.2 Contaminated Zone

Available characterization data for the Z-Ditches (DOE/RL-2003-11, Section 3.2.1) indicate the highest concentrations of radionuclide contamination occur within the interval from 1.5 to 5.3 m (4.9 to 17 ft) below ground surface (bgs). Contaminant concentrations decrease with depth and are generally less than 1 pCi/g at depths of more than 6 m (20 ft) bgs. Two Z Ditches configurations were evaluated for the feasibility study. The first configuration is called the baseline configuration. This case represents baseline conditions and assumes that the contamination that resides in the interval from 1.5 to 5.3 m (4.9 to 17 ft) bgs is uniformly distributed within the top 7 m (23 ft). For the baseline configuration, an input value of zero (0) was used for cover depth and the input value for the contamination zone is 7 m (23 ft) based the distribution of contamination within the soil column (assumes stabilization cover is included as part of the soil column).

The second configuration is called the current configuration. This case represents the waste site as it currently exists. The Z Ditches is currently maintained with 1 m (3 ft) of stabilization cover, therefore an input value of 1 m (3 ft) is assigned to the RESRAD cover thickness parameter and contaminants are assumed to be uniformly distributed over the depth interval from 1 to 7 m [3 to 23 ft] bgs at their assigned exposure point concentrations (EPCs). For the current configuration case, an input value of 6 m (20 ft) is assigned to the RESRAD contaminated zone thickness parameter.

F4.3 Exposure Point Concentrations

The contaminants of potential concern (COPCs) for this analysis are consistent with the Z-Ditches radionuclide COPCs identified in the RI baseline risk assessment (DOE/RL-2003-11, Section 5.2.2). RESRAD requires an EPC for each COPC. For the RI baseline risk assessment, EPCs were developed in accordance with EPA guidance in effect at that time (EPA, 1992) based on analytical data from soil samples collected within the Z-Ditches. EPCs were calculated as the 95 percent upper confidence limit (UCL) on the mean soil concentration except for radionuclides where the calculated 95 percent UCL was greater than the maximum detected concentration. In those cases, the maximum concentration was used in place of the 95 percent UCL. The EPC statistical calculation procedure used for the RI baseline risk assessment is described in Appendix E of the RI report (DOE/RL-2003-11).

Subsequent to the RI report, EPA modified its guidance on calculating EPCs for environmental data sets (EPA 2002). In an effort to understand the uncertainties associated with the Z-Ditches plutonium isotope data set, the RI data set has been re-evaluated using EPA's revised methodology for calculating EPCs. Results of this supplemental plutonium evaluation are presented in *Z-Ditches Study for the 200-CW-5 Cooling Water Operable Unit* (SGW-37174). The evaluation was performed using EPA's ProUCL 4.0 analysis tool (EPA/600/R-07/038). ProUCL 4.0 contains statistical methods to address data sets both with and without nondetects. The Z-Ditches data set has nondetects. Laboratory analytical results for the plutonium isotopes (Pu-238, Pu-239, Pu-239/240) were combined in the SGW-37174 evaluation to provide an aggregate total plutonium EPC. The evaluation included a statistical test to determine the presence of outliers associated with the plutonium isotope data set. Results of the outlier test indicated the presence of two potential Pu-239/240 statistical outliers, with concentrations of 1.3×10^7 pCi/g and 7.5×10^5 pCi/g, located at the inlet to the 216-U-10 Pond and near the northern headwall of the Z-Ditches, respectively. Removal of these two data set outliers from the EPC calculation yielded an aggregate plutonium EPC of 17,451 pCi/g. By comparison, the Pu-239 EPC used for the RI risk assessment was 4,460,000 pCi/g (DOE/RL-2003-11, Table 5-4).

Additional ProUCL 4.0 analysis was performed for the present analysis to apply EPA's revised EPC calculation methodology to all radionuclide COPCs identified at the Z-Ditches. Table F-2 presents the results of the evaluation. For this evaluation, the plutonium isotopes are analyzed individually in ProUCL rather than in aggregate to support the calculation of isotope-specific risk contributions.

Table F-2. Z-Ditches Summary of Statistics and Exposure Point Concentrations

Constituent	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result (pCi/g)	Maximum Nondetected Result (pCi/g)	Minimum Detected Result (pCi/g)	Maximum Detected Result (pCi/g)	Average Concentration (pCi/g)	EPC (pCi/g)	EPC Basis
Americium-241	286	284	99%	0.19	15	0.014	7.87E+06	30,656	202,640	97.5% KM (Chebyshev) UCL
Cesium-137	187	184	98%	0.04	0.04	0.0021	66,041	371	2,571	97.5% KM (Chebyshev) UCL
Plutonium-238	62	54	87%	0.034	0.46	0.015	5,500	402	1,302	97.5% KM (Chebyshev) UCL
Plutonium-239 + Plutonium-239/240	281	279	99%	0.46	0.53	0.001	7.80E+05	8,257	28,291	97.5% KM (Chebyshev) UCL
Radium-226	12	12	100%	--	--	0.40	5,200	851	5,200	Max Detect
Radium-228	4	2	50%	0.37	0.37	0.69	0.81	0.47	0.81	Max Detect
Strontium-90	30	23	77%	2.5	9.6	0.28	216	19	95.18	99% KM (Chebyshev) UCL
Thorium-228	4	1	25%	0.47	1.8	0.66	0.66	0.58	0.66	Detected Result
Thorium-230	4	3	75%	1.1	1.1	0.50	8.4	4.0	8.4	Max Detect
Thorium-232	4	1	25%	0.7	1.7	0.71	0.71	0.57	0.71	Detected Result
Uranium-233/234	4	1	25%	0.68	2.5	0.36	0.36	0.75	0.36	Detected Result
Uranium-238	4	2	50%	1.1	1.2	0.44	0.77	0.59	0.77	Max Detect

EPA/600/R-07/038, *ProUCL Version 4.0 User Guide*.

-- = not applicable

KM (Chebyshev) = UCL based on Kaplan-Meier estimates using Chebyshev inequality. Computed with ProUCL Version 4.0 (EPA/600/R-07/038)

Laboratory analytical results reported as undifferentiated Pu-239/240 are treated as entirely Pu-239 and combined with the Pu-239 analytical results. This assumption is considered reasonable because in most cases Pu-239 is the dominant isotope. For purposes of this analysis, the two Pu-239/240 data set outliers are removed from the EPC calculation. Laboratory analytical results reported as undifferentiated U-233/234 are treated as entirely U-234 because in most cases U-234 is the dominant isotope.

