

## AR TARGET SHEET

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Draft A

# Feasibility Study for the 200-CS-1 Chemical Sewer Group Operable Unit

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



**United States  
Department of Energy**  
P.O. Box 550  
Richland, Washington 99352

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Assistant Secretary for Environmental Management



**United States  
Department of Energy**  
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## CONTENTS

1			
2	1.0	INTRODUCTION .....	1-1
3	1.1	REMEDIAL INVESTIGATION ACTIVITIES .....	1-2
4	1.2	FEASIBILITY STUDY PURPOSE .....	1-3
5	1.3	SCOPE .....	1-4
6	1.4	REPORT ORGANIZATION .....	1-4
7	1.5	REFERENCES .....	1-6
8	2.0	BACKGROUND INFORMATION .....	2-1
9	2.1	OPERABLE UNITS BACKGROUND AND HISTORY .....	2-1
10		2.1.1 Buildings and Ancillary Facilities .....	2-1
11		2.1.2 Operable Unit Description .....	2-2
12	2.2	PHYSICAL SETTING .....	2-8
13		2.2.1 Meteorology .....	2-8
14		2.2.2 Topography .....	2-9
15		2.2.3 Geology .....	2-9
16		2.2.4 Hydrostratigraphy .....	2-11
17	2.3	NATURAL RESOURCES .....	2-13
18		2.3.1 Vegetation .....	2-13
19		2.3.2 Wildlife .....	2-14
20		2.3.3 Species of Concern .....	2-15
21		2.3.4 Cultural Resources .....	2-15
22		2.3.5 Aesthetics, Visual Resources, and Noise .....	2-16
23		2.3.6 Socioeconomics .....	2-17
24	2.4	WASTE SITE DESCRIPTIONS .....	2-18
25		2.4.1 Representative Sites .....	2-18
26		2.4.2 Summary of Data Collection Activities .....	2-22
27	2.5	EVALUATION OF ANALOGOUS WASTE SITES .....	2-25
28		2.5.1 Assignment of Analogous Sites .....	2-25
29		2.5.2 Analogous Sites .....	2-25
30	2.6	BASELINE RISK ASSESSMENT SUMMARY .....	2-26
31		2.6.1 Remedial Investigation Baseline Risk Assessment Overview .....	2-26
32		2.6.2 Land-Use Characterization .....	2-28
33		2.6.3 Beneficial Groundwater Use .....	2-29
34		2.6.4 Conceptual Exposure Model for Human Exposure .....	2-29
35		2.6.5 Potential Ecological Exposure Pathways .....	2-31
36	2.7	HUMAN HEALTH EVALUATION FOR NONRADIOLOGICAL	
37		CONSTITUENTS .....	2-31
38		2.7.1 Nonradiological Contaminants of Potential Concern for Human	
39		Health .....	2-32
40		2.7.2 Data Evaluation .....	2-32
41		2.7.3 Identification of Essential Nutrients .....	2-32
42		2.7.4 Background Screening .....	2-33
43		2.7.5 Screening to WAC 173-340 Soil and Groundwater	
44		Protection-Screening Standards .....	2-34

1	2.7.6	Summary of Nonradiological Contaminant of Potential Concern and Uncertainty Analysis.....	2-36
2			
3	2.8	HUMAN HEALTH EVALUATION FOR RADIOLOGICAL	
4		CONSTITUENTS.....	2-36
5	2.8.1	Selection of Radiological Contaminants of Potential Concern in	
6		Shallow-Zone Soil Samples.....	2-37
7	2.8.2	Background Screening.....	2-37
8	2.8.3	RESRAD Assumptions and Input Parameters.....	2-37
9	2.8.4	RESRAD Results.....	2-38
10	2.8.5	Human Health Evaluation of Radiological Contaminants of	
11		Potential Concern and Impacts to Groundwater.....	2-39
12	2.9	ECOLOGICAL RISK SCREENING.....	2-40
13	2.9.1	Exposure Parameter Estimates.....	2-41
14	2.9.2	Ecological Toxicity of Contaminants of Potential Ecological	
15		Concern.....	2-41
16	2.9.3	Screening-Level Risk Calculations.....	2-41
17	2.9.4	Ecological Risk Assessment Summary and Uncertainty	
18		Assessment.....	2-42
19	2.10	REMEDIAL INVESTIGATION BASELINE RISK ASSESSMENT	
20		SCREENING VALUES.....	2-42
21	2.11	BASELINE RISK ASSESSMENT – EXTENDED ANALYSIS.....	2-43
22	2.11.1	Introduction and Basis.....	2-43
23	2.11.2	Extended Analysis Approach Overview.....	2-47
24	2.12	BASELINE RISK ASSESSMENT EXTENDED ANALYSIS OF THE	
25		216-A-29 DITCH SITE.....	2-49
26	2.12.1	Summary.....	2-49
27	2.12.2	Extended Risk Analysis of the 216-A-29 Ditch.....	2-50
28	2.12.3	Spatial and Data Aggregation Considerations.....	2-52
29	2.12.4	Summary of the Nature and Extent of Contamination and	
30		Implications for the Feasibility Study.....	2-57
31	2.12.5	Groundwater Impacts from Vadose Zone Contamination.....	2-58
32	2.12.6	Revised Assessments Using Robust 95%UCL Exposure-Point	
33		Concentrations.....	2-63
34	2.12.7	Intruder-Exposure Scenario.....	2-64
35	2.12.8	Overall Summary of the Baseline Risk Assessment Extended	
36		Analysis.....	2-68
37	2.13	BASELINE RISK ASSESSMENT EXTENDED ANALYSIS OF THE	
38		216-B-63 TRENCH SITE.....	2-71
39	2.13.1	Summary.....	2-71
40	2.13.2	Extended Risk Analysis of the 216-B-63 Trench.....	2-72
41	2.13.3	Synthesis of the Nature and Extent of Contamination.....	2-72
42	2.13.4	Spatial and Data Aggregation Considerations.....	2-73
43	2.13.5	Groundwater Impacts from Vadose Zone Contamination.....	2-75
44	2.13.6	Revised Assessments Using Robust 95%UCL Exposure-Point	
45		Concentrations.....	2-75
46	2.13.7	Intruder Exposure Analysis.....	2-76
47	2.13.8	Overall Summary Baseline Risk Assessment Extended Analysis.....	2-77

1	2.14	BASILINE RISK ASSESSMENT EXTENDED ANALYSIS OF THE	
2		216-S-10 DITCH SITE .....	2-78
3		2.14.1 Summary .....	2-78
4		2.14.2 Extended Analysis of the 216-S-10 Ditch .....	2-79
5		2.14.3 Synthesis of the Nature and Extent of Contamination .....	2-79
6		2.14.4 Summary of the Nature and Extent of Contamination and	
7		Implications for the Feasibility Study .....	2-81
8		2.14.5 Groundwater Impacts from Vadose Zone Contamination .....	2-82
9		2.14.6 Revised Assessments Using Robust 95%UCL Exposure-Point	
10		Concentrations .....	2-83
11		2.14.7 Intruder Exposure Scenario.....	2-84
12		2.14.8 Overall Summary Baseline Risk Assessment Extended Analysis .....	2-84
13	2.15	BASILINE RISK ASSESSMENT EXTENDED ANALYSIS OF THE	
14		216-S-10 POND SITE .....	2-85
15		2.15.1 Summary .....	2-85
16		2.15.2 Extended Analysis of the 216-S-10 Pond .....	2-86
17		2.15.3 Synthesis of the Nature and Extent of Contamination.....	2-86
18		2.15.4 Spatial and Data Aggregation Considerations .....	2-86
19		2.15.5 Summary of the Nature and Extent of Contamination and	
20		Implications for the Feasibility Study.....	2-88
21	2.16	SUMMARY OF RISK-BASED ISSUES FOR THE FEASIBILITY	
22		STUDY .....	2-88
23	2.17	REFERENCES .....	2-89
24	3.0	DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES AND	
25		PRELIMINARY REMEDIATION GOALS .....	3-1
26	3.1	LAND USE.....	3-1
27		3.1.1 Current Land Use.....	3-1
28		3.1.2 Anticipated Future Land Use.....	3-3
29		3.1.3 Regional Land Use.....	3-7
30		3.1.4 Groundwater Use .....	3-7
31		3.1.5 Use of Industrial Cleanup Standards Under WAC 173-340.....	3-7
32	3.2	CONTAMINANTS OF POTENTIAL CONCERN .....	3-9
33	3.3	REMEDIAL ACTION OBJECTIVES .....	3-9
34		3.3.1 Summary of Risk-Based Issues for the Feasibility Study.....	3-10
35		3.3.2 Remedial Action Objectives .....	3-11
36	3.4	PRELIMINARY REMEDIATION GOALS .....	3-12
37		3.4.1 Direct Exposure Preliminary Remediation Goals for	
38		Nonradioactive Contaminants.....	3-13
39		3.4.2 Direct Exposure Remediation Goals for Radionuclides .....	3-14
40		3.4.3 Remediation Goals for the Protection of Groundwater and Surface	
41		Water.....	3-15
42	3.5	REFERENCES .....	3-16
43	4.0	IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES .....	4-1
44	4.1	GENERAL RESPONSE ACTIONS.....	4-1
45	4.2	SCREENING AND IDENTIFICATION OF TECHNOLOGIES.....	4-2

1	4.2.1	Rescreening of Implementation Plan Remedial Technologies	
2		Based on Risk Assessment Results.....	4-2
3	4.3	SUMMARY OF REMEDIAL TECHNOLOGIES AND PROCESS	
4		OPTIONS RETAINED FOR THE 200-CS-1 OPERABLE UNIT	
5		ALTERNATIVE DEVELOPMENT .....	4-9
6	4.4	REFERENCES .....	4-9
7	5.0	REMEDIAL ACTION ALTERNATIVES.....	5-1
8	5.1	DEVELOPMENT OF ALTERNATIVES.....	5-1
9	5.2	DESCRIPTION OF ALTERNATIVES .....	5-2
10	5.2.1	Alternative 1 – No Action.....	5-2
11	5.2.2	Alternative 2 – Maintain Existing Soil Cover, Monitored Natural	
12		Attenuation, and Institutional Controls.....	5-3
13	5.2.3	Alternative 3 – Removal, Treatment, and Disposal.....	5-4
14	5.2.4	Alternative 4 – Engineered Barrier .....	5-5
15	5.3	REFERENCES .....	5-7
16	6.0	DETAILED ANALYSIS OF ALTERNATIVES.....	6-1
17	6.1	DESCRIPTION OF EVALUATION CRITERIA.....	6-1
18	6.1.1	Overall Protection of Human Health and the Environment.....	6-2
19	6.1.2	Compliance with Applicable or Relevant and Appropriate	
20		Requirements .....	6-3
21	6.1.3	Long-Term Effectiveness and Permanence .....	6-3
22	6.1.4	Reduction of Toxicity, Mobility, or Volume through Treatment.....	6-4
23	6.1.5	Short-Term Effectiveness .....	6-4
24	6.1.6	Implementability .....	6-5
25	6.1.7	Cost .....	6-5
26	6.1.8	State Acceptance.....	6-6
27	6.1.9	Community Acceptance.....	6-6
28	6.2	DETAILED ANALYSIS OF ALTERNATIVES.....	6-6
29	6.2.1	Detailed Analysis of Alternative 1 – No Action.....	6-6
30	6.2.2	Detailed Analysis of Alternative 2 – Maintain Existing Soil Cover,	
31		Monitored Natural Attenuation, and Institutional Controls.....	6-9
32	6.2.3	Detailed Analysis of Alternative 3 – Removal, Treatment, and	
33		Disposal.....	6-13
34	6.2.4	Detailed Analysis of Alternative 4 – Engineered Barrier .....	6-17
35	6.3	NEPA VALUES EVALUATION .....	6-22
36	6.3.1	Description of NEPA Values.....	6-22
37	6.3.2	Detailed Evaluation of NEPA.....	6-23
38	6.4	REFERENCES .....	6-27
39	7.0	COMPARATIVE ANALYSIS OF ALTERNATIVES.....	7-1
40	7.1	OVERALL PROTECTION OF HUMAN HEALTH AND THE	
41		ENVIRONMENT .....	7-1
42	7.2	COMPLIANCE WITH APPLICABLE OR RELEVANT AND	
43		APPROPRIATE REQUIREMENTS.....	7-2
44	7.3	LONG-TERM EFFECTIVENESS AND PERMANENCE .....	7-2

1	7.4	REDUCTION IN TOXICITY, MOBILITY, OR VOLUME THROUGH	
2		TREATMENT .....	7-3
3	7.5	SHORT-TERM EFFECTIVENESS .....	7-3
4	7.6	IMPLEMENTABILITY .....	7-4
5	7.7	COST .....	7-4
6	7.8	REFERENCES .....	7-5
7	8.0	CONCLUSIONS AND PATH FORWARD .....	8-1
8	8.1	FEASIBILITY STUDY SUMMARY .....	8-1
9		8.1.1 216-A-29 Ditch Site.....	8-1
10		8.1.2 216-B-63 Trench Site.....	8-1
11		8.1.3 216-S-10 Ditch Site.....	8-2
12		8.1.4 216-S-10 Pond and its Analogous Waste Site .....	8-2
13	8.2	PATH FORWARD .....	8-2
14		8.2.1 Plug-in Approach of the 200-CS-1 Operable Unit Waste Sites.....	8-3
15	8.3	CLOSURE OF RCRA TREATMENT, STORAGE, AND/OR DISPOSAL	
16		UNITS.....	8-5
17	8.4	PUBLIC INVOLVEMENT IN THE PLUG-IN APPROACH.....	8-7
18	8.5	REFERENCES .....	8-7
19	9.0	REFERENCES .....	9-1
20			

## APPENDICES

1

2	A	WASTE SITE PHOTOS.....	A-i
3	B	POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE	
4		REQUIREMENTS.....	B-i
5	C	NATIVE AMERICAN EXPOSURE SCENARIO RISK ASSESSMENT.....	C-i
6	D	COST ESTIMATE BACKUP .....	D-i
7	E	CLOSURE PLAN FOR THE 216-A-29 DITCH.....	E-i
8	F	SEASONAL SOIL COMPARTMENT MODEL.....	F-i

9

## FIGURES

10

11	Figure 1-1.	Location of the Hanford Site and the 200-CS-1 Operable Unit Waste Sites.....	1-8
12	Figure 1-2.	Location of the 200-CS-1 Operable Unit Waste Sites in the 200 East Area.....	1-9
13	Figure 1-3.	Location of the 200-CS-1 Operable Unit Waste Sites in the 200 West Area. ....	1-1
14	Figure 2-1.	Stratigraphic Column for the 200 Areas. ....	2-96
15	Figure 2-2.	Geologic Cross Section Through the 216-A-29 Ditch.....	2-97
16	Figure 2-3.	Geologic Cross Section Through the 216-B-63 Trench.....	2-98
17	Figure 2-4.	Hydrogeologic Cross Section at the 216-S-10 Pond and Ditch (from PNNL-	
18		14070).....	2-99
19	Figure 2-5.	Location of the 216-A-29 Trench Borehole and Test Pit Locations.....	2-100
20	Figure 2-6.	Location of the 216-B-63 Trench Borehole and Test Pit Locations. ....	2-101
21	Figure 2-7.	Location of the 216-S-10 Ditch Borehole and Test Pit Locations.....	2-102
22	Figure 2-8.	Contaminant Distribution Model for the 216-A-29 Ditch. ....	2-103
23	Figure 2-9.	Contaminant Distribution Model for the 216-B-63 Trench. ....	2-104
24	Figure 2-10.	Contaminant Distribution for the 216-S-10 Ditch. ....	2-105
25	Figure 2-11.	Contaminant Distribution for the 216-S-10 Pond. ....	2-106

1 Figure 2-12. Application of the Analogous Site Approach. .... 2-107

2 Figure 2-13. Conceptual Iterative Evaluation and Refinement of Risk Assessment  
3 Information in the Remedial Investigation/Feasibility Study. .... 2-109

4 Figure 2-14. Conceptual Site Model for Risk Assessment. .... 2-110

5 Figure 2-15. Summary of Nature and Extent of Contamination for the 216-A-29 Ditch  
6 Representative Site. .... 2-111

7 Figure 2-16. Example Interpretation for Arsenic at the 216-A-29 Ditch. .... 2-113

8 Figure 2-17. SESOIL Model Configuration for 216-A-29 Ditch. .... 2-114

9 Figure 2-18. SESOIL Processes. .... 2-115

10 Figure 2-19. 216-A-29 Ditch, Estimated Impacts of Arsenic in Vadose Zone Soils on  
11 Groundwater. .... 2-116

12 Figure 2-20. 216-A-29 Ditch, Estimated Impacts of Cadmium in Vadose Zone Soils on  
13 Groundwater. .... 2-117

14 Figure 2-21. 216-A-29 Ditch, Estimated Impacts of Silver in Vadose Zone Soils on  
15 Groundwater. .... 2-118

16 Figure 2-22. 216-A-29 Ditch, Estimated Impacts of Nitrate, Nitrate/Nitrite and Sulfate in  
17 Vadose Zone Soils on Groundwater. .... 2-119

18 Figure 2-23. Intruder Scenario Conceptual Site Model and Garden. .... 2-120

19 Figure 2-24. Summary of Nature and Extent of Contamination for the 216-B-63 Trench  
20 Representative Site. .... 2-121

21 Figure 2-25. 216-B-63 Trench, Estimated Impacts of Nitrate and Nitrate/Nitrite in  
22 Vadose Zone Soils on Groundwater. .... 2-123

23 Figure 2-26. Display of Strontium-90 Concentrations in the 0- to 15-Foot Interval. .... 2-124

24 Figure 2-27. Summary of Nature and Extent of Contamination for the 216-S-10 Ditch  
25 Representative Site. .... 2-125

26 Figure 2-28. 216-S-10 Ditch, Estimated Impacts of Silver in Vadose Zone Soils on  
27 Groundwater. .... 2-127

28 Figure 2-29. Summary of Nature and Extent of Contamination for the 216-S-10 Pond  
29 Representative Site. .... 2-128

30 Figure 2-30. 216-S-10 Pond Distribution of Silver in Soils 0 to 15 feet. .... 2-129

1 Figure 5-1. Generalized Removal, Treatment, and Disposal Alternative (Alternative 3). ..... 5-8

2 Figure 5-2. Evapotranspiration Barrier. .... 5-9

3 Figure 6-1. Logic Diagram for Selecting Applicable Alternatives..... 6-29

4

## TABLES

1		
2	Table 2-1. Lithofacies of the Cold Creek Unit. ....	2-130
3	Table 2-2. Representative Site and Analogous Waste Site.....	2-131
4	Table 2-3. Summary of Contaminants of Potential Concern Exceeding Screening Levels	
5	for the Baseline Risk Assessment Human Health Risk Assessment.....	2-133
6	Table 2-4. Summary of Contaminants of Potential Concern and Potential Threat to	
7	Groundwater.....	2-134
8	Table 2-5. Summary of RESRAD Dose, Risk, and Groundwater Protection Modeling	
9	Results from Baseline Risk Assessment. ....	2-135
10	Table 2-6. Baseline Risk Assessment Hazard Quotients for Contaminants of Ecological	
11	Concern for which Industrial Land-Use Screening Levels Are Available.....	2-136
12	Table 2-7. Summary of Screening Values from Remedial Investigation. (2 Pages).....	2-137
13	Table 2-8. Summary of Contaminants of Potential Concern Exceeding Screening Levels	
14	for the Remedial Investigation Baseline Risk Assessment. (2 Pages) .....	2-140
15	Table 2-9. Summary of Screening Values. (2 Pages).....	2-142
16	Table 2-10. Summary of Contaminants of Potential Concern and Potential Threat to	
17	Groundwater.....	2-144
18	Table 2-11. 216-A-29 Ditch Contaminants of Potential Concern. ....	2-145
19	Table 2-12. 216-A29 Trench Summary of Extended Nature and Extent of Contamination	
20	Assessment. (6 Pages).....	2-146
21	Table 2-13. 216-A-29 Ditch Summary and Rationale of Constituents for Extended	
22	Groundwater Impacts Evaluation.....	2-152
23	Table 2-14. 216-A-29 Ditch Chemical-Specific Modeling Inputs. ....	2-153
24	Table 2-15. 216-A-29 Ditch Summary of Re-Evaluation of Select Screening Results	
25	Using the Robust 95% Upper Confidence Limit.....	2-154
26	Table 2-16. 216-A-29 Ditch Summary and Rationale of Constituents for Intruder	
27	Scenario Evaluation. (2 Pages).....	2-155
28	Table 2-17. Exposure Factors for the Child-to-Adult Receptor Intruder Exposure	
29	Scenario. ....	2-157
30	Table 2-18. Intruder Scenario Chemical-Specific Input Parameters. ....	2-158

1	Table 2-19. 216-A-29 Ditch, Intruder Risk Assessment Nonradiological Results.....	2-158
2	Table 2-20. 216-A-29 Ditch, Intruder Risk Assessment Radiological Results. ....	2-158
3	Table 2-21. 216-A-29 Ditch Summary of Extended Analysis Findings. (2 Pages).....	2-159
4	Table 2-22. 216-B-63 Trench Contaminants of Potential Concern. ....	2-161
5	Table 2-23. 216-B-63 Trench Summary of Extended Nature and Extent of	
6	Contamination Assessment. (3 Pages) .....	2-162
7	Table 2-24. Chemical-Specific Modeling Inputs for the 216-B-63 Trench.....	2-166
8	Table 2-25. Comparison of Controlling Screening Values with Robust UCL95%	
9	Concentrations.....	2-166
10	Table 2-26. 216-B-63 Trench, Summary and Rationale of Constituents for Intruder	
11	Scenario Evaluation.....	2-167
12	Table 2-27. 216-B-63 Trench, Intruder Risk Assessment Results for Strontium-90.....	2-168
13	Table 2-28. 216-B-63 Trench, Summary of Extended Analysis Findings. ....	2-169
14	Table 2-29. 216-S-10 Ditch Contaminants of Potential Concern. ....	2-170
15	Table 2-30. 216-S-10 Ditch Summary of Extended Nature and Extent of Contamination	
16	Assessment. (4 Pages) .....	2-171
17	Table 2-31. 216-S-10 Trench Summary and Rationale of Constituents for Extended	
18	Groundwater Impacts Evaluation.....	2-175
19	Table 2-32. 216-S-10 Ditch Chemical-Specific Modeling Inputs.....	2-176
20	Table 2-33. 216-S-10 Ditch Comparison of Controlling Screening Values with Robust	
21	UCL95% Concentrations. ....	2-176
22	Table 2-34. 216-S-10 Trench Summary and Rationale of Constituents for Intruder	
23	Scenario Evaluation.....	2-177
24	Table 2-35. 216 S-10 Ditch Intruder Risk Summary.....	2-178
25	Table 2-36. 216-S-10 Ditch Summary of Extended Analysis Findings. ....	2-179
26	Table 2-37. 216-S-10 Pond Contaminants of Potential Concern.....	2-180
27	Table 2-38. 216-S-10 Pond Summary of Extended Nature and Extent of Contamination	
28	Assessment. ....	2-181
29	Table 2-39. Summary of Risk-Based Issues for the Feasibility Study. ....	2-182

DOE/RL-2005-63 DRAFT A

1 Table 3-1. Summary of Risk-Based Issues for the Feasibility Study. .... 3-19

2 Table 3-2. 200-CS-1 Operable Unit Preliminary Remediation Goals. .... 3-20

3 Table 3-3. 200-CS-1 Basis of Preliminary Remediation Goals. .... 3-21

4 Table 4-1. Technology Types and Process Options for Soil. (2 Pages) ..... 4-11

5 Table 5-1. Summary of Remedial Alternatives and Associated Components. .... 5-10

6 Table 6-1. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover,  
7 Monitored Natural Attenuation, and Institutional Controls. (2 Pages) ..... 6-30

8 Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and  
9 Disposal. (2 Pages) ..... 6-32

10 Table 6-3. Detailed Analysis Summary for Alternative 4 – Capping. (2 Pages) ..... 6-34

11 Table 8-1. Preferred Alternative for the Representative Site 216-A-29 Ditch. .... 8-9

12 Table 8-2. Preferred Alternative for the Representative Site 216-B-63 Trench. .... 8-10

13 Table 8-3. Preferred Alternative for the Representative Site 216-S-10 Ditch. .... 8-11

14 Table 8-4. Preferred Alternative for the Representative Site 216-10-Pond and Analogous  
15 Waste Sites. .... 8-12

16 Table 8-5. Preferred Alternative for the Representative Site 216-11 Pond. .... 8-13

17 Table 8-6. Post-Record of Decision Sampling. .... 8-14

18

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2

## TERMS

1		
2	95%UCL	95th upper confidence level
3	ARAR	applicable or relevant and appropriate requirement
4	BCG	biota concentration guide
5	BG	background
6	bgs	below ground surface
7	BRA	baseline risk assessment
8	c/min	counts per minute
9	CERCLA	<i>Comprehensive Environmental Response, Compensation, and Liability Act of 1980</i>
10		
11	CFR	<i>Code of Federal Regulations</i>
12	COC	contaminant of concern
13	COPC	contaminant of potential concern
14	COPEC	contaminant of potential ecological concern
15	CSM	conceptual site model
16	DOE	U.S. Department of Energy
17	DW	drinking water
18	ECO	Ecological
19	Eco	Ecological
20	Ecology	Washington State Department of Ecology
21	Eco-SSL	ecological soil-screening level
22	ELACR	excess lifetime added cancer risk
23	ELCR	excess lifetime cancer risk
24	EPA	U.S. Environmental Protection Agency
25	EPC	exposure-point concentration
26	ERDF	Environmental Restoration Disposal Facility
27	ET	evapotranspiration
28	foc	fractional organic carbon
29	FS	feasibility study
30	FY	fiscal year
31	GPC	groundwater protection concentration
32	GRA	general response action
33	GW	groundwater
34	HCP	<i>Final Hanford Comprehensive Land-Use Plan - Environmental Impact Statement (DOE/EIS-0222-F)</i>
35		
36	HH	human health
37	HI	hazard index
38	HQ	hazard quotient
39	HSRAM	<i>Hanford Site Risk Assessment Manual</i>
40	IC	institutional control
41	IESC	industrial ecological-screening concentration

1	Implementation Plan	<i>200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program (DOE/RL-98-28)</i>
2		
3		
4	IRIS	<i>Integrated Risk Information System</i>
5	$K_d$	distribution coefficient
6	MCL	maximum contaminant level
7	MESC	maintain existing soil cover
8	MNA	monitored natural attenuation
9	mrem	millirem
10	N/A	not applicable
11	NCP	“National Oil and Hazardous Substances Pollution Contingency Plan” (40 CFR 300)
12		
13	NEPA	<i>National Environmental Policy Act of 1969</i>
14	NMLS	Neutron-Moisture Logging System
15	NOAEL	no observed adverse-effect level
16	NPL	“National Priorities List” (40 CFR 300, Appendix B)
17	OU	operable unit
18	PNNL	Pacific Northwest National Laboratory
19	PRG	preliminary remediation goal
20	PUREX	Plutonium-Uranium Extraction Plant
21	RAIS	<i>Risk Assessment Information System</i>
22	RAO	remedial action objective
23	RCRA	<i>Resource Conservation and Recovery Act of 1976</i>
24	RDR/RAWP	remedial design report/remedial action work plan
25	REDOX	Reduction-Oxidation Plant
26	RESRAD	RESidual RADioactivity (dose model)
27	RfD	chronic reference dose
28	$RfD_{oral}$	oral chronic reference dose
29	RI	remedial investigation
30	RI/FS	remedial investigation/feasibility study
31	RI BRA	remedial investigation baseline risk assessment
32	RI Report	<i>Remedial Investigation Report for the 200-CS-1 Chemical Sewer Group Operable Unit (DOE/RL-2004-17)</i>
33		
34	RL	U.S. Department of Energy, Richland Operations Office
35	ROD	record of decision
36	RTD	removal, treatment, and disposal
37	SESOIL	Seasonal Soil Compartment Model
38	SGLS	Spectral Gamma-Ray Logging System
39	SLERA	screening-level ecological risk assessment
40	TBP	tributyl phosphate
41	TMV	toxicity, mobility, or volume through treatment
42	TPH	total petroleum hydrocarbon
43	Tri-Parties	U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Ecology
44		
45	Tri-Party Agreement	<i>Hanford Federal Facility Agreement and Consent Order</i>

DOE/RL-2005-63 DRAFT A

1	TRU	waste materials contaminated with more than 100 nCi/g of
2		transuranic materials having half-lives longer than 20 years)
3	TSD	treatment, storage, and/or disposal (unit)
4	UPR	unplanned release
5	UUSC	unrestricted use screening concentration
6	WAC	<i>Washington Administrative Code</i>
7	WIDS	<i>Waste Information Data System</i>

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2

## METRIC CONVERSION CHART

Into Metric Units			Out of Metric Units		
<i>If You Know</i>	<i>Multiply By</i>	<i>To Get</i>	<i>If You Know</i>	<i>Multiply By</i>	<i>To Get</i>
<b>Length</b>			<b>Length</b>		
inches	25.4	Millimeters	millimeters	0.039	inches
inches	2.54	Centimeters	centimeters	0.394	inches
feet	0.305	Meters	meters	3.281	feet
yards	0.914	Meters	meters	1.094	yards
miles	1.609	Kilometers	kilometers	0.621	miles
<b>Area</b>			<b>Area</b>		
sq. inches	6.452	sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.093	sq. meters	sq. meters	10.76	sq. feet
sq. yards	0.0836	sq. meters	sq. meters	1.196	sq. yards
sq. miles	2.6	sq. kilometers	sq. kilometers	0.4	sq. miles
acres	0.405	Hectares	hectares	2.47	acres
<b>Mass (weight)</b>			<b>Mass (weight)</b>		
ounces	28.35	Grams	grams	0.035	ounces
pounds	0.454	Kilograms	kilograms	2.205	pounds
ton	0.907	metric ton	metric ton	1.102	ton
<b>Volume</b>			<b>Volume</b>		
teaspoons	5	Milliliters	milliliters	0.033	fluid ounces
tablespoons	15	Milliliters	liters	2.1	pints
fluid ounces	30	Milliliters	liters	1.057	quarts
cups	0.24	Liters	liters	0.264	gallons
pints	0.47	Liters	cubic meters	35.315	cubic feet
quarts	0.95	Liters	cubic meters	1.308	cubic yards
gallons	3.8	Liters			
cubic feet	0.028	cubic meters			
cubic yards	0.765	cubic meters			
<b>Temperature</b>			<b>Temperature</b>		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius	Celsius	multiply by 9/5, then add 32	Fahrenheit
<b>Radioactivity</b>			<b>Radioactivity</b>		
picocuries	37	Millibecquerel	millibecquerel	0.027	picocuries

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## CHAPTER 1.0 TERMS

1		
2	ARAR	applicable or relevant and appropriate requirement
3	CERCLA	<i>Comprehensive Environmental Response, Compensation, and</i>
4		<i>Liability Act of 1980</i>
5	CFR	<i>Code of Federal Regulations</i>
6	DOE	U.S. Department of Energy
7	Ecology	Washington State Department of Ecology
8	EPA	U.S. Environmental Protection Agency
9	FS	feasibility study
10	GRA	general response action
11	Implementation Plan	<i>200 Areas Remedial Investigation/Feasibility Study</i>
12		<i>Implementation Plan – Environmental Restoration Program,</i>
13		<i>DOE/RL-98-28</i>
14	NPL	“National Priorities List” (40 CFR 300, Appendix B)
15	OU	operable unit
16	PUREX	Plutonium-Uranium Extraction (Plant or process)
17	RCRA	<i>Resource Conservation and Recovery Act of 1976</i>
18	RDR/RAWP	remedial design report/remedial action work plan
19	RAO	remedial action objective
20	REDOX	Reduction-Oxidation (Plant or process)
21	RI Report	<i>Remedial Investigation Report for the 200-CS-1 Chemical Sewer</i>
22		<i>Group Operable Unit (DOE/RL-2004-17)</i>
23	ROD	record of decision
24	RI	remedial investigation
25	RL	U.S. Department of Energy, Richland Operations Office
26	SESOIL	Seasonal Soil Compartment Model
27	Tri-Parties	U.S. Department of Energy, U.S. Environmental Protection
28		Agency, and Washington State Department of Ecology
29	Tri-Party Agreement	<i>Hanford Federal Facility Agreement and Consent Order</i>
30	WAC	<i>Washington Administrative Code</i>

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2

## 1.0 INTRODUCTION

1  
2 The Hanford Site, managed by the U.S. Department of Energy (DOE), encompasses  
3 approximately 1,517 km<sup>2</sup> (586 mi<sup>2</sup>) in the Columbia Basin of south-central Washington State.  
4 In 1989, the U.S. Environmental Protection Agency (EPA) placed the 100, 200, 300, and  
5 1100 Areas of the Hanford Site on the National Oil and Hazardous Substances Pollution  
6 Contingency Plan (NCP),” Appendix B, “National Priorities List” (NPL) (40 *Code of Federal*  
7 *Regulations* [CFR] 300) pursuant to the *Comprehensive Response, Compensation, and Liability*  
8 *Act of 1980* (CERCLA). The 200 Area NPL site consists of the 200 West Area and 200 East  
9 Area (Figure 1-1), which contain waste management facilities and inactive irradiated fuel  
10 reprocessing facilities, and the 200 North Area, formerly used for interim storage and staging of  
11 irradiated fuel. Several waste sites in the 600 Area, which are located near the 200 Areas, also  
12 are included in the 200 Area NPL site. The 200 Area consists of approximately 850 waste sites  
13 organized into 23 waste site groups, called operable units (OU). The 200-CS-1 Chemical Sewer  
14 Group OU is the focus of this Feasibility Study (FS).

15 The process for characterization and remediation of waste sites at the Hanford Site is addressed  
16 in the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology  
17 et al. 1989). In 2002, the U.S. Department of Energy, Richland Operations Office (RL), the  
18 EPA, and the Washington State Department of Ecology (Ecology) (the Tri-Parties) renegotiated  
19 the 200 Areas waste site cleanup milestones under the Tri-Party Agreement; the results of these  
20 negotiations are documented in Tri-Party Agreement change forms M-13-02-01, M-15-02-01,  
21 M-16-02-01, and M-20-02-01.

22 The 200-CS-1 Chemical Sewer Group Operable Unit (200-CS-1 OU) consists of five waste sites.  
23 The waste unit designations and their aliases are as follows:

- 24     • 216-A-29 Ditch, Snow’s Canyon, Plutonium-Uranium Extraction (PUREX) Plant  
25        Chemical Sewer
- 26     • 216-B-63 Trench, B Plant Chemical Sewer
- 27     • 216-S-10 Ditch, 202 Chemical Sump #1 and Ditch, Chemical Sewer Trench, Open Ditch  
28        to the Chemical Sewer Trench
- 29     • 216-S-10 Pond, 202 Chemical Sump #1 and Ditch, Chemical Sewer Trench
- 30     • 216-S-11 Pond, 202-S Chemical Sump #2, Chemical Sewer Trenches, 216-S-11 Swamp.

31 The characterization and remediation of waste sites at the Hanford Site are addressed in the  
32 Tri-Party Agreement (Ecology et al. 1989). This agreement addresses the integration of cleanup  
33 programs under CERCLA and the *Resource Conservation and Recovery Act of 1976* (RCRA) to  
34 provide a standard approach to directing cleanup activities in a consistent manner and to ensure  
35 that applicable regulatory requirements are met.

## 1 1.1 REMEDIAL INVESTIGATION ACTIVITIES

2 DOE/RL-2004-17, *Remedial Investigation Report for the 200-CS-1 Chemical Sewer Group*  
3 *Operable Unit* (RI Report), focuses on the characterization of these waste sites. The  
4 216-S-10 Ditch and 216-S-10 Pond are considered one RCRA treatment, storage, and/or disposal  
5 (TSD) unit.

- 6 • 216-A-29 Ditch
- 7 • 216-B-63 Trench
- 8 • 216-S-10 Ditch
- 9 • 216-S-10 Pond.

10 All of these sites are RCRA TSD units. The 216-S-10 Ditch and 216-S-10 Pond are described  
11 together on one RCRA Part A Permit Application form (216-S-10 Ditch and Pond) as one TSD  
12 unit.

13 The RI was conducted from November 1999 to April 2003 in accordance with the Work Plan  
14 (DOE/RL-99-44, *200-CS-1 Operable Unit RI/FS Work Plan and RCRA TSD Unit Sampling*  
15 *Plan*). Supplemental data for the 216-A-29 Ditch were collected in July 1998 and included in  
16 this RI evaluation. In addition, supplemental data for the 216-B-63 Trench were collected in  
17 January 1998.

18 Data were collected to characterize the nature and vertical extent of chemical and radiological  
19 contamination and the physical conditions in the vadose zone underlying the historical  
20 boundaries of the four waste sites. Twelve test pits were excavated and sampled to determine the  
21 vertical and lateral extent of contamination within the area historically defined as the waste site  
22 boundary. The distribution of the test pits is as follows:

- 23 • Three test pits at the 216-A-29 Ditch
- 24 • Two test pits at the 216-B-63 Trench
- 25 • Three test pits at the 216-S-10 Ditch
- 26 • Four test pits at the 216-S-10 Pond.

27 In addition, four boreholes, one at each representative site, were drilled, sampled, and logged  
28 with a high-resolution Spectral Gamma-Ray Logging System to provide continuous vertical logs  
29 of gamma-emitting radionuclides and were logged with a Neutron Moisture-Logging System to  
30 identify moisture changes. Two additional existing wells, 299-W26-6 and 699-32-77, were  
31 logged with a high-resolution Spectral Gamma-Ray Logging System. Historical data from 1998  
32 in two additional test pits (Areas 8 and 9 at the 216-A-29 Ditch) and one additional borehole  
33 (Borehole B8079 at the 216-B-63 Trench) also were evaluated. These activities are summarized  
34 in BHI-01651, *200-CS-1 Operable Unit Test Pit Summary Report for Fiscal Year 2002*;  
35 WMP-17755, *200-CS-1 Operable Unit Field Summary Report for Fiscal Year 2003*; and  
36 PNNL-13198, *Borehole Data Package for the 216-S-10 Pond and Ditch Well 299-W26-13*.

37 The waste sites are contained in two areas shown in Figures 1-2 and 1-3. The 200-CS-1 OU  
38 waste sites primarily are surface manmade ponds, ditches, or trenches and were created to  
39 dispose of the chemical sewer discharges from the separation/concentration processes (e.g., those  
40 at the PUREX Plant and the Reduction-Oxidation (REDOX) Plant, and the B Plant

1 cesium/strontium recovery operations). Early chemical sewer wastes were combined with larger  
2 cooling water and steam condensate streams during the bismuth phosphate and uranium recovery  
3 processes and were discharged to ponds and ditches. The 200-CS-1 OU consists primarily of  
4 waste sites that received unknown but probably dilute quantities of inorganic and/or organic  
5 chemicals. Radionuclide inventories are very small to negligible, although uranium is present at  
6 several sites, particularly the 216-S-10 Ditch, which received an estimated 215 kg of uranium in  
7 an unplanned release. The process history for the 200-CS-1 OU waste sites is described in detail  
8 in the Work Plan (DOE/RL-99-44).

## 9 1.2 FEASIBILITY STUDY PURPOSE

10 The purpose of this FS is to develop and evaluate alternatives for remediation of the waste sites  
11 in the 200-CS-1 OUs. This FS will refine preliminary applicable or relevant and appropriate  
12 requirements (ARAR) (Appendix B), remedial action objectives (RAO), and general response  
13 actions (GRA) initially identified in DOE/RL-98-28, *200 Areas Remedial*  
14 *Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*  
15 (Implementation Plan). Technology screening and alternative development initially performed  
16 in the Implementation Plan will be reviewed and refined, as necessary, based on the site-specific  
17 data generated in the 200-CS-1 OU RI and other sources of existing information. The  
18 alternatives considered provide a range of potential response actions (e.g., no action, remove and  
19 dispose, containment) that are appropriate to address site-specific risk conditions. The  
20 alternatives will be evaluated against the CERCLA criteria. The Tri-Parties will use this FS as  
21 the basis for selecting a remedy to mitigate potential risks to human health and the environment.  
22 A preferred remedial alternative (or alternatives) will be presented to the public in a proposed  
23 plan for review and comment.

24 A secondary purpose of this FS is to support the closure of the four waste sites described as three  
25 TSD units. Information supporting the closure of these TSD units is included in existing  
26 200-CS-1 RI/FS documents, including the Work Plan (DOE/RL-99-44) and the RI Report  
27 (DOE/RL-2004-17) and the closure plans in Appendix E. Information to support the closure also  
28 is included in this FS, and will be included in the proposed plan. The future remedial design  
29 report/remedial action work plan (RDR/RAWP), which will be prepared following the record of  
30 decision (ROD) for these waste sites, will provide additional details to support the closure. The  
31 closure will be integrated into the 200-CS-1 OU CERCLA process and documented in  
32 WA7890008967, *Hanford Facility Resource Conservation and Recovery Act Permit, Dangerous*  
33 *Waste Portion, Revision 8, for the Treatment, Storage, and Disposal of Dangerous Waste*  
34 (Permit).

35 Closure plans for these TSD units have been prepared. The 216-B-63 Trench and  
36 216-S-10 Ditch and Pond closure plans will be submitted apart from the FS. These TSD unit  
37 closure can be clean closed as is without any remediation actions coordination needed with the  
38 FS. The 216-A-29 Ditch closure plan is attached to this FS because remedial actions are  
39 necessary to clean close this unit (Appendix E). The information contained in the closure plans  
40 will be used to prepare the Permit modifications. The permit modification will consist of the  
41 addition of a chapter to Part V of the Permit, which will consist of two parts: the first part will  
42 include permit conditions necessary to further explain or modify the closure plan and the second

1 part, which will be the actual closure plan text. The permit conditions and closure plan in the  
2 Part V will become an enforceable part of the Permit. If changes to the chapter and attachment  
3 are needed, they will be subject to the Permit modification process.

4 The waste sites identified as TSD units are included in the Tri-Party Agreement (Ecology et  
5 al. 1989) as a land-disposal unit. Information on the TSD unit is provided in the Work Plan  
6 (DOE/RL-99-44), the RI Report (DOE/RL-2004-17), and the closure plans contained in  
7 Appendix E.

### 8 **1.3 SCOPE**

9 Cleanup of the 200-CS-1 OU waste sites is a source control action that addresses contaminated  
10 soil and structures (e.g., concrete, pipelines) associated with ponds, ditches, trenches, and  
11 unplanned release sites. Other than the requirement for the source control action to be protective  
12 of groundwater and surface water, the scope does not include remediation of groundwater that  
13 may be beneath these waste sites. Contaminated groundwater is addressed by the 200-UP-1,  
14 200-BP-5, and 200-PO-1 OUs.

### 15 **1.4 REPORT ORGANIZATION**

16 The essential elements of the FS process are presented in Chapters 1.0 through 8.0, and are  
17 summarized as follows.

- 18 • Chapter 1.0 presents the purpose, scope, and regulatory framework for the FS, as well as  
19 this overview of report organization.
- 20 • Chapter 2.0 presents descriptions of the physical setting, waste sites, and site  
21 contamination; compares analogous sites with the representative sites; and summarizes  
22 risk assessments.
- 23 • Chapter 3.0 discusses land-use assumptions and develops the overall cleanup objectives  
24 and media-specific goals for the waste sites.
- 25 • Chapter 4.0 refines the technologies identified for these OUs and waste sites in the  
26 Implementation Plan (DOE/RL-98-28) by evaluating new information on existing  
27 technologies or promising and relevant emerging technologies. The technologies are  
28 broadly screened for applicability to the waste sites in the FS. Screening considerations  
29 include effectiveness (likelihood of meeting RAOs for the specific contaminants present  
30 at the site), implementability relative to specific site conditions, status of technology  
31 development, and relative cost.
- 32 • Chapter 5.0 describes the remedial alternative development process, initially conducted  
33 as part of the Implementation Plan (DOE/RL-98-28) development, and uses that  
34 information in concert with site-specific data from the RI to refine the remedial  
35 alternatives to be carried forward for detailed and comparative analyses.

- 1 • Chapter 6.0 presents a detailed analysis of each of the remedial alternatives against seven  
 2 CERCLA evaluation criteria (protection of human health and the environment; regulatory  
 3 compliance; long-term effectiveness; reduction of toxicity, mobility, or volume;  
 4 short-term effectiveness; implementability; and cost) as defined in EPA/540/G-89/004,  
 5 *Guidance for Conducting Remedial Investigations and Feasibility Studies under*  
 6 *CERCLA, (Interim Final)*. This chapter also assesses each alternative relative to *National*  
 7 *Environmental Policy Act of 1969* values, as required by DOE policy.
- 8 • Chapter 7.0 presents the comparative analysis of the six remedial alternatives and  
 9 identifies their relative advantages and disadvantages, based on the seven CERCLA  
 10 evaluation criteria. The results of this analysis provide a basis for selecting a remedial  
 11 alternative for each representative waste site and its analogous waste sites.
- 12 • Chapter 8.0 summarizes the conclusions of the FS. This chapter also presents the  
 13 preferred alternatives and path forward for remediation of the 200-CS-1 OU waste sites.
- 14 • Chapter 9.0 contains all references for the main body of the report; each appendix  
 15 contains its own reference section.
- 16 • Appendix A includes current photographs of the waste sites showing the amount and type  
 17 of vegetation present on and/or around the waste sites.
- 18 • Appendix B presents an analysis of regulatory requirements and available guidance with  
 19 respect to the 200-CS-1 OU.
- 20 • Appendix C presents the Native American risk evaluation, including the methodology,  
 21 results, and uncertainties with data.
- 22 • Appendix D presents the basis for the comparative cost estimates. Detailed cost  
 23 estimates, including applicable alternatives and derived costs for analogous sites, are  
 24 provided for each representative site.
- 25 • Appendix E presents the closure plan for the TSD: 216-A-29 Ditch.
- 26 • Appendix F presents information on the Seasonal Soil Compartment Model (SESOIL)  
 27 and a crosswalk to *Washington Administrative Code* (WAC) 173-340-747(8), "Deriving  
 28 Soil Concentrations for Ground Water Protection," "Alternative Fate and Transport  
 29 Models," as allowed by Method C at WAC 173-340-745(5)(b)(iii)(A), "Ground Water  
 30 Protection," alternative methods.

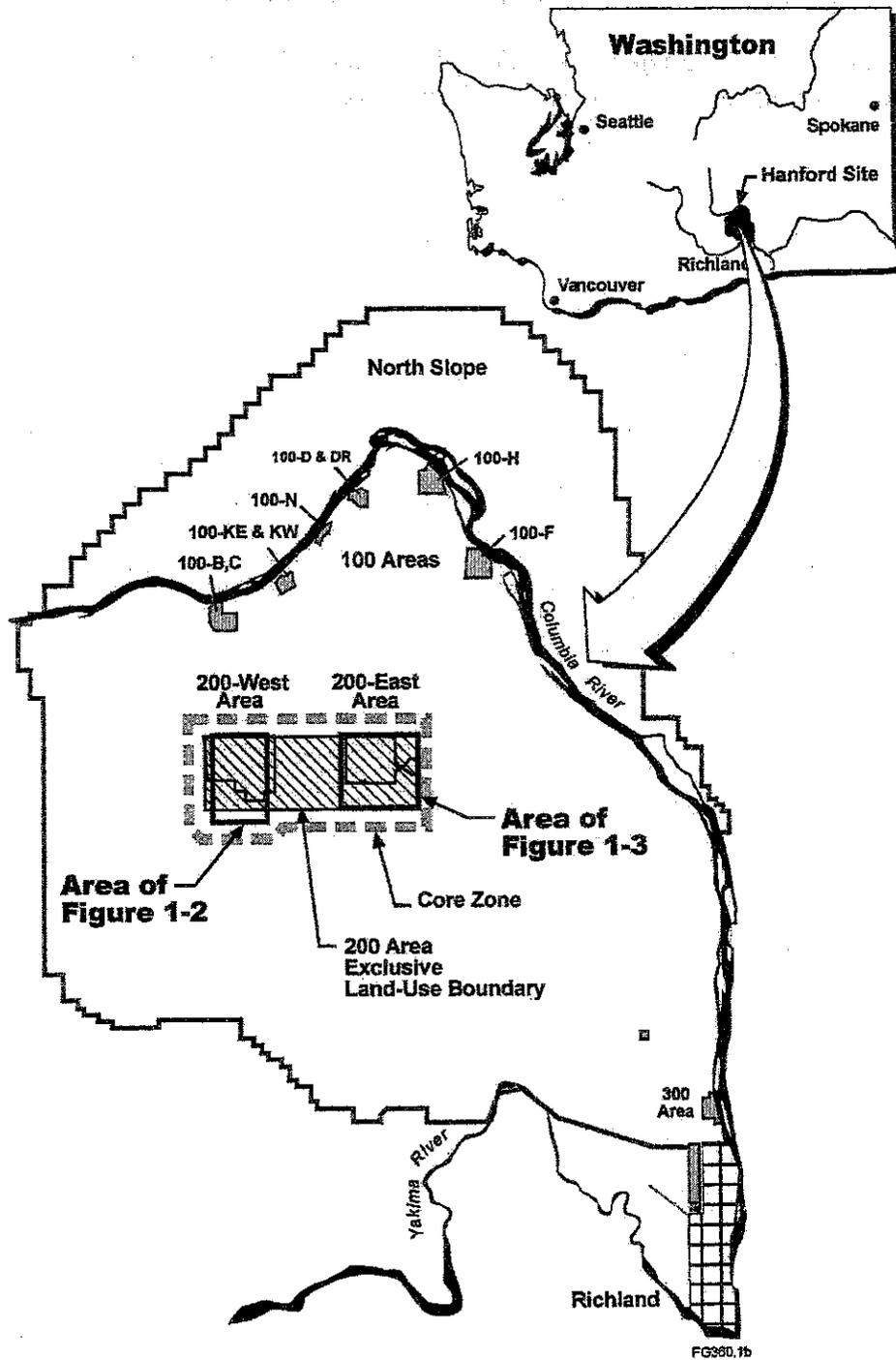
## 1 1.5 REFERENCES

- 2 40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan,"  
3 Appendix B, "National Priorities List," Title 40, *Code of Federal Regulations*, Part 300,  
4 as amended.
- 5 BHI-01651, 2002, *200-CS-1 Operable Unit Test Pit Summary Report for Fiscal Year 2002*,  
6 Rev. 0, Bechtel Hanford, Inc., Richland, Washington.
- 7 *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*,  
8 42 USC 9601, et seq.
- 9 DOE/RL-98-28, 1999, *200 Areas Remedial Investigation/Feasibility Study Implementation*  
10 *Plan – Environmental Restoration Program*, Rev. 0, U.S. Department of Energy,  
11 Richland Operations Office, Richland, Washington.
- 12 DOE/RL-99-44, 2000, *200-CS-1 Operable Unit RI/FS Work Plan and RCRA TSD Unit Sampling*  
13 *Plan*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland,  
14 Washington.
- 15 DOE/RL-2004-17, 2004, *Remedial Investigation Report for the 200-CS-1 Chemical Sewer*  
16 *Group Operable Unit*, Rev. 0, U.S. Department of Energy, Richland Operations Office,  
17 Richland, Washington.
- 18 Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order*,  
19 2 vols., Washington State Department of Ecology, U.S. Environmental Protection  
20 Agency, and U.S. Department of Energy, Olympia, Washington, as amended.
- 21 EPA/540/G-89/004, 1988, *Guidance for Conducting Remedial Investigations and Feasibility*  
22 *Studies under CERCLA, (Interim Final)*, OSWER 9355.3-01, Office of Solid Waste and  
23 Emergency Response, U.S. Environmental Protection Agency, Washington, D.C.
- 24 *National Environmental Policy Act of 1969*, 42 USC 4321, et seq.
- 25 PNNL-13198, 2000, *Borehole Data Package for the 216-S-10 Pond and Ditch*  
26 *Well 299-W26-13*, Rev. 0, Pacific Northwest National Laboratory, Richland, Washington.
- 27 *Resource Conservation and Recovery Act of 1976*, 42 USC 6901, et seq.
- 28 WA7890008967, 2004, *Hanford Facility Resource Conservation and Recovery Act Permit*,  
29 *Dangerous Waste Portion, Revision 8, for the Treatment, Storage, and Disposal of*  
30 *Dangerous Waste*, Washington State Department of Ecology, Richland, Washington, as  
31 amended.
- 32 WAC 173-340-745(5)(b)(iii)(A), "Soil Cleanup Standards for Industrial Properties," "Method C  
33 Industrial Soil Cleanup Levels," "Standard Method C Industrial Soil Cleanup Levels,"  
34 "Human Health Protection," "Ground Water Protection," *Washington Administrative*  
35 *Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

DOE/RL-2005-63 DRAFT A

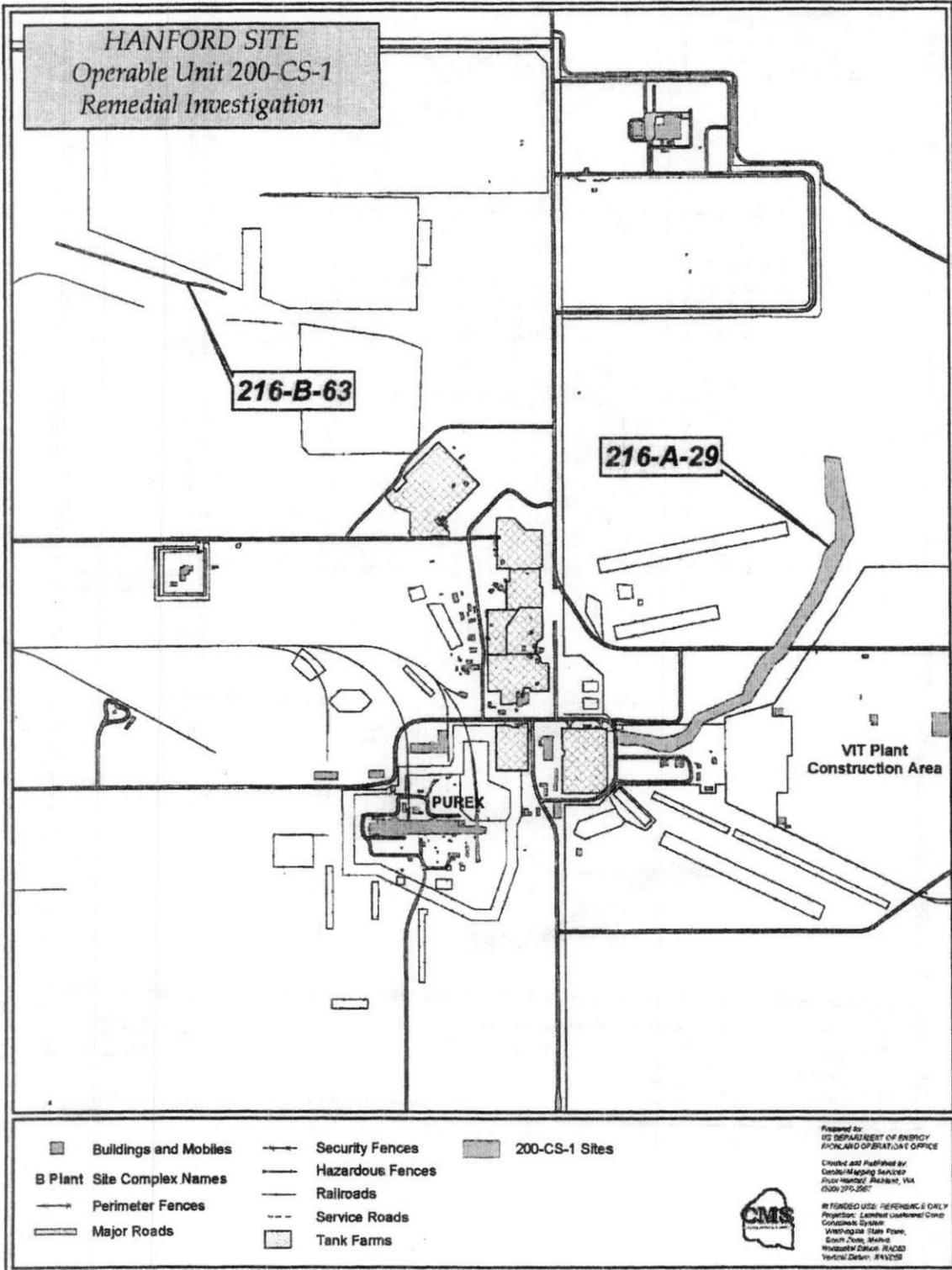
- 1 WAC 173-340-747(8), "Deriving Soil Concentrations for Ground Water Protection,"
- 2 "Alternative Fate and Transport Models," *Washington Administrative Code*, as amended,
- 3 Washington State Department of Ecology, Olympia, Washington.
  