Table F-2 identifies the basis for the EPC value assigned to each COPC included in the analysis. The first preference was to assign the recommended UCL value as reported in the ProUCL output. For radionuclides where the recommended UCL was greater than the maximum detected concentration, or where the number of detections was too small to allow calculation of a valid UCL, the maximum detected concentration was used in place of the calculated UCL. Comparison of the Table F-2 values with the values reported in the RI risk assessment (DOE/RL-2003-11, Table 5-4) results in the following differences:

- A reduction in the Pu-239 EPC from 4,460,000 pCi/g to 28,291 pCi/g
- An increase in the Am-241 EPC from 76,152 pCi/g to 202,640 pCi/g
- An increase in the Cs-137 EPC from 951 pCi/g to 2,571 pCi/g
- No change in the Ra-226 EPC (5,200 pCi/g)

F4.4 Distribution Coefficients

In addition to EPCs, RESRAD requires a distribution coefficient (K_d) for each COPC and daughter product. Table F-3 lists the K_d values assigned for this analysis. Radionuclides shown as daughter products are automatically included by the RESRAD code (with initial EPCs of zero pCi/g) when the parent radionuclide (COPC) is selected. K_d values for the RI risk assessment (DOE/RL-2003-11, Table 5-20) were taken from PNNL-11800. K_d values for the present analysis are taken preferentially from a more recent data source (PNNL-14702) and then from PNNL-11800 for isotopes not addressed in PNNL-14702.

Table F-3. Radionuclide-Specific Distribution Coefficients (K_d)

Radionuclide	K_d (cm^3/g)	Reference
Americium-241	300	PNNL-11800
Cesium-137	2000	PNNL-14702
Plutonium-238	600	PNNL-14702
Plutonium-239	600	PNNL-14702
Radium-226	20	PNNL-11800
Radium-228	20	PNNL-11800
Strontium-90	22	PNNL-14702
Thorium-228	1000	PNNL-11800
Thorium-230	1000	PNNL-11800
Thorium-232	1000	PNNL-11800
Uranium-234	0.8	PNNL-14702

Table F-3. Radionuclide-Specific Distribution Coefficients (K_d)

Radionuclide	K_d (cm^3/g)	Reference
Uranium-238	0.8	PNNL-14702
Daughter Radionuclides		
Actinium-227	300	PNNL-11800
Lead-210	6000	PNNL-11800
Neptunium-237	10	PNNL-14702
Protactinium-231	15	PNNL-11800
Thorium-229	1000	PNNL-11800
Uranium-233	0.8	PNNL-14702
Uranium-234	0.8	PNNL-14702
Uranium-235	0.8	PNNL-14702

PNNL-11800, *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*.
PNNL-14702, *Vadose Zone Hydrology Data Package for Hanford Assessments*.

K_d values for cesium, plutonium, strontium, neptunium, and uranium are best estimate values for sand dominated sediment from PNNL-14702 (Table 4.11, Waste Chemistry/Source Category 4: Low Organic/Low Salt/Near Neutral, Intermediate Impact - Sand). The values for these isotopes do not differ significantly from the PNNL-11800 values used for the RI risk assessment. PNNL-14702 does not provide K_d values for americium, actinium, lead, protactinium, radium, and thorium. Consistent with the RI risk assessment, K_d values assigned to these isotopes are best estimate values from PNNL-11800 (Table E.10, Source-Zone Category F, Low Organic/Low Salts/Near Neutral).

The Waste Chemistry/Source Category 4 values from PNNL-14702 and Source-Zone Category F values from PNNL-11800 were selected because these categories best represent the type of waste that was disposed of to the Z-Ditches. For consistency with the RI risk assessment, the K_d values shown in Table F-3 are assigned to all RESRAD layers (contaminated zone, uncontaminated zone, and saturated zone). No gravel correction is applied for this analysis.

F5 Risk Analysis Results

The following sections describe the risk analysis results for the CTUIR and Yakama Nation Exposure Scenarios.

F5.1 CTUIR Exposure Scenario

The following sections describe the baseline and current site configuration cases for the CTUIR Exposure Scenario.

F5.1.1 Baseline Configuration Case

For the CTUIR exposure scenario baseline configuration case, Tables F-4 and F-5 and Figures F-1 and F-2 provide the RESRAD analysis results. Table F-4 provides a summary of the results while Table F-5 provides a detailed breakdown of radionuclide- and pathway-specific ELCR contributions. Figure F-1 displays time-dependent changes in ELCR values for the primary contributing radionuclides, while Figure F-2 displays time-dependent changes in the ELCR value for the primary contributing pathway.

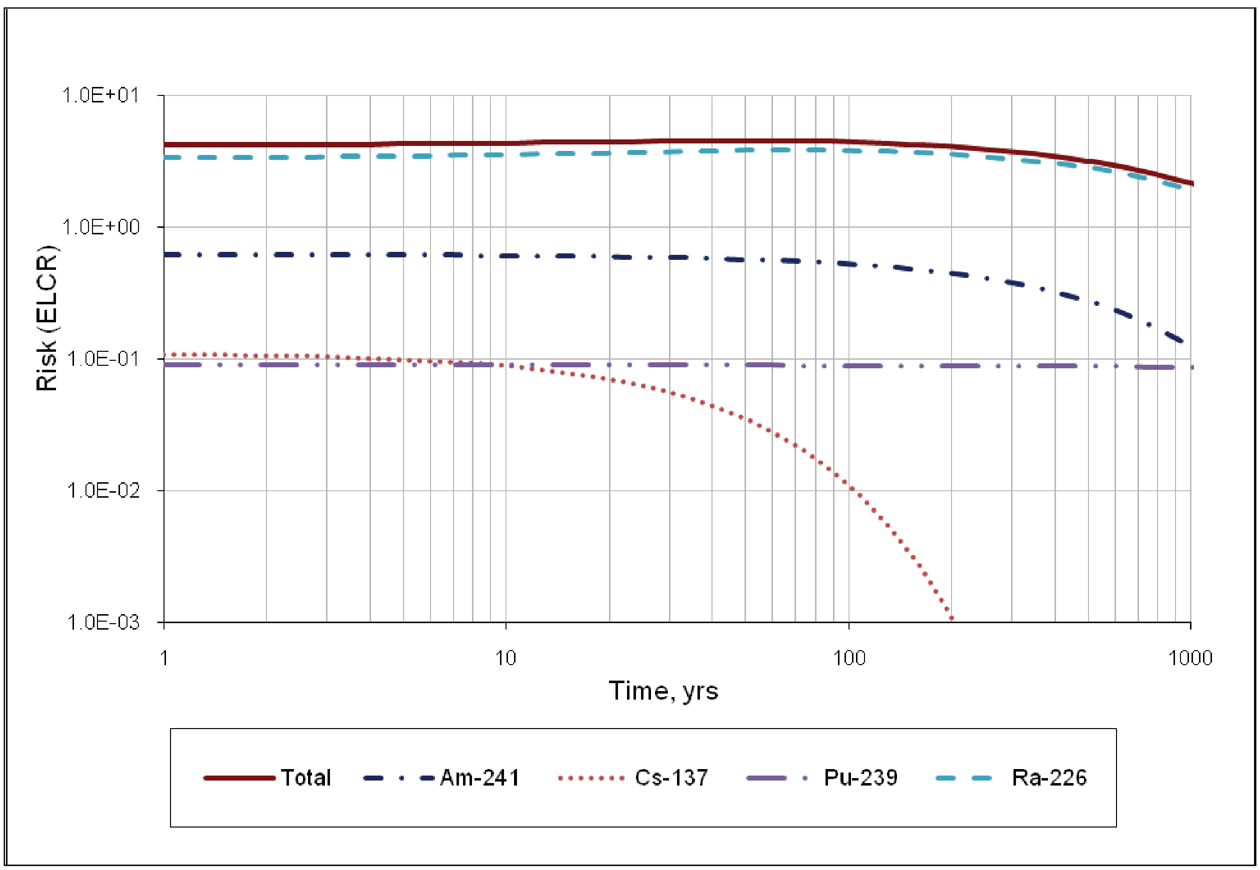
Table F-4. Maximum Radiological Risk for the CTUIR Exposure Scenario at the Z-Ditches