- 4 WMP-17755, 2003, *200-CS-1 Operable Unit Field Summary Report for Fiscal Year 2003*,
- 5 Rev. 0, Fluor Hanford, Inc., Richland, Washington.

1 Figure 1-1. Location of the Hanford Site and the 200-CS-1 Operable Unit Waste Sites.



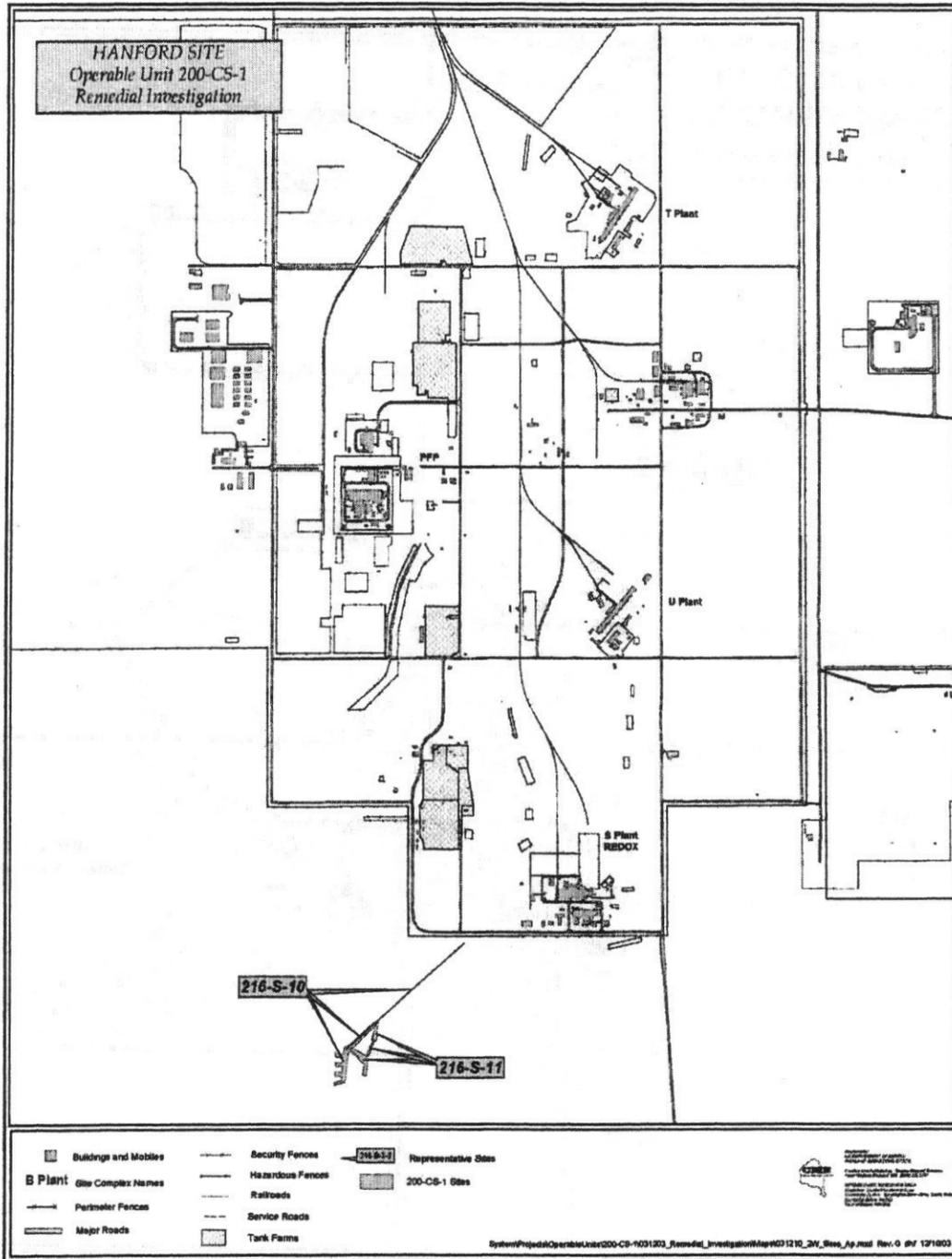
2

1 Figure 1-2. Location of the 200-CS-1 Operable Unit Waste Sites in the 200 East Area.



system\Projects\OperableUnits\200CS1\031201\_Webb\_Remedia\_Investigation\Map\031211\_2E\_Sites\_Ap.mxd Rev. 0 dtd 12/1/03

Figure 1-3. Location of the 200-CS-1 Operable Unit Waste Sites in the 200 West Area.



## CHAPTER 2.0 TERMS

1		
2	95%UCL	95th upper confidence level
3	BCG	biota concentration guide
4	BG	background
5	bgs	below ground surface
6	BRA	baseline risk assessment
7	c/min	counts per minute
8	CERCLA	<i>Comprehensive Environmental Response, Compensation, and</i>
9		<i>Liability Act of 1980</i>
10	COPC	contaminant of potential concern
11	COPEC	contaminant of potential ecological concern
12	CSM	conceptual site model
13	DOE	U.S. Department of Energy
14	DW	drinking water
15	ECO	Ecological
16	Ecology	Washington State Department of Ecology
17	ELACR	excess lifetime added cancer risk
18	ELCR	excess lifetime cancer risk
19	Eco-SSL	ecological soil-screening level
20	EPA	U.S. Environmental Protection Agency
21	EPC	exposure-point concentration
22	foc	fractional organic carbon
23	FS	feasibility study
24	FY	fiscal year
25	GPC	groundwater protection concentration
26	GW	groundwater
27	HI	hazard index
28	HQ	hazard quotient
29	IESC	industrial ecological-screening concentration
30	IRIS	<i>Integrated Risk Information System</i>
31	$K_d$	distribution coefficient
32	MCL	maximum contaminant level
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35	NOAEL	no observed adverse-effect level
36	OU	operable unit
37	PNNL	Pacific Northwest National Laboratory
38	PRG	preliminary remediation goal
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40	RAIS	<i>Risk Assessment Information System</i>
41	REDOX	Reduction-Oxidation Plant
42	RESRAD	RESidual RADioactivity (dose model)
43	RfD	chronic reference dose
44	RfD <sub>oral</sub>	oral chronic reference dose
45	RI	remedial investigation

DOE/RL-2005-63 DRAFT A

1	RI/FS	remedial investigation/feasibility study
2	RI BRA	remedial investigation baseline risk assessment
3	SGLS	Spectral Gamma-Ray Logging System
4	SLERA	screening-level ecological risk assessment
5	TPH	total petroleum hydrocarbon
6	TBP	tributyl phosphate
7	Tri-Parties	U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Ecology
8		
9	UPR	unplanned release
10	UUSC	unrestricted use screening concentration
11	WAC	<i>Washington Administrative Code</i>
12	WIDS	<i>Waste Information Data System</i>
13		

## 2.0 BACKGROUND INFORMATION

### 2.1 OPERABLE UNITS BACKGROUND AND HISTORY

This chapter discusses the background and history of waste sites within the 200-CS-1 Operable Unit (OU), including descriptions of the liquid waste-generating processes, the physical setting, natural resources, cultural resources, socioeconomics, representative sites, the nature and extent of contamination at individual waste sites, and a risk evaluation summary.

The four representative sites to be characterized for the 200-CS-1 OU are identified in DOE/RL-96-81, *Waste Site Grouping for 200 Areas Soil Investigations*; DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program (Implementation Plan)*; and BHI-01276, *200-CS-1 Operable Unit DQO Summary Report*. These representative sites are the 216-A-29 Ditch, the 216-B-63 Trench, the 216-S-10 Ditch, and the 216-S-10 Pond. The representative sites were selected for evaluation in a remedial investigation (RI) because of similar effluent volumes and contaminant inventories. The waste sites received an unknown but probable dilute concentration of inorganic and/or organic chemicals. The radionuclide inventories are likely very small to negligible, although several sites contain a uranium component.

Characterization of the four representative sites was presented in DOE/RL-2004-17, *Remedial Investigation Report for the 200-CS-1 Chemical Sewer Group Operable Unit*. This chapter also summarizes the available information for analogous waste sites (i.e., sites that are not identified as representative sites within the OU). This information is presented for correlating analogous sites with representative sites. Relationships between analogous and representative sites are developed to support the evaluation of remedial alternatives by application of the analogous site approach described in this chapter and in the Implementation Plan (DOE/RL-98-28).

#### 2.1.1 Buildings and Ancillary Facilities

The Hanford Site, established in 1943, originally was designed, built, and operated to produce plutonium for nuclear weapons using production reactors and chemical reprocessing plants. In March 1943, construction began on three reactor facilities (B, D, and F Reactors) in the 100 Areas and three chemical processing facilities (B, T, and U Plants) in the 200 Areas. Operations in the 200 East and West Areas mainly were related to separation of special nuclear materials from spent nuclear fuel (i.e., fuel withdrawn from a nuclear reactor following irradiation). Operations in the 200 Areas took place in eight main processing areas:

- 200 North Area – The 200 North Area was used for temporary storage of irradiated nuclear fuel and contaminated equipment.
- B Plant – In the B Plant, the bismuth phosphate process was used to separate plutonium from irradiated fuel rods. Recovery of cesium, strontium, and rare earth metals also was carried out at B Plant.

- 1 • S Plant – In the S Plant, the reduction/oxidation (REDOX) process was used to separate  
2 plutonium from irradiated fuel rods.
- 3 • T Plant – In the T Plant, the bismuth phosphate process was used to separate plutonium  
4 from irradiated fuel rods.
- 5 • A Plant – In the Plutonium-Uranium Extraction (PUREX) Plant, the tributyl phosphate  
6 (TBP) process was used to separate plutonium from irradiated fuel rods.
- 7 • C Plant – In the Hot Semiworks Plant, pilot-plant tests of the REDOX process were  
8 conducted before startup of S Plant.
- 9 • U Plant – In the U Plant, the TBP process was used to recover uranium from  
10 bismuth-phosphate process wastes.
- 11 • Z Plant – In the Z Plant, dibutyl butyl phosphate, TBP, carbon tetrachloride, and acids  
12 were used in the americium and plutonium separation and recovery process.

13 The following sections identify the buildings and processes involved in discharging effluent to  
14 the 200-CS-1 OU waste sites.

#### 15 2.1.2 Operable Unit Description

16 Waste sites in the 200-CS-1 OU received liquid waste streams (principally nonradioactive dilute  
17 chemicals) from B Plant, A Plant (PUREX), and S Plant (REDOX). Virtually every process step  
18 in any of the separations and radionuclide recovery projects required addition of solid chemicals,  
19 or more routinely, pre-mixed chemical solutions. Liquid concentrated nitric, phosphoric, and  
20 formic acids; sodium hydroxide; and aluminum nitrate were taken to the canyon buildings in  
21 railcar quantities and unloaded into the 211 Chemical Storage Tank Farm at each separation  
22 building. Most other chemical solutions were mixed on site to pre-established concentrations  
23 and volumes in the Aqueous or Solvent Makeup sections of the plant. Dry chemicals were  
24 weighed and added to demineralized water, also produced in the plants. Liquids such as acids  
25 and caustics were piped into large tanks in the same area.

26 As described in the introduction, chemical sewer wastes consisted primarily of makeup tank  
27 rinses, with lesser quantities of off-specification batches of chemicals, or overflow chemicals  
28 from tanks during aqueous makeup. Improper valving at outdoor chemical storage tanks during  
29 chemical unloading or transfer operations also may have yielded chemical sewer wastes.

30 The construction of separate waste sites for chemical sewer wastes generally emerged as a  
31 development in the REDOX Plant's waste treatment and later was applied to the PUREX and  
32 waste fractionation processes. These wastes were discharged to separate ditches or ditch/pond  
33 systems.

34 In almost all respects, the inventory of contaminants in these waste streams is difficult to assess  
35 from process knowledge. Only incomplete records of wastes disposed to sites in this waste  
36 group are known. However, several sites were issued *Resource Conservation and Recovery Act*

1 of 1976 (RCRA) Part A Permits based on reported, but unreferenced, waste discharge  
2 inventories. Most of the chemicals disposed to these streams are expected to have broken down  
3 or reacted in the environment and are expected to be largely undetectable. Some inorganic  
4 compounds (e.g., cadmium, chromium, and nitrate) could remain sufficiently intact and would be  
5 detectable in the environment. Except for chlorinated hydrocarbons, most organic compounds  
6 and reactive inorganic compounds are expected to have been biodegraded or to have reacted in  
7 the environment.

8 In all cases, the waste streams were run in a non-contact manner, that is, a barrier separated the  
9 liquids in this category from contaminated process liquids, with little consequent potential for  
10 routine radiological contamination. Additional background information on the history of  
11 operations, important waste-generating processes, and liquid waste disposal practices at the  
12 various processing areas is provided in Section 3.2 and Appendix H of the Implementation Plan  
13 (DOE/RL-98-28).

14 Over time, coils that circulated steam and cooling water inside chemical process tanks were  
15 known to develop pinholes and hairline cracks because of the corrosive chemicals and high  
16 thermal gradients in these tanks. These minor defects usually did not lead to contamination of  
17 the steam and cooling water because the pressure in the pipe coils was greater than the pressure  
18 in the process or condenser vessels; however, on occasions when the pressure in the coils was  
19 reduced or suspended, minor leakage through the flaws led to waste stream contamination.  
20 Other accidental releases from causes such as operator error also have contributed to  
21 contamination of the effluents discharged to the waste facilities in this OU.

#### 22 2.1.2.1 216-A-29 Ditch

23 The 216-A-29 Ditch received discharge from the PUREX Plant chemical sewer. The ditch was  
24 uncovered and unlined and followed the natural topography. The ditch originated from the  
25 southeastern side of the A Tank Farm (east of the AP Tank Farm) outside the 200 East Area  
26 perimeter fence. The ditch was estimated to be 1,220 m (4,000 ft) long and 1.8 m (6 ft) wide and  
27 varied from 0.6 to 4.6 m (2 to 15 ft) deep. Structures in the 216-A-29 Ditch included a concrete  
28 spillway for the first 3 m (10 ft) from the point of inflow, a culvert under the 200 East Area  
29 perimeter road, and a wood platform and slide gate for flow control at the two earthen dams.  
30 The head end of the ditch was modified in 1983 to allow the construction of the AP Tank Farm.  
31 The end of the ditch connects to the 216-B-3-3 Ditch and finally to the 216-B-3 Pond.

32 The following waste streams, which are summarized from the stream-specific report  
33 (WHC-EP-0342, Addendum 2, *PUREX Plant Chemical Sewer Stream-Specific Report*),  
34 contributed to the 216-A-29 Ditch:

- 35     • Various floor drains: 202-A Pipe and Operations Gallery; air compressor, process  
36       blower, and service blower rooms in 202-A; 211-A Pump House; and 202-A Instrument  
37       and Maintenance Shops
- 38     • 618-1 and 618-2 Flash Tanks containing heating coils, spray water, and steam condensate
- 39     • 206-A Fractionator condensers and reboiler cooling water and steam condensate

- 1 • Sink drain from the battery room, instrument shop, and maintenance shop in 202-A
- 2 • 202-A Laboratory ventilation room; heating, ventilation, and air conditioning-related
- 3 drainage
- 4 • 202-A Laboratory nonradioactive clothing change room drains
- 5 • 202-A Blower Room condensate
- 6 • Overflow from various demineralized water storage tanks
- 7 • Overflow from the emergency water supply tank
- 8 • Raw water used to continuously flush the PUREX Plant chemical sewer line.

9 The PUREX Plant chemical sewer operated between November 1955 and July 1991. At the  
10 beginning of its operation, the 216-A-29 Ditch received discharge from the PUREX Plant  
11 cooling water and discharge from the chemical sewer. HW-60807, *Unconfined Underground*  
12 *Radioactive Waste and Contamination in the 200 Areas – 1959*, indicates an area labeled  
13 “A Swamp,” which was located where the cooling water may have joined the chemical sewer  
14 ditch (i.e., within the Grout Treatment Facility).

15 In early 1980, because of effluent monitoring requirements, the chemical sewer lines feeding the  
16 216-A-29 Ditch required upgrades to allow for monitoring and diversion capabilities.

17 A diversion box was upgraded and connected to the 216-A-42 Retention Basin. The basin  
18 received chemically or radioactively contaminated diversions from the PUREX Plant chemical  
19 sewer line, cooling water line, and steam condensate discharge (Vitro-R-642, *Title I Report,*  
20 *Chemical Sewer Sampling, Monitoring, Flow Totalizing and Diverting System (PUREX),*  
21 *Project B-190*).

22 During 1990, plans were developed and approved to discontinue discharges to and close the  
23 216-A-29 Ditch (WHC-SD-EN-AP-031, *Interim-Status Groundwater Quality Assessment*  
24 *Program Plan for the 216-A-29 Ditch*), and in 1991 all discharges were discontinued.

25 Stabilization of the 216-A-29 Ditch was performed in three phases from July to October 1991.  
26 In the first phase, bulldozers were used to push the top layers of soil from within the surface  
27 contamination zone and the ditch spoil piles into the bottom of the 216-A-29 Ditch. By taking  
28 large amounts of soil from the 216-A-29 Ditch banks, not only were the ditch bottom sediments  
29 safely covered, but also the surrounding banks were likely to be uncontaminated. The concrete  
30 spillway was covered with clean soil, and the ends of the culvert were filled with concrete. The  
31 slide gate structure and the two earthen dams were lowered, and the wood platform and  
32 associated hardware were demolished and disposed of in the ditch.

33 In the second phase, the consolidated soils were covered with clean material. In the section of  
34 the 216-A-29 Ditch inside the 200 East Area perimeter fence, the fill was brought up to the  
35 surrounding grade. The fill, the Hanford formation sand, was brought from the Grout Project  
36 spoil pile and the 216-B-3 Main Pond spoil pile. Outside of the 200 East Area fence, all clean  
37 fill came from the upper banks of the 216-A-29 Ditch. The fill was placed in a series of terraces

1 progressing down the ditch. A terrace was placed for every 1.8 m (6 ft) decrease in streambed  
2 elevation. The face of each terrace and earth dam was armored with 15 to 25 cm (6 to 10 in.) of  
3 gravel. Eleven terraces were constructed.

4 The third phase consisted of revegetating and reposting the area disturbed by the stabilization  
5 activities. A high-nitrogen fertilizer was spread over the area at a rate of 140 kg/ha (125 lb/ac).  
6 Siberian wheatgrass and Thickspike wheatgrass then were planted, followed by the placement of  
7 straw mulch. The area was reposted as an underground radioactive material zone after surface  
8 radiological surveys were completed and soil samples were taken and analyzed. The  
9 underground radioactive material zone encompasses 2.6 ha (6.4 ac).

10 In 2001, sampling was conducted at the 216-A-29 Ditch in an area where a proposed waste  
11 transfer line from the AP Tank Farm to the Waste Treatment Plant crossed the ditch. Details of  
12 the sampling and the results are provided in Chapters 2.0 and 3.0, respectively. Washington  
13 State Department of Ecology (Ecology) approval of the construction of the transfer line over the  
14 216-A-29 Ditch was granted in June 2002 (Price 2002, "Re: Waste Transfer Line Crossing Over  
15 the 216-A-29 Ditch Treatment, Storage, and Disposal Unit, 02-RCA-0301").

16 The 216-A-29 Ditch received both dangerous and radioactive liquid effluent. The ditch received  
17 22,700,000 L/day (6,000,000 gal/day) at an average flow rate of 3,760 L/min (970 gal/min). The  
18 dangerous waste received includes corrosive waste (Dangerous Waste Code D002) consisting  
19 primarily of acidic waste, sulfuric acid, and sodium hydroxide. The discharges, consisting of  
20 acidic and caustic wastes, were the result of backwashes from the regeneration of demineralizer  
21 columns in the PUREX Plant. Dangerous waste also consisted of the toxicity characteristic  
22 waste (D006) and the state-only waste WT02. Hydrazine (Dangerous Waste Code U133) also  
23 was discharged to the ditch, along with heavy metals including cadmium nitrate and lead  
24 (DOE/RL-99-44, *200-CS-1 Operable Unit RI/FS Work Plan and RCRA TSD Unit Sampling Plan*  
25 [Work Plan]).

#### 26 2.1.2.2 216-B-63 Trench

27 The 216-B-63 Trench was constructed before 1970 as a percolation trench to receive emergency  
28 cooling water and chemical sewer waste from B Plant (221-B Canyon Building). The trench was  
29 taken out of service in 1992. The ditch was an open, unlined, manmade earthen trench that was  
30 closed at one end (it did not convey effluent to another facility). The trench is located entirely  
31 within the 200 East Area perimeter fence. The trench was approximately 427 m (1,400 ft) long,  
32 1.2 m (4 ft) wide, and averaged 3 m (10 ft) deep. The side slope was 1.5:1. The first 3.1 m  
33 (10 ft) of the trench contained a 5.1 cm (2-in.) rockfill. A 40.6 m (16-in.) inlet pipe  
34 approximately 1.5 m (5 ft) long entered the trench 1 m (3 ft) below grade.

35 Contributors to the 216-B-63 Trench included the 2902-B High Tank (potable sanitary water),  
36 cooling water from B Plant and Waste Encapsulation and Storage Facility air-compressor  
37 aftercoolers, some of the 221-B Canyon Building steam condensate, and the demineralizer  
38 effluent. Minor contributions came from chemical makeup overflow systems (e.g., sodium  
39 hydroxide, sodium nitrite), air conditioning units, and space heaters. These minor contributions  
40 were determined to be controlled to levels below dangerous waste designation limits. Specific

1 sources of each are presented in the stream-specific report (WHC-EP-0342, Addendum 6,  
2 *B Plant Chemical Sewer Stream-Specific Report*).

3 The 216-B-63 Trench received B Plant cooling waste and in-tank solidification cooling water  
4 from March 1970 to May 1970 (ARH-2015, *Radioactive Liquid Wastes Discharged to Ground in*  
5 *the 200 Areas During 1970*). The trench began receiving cooling water on March 22, 1970, after  
6 an unplanned release (UPR) (UPR-200-E-138) of 1,000 Ci of <sup>90</sup>Sr into the 216-B-2-2 Ditch. In  
7 May 1970, the trench began receiving B Plant chemical sewer effluent. The B Plant chemical  
8 sewer pipeline went directly to the 216-B-63 Trench. The 207-B Retention Basin was used to  
9 retain low-level, nonhazardous liquid waste (cooling water) in route to the 216-B-2 series ditches  
10 (located east of the structure). Chemical sewer waste did not pass through the 207-B Retention  
11 Basin, but cooling water was routed through the retention basin from March to May 1970. In  
12 August 1970, the bottom and sides of the 216-B-63 Trench were dredged out as a result of  
13 UPR-200-E-138. The dredgings had readings of approximately 3,000 counts per minute (c/min)  
14 of beta-gamma activity and were buried in the 218-E-12B Burial Grounds. The 216-B-2 series  
15 ditches, which are parallel to the 216-B-63 Trench, were used initially to dispose of liquid waste  
16 from the 207-B Retention Basin. The basin is located 610 m (2,000 ft) northeast of B Plant,  
17 immediately south of the B Tank Farms.

18 An upgrade to the chemical sewer system that discharged to the 216-B-63 Trench was planned in  
19 1980 after it was estimated that a volume of more than 1,140,000 L/day (300,000 gal/day) could  
20 be leaking into the ground from the sewer (RHO-CD-1010, *B Plant Chemical Sewer System*  
21 *Upgrade*). Leakage had been documented at the chemical sewer for about 10 years from the date  
22 of this recommended upgrade. About half of this amount of liquid was lost by leakage before  
23 reaching a measuring station at the 207-B Retention Basin. The pipelines that were known or  
24 suspected of leaking were relined or replaced by Project B-496 in 1985. The 38 cm (15-in.)  
25 vitrified clay pipe downstream of manhole No. 12, which is the beginning of the treatment,  
26 storage, and/or disposal (TSD) unit piping and conveyed effluent to 216-B-63 Trench, was not  
27 replaced because it did not have known leakage problems (SD-496-CDR-001, *Conceptual*  
28 *Design Report Chemical Sewer Upgrade, 221-B Project B-496*). Chemical and radiological  
29 analyses of the contaminated sediments excavated during the pipeline upgrade were not found.  
30 The leak occurred at the head end of the pipeline adjacent to the B Plant facility boundary.

31 The trench was isolated and interim stabilized in December 1994 and January 1995. The weir  
32 box at the head end of the trench was filled with concrete and the valve stems at the  
33 207-B Retention Basin were cut off. A prestabilization civil survey was performed, the trench  
34 was covered with clean soil and marked with concrete posts, and a post-stabilization civil survey  
35 was performed.

36 The 216-B-63 Trench received both dangerous and radioactive liquid effluent. The dangerous  
37 waste received from 1970 until October 1985 included corrosive waste (Dangerous Waste  
38 Code D002) consisting primarily of sodium hydroxide, sulfuric acid, and sodium nitrate. After  
39 1985, effluents were treated to maintain a combined pH of between 4 and 10 and no longer were  
40 considered dangerous waste. Radiological inventory at the trench, decayed to January 1999  
41 (DOE-RL 96-81), includes 21.2 kg of total uranium, 0.57 kg of total plutonium, 0.035 kg <sup>241</sup>Am,  
42 0.51 kg <sup>137</sup>Cs, and 1.94 kg of <sup>90</sup>Sr. The approximate average flow rate of wastewater discharged  
43 to the 216-B-63 Trench varied from 378,000 to 1,408,000 L/day (100,000 to 400,000 gal/day).

1 Approximately 68,100,000 kg/yr (or 473,000 L/day [125,000 gal/day]) of corrosive waste were  
2 managed in the 216-B-63 Trench for the period from 1970 to 1992 (DOE/RL-99-44).

### 3 2.1.2.3 216-S-10 Ditch

4 The 216-S-10 Ditch started receiving discharge from the REDOX Plant in August 1951.  
5 This ditch was part of a system that includes the 216-S-10 and 216-S-11 Ponds. In addition  
6 to these three sites, during May 1954 (HW-43121, *Tabulation of Radiological Liquid Waste*  
7 *Disposal Facilities*) an approximate 4,048 m<sup>2</sup> (1-a) overflow from the ditch released an estimated  
8 215 kg of uranium from the ditch in the southeast dike of the 216-S-11 Pond. After the UPR, the  
9 ditch was dredged, and the sludge was removed and placed in unknown low spots on both sides  
10 of the ditch. The ditch then was covered with 0.6 m (2 ft) of soil.

11 The 216-S-10 Ditch was an uncovered, unlined manmade ditch that received wastewater from  
12 the REDOX Plant. The ditch originated outside the perimeter fence and was estimated to be  
13 686 m (2,250 ft) long, 1.8 m (6 ft) wide, and averaged 1.8 m (6 ft) deep.

14 Approximately 50 waste streams contributed to the 216-S-10 Ditch (WHC-EP-0342,  
15 *Addendum 9, S Plant Wastewater Stream-Specific Report*). The routine waste stream sources  
16 include the compressor cooling water from the 202-S Building and the sanitary water overflow  
17 from the water tower. The remaining sources were infrequent additions and include  
18 202-S Building floor drains and funnel drains, 211-S Tank Farm (a storage area) pump drains,  
19 tank drains, station drains, chemical sewer line man-holes, and 276-S Building floor drains. The  
20 effluent to the chemical sewer was composed of approximately 60 percent REDOX Plant raw  
21 water, 20 percent sanitary water, and 20 percent steam condensate.

22 The 216-S-10 system was developed in February 1954 when it became apparent that more  
23 leaching surface was needed. At that time, the 216-S-10 Pond was constructed to provide more  
24 leaching surface. The two 216-S-11 Leach Pond lobes on the southeast side of the  
25 216-S-10 Ditch were constructed to provide even more leaching surface in May 1954. Plugging  
26 of the system occurred in part because of inadvertent dumping of aluminum nitrate nonahydrate  
27 solutions. In 1955, 0.6 m (2 ft) of sediment was dredged from the bottom of the 216-S-10 Ditch  
28 to improve water percolation in the ditch. The contaminated sediments were buried in  
29 excavation pits along the sides of the ditch. The depth and location of the pits are unknown  
30 (RHO-CD-798, *Current Status of the 200 Area Ponds*).

31 The south end of the 216-S-10 Ditch remained in use until 1984, when the ditch was backfilled  
32 and stabilized. The north end of the ditch remains open to a depth of approximately 3 m (10 ft).  
33 The north end of the 216-S-10 Ditch last received discharges during 1991 (BHI-00176, *S Plant*  
34 *Aggregate Area Management Study Technical Baseline Report*), and the supplying pipeline was  
35 plugged with concrete near the outfall in July 1994.

36 A hazardous waste discharge from the Chemical Engineering Laboratory to the 216-S-10 Ditch  
37 and Pond occurred in September 1983. The 420 L (110 gal) of double-shell slurry simulant,  
38 consisting of sodium nitrate (46 percent), sodium hydroxide (41 percent), and small quantities of  
39 sodium phosphate, sodium fluoride, sodium chloride, and potassium chromate, were sent via the  
40 sewer to the ditch and pond. This discharge exhibited the dangerous waste characteristics of  
41 ignitability (D001), corrosivity (D002), characteristic waste (D007), and toxic state-only waste

1 (WT01, WT02). Approximately 450 kg (1,000 lb) of dangerous waste were discharged to the  
2 ditch and pond.

3 Radiological inventory at the ditch, decayed to January 1999 (DOE-RL 96-81), includes 199 kg  
4 of total uranium, 0.1 kg of total plutonium, 0.015 kg <sup>241</sup>Am, 1.00 kg <sup>137</sup>Cs, and 0.86 kg of <sup>90</sup>Sr.  
5 During operations, the maximum volume of wastewater discharged to the 216-S-10 Ditch and  
6 Pond was approximately 568,000 L/day (150,000 gal/day). The annual volume of effluent  
7 discharged was approximately 1.9 L x 10<sup>8</sup> L (5.0 x 10<sup>7</sup> gal) (DOE/RL-99-44).

#### 8 **2.1.2.4 216-S-10 Pond**

9 The 216-S-10 Pond received discharge from the REDOX Plant. This pond was part of a system  
10 that included the 216-S-10 Ditch and the 216-S-11 Pond. The pond was dug in 1954 at the  
11 southwest end of the 216-S-10 Ditch to provide additional percolation surface.

12 The 216-S-10 Pond was an irregular-shaped, manmade pond that covered approximately  
13 20,234 m<sup>2</sup> (5 a) and included four finger-leach trenches. The pond was approximately 2.4 m  
14 (8 ft) at its deepest point. The pond was fed by the 216-S-10 Ditch. Both the ditch and pond  
15 were designed to dispose of liquids through percolation into the soil column.

16 Contributors to the pond and system description are similar to that of the 216-S-10 Ditch.  
17 In 1984, concurrent with the 216-S-10 Ditch, the pond was stabilized (DOE/RL-99-44).

## 18 **2.2 PHYSICAL SETTING**

19 The following sections briefly describe the meteorology, topography, and hydro-geologic  
20 frameworks for the 200-CS-1 OU waste sites. Additional discussions are provided in  
21 DOE/RL-92-19, *200 East Groundwater Aggregate Area Management Study Report*;  
22 PNNL-13788, *Hanford Site Groundwater Monitoring for Fiscal Year 2001*; PNNL-13910,  
23 *Hanford Site Environmental Report for Calendar Year 2001*; and PNNL-6415, *Hanford Site*  
24 *National Environmental Policy Act (NEPA) Characterization*.

### 25 **2.2.1 Meteorology**

26 The Hanford Site lies east of the Cascade Mountains and has a semiarid climate caused by the  
27 rain shadow effect of the mountains. Climatological data are monitored at the Hanford  
28 Meteorological Station and other locations throughout the Hanford Site. From 1945 through  
29 2001, the recorded maximum temperature was 45 °C (113 °F), and the recorded minimum  
30 temperature was -30.6 °C (-23 °F) (PNNL-6415). The two extremes occurred during August  
31 and February, respectively. The monthly average temperature ranged from a low of -0.24 °C  
32 (31.7 °F) in January to a high of 24.6 °C (76.3 °F) in July. The annual average relative humidity  
33 is 54 percent (PNNL-6415).

34 Most precipitation occurs during late autumn and winter, with more than half of the annual  
35 amount occurring from November through February (PNNL-6415). Normal annual precipitation  
36 is 17.7 cm (6.98 in.). Because this area typically receives less than 25.5 cm (10 in.) of  
37 precipitation a year, the climate is considered to be semiarid (PNNL-6415).

1 The prevailing wind direction at the Hanford Monitoring Station is from the northwest during all  
2 months of the year (PNNL-6415). Monthly average wind speeds are lowest during the winter  
3 months and average about 3 m/s (6 to 7 mi/h). The highest average wind occurs during the  
4 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.

### 5 2.2.2 Topography

6 The 200-CS-1 OU is located on the 200 Area Plateau, which is a broad, relatively flat, prominent  
7 terrace (Cold Creek Bar) near the center of the Hanford Site. The Cold Creek Bar was formed  
8 about 13,000 years ago during the last cataclysmic flood from glacial Lake Missoula. The Cold  
9 Creek Bar trends generally east-west with elevations between 197 and 225 m (647 and 740 ft)  
10 above mean sea level. The plateau drops off rather steeply to the north and northwest into a  
11 former flood channel with elevation changes of between 15 and 30 m (50 and 100 ft). The  
12 plateau decreases more gently in elevation to the south into the Cold Creek Valley and to the east  
13 toward the Columbia River. Most of the 200 West Area and the southern half of the 200 East  
14 Area are situated on the Cold Creek Bar, while the northern half of the 200 East Area lies within  
15 the former flood channel. A secondary flood channel running southerly from the main channel  
16 bisects the 200 West Area. The 200-CS-1 OU representative and TSD sites are located in the  
17 200 West and 200 East Areas on the plateau. Surface elevations in the vicinity of the 200 West  
18 Area sites range from approximately 198 to 204 m (650 to 670 ft). Surface elevations in the  
19 vicinity of the 200 East Area sites range from approximately 177 to 207 m (580 to 680 ft).

### 20 2.2.3 Geology

21 The 200-CS-1 OU is located in the Pasco Basin, one of several structural and topographic basins  
22 of the Columbia Plateau. Basalts of the Columbia River Basalt Group and a sequence of  
23 suprabasalt sediments underlie the 200-CS-1 OU waste sites. From oldest to youngest, the major  
24 geologic units of interest are the Elephant Mountain Member, the Ringold Formation, the Cold  
25 Creek unit, the Hanford formation, and surficial deposits. Figure 2-1 shows a generalized  
26 stratigraphic column for the 200 Areas. Geologic cross sections of the waste sites that show the  
27 depth, thickness, and variability of these geologic units are shown in Figures 2-2 through 2-4.

28 **Elephant Mountain Member.** The Elephant Mountain Member is the uppermost basalt unit  
29 (i.e., bedrock) in the 200 Areas. Except for a small area north of the 200 East Area boundary  
30 where it has been eroded away, the Elephant Mountain Member is laterally continuous  
31 throughout the 200 Areas. The RI field investigations did not penetrate to the basalt. Based on  
32 previous investigations and nearby wells, the top of basalt is approximately 67 to 119 m (220 to  
33 390 ft) deep at the 216-A-29 Ditch, 81 m (264 ft) deep at the 216-B-63 Trench, 173 to 179 m  
34 (567 to 587 ft) deep at the 216-S-10 Ditch, and 179 m (587 ft) deep at the 216-S-10 Pond  
35 (DOE/RL-99-44; PNNL-13198, *Borehole Data Package for the 216-S-10 Pond and Ditch*  
36 *Well 299-W26-13; WMP-17755, 200-CS-1 Operable Unit Field Summary Report for Fiscal*  
37 *Year 2003; PNNL-12261, Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East*  
38 *Area and Vicinity, Hanford Site, Washington; and PNNL-13858, Revised Hydrogeology for the*  
39 *Suprabasalt Aquifer System, 200-West Area and Vicinity, Hanford Site, Washington). The basalt*  
40 *is overlain by the Ringold Formation, except at the 216-B-63 Trench, where the basalt is directly*  
41 *overlain by the Hanford formation (DOE/RL-99-44; PNNL-12261) and possibly gravels of the*

1 Cold Creek unit (DOE/RL-2002-39, *Standardized Stratigraphic Nomenclature for the*  
2 *Post-Ringold-Formation Sediments Within the Central Pasco Basin*).

3 **Ringold Formation.** The Ringold Formation consists of an interstratified fluvial-lacustrine  
4 sequence of unconsolidated to semiconsolidated clay, silt, sand, and granule-to-cobble gravel  
5 deposited by the ancestral Columbia River. These sediments consist of the following four major  
6 units, from oldest to youngest (see Figure 2-1): the fluvial gravel and sand of unit 9 (basal  
7 coarse), the buried soil horizons, overbank, and lake deposits of unit 8 (lower mud), the fluvial  
8 sand and gravel of unit 5 (upper coarse), and the lacustrine mud of unit 4 (upper fines). Units 9  
9 and 5 consist of a silty-sandy gravel with secondary lenses and interbeds of gravelly sand, sand,  
10 and muddy sands to silt and clay. Unit 8 (lower mud) consists mainly of silt and clay. Unit 4  
11 (upper fines) consists of silty overbank deposits and fluvial sand. Units 6 and 7 are not present  
12 in the 200 West and 200 East Areas (PNNL-12261; PNNL-13858). The Ringold Formation is  
13 overlain by the Cold Creek unit in the 200 West Area and in parts of the 200 East Area.

14 **Cold Creek Unit.** The Cold Creek unit is the new standardized name for several post-Ringold  
15 Formation and pre-Hanford formation units present in the 200 West and East Areas  
16 (DOE/RL-2002-39). The Cold Creek unit includes the former Plio-Pleistocene unit, caliche,  
17 early Palouse soil, Pre-Missoula gravels, and sidestream alluvial facies described in previous Site  
18 reports. The Cold Creek unit has been divided into five lithofacies. The five lithofacies units are  
19 differentiated based on grain size, sedimentary structure, sorting, fabric, and mineralogy as  
20 follows:

- 21 • Fine-grained, laminated to massive (fluvial-overbank and/or eolian deposits, formerly the  
22 early Palouse soil)
- 23 • Fine-to coarse-grained, calcium-carbonate cemented (calcic paleosol, formerly the  
24 caliche)
- 25 • Coarse-grained, multilithic (mainstream alluvium, formerly the Pre-Missoula gravels)
- 26 • Coarse-grained, angular, basaltic (colluvium)
- 27 • Coarse-grained, rounded, basaltic (sidestream alluvium, formerly sidestream alluvial  
28 facies) (DOE/RL-2002-39).

29 Based on the Cold Creek unit facies distribution from DOE/RL-2002-39, the Cold Creek unit  
30 present beneath the 200 West Area waste sites includes the overbank/eolian and the calcic  
31 paleosol facies and the Cold Creek unit present beneath the 200 East Area waste sites is the  
32 mainstream alluvium. Descriptions of the five lithofacies units, depositional environments, and  
33 association with previous site nomenclature are shown in Table 2-1.

34 **Hanford Formation.** The Hanford formation is the informal stratigraphic name used to describe  
35 the Pleistocene cataclysmic flood deposits within the Pasco Basin. The Hanford formation  
36 consists predominantly of unconsolidated sediments that range from boulder-size gravel to sand,  
37 silty sand, and silt. The sorting ranges from poorly sorted (for gravel facies) to well sorted (for  
38 fine sand and silt facies). The Hanford formation is divided into three main lithofacies:  
39 interbedded sand- to silt-dominated (formerly Touchet beds or slackwater facies);

1 sand-dominated (formerly sand-dominated flood facies); and gravel-dominated (formerly Pasco  
2 gravels) that have been further subdivided into 11 textural-structural lithofacies  
3 (DOE/RL-2002-39). Beneath the 200-CS-1 OU waste sites, the Hanford formation includes the  
4 gravel-dominated and sand-dominated facies. The gravel-dominated facies are cross-stratified,  
5 coarse-grained sands and granule-to-boulder gravel. The gravel is uncemented and matrix poor.  
6 The sand-dominated facies are well-stratified fine- to coarse-grained sand and granule gravel.  
7 Silt in these facies is variable and may be interbedded with the sand. Where the silt content is  
8 low, an open-framework texture is common. Clastic dikes are common in the Hanford formation  
9 but rare in the Ringold Formation (DOE/RL-98-28; DOE/RL-2002-39). They appear as vertical  
10 to subvertical sediment-filled structures especially within sand- and silt-dominated units.  
11 The Hanford formation is locally overlain by veneers of surficial deposits.

12 **Surficial Deposits.** Surficial deposits include Holocene eolian sheets of sand that form a thin  
13 veneer over the Hanford formation across the site except in localized areas where the deposits  
14 are absent. Surficial deposits consist of very fine- to medium-grained sand to occasionally silty  
15 sand. Silty deposits less than 1 m (3 ft) thick also have been documented at waste sites where  
16 fine-grained, wind-blown material has settled out through standing water over many years. Fill  
17 material was placed in and over representative waste sites during construction and for  
18 contamination control. The fill consists of reworked Hanford formation sediments and/or  
19 surficial sand and silt. The thickness of the fill material varies from 0.3 to 2.1 m (1 to 7 ft) at the  
20 representative waste sites (BHI-01651, *200-CS-1 Operable Unit Test Pit Summary Report for*  
21 *Fiscal Year 2002; WMP-17755).*

#### 22 2.2.4 Hydrostratigraphy

23 Vadose zone hydrostratigraphic units within the 200-CS-1 OU include the Ringold Formation,  
24 the Cold Creek unit, the Hanford formation, and surficial deposits (see Figure 2-1). The  
25 unconfined aquifer hydrostratigraphic units within the 200-CS-1 OU include the Ringold  
26 Formation and the Hanford formation. The base of the unconfined aquifer is the top of the  
27 Ringold Formation unit 8 (lower mud) or the top of basalt (Elephant Mountain Member).

28 **Vadose Zone.** The vadose zone is the area between the ground surface and the water table.  
29 At the 200 East Area representative sites, the vadose zone varies from 82.4 m (270.2 ft) thick at  
30 the 216-A-29 Ditch to about 75 m (245 ft) thick at the 216-B-63 Trench. The vadose zone is  
31 entirely within Hanford formation sediments at the 216-B-63 Trench. At the 216-A-29 Ditch,  
32 the vadose zone is predominantly Hanford formation sediments with a thin section of Ringold  
33 Formation sediments above the water table.

34 At the 200 West Area representative sites, the vadose zone varies from 68 m (223 ft) thick at the  
35 216-S-10 Ditch to 61 m (200.5 ft) thick at the 216-S-10 Pond. Sediments within the vadose zone  
36 at these waste sites include the Hanford formation, the Cold Creek unit, and part of the Ringold  
37 Formation unit 5.

38 Moisture content in the 200 Areas vadose zone typically ranges between 2 and 10 percent under  
39 ambient conditions (DOE/RL-98-28), but historically has ranged widely from 10 percent to  
40 saturation (perched water) at liquid waste disposal sites. Before 1995, liquid waste sites  
41 provided a significant driving force for contaminant transport. With the reduction of artificial

1 recharge in the 200 Areas since 1995, the downward flux of liquid in the vadose zone beneath  
2 waste sites has been decreasing. However, moisture content in the vadose zone near waste sites  
3 is expected to remain elevated over preoperational conditions for some time. In the absence of  
4 artificial recharge, recharge from natural precipitation becomes the dominant driving force for  
5 moving contamination remaining in the vadose zone to groundwater.

6 Data collected with the neutron-moisture logging tool indicate that volumetric moisture content  
7 beneath the 200 West Area representative sites ranged from 2 to 15 percent over the logged  
8 intervals. The highest moisture content correlated with the top of the Cold Creek unit at 41 m  
9 (134 ft) depth at the 216-S-10 Pond borehole (PNNL-13198). Calibration data were not  
10 available for the casing sizes used in drilling the 200 East Area representative waste site  
11 boreholes, so volumetric moisture contents were not calculated for the neutron logs from these  
12 boreholes (WMP-17755).

13 The borehole drilled at the 216-A-29 Ditch encountered perched water at about 78.6 to 78.9 m  
14 (258 to 259 ft) below ground surface (bgs) that was sitting atop a 1.4 m- (4.5-ft-) thick very  
15 dense, compacted silt/clay layer of the Ringold Formation.

16 A limited number of soil samples were collected to determine moisture content, grain-size  
17 distribution, and bulk density. Laboratory moisture content ranged from 2.5 to 14.3 percent  
18 (equivalent to 4.9 to 27.9 volumetric moisture percent). Bulk densities ranged from 1.38 to  
19 2.07 g/cm<sup>3</sup>. The results were published in WMP-17755, Appendix C, and PNNL-13198,  
20 Appendix B.

21 **Unconfined Aquifer.** The uppermost or unconfined aquifer beneath the 216-A-29 Ditch is  
22 approximately 2 to 24 m (7 to 79 ft) thick and is contained within sediments of the Hanford  
23 formation and Ringold Formation. The aquifer extends from the water table to the top of the  
24 basalt or, in some areas, the lower mud (unit 8) of the Ringold Formation. Groundwater flow is  
25 to the west-southwest because the groundwater mound from the 216-B-3 Pond system is  
26 diminishing. The average groundwater flow velocities range from approximately 0.01 to  
27 0.04 m/day (0.003 to 0.012 ft/day) (PNNL-14187, *Hanford Site Groundwater Monitoring for*  
28 *Fiscal Year 2002*). The water table beneath the ditch has declined significantly since the  
29 discharges to the 216-B-3 Pond system were reduced in 1988 and eliminated by 1995.

30 The uppermost or unconfined aquifer beneath the 216-B-63 Trench is 3.4 to 6.1 m (11.2 to  
31 20.0 ft) thick and is contained within the sediments of the Hanford formation. The aquifer  
32 extends from the water table to the top of the basalt. The Ringold Formation is absent beneath  
33 the trench. Groundwater flow has been generally east to west because of the groundwater  
34 recharge from the 216-B-3 Pond system, but the hydraulic gradient in this area is changing as the  
35 groundwater mound created by the pond system diminishes. Groundwater flow velocity is  
36 estimated to be 0.1 m/day (0.03 ft/day) (PNNL-14187). The water table is nearly flat beneath the  
37 trench and has been declining since the discharges to the 216-B-3 Pond system ceased.

38 The uppermost or unconfined aquifer beneath the 216-S-10 Pond and Ditch is about 61 m  
39 (200 ft) thick and is contained within sediments of the Ringold Formation units 4 and 5.  
40 The aquifer extends from the water table to the lower mud (unit 8) of the Ringold Formation.  
41 Groundwater flow is to the east-southeast at a rate between 0.007 m/day and 0.3 m/day

1 (0.023 and 0.98 ft/day) (PNNL-14187). The water table beneath the pond and ditch has declined  
2 significantly since the discharges to the U Pond system ceased in 1984.

### 3 2.3 NATURAL RESOURCES

4 Natural resources in the study area and vicinity include vegetation and wildlife resources.  
5 Biological and ecological information aids in evaluating impacts to the environment from  
6 contaminants in the soils, including potential effects of implementing remedial actions and  
7 identification of sensitive habitats and species. This section also considers cultural and aesthetic  
8 resources and socioeconomics associated with activities in the 200 Areas.

9 Survey data collected in 2000 and 2001 for the 200 Areas Central Plateau as part of the  
10 Ecological Compliance Assessment Project were compiled to support Central Plateau ecological  
11 evaluations (DOE/RL-2001-54, *Central Plateau Ecological Evaluation*). The information  
12 includes plant community descriptions, identification of plant and wildlife species, and avian  
13 census data. Designated levels of habitat under DOE/RL-96-32, *Hanford Site Biological*  
14 *Resources Management Plan*, including rare plant populations, are identified and mapped. The  
15 data were collected before the Command 24 fire occurred in 2000. The fire, however, did not  
16 impact any of the waste sites being considered in this FS.

#### 17 2.3.1 Vegetation

18 Vegetation in the study area is characterized by native shrub-steppe, interspersed with large areas  
19 of disturbed ground dominated by annual grasses and forbs. In the native shrub-steppe, the  
20 dominant shrub is big sagebrush (*Artemisia tridentata*). The understory is dominated by the  
21 native perennial, Sandberg's bluegrass (*Poa sandbergii*), and the introduced annual, cheatgrass  
22 (*Bromus tectorum*). Other shrubs typically present include rabbitbrush (*Chrysothamnus spp.*),  
23 spiny hopsage (*Grayia spinosa*), and antelope bitterbrush (*Purshia tridentata*). Other native  
24 bunchgrasses that also are present include Indian ricegrass (*Oryzopsis hymenoides*) and  
25 needle-and-thread grass (*Stipa comata*). Common herbaceous species include turpentine  
26 cymopteris (*Cymopteris terebinthinus*), globemallow (*Sphaeralcea munroana*), balsamroot  
27 (*Balsamorhiza careyana*), milkvetch (*Astragalus spp.*), yarrow (*Achillea millefolium*), dwarf  
28 evening primrose (*Camissonia pygmaea*), and daisy (*Erigeron spp.*). Dwarf evening primrose is  
29 a rare plant and has not been encountered in the study area.

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

## 1 2.3.2 Wildlife

2 The largest mammal frequenting the study area is the mule deer (*Odocoileus hemionus*). Mule  
3 deer are much more common along the Columbia River; the few that forage throughout the  
4 200 Areas make up a distinct group called the Central Population (PNNL-11472, *Hanford Site*  
5 *Environmental Report for Calendar Year 1996*). A large elk herd (*Cervus canadensis*) currently  
6 resides on the Fitzner-Eberhardt Arid Lands Ecology Reserve. Elk, which are more dependent  
7 on open grasslands for forage, seek the cover of sagebrush and other shrub species during the  
8 summer months. The Rattlesnake Hills herd of elk that inhabits the Hanford Site primarily  
9 occupies the Arid Lands Ecology Reserve and private lands that adjoin the reserve to the south  
10 and west. They occasionally are seen in the 200 Areas and just south of them and have been  
11 sighted at the White Bluffs boat launch on the Hanford Site. The herd tends to congregate on the  
12 Arid Lands Ecology Reserve in the winter and disperses during the summer months to higher  
13 elevations on the Arid Lands Ecology Reserve, private land to the west of the Arid Lands  
14 Ecology Reserve, and the Yakima Training Center. In March 2000, about 200 elk were removed  
15 from the Arid Lands Ecology Reserve and relocated, and another 31 elk were removed during  
16 2002. Special hunts adjacent to the Hanford Site in 2000 accounted for the removal of  
17 207 additional elk. The "24 Command Fire" in June 2000 temporarily destroyed nearly all of the  
18 elk forage on the Arid Lands Ecology Reserve. The herd moved onto unburned private land  
19 west of the Site, to unburned areas in the center of the Hanford Site, and along the Columbia  
20 River near the 100 B/C and 100 K Areas. Elk have returned to burned areas as the vegetation  
21 recovers (PNNL-6415).

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

25 Other mammals common to the 200 Areas are badgers (*Taxidea taxus*), coyotes (*Canis latrans*),  
26 Great Basin pocket mice (*Perognathus parvus*), northern pocket gophers (*Thomomys talpoides*),  
27 and deer mice (*Peromyscus maniculatus*). Badgers are known for their digging ability and have  
28 been suspected of excavating contaminated soil at 200 Areas radioactive waste sites  
29 (BNWL-1794, *Distribution of Radioactive Jackrabbit Pellets in the Vicinity of the B-C Cribs,*  
30 *200 East Area*). The majority of badger diggings are a result of searches for food, especially for  
31 other burrowing mammals such as pocket gophers and mice. Pocket gophers, Great Basin  
32 pocket mice, and deer mice are abundant herbivores in the 200 Areas. These small mammals can  
33 excavate significant amounts of soil as they construct their burrows (e.g., Hakonson et al. 1982,  
34 "Disturbance of a Low-Level Waste Burial Site Cover by Pocket Gophers"). Mammals  
35 associated with buildings and facilities include Nuttall's cottontails (*Sylvilagus nuttallii*), house  
36 mice (*Mus musculus*), Norway rats (*Rattus norvegicus*), and various bat species.

37 Common bird species in the study area include the starling (*Sturnus vulgaris*), horned lark  
38 (*Eremophila alpestris*), meadowlark (*Sturnella neglecta*), western kingbird (*Tyrannus verticalis*),  
39 rock dove (*Columba livia*), black-billed magpie (*Pica pica*), and raven (*Corvus corax*).  
40 Burrowing owls (*Athene cunicularia*) commonly nest in the 200 Areas in abandoned badger or  
41 coyote holes, or in open-ended stormwater pipes along roadsides in more industrialized areas.  
42 Loggerhead shrike (*Lanius ludovicianus*) and sage sparrow (*Amphispiza belli*) are common

1 nesting species in habitats dominated by sagebrush. Long-billed curlews (*Numenius*  
2 *americanus*) have been observed nesting on inactive waste sites.

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

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

### 11 2.3.3 Species of Concern

12 The Hanford Site is home to a number of species of concern, but many of these are associated  
13 with the Columbia River and its shoreline. Two Federally protected species have been observed  
14 at the Hanford Site, the Aleutian Canada goose (*Branta canadensis leucopareia*) and the bald  
15 eagle (*Haliaeetus leucocephalus*). Both depend on the river corridor and rarely are seen in the  
16 Central Plateau. As migratory birds, these species also are protected under the *Migratory Bird*  
17 *Treaty Act of 1918*.

18 Several threatened, endangered, and candidate species are found in and near the 200 Areas.  
19 These species include the ferruginous hawk (*Buteo regalis*), burrowing owl, loggerhead shrike,  
20 long-billed curlew, and sage sparrow. Plant species of concern (which include those listed as  
21 state endangered, threatened, sensitive, and monitored) that may occur in the study area include  
22 dwarf evening primrose and Piper's daisy (*Erigeron piperianus*) (WNHP 1998, *Washington Rare*  
23 *Plant Species by County*).

24 Plant and animal species of concern, their designations, and the places of their occurrence can  
25 change over time. At this time, it is not anticipated that remediation of the 200-SC-1 OU will  
26 affect any species of concern, but incorporating the needs of these species into project planning  
27 will help to mitigate any potential effects. Especially important is avoiding, where possible,  
28 undisturbed shrub-steppe habitat because this is important to many species of concern. The  
29 undisturbed shrub-steppe in the Central Plateau was designated as Level 3 habitat in  
30 DOE/RL-96-32, which requires mitigation of any disturbance (for example through avoidance  
31 and minimization) and possibly rectification and compensation. More detailed direction on  
32 protecting Level 3 habitats and species of concern is provided in DOE/RL-96-32. In addition,  
33 site-specific environmental surveys, required before ground disturbance can occur, serve as a  
34 final check to ensure that ecological resources are adequately protected.

### 35 2.3.4 Cultural Resources

36 A comprehensive archaeological survey of the 200 Areas found artifacts in conjunction with  
37 areas of high topographic relief and in the vicinity of sources of permanent water, but few  
38 artifacts associated with open, inland flats (PNL-7264, *Archaeological Survey of the 200 East*

1 and 200 West Areas, Hanford Site, Washington). In the 200 West Area, the only culturally  
2 sensitive area identified is the historic White Bluffs Road that crosses the northwest corner of the  
3 site. The report concluded that additional cultural resource reviews are required only for  
4 proposed projects within 100 m (328 ft) of this road. The waste sites associated with the  
5 200-CS-1 OU are not within 100 m (328 ft) of this road (PNL-7264).

6 PNL-7264 addressed only undisturbed portions of the 200 Areas and did not address facilities  
7 and structures. The *National Historic Preservation Act of 1966* requires agencies to consult with  
8 the State Historic Preservation Officer and the Advisory Council on Historic Preservation to  
9 ensure that all potentially significant cultural resources, including structures and associated sites,  
10 have been adequately identified, evaluated, and considered in planning for a proposed  
11 undertaking (e.g., remediation, renovation, or demolition) (DOE/RL-97-56, *Hanford Site*  
12 *Manhattan Project and Cold War Era Historic District Treatment Plan*).