Configuration	Maximum Risk*	
	ELCR	Time (years)
Current Site Configuration	1.43E-05	0
Baseline Configuration	Greater than 1.00E-02	50

Notes:

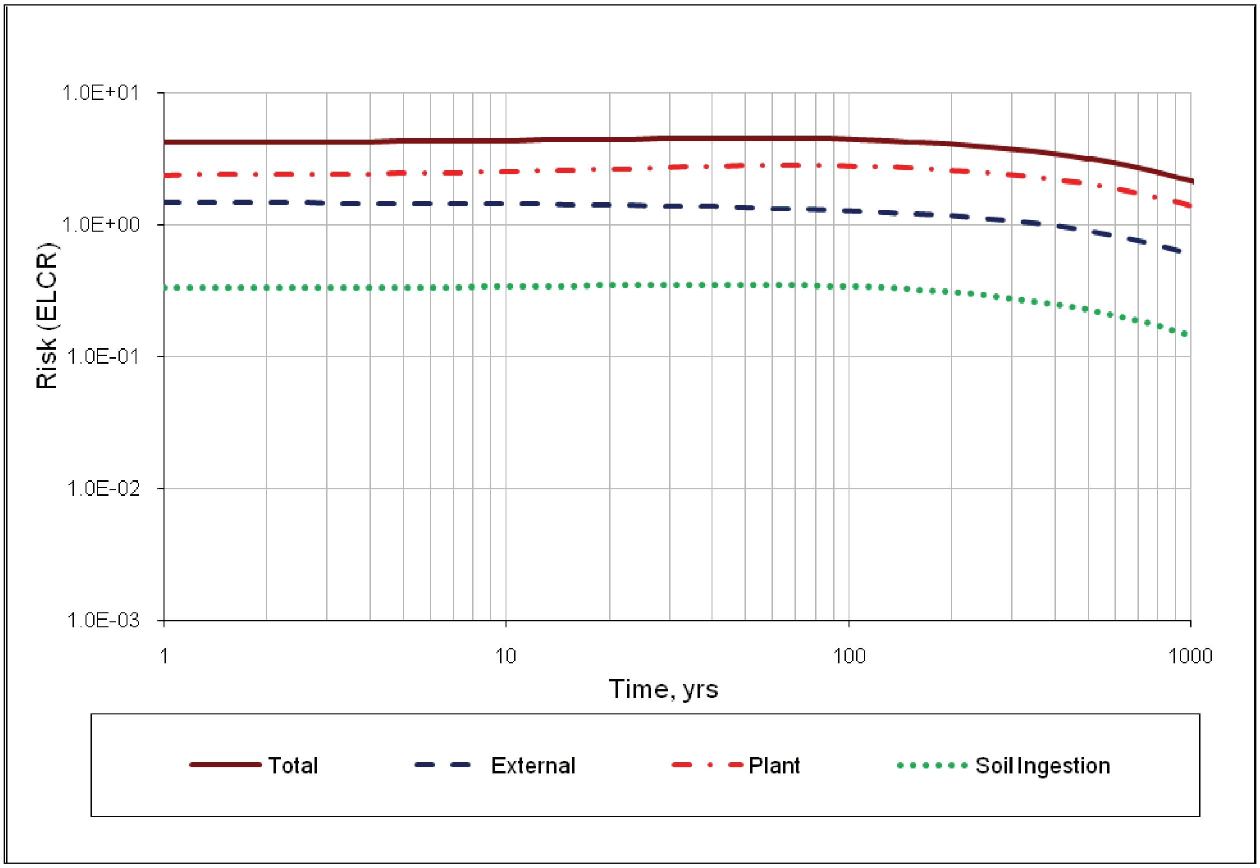
* Calculated with RESRAD over a 1,000-year simulation period.

ANL, 2009, *RESRAD*, Version 6.5.



Note: For risks greater than 1.00E-02, the total ELCR is reported as “Greater than 1 x 10-2” Radiological risks are calculated using RESRAD and will report risks that are greater than one, which is not possible. Because RESRAD assumes risks are linear beyond 1E-02, this assumption is inconsistent with EPA guidance, risk results greater than 1E-02 were truncated to “greater than 10-2”.

Figure F-1. Excess Lifetime Cancer Risk for the CTUIR Exposure Scenario at the Z-Ditches–Risk Contributions Over Time for Dominant Radionuclides (Baseline Configuration)



Note: For risks greater than 1.00E-02, the total ELCR is reported as "Greater than 1 x 10^{-2}". Radiological risks are calculated using RESRAD and will report risks that are greater than one, which is not possible. Because RESRAD assumes risks are linear beyond 1E-02, this assumption is inconsistent with EPA guidance, risk results greater than 1E-02 were truncated to "greater than 10-2".

Figure F-2. Excess Lifetime Cancer Risk for the CTUIR Exposure Scenario at the Z-Ditches– Risk Contributions Over Time for Dominant Exposure Pathways (Baseline Configuration)

Table F-5. Primary Radionuclide and Exposure Pathway Contributions to Risk for the CTUIR Exposure Scenario at the Z-Ditches (Baseline Configuration)

Total ELCR	Time (Years)	Primary Radionuclides	Total ELCR	Pathway
Greater than 1 x 10^{-2}	0	Ra-226	29%	External
		Am-241	4%	
		Cs-137	2%	
		Ra-226	48%	Plant
		Am-241	6%	
		Pu-239	1%	
		Ra-226	2%	Soil Ingestion
		Am-241	5%	

Table F-5. Primary Radionuclide and Exposure Pathway Contributions to Risk for the CTUIR Exposure Scenario at the Z-Ditches (Baseline Configuration)

Total ELCR	Time (Years)	Primary Radionuclides	Total ELCR	Pathway
Greater than 1 x 10^{-2}	50	Ra-226	26%	External
		Am-241	3%	
		Ra-226	55%	Plant
		Am-241	5%	
		Pu-239	1%	
		Ra-226	3%	Soil Ingestion
		Am-241	4%	
Greater than1 x 10^{-2}	150	Ra-226	26%	External
		Am-241	3%	
		Ra-226	58%	Plant
		Am-241	5%	
		Pu-239	1%	
		Ra-226	3%	Soil Ingestion
		Am-241	4%	
Greater than 1 x 10^{-2}	500	Ra-226	26%	External
		Am-241	2%	
		Ra-226	59%	Plant
		Am-241	3%	
		Pu-239	1%	
		Ra-226	3%	Soil Ingestion
		Am-241	3%	
		Pu-239	1%	
Greater than 1 x 10^{-2}	1,000	Ra-226	27%	External
		Am-241	1%	
		Ra-226	60%	Plant
		Am-241	2%	
		Pu-239	2%	
		Ra-226	3%	Soil Ingestion
		Am-241	2%	
		Pu-239	2%	

Notes:

Calculated with RESRAD over a 1,000-year simulation period. For risks greater than 1.00E-02, the total ELCR is reported as “Greater than 1 x 10^{-2}”. Radiological risks are calculated using RESRAD and will report risks that are greater than one, which is not possible. Because RESRAD assumes risks are linear beyond 1E-02, this assumption is inconsistent with EPA guidance, risk results greater than 1E-02 were truncated to “greater than 10-2”.