13 DOE/RL-97-56 was developed to address these requirements and to determine the eligibility of  
14 historic properties for the "National Register of Historic Places" (36 CFR 60). DOE/RL-97-56  
15 evaluated and classified waste sites and structures on the Hanford Site, including those in the  
16 200 Areas, and proposed recommendations for mitigation. Treatment options for mitigation  
17 were determined using 36 CFR 60.4, "Criteria for Evaluation." None of the waste sites in the  
18 200-CS-1 OU that are subjects of this FS were recommended for individual documentation as  
19 contributing properties. Sites beginning with "216" (e.g., 216-A-29 Ditch, 216-S-10 Ditch) were  
20 categorized as "noncontributing/exempt properties" (i.e., properties that are exempted from  
21 documentation requirements as potential historic sites) (DOE/RL-97-56). Some sites not  
22 addressed in DOE/RL-97-56, such as UPRs and septic tanks that were not considered to be  
23 significant enough to be evaluated as part of that effort, will be evaluated under site-specific  
24 pre-remediation cultural resource reviews.

25 No cultural resources have been directly associated with OU waste sites (PNL-7264,  
26 DOE/RL-97-56, PNNL-6415); however, site-specific cultural resource reviews will be required  
27 for each waste site before remediation or other ground-disturbing activities are begun. In  
28 addition to the site-specific review, a cursory field review of plant and animal life may be  
29 conducted in concert with this effort.

### 30 2.3.5 Aesthetics, Visual Resources, and Noise

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

38 Studies at the Hanford Site on the propagation of noise have been concerned primarily with  
39 occupational noise at work sites. Environmental noise levels have not been extensively  
40 evaluated because of the remoteness of most Hanford Site activities and their isolation from  
41 receptors covered by Federal or state statutes. Most industrial facilities on the Hanford Site are

1 located far enough away from the Site boundary that noise levels at the boundary are not  
2 measurable or are indistinguishable from background noise levels (PNNL-6415).

### 3 2.3.6 Socioeconomics

4 Activity on the Hanford Site plays a dominant role in the socioeconomics of the Tri-Cities and  
5 other parts of Benton and Franklin counties. The agricultural community also has a significant  
6 effect on the local economy. Any major changes in Hanford Site activity would potentially  
7 affect the Tri-Cities and other areas of Benton and Franklin Counties. Unless otherwise  
8 specifically cited, data in this section are collected from interviews with the referenced  
9 organization.

10 The Hanford Site is the largest single source of employment in the Tri-Cities. During fiscal year  
11 (FY) 2002, an average of 10,892 employees were employed by the U.S. Department of Energy  
12 (DOE), Office of River Protection and its prime contractor CH2M HILL Hanford Group, Inc.;  
13 DOE-Richland Operations Office and its prime contractor Fluor Hanford, Inc.; Battelle  
14 Memorial Institute; Bechtel Hanford, Inc.; and the Hanford Environmental Health Foundation.  
15 The FY 2002 year-end employment at the Hanford Site was 10,938, up from 10,670 in FY 2001.  
16 In addition to these totals, Bechtel National, Inc., and its prime subcontractor, Washington Group  
17 International, employed 3,013 at the end of FY 2002, up from 1,350 at the end of FY 2001. In  
18 December 2000, the Office of River Protection awarded a contract to Bechtel National, Inc., to  
19 design, build, and start up waste treatment facilities for the glassification of liquid radioactive  
20 waste. According to the Washington State Labor Market and Economic Analysis, the annual  
21 average number of employees at the Hanford Site is down considerably from a peak of 19,200 in  
22 FY 1994, but still represents 15 percent of the 94,000 total jobs in the economy.

23 In addition to the Hanford Site, other key employers in the area are as follows:

- 24 • Energy Northwest
- 25 • The agricultural community (including the Lamb Weston food processing plants)
- 26 • Iowa Beef Processing
- 27 • Framatome – Advanced Nuclear Products (formerly Siemens, Inc.)
- 28 • Boise Cascade Corporation, Paper and Corrugated Container Divisions
- 29 • Burlington Northern and Santa Fe Railroads.

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

32 An estimated total of 147,600 people lived in Benton County and 51,300 lived in Franklin  
33 County during 2002, for a total of 198,900, which is up almost 4 percent from 2000. According  
34 to the 2000 Census, population totals for Benton and Franklin Counties were 142,475 and  
35 49,347, respectively. Both Benton and Franklin counties grew at a faster pace than Washington  
36 as a whole in the 1990s. The population of Benton County grew 26.6 percent, up from  
37 112,560 in 1990. The population of Franklin County grew 31.7 percent, up from 37,473 in 1990  
38 (Census 2001, *Poverty Thresholds in 2000, by Size of Family and Number of Related Children*  
39 *Under 18 Years*).

1 Based on the 2000 census, the 80 km (50-mi) radius area surrounding the Hanford Site had a  
2 total population of 482,300 and a minority population of 178,500.<sup>1</sup> The ethnic composition of  
3 the minority population is primarily White Hispanic (24 percent), self-designated "other and  
4 multiple" races (63 percent), and Native American (6 percent). Asians and Pacific Islanders  
5 (4 percent) and African American (3 percent) make up the rest. The Hispanic population resides  
6 predominantly in Franklin, Yakima, Grant, and Adams counties. Native Americans within the  
7 80 km (50-mi) area reside primarily on the Yakama Reservation and upstream of the Hanford  
8 Site near the town of Beverly, Washington. PNNL-6415 provides maps showing distributions of  
9 minority and low-income populations.

## 10 2.4 WASTE SITE DESCRIPTIONS

11 This section describes the four selected representative sites for the 200-CS-1 OU. Detailed  
12 descriptions of these representative sites are provided to support development of contaminant  
13 distribution models, to evaluate risk, and to provide a baseline for implementing the analogous  
14 site approach in support of the remedial investigation/feasibility study (RI/FS) process. Data for  
15 these sites are presented in DOE/RL-2004-17.

16 All four of these sites are RCRA TSD units. Two of these sites, the 216-A-29 Ditch, and the  
17 216-S-10 Ditch, also are representative sites as identified in DOE/RL-96-81; and DOE/RL-99-44  
18 for evaluation as part of the RI. The representative sites were evaluated by implementing the  
19 data quality objective (DQO) process. The DQO process was used to determine what data  
20 should be collected to assess site conditions and support remedial decision making. The current  
21 Part A forms for these units are contained in Appendix A of DOE/RL-99-44. The remaining site,  
22 the 216-S-11 Pond, is an RPP site (a site category created to address releases of RCRA  
23 hazardous wastes or constituents from sources other than TSD units regardless of the date of  
24 waste receipt at the unit).

### 25 2.4.1 Representative Sites

#### 26 2.4.1.1 216-A-29 Ditch

27 The 216-A-29 Ditch received discharge from the PUREX Plant chemical sewer. The ditch was  
28 uncovered and unlined and followed the natural topography. The ditch originated from the  
29 southeastern side of the A Tank Farm (east of the AP Tank Farm) outside the 200 East Area  
30 perimeter fence. The ditch was estimated to be 1,220 m (4,000 ft) long and 1.8 m (6 ft) wide and  
31 varied from 0.6 to 4.6 m (2 to 15 ft). Structures in the 216-A-29 Ditch included a concrete

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<sup>1</sup>PNNL-6415 shows the total population "within" 80 km as 511,500, which was estimated by a geographical information system from the populations of individual census block groups, the smallest geographic area for which both minority and poverty status were estimated in the 2000 Census. The higher number resulted because the total population of a census block group previously was assigned to the 80 km area if *any part* of the block group lay within 80 km of the Hanford Meteorological Station in the middle of the Hanford Site. The new estimate splits boundary block groups to include only those portions within 80 km, which should result in a lower and more accurate estimate.

1 spillway for the first 3 m (10 ft) from the point of inflow, a culvert under the 200 East Area  
2 perimeter road, and a wood platform and slide gate for flow control at the two earthen dams.  
3 The head end of the ditch was modified in 1983 to allow the construction of the AP Tank Farm.  
4 The end of the ditch connects to the 216-B-3-3 Ditch and finally to the 216-B-3 Pond.

5 In early 1980, because of effluent monitoring requirements, the chemical sewer lines feeding the  
6 216-A-29 Ditch required upgrades to allow for monitoring and diversion capabilities.  
7 A diversion box was upgraded and connected to the 216-A-42 Retention Basin. The basin  
8 received chemically or radioactively contaminated diversions from the PUREX Plant chemical  
9 sewer line, cooling water line, and steam condensate discharge (Vitro-R-642).

10 During 1990, plans were developed and approved to discontinue discharges to and close the  
11 216-A-29 Ditch (WHC-SD-EN-AP-031), and in 1991 all discharges were discontinued.

12 Stabilization of the 216-A-29 Ditch was performed in three phases from July to October 1991.  
13 In the first phase, bulldozers were used to push the top layers of soil from within the surface  
14 contamination zone and the ditch spoil piles into the bottom of the 216-A-29 Ditch. By taking  
15 large amounts of soil from the 216-A-29 Ditch banks, not only were the stream sediments safely  
16 covered, but the surrounding banks were likely to be uncontaminated. The concrete spillway  
17 was covered with clean soil, and the ends of the culvert were filled with concrete. The slide gate  
18 structure and the two earthen dams were lowered, and the wood platform and associated  
19 hardware were demolished and disposed of in the ditch.

20 In the second phase, the consolidated soils were covered with clean material. In the section of  
21 the 216-A-29 Ditch inside the 200 East Area perimeter fence, the fill was brought up to the  
22 surrounding grade. The fill was brought from the Grout Project spoil pile and the 216-B-3 Main  
23 Pond spoil pile. Outside of the 200 East Area fence, all clean fill came from the upper banks of  
24 the 216-A-29 Ditch. The fill was placed in a series of terraces progressing down the ditch.  
25 A terrace was placed for every 1.8 m (6 ft) decrease in streambed elevation. The face of each  
26 terrace and earth dam was armored with 15 to 25 cm (6 to 10 in.) of gravel. A total of  
27 11 terraces were constructed.

28 The third phase consisted of revegetating and reposting the area disturbed by the stabilization  
29 activities. A high-nitrogen fertilizer was spread over the area. Siberian wheatgrass and  
30 Thickspike wheatgrass then were planted. The area was reposted as an underground radioactive  
31 material zone after surface radiological surveys were completed and soil samples were taken and  
32 analyzed. The underground radioactive material zone encompasses 2.6 ha (6.4 ac).

33 The 216-A-29 Ditch received both dangerous and radioactive liquid effluent. The ditch received  
34 22,700,000 L/day (6,000,000 gal/day) at an average flow rate of 3,760 L/min (970 gal/min). The  
35 dangerous waste received consisted primarily of acidic waste, sulfuric acid, and sodium  
36 hydroxide. The discharges, consisting of acidic and caustic wastes, were the result of  
37 backwashes from the regeneration of demineralizer columns in the PUREX Plant. Dangerous  
38 waste also consisted of the toxicity characteristic waste (D006) and Hydrazine (Dangerous Waste  
39 Code U133) also was discharged to the ditch, along with heavy metals including cadmium nitrate  
40 and lead (Work Plan [DOE/RL-99-44]).

#### 1 2.4.1.2 216-B-63 Trench

2 The 216-B-63 Trench was constructed before 1970 as a percolation trench to receive emergency  
3 cooling water and chemical sewer waste from B Plant (221-B Canyon Building). The ditch was  
4 an open, unlined, manmade earthen trench that was closed at one end (it did not convey effluent  
5 to another facility). The trench is located entirely within the 200 East Area perimeter fence. The  
6 trench was approximately 427 m (1,400 ft) long, 1.2 m (4 ft) wide, and averaged 3 m (10 ft)  
7 deep. The side slope was 1.5:1. The first 3.1 m (10 ft) of the trench contained a 5.1 cm (2-in.)  
8 rock fill. A 40.6 m (16-in.) inlet pipe approximately 1.5 m (5 ft) long entered the trench 1 m  
9 (3 ft) below grade. The trench was taken out of service in 1992.

10 Contributors to the 216-B-63 Trench included the 2902-B High Tank (potable sanitary water),  
11 cooling water from B Plant and Waste Encapsulation and Storage Facility air-compressor after  
12 coolers, some of the 221-B Canyon Building steam condensate, and the demineralizer effluent.  
13 Minor contributions came from chemical makeup overflow systems (e.g., sodium hydroxide,  
14 sodium nitrite), air conditioning units, and space heaters. These minor contributions were  
15 determined to be controlled to levels below dangerous waste designation limits. Specific sources  
16 of each are presented in the stream-specific report (WHC-EP-0342, Addendum 6).

17 The 216-B-63 Trench received B Plant cooling waste and in-tank solidification cooling water  
18 from March 1970 to May 1970 (ARH-2015). The trench began receiving cooling water on  
19 March 22, 1970, after an UPR (UPR-200-E-138) of 1,000 Ci of <sup>90</sup>Sr into the 216-B-2-2 Ditch. In  
20 May 1970, the trench began receiving B Plant chemical sewer effluent. The B Plant chemical  
21 sewer pipeline went directly to the 216-B-63 Trench. The 207-B Retention Basin was used to  
22 retain low-level, non-hazardous liquid waste (cooling water) in route to the 216-B-2 series  
23 ditches (located east of the structure). Chemical sewer waste did not pass through the  
24 207-B Retention Basin, but cooling water was routed through the retention basin from March to  
25 May 1970. In August 1970, the bottom and sides of the 216-B-63 Trench were dredged out as a  
26 result of UPR-200-E-138. The dredgings had readings of approximately 3,000 c/min of  
27 beta-gamma activity and were buried in the 218-E-12B Burial Grounds. The 216-B-2 series  
28 ditches, which are parallel to the 216-B-63 Trench, were used initially to dispose of liquid waste  
29 from the 207-B Retention Basin. The basin is located 610 m (2,000 ft) northeast of B Plant,  
30 immediately south of the B Tank Farms.

31 An upgrade to the chemical sewer system that discharged to the 216-B-63 Trench was planned in  
32 1980 after it was determined that an estimated volume of more than 1,140,000 L/day  
33 (300,000 gal/day) could be leaking into the ground from the sewer (RHO-CD-1010). Leakage  
34 had been documented at the chemical sewer for about 10 years from the date of this  
35 recommended upgrade. About half of this amount of liquid was lost by leakage before reaching  
36 a measuring station at the 207-B Retention Basin. The pipelines that were known or suspected  
37 of leaking were relined or replaced by Project B-496 in 1985. The 38 cm (15-in.) vitrified clay  
38 pipe downstream of manhole No. 12, which is the beginning of the TSD unit piping and  
39 conveyed effluent to 216-B-63 Trench, was not replaced because it did not have known leakage  
40 problems (SD-496-CDR-001). Chemical and radiological analyses of the contaminated  
41 sediments excavated during the pipeline upgrade were not found. The leak occurred at the head  
42 end of the pipeline adjacent to the B Plant facility boundary.

1 The trench was isolated and interim stabilized in December 1994 and January 1995. The weir  
2 box at the head end of the trench was filled with concrete and the valve stems at the  
3 207-B Retention Basin were cut off. A pre-stabilization civil survey was performed, the trench  
4 was covered with clean soil and marked with concrete posts, and a post-stabilization civil survey  
5 was performed.

6 The 216-B-63 Trench received both dangerous and radioactive liquid effluent. The dangerous  
7 waste received from 1970 until October 1985 included corrosive waste consisting primarily of  
8 sodium hydroxide, sulfuric acid, and sodium nitrate. After 1985, effluents were treated to  
9 maintain a combined pH of between 4 and 10 and no longer were considered dangerous waste.  
10 Radiological inventory at the trench, decayed to January 1999 (DOE-RL 96-81), includes  
11 21.2 kg of total uranium, 0.57 kg of total plutonium, 0.035 kg <sup>241</sup>Am, 0.51 kg <sup>137</sup>Cs, and 1.94 kg  
12 of <sup>90</sup>Sr. The approximate average flow rate of wastewater discharged to the 216-B-63 Trench  
13 varied from 378,000 to 1,408,000 L/day (100,000 to 400,000 gal/day). Approximately  
14 68,100,000 kg/yr (or 473,000 L/day [125,000 gal/day]) of corrosive waste were managed in the  
15 216-B-63 Trench for the period from 1970 to 1992 (DOE/RL-99-44).

#### 16 2.4.1.3 216-S-10 Ditch

17 The 216-S-10 Ditch was an uncovered, unlined manmade ditch that received wastewater from  
18 the REDOX Plant. The ditch originated outside the perimeter fence and was estimated to be  
19 686 m (2,250 ft) long, 1.8 m (6 ft) wide, and averaged 1.8 m (6 ft) deep.

20 The 216-S-10 Ditch started receiving discharge from the REDOX Plant in August 1951.  
21 This ditch was part of a system that includes the 216-S-10 and 216-S-11 Ponds. In addition  
22 to these three sites, during May 1954 (HW-43121) an approximate 4,048 m<sup>2</sup> (1-a) overflow from  
23 the ditch released an estimated 215 kg of uranium from the ditch in the southeast dike of the  
24 216-S-11 Pond. After the UPR, the ditch was dredged, and the sludge was removed and placed  
25 in unknown low spots on both sides of the ditch. The ditch was then covered with 0.6 m (2 ft) of  
26 soil.

27 The 216-S-10 system was developed in February 1954 when it became apparent that more  
28 leaching surface was needed. At that time, the 216-S-10 Pond was constructed to provide more  
29 leaching surface. The two 216-S-11 Leach Pond lobes on the southeast side of the  
30 216-S-10 Ditch were constructed to provide even more leaching surface in May 1954. Plugging  
31 of the system occurred in part because of inadvertent dumping of aluminum nitrate nonahydrate  
32 solutions. In 1955, 0.6 m (2 ft) of sediment was dredged from the bottom of the 216-S-10 Ditch  
33 to improve water percolation in the ditch. The contaminated sediments were buried in  
34 excavation pits along the sides of the ditch. The depth and location of the pits is unknown  
35 (RHO-CD-798).

36 The south end of the 216-S-10 Ditch remained in use until 1984, when the ditch was backfilled  
37 and stabilized. The north end of the ditch remains open to a depth of approximately 3 m (10 ft).  
38 The north end of the 216-S-10 Ditch last received discharges during 1991 (BHI-00176), and the  
39 supplying pipeline was plugged with concrete near the outfall in July 1994.

40 A hazardous waste discharge from the Chemical Engineering Laboratory to the 216-S-10 Ditch  
41 and Pond occurred in September 1983. The 420 L (110 gal) of double-shell slurry stimulant,

1 consisting of sodium nitrate (46 percent), sodium hydroxide (41 percent), and small quantities of  
2 sodium phosphate, sodium fluoride, sodium chloride, and potassium chromate, were sent via the  
3 sewer to the ditch and pond. This discharge exhibited the dangerous waste characteristics of  
4 ignitability, corrosivity, characteristic waste, and toxic state-only waste (WT01, WT02).  
5 Approximately 450 kg (1,000 lb) of dangerous waste were discharged to the ditch and pond.

6 Radiological inventory at the ditch, decayed to January 1999 (DOE-RL 96-81), includes 199 kg  
7 of total uranium, 0.1 kg of total plutonium, 0.015 kg <sup>241</sup>Am, 1.00 kg <sup>137</sup>Cs, and 0.86 kg of <sup>90</sup>Sr.  
8 During operations, the maximum volume of wastewater discharged to the 216-S-10 Ditch and  
9 Pond was approximately 568,000 L/day (150,000 gal/day). The annual volume of effluent  
10 discharged was approximately 1.9 L x 10<sup>8</sup> L (5.0 x 10<sup>7</sup> gal) (DOE/RL-99-44).

#### 11 2.4.1.4 216-S-10 Pond

12 The 216-S-10 Pond received discharge from the REDOX Plant. This pond was part of a system  
13 that included the 216-S-10 Ditch and the 216-S-11 Pond. The pond was dug in 1954 at the  
14 southwest end of the 216-S-10 Ditch to provide additional percolation surface.

15 The 216-S-10 Pond was an irregular-shaped, manmade pond that covered approximately  
16 20,234 m<sup>2</sup> (5 a) and included four finger-leach trenches. The pond was approximately 2.4 m  
17 (8 ft) at its deepest point. The pond was fed by the 216-S-10 Ditch. Both the ditch and pond  
18 were designed to dispose of liquids through percolation into the soil column.

19 Contributors to the pond and system description are similar to that of the 216-S-10 Ditch.  
20 In 1984, concurrent with the 216-S-10 Ditch, the pond was stabilized (DOE/RL-99-44).

#### 21 2.4.2 Summary of Data Collection Activities

22 This section summarizes the data collection activities performed during the 200-CS-1 OU RI, as  
23 well as data contained in WMP-17755; BHI-01651; PNNL-13198; BHI-062455, *Transmittal of*  
24 *Final Letter Report on Sampling and Analytical Activities at the 216-A-29 Ditch*; and  
25 BHI-01177, *Borehole Summary Report for the 216-B-2-2 Ditch*. This section also covers  
26 drilling, sampling, analysis, and geophysical logging. The following section, "Nature and Extent  
27 of Contamination," discusses the analytical results.

28 The RI was conducted from November 1999 to April 2003 at the two representative sites and  
29 two additional TSD sites, in accordance with the Work Plan (DOE/RL-99-44). The field  
30 investigations at the four waste sites included excavating 12 test pits and drilling 4 boreholes to  
31 collect soil samples, to define the vertical and lateral extent of contamination within the area  
32 historically defined as the waste site boundary. A total of 146 samples were collected and  
33 analyzed for radionuclides, metals, anions, polychlorinated biphenyls, volatile and semivolatiles  
34 organics, and physical properties. The four boreholes were logged with a high-resolution  
35 Spectral Gamma-Ray Logging System (SGLS) to provide continuous vertical logs of  
36 gamma-emitting radionuclides and were logged with a Neutron Moisture-Logging System  
37 (NMLS) to identify moisture changes. Two additional existing wells were logged with a  
38 high-resolution SGLS. The data collected are considered to be of sufficient quantity and quality  
39 to support the risk assessment activities and to support evaluation of remedial alternatives and  
40 identify preferred remedial actions.

1 The test pit locations, shown in Figures 2-5 through 2-7, were prepared by removing 0.3 to 0.6 m  
2 (1 to 2 ft) of topsoil from the site. The test pits were excavated to a maximum depth of 7.6 m  
3 (25 ft) bgs using a track-hoe. Samples were obtained directly from the track-hoe bucket at  
4 intervals of approximately 0.7 m (2.5 ft). Before being placed in a sample jar, soil samples were  
5 screened in the field for alpha and beta-gamma radioactivity to assist in selecting sample points,  
6 to support worker health and safety, and to provide shipping information. A radiological control  
7 technician using field instruments performed radiological screening. Samples were analyzed for  
8 chemical, radiological, and physical properties. The test pits were backfilled in the reverse order  
9 from which they were excavated using the track-hoe. The front-end loader was then used to  
10 backfill the site with topsoil and/or gravel.

11 The boreholes, shown in Figures 2-5 through 2-7, were drilled using a cable-tool drill rig. The  
12 boreholes were advanced to total depth using drive barrels and split-spoon samplers. Split-spoon  
13 samplers were the primary sampling device used to collect chemical, radiological, and physical  
14 property samples. The three boreholes were decommissioned with granular bentonite after  
15 reaching total depth, in accordance with *Washington Administrative Code (WAC) 173-160*,  
16 "Minimum Standards for Construction and Maintenance of Wells."

17 Data were collected to characterize the nature and vertical extent of chemical and radiological  
18 contamination and the physical conditions in the vadose zone underlying the historical  
19 boundaries of the 216-A-29 Ditch, 216-B-63 Trench, 216-S-10 Ditch, and the 216-S-10 Pond.  
20 Drilling, test pit excavation, surface and borehole geophysical surveys, and soil sampling and  
21 analysis were conducted during the field activities. All boreholes and test pits were completed,  
22 and all samples were collected and analyzed for chemical of concern, as identified in BHI-01276  
23 and the Work Plan (DOE/RL-99-44).

#### 24 2.4.2.1 216-A-29 Ditch Characterization

25 Borehole B8826 was drilled and sampled in the 216-A-29 Ditch east of the AP Tank Farm in the  
26 200 East Area (Figure 2-5). Test pits AD-1 through AD-3 were excavated and sampled at the  
27 216-A-29 Ditch in FY 2002 (BHI-01651) and details are summarized in this RI report. Data  
28 collected from Test Pit AD-3 was in addition to the data required by the Work Plan and was used  
29 to support the decision-making process for locating a proposed waste transfer line to the Waste  
30 Vitrification Plant as part of Project W-211. The characterization activities for the AD-3 site  
31 were performed in accordance with BHI-01562, *Sampling and Analysis Instruction for the*  
32 *216-A-29 Ditch for Project W-211*. Borehole B8826 was drilled through the 216-A-29 Ditch and  
33 sampled during FY 2003. The borehole was terminated at 83.2 m (273 ft). The borehole was  
34 logged using a high-resolution SGLS and an NMLS. The borehole was drilled to better define  
35 stratigraphy and to assess the nature and vertical extent of chemical and radiological  
36 contamination, as well as to determine the physical properties of the soil beneath the waste site.

37 One borehole, B8826, was drilled and sampled during FY 2003. The borehole was drilled  
38 through the 216-A-29 Ditch, from the ground surface to depth of 83.2 m (273 ft). Figure 2-8  
39 shows the contaminant distribution for the 216-A-29 Ditch.

#### 1 2.4.2.2 216-B-63 Trench Characterization

2 Borehole B8827 was drilled and sampled and test pits BT-1 and BT-2A were excavated and  
3 sampled in the 216-B-63 Trench, located east of the B Tank Farm in the 200 East Area  
4 (Figure 2-6). The two samples scheduled to be taken from Test Pit BT-1 at depths of 6.1 to  
5 7.6 m (20 and 25 ft) were not obtained because the test pit caved in excessively. Excavation  
6 equipment regulated for use in contaminated environments was unavailable, so sampling at Test  
7 Pit BT-2 in FY 2002 was terminated on November 2, 2001, after sampling at the 2.3 to 2.6 m  
8 (7.5 to 8.5 ft) depth. At that point, the soil was returned to the sampling pit in the reverse order  
9 from which it was excavated. Test Pit BT-2A was excavated and sampled to 7.6 m (25 ft) on  
10 November 11, 2002. This test pit was designated "BT-2A" to distinguish it from the FY 2002  
11 operations.

12 Borehole B8827 was drilled through 216-B-63 Trench and sampled during FY 2003. The  
13 borehole was terminated at 31.4 m (103 ft). The borehole was logged using a high-resolution  
14 SGLS and an NMLS. The borehole was drilled to better define stratigraphy and to assess the  
15 nature and vertical extent of chemical and radiological contamination, as well as to determine the  
16 physical properties of the soil beneath the waste site. Figure 2-9 shows the contaminant  
17 distribution for the 216-B-63 Trench.

#### 18 2.4.2.3 216-S-10 Ditch Characterization

19 Borehole B8828 was drilled and sampled adjacent to the 216-S-10 Ditch, and Test Pits SD-1,  
20 SD-2, and SD-3 were excavated and sampled in the 216-S-10 Ditch located in the 200 West Area  
21 (Figure 2-7). Borehole B8828 was completed as a RCRA monitoring well and renumbered as  
22 Well 299-W26-14 to support the RCRA monitoring program. Borehole B8828 was drilled  
23 through the 216-S-10 Ditch and sampled during FY 2003. The borehole was terminated at  
24 81.4 m (267 ft). The borehole was logged using a high-resolution SGLS and an NMLS. The  
25 borehole was drilled to better define stratigraphy and to assess the nature and vertical extent of  
26 chemical and radiological contamination, as well as to determine the physical properties of the  
27 soil beneath the waste site. An additional test pit, SD-3, was excavated in the 216-S-10 Ditch at  
28 the original location of the planned Borehole B8828 to gather characterization data below the  
29 waste site. Borehole B8828 was moved adjacent to the ditch. Figure 2-10 shows the  
30 contaminant distribution for the 216-S-10 Ditch. The maximum concentration of uranium found  
31 was 1.4 mg/kg, which is below the background concentration of 3.21mg/kg.

#### 32 2.4.2.4 216-S-10 Pond Characterization

33 Test Pits SP-1, SP-2, SP-3, and SP-4 were excavated and sampled in the 216-S-10 Pond  
34 (Figure 2-7). Borehole B8817 was drilled adjacent to the 216-S-10 Pond and sampled in  
35 FY 1999. Additional details are provided in PNNL-13198. The location of Borehole B8817 is  
36 shown on Figure 2-7. Borehole B8817 was completed as a RCRA monitoring well and  
37 renumbered as Well 299-W26-13. The borehole was logged using a high-resolution SGLS and  
38 an NMLS. The borehole was drilled to better define stratigraphy and to assess the nature and  
39 vertical extent of chemical and radiological contamination, as well as to determine the physical  
40 properties of the soil beneath the waste sites. Figure 2-11 shows the contaminant distribution for  
41 the 216-S-10 Pond.

## 2.5 EVALUATION OF ANALOGOUS WASTE SITES

DOE/RL-96-81 describes the grouping of 200 Areas waste sites based on process. Sites that received waste associated with a certain process were grouped by waste category (e.g., cooling water). The waste categories then were grouped based on more specific process details. This streamlining approach was implemented to reduce the amount of characterization and evaluation required to support remedial action decision making. Application of the concept takes into account similarities between waste sites such as waste stream type, discharge history, and geology, as well as the available characterization data, to assess the nature and extent of contamination. The concept builds on the knowledge gained from the characterization of a few waste sites (representative sites) that are indicative of worst case and typical OU conditions. Selection of representative sites generally is based on waste stream inventory, the volume of effluent discharged, and the knowledge gained from previous characterization efforts performed before the RI.

### 2.5.1 Assignment of Analogous Sites

This section contains the rationale used to align potential analogous waste sites to the representative sites and other characterized waste sites. Key to the logic is the comparison of the characteristics of representative and potential analogous sites as well as the identification of potential remedial alternatives that may apply. Important considerations of the physical system include the following:

- Waste stream received
- Volume of effluent received in relation to the available pore volume for the waste site
- Types and amounts of contaminants received; contaminant inventory
- Waste site size
- Waste site configuration and construction (e.g., crib, trench, UPR)
- Expected distribution of contaminants/nature and extent of contamination
- Neighboring waste sites, structures, or utilities
- Geologic setting
- Potential for hydrologic and contaminant impacts to groundwater.

Figure 2-12 shows the process for evaluating the analogous sites against the representative sites for the RI/FS process through the confirmatory and design sampling processes. The rationale for assigning each waste site to a representative site is presented in Table 2-2.

### 2.5.2 Analogous Sites

The five waste sites included in the 200-CS-1 OU represent 1 of the 23 process-based OUs in the 200 Areas. Four of the sites are TSD and the other site is a RCRA past practice site. Based on the analogous group assignment criteria above, one analogous site have been developed for this FS. Table 2-2 identifies the one representative site and its analogous site, plus supporting information for determining how the analogous site compared to the representative site.

1 The 216-S-11 Pond is analogous to the 216-S-10 Pond. The site was operated from May 1954 to  
2 August 1965. The site provided additional leaching capacity for the disposal of water from the  
3 216-S-10 Ditch. As such, it received the same waste stream as the 216-S-10 Pond and performed  
4 the same function as the 216-S-10 Pond.

5 Table 2-2 provides a detailed comparison of the representative site and its analogous site. This  
6 table indicates the type and level of contamination; amount of waste received at each site, where  
7 known; available soil pore volume; and rationale for inclusion of the analogous sites.

## 8 **2.6 BASELINE RISK ASSESSMENT SUMMARY**

9 This section provides the results of the RI baseline risk assessment (RI BRA) and a refined risk  
10 evaluation of the BRA. The first portion of this section summarizes the RI BRA, which includes  
11 the human health risk assessment for nonradionuclides, the RESidual RADioactivity (RESRAD)  
12 modeling for radionuclides, and the ecological risk assessment. The latter portion takes the BRA  
13 findings and evaluates them in terms of FS needs using conventional risk assessment refinement  
14 tools.

15 This process of continual evaluation, extension, and refinement in the FS is consistent with  
16 EPA/540/G-89/004, *Guidance for Conducting Remedial Investigations and Feasibility Studies*  
17 *under CERCLA, (Interim Final)*, OSWER 9355.3-01. The process of using the BRA as the  
18 foundation for extended analysis and refinement is shown conceptually in Figure 2-13 as a  
19 logical extension of the RI Report into the FS. The process is essentially a sequential narrowing  
20 and refining of the RI data aimed at defining the set of decisive risk-based issues.

21 Sections 2.7 through 2.13 summarize the RI BRA. The extension and refinement of the risk  
22 assessment is found in Sections 2.14 through 2.17.

### 23 **2.6.1 Remedial Investigation Baseline Risk** 24 **Assessment Overview**

25 The following RI BRA summary is condensed from Chapter 4.0 of the RI Report  
26 (DOE/RL-2004-17). This evaluation consists of a discussion of the conceptual site model  
27 (CSM), the human health risk assessment for nonradionuclide contaminants, and RESRAD  
28 modeling to assess the dose and risk from radionuclides. The dose and risk evaluation provides a  
29 characterization of site risks to determine if remedial actions are warranted and to support  
30 evaluation of remedial alternatives in the FS. In addition, this section includes a summary of the  
31 ecological risk screening of the 200-CS-1 OU contaminants against screening concentrations in  
32 WAC 173-340-900, "Tables," Table 749-3, for nonradionuclides and in DOE-STD-1153-2002,  
33 *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*, for  
34 radionuclides. The latter document was prepared for the DOE by the Biota Dose Assessment  
35 Committee. This document presents screening levels or biota concentration guides (BCG) for  
36 radionuclides along with a methodology for conducting ecological risk assessments for  
37 radionuclides. DOE/RL-2001-54 contains additional details on DOE-STD-1153-2002.

### 1 2.6.1.1 Physical Setting

2 Four sites were sampled and evaluated in the 200-CS-1 OU RI: 216-A-29 Ditch,  
3 216-B-63 Trench, 216-S-10 Ditch, and the 216-S-10 Pond. These sites are former ponds and  
4 ditches that received inorganic and organic chemicals as part of process water and chemical  
5 sewer waste streams. The waste sites are described in detail in Chapter 2.0 of the RI Report  
6 (DOE/RL-2004-17). These sites lie on the Central Plateau in and near an industrial area. The  
7 areas proximal to these representative sites have been disturbed by operations for several  
8 decades. The Hanford Site climate is classified as mid-latitude semiarid or mid-latitude desert,  
9 depending on the climatological classification scheme. Most precipitation occurs during late  
10 autumn and winter with more than half the annual amount occurring from November through  
11 February (PNNL-6415). Normal annual precipitation is 17.7 cm (6.98 in.). Additional  
12 discussion of the physical setting can be found in Chapter 4.0 of the RI Report  
13 (DOE/RL-2004-17).

### 14 2.6.1.2 Ecological Setting

15 The overarching classification for the ecology of the Hanford Site area is shrub-steppe, although  
16 this broad classification can be refined into a number of separate types of communities found  
17 within the shrub-steppe. The area surrounding the 200-CS-1 OU representative sites contains  
18 two of the eight representative vegetation community types found on the Central Plateau. At the  
19 sites in the 200 East Areas, the vegetation surrounding the waste site consists of crested  
20 wheatgrass. In the 200 West Areas, both the 216-S-10 Pond and 216-S-10 Ditch lie in the  
21 cheatgrass/Sandberg's bluegrass vegetation community. All of the eight vegetation communities  
22 and the available census data on plant, bird, and mammal species are described in depth  
23 DOE/RL-2001-54. Site-specific descriptions of the vegetation and wildlife in the two  
24 communities found at the representative sites can be found in Chapter 4.0 of the RI Report  
25 (DOE/RL-2004-17).

### 26 2.6.1.3 Sensitive Habitats

27 Sensitive habitats include those identified in DOE/RL-96-32 as rare or wetlands (or riparian)  
28 habitat. There are no sensitive or rare habitats associated with the 200-CS-1 representative sites;  
29 wetlands do not occur within the vicinity of the representative sites.

### 30 2.6.1.4 Endangered, Threatened, and Sensitive Species

31 Two Federally protected species have been observed at the Hanford Site, the Aleutian Canada  
32 goose and the bald eagle (*Haliaeetus leucocephalus*). Both depend on the river corridor and  
33 rarely are seen in the Central Plateau. The ferruginous hawk (*Buteo regalis*) and the sage grouse  
34 (*centrocercus urophasianus*) are state threatened species that reside in the sagebrush/steppe  
35 habitat; a small population of ferruginous hawks nests in the 200 Areas.

36 Several additional state and Federal special-status species, such as burrowing owls (*Athene*  
37 *cunicularia*), loggerhead shrike (*Lanus ludovicianusi*), long-billed curlew (*Numenius*  
38 *americanus*) and the sage sparrow (*Amphispiza belli*), are found in and near the 200 Areas.  
39 Of these, only the long-billed curlew is expected to be associated with the vegetation  
40 communities at these representative sites, though burrowing owls may be attracted to

1 disturbed sites. No plants, invertebrates, amphibians, reptiles, or mammals on the Federal or  
2 Washington State threatened and endangered or sensitive species lists are known to inhabit the  
3 Central Plateau.

#### 4 **2.6.1.5 Rare Plants**

5 Rare plant species are vascular plant species listed by the Washington Natural Heritage Program  
6 (WNHP 1998) as endangered, threatened, or sensitive in Washington State. Rare plants and  
7 sensitive habitats of concern occur within the 200 East and 200 West fence lines, though not at  
8 the representative sites.

#### 9 **2.6.1.6 Mammals of Concern**

10 The state has classified the pygmy rabbit (*Brachylagus idahoensis*) as a candidate endangered  
11 species. None has been observed to date in the Central Plateau.

#### 12 **2.6.1.7 New-to-Science Species**

13 The Nature Conservancy conducted a biodiversity survey of plants, mammals, reptiles and  
14 amphibians, birds, and insects at the Hanford Site between 1994 and 1998 (TNC 1999,  
15 *Biodiversity Inventory and Analysis of the Hanford Site, Final Report 1994-1999*). This survey  
16 found 2 species and 1 variety of plants and 41 species and 2 subspecies of insects that had not  
17 been known to science. Except possibly for some of the insects, none of these new-to-science  
18 species is expected to be located near the 200-CS-1 OU waste sites.

#### 19 **2.6.2 Land-Use Characterization**

20 The land-use boundary around the 200 East and 200 West Areas Core Zone has been designated  
21 as industrial-exclusive in DOE/EIS-0222-F, *Final Hanford Comprehensive Land-Use Plan*  
22 *Environmental Impact Statement*. Based on DOE/EIS-0222-F and the associated 64 FR 61615,  
23 "Record of Decision: Hanford Comprehensive Land-Use Plan Environmental Impact Statement  
24 (HCP EIS)" industrial-exclusive land use is defined as "preserving DOE control of the  
25 continuing remediation activities and use of the existing compatible infrastructure required to  
26 support activities such as dangerous waste, radioactive waste, and mixed waste treatment,  
27 storage, and disposal facilities" (DOE/EIS-0222-F). All of the waste sites associated with the  
28 200-CS-1 OU are located within this industrial-exclusive land-use area. Therefore, the waste  
29 sites chosen within the 200 West and 200 East Areas are being evaluated primarily under  
30 industrial land use. An unrestricted surface-land-use scenario also was assessed in the RI BRA  
31 to provide decision makers with information on potential human health impacts associated with  
32 worst-case exposure conditions. However, the unrestricted surface-land-use scenario does not  
33 factor directly into the FS evaluation process. Consequently, other than for informative  
34 reference, the unrestricted surface-land-use scenario will not be addressed in the extended risk  
35 analysis.

36 Ecological-screening criteria assigned to both industrial and unrestricted land-use scenarios also  
37 were evaluated. Based on standards in specific sections of Ecology guidance (WAC 173-340,  
38 "Model Toxics Control Act -- Cleanup"), the lowest of the plant, soil biota, and wildlife

1 screening levels for ecological risk were used to assess the unrestricted surface-land-use  
 2 scenario, whereas only the wildlife ecological risk screening levels are being used for screening  
 3 under the industrial-land-use scenario. Once again, only the industrial-land-use scenario wildlife  
 4 ecological risk screening information is relevant to the FS process.

### 5 2.6.3 Beneficial Groundwater Use

6 Regardless of the land-use designation for soil, groundwater cleanup levels are based on the  
 7 highest beneficial use and reasonable maximum exposure expected to occur under both current  
 8 and potential future waste site use. Groundwater use is not an issue for ecological receptors at  
 9 these sites because no groundwater connection to the surface is available to allow wildlife  
 10 access. In addition, the aquifer is too deep for plant roots to bring groundwater from the aquifer  
 11 back to the surface at the sites. Local groundwater is not a current source of drinking water at  
 12 the 200-CS-1 OU waste sites. In addition, groundwater beneath the waste sites is not anticipated  
 13 to become a future source of drinking water until groundwater risk-based concentrations are met.  
 14 Under current conditions, no complete human exposure pathways to groundwater are assumed at  
 15 the waste sites. The risks for the Central Plateau were evaluated in PNNL-13788. Groundwater  
 16 remediation will be addressed through the appropriate groundwater OUs (200-BP-5, 200-PO-1,  
 17 200-UP-1).

### 18 2.6.4 Conceptual Exposure Model for Human 19 Exposure

20 An exposure pathway is the means by which a contaminant moves from a source to a receptor  
 21 (a potentially exposed individual or organism). A complete exposure pathway has the following  
 22 five elements:

- 23     • A contaminant source
- 24     • A mechanism for contaminant release
- 25     • An environmental transport medium
- 26     • An exposure point (i.e., a location where people or wildlife can come into contact with  
 27 the contaminants)
- 28     • A feasible route of exposure (ingestion, dermal contact, direct exposure, or inhalation).

29 Figure 2-14 is a condensed and refined version of the CSM from the RI BRA. Exposure can  
 30 occur when contaminants migrate from their source to an exposure point or when a receptor  
 31 moves into direct contact with contaminants or contaminated media close to the source. An  
 32 exposure pathway is complete if a means is available for the receptor to be exposed through  
 33 ingestion, inhalation, direct exposure, or dermal absorption at a location where site-related  
 34 contaminants are present. No exposure (and therefore no risk) exists unless the exposure  
 35 pathway is complete.

1 Evaluation of the exposure pathway model is a key feature in the RI/FS risk-assessment process.  
2 The CSM also is used in the FS to evaluate remedial action by considering pathway  
3 modifications (e.g., contaminant sources, releases, transport or exposure points) through the use  
4 of technologies and institutional controls.

#### 5 **2.6.4.1 Potential Human Exposure Pathways**

6 The four sites (216-A-29 Ditch, 216-B-63 Trench, 216-S-10 Ditch, and the 216-S-10 Pond) are  
7 located within the Core Zone, based on DOE/EIS-0222-F. The most probable future land use in  
8 these areas is continued industrial uses. Examination of Figure 2-14 demonstrates that all  
9 potentially complete human exposure pathways are associated with exposure to shallow zone  
10 soils, which has been defined as extending from the ground surface to a depth of 4.6 m  
11 (15 ft) bgs. This soil depth is associated with potential exposure under an industrial land-use  
12 scenario in WAC 173-340-740(6)(d), and WAC 173-340-745(7). This represents a reasonable  
13 estimate of the depth of soil that could be excavated and distributed at the soil surface as a result  
14 of site development activities.”

15 In the RI BRA, potential exposure concentrations at each site were represented by the maximum  
16 detected concentration in the 0 to 4.6 m (0 to 15 ft) soil column, referred to as “shallow-zone  
17 soil.” An upper confidence limit (e.g., 95%UCL) on an average concentration is the generally  
18 recommended approach for estimating an exposure-point concentration (EPC) (EPA 2002,  
19 *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste*  
20 *Sites*, OSWER 9285.6-10). However, because of the nature of the analysis expressed in the  
21 RI BRA, it was believed that a maximum concentration should be used which resulted in a  
22 highly conservative assessment. While potentially appropriate for a screening level assessment,  
23 the use of a maximum values to estimate EPCs for contaminants that are spatially dispersed over  
24 a sizeable exposure area may not be as suitable a technique as the use of a 95%UCL computed  
25 with the robust methods suggested in OSWER 9285.6-10. On this basis, the effects of using a  
26 95%UCL concentration estimate, in lieu of the maximum concentration to assess exposure, will  
27 be considered in the extended risk assessment.

#### 28 **2.6.4.2 Groundwater Pathway**

29 Exposure to groundwater constituents was not directly incorporated into the exposure models for  
30 either radionuclides or nonradionuclides because groundwater in the 200 Areas is not used as  
31 drinking water and is not anticipated to be a drinking water resource in the future. In the  
32 RI BRA, potential impacts to groundwater for nonradionuclides were screened by comparing the  
33 maximum detected soil concentration at any depth in the vadose zone to WAC 173-340-747,  
34 “Deriving Soil Concentrations for Ground Water Protection,” soil screening values developed for  
35 groundwater protection. The use of these conservative generic screening values to assess the  
36 potential impacts to groundwater, in light of site-specific conditions, will be considered in the  
37 extended risk assessment. Potential groundwater impacts of radionuclides were evaluated within  
38 the RESRAD modeling framework.

### 1 2.6.5 Potential Ecological Exposure Pathways

2 The RI BRA found that the major ecological exposure pathways expected at the representative  
3 sites in the 200-CS-1 OU waste site are direct ingestion of contaminated soil and ingestion of  
4 food items that have taken up contaminants from soil. Although some standing water potentially  
5 could remain after precipitation events, these sites have no permanent bodies of water.  
6 Therefore, only pathways associated with exposure to contaminated soil were considered to be  
7 complete. Species potentially present at the representative sites include both surface-dwelling  
8 species and a number of burrowing species such as harvester ants.

9 The exposure pathways included when developing the screening levels in the RI BRA included  
10 complete exposure pathways except for inhalation and dermal exposure. Although these  
11 pathways contribute to the dose of contaminants of potential ecological concern (COPEC)  
12 received by animals, the contribution from these pathways is expected to be relatively small and  
13 not contribute significantly to receptor exposure (EPA 2003, *Guidance for Developing*  
14 *Ecological Soil Screening Levels*, OSWER Directive 9285.7-55).

15 Once again, the soil concentrations used to represent the EPCs for contaminants at this site were  
16 the maximum detected concentrations seen at any point within the top 4.6 m (15 ft) of the soil  
17 column below ground surface. Again, effects of using maximum concentrations to assess  
18 exposure will be considered in the extended risk analysis.

## 19 2.7 HUMAN HEALTH EVALUATION FOR 20 NONRADIOLOGICAL CONSTITUENTS

21 As discussed in the RI BRA, potential adverse health effects are evaluated in the absence of any  
22 remedial action. This evaluation generally consists of four steps: data collection and analysis,  
23 exposure assessment, toxicity assessment, and risk characterization (EPA/540/1-89/002, *Risk*  
24 *Assessment Guidance for Superfund (RAGS), Volume I -- Human Health Evaluation Manual,*  
25 *(Part A) Interim Final*, OSWER 9285.7-01A). In addition to this overarching directive, the  
26 following guidance was used in conducting the human health evaluation for nonradiological  
27 constituents:

- 28 • Ecology 94-145, *Cleanup Levels and Risk Calculations under the Model Toxics Control*  
29 *Act Cleanup Regulation; CLARC, Version 3.1*, which provides screening levels for  
30 nonradioactive analytes regulated under WAC 173-340-740, WAC 173-340-745, and  
31 WAC 173-340-747.
- 32 • DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive*  
33 *Analytes*, which provides soil background concentrations for nonradioactive analytes.

34 These primary guidance documents define the main framework of the screening level RI BRA.

### 2.7.1 Nonradiological Contaminants of Potential Concern for Human Health

Contaminants of potential concern (COPC) are those constituents that pose potentially unacceptable human health risks. Actions to improve the understanding of COPC distribution and/or migration in the environment or actions to mitigate potential exposures are evaluated in this FS. The technical approach for identifying nonradionuclide COPCs is discussed in detail in the RI Report (DOE/RL-2004-17) and summarized in the following sections. Figure 2-15 presents the general approach to the COPC screening process used in the RI BRA. The approach is widely used in screening COPCs for risk assessment at hazardous waste sites; it is frequently tailored to site-specific circumstances.

### 2.7.2 Data Evaluation

- All soil data collected under the 200-CS-1 OU Work Plan (DOE/RL-99-44) was considered in the human health evaluation.
- All nonradiological constituents detected in one or more samples were included in the human health risk evaluation. Sample data with estimated concentrations ("B" or "J" qualification flags) were evaluated at the reported concentration in the risk evaluation. Rejected ("R" qualified) data were not used in the risk evaluation. If duplicate sample results were available for a sample, the highest of the reported concentrations was used in the risk evaluation.
- The main distinction for data use in the human health risk evaluation was the sample depth. Maximum detected concentrations from analytical data from samples collected in shallow-zone soils (depths of 4.6 m [15 ft] or less) were evaluated for direct contact by comparison to WAC 173-340-740 (unrestricted) and WAC 173-340-745 (industrial) soil cleanup standards. Maximum detected concentrations from analytical data from samples collected at all depths (deep-zone soils) were evaluated for potential groundwater impacts by comparison with soil cleanup values calculated using the fixed-parameter three-phase partition model described in WAC 173-340-747.

Sample results for the 200-CS-1 OU representative sites can be found in Tables 4-1 through 4-4 of the RI Report (DOE/RL-2004-17).

The COPC determination process included standard evaluation steps proved by guidance as summarized in the following sections.

### 2.7.3 Identification of Essential Nutrients

Chemicals that are considered essential human nutrients, that are toxic only at high doses, and that are present at concentrations only slightly higher than naturally occurring levels, are not generally evaluated in a human health risk assessment (EPA/540/1-89/002). Examples of such chemicals described in EPA/540/1-89/002, Section 5.9.4, include iron, magnesium, calcium, potassium, and sodium. To ensure that site concentrations are not significantly elevated above

1 background levels, these analytes were included in the background screening before being  
2 eliminated as essential nutrients.

### 3 2.7.4 Background Screening

4 As described in the RI Report (DOE/RL-2004-17), detected constituents that are not essential  
5 nutrients were screened for consideration in the risk-based evaluation by comparing the  
6 maximum detected concentration with background concentrations. Generally, the Hanford Site  
7 lognormal 90<sup>th</sup>-percentile background values are used as the benchmark to identify potentially  
8 site-related contaminants in the background screening, as recommended in DOE/RL-92-24.<sup>2</sup>  
9 Background criteria have not been developed for organic chemicals in Hanford Site soils.  
10 Therefore, concentrations of these constituents have been compared to soil cleanup levels  
11 without a prior background screening.

12 The results of the background comparisons for inorganic chemicals, indicating those chemicals  
13 detected above background levels in one or more samples and detected chemicals for which  
14 background data are unavailable, are presented in Table 4-5 of the RI Report  
15 (DOE/RL-2004-17). A summary of the RI BRA background comparisons indicates that the  
16 following constituents are present in shallow- and/or deep-zone soil at maximum concentrations  
17 greater than background or do not have an applicable background value and will be evaluated by  
18 comparison to WAC soil cleanup levels:

- 19     ◦ **216-S-10 Ditch.** Arsenic, bismuth, boron, total chromium, hexavalent chromium, copper,  
20     lead, mercury, molybdenum, nickel, nitrate, nitrite, nitrate/nitrite, phosphate, selenium,  
21     silver, sulfide, thallium, vanadium, and zinc.
- 22     ◦ **216-S-10 Pond.** Barium, boron, total chromium, hexavalent chromium, cyanide, lead,  
23     mercury, molybdenum, nickel, nitrate, nitrite, nitrate/nitrite, phosphate, selenium, silver,  
24     sulfide, thallium, vanadium, and zinc.
- 25     ◦ **216-B-63 Trench.** Ammonia, bismuth, boron, cadmium, total chromium, hexavalent  
26     chromium, copper, molybdenum, nickel, nitrate, nitrite, nitrate/nitrite, phosphate,  
27     selenium, sulfide, thallium, vanadium, and zinc.
- 28     ◦ **216-A-29 Ditch.** Ammonia, arsenic, barium, bismuth, boron, cadmium, calcium, total  
29     chromium, hexavalent chromium, chloride, copper, fluoride, lead, mercury, molybdenum,  
30     nickel, nitrate, nitrite, nitrate/nitrite, potassium, selenium, silver, sodium, sulfate, sulfide,  
31     thallium, uranium, vanadium, and zinc.

32 Maximum detected values of the essential nutrients calcium, potassium, and sodium were above  
33 background levels only at the 216-A-29 Ditch. As discussed in the RI Report  
34 (DOE/RL-2004-17), the maximum values for these analytes ranged from approximately

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<sup>2</sup> This is a non-inferential comparison used mainly to streamline the process when rigorous statistical processes cannot be used.

1 5 percent (potassium) to 40 percent (calcium) greater than background levels. Although  
2 technically in excess of the screening criteria, the maximum concentrations of these analytes are  
3 consistent with the condition of being only slightly higher than background (EPA/540/1-89/002).  
4 Therefore, these essential nutrients were not evaluated further in the risk assessment.

#### 5 **2.7.5 Screening to WAC 173-340 Soil and** 6 **Groundwater Protection-Screening Standards**

7 One of the principal discrimination techniques used in the screening-level evaluation is that of  
8 comparing measured environmental media concentrations to recognized benchmark  
9 concentrations. The benchmark concentrations typically are indexed to accepted, and frequently  
10 conservative, exposure models and toxicity assumptions. At the same time, for purposes of  
11 screening media and exposure pathways, the measured environmental media concentrations used  
12 to gauge the risk posed by site conditions often are biased and expressive of near worst-case  
13 conditions rather than more likely, or typical, exposure conditions. For the four 200-CS-1 OU  
14 reference sites, the screening benchmark concentrations taken from WAC 173-340 are  
15 intentionally conservative values based on protective exposure assumptions and traditional  
16 U.S. Environmental Protection Agency (EPA) Integrated Risk Assessment System (IRIS)  
17 toxicity information. Additionally, maximum measured reference site soil concentrations were  
18 used to gauge the threat posed by the entire representative site. Thus, as reported in the  
19 RI Report (DOE/RL-2004-17), the results of the process of comparing WAC 173-340 soil and  
20 groundwater protection screening standards to maximum concentrations from the representative  
21 sites to process are regarded as highly protective and express a significant err on the side of  
22 safety. The results of the screening can be used with a high degree of confidence that, if media  
23 and pathways are screened out, residual risks are well within acceptable limits.

24 Inorganic constituents with maximum detected concentrations exceeding background screening  
25 values, and organic chemicals detected in one or more samples, were screened using  
26 WAC 173-340-740 and WAC 173-340-745 cleanup standards. The maximum detected  
27 concentration in the upper 4.6 m [15 ft] (shallow-zone soil) was compared to direct-contact  
28 cleanup levels for industrial land use (WAC 173-340-745 standards) and unrestricted land use  
29 (WAC 173-340-740 standards). As described previously, industrial land use is the primary basis  
30 for identifying potential COCs in the screening assessment of direct soil contact. Screening for  
31 residential land use, which represents worst-case exposure intensity, was provided only for  
32 information.

33 The maximum detected concentration of inorganic constituents deep-zone soil was compared to  
34 WAC soil cleanup levels for groundwater protection. Groundwater cleanup levels and  
35 analyte-specific chemical properties used in the calculation of the soil cleanup levels were  
36 obtained from Ecology 94-145. The fixed-parameter (default values) variant of the three-phase  
37 equilibrium-partitioning model (WAC 173-340-747) was used for calculating soil cleanup levels  
38 for groundwater protection. Additional information on this screening step, including exposure  
39 parameter assumptions for industrial and unrestricted land use, and values used in the  
40 three-phase equilibrium-partitioning model, are found in the RI Report (DOE/RL-2004-17).

1 Table 2-3 shows the results of the screening comparisons (see Figure 2-15) between the BRA  
 2 and the maximum concentrations detected above WAC levels for direct contact under the  
 3 industrial land-use scenario. The X-mark indicates that the maximum concentration exceeded  
 4 the screening concentration in the upper 4.6 m [15 ft] (shallow-zone soil). The actual  
 5 direct-contact comparisons and groundwater protection comparisons for organic and inorganic  
 6 chemicals at each site are presented in the RI Report (DOE/RL-2004-17).

7 Inspection of Table 2-3 reveals that, for industrial land use, maximum detected values in  
 8 shallow-zone soil exceeded WAC 173-340-745 industrial direct exposure-screening values, or  
 9 screening values were unavailable, for the following constituents:

- 10 • **216-A-29 Ditch.** Bismuth and TBP
- 11 • **216-B-63 Trench.** Bismuth
- 12 • **216-S-10 Ditch.** Bismuth
- 13 • **216-S-10 Pond.** None.

14 For groundwater protection, maximum detected values of regulated chemicals in deep-zone soil  
 15 exceeded WAC 173-340-747 groundwater protection-screening values, or screening values were  
 16 unavailable, for the following constituents:

- 17 • **216-A-29 Ditch.** Aroclor 1254,<sup>3</sup> arsenic, benzo(a)anthracene, bismuth, cadmium,  
 18 chrysene, 1,2-dichloroethane, mercury, methylene chloride, nitrate, nitrate/nitrite, silver,  
 19 sulfate, TBP, and uranium.
- 20 • **216-B-63 Trench.** Benzene, bismuth, cadmium, nitrate, and nitrate/nitrite.
- 21 • **216-S-10 Ditch.** Aroclor 1254, arsenic, benzo(a)anthracene, benzo(a)pyrene,  
 22 benzo(b)fluoranthene, benzo(k)fluoranthene, bismuth, chrysene, mercury, and silver.
- 23 • **216-S-10 Pond.** Methylene chloride and vinyl chloride.

24 Risk-screening criteria were available for all constituents excepting bismuth and TBP. Insoluble  
 25 bismuth salts are considered to be nontoxic and are used pharmaceutically as antacids and to  
 26 control diarrhea (Amdur et al. 1991, *Casarett and Doull's Toxicology: The Basic Science of*  
 27 *Poisons*). The presence of low concentrations (less than 10 mg/kg) of bismuth at some sites  
 28 therefore is highly unlikely to constitute a potentially significant health risk. TBP is a potentially  
 29 toxic compound that has exhibited central nervous system effects in some animal studies.  
 30 However, the EPA has not published toxicity values for this compound, nor for any other  
 31 phosphate ester that might be used as a toxicity surrogate, and it is not listed in the CLARC 3.1  
 32 tables associated with WAC 173-340-740, WAC 173-340-745, and WAC 173-340-747. TBP  
 33 was detected at the 216-A-29 Ditch at a maximum concentration of approximately 0.5 mg/kg,  
 34 which is a negligible soil concentration for industrial land use, even for potent carcinogens such  
 35 as benzo(a)pyrene or central nervous system toxicants such as lead. TBP, therefore, is unlikely  
 36 to pose a significant health risk at the 216-A-29 Ditch. Scientific rationale presented in the RI

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<sup>3</sup> Aroclor is an expired trademark.

1 Report established that these two compounds do not pose a significant threat and they were  
2 omitted from further consideration as COPCs.

3 A key premise established in the RI Report is that, for site conditions where an uncontaminated  
4 vadose zone lies above the water table, and where a chemical distribution coefficient (i.e., the  
5  $K_d$  value) is relatively high, the equilibrium partitioning model (WAC 173-340-747,  
6 Equation 747-1) will not satisfactorily express the fact that a chemical is unlikely to migrate  
7 from the contaminated zone to groundwater, in all cases. This is particularly pronounced in the  
8 case of the higher molecular weight hydrophobic organic compound such as Aroclor and some  
9 metals. In the 200 Area composite analysis, it was determined that constituents with  $K_d$  values  
10 of 40 L/kg or greater are essentially immobile in the vadose zone and groundwater of this area  
11 (PNNL-11800, *Composite Analysis for Low-Level Waste Disposal in the 200-Area Plateau of the*  
12 *Hanford Site*). Table 2-4 lists those compounds from Table 2-3 that exceed the screening level  
13 for protection of groundwater and their individual  $K_d$  values, and provides a finding for each  
14 constituent. As indicated, 12 of the COPCs whose maximum soils concentrations exceeded  
15 groundwater protection-screening levels have  $K_d$ s less than 40 L/kg and would have the potential  
16 to actually reach and affect groundwater. The remaining eight COPCs whose maximum soils  
17 concentrations exceeded groundwater protection-screening levels have  $K_d$ s greater than 40 L/kg  
18 and would not have the mobility potential in the vadose zone to reach and affect groundwater.

#### 19 **2.7.6 Summary of Nonradiological Contaminant of** 20 **Potential Concern and Uncertainty Analysis**

21 Based on a review of Table 2-3, the results of the risk evaluation indicate that no potentially  
22 significant health risks are associated with direct soil contact under industrial land use, the  
23 primary land-use scenario.

24 The results of soil screening for groundwater protection found in Table 2-4 indicate that several  
25 soil constituents (Aroclor 1254, arsenic, benzene, benzo(a)anthracene, benzo(a)pyrene,  
26 benzo(b)fluoranthene, benzo(k)fluoranthene, cadmium, chrysene, 1,2-dichloroethane,  
27 fluoranthene, mercury, methylene chloride, nitrate, nitrate/nitrite, silver, sulfate, uranium, and  
28 vinyl chloride) may have potentially significant groundwater impacts. As described in  
29 Section 4.2.2 of the RI Report, the finding of potential groundwater impacts for some of these  
30 constituents is an artifact of the use of the fixed-parameter three-phase partitioning model. This  
31 model, described in WAC 173-340-747, is an equilibrium model that does not account for  
32 transport through an uncontaminated vadose zone. In fact, for most of the constituents, a  
33 considerable thickness of vadose zone separates contamination from the aquifer. As discussed in  
34 PNNL-11800, constituents with  $K_d$  values of 40 L/kg or greater are highly unlikely to be able to  
35 infiltrate through an uncontaminated vadose zone to groundwater.

#### 36 **2.8 HUMAN HEALTH EVALUATION FOR** 37 **RADIOLOGICAL CONSTITUENTS**

38 The RESRAD computer code (ANL 2002, *RESRAD for Windows*) was used to evaluate potential  
39 adverse health effects associated with residual radionuclides in soil at the four representative  
40 sites (216-A-29 Ditch, 216-B-63 Trench, 216-S-10 Ditch, and the 216-S-10 Pond). Radiological

1 COPCs were identified based on detection status and comparison to background concentrations.  
 2 The results of RESRAD modeling of potential health effects associated with exposure to  
 3 radionuclides in shallow-zone soil and groundwater impacts related to infiltration of  
 4 radionuclides in deep-zone soil are summarized below and described in detail in the RI Report  
 5 (DOE/RL-2004-17).

### 6 2.8.1 Selection of Radiological Contaminants of 7 Potential Concern in Shallow-Zone Soil Samples

8 As discussed in the RI Report (DOE/RL-2004-17), COPCs are those radionuclides that pose  
 9 potentially unacceptable radiological dose and/or cancer risks. According to the RI Report, if  
 10 exposure to radionuclide COPCs was estimated to exceed dose or risk criteria then additional  
 11 risk assessment evaluation is performed. These evaluations include improved understanding of  
 12 COPC distribution and/or migration in the environment plus actions to mitigate potential  
 13 exposures.

### 14 2.8.2 Background Screening

15 Hanford Site 90<sup>th</sup>-percentile background values were used to identify potentially Site-related  
 16 contaminants in the background screening. The background values were identified in  
 17 DOE/RL-96-12, *Hanford Site Background: Part 2, Soil Background for Radionuclides*. The  
 18 background screening was conducted separately for shallow-zone soils (0 to 4.6 m [0 to 15 ft])  
 19 and deep-zone soils (0 m to groundwater). Shallow-zone radionuclide concentrations were  
 20 evaluated for health impacts related to surface exposure, whereas radionuclide concentrations  
 21 from any depth were evaluated for potential groundwater impacts. Constituents with a maximum  
 22 detected concentration exceeding background in shallow- and/or deep-zone soil, or for which no  
 23 background value is available, were retained for evaluation in RESRAD.

24 The following constituents are present at maximum concentrations greater than background or do  
 25 not have an applicable background value and will be further evaluated for either surface  
 26 exposure and/or potential groundwater impacts:

- 27     • 216-A-29 Ditch. <sup>241</sup>Am, <sup>125</sup>Sb, <sup>137</sup>Cs, <sup>237</sup>Np, <sup>238</sup>Pu, <sup>239/240</sup>Pu, <sup>226</sup>Ra, <sup>230</sup>Th, <sup>90</sup>Sr, tritium,  
 28       and <sup>233/234</sup>U.
- 29     • 216-B-63 Trench. <sup>241</sup>Am, <sup>137</sup>Cs, <sup>237</sup>Np, <sup>63</sup>Ni, <sup>99</sup>Tc, <sup>230</sup>Th, <sup>90</sup>Sr, and tritium.
- 30     • 216-S-10 Ditch. <sup>241</sup>Am, <sup>137</sup>Cs, <sup>63</sup>Ni, <sup>239/240</sup>Pu, <sup>226</sup>Ra, <sup>228</sup>Th, <sup>230</sup>Th, <sup>232</sup>Th, <sup>90</sup>Sr, and tritium.
- 31     • 216-S-10 Pond. <sup>241</sup>Am, <sup>14</sup>C, <sup>137</sup>Cs, <sup>237</sup>Np, <sup>63</sup>Ni, <sup>239/240</sup>Pu, <sup>228</sup>Th, <sup>230</sup>Th, <sup>90</sup>Sr, and tritium.

### 32 2.8.3 RESRAD Assumptions and Input Parameters

33 Waste site-specific or Hanford Site-specific data were used where available as input parameters  
 34 for the RESRAD modeling. The types of parameters for which such data were used included

1 vadose zone hydrogeologic characteristics, radionuclide  $K_d$  values, the dimensions of each site,  
2 and the depth of cover material on each site. A detailed explanation of the derivation and  
3 application of waste site-specific and Hanford Site-specific physical data for the RESRAD  
4 modeling is provided in the RI Report (DOE/RL-2004-17).

5 Maximum detected concentrations of radionuclides in the 0 to 4.6 m (0 to 15 ft) shallow-soil  
6 zone were evaluated in RESRAD for potential radiation dose and cancer risk from surface  
7 exposure. Potential radiation dose and cancer risk associated with these concentrations were  
8 assessed under two conditions related to the presence or absence of existing cover. In the first  
9 condition, the maximum detected concentration was assumed to be uniformly present across the  
10 entire site area from 0 to 4.6 m (0 to 15 ft) bgs. In the second condition, the maximum detected  
11 concentration was assumed to be uniformly present across the entire site area to a depth of 4.6 m  
12 (15 ft), but the site-specific depth of existing cover identified in the RI data was accounted for in  
13 the RESRAD modeling. The cover material was assumed to be "clean," such that the cover was  
14 free of any radionuclides.

#### 15 2.8.4 RESRAD Results

16 Radionuclides with maximum detected concentrations in shallow-zone soil exceeding  
17 background-screening values or for which background values were unavailable were evaluated  
18 for potential human health effects using Version 6.21 of the RESRAD computer code  
19 (ANL 2002). As described in Section 4.4.2 of the RI Report, results were presented for both  
20 industrial and unrestricted surface land use and for present-day surface conditions (cover  
21 material, if present) and potential worst-case surface conditions (no cover). RESRAD output  
22 was obtained at the following model years: 0, 1, 10, 30, 100, 150, 250, 500, and 1,000. Detailed  
23 RESRAD modeling results are presented for the individual waste sites in Sections 4.4.3.1 to  
24 4.4.3.4 of the RI Report (DOE/RL-2004-17). Radionuclide doses for each exposure pathway and  
25 radionuclide are summed to calculate the total dose to an individual. For both the industrial- and  
26 unrestricted surface-land-use scenarios, radiation doses are below the 15 mrem/yr target dose  
27 limit throughout the modeling period.

28 Cancer risks for each exposure pathway and radionuclide are summed to calculate the total  
29 cancer risk to an individual. Cancer risk estimates are evaluated relative to the target risk range  
30 of  $10^{-6}$  to  $10^{-4}$  described in 40 CFR 300, "National Oil and Hazardous Substances Pollution  
31 Contingency Plan."

32 Table 2-5 summarizes the findings. The key observations are as follows:

- 33 • 216-A-29 Ditch:
  - 34 – No dose or risk exceedances for either of the industrial cover scenarios. There is an
  - 35 exceedance in dose but no risk for the industrial, no-cover scenario. There are
  - 36 projected exceedances of dose and risk for the cover and no-cover unrestricted
  - 37 scenarios.
  - 38 – Contamination (tritium) breakthroughs to groundwater in year 10 at concentration
  - 39 producing a maximum dose of 0.005 mrem/yr. The dose is insignificant.

- 1       • 216-B-63 Trench:
- 2           – No dose or risk exceedances for either the cover or no-cover industrial scenarios.
- 3           There is an exceedance in dose and risk for the unrestricted, no-cover scenarios. Note
- 4           that the exceedance disappears by year 100.
- 5           – Contamination (Tc-99) breakthroughs to groundwater in year 708 at concentration
- 6           producing a maximum dose of 0.015 mrem/yr. The dose is insignificant.
- 7       • 216-S-10 Ditch: No dose or risk exceedance, and no contaminant breakthrough to
- 8           groundwater projected over the 1,000-year modeling framework.
- 9       • 216-S-10 Pond:
- 10           – No dose or risk exceedances for either the cover or no-cover industrial scenarios
- 11           Exceedance in dose and risk for the unrestricted, no-cover scenarios. Note that the
- 12           exceedance disappears by year 10.
- 13           – No contaminant breakthrough to groundwater projected over the 1,000-year modeling
- 14           framework.

15   **2.8.5 Human Health Evaluation of Radiological**

16   **Contaminants of Potential Concern and Impacts**

17   **to Groundwater**

18   The analysis of potential surface exposure and groundwater impacts using the RESRAD

19   computer code contains protective biases meant to ensure that the results represent a reasonable

20   worst-case evaluation. Overall, the evaluation demonstrates that, for the intended industrial land

21   use, the threat of radionuclide COPCs is very small and within dose and risk limits. One

22   potential exception is the 216-A-29 Ditch where in the unlikely event that industrial use results

23   in erosion of the cover, or the unearthing of subsurface materials, a dose exceeding 15 mrem/yr

24   is projected.

25   A major uncertainty associated with the RESRAD evaluations is the use of maximum detected

26   constituent concentrations in the top 4.6 m (15 ft) of soil to represent a chronic exposure

27   concentration across the entire site. The use of maximum detected constituent concentrations

28   almost certainly introduces a very conservative bias into the radionuclide dose and risk

29   evaluations.

30   The RESRAD exposure model is based on reasonable worst-case exposure conditions, as

31   described in the RI Report (DOE/RL-2004-17). Such input parameters as soil ingestion rate,

32   exposure frequency, and exposure duration are biased toward the upper end of likely exposure

33   values. In addition to the protective bias related to specific parameter values, a question of

34   theoretical versus actual land use arises when considering the RESRAD results. Presently, the

35   primary receptors in the area of the waste sites in the 200-CS-1 OU are field personnel involved

36   with sampling and monitoring. No chronic, daily exposure scenario is being realized at these

37   sites at this time. Hence, the industrial doses and risks are inherently theoretical. Where

1 maximum exposure occurs at time 0, the industrial scenario results are biased from temporal  
2 discontinuity between the model time and a time when the exposure scenario might actually be  
3 realized. This situation is dramatically exacerbated in the unrestricted surface-land-use scenario.  
4 The probability of realizing a future land-use scenario involving intensive small-scale  
5 agriculture, where residents are consuming a variety of home-raised agricultural products over a  
6 period of 30 years, is in all likelihood very slight and unrealistic for the foreseeable future.

7 Generally, considering the overall lack of significant threat suggested by the marginal results  
8 summarized in Table 2-5, when taken in light of the considerable conservative protective bias, it  
9 appears that radionuclide COPCs detected at the 200 CS-1 representative sites pose little actual  
10 human health threat.

## 11 2.9 ECOLOGICAL RISK SCREENING

12 The ecological risk-screening process, which is summarized below and employed in the  
13 RI Report, was very analogous to the process used to screen soil for human health consideration  
14 (see Figure 2-15):

All positive detections in soil < 15 feet bgs

Essential nutrient screen

Background screen

Ecotoxicity-based soil concentration screen

15  
16 According to the RI Report (DOE/RL-2004-17), Steps 1 and 2 of the ecological risk assessment  
17 guidelines for Superfund process (EPA/540/R-97/006, *Ecological Risk Assessment Guidance for*  
18 *Superfund: Process for Designing and Conducting Ecological Risk Assessments [Interim*  
19 *Final]*) consist of a risk screening that compares concentrations of COPECs in media at the site  
20 to ecotoxicity-based soil concentrations. According to EPA, this two-step process is essentially  
21 equivalent to a screening-level ecological risk assessment (SLERA). In many cases, a SLERA  
22 provides suitable information necessary to categorize site conditions as acceptable for specific  
23 land uses. Thus, for practical purposes, the RI BRA ecological risk assessment meets the  
24 functional definition of a SLERA.

25 For risk screening at the 200-CS-1 OU representative sites, pre-established soil-screening levels  
26 for protection of wildlife (from WAC 173-340-900, Table 749-3) were compared to the  
27 maximum detected soil concentration. The ecological soil-screening level (Eco-SSL) developed  
28 by the EPA (EPA 2003, OSWER Directive 9285.7-55) for screening soils at contaminated sites  
29 also were used for comparison to concentrations of nonradionuclides for which Washington State  
30 values were not available. Soil concentrations of radionuclides were compared to the dose-based  
31 soil-screening levels developed in the BCG for protection of terrestrial systems

1 (DOE-STD-1153-2002). All of these screening levels were developed based on mathematical  
2 models incorporating estimates of intake through food and soil ingestion pathways.

3 These screening levels are based on modeled risk to generalized receptors representing plants,  
4 soil biota, mammals, and birds. The conservatively derived levels are expected to be protective  
5 of plant and animal species currently found at these sites, as well as those species that may  
6 inhabit the sites in the future.

### 7 2.9.1 Exposure Parameter Estimates

8 Most of the screening values used in this analysis assume that the receptor is exposed to the site  
9 100 percent of the time. This assumption is the basis of the screening values developed for the  
10 BCG and the Eco-SSLs.

11 All screening levels considered in this analysis incorporate 100 percent bioavailability of  
12 chemicals and radionuclides in soil and food items. For many chemicals, this assumption  
13 overestimates the dose significantly, and therefore overstates the potential risk to the ecological  
14 receptor. The exposure parameters used in developing the screening values are designed to  
15 provide a significant level of conservatism for a screening assessment.

### 16 2.9.2 Ecological Toxicity of Contaminants of Potential 17 Ecological Concern

18 The exposure routes considered in developing the screening levels are direct ingestion of food  
19 and soil. The toxicity values used to develop the screening values are therefore also based  
20 on ingestion. The toxicity values for the WAC 173-340-7490, "Terrestrial Ecological Evaluation  
21 Procedures," screening values and the Eco-SSLs correspond to doses that, based on the results of  
22 toxicity studies, are expected to be low enough to produce minimal or no adverse effects in the  
23 species being considered. The radionuclide screening levels are based on a total dose of  
24 0.1 rad/day to the terrestrial wildlife species. The screening levels for soil provided in the BCG  
25 include both the internal dose from ingestion of radionuclides from food or soil and the external  
26 dose from surface exposure to soil.

### 27 2.9.3 Screening-Level Risk Calculations

28 This section presents the results of the comparison of the maximum concentration detected in the  
29 upper 4.6 m (15 ft) of the soil column at each of the waste sites with the applicable screening  
30 levels. As discussed above, the preliminary risk compares the maximum concentrations of  
31 COPECs in soil to ecotoxicity-based soil concentrations as illustrated in Equation 1.

$$32 \quad HQ_{\text{Concentration}} = \frac{\text{Maximum soil concentration < 15 ft bgs}}{\text{Ecotoxicity - based soil concentration}}, \text{ Eq. 1}$$

1 The resulting ratio of this comparison is conveniently referred to as the hazard quotient (HQ) for  
 2 ratioed concentrations. The maximum concentration of each chemical was compared to its  
 3 screening value for industrial land use and its screening value for unrestricted surface land use.  
 4 In the same fashion, the maximum concentration of each radionuclide was compared to its BCG,  
 5 which is the screening level for both the industrial and unrestricted surface land-use scenarios.

6 A summary of the screening SLERA calculation results is presented in Table 2-6.

7 The main points apparent from Table 2-6 include the following.

- 8 • Only 15 COPECs produce HQs exceeding 1.0. Of these, only five constituents (boron,  
 9 total chromium, silver, vanadium, and Aroclor 1254) produce HQs greater than 10.
- 10 • Only one radionuclide COPEC, radioactive strontium, has a HQ exceeding 1.0.
- 11 • Most of the other ten compounds have relatively small HQ unity exceedances. Notably,  
 12 arsenic, cadmium, copper, molybdenum, thallium, zinc, and radioactive strontium HQs  
 13 are between 1.0 and 2.0. Considering the conservatism underlying the HQ estimates,  
 14 these exceedance are probably insignificant from a practical perspective.
- 15 • The 216-A-29 Ditch has the most HQ exceedances (ten), followed by the 216-S-10 Ditch  
 16 (nine), 216-B-63 Trench (four), and the 216-S-10 Pond (three).

#### 17 **2.9.4 Ecological Risk Assessment Summary and** 18 **Uncertainty Assessment**

19 The media screening levels used in this screening assessment were designed to provide  
 20 concentrations that were highly protective enough to be used to screen out potential  
 21 contaminants at a wide range of sites. As indicated above, considering the number of  
 22 constituents for which HQs were computed (e.g., all metals, inorganic, organics and  
 23 radionuclides totals to approximately 240 candidate constituents), the data suggest that  
 24 contaminant occurrence at elevated concentrations is not widespread. Moreover, with the  
 25 exception of several compounds (boron, total chromium, silver, vanadium, and Aroclor 1254),  
 26 the screening calculations do not suggest notably high levels of COPECs. This finding, when  
 27 coupled with knowledge that the eco-toxicology screening criteria are conservative in their  
 28 character and that maximum concentrations were used in the HQ computations, suggests that  
 29 there is little concern for significant ecological risks resulting in material damage at any of the  
 30 200-CS-1 OU representative sites.

#### 31 **2.10 REMEDIAL INVESTIGATION BASELINE** 32 **RISK ASSESSMENT SCREENING VALUES**

33 A summary of all of the screening values used in RI can be found in Table 2-7. This table  
 34 presents the background values, industrial direct-contact screening values, groundwater  
 35 protection values, and industrial ecological-screening values by each constituent and provides the  
 36 overall most restrictive or governing value. The overall screening level RI BRA summary, in

1 terms of the COPCs whose maximum concentrations exceeded screening concentrations, is  
2 presented in Table 2-7. Inspection of Table 2-7 reveals the following.

- 3     • The Hanford Site background benchmark is the governing screening value for only six  
4       constituents.
- 5     • The industrial direct-contact screening values is the controlling value for only two  
6       constituents.
- 7     • For 35 constituents, including nearly all organic compounds, the groundwater protection  
8       benchmark is the most restrictive value.
- 9     • The industrial scenario ecological-screening value is the most restrictive screening value  
10      for 11 constituents.

11 The primary risk-based issues addressed here are protection of groundwater and limited threats  
12 to ecological receptors.

## 13 **2.11 BASELINE RISK ASSESSMENT –** 14 **EXTENDED ANALYSIS**

### 15 **2.11.1 Introduction and Basis**

16 The RI BRA was conducted using a conventional regulatory-based screening-level technique  
17 involving the following activities:

- 18     • Evaluating the data for undetected constituents
- 19     • Screening data against background constituents
- 20     • Making human health risk assessment determinations for nonradiological constituents
- 21     • Evaluating ecological risk using indicator concentrations
- 22     • Evaluating human health dose and risk for radiological constituents using RESRAD
- 23     • Comparing data to WAC 173-340-745
- 24     • Evaluating impacts to groundwater through fate and transport evaluation.

25 This approach is generally consistent with the paradigm established by the National Academy of  
26 Sciences (NAP 1983, *Risk Assessment in the Federal Government: Managing the Process*) and  
27 EPA/540/1-89/002. The process set forth by these agencies emphasizes the need to identify and  
28 clarify uncertainties with the goal of providing to decision makers as clear a picture of the threats  
29 posed by environmental contaminants as possible. Frequently, resolving uncertainties requires  
30 an iterative analytical approach. The extended analysis is an iteration of the RI BRA, conducted  
31 within the envelope of guidance, intended to resolve uncertainties and provide decision makers  
32 as clear a picture as possible.

33 This process of iterative evaluation, extension, and refinement in the FS is consistent with  
34 CERCLA guidance (EPA/540/G-89/004). The process of using the RI BRA as a foundation for  
35 extended analysis and refinement is shown conceptually in Figure 2-13 as a logical extension of

1 the RI into the FS. The process is essentially a sequential narrowing and refining of the RI data  
2 aimed at defining the set of decisive risk-based issues to be evaluated in the FS.

3 The RI BRA, summarized in Section 2.6 and detailed in the RI, is a diagnostic protocol in which  
4 the data are evaluated according to established binary decision rules that result in including or  
5 excluding COPCs from considerations. A conservative bias built into the process ensures that  
6 potential threats are not overlooked. Screening-level techniques, such those employed in the  
7 RI BRA, are powerful analytical tools that are widely used in the environmental regulatory area.  
8 Some attributes of screening-level techniques include the following:

- 9 • Allows the efficient examination of large volumes of data to identify potential COPCs,  
10 pathways, and receptors
- 11 • Promotes consistency in assessments of different media and different sites
- 12 • Focuses the assessment on the most important media and COPCs.

13 Overall, the screening techniques are a key component of the RI BRA that allows the analyst to  
14 focus on the threats that govern the need for remedial action. At the same time, however, the  
15 screening-level techniques have limitations that, based on the individual site-specific conditions,  
16 can significantly affect the findings and interpretations. For example, the screening process  
17 may:

- 18 • Fail to take into account the site-specific nature and extent of the contamination, due to  
19 its scripted numerical nature
- 20 • Mask expression of some meaningful lower concentration data and non-detection reports  
21 when high-end exposure-point estimates (e.g., maximums) are used as the basis for  
22 comparison to conservative screening criteria
- 23 • Tend to promote a sample-by-sample "bright line" evaluation framework that can be  
24 inconsistent with the concept of spatially integrated exposure.

25 A review of the RI Report and the RI BRA indicates that all these characteristics have been  
26 expressed to some degree. The large quantity of RI data from the representative sites has been  
27 efficiently sorted and categorized and COPCs evaluated, and those with maximum  
28 concentrations that exceeded screening threshold have been identified.

29 A summary of COPCs for the four 200-CS-1 OU representative sites is provided in Table 2-8  
30 (DOE/RL-2004-17). The table is a condensation of RI BRA Tables 4-12 and 4-38  
31 (DOE/RL-2004-17). Table 2-8 summarizes the key RI BRA findings that are pertinent to the FS.  
32 Inspection of Table 2-8 shows the 35 constituents that remained after the screening process. As  
33 an indication of the power of the screening techniques, these 35 constituents have been culled  
34 from a list of approximately 180 constituents for which analytical results were obtained. This  
35 efficient distillation of a large volume of data was accomplished largely<sup>4</sup> by comparing the

---

<sup>4</sup> The screening process also relied on a background comparison process.

1 maximum detected concentration found in the upper 15 ft (4.6 m) vadose zone with the approved  
2 screening concentrations listed in Table 2-9.<sup>5</sup>

3 Examination of Table 2-8 reveals that the following:

- 4     • Direct human exposure is not a notable pathway of concern. Bismuth at the  
5       216-S-10 Ditch, 216-B-63 Trench, and 216-A-29 Pond and TBP and Pu-239/240 at the  
6       216-A-29 Ditch are the only shallow-soil COPCs detected with concentrations exceeding  
7       industrial risk-based screening values.
- 8     • Protection of groundwater, based on the occurrence of COPCs in the shallow soils,  
9       appears to be a significant concern. This RI BRA conclusion stems from the significant  
10      number of shallow-soil COPCs with at least one measurement exceeding groundwater  
11      protection screening values (e.g., 15 COPCs at the 216-A-29 Ditch).
- 12    • Ecological concerns, based on the occurrence of COPCs in the shallow soils with at least  
13      one concentration exceeding screening ecological risk benchmarks, appear to be  
14      significant. Again, this conclusion from the RI BRA is inferred by a significant number  
15      of shallow-soil COPCs with maximum concentrations exceeding ecological protection  
16      screening values (e.g., eight COPCs at the 216-S-10 Ditch).

17 Based exclusively on the screening-level RI BRA, Table 2-8 would serve as the remediation  
18 candidate agenda for FS. However, before developing remedial action objectives (RAO),  
19 preliminary remediation goals (PRG), and other FS tasks, the RI BRA was examined in order to  
20 ensure that the issues stemming from the RI BRA were reasonable. Overall, the RI BRA  
21 identified the key topics for the FS to consider. However, several practical issues surfaced from  
22 the examination, which suggests that some iterative extended analysis is appropriate to  
23 supplement the screening-level RI BRA results and possibly, to refine the remediation list of  
24 options. Examples of these issues include the following:

- 25     • The occurrence of several organic COPCs including methylene chloride,  
26       1,2-dichloroethane, benzene, and vinyl chloride throughout the data may be artifacts of  
27       the analytical process and do not correlate well with the waste site process history.  
28       Additionally, a review of the analytic records suggests that some of the organics data may  
29       have been misreported and resulted in the inclusion of constituents that are not actually  
30       present at the site(s). If these constituents are artifacts of the analytical process, and not  
31       actually waste activity-related COPCs, they should not be included as candidates for  
32       remedial actions.
- 33     • Some of the RI data is skewed by outlier data points. Overall, the RI data support a  
34       nature and extent of contamination interpretation that the sources of contamination were  
35       generally dilute and aqueous and, subsequently, that the occurrence of constituents in the  
36       soils is not extensive. The RI indicates that there may be a number of localized areas

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<sup>5</sup> The approved screening concentration table (Table 2-9) is re-introduced here because it will be referenced many times in the following analysis.

1 where elevated residual constituent concentrations exist, but constituent concentrations in  
2 the bulk of the potentially affected environments are not appreciably elevated. The  
3 outlier data, in these instances, may tend to overshadow the overall character of the data  
4 and, as a result, present a biased concentration profile. This characteristic may affect the  
5 screening steps that use high-end exposure concentration estimates, particularly those  
6 comparisons where maximum concentrations are used to represent the extent of the  
7 potentially affected environment.

- 8 • Several of the background comparisons, while conducted in accordance with the  
9 screening protocol, imply that some constituents are the results of waste-related activities  
10 and have been included as candidate COPCs. However, considering additional  
11 information outside the screening protocol could reveal that their inclusion as COPCs is  
12 more an artifact of the evaluation method than their existence at the site at elevated  
13 concentrations.
- 14 • The RI BRA results suggest that the groundwater is at significant risk of being impacted  
15 by constituents in the vadose zone soils. Table 2-8 indicates that for many of the  
16 constituents, including nearly all organic compounds, RAOs should be developed to  
17 address groundwater protection. This premise is counter to the RI findings that  
18 constituent concentrations in the bulk of the potentially affected environment are not  
19 significantly elevated. Additionally, many of the constituents identified in Table 2-8 as  
20 candidates for remedial action based on groundwater protection are not expected to be  
21 mobile in the vadose zone. For example, arsenic, mercury, and the polycyclic aromatic  
22 hydrocarbons, e.g., benzo(a)pyrene, are identified as constituents whose concentrations  
23 exceed groundwater protection-screening values. However, these compounds are not  
24 expected to pose a threat to groundwater because they are not mobile in the vadose zone.<sup>6</sup>

25 These types of revelations are not uncommon when screening-level risk assessments are  
26 reviewed from a practical perspective. They illustrate that, although the analytical power of the  
27 screening process is highly efficient at isolating potential key issues, some significant  
28 uncertainties may remain. As a result, additional analysis can be useful to clarify the  
29 uncertainties, and focus the risk assessment on addressing the substantial threats to human and  
30 ecological receptors.

---

<sup>6</sup> An important finding established in the RI is that shallow-soil contamination does not pose a threat to the saturated groundwater zone typically found at a depth of approximately 270 ft (82 m) bgs. The apparent paradox between this finding and the screening results illustrated in Table 2-8 is due to the use of groundwater-screening values developed using Equation 741-1 in WAC 173-340-747. Equation 741-1 does not capture and express the situation where a thick, uncontaminated vadose zone lies above the water table coupled with constituents that are relatively immobile, as determined by the chemical's distribution coefficient (i.e., the  $K_d$  value). In the 200 Area composite analysis, it was determined that constituents with  $K_d$  values of 40 L/kg or greater are essentially immobile in the vadose zone and groundwater of this area (PNNL-11800). Table 2-10 lists those compounds from Table 2-8 that exceed screening levels for protection of groundwater and their individual  $K_d$  values, and provides a finding for each constituent. As indicated, 12 of the COPCs whose maximum soils concentrations exceeded groundwater protection screening levels have  $K_d$ s less than 40 L/kg and would have the potential to actually reach and affect groundwater. The remaining eight COPCs have  $K_d$ s greater than 40 L/kg and would not have the mobility potential in the vadose zone to reach and affect the saturated groundwater.

## 1 2.11.2 Extended Analysis Approach Overview

2 The purpose of the extended analysis is to clarify uncertainties in the RI BRA findings that may  
 3 affect the evaluation of remedial action in the FS. The findings of the screening level BRA will  
 4 be examined in detail using refinement techniques that are common to the environmental  
 5 regulatory and risk assessment arena. Some aspects that will be considered in the extended  
 6 analysis include the following:

- 7 • A review of the RI nature and extent of contamination and further examination and  
 8 interpretation of the EPC estimates in light of the whole of the data, including  
 9 non-detections and spatial considerations. When considering EPC estimates in light of  
 10 the whole of the data, it is important to determine how many measurements actually  
 11 exceed screening concentrations. For example, in screening assessments using maximum  
 12 concentrations, it is not unusual for a single measurement to exceed a screening value  
 13 while the remainder of the measurements do not. In such cases, the bulk or whole of the  
 14 data do not exceed the criterion, thus indicating that, overall, there is not a concern for the  
 15 effect that the screening value is intended to signify.
- 16 • A review of the comparison to screening values using EPCs generated with more robust  
 17 statistical techniques found in EPA guidance for calculating upper 95 percent confidence  
 18 limits on mean concentrations (i.e., 95%UCL). Generally, maximum concentrations  
 19 were used in the RI BRA screening.
- 20 • An expanded and iterative assessment of the potential threat that constituents in the  
 21 vadose zone may have on groundwater, based on a CSM and alternative transport and  
 22 fate model that better reflect actual site-specific conditions. The alternative transport  
 23 model and the rationale for its use are discussed in detail in Appendix F.
- 24 • Evaluation of an intruder human health exposure scenario.

25 The CSM is the framework for assessing exposure pathways. Figure 2-14 is a condensed and  
 26 refined version of the CSM from the RI BRA. Exposure can occur when contaminants migrate  
 27 from their source to an exposure point or when a receptor moves into direct contact with  
 28 contaminants or contaminated media close to the source. An exposure pathway is complete if a  
 29 means is available for the receptor to be exposed through ingestion, inhalation, direct exposure,  
 30 or dermal absorption at a location where site-related contaminants are present. No exposure (and  
 31 therefore no risk) exists unless the exposure pathway is complete.

32 Evaluation of the exposure pathway model is a key feature in the RI/FS risk-assessment process.  
 33 The CSM also is used in the FS to evaluate remedial action by considering pathway  
 34 modifications (e.g., contaminant sources, releases, and transport or exposure points) through the  
 35 use of technologies and institutional controls.

36 Each of the four representative sites will be evaluated individually in the following sections. The  
 37 general format for extended analysis of each site will be as follows.:

- 38 1. A concise summary of the extended analysis findings will be presented at the beginning  
 39 of each site evaluation. The summary will aid the reader interested only in the results and

- 1 will help focus the reader who is seeking further explanation of how the refined analysis  
2 conclusions were reached.
- 3 2. A summary of the RI BRA findings, including the RI BRA COPCs. Presented in a table,  
4 this summary of the RI BRA findings serves as the embarkation point for the extended  
5 analysis.
- 6 3. A synthesis of the nature and extent of contamination gleaned from the RI data. The  
7 synthesis will use a figure showing the site in plan view with the sampling locations.  
8 Analytical results for the RI BRA COPC will be posted in the figure in an adjacent table.  
9 The nature and extent of contamination will be synthesized and interpreted in light of the  
10 spatial patterns and concentration profiles. Anomalous results as well as RI BRA COPCs  
11 included as process residuals<sup>7</sup> will be addressed. Summary statistics including the  
12 maximum, mean, and 95%UCL will be provided for comparison to the RI BRA  
13 screening values including benchmarks for the following:
- 14 • Background
  - 15 • Industrial direct contact
  - 16 • Groundwater protection
  - 17 • Ecological exposures.
- 18 The synthesis will expand the basic screening comparison used and identify the RI BRA  
19 COPCs by introducing additional background concentration information, considering  
20 mean and 95%UCL concentration information, and in some cases, by interpreting  
21 ecological-screening values in light of site-specific circumstances. Each figure plan view  
22 and data tabulation will be supplemented with a companion table where the key  
23 interpretive aspects of the synthesis will be identified and explained, as necessary.
- 24 4. Constituents identified as posing a threat to groundwater will be evaluated in a two-step  
25 manner. First, constituent-specific mobility characteristics will be considered by  
26 reviewing distribution coefficients. If appropriate, a second evaluation using an  
27 alternative transport and fate model will be conducted.
- 28 5. The analysis of potential human health and ecological impacts will be reevaluated using  
29 95%UCL concentration information.
- 30 6. An intruder exposure scenario will be provided to supplement the RI BRA.
- 31 7. A detailed summary of the extended analysis findings will be presented at the end of each  
32 site evaluation.

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<sup>7</sup> In some cases, constituents identified by the analytical process are carried through the risk assessment because there are no approved screening values (e.g., background or toxicity data) for comparison. These constituents are referred to as process residuals. In many cases, the process residuals are of no consequence from a risk assessment perspective. Process residuals will be eliminated as COPCs if appropriate.

1 Each site will be re-evaluated following this general format. The first site to be evaluated will be  
2 the 216-A-29 Ditch followed by the 216-B Trench, 216-S-10 Ditch, and 216-S-10 Pond. This  
3 sequence was intentionally selected because it corresponds to addressing the sites in order of  
4 decreasing complexity. The evaluation for the 216-A-29 Ditch will be presented in significant  
5 detail in order to illustrate the approaches. However, as the extended analysis progresses through  
6 the remaining three sites, discussion of the analytical detail will be curtailed in order to minimize  
7 repetition. Additionally, as common findings influencing other sites are revealed (e.g., errant  
8 analytical results), they will be incorporated by referring the reader to the original disclosure;  
9 again, to minimize repetition and streamline the report.

## 10 2.12 BASELINE RISK ASSESSMENT EXTENDED 11 ANALYSIS OF THE 216-A-29 DITCH SITE

12 This section presents the BRA extended analysis for the 216-A-29 Ditch site. The section begins  
13 with a concise summary followed by a detailed discussion of the analysis leading to the findings.

### 14 2.12.1 Summary

15 Twenty-one constituents were identified by the RI BRA as COPCs for additional consideration.  
16 These constituents were identified based on maximum concentrations exceeding one or more of  
17 the following:

- 18 • Direct industrial exposure
- 19 • Protection of groundwater
- 20 • Ecological risk associated with an industrial setting.

21 The extended risk analysis was performed to clarify the RI BRA findings and reduce  
22 uncertainties. Based on the extended risk analysis, the risk assessment findings are as follows.

- 23 • The site is not highly contaminated and contamination is not widespread. Reported  
24 concentrations are not particularly elevated and those that are higher are found in  
25 localized hot spots. Hot spots are found at depths of about 1.5 to 3 m (5 to 10 ft) bgs.  
26 Consequently, the threat that they may pose to humans and ecological receptors is  
27 actually minimal.
- 28 • There are no unacceptable direct-exposure risks to industrial workers. Additionally,  
29 there are no unacceptable risks to the hypothetical future intruder.
- 30 • Nitrate/nitrate (as N), detected in a hot spot, has the potential to migrate from the vadose  
31 zone soil and contact groundwater after approximately 785 years. The predicted  
32 maximum concentration is 14 mg/L, which marginally exceeds the Federal primary  
33 drinking water standard of 10 mg/L.
- 34 • In one sample, Aroclor 1254 exceeds the ecological-screening value. The single  
35 occurrence of Aroclor 1254 is at a depth of 1.5 m (5 ft) below the surface, which suggests  
36 that the threat to ecological receptors is actually very small.

## 2.12.2 Extended Risk Analysis of the 216-A-29 Ditch

Table 2-11 is a distillation of Table 2-8 to reflect only those COPCs found in the 216-A-29 Ditch representative site. Table 2-11 will serve as the basis for the extended evaluation of the 216-A-29 Ditch RI BRA findings.

The findings effecting the evaluation of remedial actions at the 216-A-29 Ditch for the industrial land use scenarios are as following:

- Bismuth, TBP, and Pu-239/240 were identified as posing a potential threat to industrial receptors through direct contact. Bismuth and TBP are process residuals. This finding suggests that RAOs should be developed to address this finding. However, as noted in the RI BRA, this finding is not based on an actual assessment of exposure and risks; rather there was no appropriate toxicological data on which to base an evaluation and these compounds were retained based on a default assumption. The RI BRA presented a reasonable scientific rationale that offset the concern. Bismuth and TBP will be omitted from further consideration and an RAO to address bismuth and TBP is not necessary.<sup>8</sup> Plutonium-239/240 will be further evaluated.

- Fifteen constituents were identified as posing a threat to groundwater including Aroclor 1254, arsenic, benzo(a)anthracene, bismuth, cadmium, chrysene, 1,2-dichloroethane, mercury, methylene chloride, nitrate, nitrate/nitrite, silver, sulfate, uranium, and TBP.

However, only 10 of the 15 (arsenic, cadmium, 1,2-dichloroethane, mercury, methylene chloride, nitrate, nitrate/nitrite, silver, sulfate and uranium) actually were regarded as having sufficient mobility in the vadose zone (i.e.,  $K_d$  less than 40 L/kg) to reach and affect the groundwater (see Table 2-10). The groundwater impact screening concentrations used in the RI BRA (Table 2-9) were derived from WAC 173-340-747, Equation 747-1, which is a simplified three-phase partitioning model that does not incorporate site-specific information. Thus, additional evaluations will be conducted to clarify the nature of the threat that these constituents pose to groundwater.

- Ten constituents (arsenic, boron, cadmium, lead, molybdenum, selenium, silver, uranium, vanadium, and Aroclor 1254) were identified as potentially posing a threat to ecological receptors. This finding was based on HQs computed using the maximum measured concentration and generally applicable, though conservative, screening values. Computed HQs ranged from 1.1 for uranium to 52 for vanadium. Other constituents with notable HQs include arsenic (HQ = 1.7), cadmium (HQ = 2.0), and molybdenum (HQ = 1.4). Additional evaluation will be conducted to clarify the extent that these and other constituents pose a significant risk to ecological receptors.
- Using the maximum measured concentration, Pu-239 was found to produce a dose of 35 mrem/yr in the case of the industrial scenario with no cover. This dose exceeds the

<sup>8</sup> Readers note that this finding is common to other sites and will be referenced in succeeding sections.

1 15 mrem/yr dose limit. Again, to clarify the scale that Pu-239 poses a significant risk to  
2 industrial receptor, extended analysis will be conducted.

3 In the following sections, extended analysis will be provided to address these and related issues  
4 affecting the feasibility study.

#### 5 2.12.2.1 Synthesis of the Nature and Extent of Contamination

6 An initial step in the extended evaluation is to revisit the COPCs and assess the nature and extent  
7 of their occurrence in the affected environment as being representative of site conditions.

8 According to the RI BRA protocol, maximum soils concentrations were employed as the  
9 constituent concentration or "metric" for identifying a COPC. In some cases, maximum  
10 concentrations may not be representative of site conditions. Situations where the maximum  
11 concentration is not a representative metric may include the following:

- 12 • When the greater part of the data is found to be at much lower concentrations
- 13 • When a large portion of the data set is non-detection reports
- 14 • When the data is spatially distributed such that the location of the maximum is not  
15 representative of the majority of the site (i.e., a hot spot).

16 The occurrence of any of these situations can lead to a mischaracterization.

17 The following evaluation will assess the data to gauge whether the maximum concentration used  
18 to specify COPCs has resulted in mischaracterization of site conditions. The assessment will  
19 review the spatial distribution of the COPCs and evaluate alternative statistical measures for  
20 summarizing site conditions.

21 Figure 2-15 provides a summary of key features of the 216-A-29 Ditch site, including the  
22 locations of the test pits and borings from which samples were obtained. A summary of the  
23 analytical results from the test pits and borings also is provided in Figure 2-15. Note that the  
24 individual analytical results are all tabulated in columns; results from each sample location are  
25 arranged in rows so that one can compare concentrations between sample locations. At each  
26 location, the data are present in sequence of decreasing elevation. This cross-tabulation format is  
27 intended to promote a synthesis of analytical results with their spatial arrangement as depicted on  
28 the illustration portion of the Figure 2-15. Additionally, providing the analytical data in this  
29 format facilitates an integrated examination of the whole of data comprising the composite of  
30 exposure-point information. This is important because, as discussed previously, theoretically,  
31 the entire 0 to 4.6 m (0 to 15 ft) depth interval is regarded as the potential exposure media (see  
32 Figure 2-14, the CSM). Theoretically, receptors can be exposed to all constituents and  
33 concentrations in this media on a proportional basis as a function of exposure duration, as  
34 expressed by Equation 2.

35 Exposure  $\sim \int_{\min}^{\max}$  Proportional weight of concentrations and exposure factors, Eq. 2

1 Using this interpretive framework, one can view the Aroclor 1254 result site-wide by looking  
2 down the column and noting the following.

- 3 • There was only one detection, 9,400 µg/kg J,<sup>9</sup> in 36 samples (excluding the split from the  
4 count); the remaining whole of the site is unaffected.
- 5 • The sole Aroclor 1254 detection is in the 1.2 to 1.5 m (4 to 5 ft) bgs interval at AD-1.
- 6 • Detection limits for the non-detections were very consistent through the remainder of the  
7 samples (~35 to 40 µg/kg).

8 Interpreting this information in the framework set forth in Equation 1 would imply that a  
9 receptor would be exposed to the 9,400 µg/kg for only 1/36<sup>th</sup> (less than 3%) of the specified  
10 exposure duration. Alternatively, for 97 percent of the time that receptors are exposed, they  
11 would not have contact with Aroclor 1254.

12 Looking across the rows gives an indication of the magnitude of occurrence of each constituent.  
13 An impression for the spatial distribution also can be obtained by comparing the overall evidence  
14 of contamination in the bulk of a sample location. For example, it is evident by the number of  
15 constituents and the magnitude of the positive detections that there is more impact at AD-1 and  
16 AD-3 than at the Area 8 and Area 9 test pits. This interpretation generally correlates with a  
17 waste activity model of releases of aqueous process materials near AD-1 (e.g., "the headwaters  
18 of the ditch") with flow and settling occurring as flow moved northerly to the distal end where  
19 AD-2 is located.

### 20 2.12.3 Spatial and Data Aggregation Considerations

21 Figure 2-15 reveals that, in general, the occurrence of constituents is limited to the intervals of  
22 1.2 to 3 m (4 to 10 ft). There is a marked transition from detections with sizable values to  
23 smaller values, coupled with an increase in the number of non-detections as the data are viewed  
24 moving down the soil strata. It is notable that at the boring (B8826), installed near the headwater  
25 (i.e., source area of the ditch), at depths below 3 m (10 ft), nearly all laboratory reports are  
26 non-detections and the profiles of most of the naturally occurring constituents (e.g., arsenic) have  
27 leveled off. This suggests that contamination is limited to the upper 3 m (10 ft) of the soil  
28 column.

29 Table 2-12 provides a summary interpretation of select constituents whose concentrations  
30 profiles are provided in Figure 2-15. Note that, with the exception of methylene chloride and  
31 1,2-dichloroethane,<sup>10</sup> the table includes each COPC from the RI BRA and the Hanford Site  
32 background screening value, as well as each constituent's industrial-direct contact, groundwater

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<sup>9</sup> The "J" qualifier means that the reported concentration is estimated analytical result.

<sup>10</sup> Review of the data quality packages found that methylene chloride was a problem laboratory contaminant with the volatile organic compound analysis and 1,2-dichloroethane was incorrectly reported as a positive detection. Methylene chloride was reported at other sites and this finding will be referenced in succeeding sections.

1 protection, and industrial ecological-screening value. The last three columns identify the  
 2 maximum concentration measured in the RI and its sample location, the mean and 95%UCL on  
 3 the mean concentration,<sup>11</sup> and a remark section where brief summary observations are provided.  
 4 This table will be used to cite observations culled from the synthesis of the data through spatial  
 5 aggregation.

6 As an example of how information of Figure 2-15 is synthesized with the screening  
 7 concentrations, the following example using arsenic is provided. In viewing the profile of  
 8 arsenic concentrations in Figure 2-15, and noting the corresponding information in Table 2-12,  
 9 the following synthesis is obtained:

- 10 • The Hanford Site background benchmark is 6.5 mg/kg, the industrial-direct contact,  
 11 groundwater protection, and industrial ecological-screening concentrations are 87.5,  
 12 0.0304, and 7 mg/kg, respectively. One immediately notes that the groundwater  
 13 protection-screening concentration is not a practical benchmark because it is actually less  
 14 than background.<sup>12</sup>
- 15 • The maximum arsenic concentration measured in the RI is 12.2 mg/kg in test pit AD-3 in  
 16 the 2.6 to 2.9 m (8.5 to 9.5 ft) bgs interval. Note that the arsenic concentration in the  
 17 overlying interval (1.8 to 2.1 m [6 to 7 ft] bgs) is comparable: 12.1 mg/kg. The mean  
 18 and 95%UCL arsenic concentrations are 4.5 and 7 mg/kg, respectively. From a synthesis  
 19 and interpretive viewpoint, these two metrics of central tendency at the site are as  
 20 follows:
  - 21 – Comparable to the Hanford Site background concentration (6.5 mg/kg)
  - 22 – Far below the industrial-direct exposure benchmark
  - 23 – Notably above the groundwater protection concentration
  - 24 – Less than or equal to (in the case of the 95%UCL) the governing industrial<sup>13</sup>  
 25 ecological-screening concentration.

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<sup>11</sup> The mean and 95%UCL computations use a proxy value of one-half the detection limit for non-detect reports, and "J," "E", and "B" qualified reports are taken at face value. The 95%UCLs are computed with ProUCL in accordance with OSWER 9285.6-10. Most of the UCL calculations relied on ProUCL's non-parametric calculation routines. Non-parametric 95%UCL concentrations will nearly always be higher than their counterpart parametric estimations (i.e., based on normal or lognormal distributions). Use of the non-parametric methods cited in OSWER 9285.6-10 and their implementation with EPA's ProUCL software provides a suitable alternative to the traditional "default to the maximum" technique imposed when the data cannot be fitted to a normal or lognormal distribution.

<sup>12</sup> The occurrence of computed risk-based concentrations being less than background is not unusual in regulatory risk assessment. It is important to recognize when this occurs and to supplement the risk management process with extended assessment.

<sup>13</sup> The governing screening value is the lowest value that is not below background.

- 1 • Additional review of the arsenic concentration profile across all sample locations and  
 2 depths indicates that there appears to be tendency for higher arsenic concentrations to be  
 3 found in the upper intervals (e.g., between 1.2 to 3 m [4 and 10 ft] bgs). Additionally, the  
 4 occurrence of arsenic does not appear to vary dramatically. The range of concentrations  
 5 from the 1<sup>st</sup> to the 99<sup>th</sup> percentiles is only a factor of about 7 as indicated by the percentile  
 6 distribution below:

7 - Percentiles for arsenic

8 1.0% = 1.8 mg/kg  
 9 5.0% = 2.01 mg/kg  
 10 10.0% = 2.1 mg/kg  
 11 25.0% = 2.3 mg/kg  
 12 50.0% = 2.8 mg/kg  
 13 75.0% = 5.8 mg/kg  
 14 90.0% = 9.2 mg/kg  
 15 95.0% = 12.1 mg/kg  
 16 99.0% = 12.2 mg/kg.

17 The Hanford Site background (6.5 mg/kg) and the governing industrial ecological-screening  
 18 value (7 mg/kg) would rank at about the 80<sup>th</sup> percentile among the arsenic concentrations  
 19 measured at the site. Only six measurements actually exceed the Hanford Site background  
 20 arsenic benchmark; they are all found in the 1.2 to 3 m (4 to 10 ft) bgs strata.

21 Based on this synthesis and summation, there is some reservation to conclude that the arsenic  
 22 measured in the RI is actually the result of waste-related activity. This uncertainty stems from a  
 23 premise that the waste-related contamination is not subtle and that it should generally be  
 24 discernable when profiled as in Figure 2-15. This assertion is developed in Figure 2-16 where  
 25 site data are combined with the Hanford Site background metric and nested within arsenic  
 26 background data collected by the United States Geological Survey (i.e., the so-called  
 27 "Shacklette" data<sup>14</sup>). Important observations from Figure 2-16 include the following:

- 28 • All site measurements (e.g., mean, 95%UCL, maximum,) are actually clustered closely to  
 29 estimates of background arsenic concentrations.
- 30 • The Site mean (4.9 mg/kg) is comparable to, and actually less than, the western  
 31 United States mean (7 mg/kg).
- 32 • The approximate western 95%UCL of 10.9 mg/kg and the Hanford Site background  
 33 benchmark (90<sup>th</sup> percentile value) of 6.5 mg/kg actually bracket the Site 90<sup>th</sup> percentile  
 34 value of 9 mg/kg 95%UCL of 7 mg/kg and the Site 95%UCL of 7 mg/kg.

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<sup>14</sup> Shacklette and Boerngen 1984, *Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States*, is widely used as a reliable source for gauging the significance of inorganic constituents found in soils. It provides a broad measure of the nature and extent of naturally occurring inorganic constituents found in surficial materials in the United States.

- 1       • The Site maximum, 12.2 mg/kg, is comparable to the 10.9 mg/kg western United States  
2       95%UCL and far below the western United States maximum of 97 mg/kg.

3 Overall, this interpretation suggests that arsenic may be slightly elevated in discrete locations, as  
4 evidenced by the apparent slightly elevated concentrations observed in the upper intervals. The  
5 elevated concentrations appear to be restricted to the upper 1.2 to 3 m (4 to 10 ft) bgs strata. The  
6 governing industrial ecological-screening concentration and 95%UCL concentration are both  
7 7 mg/kg; the maximum concentration is 12.2 mg/kg. These three values are well within the same  
8 order of magnitude. Considering the distribution of arsenic in the soils, and the assumption that,  
9 in order for ecological exposure to occur, a burrowing animal would need nearly full-time  
10 contact with the affected soils at the 95%UCL, it (the 95%UCL) is the most realistic, yet still  
11 conservative, EPC metric. In this case, because the governing screening value and the 95%UCL  
12 are equal (i.e., 7 mg/kg), it is reasonable to conclude that the distribution of arsenic  
13 concentrations measured at the 216-A-29 Ditch do not pose an appreciable risk and no RAO is  
14 necessary.

15 The detailed interpretation above for arsenic is intended to illustrate the rationale for  
16 synthesizing and integrating spatial summary statistical information into the extended analysis.  
17 Other interpretations using this rationale can be gleaned from the information in Figure 2-15.  
18 Several key findings affecting the FS process that are apparent from Figure 2-15 and summarized  
19 in Table 2-12 include the following.

- 20       • Boron concentrations measured in the soils do not appear to be elevated, based on  
21 comparison to relevant literature information (e.g., Washington soils up to 70 mg/kg).  
22 The industrial ecological-screening value is based on protection of plants and may not be  
23 appropriate for this application involving subsurface soils. Moreover, as indicated in  
24 Table 2-12, the default ecological-screening benchmark (0.5 mg/kg) may not be relevant  
25 for this situation. ES/ER/TN-86/R3, *Toxicological Benchmarks for Wildlife:*  
26 *1996 Revision* cites no observable adverse-effect levels for small mammals in the range  
27 of 103 to 414 mg/kg. Note that boron was reported at essentially these same  
28 concentrations at the sites. This finding will be referenced in succeeding sections.
- 29       • Elevated cadmium concentrations, though evident at AD-1 (1.2 to 1.8 m [4 to 6 ft] bgs),  
30 at AD-2 (2.3 to 2.6 m [7.5 to 8.5 ft] bgs), and B8626 (1.2 to 1.8 m [4 to 6 ft] bgs) are  
31 apparently localized. The mean and 95%UCL concentration are below the  
32 industrial-direct contact and ecological-screening values. The groundwater  
33 protection-screening value is comparable to the Hanford Site background.
- 34       • Lead contamination is elevated locally at AD-1 (1.2 to 1.8 m [4 to 6 ft] bgs), AD-2 (2.3 to  
35 2.6 m [7.5 to 8.5 ft] bgs), and B8626 (1.2 to 1.8 m [4 to 6 ft] bgs), and at the Area 8  
36 location (4 m [13 ft] bgs). Most other samples are below or near the Hanford Site  
37 background. The mean and 95%UCL concentrations are well below all three screening  
38 values.
- 39       • Mercury concentrations appear to be elevated locally at AD-1 (1.2 to 1.8 m [4 to 6 ft]  
40 bgs), AD-2 (2.3 to 2.6 m [7.5 to 8.5 ft] bgs), and B8626 (1.2 to 1.8 m [4 to 6 ft] bgs), and  
41 at the Area 8 location (4 m [13 ft] bgs); most other sample concentrations are below or

1 near the Hanford Site background. Once again, the mean and 95%UCL concentration are  
2 below all three screening values.