ANL, 2009, *RESAD*, Version 6.5.

The RESRAD calculations indicate that contributions from four radionuclides (Ra-226, Am-241, Pu-239, and Cs-137) account for over 99 percent of the total ELCR over the 1,000-year simulation period. Contributions from other radionuclide COPCs (Pu-238, Ra-228, Sr-90, Th-228, Th-230, Th-232, U-234, and U-238) do not exceed 1 percent of the total ELCR. Radium-226 is the primary contributor to the total ELCR over the duration of the assessment. Cesium-137, with a half-life of 30 years, makes a significant contribution only early in the assessment. From 50 to 1,000 year, the total ELCR is driven by Ra-226 with secondary contributions from Am-241 and Pu-239. The total ELCR is dominated by pathway contributions from external radiation exposure, plant consumption, and soil ingestion. Pathway contributions from dust inhalation and meat and milk consumption do not exceed 1 percent of the total ELCR.

For the CTUIR exposure scenario baseline configuration case, the maximum ELCR occurs at 50 years from the present time at values greater than 1 x 10^{-2}. The primary contributors to the maximum ELCR are Ra-226 from external radiation exposure (26 percent), plant consumption (55 percent), and soil ingestion (3 percent); Am-241 from external radiation consumption (3 percent), plant consumption (5 percent), and soil ingestion consumption (4 percent); Pu-239 for plant consumption (1 percent). Another primary contributor to risk at 50 years is from ingrowth of lead-210, a radiological decay product of radium-226. The lead-210 exposure contributions arise primarily through the plant ingestion pathway. The contributions reported in Table F-5 from plant ingestion represent the sum of contributions from parent radium-226 and daughter lead-210.

At the end of the assessment period, the total ELCR is greater than 1 x 10^{-2}. After 1,000 years, the primary contributors to the total ELCR are Ra-226 from external radiation exposure (27 percent), plant consumption (60 percent), and soil ingestion (3 percent for the CTUIR exposure scenario); Am-241 from external radiation exposure (1 percent), plant consumption (2 percent), and soil consumption (2 percent); and Pu-239 from plant consumption (2 percent), and soil ingestion (2 percent).

Based on RESRAD calculations, the total ELCR for the CTUIR exposure scenario baseline configuration case is projected to remain above EPA's target risk threshold of 1 x 10^{-4} for at least 100,000 years (RESRAD's maximum calculation time). The ELCR for Am-241, which has a half-life of 432 years, is projected to remain above the 1 x 10^{-4} threshold for approximately 18,000 years. The ELCR contribution from Ra-226, which has a half-life of 1,600 years, is projected to remain above the 1 x 10^{-4} risk threshold for approximately 14,000 years. In addition, the ELCR contribution for Pu-239, which has a half-life of 24,065 years, is projected to remain above the 1 x 10^{-4} risk threshold for at least 100,000.

Analysis results indicate that over the 1,000-year simulation period there are no exposure contributions from water-dependent pathways (i.e., use of groundwater for drinking water, crop irrigation, and livestock water). The RESRAD calculations indicate that leaching would not cause radionuclides in the soil beneath the Z-ditches to reach the water table during the 1,000-year simulation period.

F5.1.2 Current Site Configuration Case

Table F-4 summarizes the maximum ELCR results for the CTUIR exposure scenario current site configuration case. The maximum ELCR for the CTUIR exposure scenario occurs at the beginning of the simulation period (time zero) at a value slightly greater than 1×10^{-5}. Figure F-3 shows time-dependent changes in ELCR over the 1,000-year simulation period. Table F-6 shows the primary radionuclide and exposure pathway contributions to ELCR.

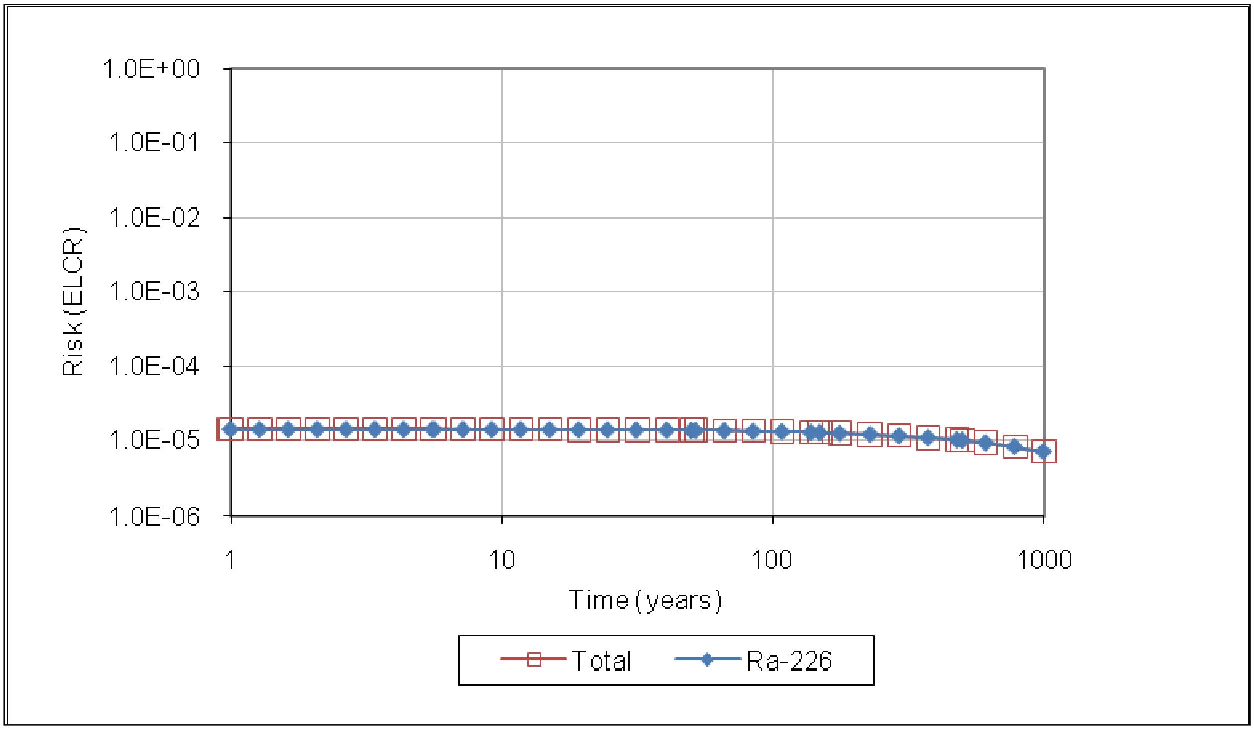


Figure F-3. RESRAD Analysis for the CTUIR Exposure Scenario at the Z-Ditches - Excess Lifetime Cancer Risk Over Time (Current Site Configuration)

Table F-6. Primary Radionuclide and Exposure Pathway Contributions to Risk for the CTUIR Exposure Scenario at the Z-Ditches (Current Site Configuration)

Total Excess Lifetime Cancer Risk	Time (Years)	Primary Radionuclide	Percentage of Total Risk	Pathway
1.43E-05	0	Ra-226	99.5%	External
1.37E-05	50	Ra-226	99.8%	External
1.28E-05	150	Ra-226	99.9%	External
9.98E-06	500	Ra-226	99.8%	External
7.01E-06	1,000	Ra-226	99.7%	External

Note: Calculated with RESRAD over a 1,000-year simulation period.
ANL, 2009, *RESAD*, Version 6.5.