- 3 • Molybdenum appears to be mis-categorized as a COPC in the RI BRA. The maximum  
4 measured concentration, 3.2 mg/kg, is less than all three screening values.
- 5 • Selenium concentrations appear to be elevated at one location: the Area 8 test pit at 4 m  
6 (13 ft) bgs. The site central tendency measures, mean (1.0 mg/kg), and 95%UCL  
7 (4.0 mg/kg) are also within the expected applicable literature range. The 1.0 mg/kg mean  
8 is, for practical purposes, equivalent to the Hanford Site background value of 0.78 mg/kg.  
9 As indicated in Table 2-12, and amplified in the table remarks, the default  
10 ecological-screening value (0.3 mg/kg) may not be applicable to this situation. The  
11 default value appears to be a plant concentration that is protective of herbivores.  
12 ES/ER/TN-86/R3 illustrates derivation of soil-screening levels, based on no observed  
13 adverse-effect levels for the meadow vole (*Microtus pennsylvanic*) of 14.8 mg/kg.
- 14 • Concentrations of silver appear to be anomalously high at AD-1 (1.2 to 1.8 m [4 to 6 ft]),  
15 as well as at AD-2 (2.3 to 2.6 m [7.5 to 8.5 ft]), B8826 (1.2 to 1.8 m [4 to 6 ft]), and the  
16 Area 8 test pit in the 4 m (13-ft) interval. As indicated, when these data are aggregated,  
17 the mean concentration (1.9 mg/kg) is approximately equal to the ecological-screening  
18 value; the 95%UCL (8.7 mg/kg) exceeds the governing benchmark value.
- 19 • Uranium concentrations appear to be anomalously elevated at AD-2 (2.3 to 2.6 m [7.5 to  
20 8.5 ft]) and AD-3 (1.8 to 2.7 m [6 to 9 ft] intervals). The central tendency mean  
21 concentration (1.3 mg/kg) and the 95%UCL (1.6 mg/kg) are actually within the range of  
22 background and well below the governing ecological protection-screening value.
- 23 • Vanadium concentrations, with the exception of apparent anomalously elevated samples  
24 from AD-2 (2.3 to 2.6 m [7.5 to 8.5 ft]) appear to be uniformly distributed. The central  
25 tendency mean concentration (64.2 mg/kg) and the 95%UCL (69.8 mg/kg) are actually  
26 within the range of background. As indicated, there is significant uncertainty of the  
27 verity of the 2.0 mg/kg ecological-screening value.<sup>15</sup>
- 28 • Nitrate concentrations (as N) appear to be elevated, most notably at AD-1 (1.2 to 1.8 m  
29 [4 to 6 ft]), as well as at other locations. As indicated, however, the mean and 95%UCL  
30 concentrations (35.7 and 66.9 mg/kg, respectively), while still above the Hanford Site  
31 background, are substantially lower than the maximum and bracket the governing  
32 groundwater protection screening value.
- 33 • Nitrate and nitrite concentrations (as N) also appear to be elevated at AD-2 (2.3 to 2.6 m  
34 [7.5 to 8.5 ft]), as well as at other locations. As indicated, however, the mean and

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<sup>15</sup> In addition to the uncertainty in the value conveyed by the authors, there is a practical aspect. According to Schacklette (et al. 1984), the observed range of vanadium in soils in the western United States is 7 to 500 mg/kg. If, in fact vanadium soil concentrations in the range of 2.0 mg/kg were hazardous to plants, there would be observable widespread ecological impacts throughout the western United States.

1 95%UCL concentrations (36.1 and 116.3 mg/kg, respectively) are well below the  
2 maximum, indicating that the bulk of the soils are not as adversely affected as the  
3 maximum reported concentration might imply.

- 4 • Sulfate concentrations (2,970 mg/kg) appear to be elevated at AD-1 (1.2 to 1.8 m [4 to  
5 6 ft]), although levels at most other locations appear to be much lower, generally within  
6 the range of background.
- 7 • Aroclor 1254 was detected at a concentration exceeding the ecological-screening value in  
8 one sample at the site at 9,400  $\mu\text{g}/\text{kg}$ . The location, AD-1 (1.2 to 1.8 m [4 to 6 ft]), has  
9 consistently been called out as a spot where elevated concentrations of COPC reside. No  
10 attempt was made to compute summary statistics because all other laboratory results were  
11 reported as non-detections (typical detection limits were in the range of  $\sim 35 \mu\text{g}/\text{kg}$ ). The  
12 detection rate for Aroclor 1254 (1 in 40 samples) is 2.5 percent, which is technically  
13 below the EPA's 5 percent guideline for exclusion based on low detection frequency  
14 (EPA/540/1-89/002). Note the result is qualified as an estimated value because the  
15 sample was diluted to obtain satisfactory laboratory performance.

16 Benzo(a)anthracene and chrysene were detected at concentrations exceeding their respective  
17 groundwater-screening values and also in samples collected at AD-1 (1.2 to 1.8 m [4 to 5 ft]).  
18 Both compounds also were detected at AD-3 (1.8 to 2.1 m [6 to 7 ft]), but at concentrations less  
19 than the groundwater-screening values. Again, summary statistics were not computed because  
20 all other laboratory results were reported as non-detections (typical detection limits were in the  
21 range of  $\sim 350 \mu\text{g}/\text{kg}$ ). These detection rates (5 percent[2 in 40 samples]) just meet EPA's  
22 5 percent guideline for exclusion based on low detection frequency (EPA/540/1-89/002). The  
23 results are "J" qualified as estimates because the samples were diluted.

#### 24 2.12.4 Summary of the Nature and Extent of 25 Contamination and Implications for the 26 Feasibility Study

27 The use of maximum concentrations for screening has effectively identified a subset of  
28 constituents as COPCs. However, as indicated above, the nature and extent of contamination are  
29 characterized as highly localized, not uniformly distributed. In this situation, receptors will  
30 receive exposure not only to the elevated concentrations found in the localized anomalies but  
31 also to the concentrations found in the areas that are not elevated. As a result, exposure is  
32 actually an integrated function of concentrations over space, as suggested by Equation 1. An  
33 integrated interpretation of Figure 2-15 indicates that, while there are specific locations where  
34 elevated constituent concentrations are found (particularly in the upper 1.5 to 3 m [5 to 10 ft]  
35 strata), there are also a greater number of locations where there are no detections and/or  
36 concentrations are similar to background levels. These conclusions are based primarily on the  
37 following findings.

- 38 • Contamination is not widely dispersed over the site at elevated concentrations. Rather,  
39 there are specific locations where elevated concentrations are consistently reported. The  
40 locations include pits in the 1.5 to 3 m [5 to 10 ft] intervals at AD-1, AD-2, and boring

1 B8826. Additionally, elevated concentrations were occasionally found in the 4 m (13-ft)  
2 interval at test pit Area 8.

- 3 • Certain constituents, identified as COPCs because their maximum concentrations  
4 exceeded screening values, are likely to have been mis-categorized because they are not  
5 widely dispersed at elevated concentrations and their central tendency concentrations  
6 (e.g., mean and 95%UCL) do not exceed background. These constituents include the  
7 following:

- 8 – Arsenic, boron, selenium, uranium, and vanadium.

- 9 • Other constituents identified as COPCs (because their maximum concentrations exceeded  
10 screening values) that are not widely dispersed at elevated concentrations, and whose  
11 maximum reported concentration does not represent overall site conditions, include the  
12 following:

- 13 – Aroclor 1254, benzo(a)anthracene, chrysene, cadmium, lead, silver, nitrate (as N),  
14 nitrate-nitrite (as N), and Pu-239/24. The maximum concentrations of these  
15 constituents were reported in the 1.2 to 1.5 m (4 to 5 ft) interval of AD-1.

16 Further evaluation will be necessary to clarify the degree to which the constituents identified  
17 above actually potentially pose unacceptable risk to humans, ecological receptors, and  
18 groundwater.

19 In addition, as discussed previously, molybdenum was apparently mis-classified as a COPC (see  
20 the anomalously high “split” sample in B8826). Methylene chloride has been verified as a  
21 laboratory artifact, and the single detection of 1,-2-dichloroethane was misreported.

### 22 2.12.5 Groundwater Impacts from Vadose Zone 23 Contamination

24 The RI BRA found that 16 constituents<sup>16</sup> posed a significant threat to groundwater because their  
25 maximum measured concentrations exceeded their groundwater impact-screening  
26 concentrations. Overall, from an FS perspective, this was a highly significant finding because  
27 many of the resulting PRGs that would be protective of groundwater, derived from  
28 WAC 173-340-747, Equation 747-1, would likely drive development of RAOs that ultimately  
29 might prove impracticable to implement. Inspection of Table 2-9 reveals that the groundwater  
30 protection-screening value for many constituents is very low and, in some instances, implausible  
31 (e.g., below background levels). For example, the arsenic groundwater protection concentration  
32 value, computed according to WAC 173-340-747, Equation 747-1, is 0.0304 mg/kg. This  
33 concentration is more than 100 times below the Hanford Site background arsenic concentration,

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<sup>16</sup> Aroclor 1254, arsenic, benzo(a)anthracene, bismuth, cadmium, chrysene, 1,2-dichloroethane, mercury, methylene chloride, nitrate, nitrate/nitrite, selenium, silver, sulfate, tributyl phosphate, and uranium.

1 making the groundwater protection-screening concentration impractical as a gauge for assessing  
2 the consequences of arsenic soils concentrations.

3 Previous discussions have identified the usefulness of an expanded assessment of the potential  
4 that constituents in the vadose zone may have on groundwater. The expanded assessment  
5 involves two phases:

6 • Phase I, Qualitative

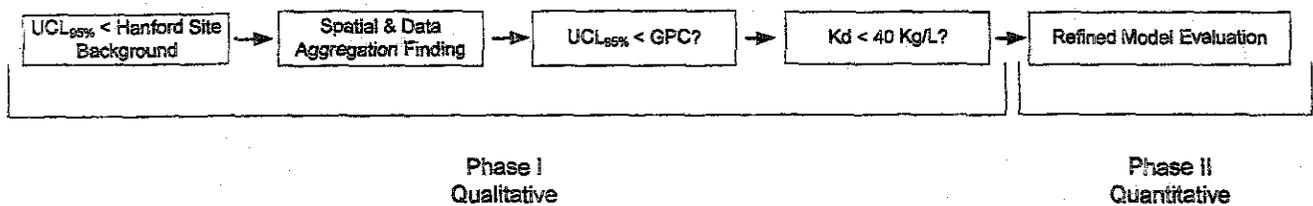
- 7 – Identifying COPCs with potential to impact groundwater using Equation 747-1
- 8 – Refining according to the spatial and data aggregation analysis, as appropriate
- 9 – Assessing migration potential qualitatively using the  $K_d \leq 40$  kg/L benchmark.

10 • Phase II, Quantitative

- 11 – Reevaluating the potential impacts to groundwater with an alternative transport and  
12 fate model that more accurately expresses site-specific conditions.

13 This process is illustrated conceptually below.

14



15

16 The Phase I Qualitative results are summarized in Table 2-13. A review of the table indicates the  
17 following.

- 18 • Lead, mercury, selenium, silver, uranium, Aroclor 1254, and Benzo(a)anthracene,  
19 concentrations evaluated as the 95%UCL, do not exceed the groundwater protection  
20 concentration (GPC).
- 21 • Lead, mercury, uranium, Aroclor 1254, benzo(a)anthracene, and chrysene have  $K_d$ s  
22 greater than 40 kg/L.
- 23 • Arsenic, cadmium, nitrate (as N), nitrate/nitrite (as N), and sulfate qualify for Phase II  
24 analysis of their potential to adversely affect groundwater. Arsenic concentrations,  
25 evaluated at the 95%UCL, do not appear to be significantly elevated at the site; however,  
26 as a conservative measure, it also will be evaluated. Additionally, silver's 95%UCL  
27 concentration is marginally below the GPC and its  $K_d$  is notably less than 40 kg/L; it will  
28 be evaluated as well.

29 Phase II of the extended evaluation entails assessing the potential impacts that residual soil  
30 concentrations of arsenic, cadmium, silver, nitrate (as N), nitrate/nitrite (as N), and Sulfate could  
31 have on groundwater under baseline conditions. Baseline conditions assume that the present

1 conditions remain unchanged. In accordance with WAC 173-340-747(8), this evaluation uses  
 2 site- and chemical-specific information as inputs into a widely recognized vadose zone leaching  
 3 and transport model, SESOIL (GSC 1998, *SESOIL*), to investigate the possibility that residual  
 4 soil contamination can affect the deeper saturated groundwater.<sup>17</sup> SESOIL is a compartment  
 5 model that computes the mass movement of constituents from overlying strata to the underlying  
 6 strata using infiltration computed from local meteorological information, water balance, and  
 7 constituent-partitioning algorithms. SESOIL helps clarify the groundwater impacts assessment,  
 8 over the use of WAC 173-340-747, Equation 747-1 by:

- 9 • Using local climatological data to drive the moisture flux
- 10 • Incorporating the significant depth to groundwater that is intrinsic to the Hanford Site
- 11 • Integrating constituent migration and attenuation over time.

12 A conceptualization of the SESOIL model for the 216-A-29 Ditch is presented in Figure 2-17.  
 13 The inset table in Figure 2-17 identifies the key SESOIL modeling input variables. Examination  
 14 of the SESOIL conceptualization (Figure 2-17) indicates that waste layer or "source volume" is  
 15 assumed to envelope the entire length, width, and depth of the ditch (to a depth of 4.6 m [15 ft]).  
 16 This volume is assumed to be contaminated at the 95%UCL concentration of each constituent.

17 Figure 2-18, a composite from several figures, illustrates the main process features of SESOIL.  
 18 The hydrologic cycle (left side) illustrates the processes simulated in the model's hydrologic  
 19 cycle including evapotranspiration, infiltration, moisture retention, and groundwater runoff  
 20 (i.e., recharge). The right side of Figure 2-18 illustrates some of the processes SESOIL can  
 21 simulate.

22 The constituent-partitioning aspect of SESOIL is largely governed by the distribution coefficient  
 23 (e.g.,  $K_d$ ) in a manner similar to that used by Equation 747-1 (i.e., both models rely on a  
 24 retardation factor that is controlled by the  $K_d$ ). Constituent penetration through the vadose-zone  
 25 is computed by the equation at the bottom of the figure where the hydrological and pollutant fate  
 26 cycles are joined. When the SESOIL model predicts that a constituent penetrates the  
 27 vadose-zone, a conservative estimate of the groundwater concentration is given by the Summers  
 28 Mixing Model (illustrated on the pollutant fate cycle) to estimate the groundwater  
 29 concentrations. Additional discussion of the SESOIL Model can be found in Appendix F.

30 Chemical-specific input parameters for the 216-A-29 Ditch constituents are found in Table 2-14.  
 31 As indicated, with the exception of nitrate, nitrate/nitrite, and sulfate, the  $K_d$ s are taken from

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<sup>17</sup> SESOIL is an acronym for Seasonal Soil Compartment Model. SESOIL was developed originally by the EPA's Office of Water and Toxic Substances. The model has been upgraded several times, including a major effort by the Oak Ridge National Laboratory in 1995. The model is currently licensed by General Sciences Corporation (GSC 1998). SESOIL is commonly used in the hazardous waste industry to assess soil to groundwater impacts at CERCLA and RCRA sites. Various states, including Colorado and Kansas, use SESOIL to evaluate the impacts that contaminants in soils may have on groundwater. SESOIL is generally considered a screening-level tool and its use constitutes a significant refinement over Equation 747-1. Appendix F contains an analysis of SESOIL as an alternative transport and fate model in accordance with WAC 173-340-747(8) requirements. The appendix also contains an extensive description, the technical foundation, descriptions of its uses, and related technical information regarding SESOIL.

1 Ecology's CLARC database (<https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx>)  
 2 (Ecology 2003). The results of the extended assessment of the potential impacts that residual  
 3 soil concentrations of arsenic, cadmium, silver, nitrate (as N), nitrate/nitrite (as N), and sulfate  
 4 could have under baseline conditions are presented in Figures 2-19, 2-20, 2-21, and 2-22, and are  
 5 summarized below:

- 6 • Figure 2-19 illustrates a summary of the predicted impacts that arsenic concentrations in  
 7 the vadose zone soils (0 to 4.6 m [0 to 15 ft]), at their 95%UCL concentration of 7 mg/kg,  
 8 will have over a 1,000-year period. The line shown is the trend line fitted to the actual  
 9 soil moisture concentration computed by SESOIL. The figure shows the depth  
 10 of maximum penetration (in feet) at selected time intervals and the concentration at the  
 11 location of maximum penetration at the selected time interval. Most  
 12 importantly, SESOIL predicts that arsenic will not reach the groundwater; the maximum  
 13 penetration into the vadose zone from the waste layer is only 8.5 m (28 ft), which is well  
 14 above the 82.3 m (270 ft) depth of the saturated zone. The actual migration distance from  
 15 the bottom of the waste layer into the vadose zone predicted by SESOIL is 4 m (13 ft)  
 16 (4.6 – 8.5 m [15 ft – 28 ft]) of source thickness [see Figure 2-17]). The vadose soil  
 17 moisture concentration at the depth of maximum penetration is approximately 0.08 mg/L.
- 18 • Figure 2-20 illustrates a summary of the predicted impacts that cadmium concentrations  
 19 in the vadose zone soils (0 to 4.6 m [0 to 15 ft]), at their 95%UCL concentration of  
 20 6.1 mg/kg, will have over a 1,000-year period. SESOIL predicts that cadmium will not  
 21 reach the groundwater; the maximum penetration into the vadose zone is 22.3 m (73 ft),  
 22 which, again, is well above the 82.3 m (270-ft) depth of the saturated zone. The actual  
 23 migration distance from the bottom of the waste layer into the vadose zone computed by  
 24 SESOIL is 17.7 m (58 ft) (4.6 – 22.3 m [15 ft – 73 ft]), and the vadose soil moisture  
 25 concentration at the depth of maximum penetrations is approximately 0.20 mg/L.
- 26 • Figure 2-21 illustrates a summary of the predicted impacts that silver concentrations in  
 27 the vadose zone soil (0 to 4.6 m [0 to 15 ft]), at their 95%UCL concentration of  
 28 8.7 mg/kg, will have over a 1,000-year period. SESOIL predicts that silver will not reach  
 29 the groundwater. The maximum penetration into the vadose zone is 19.2 m (63 ft) (well  
 30 above the 82.3 m (270-ft) depth of the saturated zone). The predicted net penetration  
 31 depth into the vadose zone is 14.6 m (48 ft) (4.6 – 19.2 m [15 ft – 63 ft]) where a soil  
 32 moisture concentration of 0.3 mg/L is anticipated.
- 33 • Figure 2-22 illustrates a summary of the predicted impacts that nitrate, nitrate/nitrite, and  
 34 sulfate concentrations in the vadose zone soils (0 to 4.6 m [0 to 15 ft]), at their 95%UCL  
 35 concentrations (66.9, 116.3, and 704.6 mg/kg, respectively) will have over a 1,000-year  
 36 period. These three inorganic constituent have similar ionic properties and are likely to  
 37 be found as ions (i.e., a negative charge) in aqueous environments and may tend to be  
 38 mobile in the soil environment. This feature is taken into account by the small  $K_d$  value  
 39 shown in Table 2-14 ( $K_d = 1.17$  kg/L) and the 99 percent water solubility.

40 As indicated in Figure 2-22, the SESOIL model predicts that these constituents could  
 41 reach the groundwater at approximately simulation year 785 (calendar year 2791). The

1 inset table near the bottom of Figure 2-22 show that the maximum predicted groundwater  
2 concentrations over the 1000-year simulation period are as follows:

- 3 - Nitrate/nitrite = 14 mg/L
- 4 - Nitrate = 8 mg/L
- 5 - Sulfate = 87 mg/L.

6 The scale of these predicted impacts can be gauged by comparing the simulated concentrations  
7 to the potential groundwater concentration benchmarks provided in the inset table near the  
8 bottom of Figure 2-22. With the exception of nitrate/nitrite, all maximum predicted groundwater  
9 concentrations are below their corresponding state and/or Federal water quality standards. The  
10 maximum nitrate/nitrite concentration of 14 mg/L is slightly in excess of the Federal drinking  
11 water standard, which is 10 mg/L.

12 An important aspect in considering the magnitude of the predicted excess in the Federal drinking  
13 water standard (14 mg/L predicted vs. the 10 mg/L standard) is the intended use and  
14 corresponding regulatory protection requirements for the groundwater. Currently, the  
15 groundwater is not used for consumptive purposes and the drinking water standard used to gauge  
16 the predicted concentrations may have no health protection or regulatory basis. Additionally,  
17 there are no plans to use the groundwater for consumption. Notably, the state does not have a  
18 groundwater standard for nitrate/nitrite; thus, there is no actual governing maximum  
19 concentration limit.

20 The differences and similarities between the modeling results for the metals (arsenic, cadmium  
21 and silver) and the inorganic anions (nitrate, nitrate/nitrite, and sulfate) can be traced to the  
22 variations in their chemical-specific fate and transport properties found in Table 2-14, where the  
23 following key aspects are evidenced as follows:

- 24 • Arsenic, cadmium, and silver source concentrations ranging from 6.1 to 8.7 mg/kg, and  
25  $K_{ds}$  ranging from 6.7 to 29 L/kg
- 26 • Nitrate, nitrate/nitrite, and sulfate have notably higher source concentrations (66.9 to  
27 704.6 mg/kg) a comparatively lower  $K_d$  (1.17 L/kg), and a very high water solubility  
28 (i.e., 99 percent is essentially miscible).

29 In general, all other factors being equal, predicted concentrations in the environment will vary  
30 directly with the source terms and inversely with the  $K_d$ . Thus, in the case of the inorganic  
31 anions (nitrate, nitrate/nitrite, and sulfate), the combination of higher source concentrations and  
32 much greater environmental mobility accounts for their predicted migration to groundwater,  
33 while the metal constituents (arsenic, cadmium, and silver) do not fully penetrate the vadose  
34 zone and never reach the groundwater.

35 The analysis also lends credibility to the use of the benchmark  $K_d$  of 40 kg/L as a conservative  
36 gauge for discriminating among constituents that do not have the potential to impact  
37 groundwater in the Phase I aspect of the extended groundwater impacts analysis. Once again,  
38 inspection of Table 2-14 indicates that the  $K_{ds}$  for the metals (arsenic, cadmium, and silver) are  
39 notably smaller than the benchmark 40 kg/L  $K_d$ . Yet, review of the maximum vadose zone

1 penetrations of these constituents in Figures 2-19 through 2-21 reveals that, over a 1,000-year  
2 simulation period, vertical migration through the vadose zone is actually very small (penetration  
3 is only 17.7 m (58 ft) in the case of cadmium which has a  $K_d$  of 6.7 kg/L). Thus, identifying and  
4 evaluating constituents that do not have the potential to affect groundwater with benchmark  $K_d$   
5 greater than 40 kg/L appears to be very conservative.

6 Based on this assessment, only nitrate/nitrite presents a threat of adversely affecting groundwater  
7 at the site. Considering the conservatism and uncertainty inherent in groundwater predictions  
8 785 years in the future, there appears to be little concern for vadose zone contaminants to  
9 adversely impact groundwater. However, RAOs and PRGs may be developed for nitrate/nitrite  
10 in Chapter 3.0, as appropriate.

#### 11 2.12.6 Revised Assessments Using Robust 95%UCL Exposure-Point 12 Concentrations

13 Throughout the RI BRA, maximum concentrations were frequently used for making comparisons  
14 to screening concentrations. As indicated previously, this technique is suitable for coarse-scale  
15 screening, identifying COPCs, and for reducing the data to a focused set for further evaluations.  
16 In the extended analysis, the screening can be refined by comparing 95%UCL concentrations to  
17 screening values. The 95%UCL concentrations are referred to as "robust" because they are  
18 computed with statistical techniques described in OSWER 9285.6-10 (EPA 2002) using the  
19 ProUCL software that accompanies it.<sup>18</sup> This step is intended to better clarify the issue of the  
20 degree to which constituents identified as COPCs through the use of maximum concentrations  
21 for screening, and that are found at elevated concentrations in specific locations, pose  
22 unacceptable risks. Table 2-15 contrasts the 95%UCL concentration of constituents whose  
23 maximum concentration exceeded either the industrial ecological-screening concentration or  
24 industrial direct-contact screening value with those corresponding screening values. The  
25 maximum concentrations are included as well. Inspection of the table reveals the following

- 26 • 95%UCL concentrations are lower than, or equal to, the industrial ecological-screening  
27 concentrations for arsenic, cadmium, and lead. On this basis, these constituents do not  
28 exceed the screening criteria and therefore, do not pose unacceptable risks.
- 29 • Reviewing the industrial direct-contact maximum dose and risk estimates for Pu-239/240  
30 indicates that, based on the 95%UCL concentration, the revised estimates are  
31 10.5 mrem/yr and 3E-5, respectively. These revised dose and risk estimates are less than  
32 their respective assessment criteria (15 mrem/yr and 1E-4 risk). On this basis,  
33 Pu-239/240 does not exceed the screening criteria and does not pose unacceptable risk.

---

<sup>18</sup> The techniques in ProUCL automatically attempt to fit several distributions and select a best fit, if possible. Summary statistics, including the 95%UCL, are then computed using the fitted distribution. In cases where a suitable distribution fit cannot be made, the algorithm provides non-parametric or "distribution free" 95%UCL. These techniques are frequently referred to as robust methods because they expand the analysis capabilities within the norms of sound statistical practice. In most cases, the algorithm provided 95%UCL values based on the non-parametric statistics.

1 As indicated in Table 2-15, selenium and silver 95%UCL concentrations exceed the industrial  
 2 ecological-screening concentrations, although selenium's value (4 mg/kg) is equivalent to the  
 3 upper end of the range of selenium concentrations found in the western United States of  
 4 4.3 mg/kg (Schacklette and Boerngen 1984). Notably, selenium's 95%UCL concentration is  
 5 well below the toxicity-based screening value of 14.8 mg/kg developed in ES/ER/TN-86/R3.  
 6 The single detection of Aroclor 1254, 9,400 µg/kg, exceeds the industrial ecological-screening  
 7 concentration. No attempt was made to compute a 95%UCL for Aroclor 1254; there is only one  
 8 detection in all samples collected from the site.

### 9 **2.12.7 Intruder-Exposure Scenario**

10 This section provides an assessment of risks associated with a human health intruder-exposure  
 11 scenario; an intruder scenario was not provided in the RI BRA.

12 Land use within the core zone of the 200 Area is currently considered industrial (exclusive) and  
 13 is defined as "preserving DOE control of the continuing remediation activities and use of the  
 14 existing compatible infrastructure required to support activities such as dangerous waste,  
 15 radioactive waste, and mixed waste treatment, and storage and disposal facilities"  
 16 (DOE/EIS-0222-F). Future land use at the Hanford Site is uncertain; however, the DOE, the  
 17 Ecology, and the EPA (i.e., Tri-Parties) have agreed that an industrial scenario will be used to  
 18 evaluate waste sites within the core zone. Accordingly, the RI BRA addressed exposure that  
 19 could occur as a result of industrialization of the sites.

20 The remediation decision process in the FS will not use the unrestricted-use scenario results.  
 21 However, it has been regarded as possible, though not likely, that, at some time in the future, an  
 22 intruder-exposure scenario could occur. The intruder scenario is envisioned to occur at a time  
 23 well into the future when institutional controls may lapse and individuals can have access to the  
 24 200 Area representative sites. In this manner, humans could be exposed to residual soil  
 25 constituents.

26 This section develops and presents the intruder scenario through the following sequence.

- 27 1. COPCs are reviewed and assessed by comparing 95%UCL concentrations to background  
 28 and unrestricted use screening concentrations to determine which constituents should be  
 29 used in the intruder risk calculations. The unrestricted-use screening concentration is an  
 30 appropriate screening metric in this instance because, as discussed below, the intruder  
 31 scenario is a variant of a residential (e.g., ~ unrestricted use) scenario.
- 32 2. The intruder scenario will be developed through discussions of its characteristics and  
 33 exposure- and chemical-specific factors.
- 34 3. The results and discussion will be presented in terms of their implication for the FS.

#### 35 **2.12.7.1 Intruder Scenario Contaminants of Potential Concern**

36 Step one of this assessment, identification of COPCs for the intruder scenario, is summarized in  
 37 Table 2-16. As indicated in the table, comparing 95%UCL concentrations to background and

1 unrestricted-use screening concentrations, reveals that arsenic, sulfate, Aroclor 1254,  
2 benzo(a)anthracene, and chrysene will be included in the intruder scenario assessment.  
3 Plutonium-239/240 also will be assessed using RESRAD; it will be discussed separately.

#### 4 **2.12.7.2 Intruder Scenario Discussion and Exposure Parameters**

5 The second step, development of the scenario and discussions of the exposure and chemical  
6 specific factors, is presented below.

7 The intruder scenario assumes that a receptor is residing within the vicinity of the 200 Area and  
8 he/she obtains a substantial portion of his/her daily vegetable intake from a home garden. A  
9 portion of the garden soils are assumed to be contaminated with drill cuttings taken from a well  
10 drilled through the waste site. The drill cuttings are blended with unaffected soils to make up an  
11 amalgam of garden soils, which become the source for exposure. Main characteristics of the  
12 intruder scenario are as follows:

- 13     ◦ Direct contact with the soils during gardening, including incidental ingestion of soils,  
14       inhalation of dust arising from the garden, and dermal contact with the garden soils
- 15     ◦ Secondary contact indoors with dust that originated as garden soils, including additional  
16       incidental ingestion, inhalation, and dermal contact
- 17     ◦ Consumption of vegetables and fruits grown from the garden.
- 18     ◦ Irradiation from radionuclides in the soil
- 19     ◦ Exposure occurring 365 days/yr for 30 years.

20 For purposes of evaluating the impacts of the intruder scenario, it is presumed that after  
21 150 years an intruder could obtain access to the area. The scenario assumes no significant  
22 attenuation of nonradionuclides; however, natural decay of radionuclides is assumed to occur  
23 over the 150-year period. The scenario is intentionally conservative and may not actually be  
24 plausible. For example, it may not be possible for a garden of the size specified to produce  
25 enough fruits and vegetables to support the consumption specified.

26 Figure 2-23 is a condensed version of the Site CSM (from Figure 2-14), modified to reflect the  
27 exposure setting with an insert at the bottom illustrating the conceptualization of the potential  
28 garden soils (the exposure media) and its relationship to site soils and drill cuttings. As  
29 indicated, the cuttings are derived from a very large boring of 0.6 m (2 ft) in diameter to produce  
30 14.4 m (47.2 ft<sup>3</sup>) of contaminated material soil. The boring is envisioned as a necessity to  
31 provide water for the garden. When the cuttings are uniformly blended with other unaffected  
32 soils to create the garden, the total garden volume comes to 322.6 m (1,058 ft<sup>3</sup>) and a blending  
33 factor of 21.5 is obtained. As indicated in the CSM portion of Figure 2-23, complete exposure  
34 pathways include external irradiation from radionuclides in garden soils, incidental ingestion of  
35 garden soils, inhalation of dust from the garden, and consumption of home-raised foodstuffs.

36 Exposure factors used to characterize the scenario are presented in Table 2-17. As indicated, the  
37 intruder receptor is the hybrid of a small child-adult receptor, occasionally referred to as the

1 child-to-adult receptor. Most of the exposure factors were taken from DOE/RL-91-45, *Hanford*  
 2 *Site Baseline Risk Assessment Methodology*; all others were taken from relevant EPA guidance.  
 3 In addition to the human exposure factors, several chemical-specific variables are necessary to  
 4 compute exposures and they are listed in Table 2-17. Figure 2-23 also included an assessment of  
 5 the risks associated with the installation of the large boring. This exposure may be addressed if  
 6 the intruder exposure suggests that it is necessary to understand the risk associated with the  
 7 entire scenario.<sup>19</sup>

8 Toxicity information (cancer slope factors and reference doses) were obtained from the  
 9 Ecology's CLARC database (<https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx>)  
 10 (Ecology 2003). As indicated, sulfate is a COPC for the intruder scenario. A review of  
 11 Ecology's CLARC database, EPA's IRIS database, and the Center for Disease Control's Agency  
 12 for Toxic Substances and Disease Registry database did not generate appropriate information to  
 13 assess the toxicity of exposure to sulfate. The search was expanded and a relevant toxicity  
 14 summary from the DOE's *Risk Assessment Information System* (RAIS) was obtained; it is  
 15 summarized below:

16 "In regards to sulfate, pursuant to the Safe Drinking Water Act, the U.S. EPA has  
 17 proposed Maximum Contaminant Level Goals of either 400 or 500 mg/L to protect  
 18 infants, and has identified a LOAEL (Lowest-Observed-Adverse-Effect-Level) of  
 19 630 mg/L based on diarrhea in infants receiving formula made with high-sulfate water.  
 20 The Drinking Water Standards of the U.S. Public Health Service recommend that sulfate  
 21 in water should not exceed 250 mg/L, except when no more suitable supplies are or can  
 22 be made available (RAIS, 2005)."<sup>20</sup>

23 Based on this information, a provisional reference dose, based on the administered dose that an  
 24 infant would receive from consumption of sulfate in drinking water at a concentration of  
 25 250 mg/L, was derived by Equation 3:

26 Administered oral dose sulfate:

$$27 \quad \frac{250 \text{ mg}}{\text{L}} \times \frac{1.0 \text{ L}}{\text{day}} \times \frac{1}{16 \text{ kg}} = \frac{15.6 \text{ mg}}{\text{kg} \cdot \text{day}}, \text{ Eq. 3}$$

28 Equation 3 shows that the administered oral dose associated with infant consumption of sulfate  
 29 in drinking water at a concentration of 250 mg/L is 15.6 mg/kg-day. Because the drinking water  
 30 concentration (250 mg/L) citation is from a reputable source and is based on observed effects in  
 31 humans, uncertainty in the administered dose estimate, as a basis for a provisional chronic

---

<sup>19</sup> The characteristics of the intruder scenario include consumption of home-grown fruits and vegetables and continuous exposure for 30 years. Installation of the boring is likely to take several days. In all likelihood, the 30-year residential-like intruder scenario produces much greater exposure than what would be experienced by a several-day well driller.

<sup>20</sup> RAIS, 2005, *Toxicity Profile for Sulfate*, US Department of Energy's Risk Assessment Information System, [http://risk.lsd.ornl.gov/tox/rap\\_toxp.shtml](http://risk.lsd.ornl.gov/tox/rap_toxp.shtml).

1 reference dose (RfD,) is small. As a consequence, a modest uncertainty factor of 2 is  
2 appropriate. The provisional sulfate RfD<sub>oral</sub> is calculated according to Equation 4.

3 Provisional RfD<sub>oral</sub> sulfate:

$$4 \quad \frac{15.6 \text{ mg/kg} - \text{day}}{2} = 7.8 \text{ mg/kg} - \text{day}, \text{ Eq. 4}$$

5 The provisional RfD<sub>oral</sub> can be used until Ecology, EPA, the Centers for Disease Control, or other  
6 reputable source provides an alternative.

### 7 2.12.7.3 Intruder Scenario Results

8 Based on the input described above, the intruder scenario exposure and risk calculations were  
9 completed. The results are found in Table 2-17. Inspection of the results reveals that the  
10 following.

- 11 • The summed hazard quotients, referred to as the hazard index (HI) is 0.6. This value is  
12 notably below the benchmark HI of 1.0 that is frequently used to indicate a transition  
13 from acceptable exposure conditions to conditions warranting concern. The HI is  
14 dominated by the Aroclor 1254 component (~87 percent). According to Ecology, the  
15 toxicological basis for Aroclor 1254 is ocular toxicity (effects on the eye) and effects on  
16 the immune system; the basis for the arsenic RfD is skin lesions (Ecology 2003).  
17 Because these two impacts are mechanistically independent, the HI of 0.6 is probably not  
18 relevant and the HI Aroclor 1254 of 0.5 should be the guiding overall hazard assessment  
19 metric.
- 20 • The summed excess lifetime cancer risk (ELCR) is 2E-5 (1 in 50,000). This estimate is  
21 near the mid-point of the 1E-6 to 1E-4 risk management range. The summed ELCR is  
22 notably below the 1E-4 benchmark risk frequently used to signify the need for risk  
23 management intervention. The summed ELCR is controlled by the arsenic part  
24 (~87 percent). The controlling pathway of exposure is ingestion of home-produced  
25 foodstuffs from the garden (~96 percent). More specifically, the arsenic foodstuffs  
26 ingestion component produces an ELCR of 1E-5, which is 84 percent of the summed  
27 ELCR. This finding would suggest that exposure to arsenic through consumption of  
28 home-produced foodstuffs could be responsible for a 1E-5 (1 in 100,000) ELCR.  
29 A review of EPA's basis for its determination of arsenic carcinogenicity in humans  
30 reveals that this might not be an accurate, biologically accurate characterization,  
31 according to the following excerpt:

32 "Basis -- based on sufficient evidence from human data. An increased  
33 lung cancer mortality was observed in multiple human populations  
34 exposed primarily through inhalation. Also, increased mortality from  
35 multiple internal organ cancers (liver, kidney, lung, and bladder) and an  
36 increased incidence of skin cancer were observed in populations  
37 consuming drinking water high in inorganic arsenic (EPA 2005)."

1 As indicated, EPA's primary premise of human carcinogenicity is lung cancer from  
2 inhalation (studies of smelter workers) and internal organ and skin cancers from ingestion  
3 of drinking water containing high arsenic concentrations. Neither of these bases is  
4 directly comparable to the exposure identified in the intruder scenario where exposure is  
5 governed by exposure to soils and foodstuffs. Thus, the dominant risk aspect of the  
6 summed ELCR (i.e., arsenic ELCR of 1E-5) should be viewed with a degree of caution in  
7 light of this uncertainty and should not be used as the basis for remediation.

8 Table 2-12 identified the 95%UCL for Pu-239/240 as 200.2 pCi/g, a concentration that is notably  
9 elevated above background. To evaluate the effects of Pu-239/240, RESRAD was configured to  
10 express the intruder scenario as presented above. RESRAD computes doses and risks while  
11 integrating radioactive decay and in-growth of daughter products. The time interval for the  
12 intruder exposure was set to 150 years in the future to express the effect of the 150-year lag time  
13 before an intruder could obtain access to the area. Thus, the dose estimates are for year 150 and  
14 the risk estimates are for the time period of years 150 to 180.<sup>21</sup> Table 2-20 summarizes the  
15 results where it is shown that:

- 16 • The dose is estimated to be 0.1 mrem/yr, which is well below the benchmark 15 mrem/yr  
17 dose limit. Incidental soil ingestion and inhalation of resuspended garden soils (i.e., dust)  
18 are the dominant exposure pathways (more than 90 percent).
- 19 • The ELCR risk is 2E-8, which is well below the 1E-6 to 1E-4 risk management range  
20 commonly used to gauge the need for remediation.

21 On this basis, Pu-239/240 does not pose a significant risk to intruders who could possibly inhabit  
22 the site in the future.

23 In summary, this assessment demonstrates that the risks associated with the intruder scenario are  
24 within acceptable ranges. Consequently, an RAO is not necessary.

### 25 **2.12.8 Overall Summary of the Baseline Risk** 26 **Assessment Extended Analysis**

27 The extended risk analysis commenced where the RI BRA left off. The RI BRA was essentially  
28 a screening-level analysis that used conventional conservative techniques. The BRA extended  
29 analysis was performed to clarify findings and reduce uncertainties in the RI BRA.  
30 Conventional techniques were used in the extended analysis and included review and  
31 interpretation of the nature and extent of contamination from the RI, an expanded assessment of  
32 the potential that constituents in the vadose zone may have on groundwater, reassessment of  
33 screening results using exposure concentrations estimated with contemporary techniques, and  
34 evaluation of an intruder human health exposure scenario.

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<sup>21</sup> Plutonium decays very slowly ( $t_{1/2} \sim 24,000$  years) and the effect of this calculation on future events is not significant, in this instance.

1 The overall results of the BRA extended analysis are summarized in Table 2-20. Table 2-20 is  
2 organized to present a before and after the extended analysis comparison. Each RI BRA COPC  
3 is identified in the first column, followed by results of the three RI BRA screening-level  
4 comparisons (an X indicates that an exceedance occurred). The right side of the table indicates  
5 the corresponding results of the extended analysis. An "X" and shaded cell indicate that the  
6 RI BRA finding was offset by the extended analysis. Key findings summarized in Table 2-20  
7 include the following.

- 8 1. Twenty-one constituents were identified by the RI BRA as COPCs for additional  
9 consideration. These constituents were identified based on maximum concentrations  
10 exceeding one or more of the following: direct industrial exposure, protection of  
11 groundwater, and ecological risk associated with an industrial setting.
- 12 2. A review of the basic analytical data and the RI BRA findings disclosed that bismuth,  
13 molybdenum, methylene chloride, TBP, and 1,2-dichloroethane should not be evaluated  
14 in the FS owing to prior dismissal, misreporting, and analytical issues (indicated in the  
15 No Threat or Lab/Reporting Errors column).
- 16 3. A review of the spatial distribution (Spatial and Data Aggregation Considerations  
17 column), including the nature and extent of contamination, revealed that many of the  
18 maximum detections were from common hot spot locations. Additionally, many of the  
19 analytical reports were non-detections or were detections that could be attributable to  
20 background concentrations. The reasons that some constituents were retained in the  
21 RI BRA included there was no "Hanford Site background" data for comparison  
22 (e.g., selenium) and cases where the maximum reported concentration exceeded the  
23 90<sup>th</sup> percentile estimate of background. When these findings were evaluated further, in  
24 some cases, e.g., boron, reliable background data from the general literature were used  
25 instead. In other cases, the 95%UCL concentration, computed with robust statistical  
26 methods, was used as the metric for comparison to the 90<sup>th</sup> percentile estimate of  
27 background. As a result, three constituents (boron, uranium, and vanadium) were found  
28 to be comparable to background using this technique,<sup>22</sup> and they will be omitted from  
29 further consideration.

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<sup>22</sup> Using the UCL<sub>95%</sub> for comparison is not the same test as comparing the maximum to the 90<sup>th</sup> percentile estimate of background. Neither test is statistically rigorous; however, using the UCL<sub>95%</sub> as the comparison metric incorporates and expresses all of the data and, therefore, is more representative of the suite of concentrations to which a human or ecological receptor would actually be exposed (see Equation 1).

- 1 4. Four constituents identified as having maximum concentrations exceeding groundwater  
2 protection screening concentrations also have  $K_{ds}$  greater than the vadose zone  
3 immobility benchmark of 40 kg/L (see column entitled No Impact to GW through  
4 Vadose Zone Immobility  $K_d > 40$ ). These constituents and their  $K_{ds}$  are mercury (52),  
5 benzo(a)anthracene (357), chrysene (398), and Aroclor 1254 (309). The extended  
6 analysis found that, based on their  $K_{ds}$ , coupled with acknowledgment that the Ecology  
7 method of computing groundwater does not represent the Hanford Site very well, these  
8 constituents will be omitted from the analysis as posing a significant threat to  
9 groundwater. Moreover, the vadose zone modeling (summarized below) confirmed that  
10 the vadose zone immobility benchmark  $K_d$  of 40 kg/L is a reliable measure for gauging  
11 migration potential of constituents from the vadose zone to groundwater.
- 12 5. Six constituents (arsenic, cadmium, silver, nitrate (as N), nitrate/nitrite [as N], and  
13 sulfate) were identified as having maximum concentrations exceeding groundwater  
14 protection-screening concentrations, but  $K_{ds}$  less than the vadose zone immobility  
15 benchmark of 40 kg/L (see column entitled No Impact to GW through Vadose Zone  
16 Transport). The migration potential of these constituents was simulated with SESOIL  
17 using site-specific information. The analysis demonstrated that arsenic, cadmium, and  
18 silver have very little potential to migrate through the vadose zone. Over a 1,000-year  
19 modeling period, none of the three constituents reached the groundwater. Consequently,  
20 arsenic, cadmium, and silver should be dropped from the analysis as posing a significant  
21 threat to groundwater. Nitrate (as N), nitrate/nitrite (as N), and sulfate were found to  
22 have the potential to migrate to groundwater. However, the SESOIL analysis revealed  
23 that only nitrate/nitrite poses a threat of exceeding relevant groundwater quality criteria;  
24 the maximum predicted groundwater concentration was 14 mg/L and the Federal  
25 drinking water quality standard is 10 mg/L. The exceedance is projected to occur after  
26 about 785 years.
- 27 6. Three compounds (arsenic, cadmium, and lead), originally identified as posing a risk to  
28 ecological receptors because their maximum concentrations exceeded their industrial  
29 ecologic screening concentrations, were reassessed using the 95%UCL. The reassessment  
30 found that their 95%UCL concentrations do not exceed industrial ecologic screening  
31 concentrations and they are omitted from the analysis. Additionally, Pu-239/240,  
32 originally identified as a threat to industrial workers through direct-contact exposure  
33 based on its maximum concentration, was reassessed using the 95%UCL. The  
34 reassessment found that doses and risks conservatively computed with RESRAD using  
35 the 95%UCL concentration were within limits.
- 36 7. Based on the summary above and the detailed analysis in the foregoing sections, the  
37 following are the key risk-based findings :
- 38 • The site is not highly contaminated, contamination is not widespread, concentrations  
39 are not particularly elevated, and concentrations that are elevated are found in  
40 localized hot spots. Significant portions of the site are not affected, or exhibit  
41 constituent concentrations comparable to background. Localized areas of elevated  
42 constituents are actually found at depths of about 1.5 to 3 m (5 to 10 ft) bgs.

- 1       • There are no unacceptable direct-exposure risks to industrial workers.
- 2       • There are no unacceptable risks to the future intruder receptor that may inadvertently
- 3       reside near the site and establish a garden for the production of fruits and vegetables.
- 4       • Nitrite/nitrate (as N) has the potential to migrate through the vadose zone and affect
- 5       groundwater and result in concentrations exceeding Federal groundwater standards.
- 6       These impacts are predicted to occur after approximately 800 years.
- 7       • Selenium and silver may pose some threat to ecological receptors, based on 95%UCL
- 8       concentrations that exceed industrial ecological-screening concentrations. However,
- 9       as discussed in Table 2-15, there is significant uncertainty in this finding.
- 10      • Aroclor 1254 was reported in a single sample from one hot spot location at
- 11      9,400  $\mu\text{g}/\text{kg}$ . Based on the comparison of this concentration to the industrial
- 12      ecological-screening concentration (650  $\mu\text{g}/\text{kg}$ ), there is potential concern that
- 13      wildlife exposed to soils at this location may be at risk for adverse effects. However,
- 14      the limited occurrence of Aroclor 1254 and its sole detection in soils that are 1.5 m
- 15      (5 ft) bgs suggests that the actual threat is very small.

## 16   2.13   **BASELINE RISK ASSESSMENT EXTENDED**

### 17           **ANALYSIS OF THE 216-B-63 TRENCH SITE**

18   This section provides the extended BRA analysis for the 216-B-63 Trench representative site.  
 19   The analysis will parallel the evaluation of the 216-A-29 Ditch; however, it will be much more  
 20   concise and will rely on the discussions of methods and conceptualizations from the previous  
 21   sections.

#### 22   2.13.1 Summary

23   Nine constituents were identified by the RI BRA as COPCs for the FS to consider. These  
 24   constituents were identified based on maximum concentrations exceeding one or more of the  
 25   three screening parameters. The extended risk analysis was performed to clarify the RI BRA  
 26   findings and reduce uncertainties. Based on the extended risk analysis, the BRA findings are as  
 27   follows.

- 28      • The site is not highly contaminated, is not wide spread, concentrations are not
- 29      particularly elevated, and concentrations that are elevated are found in localized hot
- 30      spots. Localized areas of elevated constituents are actually found at depths of about
- 31      1.5 to 3 m (5 to 10 ft) bgs.
- 32      • There are no unacceptable direct-exposure risks to industrial workers. Additionally, there
- 33      are no unacceptable risks to the hypothetical future intruder.

- 1 • There are no unacceptable impacts to groundwater.
- 2 • Total radioactive strontium concentrations (as Sr-90), localized to two discrete locations,  
3 just exceed the conservative BCG and may pose some threat to ecological receptors.

#### 4 **2.13.2 Extended Risk Analysis of the 216-B-63 Trench**

5 Table 2-8 provided a summary of COPCs for the four 200-CS-1 OU representative sites,  
6 including the 216-B-63 Trench site. Table 2-22 is a condensation of Table 2-8 to reflect only  
7 those COPCs found in the 216-B-63 Trench representative site and it will serve as the basis for  
8 the extended evaluation of the 216-B-63 Trench RI BRA findings.

9 The principal findings affecting the evaluation of remedial actions at the 216-B-63 Trench for the  
10 industrial land-use scenarios are as follows:

- 11 • Bismuth was identified as posing a potential threat to industrial receptors through direct  
12 contact. Based on the evaluation of the 216-A-10 site, bismuth will be omitted from  
13 further consideration. Six constituents (bismuth, cadmium, nitrate, nitrate/nitrite, sulfate,  
14 and benzene) were identified as posing a threat to groundwater. These five constituents  
15 are regarded as having sufficient mobility in the vadose zone (i.e.,  $K_d$  less than 40 L/kg)  
16 to reach and affect the groundwater (see Table 2-10). Additional evaluations will be  
17 conducted to clarify the nature of the threat that these constituents pose to groundwater.
- 18 • Four constituents (boron, selenium, vanadium, and radioactive strontium) were identified  
19 as potentially posing a threat to ecological receptors. An additional evaluation will be  
20 conducted to clarify the extent that these constituents pose a significant risk to ecological  
21 receptors.

#### 22 **2.13.3 Synthesis of the Nature and Extent of** 23 **Contamination**

24 The initial step in the extended evaluation is to revisit the COPCs and assess the nature and  
25 extent of their occurrence in the affected environment. The assessment will review the spatial  
26 distribution of the COPCs and evaluate alternative statistical measures for summarizing site  
27 conditions. One of the principal statistical measures that will be used is the 95%UCL  
28 concentration. Figure 2-24 provides a summary of key features of the 216-B-63 Trench site  
29 including the locations of the test pits and borings from which samples were obtained. A  
30 summary of the analytical results of eight COPCs from each location also is provided.

#### 2.13.4 Spatial and Data Aggregation Considerations

An inspection of Figure 2-23 reveals that the occurrence of COPCs identified in Table 2-22 is typically limited to discrete locations. Review of the data table in Figure 2-23 shows little if any variation among all concentrations of cadmium, selenium, and vanadium. There is evidence of elevations in the concentrations of nitrate (as N) and nitrate/nitrite (as N), as well as radioactive strontium (reported as Sr-90). Additional interpretation using the rationale developed in the previous assessment from Figure 2-23 and summarized in Table 2-23 includes the following.

- Boron concentrations measured in the soils do not appear to be elevated, based on comparison to relevant literature information. Consistent with the analysis of the 216-A-29 Ditch site, boron will be omitted from further analysis.
- Cadmium concentrations are not elevated above background at the site. The reason that cadmium was identified as a COPC in the RI BRA is the single report of 2.42 mg/kg in a split sample obtained from the 5.3 to 5.8 m (17.5 to 19.0 ft) depth at B8827. The companion sample result was 0.108 mg/kg. Perusal down the column of all cadmium results demonstrates that adjudicating the split-sample result is uncharacteristic. As indicated, all other cadmium results are either non-detections or, when detected, indistinguishable from the Hanford Site background. On this basis, cadmium will be omitted from further analysis.
- Selenium concentrations are not elevated at the site. All measurements are below the Hanford Site background-screening benchmark. As mentioned in the Table 2-23 remarks, the Hanford Site background selenium-screening value was not available when the RI BRA was performed. Had it been, selenium would not have been reported as a COPC because the maximum value of 0.75 mg/kg is less than the 0.78 mg/kg screening value. On this basis, selenium will be omitted from further analysis.
- Vanadium concentrations are not elevated at the site. Once again, viewing down the column of results indicates striking consistency in the reported vanadium concentrations. As indicated in the Table 2-23 remarks, vanadium was apparently relegated as a COPC because the maximum concentration (86.6 mg/kg) exceeded the Hanford Site background (85.1 mg/kg). Notably, the governing result (86.6 mg/kg) was the only measurement that exceeded the background benchmark. Additionally, the result from the companion split sample was 78 mg/kg and below the background benchmark concentration. When the split results are averaged and folded into the remaining 0 to 4.6 m (0 to 15 ft) vanadium data, a mean of 58.2 mg/kg and 95%UCL of 65.7 mg/kg are computed. The more robust 95%UCL of 65.7 mg/kg is well below the Hanford Site background (85.1 mg/kg). On this basis, vanadium will be omitted from further analysis.
- Nitrate concentrations (as N) appear to be elevated at select locations, most notably at BT-2-1 (1.5 to 1.8 m [5 to 6 ft]), as well as at BT-1 (2.1 to 2.4 m [7 to 8 ft] and 2.9 m to 3.2 m [9.5 to 10.5 ft]). As indicated, however, the mean and 95%UCL concentrations are 30.1 and 76.4 mg/kg, respectively. While the 95%UCL concentration is above the Hanford Site background, the mean (30.1 mg/kg) is not, and both are substantially lower

1 than the maximum. Scanning down the results column indicates that the bulk of the soils  
2 are not as adversely affected as are the soils located at BT-2-1 (1.5 to 1.8 m [5 to 6 ft]).

- 3 • Nitrate and nitrite concentrations (as N) also appear to be elevated at BT-2 (1.5 to 1.8 m  
4 [5 to 6 ft]) and at BT-1 (2.1 to 2.4 m [7 to 8 ft] and 2.9 to 3.2 m [9.5 to 10.5 ft]). Again,  
5 perusal down the results column and noting the profile indicates that the bulk of the soils  
6 are not as adversely affected as the maximum reported concentration might imply.
- 7 • Benzene was detected at a concentration exceeding the groundwater screening value in  
8 one sample at the site at 8  $\mu\text{g}/\text{kg}$ . The detection rate for benzene (1 in 26 samples) is  
9 3.8 percent detection rate and is below the EPA's 5 percent guideline for exclusion based  
10 on low detection frequency (EPA/540/1-89/002). This single spurious report of benzene  
11 at a concentration only slightly above detection limits (8  $\mu\text{g}/\text{kg}$ ) is uncertain and, given  
12 the waste history, doubtful as a genuine detection. On this basis, benzene will be omitted  
13 from further evaluation.
- 14 • Radioactive strontium (as Sr-90) concentrations appear to be elevated at select locations,  
15 most notably at BT-2 (1.5 to 1.8 m [5 to 6 ft] and 2.3 to 2.6 m [7.5 to 8.5 ft]), as well as at  
16 BT-2A (1.8 to 2.1 m [6 to 7 ft]). The maximum concentrations at these locations just  
17 exceed the 22.4 pCi/g screening value. While these concentrations exceed the Hanford  
18 Site background, inspection of the whole of the data by viewing down the column  
19 indicates that Sr-90 is not elevated at BT-1 and generally, not elevated in the deeper soils  
20 overall (e.g., deeper than about 6.1 m [20 ft]). The mean and 95%UCL concentrations  
21 (5.6 pCi/g and 17.4 pCi/g, respectively), while still above the Hanford Site background,  
22 are below the 22.4 pCi/g screening value. On this basis, total radioactive strontium (as  
23 Sr-90) will be omitted as a COPC, and an RAO will not be necessary.

#### 24 **2.13.4.1 Summary of the Nature and Extent of Contamination and Implications for the** 25 **Feasibility Study**

26 This review indicates that the use of maximum concentrations for screening has effectively  
27 identified a subset of constituents as COPCs. However, as indicated above, the nature and extent  
28 of contamination is characterized as localized, not uniformly distributed. The main conclusions  
29 from the evaluation and synthesis of the nature and occurrence of contamination information  
30 presented in Figure 2-24 and Table 2-23 are as follows.