Analysis results for the CTUIR exposure scenario current configuration case indicate that the ELCR originates solely from the external gamma radiation exposure route. Radium-226 contributes over 99 percent of the total ELCR at each of the evaluated exposure intervals (0, 50, 150, 500, and 1,000 years from the present). These results indicate that the presence of the clean soil cover shields the ground surface from some but not all of the gamma radiation emitted from the contaminated soil below. With the cover in place, the ingestion and inhalation exposure routes are incomplete and are not contributors to the overall ELCR. Likewise, the food chain pathway is incomplete and does not contribute to the overall ELCR because the cover thickness is greater than the assumed plant rooting depth (RESRAD default of 0.9 m [3 ft]).

Analysis results indicate that over the 1,000-year simulation period there are no exposure contributions from water-dependent pathways (i.e., use of groundwater for drinking water, crop irrigation, and livestock water). This indicates that that radionuclide contamination currently in the soil beneath the Z-Ditches would not reach groundwater during the 1,000-year simulation.

F5.2 Yakama Nation Exposure Scenario

The following sections describe the baseline and current configuration cases for the Yakama Nation Exposure Scenario.

F5.2.1 Baseline Configuration Case

For the Yakama Nation exposure scenario baseline configuration case, Tables F-7 and F-8 and Figures F-4 and F-5 provide the RESRAD analysis results. Table F-7 provides a summary of the results while Table F-8 provides a detailed breakdown of radionuclide- and pathway-specific ELCR contributions. Figure F-4 displays time-dependent changes in ELCR values for the primary contributing radionuclides, while Figure F-5 displays time-dependent changes in the ELCR value for the primary contributing pathway.

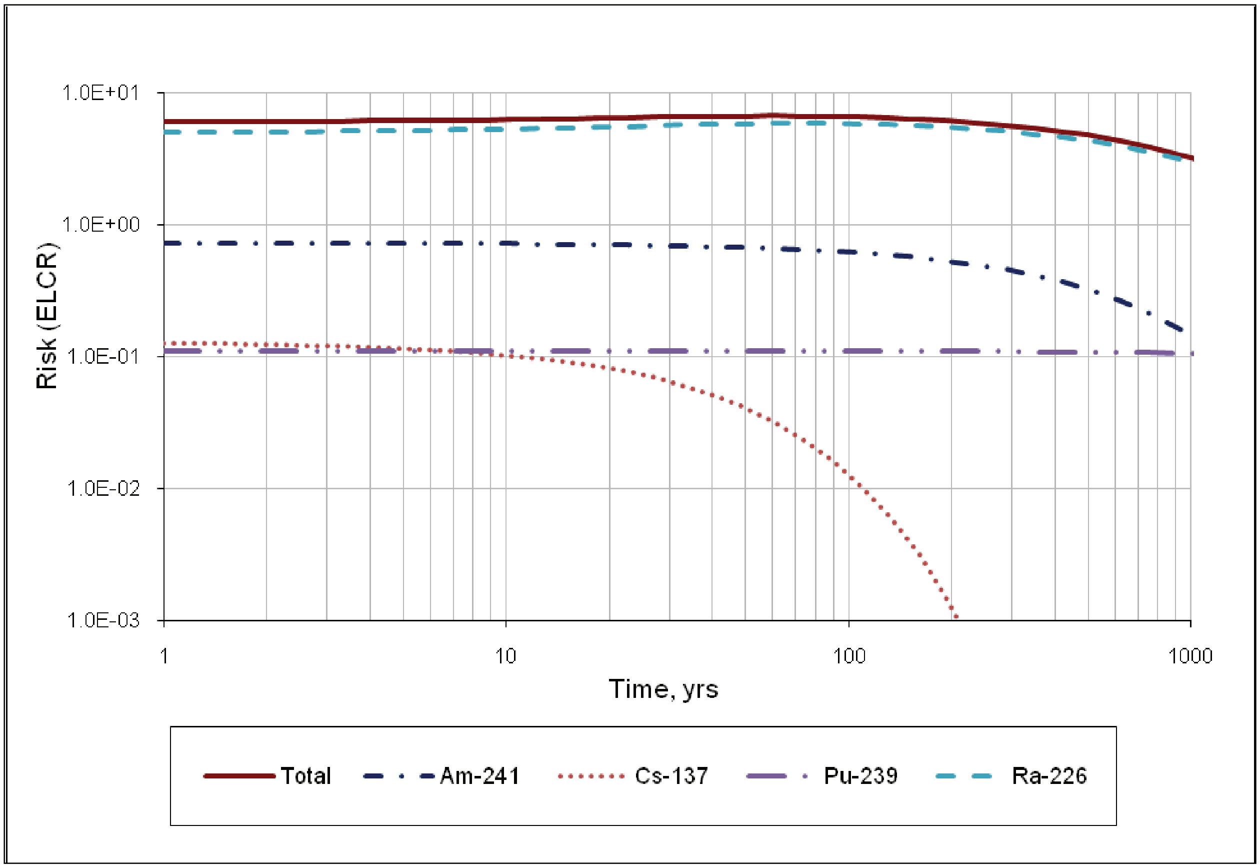
Table F-7. Maximum Radiological Risk for the Yakama Nation Exposure Scenario at the Z-Ditches

	Maximum Risk*	
Configuration	**ELCR**	**Time (years)**
Current Site Configuration	1.43E-05	0
Baseline Configuration	Greater than 1.00E-02	50

Note:
* Calculated with RESRAD over a 1,000-year simulation period.
ANL, 2009, *RESAD*, Version 6.5.

The RESRAD calculations indicate that contributions from four radionuclides (Ra-226, Am-241, Pu-239, and Cs-137) account for over 99 percent of the total ELCR over the 1,000-year simulation period. Contributions from other radionuclide COPCs (Pu-238, Ra-228, Sr-90, Th-228, Th-230, Th-232, U-234, and U-238) do not exceed 1 percent of the total ELCR. Radium-226 is the primary contributor to the total ELCR over the duration of the assessment. Cesium-137, with a half-life of 30 years, makes a significant contribution only early in the assessment. From 50 to 1,000 year, the total ELCR is driven by Ra-226 with secondary contributions from Am-241 and Pu-239. The total ELCR is dominated pathway contributions from external radiation exposure, plant consumption, and soil ingestion. Pathway contributions from dust inhalation and meat and milk consumption do not exceed 1 percent of the total ELCR.

For the Yakama Nation exposure scenario baseline configuration case, the maximum ELCR occurs at 50 years from the present time at values greater than 1×10^{-2}. The primary contributors to the maximum ELCR are Ra-226 from external radiation exposure (18 percent), plant consumption (68 percent), and soil ingestion (1 percent); Am-241 from external radiation consumption (2 percent), plant consumption (6 percent), and soil ingestion consumption (1 percent); and Pu-239 for plant consumption (1 percent). Another primary contributor to risk at 50 years is from ingrowth of lead-210, a radiological decay product of radium-226. The lead-210 exposure contributions arise primarily through the plant ingestion pathway. The contributions reported in Table F-8 from plant ingestion represent the sum of contributions from parent radium-226 and daughter lead-210.



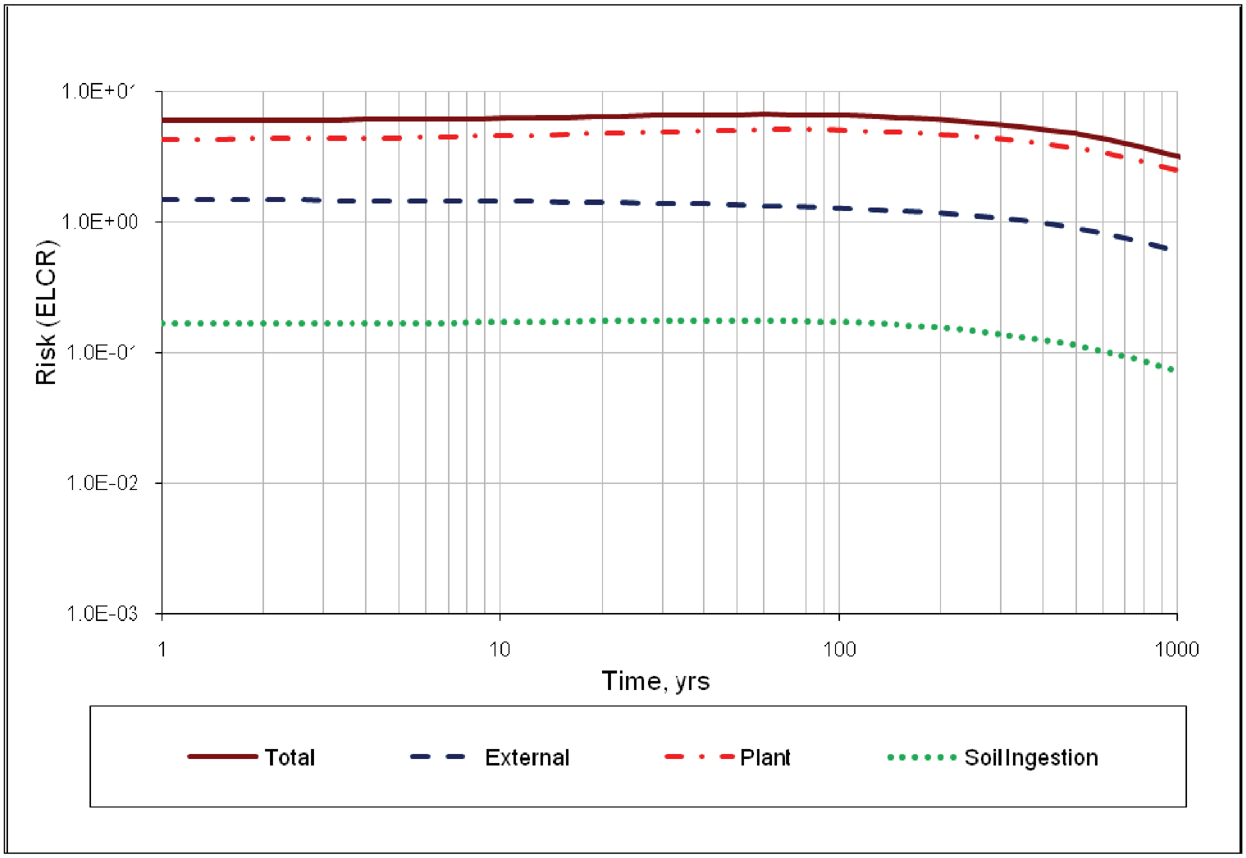
Note: For risks greater than 1.00E-02, the total ELCR is reported as “Greater than 1 x 10-2”. Radiological risks are calculated using RESRAD and will report risks that are greater than one, which is not possible. Because RESRAD assumes risks are linear beyond 1E-02, this assumption is inconsistent with EPA guidance, risk results greater than 1E-02 were truncated to “greater than 10-2”.

Figure F-4. Excess Lifetime Cancer Risk for the Yakama Nation Exposure Scenario at the Z-Ditches–Risk Contributions Over Time for Dominant Radionuclides (Baseline Configuration)

After 1,000 years, the primary contributors to the total ELCR are Ra-226 from external radiation exposure (18 percent), plant consumption (73 percent), and soil ingestion (1 percent); Am-241 from plant consumption (3 percent); and Pu-239 for plant consumption (3 percent).

Based on RESRAD calculations, the total ELCR for the Yakama Nation exposure scenario baseline configuration case is projected to remain above EPA’s target risk threshold of 1×10^{-4} for at least 100,000 years (RESRAD’s maximum calculation time). The ELCR for Am-241, which has a half-life of 432 years, is projected to remain above the 1×10^{-4} threshold for approximately 18,000 years. The ELCR contribution from Ra-226, which has a half-life of 1,600 years, is projected to remain above the 1×10^{-4} risk threshold for approximately 14,500 years. In addition, the ELCR contribution for Pu-239, which has a half-life of 24,065 years, is projected to remain above the 1×10^{-4} risk threshold for at least 100,000 years.

Analysis results indicate that over the 1,000-year simulation period there are no exposure contributions from water-dependent pathways (i.e., use of groundwater for drinking water, crop irrigation, and livestock water). The RESRAD calculations indicate that leaching would not cause radionuclides in the soil beneath the Z-ditches to reach the water table during the 1,000-year simulation period.



Note: For risks greater than 1.00E-02, the total ELCR is reported as "Greater than 1 x 10-2". Radiological risks are calculated using RESRAD and will report risks that are greater than one, which is not possible. Because RESRAD assumes risks are linear beyond 1E-02, this assumption is inconsistent with EPA guidance, risk results greater than 1E-02 were truncated to "greater than 10-2".

Figure F-5. Excess Lifetime Cancer Risk for the Yakama Nation Exposure Scenario at the Z-Ditches–Risk Contributions Over Time for Dominant Exposure Pathways (Baseline Configuration)

F5.2.2 Current Site Configuration Case

Table F-7 summarizes the maximum ELCR results for the Yakama Nation exposure scenario current configuration case. The maximum ELCR for the Yakama Nation exposure scenario occurs at the beginning of the simulation period (time zero) at a value slightly greater than 1×10^{-5}. Figure F-6 shows time-dependent changes in ELCR over the 1,000-year simulation period. Table F-9 shows the primary radionuclide and exposure pathway contributions to ELCR.