- 31 • Contamination is not widely dispersed over the site at elevated concentrations. There are  
32 specific locations where elevated concentrations are consistently reported. These  
33 locations include pits in the 1.5 to 3 m (5 to 10 ft) intervals at BT-1 and BT-2. There is  
34 evidence of contamination at B8827 at the 3 to 3.7 m (10 to 12 ft) depth.
- 35 • The only COPCs that are apparently the result of waste-related activity are nitrate (as N),  
36 nitrate/nitrite (as N), and radioactive strontium.

37 Based on these findings, additional evaluation will be necessary to clarify (1) the degree to which  
38 nitrate (as N), nitrate/nitrite (as N), and benzene pose a threat to groundwater, and (2) the  
39 ecological risks posed by radioactive strontium (as Sr-90).

### 2.13.5 Groundwater Impacts from Vadose Zone Contamination

Additional evaluation is necessary to clarify the degree to which nitrate (as N), nitrate/nitrite (as N), and benzene pose threats to groundwater. This evaluation will use site- and chemical-specific information as inputs into SESOIL (GSC 1998) to investigate whether residual soil contamination can affect the deeper-saturated groundwater. A conceptualization of the SESOIL model for the 216-A-29 Ditch is presented in Figure 2-17. The only modification for the 216-B-63 Trench site will be to adjust the source volume because the 216-B-63 Trench is not as large (approximately 426.8 m [1,400 ft] long, 1.2 m [4 ft] wide at the bottom, and 3 m [10 ft] deep). The depth of the unsaturated zone is unchanged, 82.3 m (~270 ft). Chemical-specific input parameters are found in Table 2-24.

Figure 2-25 illustrates the predicted impacts that nitrate and nitrate/nitrite concentrations in the vadose zone soils (0 to 4.6 m [0 to 15 ft]), at their 95%UCL concentration (66.9 mg/kg and 76.4 mg/kg, respectively) may have over a 1,000-year period. SESOIL predicts that these constituents could reach the groundwater around model year 785 (~2791). The estimated groundwater concentrations of nitrate and nitrate/nitrite are approximately 9 and 10 mg/L, respectively. As indicated by the inset table at the bottom of the figure, the maximum predicted groundwater nitrate concentration is just below the state groundwater standards, which is 10 mg/L. The maximum predicted nitrate/nitrite concentration is just equal to the Federal drinking water standard, which is also 10 mg/L. Readers will note that these results are similar to those presented for the 216-A-29 Ditch site (Figure 2-22). This because the source sizes and 95%UCL concentrations are very similar and the main factors affecting transport and fate, atmospheric data, soil composition, thickness of the vadose zone, and the distribution coefficients (i.e.,  $K_{ds}$ ) are the same.

Based on this assessment, and considering the inherent uncertainty in predictions 800 years in the future, it is evident that nitrate and nitrate/nitrite vadose soil concentrations do not pose a substantial threat to groundwater.

### 2.13.6 Revised Assessments Using Robust 95% UCL Exposure-Point Concentrations

The RI BRA screening based on maximum concentrations will be refined by comparing 95%UCL concentrations to screening values in the following section. Table 2-25 summarizes the results. Inspection of the table reveals that the 95%UCL concentrations for nitrate (as N) and nitrate/nitrite (as N) are notably higher than their controlling screening value. However, the Sr-90 95%UCL (17.4 pCi/g) is actually less than the controlling ecological-screening value (22.5 pCi/g). Figure 2-26 displays the array of Sr-90 concentrations in the top 4.6 m (15-ft) interval at the 216-B-63 Trench. The figure clearly illustrates the influence that two outlier samples have on the summary statistics as well as on the compliance analysis. The ecological benchmark, in this case the BCG of 22.5 pCi/g, and its relationship to the whole of the data, is illustrated in the scatter plot (upper panel). The two outliers are seen as being approximately two standard deviations above the mean (bottom panel). The two samples located at BT-2 (2.1 to

1 2.4 m [7 to 8 ft]) and BT-2A (1.8 to 2.1 m [6 to 7 ft]) are identified as statistical outliers and as  
2 clearly distinct from the rest of the data set.

3 The significance of this illustration relates to exposure potential and the risk-ensuing risk  
4 management decision. The EPA recognizes the mean concentration as the best statistical  
5 estimate of EPC (EPA/540/1-89/002). However, in light of circumstances such as those  
6 illustrated in Figure 2-26, and in order to guarantee an error on the side of safety, the 95%UCL<sup>23</sup>  
7 of the mean is recommended as the EPC (EPA/540/1-89/002). The effect of this  
8 recommendation is illustrated in Figure 2-26 and summarized by the interpretation that, while a  
9 receptor may be exposed to the maximum and other high-end concentrations, exposure to other  
10 concentrations in the data set will occur as well. Based on the distribution shown in Figure 2-26,  
11 the majority of exposure will be to concentrations in the lower end of the distribution (e.g., under  
12 5 pCi/g). However, by including the maximum and higher-end concentration in the calculation  
13 of the mean and 95%UCL, exposure to those concentrations, appropriately weighted, the  
14 higher-end values are accounted for and expressed as well. It is for this reason that the 95%UCL  
15 should be considered the EPC for basing remediation decisions. In this case, because the  
16 95%UCL is notably below the 22.5 pCi/g controlling screening value, remediation should not be  
17 considered necessary to control risks to within acceptable levels.

### 18 **2.13.7 Intruder Exposure Analysis**

19 An unrestricted use scenario was evaluated in the RI BRA, although it will not be used in the  
20 remediation decision process. The basis and rationale for the intruder analysis, along with the  
21 technical approach and details, were discussed previously in Section 2.12.6.

#### 22 **2.13.7.1 Intruder Scenario Contaminants of Potential Concern**

23 Step one of this assessment is summarized in Table 2-26. As indicated in the table, by  
24 comparing 95%UCL concentrations, none of the nonradiological constituents qualify as  
25 candidates for the intruder analysis. The total radioactive strontium 95%UCL exceeds the  
26 Hanford Site background and there is no unrestricted use screening concentration.  
27 Consequently, total radioactive strontium (as Sr-90) will be assessed in the intruder scenario  
28 using RESRAD.

#### 29 **2.13.7.2 Intruder Scenario Results**

30 The results of the intruder scenario risk assessment for total radioactive strontium (as Sr-90) are  
31 provided in Table 2-27. As indicated, the dose estimate is  $4 \text{ E-}9$  mrem/y and the ELCR is  $4\text{E-}15$ .  
32 Both of these results are far below their respective criterion of 15 mrem/yr and  $1\text{E-}4$  ELCR.  
33 Additionally, though not quantified, it is reasonably assumed that doses and risks associated with  
34 installation of the boring (several days of exposure) would be less than those shown in  
35 Table 2-27.

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<sup>23</sup>There is 95 percent confidence that the mean or average EPC is less than the  $\text{UCL}_{95\%}$ . In this case, there is 95 percent confidence that the true average Sr-90 EPC will be less than 17.4 pCi/g.

1 **2.13.8 Overall Summary Baseline Risk Assessment**  
2 **Extended Analysis**

3 The overall results of the extended analysis are summarized in Table 2-28, which is organized to  
4 present a before and after the extended analysis portrait. The layout of the table was discussed  
5 previously in the corresponding summary of the 216-A-29 Ditch site. The findings include the  
6 following.

- 7 1. Nine constituents were identified by the RI BRA as COPCs for the FS to consider, based  
8 on maximum concentrations exceeding one or more of the three main screening  
9 parameters. These exceedances are identified by check marks in the three columns  
10 entitled "Initial Screening Concentration Exceedance."
- 11 2. A review of the RI BRA findings disclosed that bismuth should not be evaluated in the  
12 FS; it was found to pose no substantial risk to human health or the environment.
- 13 3. The evaluation revealed that boron, cadmium, benzene, selenium, and vanadium  
14 concentrations could not be justified as exceeding background or were included as  
15 COPCs based on detections.
- 16 4. Four constituents (cadmium, nitrate [as N], nitrate/nitrite [as N], and benzene) were  
17 identified as having maximum concentrations exceeding groundwater protection  
18 screening concentrations and  $K_{ds}$  less than the vadose zone immobility benchmark of  
19 40 kg/L. However, as indicated previously, it was found that cadmium concentrations are  
20 not elevated, nor is there evidence of cadmium-related waste impacts; thus, its potential  
21 impact on groundwater was not evaluated. Additionally, benzene was omitted from the  
22 assessment because the single detection was determined to be spurious and not  
23 representative of the site.  
  
24 The migration potential of nitrate (as N) and nitrate/nitrite (as N) was simulated with  
25 SESOIL using site-specific information. Nitrate (as N) and nitrate/nitrite (as N) were  
26 found to have the potential to migrate to groundwater. However, their impacts do not  
27 result in exceeding pertinent groundwater quality criteria.
- 28 5. Three compounds (selenium, vanadium, and radioactive strontium) were originally  
29 identified as posing a risk to ecological receptors because their maximum concentrations  
30 exceeded industrial ecologic-screening concentrations. As discussed above, it was  
31 concluded that selenium and vanadium concentrations are not elevated. The extended  
32 analysis found that the radioactive strontium 95%UCL concentration does not exceed the  
33 ecological-screening concentration.

1 6. Based on the summary above and the detailed analysis in the forgoing sections, the  
2 following are the key risk-based findings:

- 3 • The site is not highly contaminated, contamination is not wide spread, concentrations  
4 are not particularly elevated, and concentrations that are elevated are found in  
5 localized hot spots. Significant portions of the site are not affected, or exhibit  
6 constituent concentrations comparable to background.
- 7 • Localized areas of elevated constituents are actually located at depths of about 1.5 to  
8 3 m (5 to 10 ft) bgs. Consequently, the threat that they may pose to humans and  
9 ecological receptors is actually very minimal and is not accurately expressed by the  
10 comparisons to screening levels, as suggested by the RI BRA.
- 11 • There are no unacceptable direct-exposure risks to industrial workers.
- 12 • There are no unacceptable risks to future intruder receptors that may inadvertently  
13 reside near the site and establish a garden for the production of fruits and vegetables.
- 14 • There are no unacceptable impacts to groundwater.
- 15 • There are no unacceptable impacts to ecological receptors.

## 16 **2.14 BASELINE RISK ASSESSMENT EXTENDED** 17 **ANALYSIS OF THE 216-S-10 DITCH SITE**

18 This section provides the extended BRA analysis for the 216-S-10 Ditch representative site. The  
19 analysis will parallel the evaluation of the 216-B-63 Trench; however, it will be much more  
20 concise and will rely heavily on the discussions of methods and conceptualizations from the  
21 previous sections.

### 22 **2.14.1 Summary**

23 The extended analysis has found the following.

- 24 • The site is not highly contaminated. Elevated levels of contamination were found  
25 primarily at one localized hot spot, SD-2.
- 26 • There are no unacceptable direct-exposure risks to industrial workers.
- 27 • There are no unacceptable risks to groundwater.
- 28 • There are no unacceptable risks to future intruder receptors.
- 29 • Three constituents (total chromium, silver, and Aroclor 1254) may pose some threat to  
30 ecological receptors. However, the threat is localized to the discrete location at SD-2.

### 1 2.14.2 Extended Analysis of the 216-S-10 Ditch

2 This section provides the extended BRA analysis for the 216-S-10 Ditch representative site. The  
3 analysis will parallel the evaluations of the 216-A-29 Ditch and 216-B-63 Trench; however, it  
4 will be concise and will rely on the discussions of methods from previous sections.

5 Table 2-8 provided a summary of COPCs for the four 200-CS-1 representative sites including the  
6 216-S-10 Ditch. Table 2-29 is a further condensation of Table 2-8 to reflect only those COPCs  
7 found in the 216-S-10 Ditch site.

8 The principal findings effecting the evaluation of remedial actions at the 216-S-10 Ditch for the  
9 industrial land use scenarios are as follows.

- 10     • Bismuth was identified as posing a potential threat to industrial receptors through direct  
11     contact. Consistent with previous sections, bismuth will be omitted from further  
12     consideration.
  - 13     • Ten constituents (arsenic, bismuth, mercury, silver, benzo(a)anthracene, benzo(a)pyrene,  
14     benzo(a)fluoranthene, benzo(k)fluoranthene, chrysene, and Aroclor 1254) were identified  
15     in the RI BRA as posing a threat to groundwater.
- 16 Additional evaluations will be conducted to clarify the nature of the threat that these constituents  
17 pose to groundwater.
- 18     • Nine constituents (boron, chromium [total], copper, selenium, silver, thallium, vanadium,  
19     zinc, and Aroclor 1254) were identified as potentially posing a threat to ecological  
20     receptors. Additional evaluation will be conducted to clarify the extent that these and  
21     other constituents pose a significant risk to ecological receptors.

### 22 2.14.3 Synthesis of the Nature and Extent of 23 Contamination

24 Figure 2-27 provides a summary of key features of the 216-S-10 Ditch site including the  
25 locations of the three test pits (SD-1, -2, and -3) and the single boring (B8828) from which  
26 samples were obtained. A summary of the analytical results of the 17 RI BRA COPCs from each  
27 location also is provided in the Spatial and Data Aggregation Considerations discussions.

28 A review of Figure 2-27 reveals that, in general, the occurrence of COPCs is limited to discrete  
29 locations. Most notably, looking across the rows suggests that the SD-2 location, which contains  
30 samples from near the ground surface (0 to 0.6 m [0 to 1.5 ft] bgs and 0.5 to 0.9 m [1.5 to 3.0 ft]  
31 bgs), may express the remnants of waste-related activities. Looking down the columns of each  
32 constituent reveals that with one exception,<sup>24</sup> there is an apparent discontinuity in some results  
33 obtained from the split sample collected at B8826 (7.6 to 8.2 m [25 to 27 ft] depth) where

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<sup>24</sup> There is apparent discontinuity in some results obtained from the split sample collected at B8826 (7.6 to 8.2 m [25 to 27 ft] depth) where significant disparity is evident with arsenic, mercury, selenium, and vanadium results.

1 significant disparity is apparent with arsenic, mercury, selenium, and vanadium results.  
2 Additional interpretation of Figure 2-27 using the rationale developed in Section 2.11.1, and  
3 summarized in Table 2-30, includes the following:

- 4 • Arsenic concentrations measured at the site do not appear to be related to waste activities.  
5 Arsenic concentrations detected at the site are less than the Hanford Site background  
6 screening concentration; therefore, arsenic will be omitted from further analysis.
- 7 • Boron concentrations measured in the soils do not appear to be elevated, based on  
8 comparison to relevant literature information. On this basis, and consistent with previous  
9 analyses, boron will be omitted from further analysis.
- 10 • Chromium (total) concentrations are elevated locally at SD-2 (0 to 0.5 m [0 to 1.5 ft] and  
11 0.5 to 0.9 m [1.5 to 3 ft] bgs intervals); slightly elevated chromium may exist at SD-1  
12 (1.8 to 2.1 m [6 to 7 ft] bgs). Looking down the column of chromium concentrations  
13 indicates that most other concentrations measured at the site are not distinguishable from  
14 background. Notably, at intervals 41.2 to 41.8 m (135 to 137 ft) bgs, 45.7 to 46.3 m  
15 (150 to 152 ft) bgs, and 67.1 to 67.7 m (220 to 222 ft) bgs, chromium concentrations  
16 exceeding the Hanford Site background screening benchmark concentration were  
17 detected.
- 18 • Copper concentrations are elevated locally at SD-2 (0 to 0.5 m [0 to 1.5 ft] and 0.5 to  
19 0.9 m [1.5 to 3 ft] bgs intervals). However, in looking down the column of copper  
20 concentrations, it is apparent that most other concentrations measured at the site are not  
21 distinguishable from background. As indicated in Table 2-30, the mean and 95%UCL  
22 concentrations are notably below the controlling ecological-screening concentration.
- 23 • Mercury concentrations are elevated locally at SD-2 (0 to 0.5 m [0 to 1.5 ft] and 0.5 to  
24 0.9 m [1.5 to 3 ft] bgs intervals). Once again, in looking down the column of mercury  
25 concentrations, it is apparent that most other concentrations measured at the site are  
26 comparable to background; many are reported as non-detections. As indicated in  
27 Table 2-30, the mean mercury concentration (0.5 mg/kg) is well below the controlling  
28 ecological-screening concentration (2.09 mg/kg); the 95%UCL (2.2 mg/kg) is  
29 approximately equal to the ecological-screening value.
- 30 • Selenium concentrations measured at the site do not appear to be related to waste  
31 activities. All concentrations are below background (a background screening value was  
32 not available for the RI BRA); therefore, selenium will be omitted from further analysis.
- 33 • Silver concentrations are elevated locally at SD-2 (0 to 0.5 m [0 to 1.5 ft] and 0.5 to  
34 0.9 m [1.5 to 3 ft] bgs intervals). However, with the exception of SD-2, all other  
35 concentrations measured at the site are not distinguishable from background or are  
36 non-detection reports. As indicated in the mean and 95%UCL concentrations exceed the  
37 controlling ecological-screening concentration. The median concentration, which is less  
38 sensitive to outlier measurements, is 0.1 mg/kg and is well below controlling 2.0 mg/kg  
39 ecological-screening concentration.

- 1       • Thallium analysis, obtained from three samples, ranged from 0.59 to 0.99 mg/kg and was  
2 detected in the associated blanks. These concentrations do not appear to be related to  
3 waste activities. All concentrations are less than the controlling ecological-screening  
4 concentration (1.0 mg/kg). As indicated in the Table 2-28 remarks, thallium is found in  
5 sandstones and shales at concentrations up to 1.0 mg/kg and 2.0 mg/kg, respectively  
6 (Pendias and Kabata-Pendias 1992, "Trace Elements in Soils and Plants"). On this basis,  
7 thallium will be omitted from further analysis.
- 8       • Vanadium concentrations measured at the site do not appear to be related to waste  
9 activities. This is evidenced by the general uniform distribution (looking down the  
10 column), the absence of elevated concentrations at SD-2, and the fact that the 95%UCL  
11 concentration (80.5 mg/kg) is less than the Hanford Site background screening  
12 concentration (85.1 mg/kg). The maximum vanadium concentration (87.5 mg/kg) is  
13 essentially equivalent to the Hanford Site background screening concentration  
14 (85.1 mg/kg). On this basis, vanadium will be omitted from further analysis.
- 15       • Zinc concentrations are elevated locally at SD-2 (0 to 0.5 m [0 to 1.5 ft] and 0.5 to 0.9 m  
16 [1.5 to 3 ft] bgs intervals). In looking down the column of zinc concentrations, it is  
17 apparent that, with the exception of SD-2, all other concentrations measured at the site  
18 are uniformly distributed and with a minor exception at B8828 (61 to 67.7 m [200 to  
19 222 ft]), actually less than background (67.8 mg/kg). As indicated in Table 2-30, the  
20 mean and 95%UCL concentrations are both below the controlling ecological-screening  
21 concentration. The median concentration, which is less sensitive to outlier  
22 measurements, is 53.1 mg/kg and well below the Hanford Site background concentration  
23 (67.8 mg/kg).
- 24       • Aroclor 1254 was detected in two samples at the site: at SD-2 (0 to 0.5 m [0 to 1.5 ft]  
25 and 0.5 to 0.9 m [1.5 to 3 ft] bgs intervals). The detections were 3,700 and 1,100 µg/kg.  
26 Looking down the Aroclor 1254 column on Figure 2-27 reveals that detection limits  
27 typically were in the range of 34 to 38 µg/kg. Because both detections were from the  
28 SD-2 location, no attempt was made to compute summary statistics.
- 29       • Four polycyclic aromatic hydrocarbon compounds were detected at concentrations  
30 ranging from 530 µg/k (benzo(b)fluoranthene) to 680 µg/k (chrysene). All were found in  
31 the(0 to 0.5 m [0 to 1.5 ft] interval of SD-2. Again, because both detections were from  
32 the SD-2 location, no attempt was made to compute summary statistics. As indicated in  
33 Figure 2-27, the sole analytical report that triggered inclusion of benzo(a)anthracene,  
34 benzo(a)pyrene, benzo(b)fluoranthene, and chrysene as COPCs was flagged as an  
35 estimated "J" value. This suggests that there may have been some difficulty with the  
36 analysis.

37 **2.14.4 Summary of the Nature and Extent of**  
38 **Contamination and Implications for the**  
39 **Feasibility Study**

40 The nature and extent of contamination are localized, not uniform, as indicated by consistent  
41 findings of elevated constituents at SD-2. Interpretation of Figure 2-27 indicates that, while

1 there are specific locations where elevated constituent concentrations are found (particularly in  
2 the upper interval at SD-2), there also are a comparable number of locations where there are no  
3 detections and/or concentrations are comparable to background levels. These conclusions are  
4 based primarily on the following findings.

- 5 • Waste-related contamination is not widely dispersed over the site at elevated  
6 concentrations. Rather, there are specific locations, notably SD-2 and possibly the 1.8 to  
7 2.1 m (6 to 7 ft) bgs strata at SD-2, where elevated concentrations are consistently  
8 reported.
- 9 • Five constituents (arsenic, boron, selenium, thallium, and vanadium) identified as COPCs  
10 have been categorized incorrectly because they are not widely dispersed at elevated  
11 concentrations and their aggregate concentrations (e.g., mean and 95%UCL) do not  
12 exceed background.
- 13 • Other constituents identified as COPCs (specifically, Aroclor 1254, benzo(a)anthracene,  
14 benzo(a)pyrene, benzo(b)fluoranthene, and chrysene) were identified because their  
15 maximum concentrations exceeded groundwater screening values. These values are not  
16 widely dispersed at elevated concentrations, and the maximum reported concentration is  
17 not reflective of overall site conditions. The maximum concentrations of these  
18 constituents were reported in the 0 to 0.3 m (0 to 1 ft) interval of SD-2.

19 Further evaluation will be necessary to clarify the degree to which the constituents identified  
20 above actually pose unacceptable risk to humans, ecological receptors, and groundwater.

#### 21 **2.14.5 Groundwater Impacts from Vadose Zone** 22 **Contamination**

23 The RI BRA found that ten constituents (see Table 2-29) posed a significant threat to  
24 groundwater because their maximum measured concentrations exceeded their groundwater  
25 impact screening concentrations. Table 2-9 reveals that the groundwater protection screening  
26 values for many constituents are very low and, in some instances, impracticable.

27 This section will address groundwater impacts by:

- 28 1. Identifying COPCs with potential to impact groundwater using WAC 173-340-747,  
29 Equation 747-1
- 30 2. Refining according to the spatial and data aggregation analysis, as appropriate
- 31 3. Assessing migration potential qualitatively using the  $K_d \leq 40$  kg/L benchmark
- 32 4. Reevaluating the potential impacts to groundwater with SESOIL, as necessary.

1 The first three steps of the process, summarized in Table 2-31, indicate the following.

- 2     • Silver qualifies for extended analysis of its potential to adversely affect groundwater.  
3       The 95%UCL concentration exceeds the  $K_d$ , which is less than 40 kg/L.
- 4     • Mercury, Aroclor 1254, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene,  
5       benzo(k)fluoranthene, and chrysene do not qualify for extended analysis because they  
6       have  $K_d$ s greater than 40 kg/L. They are omitted as COPCs on this basis.

7 The fourth step of the extended evaluation is assessing the potential impacts that silver could  
8 have on groundwater under baseline conditions (the present conditions remain unchanged) using  
9 SESOIL (GCS 1998). Chemical-specific input parameters for silver are found in Table 2-32.<sup>25</sup>

10 The results provided in Figure 2-28 illustrate the predicted impacts that silver concentrations in  
11 the vadose zone soils (0 to 4.6 m [0 to 15 ft]), at their 95%UCL concentration of 21.1 mg/kg, will  
12 have over a 1,000-year period. SESOIL predicts that silver will not reach the groundwater. The  
13 maximum penetration into the vadose zone is 18.9 m (62 ft), which is well above the 68 m  
14 (223 ft) depth of the saturated zone. The actual migration distance from the bottom of the waste  
15 layer into the vadose zone is only 14.3 m (47 ft) (4.6 – 18.9 m [15 ft – 62 ft]). The vadose soil  
16 moisture concentration at the depth of maximum penetrations (18.9 m [62 ft]) is estimated to be  
17 about 0.7 mg/L.

18 Based on this assessment, none of the constituents identified in Table 2-31 pose a threat to  
19 adversely affecting groundwater.

#### 20 2.14.6 Revised Assessments Using Robust 95%UCL 21 Exposure-Point Concentrations

22 In this section, the screening will be refined by comparing 95%UCL concentrations to screening  
23 values.

24 The results are shown in Table 2-33 and summarized below.

- 25     • Chromium (total), silver, and Aroclor 1254 are retained because their 95%UCL  
26       concentrations (maximum in the case of Aroclor 1254) exceed the industrial  
27       ecological-screening concentrations.
- 28     • Copper and zinc will be omitted from further consideration because their 95%UCL  
29       concentrations do not exceed the industrial ecological-screening concentration.

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<sup>25</sup> A conceptualization of the SESOIL model for the 216-A-29 Ditch is presented in Figure 2-17. The only significant change from Figure 2-17 is modification of the unsaturated zone thickness to from 76.2 m (250 ft) to 68 m (223 ft) to better reflect 216-S-10 Ditch conditions.

## 1 2.14.7 Intruder Exposure Scenario

2 Consistent with extended analyses for the previous sites, an unrestricted use scenario was  
3 evaluated in the RI BRA, although it will not be used in the remediation decision process. The  
4 intruder scenario was developed in detail in the analysis of the 216-A-29 Ditch site.

### 5 2.14.7.1 Intruder Scenario Contaminants of Potential Concern

6 Step one of this assessment is summarized in Table 2-34. As indicated, maximum  
7 concentrations of Aroclor 1254 and the polycyclic aromatic hydrocarbons exceed unrestricted  
8 use screening concentrations. Consequently, Aroclor 1254, benzo(a)anthracene, benzo(a)pyrene,  
9 benzo(b)fluoranthene, benzo(k)fluoranthene, and chrysene will be evaluated at their maximum  
10 concentrations.

### 11 2.14.7.2 Intruder Scenario Results

12 The results of the intruder scenario risk assessment are provided in Table 2-35. As indicated:

- 13 • The HQ is 0.2, which is well below the benchmark 1.0 HQ
- 14 • The ELCR is  $10^{-5}$  (1 in 100,000), which is well below the  $10^{-4}$  benchmark value,

15 Given the extreme conservatism embedded in these calculations, it is apparent that the site does  
16 not pose unacceptable risk to any hypothetical future intruder receptor.

## 17 2.14.8 Overall Summary Baseline Risk Assessment

### 18 Extended Analysis

19 The overall results of the BRA extended analysis are summarized in Table 2-36. The findings  
20 include the following.

- 21 1. A total of 17 constituents were identified by the RI BRA as COPCs for the FS to  
22 consider, based on maximum concentrations. These exceedances are identified by  
23 checkmarks in the three columns entitled "Initial Screening Concentration Exceedance."
- 24 2. The RI BRA findings disclosed that bismuth should not be evaluated in the FS; it was  
25 found to pose no substantial risk to human health or the environment.
- 26 3. A review of the spatial distribution, including the nature and extent of contamination,  
27 revealed that maximum detections were all from one location, SD-2. Additionally, many  
28 of the analytical reports were non-detections or detections that could be attributable to  
29 background concentrations.

30 Based on the synthesis of spatial distributions, and computation of robust 95%UCL  
31 concentrations, arsenic, boron, selenium, thallium, and vanadium have been omitted from  
32 the evaluation.

- 33 4. Seven constituents (mercury, Aroclor 1254, benzo(a)anthracene, benzo(a)pyrene,  
34 benzo(b)fluoranthene, benzo(k)fluoranthene, and chrysene) were identified as having

1 maximum concentrations exceeding groundwater protection screening concentrations.  
 2 However, these constituents all have  $K_{ds}$  greater than the vadose zone immobility  
 3 benchmark of 40 kg/L. As a result, they are omitted as COPCs because they do not have  
 4 the mobility potential to reach and adversely impact groundwater.

5 5. The migration potential of silver ( $K_d = 8.3$  kg/L) was simulated with SESOIL using  
 6 site-specific information and it was found that over a 1,000-year period, silver would not  
 7 penetrate the width of the vadose zone and contact groundwater. On this basis, silver was  
 8 omitted as a COPC with the potential to affect groundwater.

9 6. Eight compounds (boron, total chromium, copper, selenium, silver, vanadium, zinc, and  
 10 Aroclor 1254) originally were identified as posing a risk to ecological receptors because  
 11 their maximum concentrations exceeded industrial ecologic screening concentrations. As  
 12 discussed above, it was concluded that boron, selenium, and vanadium concentrations are  
 13 not elevated and there is no evidence to suggest that observed levels of these three  
 14 constituents are at elevated concentrations or related to waste activities. The extended  
 15 analysis found that the total chromium, silver, and Aroclor 1254 95%UCL concentrations  
 16 exceed the biota screening concentration. The exceedances come from elevated  
 17 concentrations at SD-2.

18 7. Based on the summary above and the detailed analysis in the foregoing sections, the  
 19 following are the key risk-based findings :

- 20 • The site is not highly contaminated. Elevated levels of contamination were found  
 21 primarily at one localized hot spot, SD-2. There are no unacceptable direct-exposure  
 22 risks to industrial workers.
- 23 • There are no unacceptable risks to groundwater.
- 24 • There are no unacceptable risks to future intruder receptors. Three constituents, total  
 25 chromium, silver, and Aroclor 1254, may pose some threat to ecological receptors.  
 26 However, the threat is localized to the discrete location at SD-2.

## 27 2.15 BASELINE RISK ASSESSMENT EXTENDED 28 ANALYSIS OF THE 216-S-10 POND SITE

29 This section provides the extended BRA analysis for the 216-S-10 Pond representative site.  
 30 Table 2-8 provides a summary of COPCs for the four 200-CS-1 OU representative sites,  
 31 including the 216-S-10 Pond. Table 2-36 is a condensation of Table 2-8 to reflect only those  
 32 COPCs found at the 216-S-10 Pond representative site.

### 33 2.15.1 Summary

34 Based on an analysis of the analytical data and the nature and extent of contamination, it is  
 35 concluded that there are no COPCs at the 216-S-10 Pond site and consequently, there are no  
 36 issues affecting the FS.

### 2.15.2 Extended Analysis of the 216-S-10 Pond

The principal findings effecting the evaluation of remedial actions at the 216-S-10 Pond for the industrial land-use scenarios are as follows (referring to Table 2-26).

- Bismuth was identified as posing a potential threat to industrial receptors through direct contact. Consistent with previous analyses, bismuth will be omitted from further evaluation as a COPC. Two constituents (methylene chloride and vinyl chloride) were identified as posing a threat to groundwater. Review of the analytical history indicates that methylene chloride was frequently detected in many samples collected from the 200-CS-1 representative sites and it has been identified as a laboratory contaminant. The single report of vinyl chloride was erroneously reported as a positive detection. On this basis, these constituents will be omitted from further evaluation as COPCs.
- Three constituents (boron, selenium, and silver) were identified as potentially posing a threat to ecological receptors. Additional evaluation will be conducted to clarify the extent that these constituents pose a significant risk to ecological receptors.

### 2.15.3 Synthesis of the Nature and Extent of Contamination

Figure 2-29 provides a summary of key features of the 216-S-10 Ditch site including the locations of the four test pits (SP-1, -2, -3, and -4) and the single boring (B8817) from which samples were obtained. A summary of the analytical results of the three COPCs from each location also is provided.

### 2.15.4 Spatial and Data Aggregation Considerations

An inspection of Figure 2-29 reveals that the occurrence of the three COPCs is sparse and, generally, there is no evidence of waste-related contamination at the 216-S-10 Pond site. Additional interpretation of Figure 2-29 using the rationale developed in previous sections and summarized in Table 2-37 includes the following.

- Boron concentrations measured in the soils do not appear to be elevated, based on comparison to relevant literature information. Boron has been consistently omitted from the analysis on this basis and will be omitted from further analysis.
- Selenium concentrations measured at the site do not appear to be related to waste activities. This is evidenced by extensive and generally uniform distribution (looking down the column) of non-detection reports. The maximum concentration (2.0 mg/kg) exceeds the Hanford Site background screening value, but not significantly given the range of these comparisons. Note that the six positive detections are all concentrations that are less than the typical background selenium concentrations reported from the literature. On this basis, selenium will be omitted from further analysis.

- 1 • Silver concentrations measured at the site do not appear to be related to waste activities.  
 2 This is evidenced by extensive and generally uniform distribution (looking down the  
 3 column) of non-detection reports. There are two detections of note:

- 4 – At the 2.1 to 2.4 m (7 to 8 ft) interval of SP-1, there is a detection of 1.3 mg/kg.  
 5 – At the 2.7 to 3 m (9 to 10 ft) interval of SP-2, there is a detection of 8 mg/kg.

6 These two detections, when compared to the other measurements illustrated in  
 7 Figure 2-29, are anomalous and not representative of the whole of the site. Additionally,  
 8 with the exception of the 8 mg/kg measurements at the 2.7 to 3 m (9 to 10 ft) interval of  
 9 SP-2, all measurements are less than the extended background range. Figure 2-30  
 10 provides a summary of the silver measurements from the 0 to 4.6 m (0 to 15 ft) interval.  
 11 The key observations include the following

- 12 – The sole distant outlier (8 mg/kg at the 2.7 to 3 m [9 to 10 ft] interval of SP-2) is  
 13 clearly anomalous in the right-hand portion of the scatter plot. The anomalous  
 14 maximum measurement is located at a depth of 2.7 to 3 m (9 to 10 ft). The overlying  
 15 concentration is 0.48 mg/kg; the underlying concentration is 0.22 mg/kg. At this  
 16 depth, and considering that the anomalous measurement is enveloped by soils  
 17 containing silver concentrations that are indistinguishable from the Hanford Site  
 18 background (0.73 mg/kg), it is highly unlikely that there would be any significant  
 19 ecological exposure to the 8.3 mg/kg concentration.
- 20 – Note that all other measurements and proxy values<sup>26</sup> are well below the upper end of  
 21 expected background concentration reported by Lindsay (1979, *Chemical Equilibria*  
 22 *in Soils*) (5 mg/kg).
- 23 – The summary statistics, notably the mean and median, are well below the  
 24 ecological-screening value of 2.0 mg/kg. The 95%UCL (2.8 mg/kg) is just above the  
 25 ecological-screening value.
- 26 – The percentile distribution of the data is informative because it shows that the  
 27 1.3 mg/kg (2.1 to 2.4 m [7 to 8 ft] interval of SP-1) is the 90<sup>th</sup> percentile value. This  
 28 means that 90 percent of the soils would be expected to be less than 1.3 mg/kg.  
 29 Based on this measure of distribution, it also is apparent that 95 percent of the soils  
 30 are probably less than 8.3 mg/kg. Though not shown, the 2.0 mg/kg  
 31 ecological-screening value would be approximately the 93<sup>rd</sup> percentile estimate, and  
 32 by inference, 95 percent of soils are likely to have silver concentrations that are less  
 33 than the 2.0 mg/kg ecological-screening value.
- 34 – Based on the rationale above, when reinforced by the overall lack of evidence of  
 35 waste-related contamination at the 216-S-10 Pond (see Figure 2-29), it is concluded  
 36 that the anomalous silver concentration reported at the 2.7 to 64 m (9 to 210 ft)

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<sup>26</sup> A value of ½ the detection limit is substituted for all non-detection reports (EPA/540/1-89/002).

1 interval at SP-2 does not pose a significant threat to any receptors. Consequently,  
2 silver will be omitted from further consideration.

### 3 **2.15.5 Summary of the Nature and Extent of** 4 **Contamination and Implications for the** 5 **Feasibility Study**

6 Overall, it is evident that the use of maximum concentrations for screening has effectively  
7 identified a subset of constituents as COPCs. However, as indicated above, there is no  
8 compelling evidence to suggest that the 216-S-10 Pond site was significantly impacted by  
9 waste-related activities. As a result, it is concluded that there are no COPCs at the  
10 216-S-10 Pond and further analysis is not necessary to support the FS.

## 11 **2.16 SUMMARY OF RISK-BASED ISSUES FOR** 12 **THE FEASIBILITY STUDY**

13 The previous sections have summarized the original RI BRA findings and, in turn, have extended  
14 and refined the analysis using conventional risk analysis techniques. The extended analysis was  
15 done in order to clarify the original RI BRA findings, which were generated using  
16 screening-level techniques. Based on the extended analysis, the risk-based issues are  
17 summarized in Table 2-38 and are detailed as follows.

- 18 • At the 216-A-29 Ditch

19 Nitrite/nitrate (as N) has the potential to migrate through the vadose zone and affect  
20 groundwater and result in concentrations exceeding Federal drinking water standards.  
21 This would occur in approximately 785 years. The groundwater is not currently used for  
22 consumption, nor is it anticipated that it will be used for consumption in the future.

23 Selenium and silver may pose some threat to ecological receptors, based on 95%UCL  
24 concentrations that exceed industrial ecological-screening concentrations. The elevated  
25 concentrations are restricted to localized hot spots.

26 Aroclor 1254 was reported at 9.4 mg/kg in a single sample from one of the hot spot  
27 locations. Based on the comparison of this concentration to the industrial  
28 ecological-screening concentration (650 mg/kg), there is a concern that wildlife exposed  
29 to soils at this location may be at risk for adverse effects.

- 30 • At the 216-B-63 Trench

31 There are no risk-based issues associated with the 216-B-63 Trench.

- 1       • At the 216-S-10 Ditch  
 2           Three constituents (total chromium, silver, and Aroclor 1254) may pose some threat to  
 3           ecological receptors due to slightly elevated soil concentrations. However, the threat is  
 4           localized to the discrete location at SD-2.
- 5       • At the 216-S-10 Pond  
 6           There are no risk-based issues associated with the 216-S-10 Pond.

## 7   2.17   REFERENCES

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- 10  36 CFR 60, "National Register of Historic Places," Section 60.4, "Criteria for Evaluation,"  
 11       Title 36, *Code of Federal Regulations*, Part 60, as amended.
- 12  40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," Title 40,  
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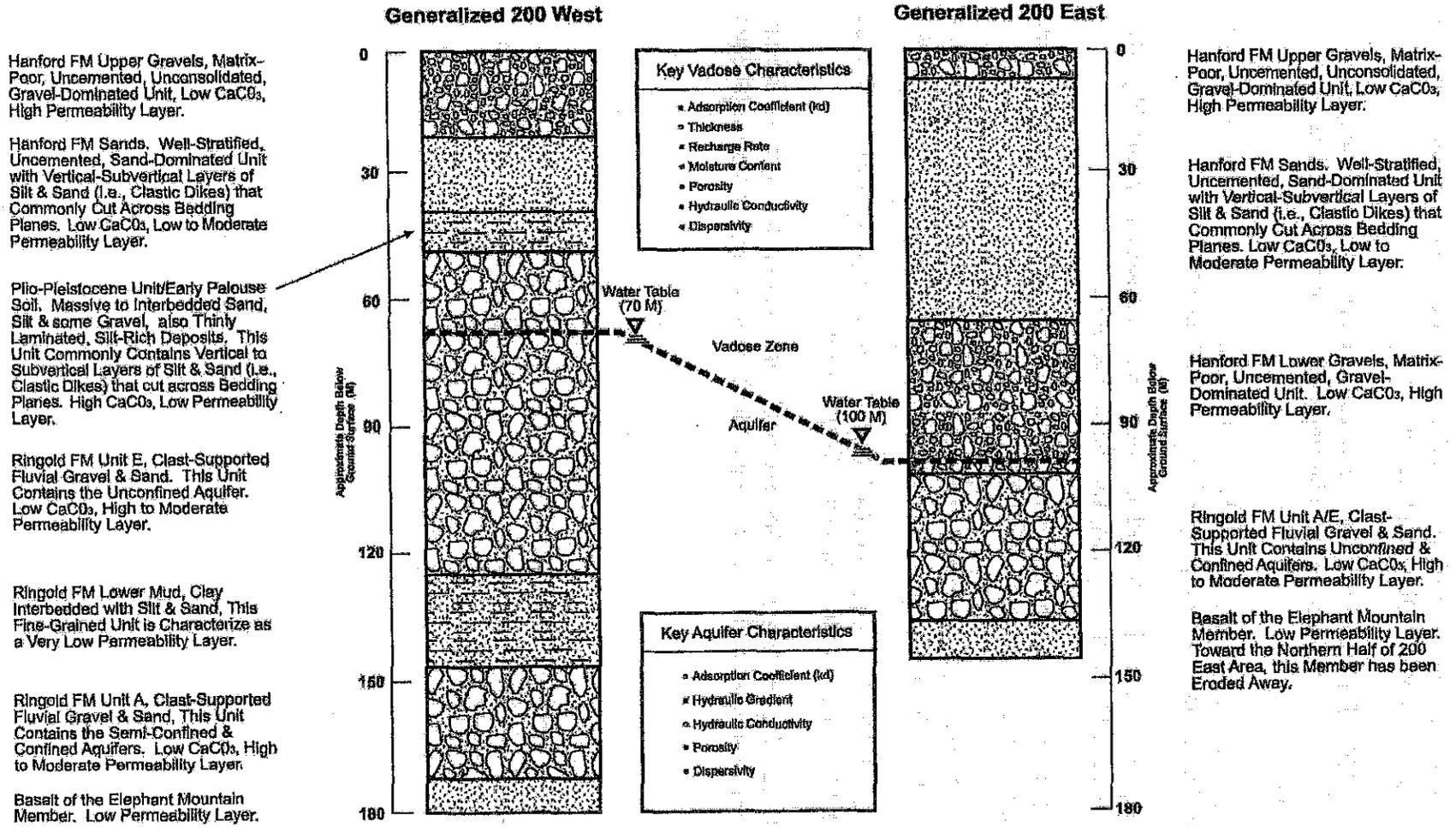
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Figure 2-1. Stratigraphic Column for the 200 Areas.

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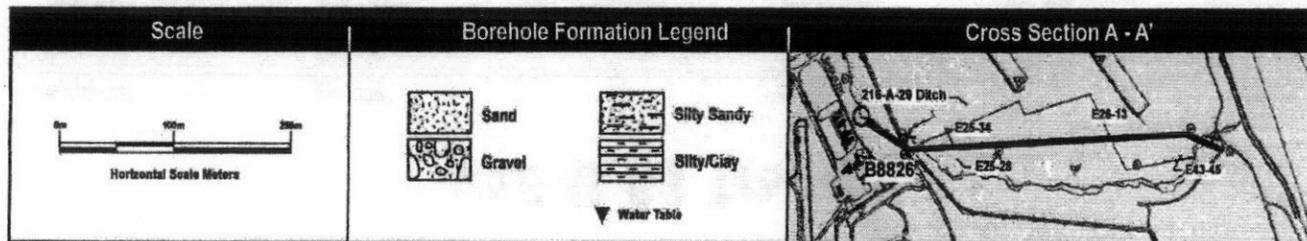
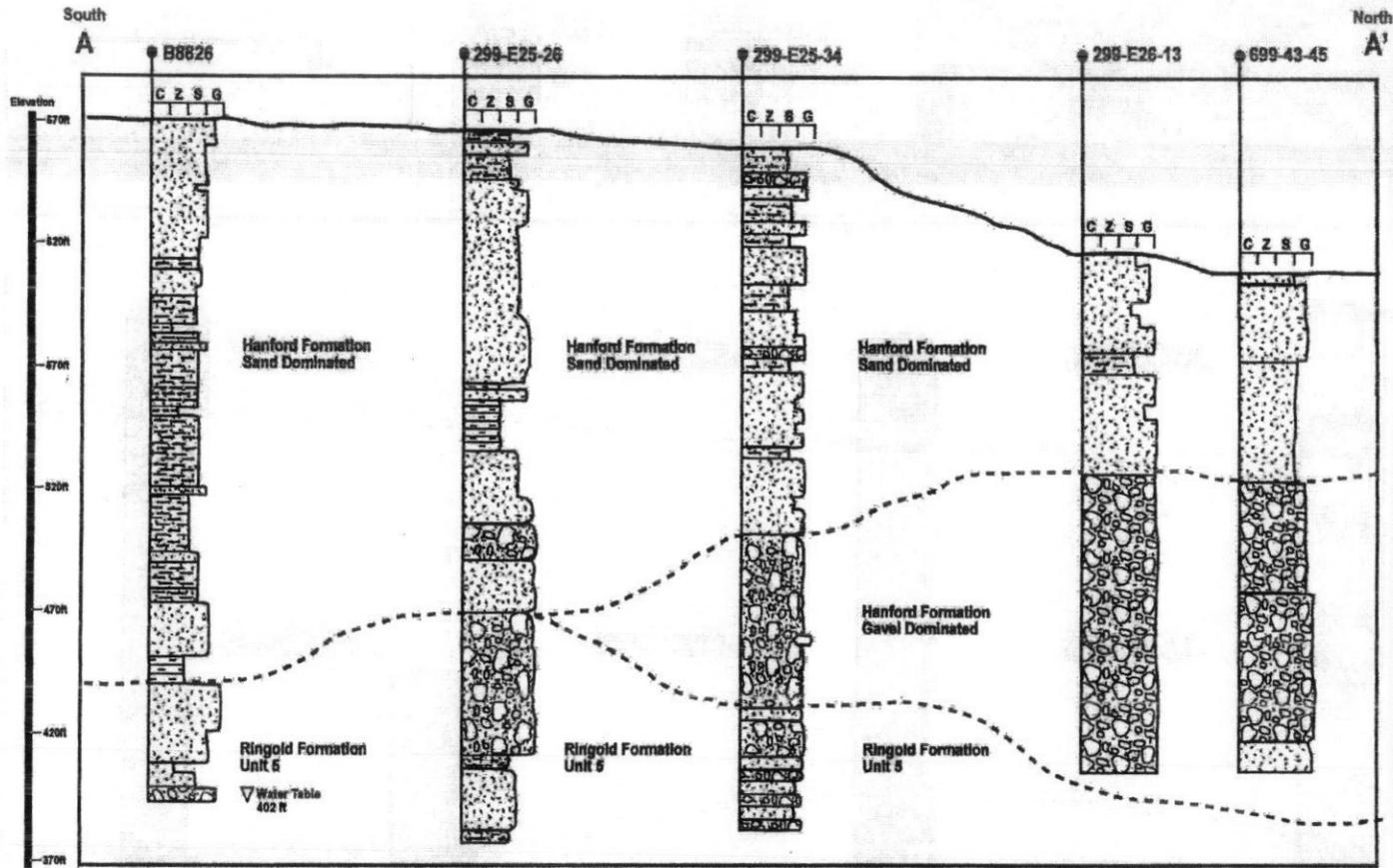


DOE/RL-2005-63 DRAFT A

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Figure 2-2. Geologic Cross Section Through the 216-A-29 Ditch.

# 216-A-29

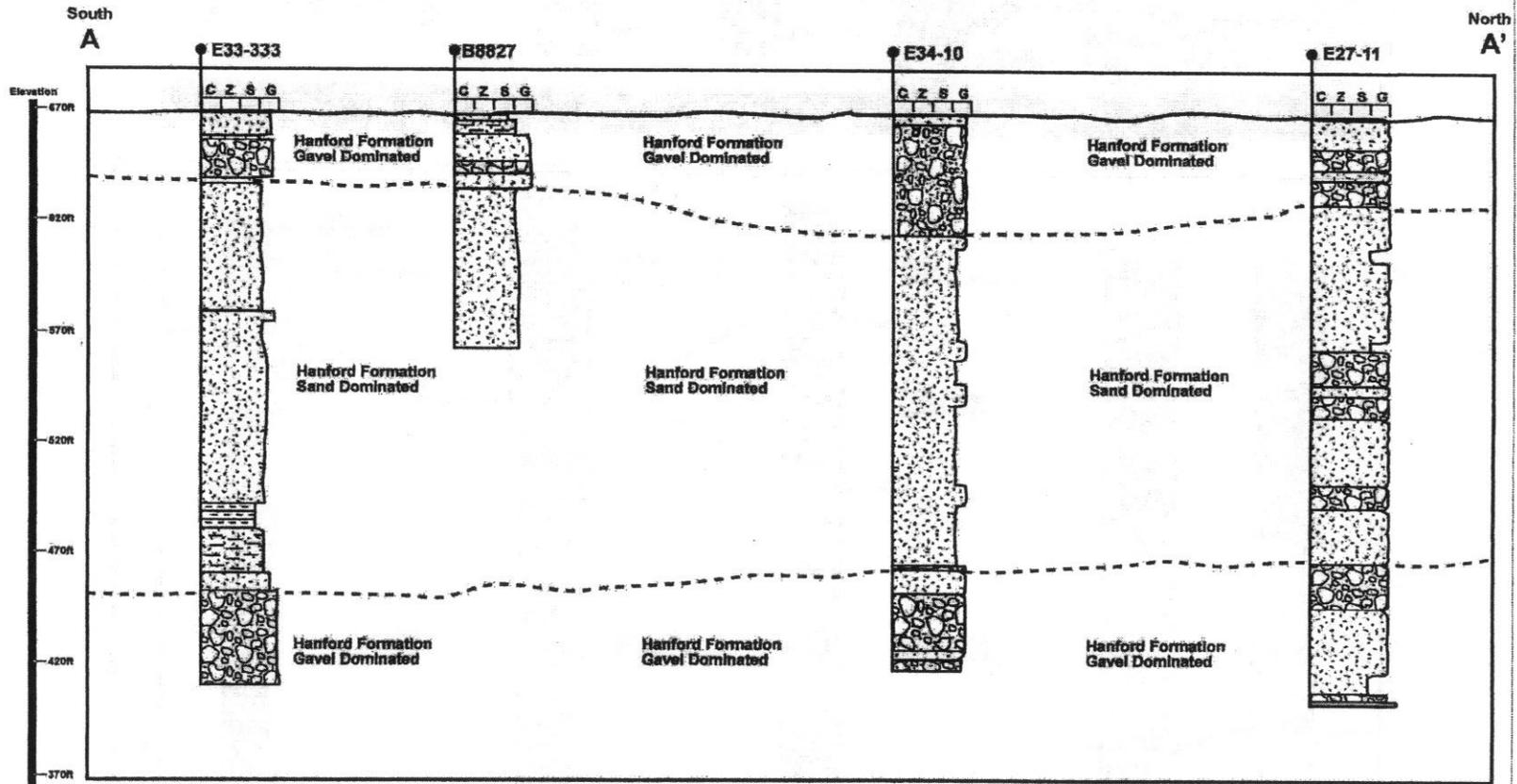


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DOE/RL-2005-63 DRAFT A

Figure 2-3. Geologic Cross Section Through the 216-B-63 Trench.

# 216-B-63 Trench



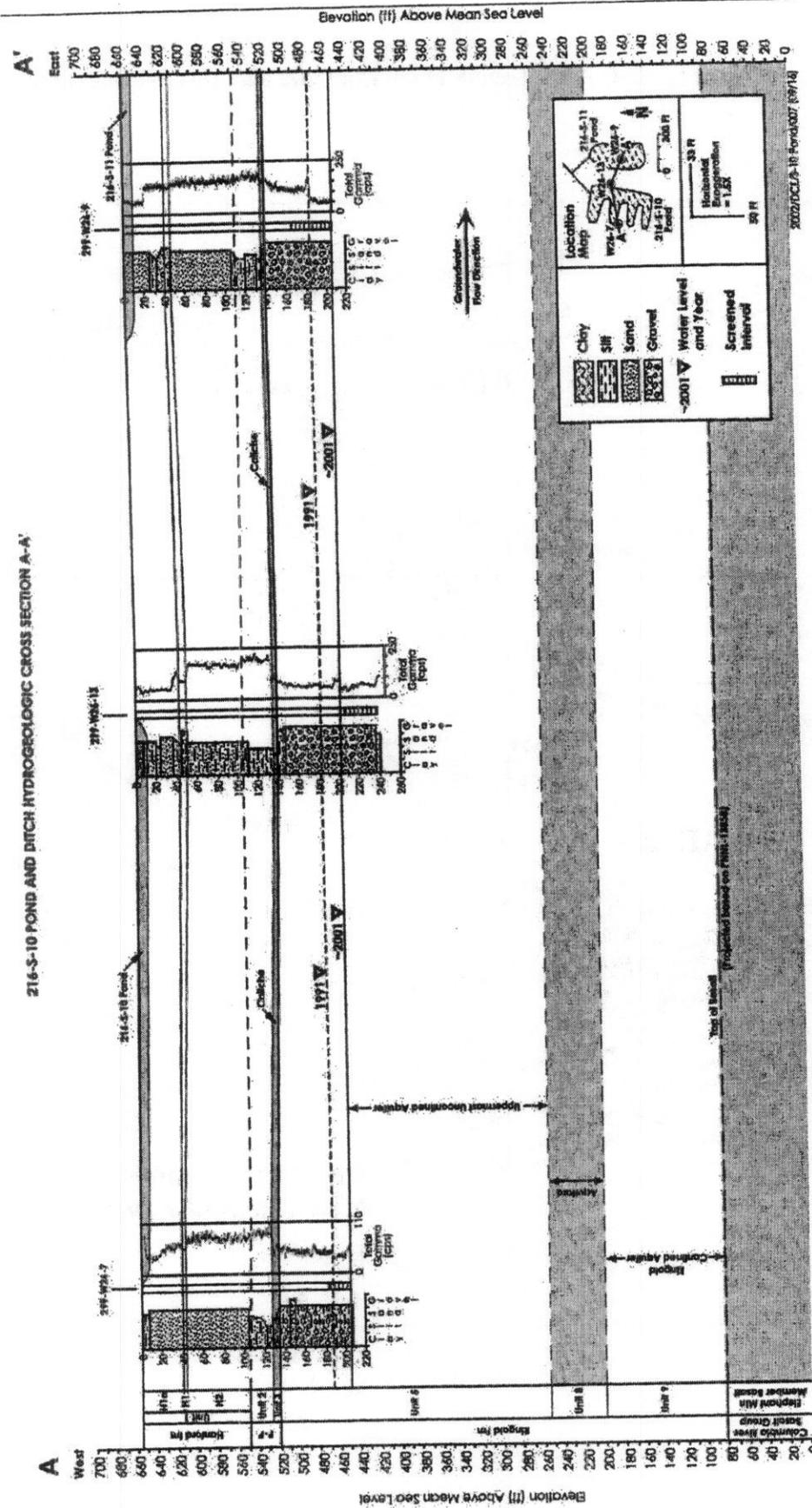
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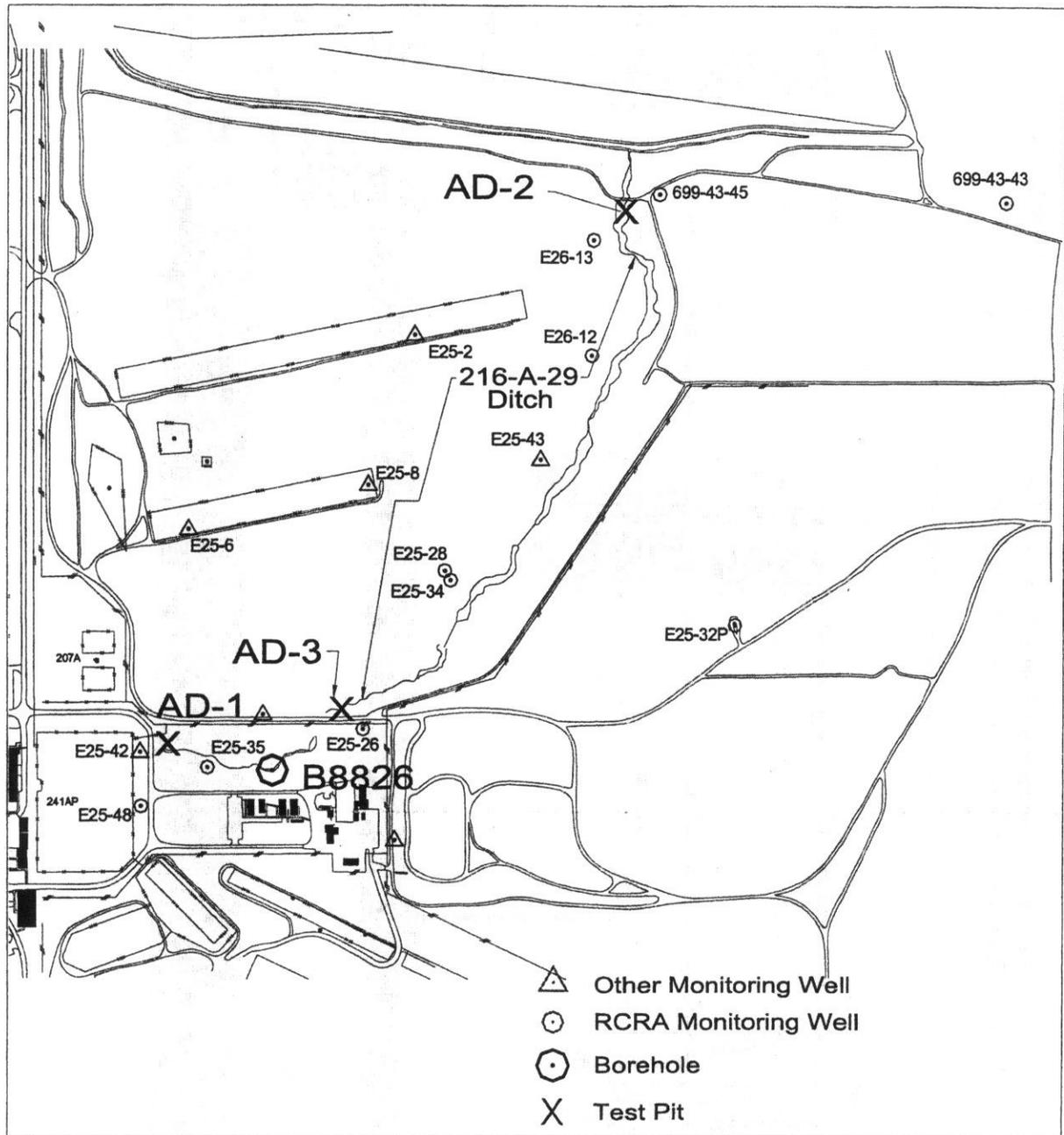


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Figure 2-4. Hydrogeologic Cross Section at the 216-S-10 Pond and Ditch.  
 From PNNL-14070, *Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch.*



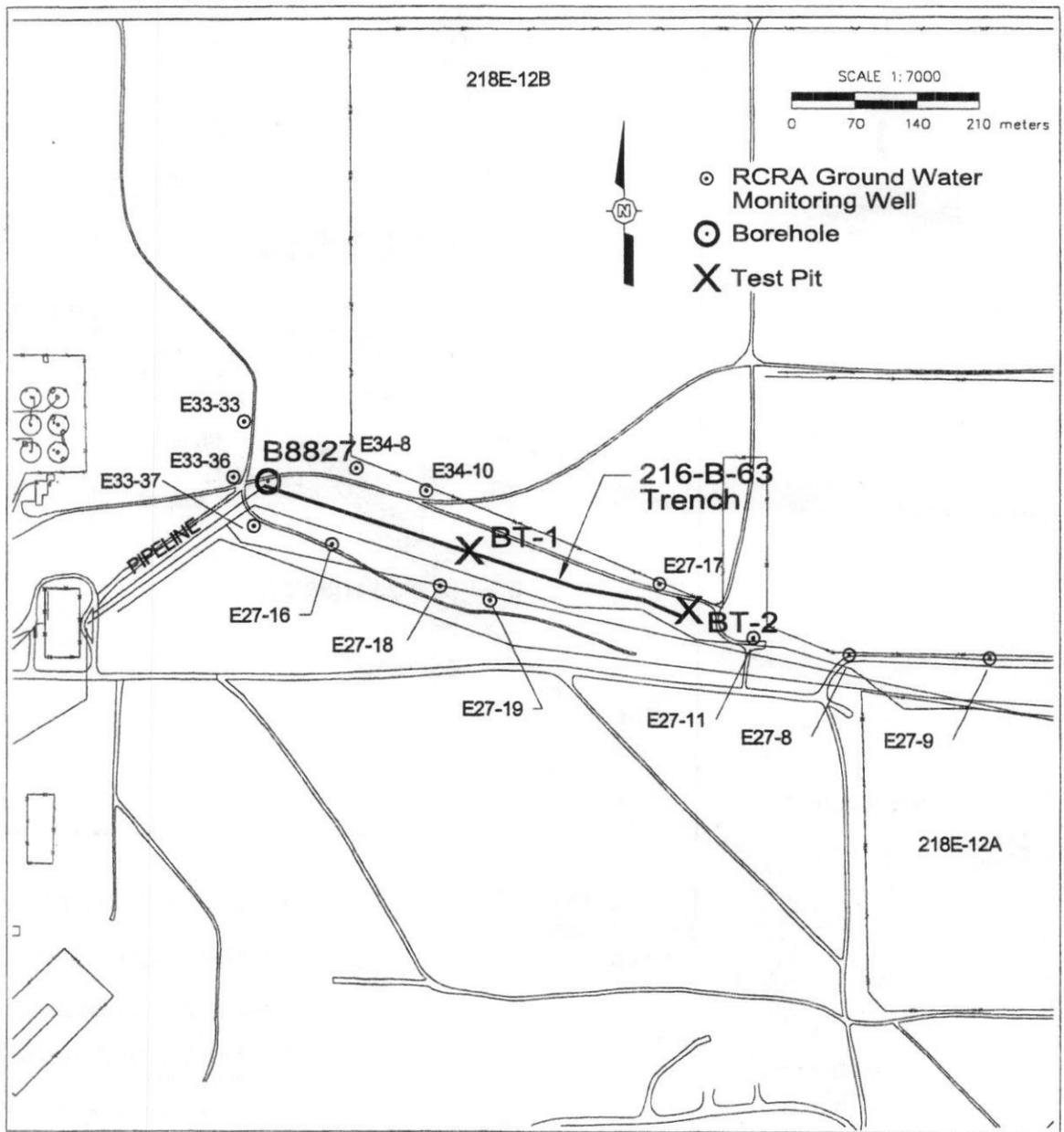
1 | Figure 2-5. Location of the 216-A-29 Trench-Ditch Borehole and Test Pit Locations.