Analysis results for the Yakama Nation exposure scenario current configuration case indicate that the ELCR originates solely from the external gamma radiation exposure route. Radium-226 contributes over 99 percent of the total ELCR at each of the evaluated exposure intervals (0, 50, 150, 500, and 1,000 years from the present). These results indicate that the presence of the clean soil cover shields the ground surface from some but not all of the gamma radiation emitted from the contaminated soil below. With the cover in place, the ingestion and inhalation exposure routes are incomplete and are not contributors to the overall ELCR. Likewise, the food chain pathway is incomplete and does not contribute to the overall ELCR because the cover thickness is greater than the assumed plant rooting depth (RESRAD default of 0.9 m [3 ft]).

Table F-8. Primary Radionuclide and Exposure Pathway Contributions to Risk for the Yakama Nation Exposure Scenario at the Z-Ditches (Baseline Configuration)

Total ELCR	Time (Years)	Primary Radionuclides	Percentage of Total ELCR	Pathway
Greater than 1 x 10^{-2}	0	Ra-226	20%	External
		Am-241	3%	
		Cs-137	2%	
		Ra-226	62%	Plant
		Am-241	8%	
		Pu-239	1%	
		Am-241	2%	Soil Ingestion
Greater than 1 x 10^{-2}	50	Ra-226	18%	External
		Am-241	2%	
		Ra-226	68%	Plant
		Am-241	6%	
		Pu-239	1%	
		Ra-226	1%	Soil Ingestion
		Am-241	1%	
Greater than 1 x 10^{-2}	150	Ra-226	17%	External
		Am-241	2%	
		Ra-226	70%	Plant
		Am-241	6%	
		Pu-239	1%	
		Ra-226	1%	Soil Ingestion
		Am-241	1%	
Greater than 1 x 10^{-2}	500	Ra-226	17%	External
		Am-241	1%	
		Ra-226	72%	Plant
		Am-241	4%	
		Pu-239	2%	
		Ra-226	1%	Soil Ingestion
Greater than 1 x 10^{-2}	1,000	Ra-226	18%	External
		Ra-226	73%	Plant
		Am-241	3%	
		Pu-239	3%	
		Ra-226	1%	Soil Ingestion

Notes: Calculated with RESRAD over a 1,000-year simulation period. For risks greater than 1.00E-02, the total ELCR is reported as "Greater than 1 x 10^{-2}". Radiological risks are calculated using RESRAD and will report risks that are greater than one, which is not possible. Because RESRAD assumes risks are linear beyond 1E-02, this assumption is inconsistent with EPA guidance, risk results greater than 1E-02 were truncated to "greater than 10-2".

ANL, 2009, *RESAD*, Version 6.5.

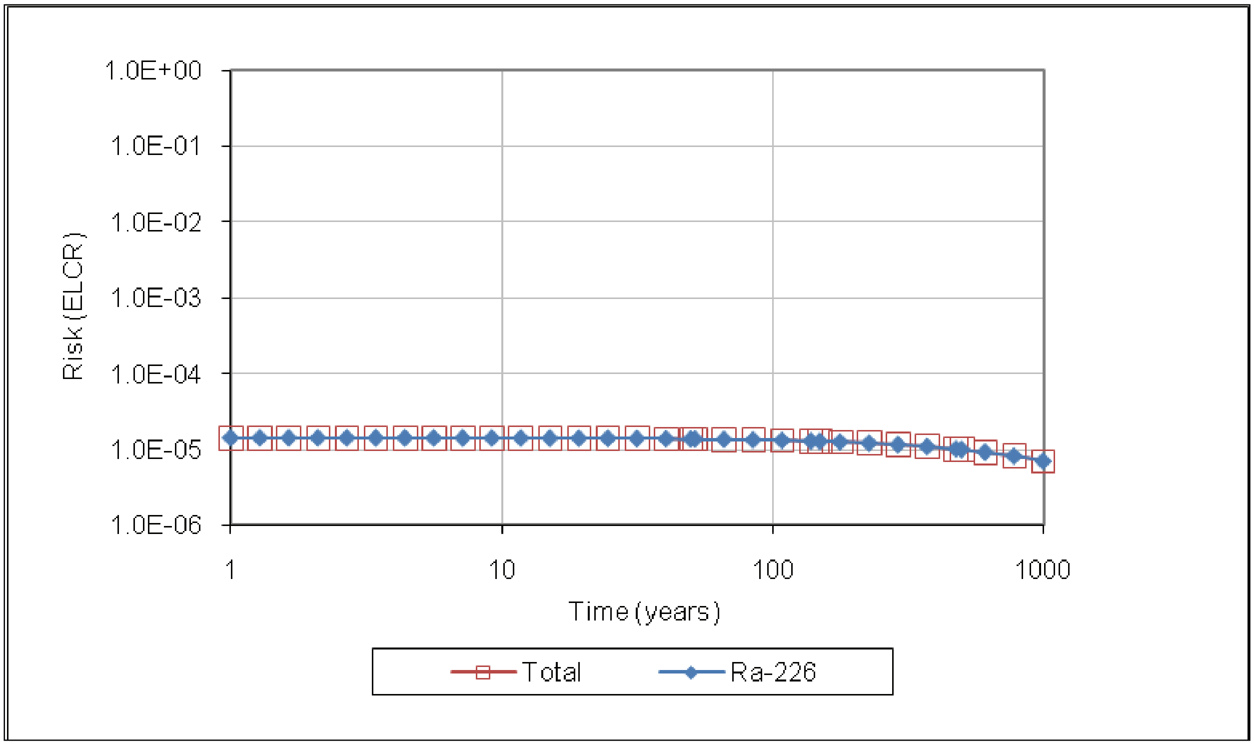


Figure F-6. RESRAD Analysis for the Yakama Nation Exposure Scenario at the Z-Ditches–Excess Lifetime Cancer Risk Over Time (Current Site Configuration)

Table F-9. Primary Radionuclide and Exposure Pathway Contributions to Risk for the Yakama Nation Exposure Scenario at the Z-Ditches (Current Site Configuration)

Total Excess Lifetime Cancer Risk	Time (Years)	Primary Radionuclide	Percentage of Total Risk	Pathway
		Yakama Nation		
1.43E-05	0	Ra-226	99.5%	External
1.37E-05	50	Ra-226	99.8%	External
1.28E-05	150	Ra-226	99.9%	External
9.98E-06	500	Ra-226	99.8%	External
7.01E-06	1,000	Ra-226	99.7%	External

Note: Calculated with RESRAD over a 1,000-year simulation period.
ANL, 2009, *RESAD*, Version 6.5.

Analysis results indicate that over the 1,000-year simulation period there are no exposure contributions from water-dependent pathways (i.e., use of groundwater for drinking water, crop irrigation, and livestock water). This indicates that that radionuclide contamination currently in the soil beneath the Z-Ditches would not reach groundwater during the 1,000-year simulation.