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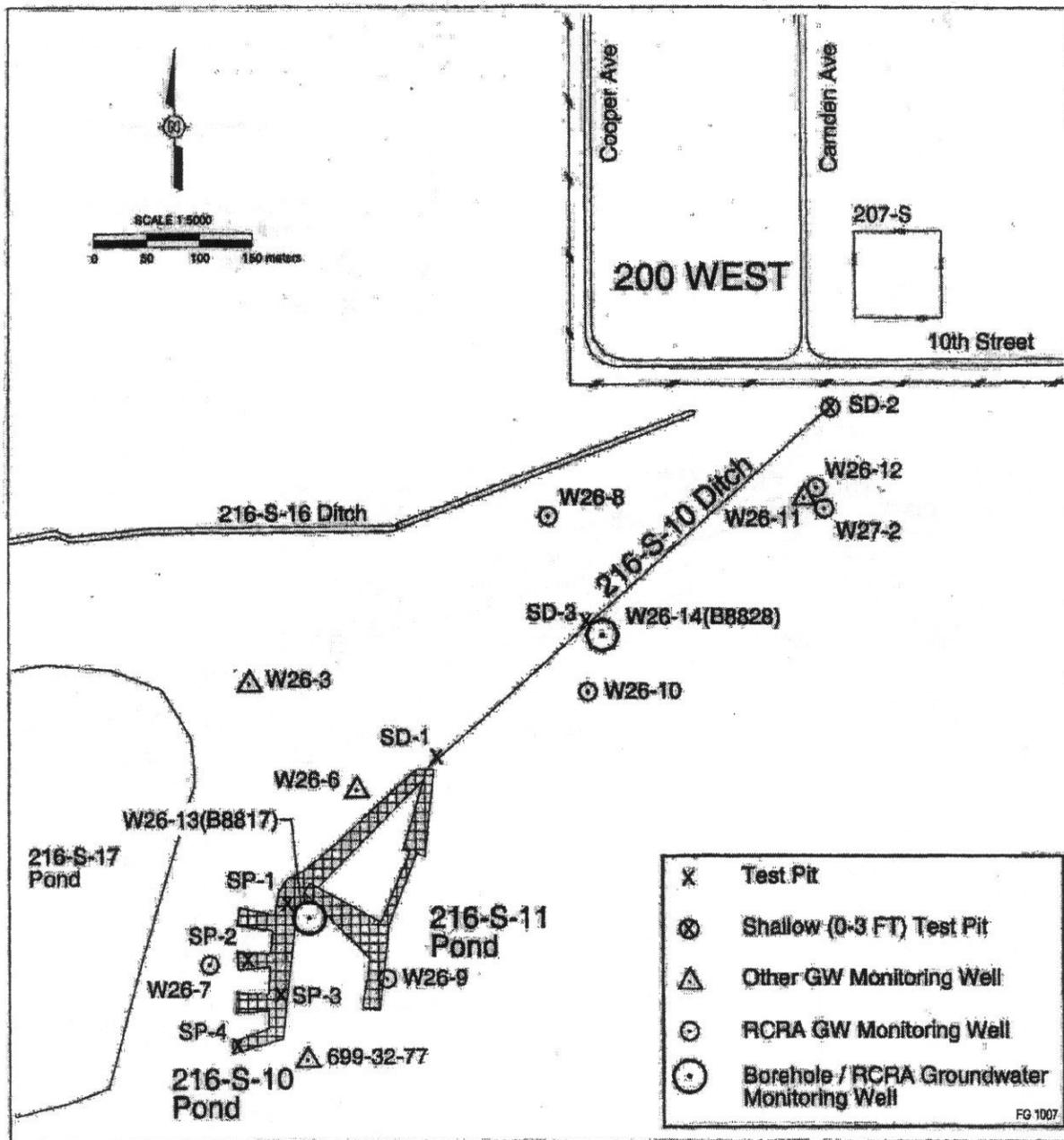
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Figure 2-6. Location of the 216-B-63 Trench Borehole and Test Pit Locations.



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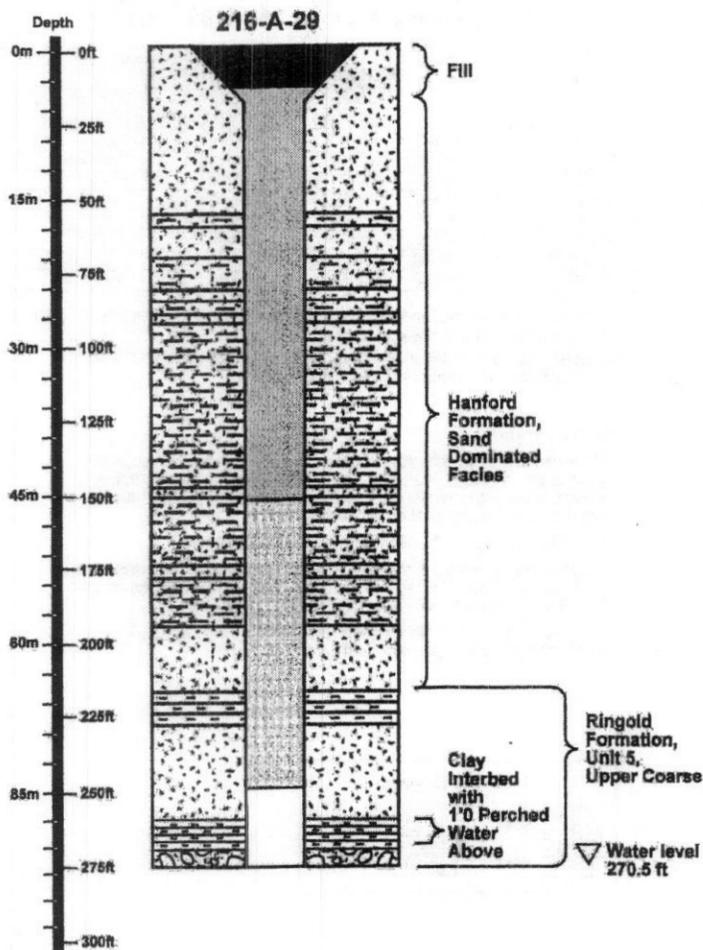
Figure 2-7. Location of the 216-S-10 Ditch Borehole and Test Pit Locations.



3

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Figure 2-8. Contaminant Distribution Model for the 216-A-29 Ditch.



Select Radionuclide and Non-Radionuclide Concentrations at the 216-A-29

Analyte	Units	Sample Depth Interval		
		0-3.4 m (0-11 ft)	>3.4m-46.4 m (>11 to 152ft)	>46.4-83.0 m (>152-272 ft)
Am-241	pCi/g	ND-145	All ND	All ND
Cs-137	pCi/g	ND-98.4	ND-0.57	All ND
Pu-238	pCi/g	ND-16.7	All ND	All ND
Pu 239/240	pCi/g	ND-667	ND-0.33	All ND
Tritium	pCi/g	Not measured	All ND	0.22-7.05
Sr-90	pCi/g	ND-0.779	ND-0.363	All ND
Mercury	mg/kg	ND-5.2	ND-1.7	ND-0.04
Silver	mg/kg	ND-42	ND-1.4	All ND
Nitrate	mg/kg	ND-119	ND-78.4	ND-0.61
Sulfate	mg/kg	14.6-2970	ND-134	3.8-28.5
Uranium, total	mg/kg	0.321-5.28	0.319-1.45	0.345-0.959
Lead	mg/kg	1.3-390	1.7-98.2	2.7-10.5
Aroclor-1254	mg/kg	ND-9.4	All ND	All ND

ND=non-detects, detection limits vary with the sample and are presented in the complete data tables in the appendix of this report.  
 1,2-Dichloroethane, benzo(a)anthracene and chrysene undetected in the borehole but were detected in at least one of the test pits at levels above the groundwater protection risk-based criteria.

**216-A-29 Ditch.**

- Received discharge from the PUREX Plant chemical sewer from various floor and sink drains, tanks, condensers, ventilation drainage and raw water used to flush chemical sewer lines. Hydrazine product (U133) and cadmium nitrate (D006) entered the ditch.
- The ditch received approximately 22,700,000 L/day (6,000,000 gal/day).
- Radiological inventory was not reported (DOE/RL-96-81).
- The ditch was estimated to be 1,220 m (4,000 ft) in length and 1.8 m (6 ft) wide. The depth of the ditch varied from 0.6 to 4.6 m (2 to 15 ft).

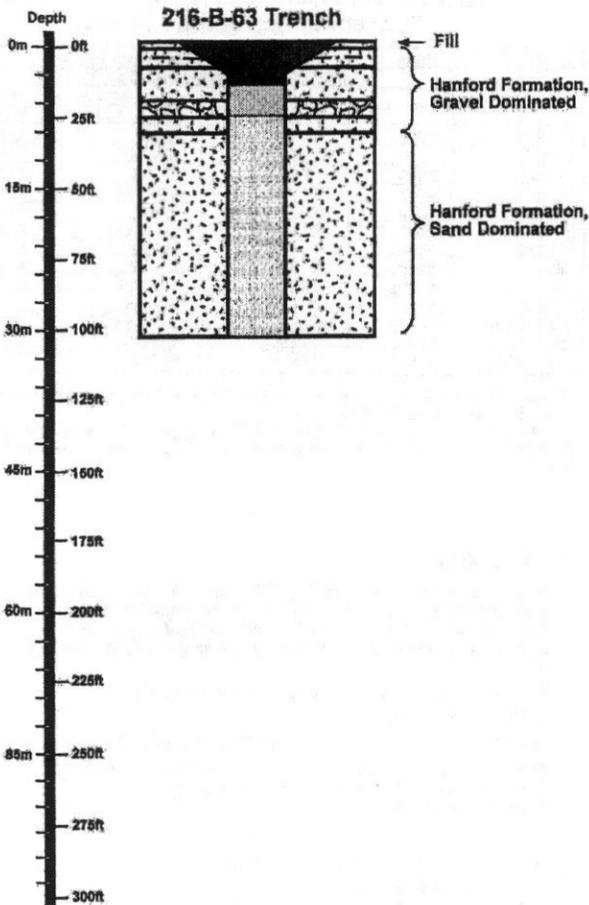
Borehole Legend	
	Sand
	Silty Sandy
	Gravel
	Silty/Clay

3

1

2

Figure 2-9. Contaminant Distribution Model for the 216-B-63 Trench.



**Select Radionuclide and Non-Radionuclide Concentrations at the 216-B-63 Trench**

Analyte	Units	Sample Depth Interval		
		0-5.2 m (0-17 ft)	>5.2-7.6 m (>17 to 25ft)	>7.6-31.4 m (>25-103 ft)
Cs-137	pCi/g	ND-3.2	All ND	All ND
Ni-63	pCi/g	All ND	2.3-15.1	2.85-5.68
Np-237	pCi/g	ND-0.05	All ND	All ND
Tc-99	pCi/g	All ND	ND-0.41	All ND
Tritium	pCi/g	All ND	ND-0.33	All ND
Sr-90	pCi/g	ND-29.5	ND-3.21	All ND
Cadmium	mg/kg	ND-0.27	ND-2.42	0.103-0.137
Nitrate	mg/kg	2.2-188	0.384-8.1	ND-1.58

ND=non-detects, detection limits vary with the sample and are presented in the complete data tables in the appendix of this report. Benzene was undetected in the borehole but were detected in one of the test pits at levels above the risk-based criteria.

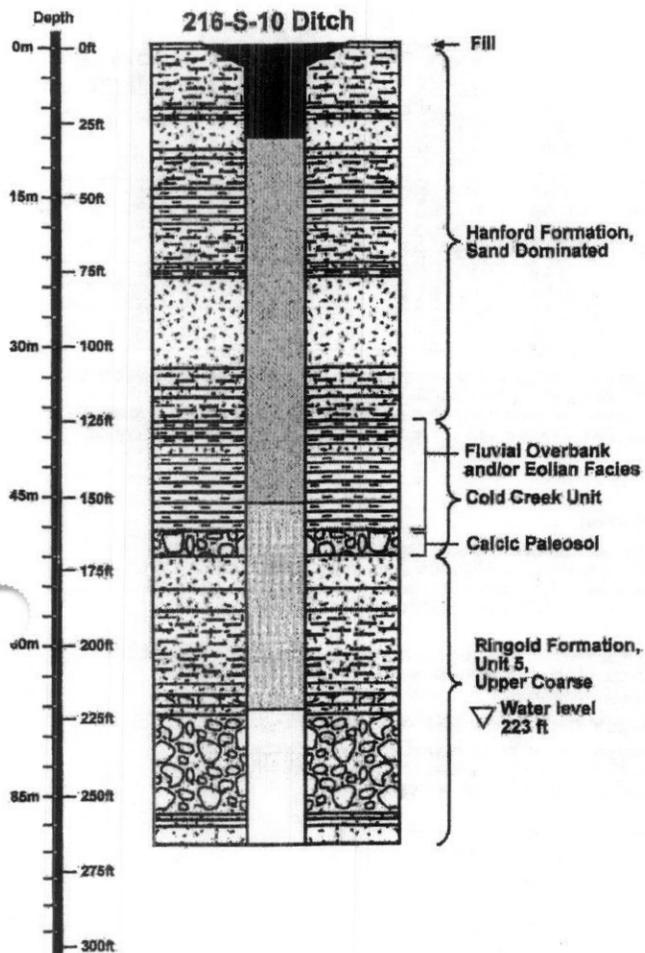
**216-B-63 Trench.**

- Received emergency cooling water and chemical sewer wastes from various sources at B Plant such as: floor, funnel, and sink drains; steam condensate and/or cooling water; tank overflow and drain effluent; sump effluent; and rainwater.
- The ditch received 473,000 L/day (125,000 gal/day).
- Radiological inventory at the trench decayed to 1999 includes 21.2 kg of total uranium, 0.37 kg of total plutonium, 0.035 kg americium-241, 0.57 Ci cesium-137, and 1.94 Ci of strontium-90.
- The trench was approximately 427 m (1,400 ft) in length, 1.2 m (6 ft) wide and averaged 3m (10 ft) in depth.



3

Figure 2-10. Contaminant Distribution for the 216-S-10 Ditch.



Select Radionuclides and Non-Radionuclide Concentration at the 216-S-10 Ditch

Analyte	Units	Sample Depth Interval		
		0-8.2 m (0-27 ft)	>8.2-46.4 m (>27-152 ft)	>46.4-67.7 m (>152-222 ft)
Cs-137	pCi/g	ND-9.13	All ND	All ND
Sr-90	pCi/g	ND-0.46	All ND	All ND
Pr-239/240	pCi/g	ND-3.24	All ND	All ND
Ni-63	pCi/g	ND-38.4	ND-2.73	ND-10.7
Ra-226	pCi/g	0.11-0.60	0.46-0.92	0.24-0.32
Th-232	pCi/g	ND-0.998	0.622-1.41	ND-0.441
Mercury	mg/kg	ND-4.3	ND-0.016	All ND
Silver	mg/kg	ND-30.4	All ND	All ND
Chromium	mg/kg	7.3-815	14.1-23.9	12-29.8
Lead	mg/kg	2.3-30	6.4-8.9	3.9-4.5
Copper	mg/kg	12-244	12-19.5	13.6-20
Nitrate	mg/kg	ND-18	All ND	All ND
Aroclor-1254	mg/kg	ND-3.7	All ND	All ND
Zinc	mg/kg	44.88-506	42.3-61	46.8-76

ND = non-detects, detection limits vary with the sample and are presented in the complete data tables in the appendix of this report. Benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and chrysene were undetected in this borehole but were detected in at least one of the test pits at levels above the groundwater protection risk-based criteria.

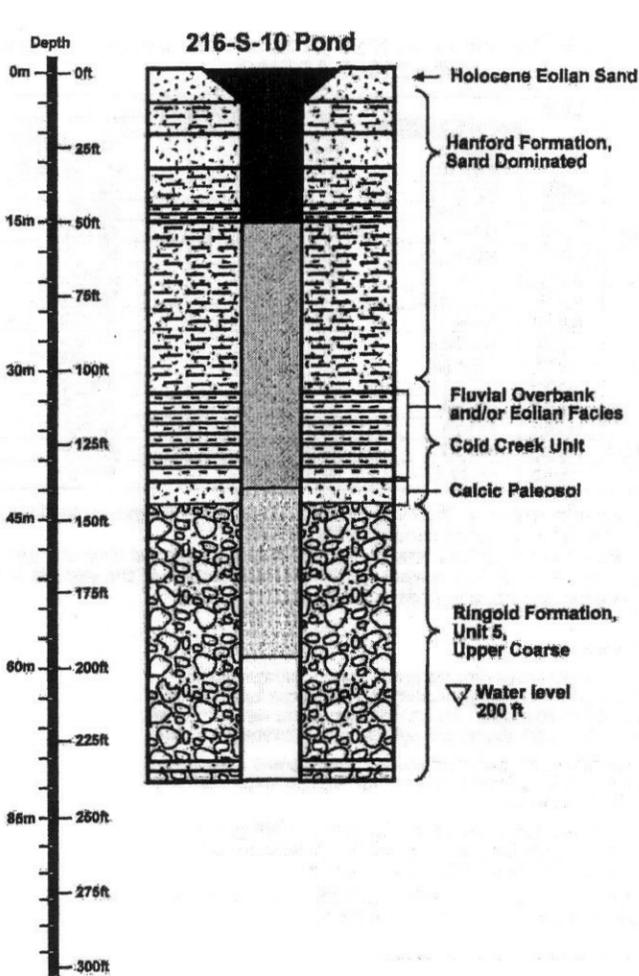
**216-S-10 Ditch.**

- Approximately 50 waste streams contributed. Sources include REDOX compressor cooling water and sanitary water overflow from the 2901-1-901 water tower. The remaining sources were infrequent and included REDOX drains and associated miscellaneous drains.
- During operations, the maximum volume of wastewater discharged daily to the 216-S-10 Pond and Ditch was approximately 568,000 L/day (150,000 gal/day).
- Radiological inventory decayed to 1999 includes 199 kg of total uranium, 0.10 kg of total plutonium, 0.015 Ci americium-241, 1.00 Ci cesium-137, and 0.86 Ci of strontium-90.
- The ditch was estimated to be 686 m (2,250 ft) in length, 1.8 m (6 ft) wide, and averaged 1.8 m (6 ft) in depth.

Borehole Legend			
	Sand		Silty Sandy
	Gravel		Silty/Clay

1  
2  
3

Figure 2-11. Contaminant Distribution for the 216-S-10 Pond.



Select Radionuclide and Non-Radionuclide Concentrations at the 216-S-10 Pond

Analyte	Units	Sample Depth Interval		
		0- 15.9 m (0-52 ft)	>15.9-41.8 m (>52 to 137ft)	>41.8 - 60.7 m (>137-189 ft)
Ni-63	pCi/g	ND-2.46	All ND	All ND
Pu-239/240	pCi/g	ND-2.33	ND-0.117	All ND
Sr-90	pCi/g	ND-1.57	All ND	All ND
Cs-137	pCi/g	ND-1.77	All ND	All ND
Barium	mg/kg	45.1-180	52.4-95.7	70.2-124
Chromium	mg/kg	6.3-26.2	7-15.9	12.5-39
Lead	mg/kg	2.2-10.3	3.2-7.2	3.3-5.2
Mercury	mg/kg	ND-0.26	ND-0.02	All ND
Silver	mg/kg	ND-8.3	All ND	All ND
Nitrate	mg/kg	4.23-30.3	ND-0.362	ND-0.52
Nickel	mg/kg	6.7-12.6	9.4-14	12.3-25.2
Zinc	mg/kg	29.5-59.7	32.2-42.6	49.6-201

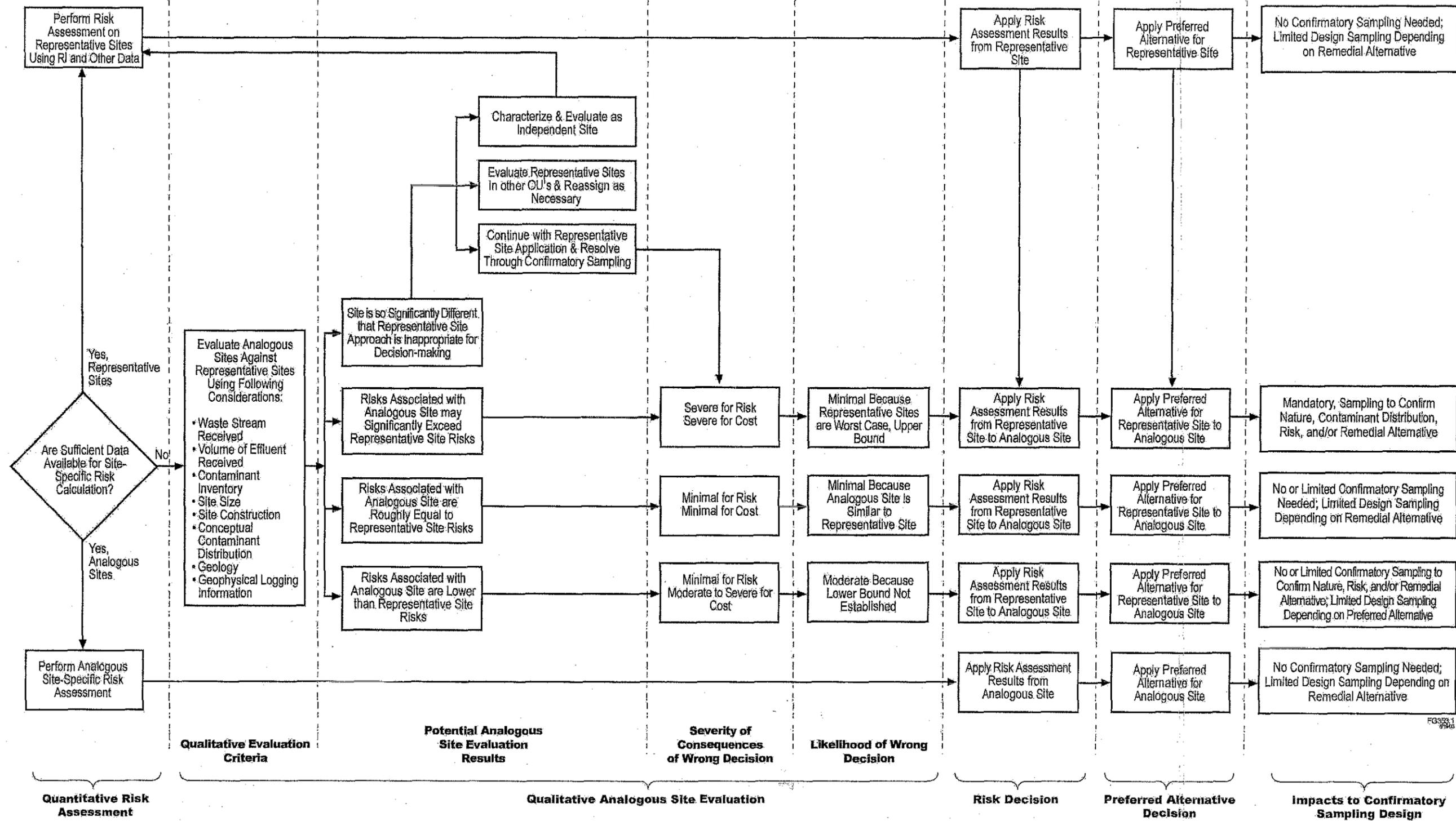
ND=non-detects, detection limits vary with the sample and are presented in the complete data tables in the appendix of this report. Vinyl chloride was undetected in the borehole but was detected in at least one of the test pits at levels above the groundwater protection risk-based criteria.

216-S-10 Pond.

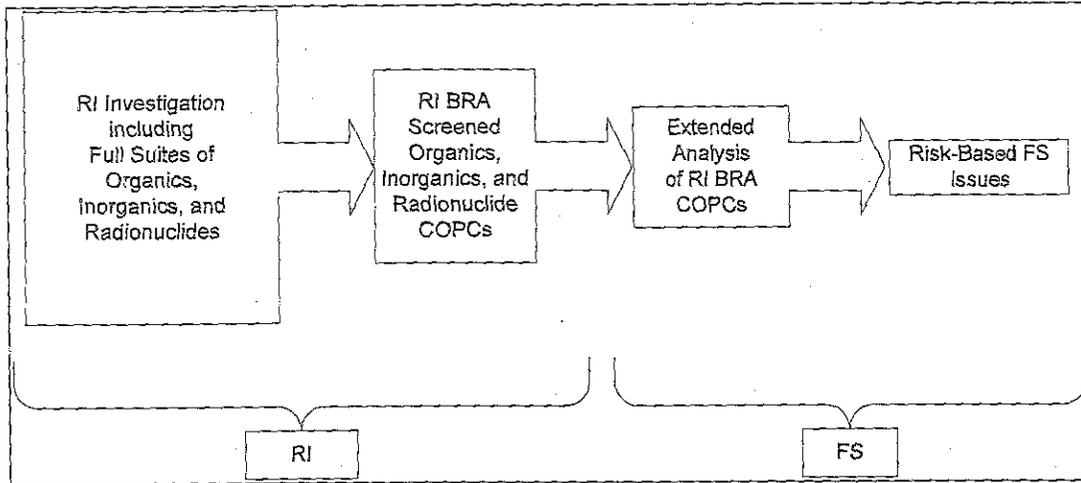
- \* Approximately 50 waste streams contributed. Sources include REDOX compressor cooling water and sanitary water overflow from the 2901-1-901 water tower. The remaining sources were infrequent and included REDOX drains and associated miscellaneous drains.
- \* During operations, the maximum volume of wastewater discharged daily to the 216-S-10 Pond and Ditch was approximately 568,000 L/day (150,000 gal/day).
- \* Radiological inventory was not reported (DOE/RL-96-81).
- \* Irregular-shaped, man-made pond that covered approximately 20,234m<sup>2</sup> (5 acres), included four finger-leach trenches, and was approximately 2.4 m (8 ft) at its deepest point.

Borehole Legend			
	Sand		Silty Sandy
	Gravel		Silty/Clay

Figure 2-12. Application of the Analogous Site Approach.

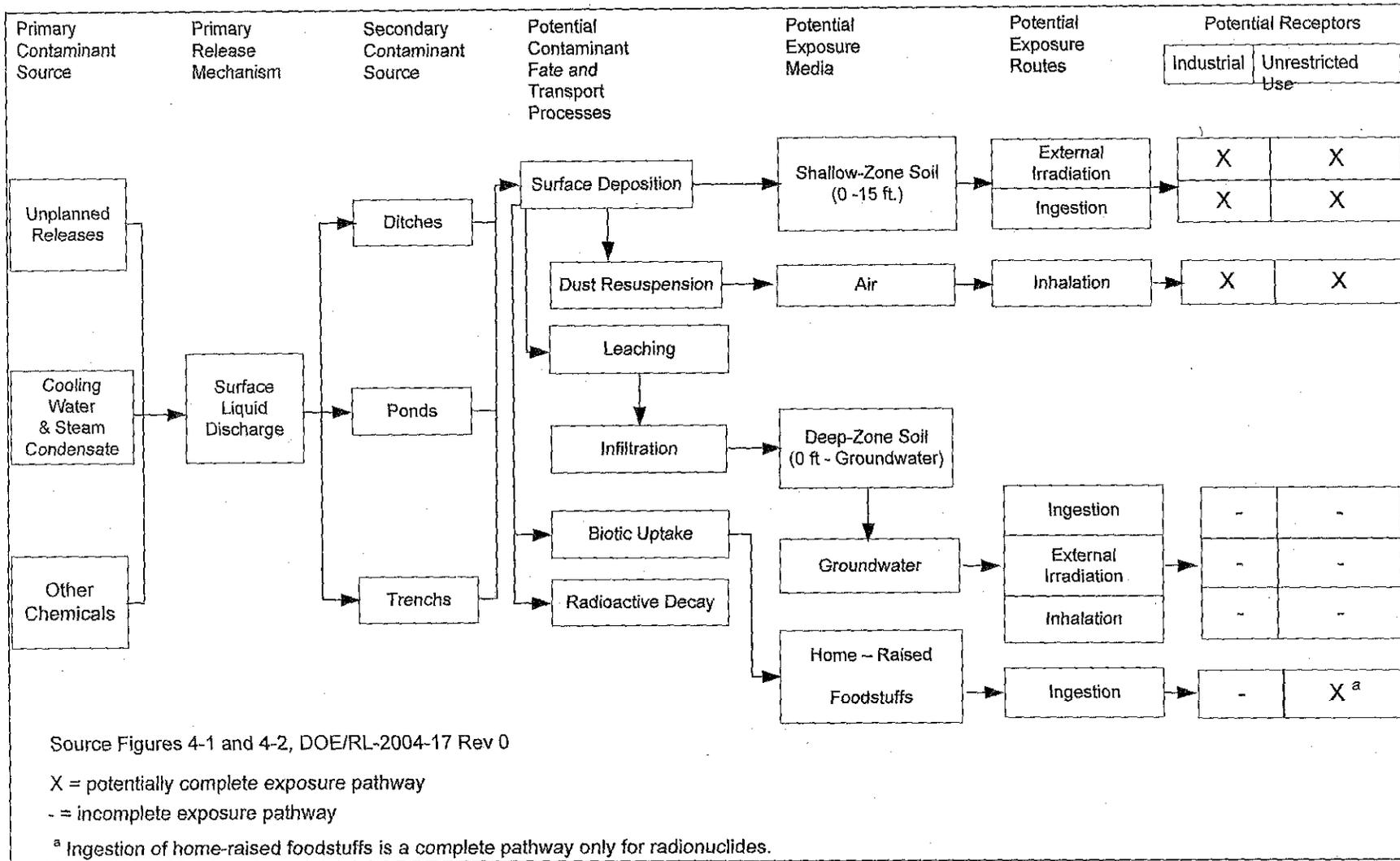


1  
2 Figure 2-13. Conceptual Iterative Evaluation and Refinement of Risk Assessment Information in  
3 the Remedial Investigation/Feasibility Study.



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Figure 2-14. Conceptual Site Model for Risk Assessment.

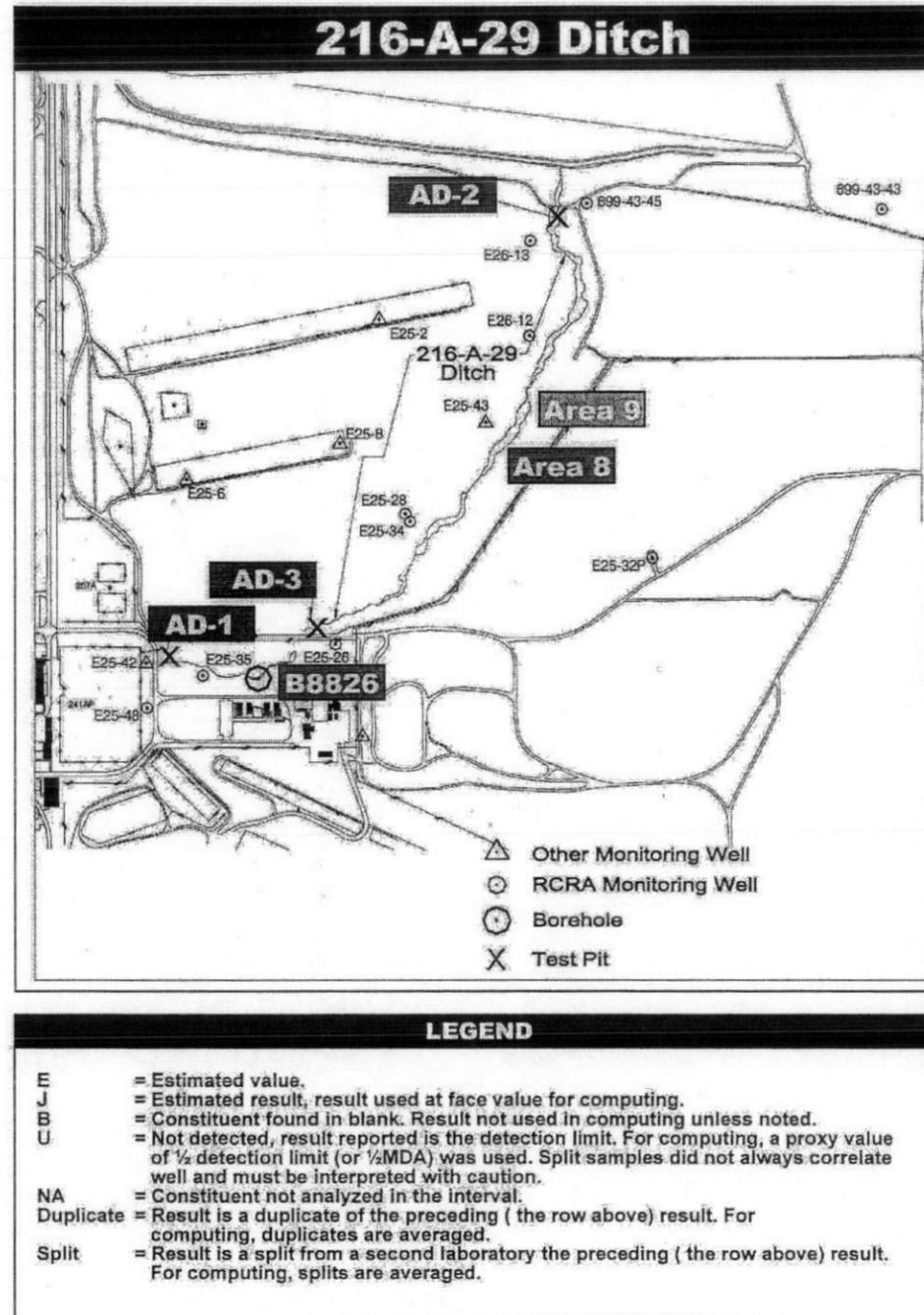


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Figure 2-15. Summary of Nature and Extent of Contamination for the 216-A-29 Ditch Representative Site.

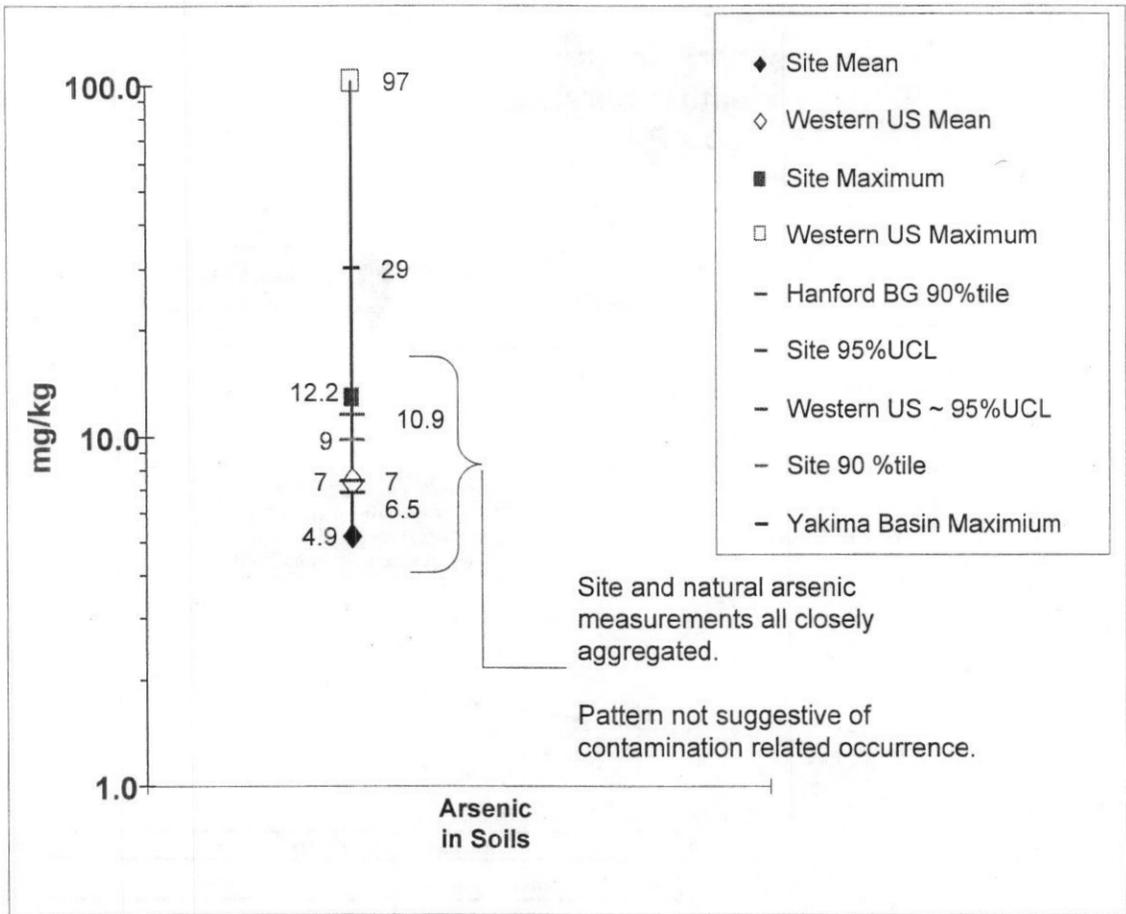


Interval (feet bgs)	Arochlor-1254	Benzo(a)anthracene	Chrysene	Arsenic	Boron	Cadmium	Lead	Molybdenum	Mercury	Nitrate (as nitrogen)	Nitrogen in Nitrite and Nitrate	Selenium	Silver	Sulfate	Uranium	Vanadium	Pu-239
<b>AD-1</b>																	
4.0 - 5.0	9400 J	180 J	210 J	5.8	3.4 J	28	76.3 J	3.2	5.2	210	210	0.99	42	2970	0.778	41.3	25.8
6.5 - 7.5	38 U	360 U	360 U	8.7	NA	0.13	6.8	NA	0.15	81.4	7.6	0.23 U	0.06 U	35.2	0.392B	64.9	0.46J
9.0 - 10.0	38 U	380 U	380 U	9.2	NA	0.03 U	9.5	NA	0.1	60.1	6.2	0.49	0.06 U	14.6	0.479B	70	0.124J
11.5 - 12.5	34 U	340 U	340 U	2.4	NA	0.03 U	2.4	NA	0.04	2.25	2.9	0.23 U	0.06 U	7.8	0.39B	62.9	0.029U
14.0 - 15.0	34 U	340 U	340 U	2.2	NA	0.03 U	2.4	NA	0.09	2.15	2.7	0.35 U	0.06 U	6.1	0.319B	52.5	0.026J
<b>AD-2</b>																	
5.0 - 6.0	37 U	380 U	380 U	7.7	2.6	0.153	7.3	0.572	0.019 U	0.292 U	30.7	0.245 U	0.067 U	15.2	0.321B	62.9	0.004U
7.5 - 8.5	39 U	400 U	400 U	3.8	NA	2.3	334	NA	2.2	53.6	406	0.55	6.2	240	3.22	90.7	5.07
Duplicate	39 U	390 U	390 U	5.4	NA	1.2	390	NA	4.3	40.9	423	0.24 U	6.6	260	5.28	104	3.31
10.0 - 11.0	35 U	350 U	350 U	2.4	NA	0.03 U	3.2	NA	0.02 U	14.1	13.9	0.22 U	0.06 U	26.6	0.306B	70.1	0.024U
Split	6.3 U	NA	240	1.8	NA	26 B	1.3	NA	0.0087 B	11.1	17.1	0.21 U	0.1 U	18.5	2.45	52.1	0.0091U
13.0 - 14.0	36 U	360 U	360 U	2.4	NA	0.03 U	3.6	NA	0.02 U	14.6	11.1	0.23 U	0.06 U	7.5	0.68B	48.7	0U
15.0 - 16.0	34 U	340 U	340 U	2.2	NA	0.03 U	3.1	NA	0.02 U	0.292 U	1.9 U	0.22 U	0.06 U	1.3 U	0.352B	36.8	0U
<b>AD-3</b>																	
6.0 - 7.0	40 U	34 J	40 J	12.1	3.1 J	0.27	11.7	0.53	0.02 U	67.6	69.6	0.27 U	0.07 U	61.7	2.76	52.9	0U
8.5 - 9.5	38 U	380 U	380 U	12.2	NA	0.3	11.1	NA	0.02 U	35.3	39	0.28	0.07 U	31.1	2.67	78	0.024U
11.0 - 12.0	34 U	350 U	350 U	3.1	NA	0.18	2.3	NA	0.01 U	50.6	5.1	0.22 U	0.06 U	6.4	1.56	85.5	0
Duplicate	34 U	340 U	340 U	2.5	NA	0.12	2.5	NA	0.02 U	52.7	5.9	0.28 U	0.06 U	6.5	1.45	58.8	0U
13.5 - 14.5	34 U	340 U	340 U	2.2	NA	0.15	2.3	NA	0.02 U	53.1	6	0.18 U	0.05 U	8.3	1.14	77.1	0U
16.0 - 17.0	35 U	350 U	350 U	3.4	NA	0.01	1.7	NA	0.02 U	76.4	7.9	0.17 U	0.05 U	6.9	1.25	65.8	0.052U
<b>B8826</b>																	
4.0 - 6.0	37 U	740 U	740 U	5.5	2.1	5.3	31.1	1	4.4	26.90	25.70	0.365 U	3	251.00	0.908	60.90	667.00
6.5 - 8.5	50 U	350 U	350 U	1.9	NA	0.34	3.7	NA	0.3 J	1.74	2.50	0.37 U	0.08 U	34.30	0.496	66.70	7.10
Duplicate	170 U	350 U	350 U	3	NA	0.29	5.4	NA	0.11 J	0.296 U	1.90	0.37 U	0.08 U	30.10	0.458	69.40	5.33
9.0 - 11.0	35 U	350 U	350 U	1.6	NA	0.58	2.5	NA	0.05 J	0.87	1.00	0.36 U	0.08 U	36.70	1.38	71.80	2.12
Split	34 U	NA	NA	2.42	NA	3.7	1.28	9.7 s	0.06	1.32	4.70	0.52	0.291	34.40	0.49	50.90	0.16
12.0 - 14.0	36 U	360 U	360 U	2.3	NA	0.14	2.6	NA	0.02 J	3.30	3.90	0.3 U	0.07 U	134.00	0.386	71.70	0.14U
14.5 - 16.5	35 U	350 U	350 U	1.8	NA	0.06	2.4	NA	0.01 U UR	0.41	0.85	0.37 U	0.08 U	15.50	0.292	77.20	0.33
19.5 - 21.5	35 U	350 U	350 U	1.6	NA	0.05	2.9	NA	0.02 U UR	0.294 U	0.30	0.31 U	0.07 U	5.20	0.321	89.30	0.02U
24.5 - 26.5	37 U	370 U	370 U	2.3	NA	0.04 U	3.6	NA	0.02 U UR	6.01	6.00	0.37 U	0.08 U	46.20	0.329	94.20	0U
60.0 - 62.0	35 U	350 U	350 U	2.1	NA	0.05	3.2	NA	0.02 U UR	3.19	3.40	0.34 U	0.07 U	11.80	0.405	72.40	0.04U
100 - 102	34 U	340 U	340 U	1.5	NA	0.01	2.2	NA	0.02 U	0.282 U	0.2 U	0.34 U	0.08 U	1.30	0.32	46.30	0U
150 - 152	35 U	350 U	350 U	2.7	NA	0.08	3.3	NA	0.02 U	0.294 U	0.18 U	0.35 U	0.08 U	1.70	0.405	31.70	0.02U
200 - 202	35 U	350 U	350 U	2.3	NA	0.05	2.9	NA	0.02 U	0.296 U	0.22 U	0.34 U	0.08 U	3.80	0.388	33.20	0U
260 - 262	41 U	410 U	410 U	6.7	NA	0.12	10.5	NA	0.04	0.61	0.30	0.64	0.1 U	28.60	0.959	53.70	0.03U
270 - 272	37 U	370 U	370 U	2.1	NA	0.45 U	2.7	NA	0.03 U	0.312 U	0.23 U	0.45 U	0.09 U	6.30	0.345	36.10	0.02U
<b>Area 8</b>																	
3	36 U	360 U	360 U	3	NA	180 B	4	NA	0.02 U	NA	NA	0.52	100 U	NA	NA	NA	NA
7	36 U	360 U	360 U	4	NA	180 B	4.5	NA	0.02 U	NA	NA	0.420 U	110 U	NA	NA	NA	NA
10	38 U	380 U	380 U	3	NA	200 B	4.3	NA	0.03	NA	NA	0.6	120 U	NA	NA	NA	NA
"10 dup"	38 U	380 U	380 U	3.3	NA	200 B	4.3	NA	0.05	NA	NA	0.69	110 U	NA	NA	NA	NA
13	40 U	400 U	400 U	2.9	NA	2.2	98.2	NA	1.7	NA	NA	0.370 U	1.4	NA	NA	NA	NA
16	34 U	340 U	340 U	7.2	NA	320 B	1.8	NA	0.020 U	NA	NA	0.68	0.90 U	NA	NA	NA	NA
<b>Area 9</b>																	
4.3	35 U	350 U	350 U	2.6	NA	150 B	0.020 U	NA	NA	NA	0.49	110 U	NA	NA	NA	NA	NA
7.3	36 U	360 U	360 U	2.6	NA	150 B	0.020 U	NA	NA	NA	440 B	110 U	NA	NA	NA	NA	NA
"7.3 dup"	35 U	350 U	350 U	2.8	NA	200 B	0.020 U	NA	NA	NA	460 B	120 U	NA	NA	NA	NA	NA
10.3	35 U	350 U	350 U	2.5	NA	440 B	0.12	NA	NA	NA	0.6	110 U	NA	NA	NA	NA	NA

\*Molybdenum result in B8826 split is apparent anomaly.

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Figure 2-16. Example Interpretation for Arsenic at the 216-A-29 Ditch.

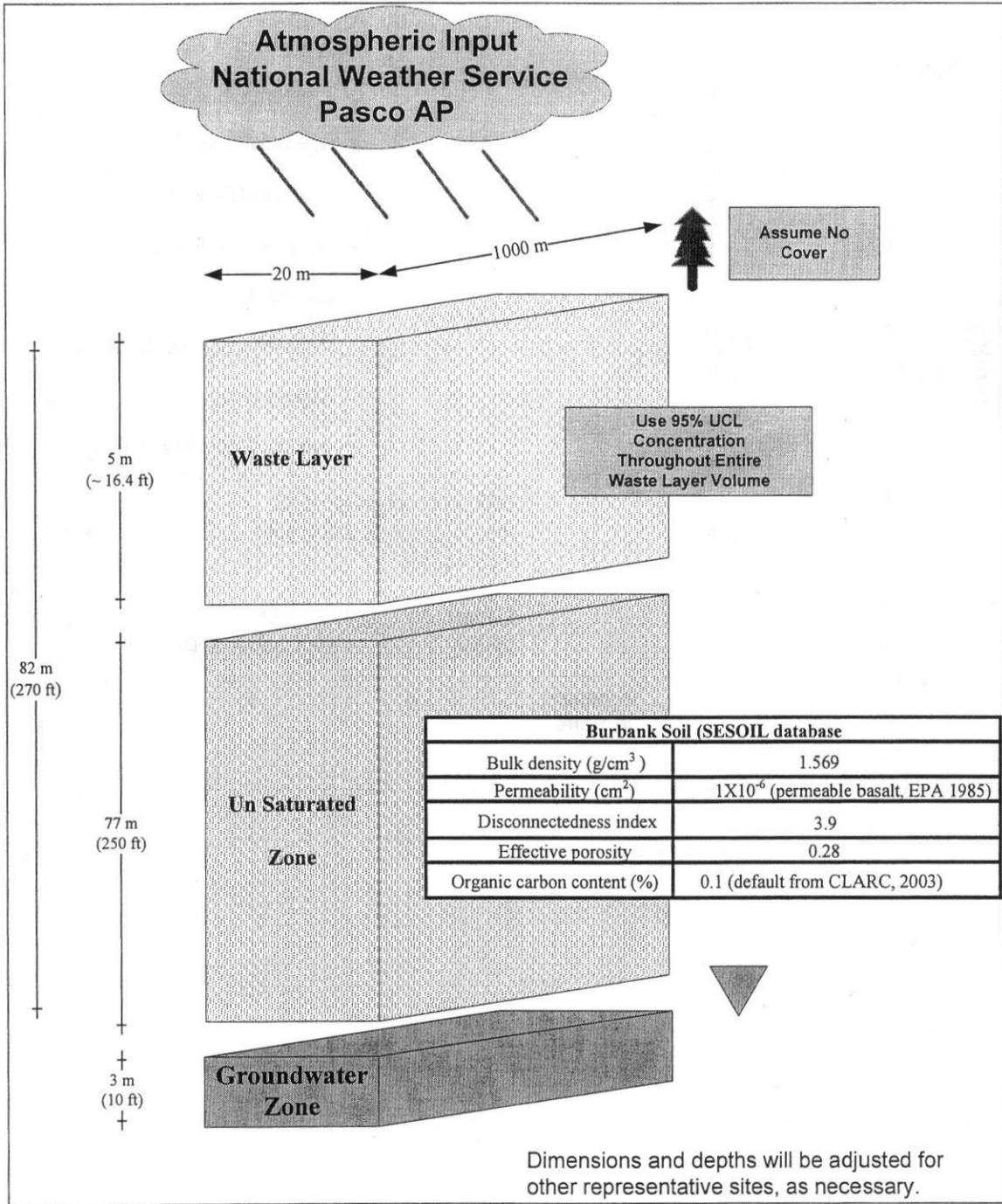


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Figure 2-17. SESOIL Model Configuration for 216-A-29 Ditch.