F6 Uncertainty Assessment

Uncertainties Associated with the Exposure Point Concentration. Another uncertainty is associated with the use of maximum detected concentrations as the exposure point concentration. In particular, the maximum detected concentration for Ra-226 is used as the EPC rather than the 95 percent upper confidence limit (95UCL) on the mean. The maximum concentration was selected as the EPC because the computed 95UCL value exceeded the maximum detected concentration due to the small number of samples collected (12 total observations). Use of the maximum concentration may over-state total health risks because samples were collected based on a biased sample design (where contamination was expected to be encountered).

Uncertainties Associated with the Groundwater Exposure Pathway. This risk assessment addresses potential exposures and resulting health risks from contaminants that currently reside in the soil and does not include existing contamination in the groundwater underlying the 200-CW-5 OU. The absence of the groundwater exposure pathway under-states potential health risks. However, health risks from potential exposure to groundwater beneath the 200-CW-5 OU will be evaluated in the 200-ZP-1 and 200-UP-1 groundwater OUs and presented in the RI/FS documents.

Uncertainties Associated with Exposure Assumptions. Another source of uncertainty is associated with limitations in available exposure assumptions. Ingestion of contaminants that could potentially bioaccumulate in wild game or plants that are gathered for ceremonial purposes were not evaluated in the two tribal-use exposure scenarios. The size of the 200-CW-5 waste sites is considered too small to support a sufficient number and variety of plants or foraging wild game for consumption. While consumption of ceremonial plants and game animals is a potentially complete exposure pathway, it is not considered reasonable to assume that those plants or animals could exist within the confines of the Z-Ditches. Therefore, this exposure route was not considered to contribute significantly to total exposure. Although the consumption of plants and wild game were not considered in this risk evaluation, exposure through the consumption of homegrown produce and livestock raised and penned on the waste site were evaluated.

F7 References

40 CFR 141, "National Primary Drinking Water Regulations," *Code of Federal Regulations*. Available at: http://www.access.gpo.gov/nara/cfr/waisidx_08/40cfr141_08.html.

ANL, 2009, *RESRAD*, Version 6.5, Environmental Assessment Division, Argonne National Laboratory, Argonne, Illinois. Available at: http://web.ead.anl.gov/resrad/register2/.

ANL/EAD-4, 2001, *User's Manual for RESRAD Version 6*, Environmental Assessment Division, Argonne National Laboratory, Argonne, Illinois. Available at: http://web.ead.anl.gov/resrad/documents/resrad6.pdf.

BHI-01177, 1998, *Borehole Summary Report for the 216-B-2-2 Ditch*, Rev. 0, Bechtel Hanford, Inc., Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D198215959.

CCN 070578, 1999, "Estimation of the Soil-Specific Exponential Parameter(b)" (letter to J.D. Fancher, CH2M HILL, Inc., from W.J. McMahon), Bechtel Hanford, Inc., Richland, Washington, June 30.

DOE/ORP-2005-01, 2006, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site*, Rev. 0, U.S. Department of Energy, Office of River Protection, Richland, Washington. Available at: http://www.hanford.gov/orp/uploadfiles/CHG_Performance_Assessment.pdf.

DOE/RL-2003-11, 2004, *Remedial Investigation for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-SC-1 Steam Condensate Group Operable Units*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2004-24, 2008, *Feasibility Study for the 200-CW-5 Cooling Water Operable Unit*, Draft B, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=0808050319.

EPA, 1991, *Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual Supplemental Guidance "Standard Default Exposure Factors" Interim Final,* OSWER Directive 9285.6-03, Office of Emergency and Remedial Response, Toxics Integration Branch, U.S. Environmental Protection Agency, Washington D.C. Available at: http://www.epa.gov/oswer/riskassessment/pdf/OSWERdirective9285.6-03.pdf.

EPA/540-R-00-007, 2000, *Soil Screening Guidance for Radionuclides: User's Guide*, OSWER Directive No. 9355.4-16A, Office of Radiation and Indoor Air, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/superfund/health/contaminants/radiation/radssg.htm.

EPA 540/R/99/006, 1999, *Radiation Risk Assessment At CERCLA Sites: Q & A*, OSWER Directive No. 9200.4-31P, Office of Emergency and Remedial Response, Office of Radiation and Indoor Air, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/superfund/health/contaminants/radiation/pdfs/riskqa.pdf.

EPA/600/R-07/038, 2007, *ProUCL Version 4.0 User Guide*, U.S. Environmental Protection Agency, Risk Assessment Forum, Washington, D.C. Available at: http://www.epa.gov/esd/tsc/images/proucl4user.pdf.

Harris, S., 2008, *Application of the CTUIR Traditional Lifeways Exposure Scenario in Hanford Risk Assessments*, Department of Science and Engineering, Confederated Tribes of the Umatilla Indian Reservation, Pendleton, Oregon.

Harris, S., and B. Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways*, Department of Science and Engineering, Confederated Tribes of the Umatilla Indian Reservation, Pendleton, Oregon.

PNNL-11800, 1998, *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.osti.gov/energycitations/servlets/purl/594543-mUGcOH/webviewable/594543.pdf.

PNNL-14702, 2006, *Vadose Zone Hydrology Data Package for Hanford Assessments*, Rev. 1, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14702rev1.pdf.

PNNL-15160, 2005, *Hanford Site Climatological Summary 2004 with Historical Data*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-15160.pdf.

Ridolfi, 2007, "Yakama Nation Exposure Scenario for Hanford Site Risk Assessment," Ridolfi Inc., Seattle, Washington.

SGW-37174, *Z-Ditches Study for the 200-CW-5 Cooling Water Operable Unit*, Rev. 0, Fluor Hanford, Inc., Richland, Washington.

WDOH/320-015, 1997, *Hanford Guidance for Radiological Cleanup,* Rev. 1, Washington State Department of Health, Olympia, Washington. Available at: http://www.doh.wa.gov/ehp/rp/environmental/cleanup.pdf.

WHC-EP-0883, 1995, *Variability and Scaling of Hydraulic Properties for 200 Area Soils*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: http://www.osti.gov/bridge/servlets/purl/188564-WXbGAs/webviewable/188564.pdf.

WHC-SD-EN-SE-004, 1993, *Site Characterization Report: Results of Detailed Evaluation of the Suitability of the Site Proposed for Disposal of 200 Areas Treated Effluent*, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Yu, C., C. Loureiro, J.J. Cheng, L.G. Jones, Y.Y. Wang, Y.P. Chia, and E Faillace, 1993, *Data Collection Handbook to Support Modeling of Radioactive Material in Soil*, ANL/EAIS-8, Argonne National Laboratory, Argonne, Illinois. Available at: http://web.ead.anl.gov/resrad/documents/data_collection.pdf.

Distribution

	MS	Quantity
U.S. Department of Energy, Richland Operations Office		
G.L. Sinton	A6-38	20
DOE Public Reading Room	H2-53	1
CH2M HILL Plateau Remediation Company		
P.A. Burke	R3-19	1
W.R. Faught	H8-15	1
E. Griffiths	R3-19	1
Publications Technical Library	H3-21	1
Administrative Record	H6-08	1
Document Clearance	H6-08	1

This page intentionally left blank.