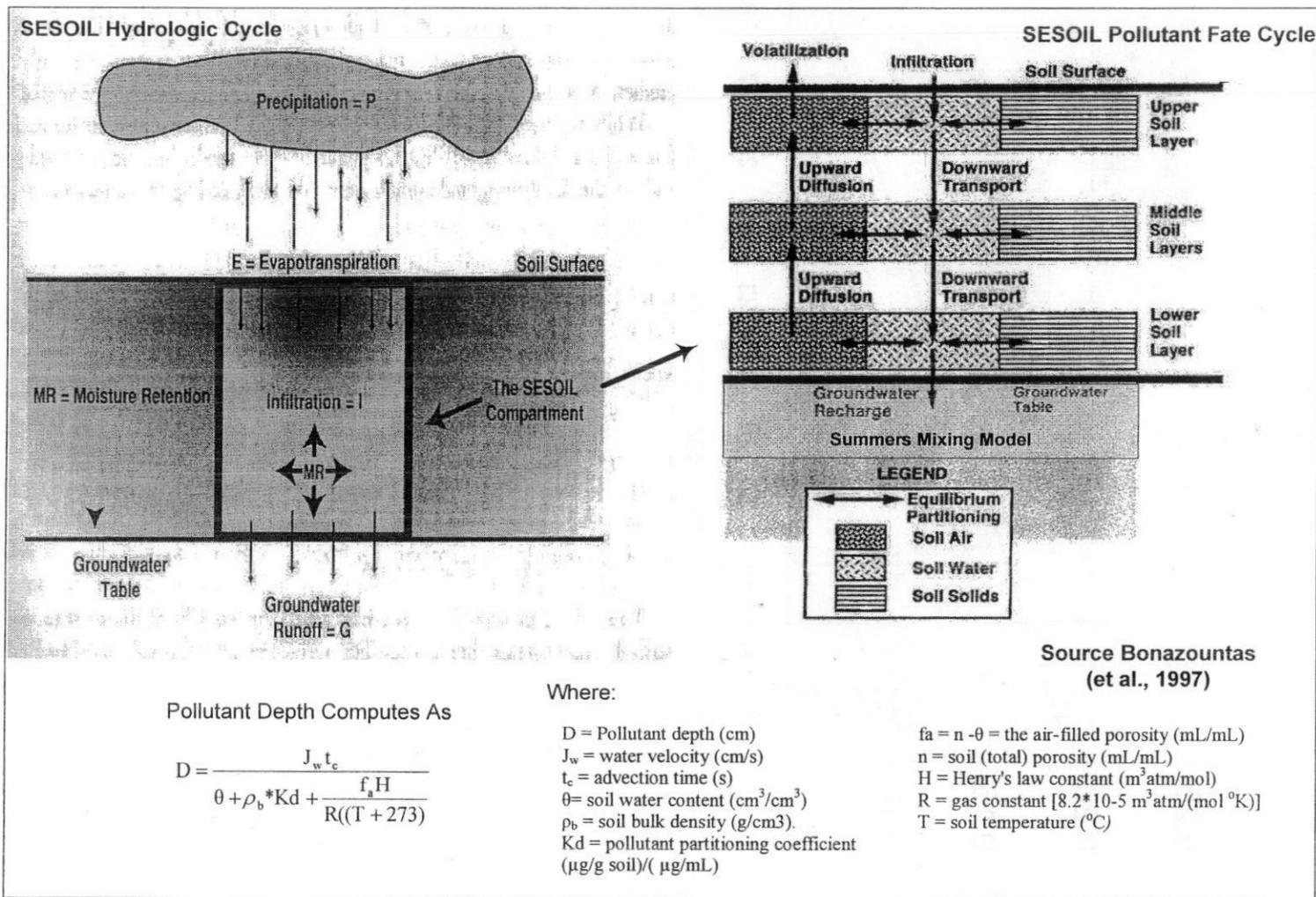
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Figure 2-18. SESOIL Processes.



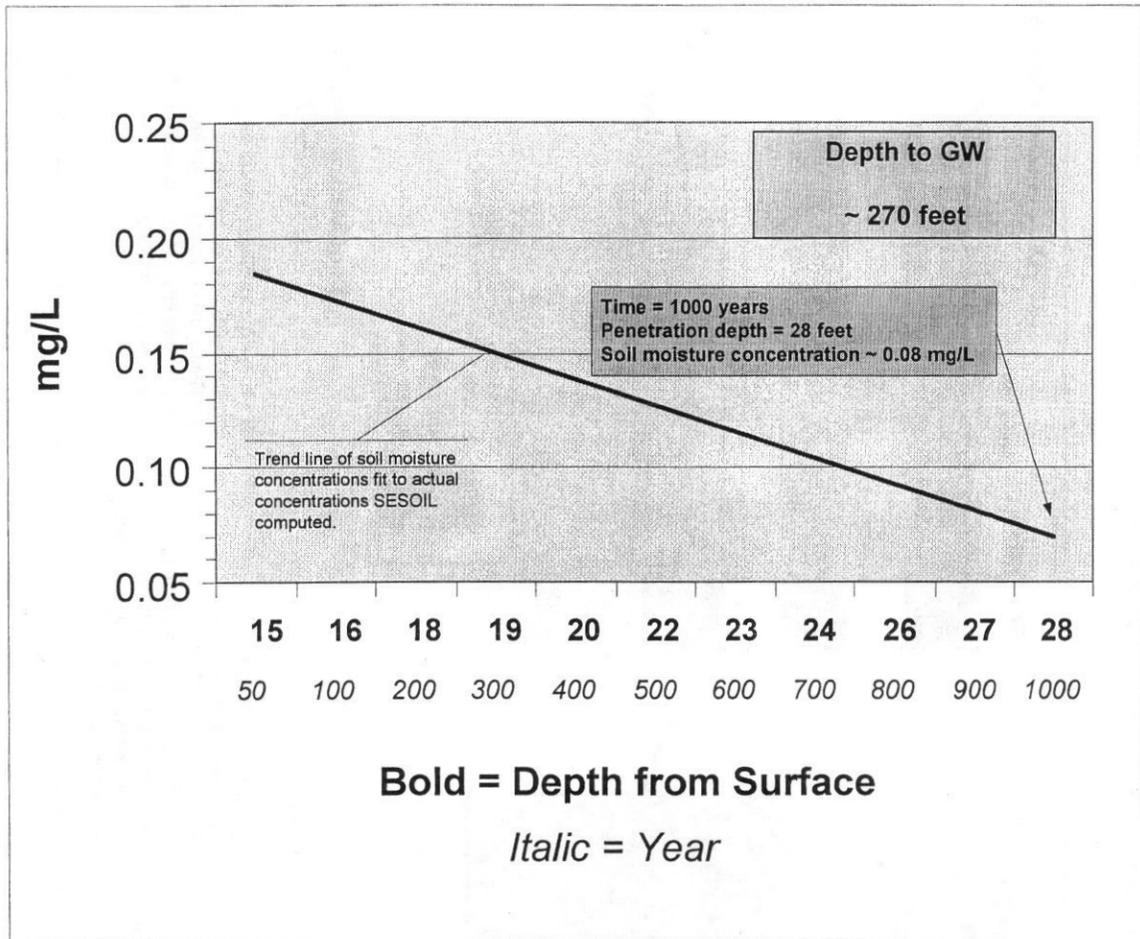
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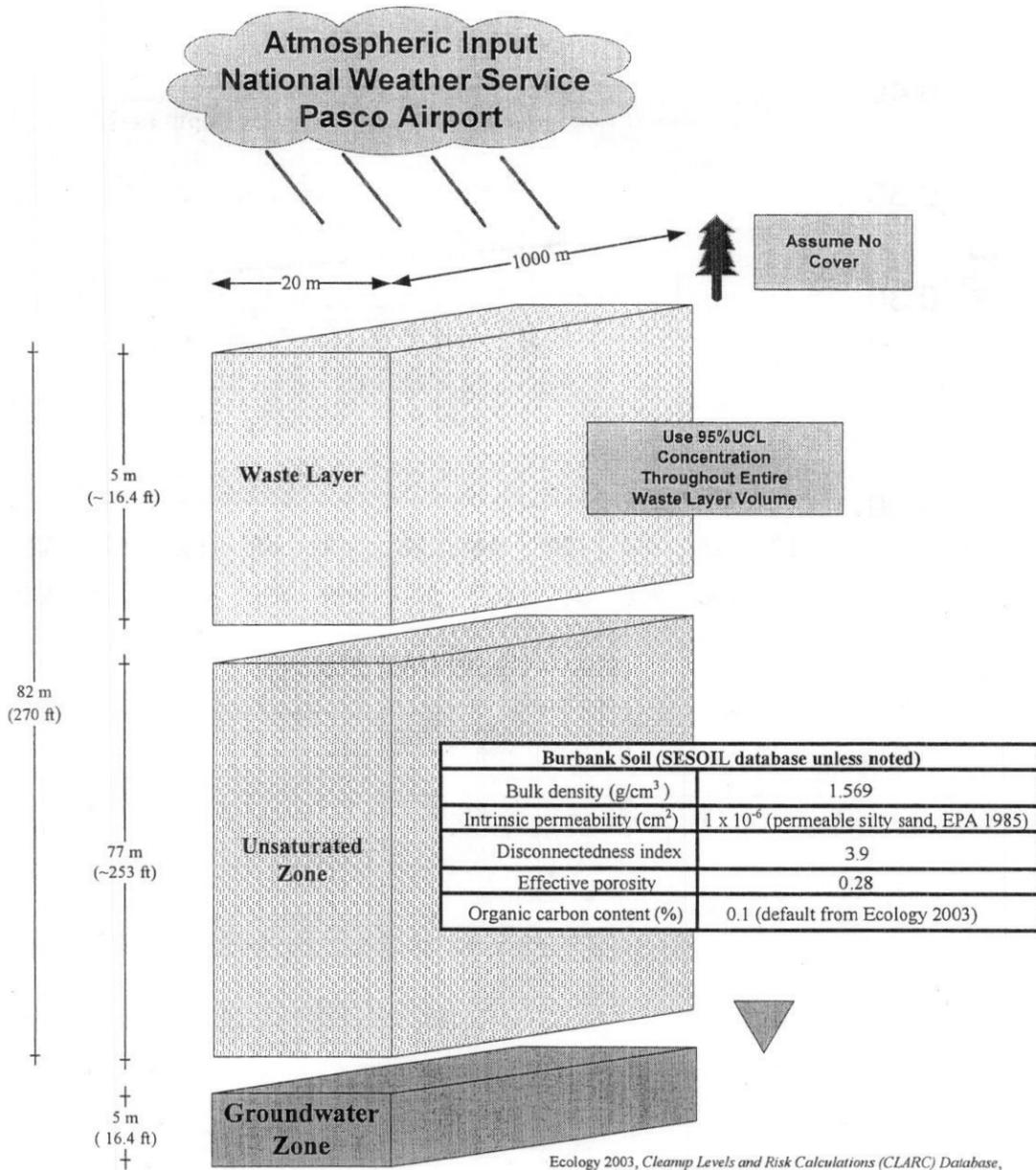
Figure 2-19. 216-A-29 Ditch, Estimated Impacts of Arsenic in Vadose Zone Soils on Groundwater.



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Figure 2-20. 216-A-29 Ditch, Estimated Impacts of Cadmium in Vadose Zone Soils on Groundwater.



Ecology 2003, *Cleanup Levels and Risk Calculations (CLARC) Database*, <https://fortress.wa.gov/ecy/clarc/CLARHome.aspx>.

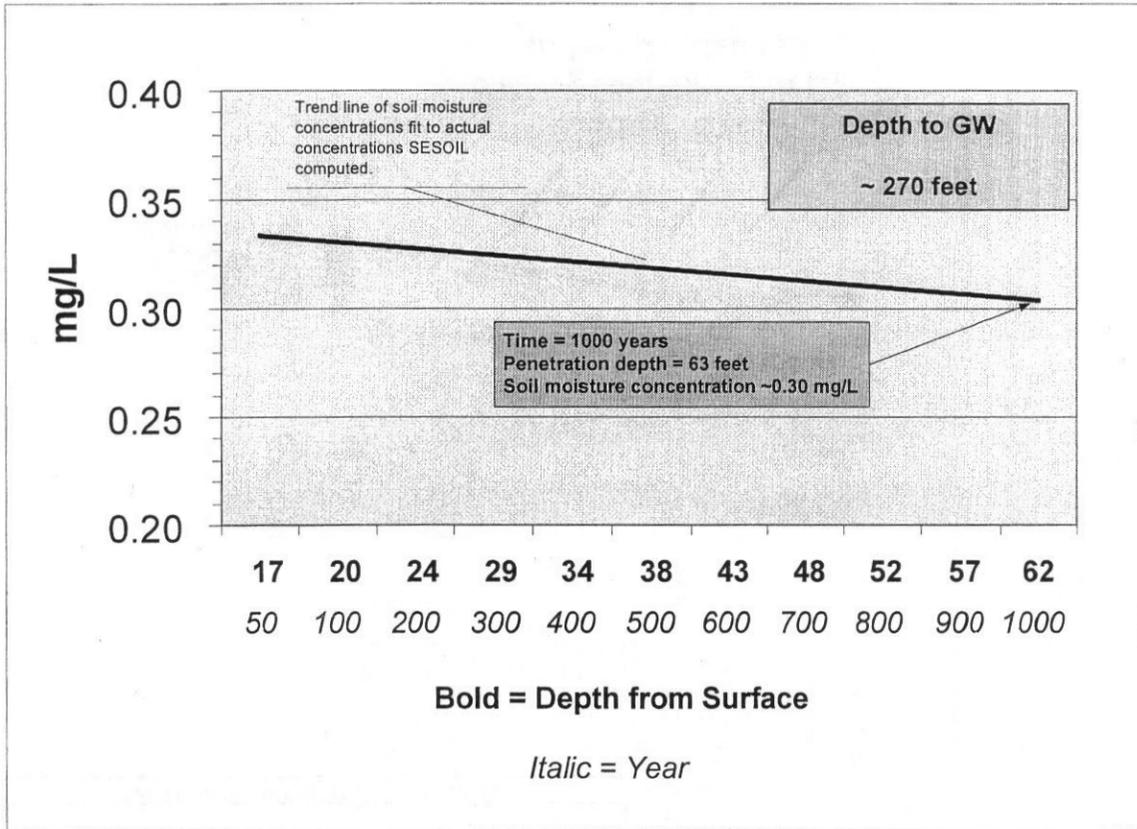
Additional model detail found in Appendix F.

Dimensions and depths will be adjusted for other representative sites, as necessary.

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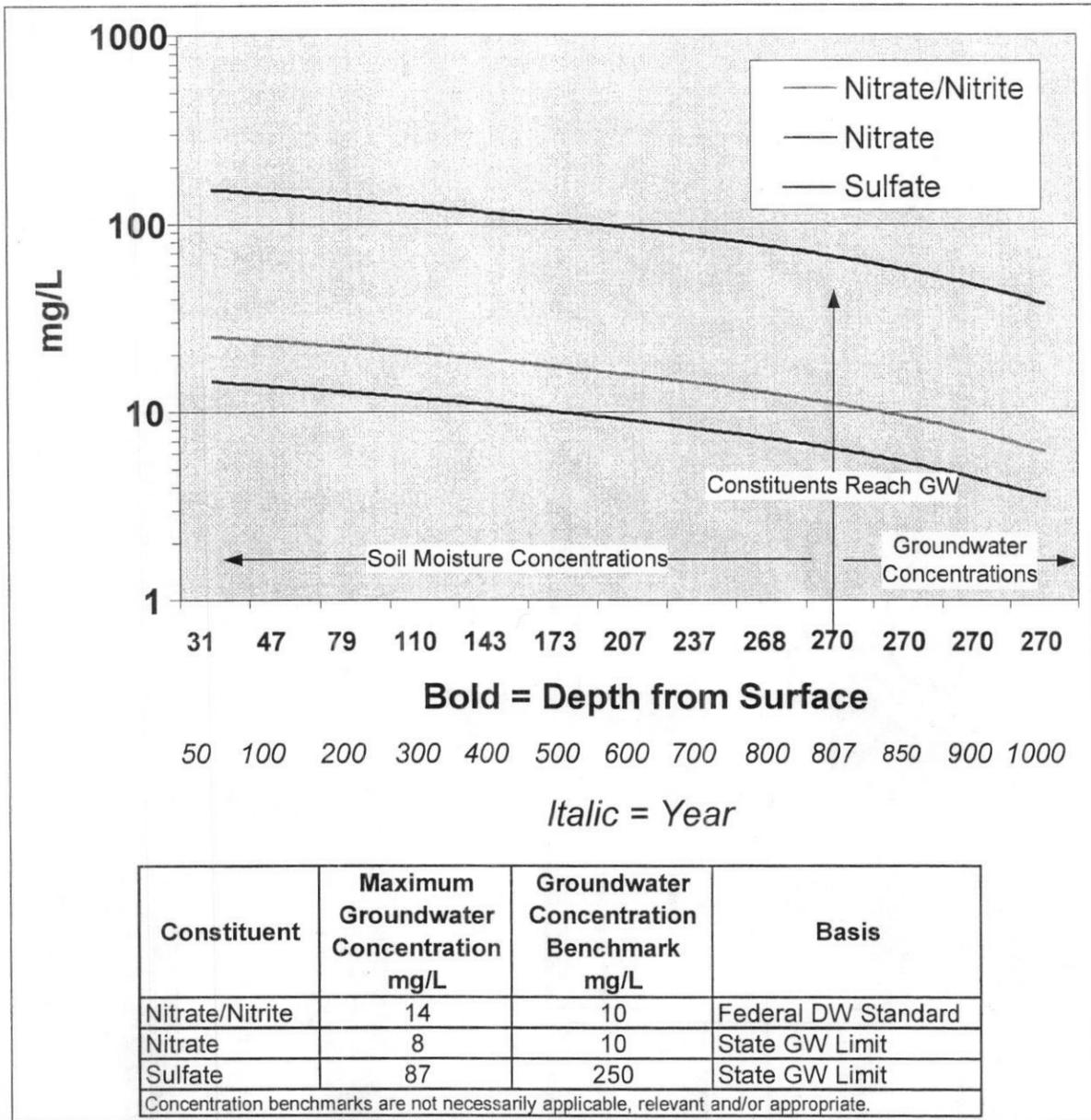
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Figure 2-21. 216-A-29 Ditch, Estimated Impacts of Silver in Vadose Zone Soils on Groundwater.



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1 Figure 2-22. 216-A-29 Ditch, Estimated Impacts of Nitrate, Nitrate/Nitrite and Sulfate in  
 2 Vadose Zone Soils on Groundwater.  
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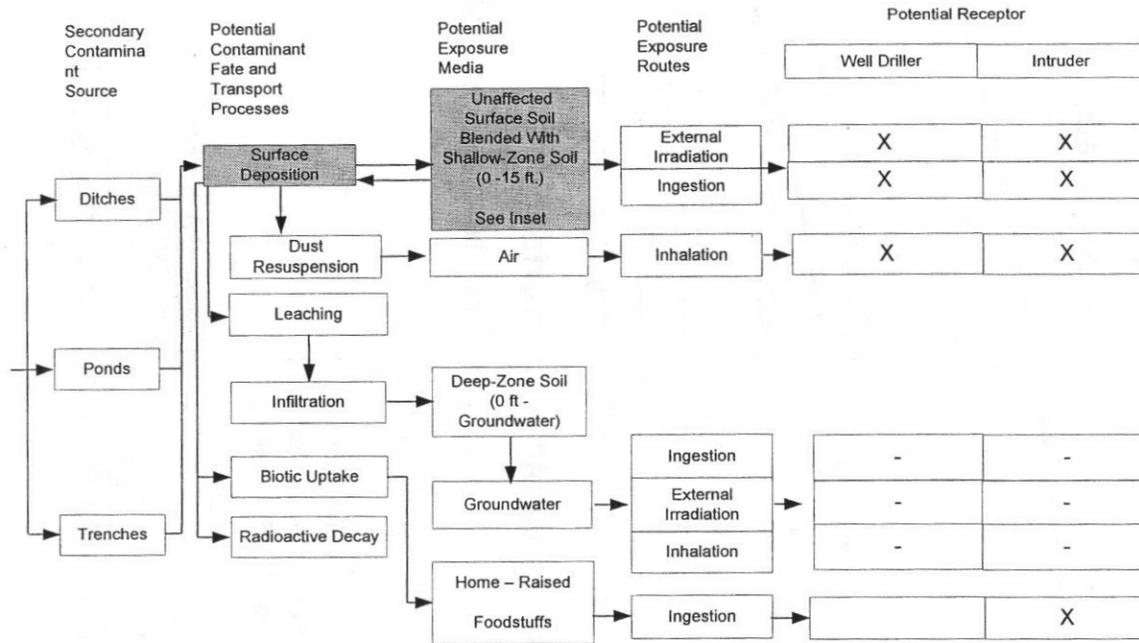


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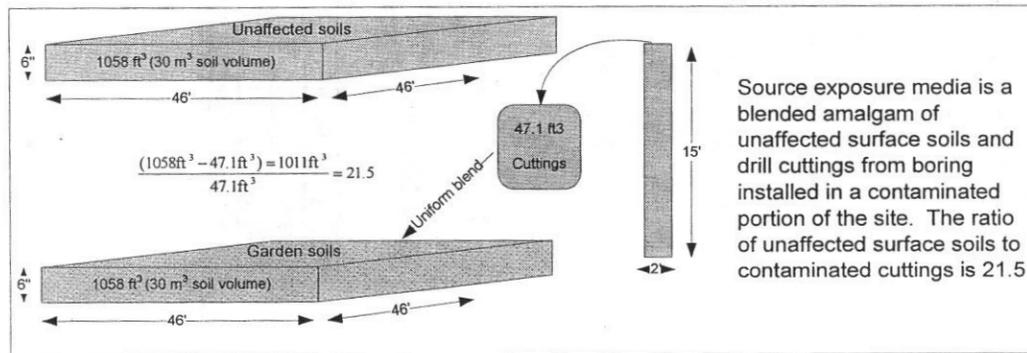
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Figure 2-23. Intruder Scenario Conceptual Site Model and Garden.



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X = potentially complete exposure pathway

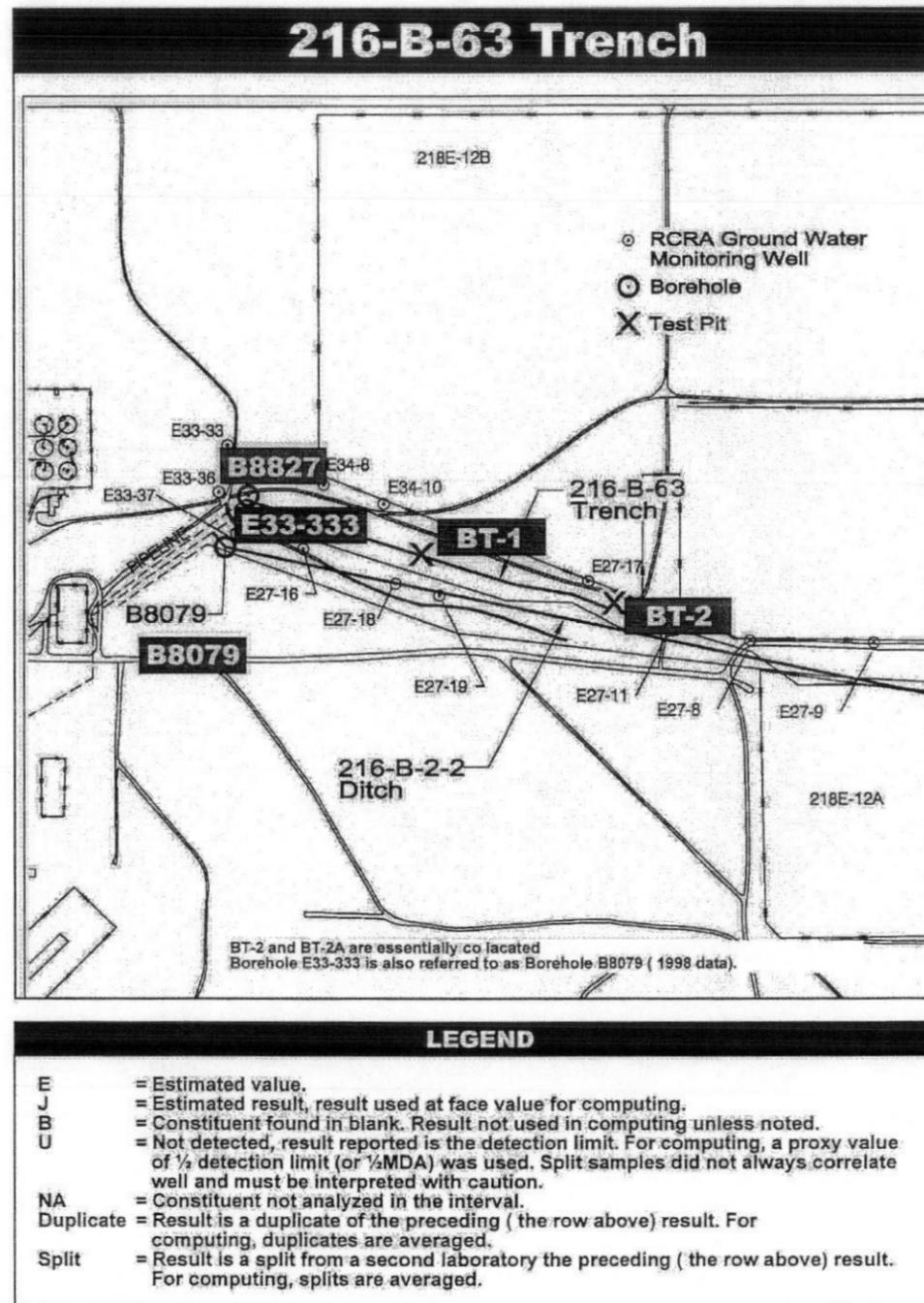
- = incomplete exposure pathway

Source exposure media is a blended amalgam of unaffected surface soils and drill cuttings from boring installed in a contaminated portion of the site. The ratio of unaffected surface soils to contaminated cuttings is 21.5

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Figure 2-24. Summary of Nature and Extent of Contamination for the 216-B-63 Trench Representative Site.



Interval (feet bgs)	Boron	Cadmium	Selenium	Vanadium	Nitrate as N	Nitrogen in Nitrite and Nitrate	Benzene	Radioactive Strontium	
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	ug/kg	pCi/g	
<b>BT-1</b>	7.0 - 8.0	2.50	0.22	0.4 U	52.6	52.4	62.4	6 U	0.38
	9.5 - 10.5	NA	0.04 U	0.38 U	57.7	45.9	49.8	6 U	0.44
	Duplicate	NA	0.06	0.39 U	58.7	62.8	85.6	6 U	0.89
	Split	NA	0.28 U	0.24 B	59.4	7.5	27.3	0.73 U	0.58
	12.0 - 13.0	NA	0.18	0.35 U	74.1	7.0	7.6	6 U	0.64
	14.5 - 15.5	NA	0.04	0.34 U	67.3	6.0	6.6	5 U	1.66
17.0 - 18.0	NA	0.04 U	0.39 U	64.2	8.1	8.5	6 U	3.21	

Interval (feet bgs)	Boron	Cadmium	Selenium	Vanadium	Nitrate as N	Nitrogen in Nitrite and Nitrate	Benzene	Radioactive Strontium	
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	ug/kg	pCi/g	
<b>BT-2</b>	5.0 - 6.0	5.8	0.27	.22 U	58.1	188.0	230	8	3.93
	7.5 - 8.5	NA	0.25	0.75	78	9.9	9.5	5 U	24.6
	Split	NA	0.021 U	0.21	86.6	9.8	9.4	0.39 U	29.5

Interval (feet bgs)	Boron	Cadmium	Selenium	Vanadium	Nitrate as N	Nitrogen in Nitrite and Nitrate	Benzene	Radioactive Strontium	
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	ug/kg	pCi/g	
<b>BT-2A</b>	6.0 - 7.0	0.95	0.2	0.42 U	81.6	6.19	7.7	6 U	24
	8.5 - 9.5	NA	0.04 U	0.37 U	46.7	2.12	2.4	5 U	0.26
	11.0 - 12.0	NA	0.04 U	0.36 U	35.4	2.94	3.5	5 U	-0.022 U
	13.5 - 14.5	NA	0.04 U	0.36 U	40.1	2.87	3.5	6 U	-0.147 U
	16.0 - 17.0	NA	0.04	0.37 U	31.2	2.55	3.3	5 U	-0.013 U
	20.0 - 21.0	NA	0.08	0.39 U	39.8	3.14	3.3	6 U	-0.008 U
	24.0 - 25.0	NA	0.03 U	0.27 U	29.3	0.384	0.51	5 U	-0.072 U

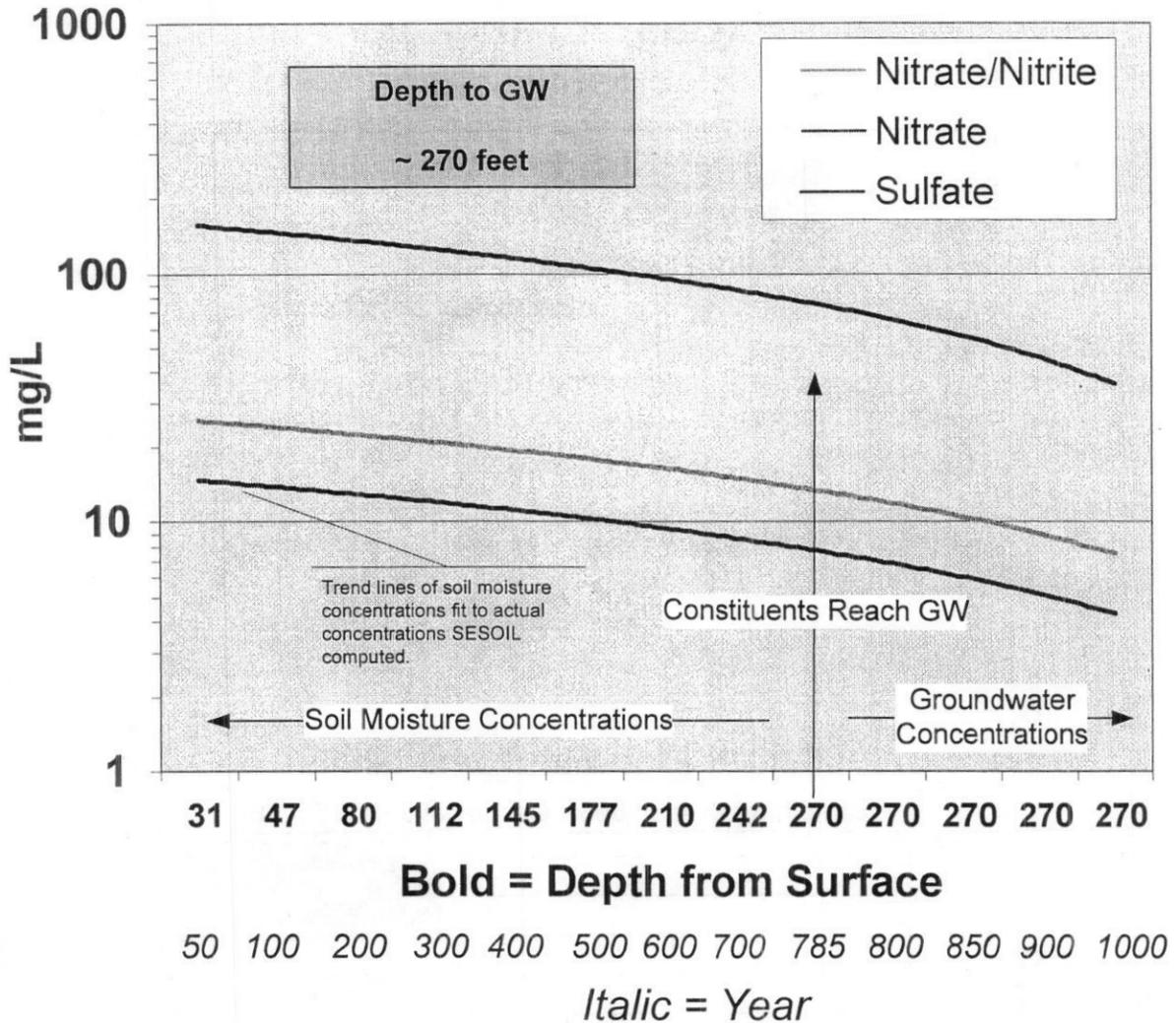
Interval (feet bgs)	Boron	Cadmium	Selenium	Vanadium	Nitrate as N	Nitrogen in Nitrite and Nitrate	Benzene	Radioactive Strontium	
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	ug/kg	pCi/g	
<b>E33-333</b>	150-152	2.9 B	.340 UN	.320 B	28.1	.205 U	.509 U J	5 U	0.0145 U
	174-179	4.9 B	.350 UN	.420 B	37.7	.206 U	.529 U J	5 U	0.011 U
	251.5-254	3 B	.360 UN	.240 U	22.9	0.255	.539 U J	5 U	0.00334 U

Interval (feet bgs)	Boron	Cadmium	Selenium	Vanadium	Nitrate as N	Nitrogen in Nitrite and Nitrate	Benzene	Radioactive Strontium	
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	ug/kg	pCi/g	
<b>B8827</b>	10.0 - 12.0	1.2	0.04 U	0.41	57.5	26	22.00	6 U	1.12
	12.5 - 14.5	NA	0.117	0.36 U	51.3	2.8	2.84	6 U	7.10
	15.0 - 17.0	NA	0.131	0.364 U	54.4	1.09	1.36	5 U	2.74
	Duplicate	NA	0.116	0.356 U	59.2	0.86	1.32	6 U	2.92
	17.5 - 19.0	NA	0.108	0.320 U	51.1	1.20	1.81	6 U	1.83
	Split	NA	2.42	3.37 U	33.3	1.19	2.30	1.6 U	1.2
	19.5 - 21.5	NA	0.072	0.358 U	50	1.92	2.55	6 U	1.35
	23.0 - 25.0	NA	0.097	0.368 U	41	1.67	1.78	6 U	0.03 U
	28.0 - 30.0	NA	0.103	0.359 U	34.7	1.59	1.95	6 U	-0.128 U
	53.0 - 55.0	NA	0.137	0.333 U	30.9	0.289 U	0.26	6 U	0.01 U
	101.0 - 103.0	NA	0.131	0.363 U	32.3	0.291 U	0.367	6 U	-0.031 U

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2 Figure 2-25. 216-B-63 Trench, Estimated Impacts of Nitrate and Nitrate/Nitrite in Vadose  
3 Zone Soils on Groundwater.

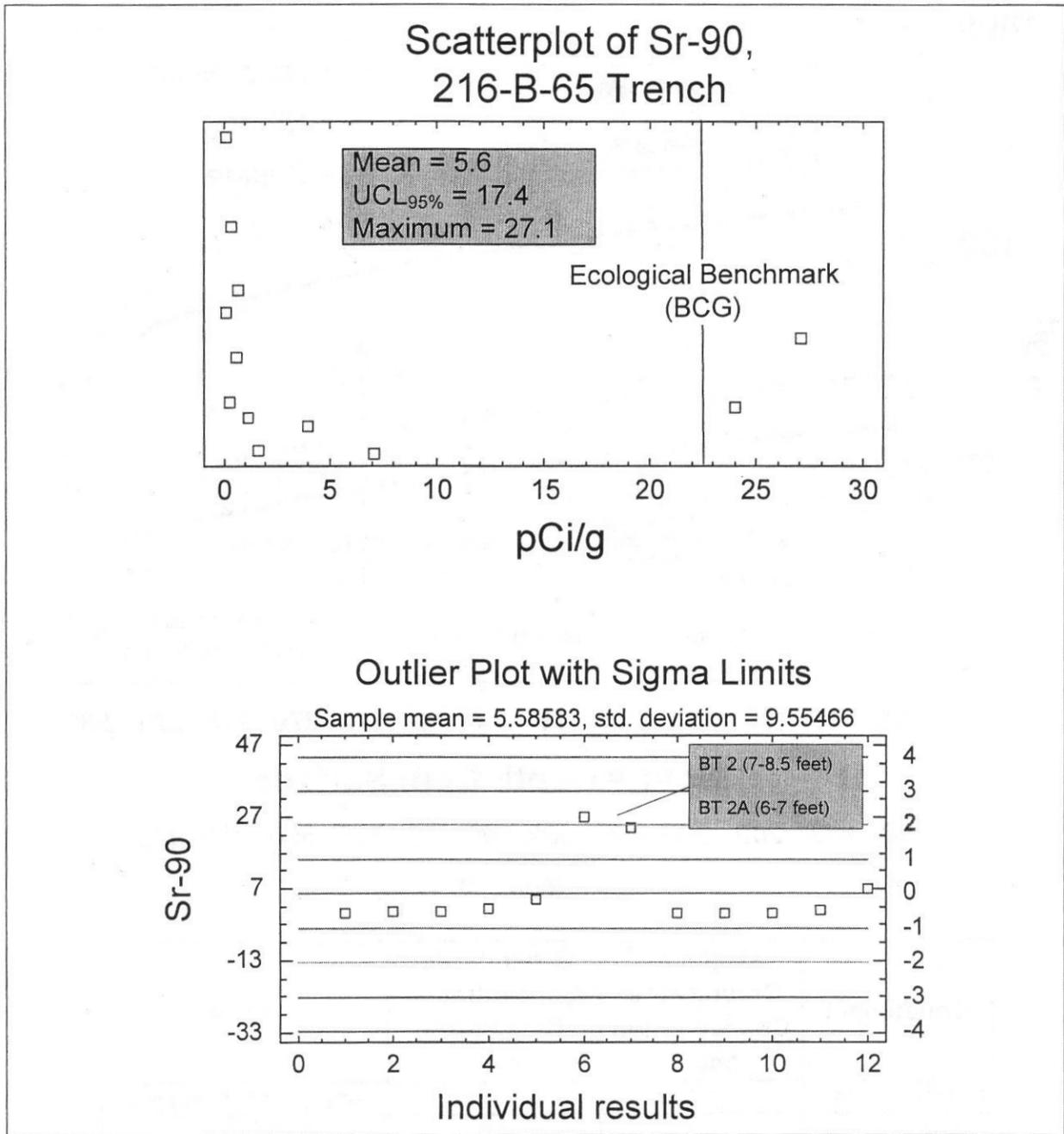


Constituent	Maximum Groundwater Concentration mg/L	Groundwater Concentration Benchmark mg/L	Basis
Nitrate/Nitrite	14	10	Federal DW Standard
Nitrate	8	10	State GW Limit
Sulfate	87	250	State GW Limit

Concentration benchmarks are not necessarily applicable, relevant and/or appropriate.

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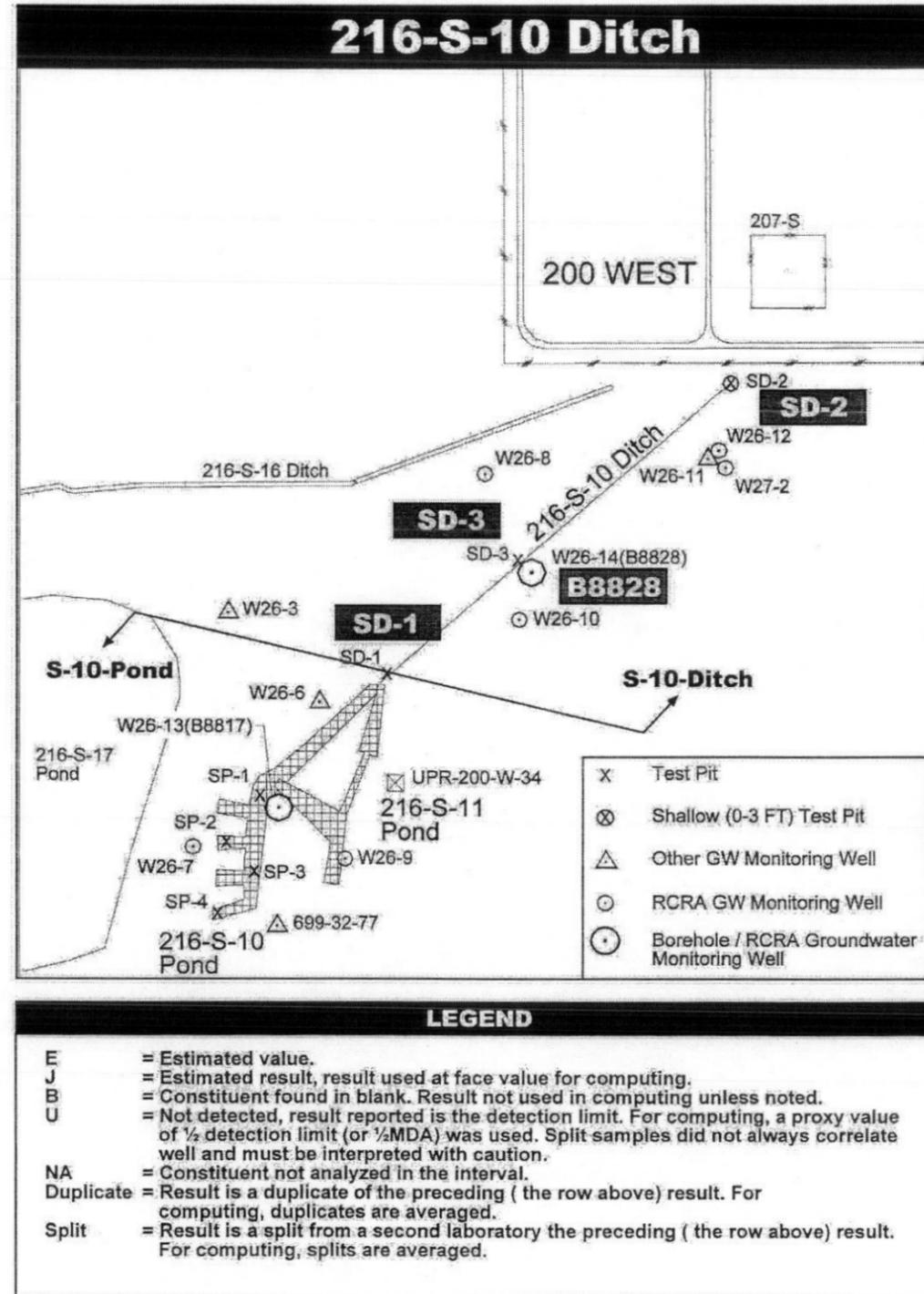
Figure 2-26. Display of Strontium-90 Concentrations in the 0- to 15-Foot Interval.



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Figure 2-27. Summary of Nature and Extent of Contamination for the 216-S-10 Ditch Representative Site.



Interval (feet bgs)	Arsenic	Bismuth	Boron	Chromium	Copper	Mercury	Selenium	Silver	Thallium	Vanadium	Zinc	Aroclor -1254	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluor-anthene	Benzo(k)fluor-anthene	Benzo(ghi)perylene	Chrysene	Cesium-137	Nickel-63	Plutonium-238
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	pCi/g	pCi/g	pCi/g
6.0-7.0	2.9 U	1.5 B	5.2	36.4	13	0.1	0.38 U	0.45 B	0.68 B	66	47.2	35 U	350 U	350 U	350 U	350 U	350 U	350 U	0.16		0 U
8.5-9.5	5.5	NA	0.15	10.6	15.6	0.03 U	0.40 U	0.15 U	NA	86.4	54.9	35 U	350 U	350 U	350 U	350 U	350 U	350 U	0.047 U		0 U
Duplicate	4.9	NA	0.1	10.6	14.1	0.03 U	0.44	0.12 U	NA	87.5	54.8	35 U	350 U	350 U	350 U	350 U	350 U	350 U	0.047 U		0 U
Split	3.8	NA	0.04	8.4	15.4	0.044	0.22 B	0.65 U	NA	82.7	53.7	7.5 U	NA	NA	NA	NA	NA	NA	0.047 U		0 U
11.0-12.0	3.1	NA	0.09	7.3	14.1	0.01 U	0.38 U	0.14 U	NA	85.5	52.4	34 U	340 U	340 U	340 U	340 U	340 U	340 U	0.047 U		0.02 U
13.5-14.5	3.0	NA	NA	11.3	12.9	0.02 U	0.38 U	0.14 U	NA	75.3	51.4	35 U	350 U	350 U	350 U	350 U	350 U	350 U	0.047 U		0.02 U
16.0-17.0	2.5	NA	NA	7.5	12.1	0.01 U	0.36 U	0.13 U	NA	75.2	48.1	34 U	340 U	340 U	340 U	340 U	340 U	340 U	0.047 U	-0.245 U	0 U

Interval (feet bgs)	Arsenic	Bismuth	Boron	Chromium	Copper	Mercury	Selenium	Silver	Thallium	Vanadium	Zinc	Aroclor -1254	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluor-anthene	Benzo(k)fluor-anthene	Benzo(ghi)perylene	Chrysene	Cesium-137	Nickel-63	Plutonium-238
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	pCi/g	pCi/g	pCi/g
0.0-1.5	2.5	2.0 B	1.5 B	815	244	4.30	0.40 U	30.4	0.99 B	69.3	506	3,700	550 J	600 J	530 J	450 J	660 J	680 J	9.13	NA	0.08
1.5-3.0	3.8	NA	NA	287	66.4	0.94	0.34 U	28.4	NA	80.4	121	1,100	360 U	360 U	360 U	360 U	360 U	360 U	0.79	NA	0.05

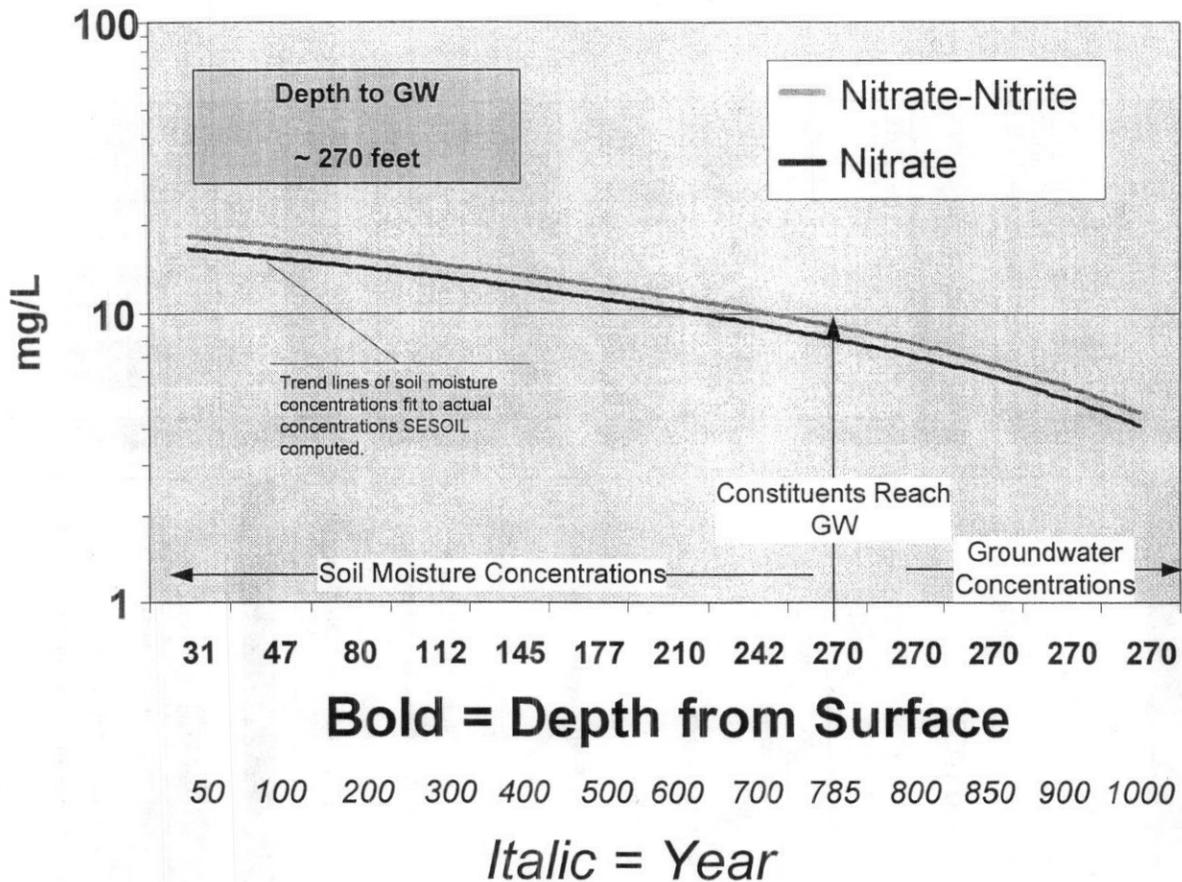
Interval (feet bgs)	Arsenic	Bismuth	Boron	Chromium	Copper	Mercury	Selenium	Silver	Thallium	Vanadium	Zinc	Aroclor -1254	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluor-anthene	Benzo(k)fluor-anthene	Benzo(ghi)perylene	Chrysene	Cesium-137	Nickel-63	Plutonium-238
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	pCi/g	pCi/g	pCi/g
3.0-4.0	3.7	0.58 U	0.78 B	18.4	13.6	0.12	0.38 U	0.68 B	0.59 B	61	44.8	34 U	340 U	340 U	340 U	340 U	340 U	340 U	0.05	NA	0 U
5.5-6.5	3.7	NA	NA	9.8	14.0	0.02 U	0.37 U	0.14	NA	84.1	54.7	35 U	350 U	350 U	350 U	350 U	350 U	350 U	0.026 U	NA	0.03 U
8.0-9.0	5.3	NA	NA	10.3	16.9	0.03	0.39 U	0.14	NA	79.4	58.3	36 U	360 U	360 U	360 U	360 U	360 U	360 U	0.03 U	NA	0.04 U
10.5-11.5	2.6	NA	NA	8.9	15.3	0.02 U	0.36 U	0.13 U	NA	76.7	49.3	34 U	340 U	340 U	340 U	340 U	340 U	340 U	0.027 U	NA	0.04 U
13.0-14.0	2.4	NA	NA	8.2	12.8	0.02 U	0.37 U	0.13 U	NA	71.7	48.8	34 U	340 U	340 U	340 U	340 U	340 U	340 U	0.022 U	NA	0.05 U

Interval (feet bgs)	Arsenic	Bismuth	Boron	Chromium	Copper	Mercury	Selenium	Silver	Thallium	Vanadium	Zinc	Aroclor -1254	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluor-anthene	Benzo(k)fluor-anthene	Benzo(ghi)perylene	Chrysene	Cesium-137	Nickel-63	Plutonium-238
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	pCi/g	pCi/g	pCi/g
20.00-22.00	5.2	35 U	35 U	8.3	15.2	0.016 U	0.581	0.082 U	NA	78.3	55.2	35 U	350 U	350 U	350 U	350 U	350 U	350 U	0.02 U	1.86 U	-0.05 U
Duplicate	4.6	35 U	35 U	8.7	13.9	0.015 U	0.45	0.083 U	NA	79.6	57.2	35 U	350 U	350 U	350 U	350 U	350 U	350 U	0.021 U	1.13	0.05 U
25.00-27.00	3	34 U	34 U	8.1	11.6	0.016	0.294 U	0.065 U	NA	71	45.4	34 U	340 U	340 U	340 U	340 U	340 U	340 U	0.01 U	2.02 U	-0.0085 U
Split	51 U	51 U	51 U	14	16.8	0.1 U	1.9	0.082 E	NA	26.1	31.8	51 U	NA	NA	NA	NA	NA	NA	0.022 U	38.40	-0.042 U
50.00-52.00	6.5	37 U	37 U	14.1	16.9	0.016	0.397 U	0.088 U	NA	70.5	61	37 U	370 U	370 U	370 U	370 U	370 U	370 U	0.1 U	1.39 U	-0.102 U
100.00-102.00	6.4	35 U	35 U	16.5	12	0.02 U	0.32 U	0.07 U	NA	34.4	42.3	35 U	350 U	350 U	350 U	350 U	350 U	350 U	0.095 U	1.01 U	0.03 U
135.00-137.00	6.7	38 U	38 U	23.5	19.5	0.02 U	0.41 U	0.09 U	NA	40.5	53.5	38 U	380 U	380 U	380 U	380 U	380 U	380 U	0.088 U	0.96 U	0 U
150.00-152.00	3.8	38 U	38 U	23.9	19.4	0.02 U	0.4 U	0.09 U	NA	37.4	51	38 U	380 U	380 U	380 U	380 U	380 U	380 U	0.12 U	2.73	0.02 U
165.00-167.00	2.2	38 U	38 U	18.5	20	0.02 U	0.37 U	0.08 U	NA	120	76	38 U	380 U	380 U	380 U	380 U	380 U	380 U	0.064 U	10.70	0.05 U
200.00-202.00	2.3	36 U	36 U	12	18.5	0.02 U	0.38 U	0.08 U	NA	131	69.9	36 U	360 U	360 U	360 U	360 U	360 U	360 U	0.061 U	4.57	-0.018 U
220.00-222.00	1	36 U	36 U	29.8	13.6	0.02 U	0.37 U	0.08 U	NA	40.1	48.8	36 U	360 U	360 U	360 U	360 U	360 U	360 U	NA	NA	NA

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Figure 2-28. 216-S-10 Ditch, Estimated Impacts of Silver in Vadose Zone Soils on Groundwater.

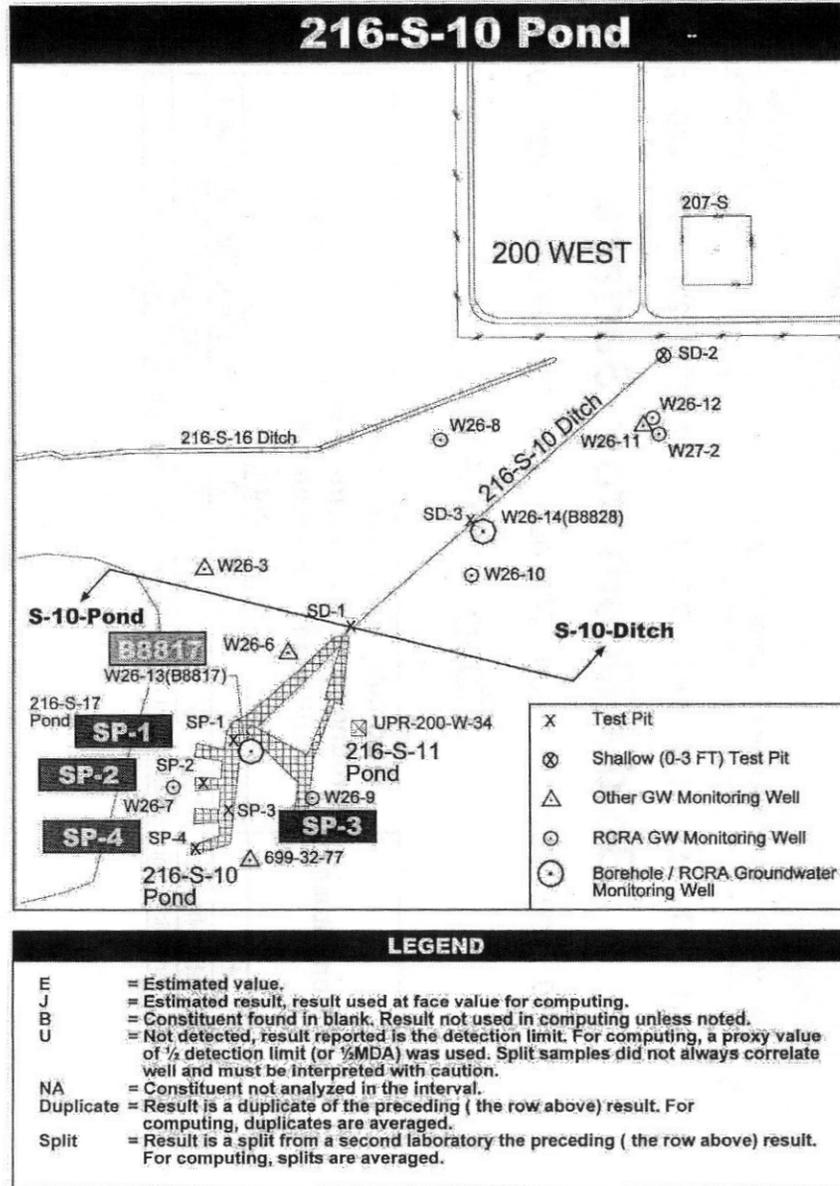


Constituent	Maximum Groundwater Concentration mg/L	Groundwater Concentration Benchmark mg/L	Basis
Nitrate	9	10	Federal DW Standard
Nitrate-Nitrite	10	10	State GW Limit

Concentration benchmarks are not necessarily applicable, relevant and/or appropriate.

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Figure 2-29. Summary of Nature and Extent of Contamination for the 216-S-10 Pond Representative Site.



Interval (feet bgs)	Boron	Selenium	Silver
	mg/kg	mg/kg	mg/kg
7.0 - 8.0	0.54	0.4 U	1.3
9.5 - 10.5	NA	0.35 U	0.39
Duplicate	NA	0.36 U	0.18
Split	NA	0.21 U	0.74 B
12.0 - 13.0	NA	0.35 U	0.13 U
14.5 - 15.5	NA	0.38 U	0.14

Interval (feet bgs)	Boron	Selenium	Silver
	mg/kg	mg/kg	mg/kg
6.5 - 7.5	0.56	0.39 U	0.48
9.0 - 10.0	NA	0.35 U	8.3
11.5 - 12.5	NA	0.35 U	0.22
14.0 - 15.0	NA	0.37 U	0.14 U

Interval (feet bgs)	Boron	Selenium	Silver
	mg/kg	mg/kg	mg/kg
6.0 - 7.0	NA	0.39 U	0.14 U
8.5 - 9.5	NA	0.36 U	0.14 U
11.0 - 12.0	NA	0.38 U	0.14 U
13.5 - 14.5	NA	0.34 U	0.28

Interval (feet bgs)	Boron	Selenium	Silver
	mg/kg	mg/kg	mg/kg
4.0 - 5.0	0.97 B	0.37 U	0.14 U
6.5 - 7.5	NA	0.40 U	0.15 U
9.0 - 10.0	NA	0.46	0.12 U
11.5 - 12.5	NA	0.39 U	0.14 U
14.0 - 15.0	NA	0.37 U	0.13 U

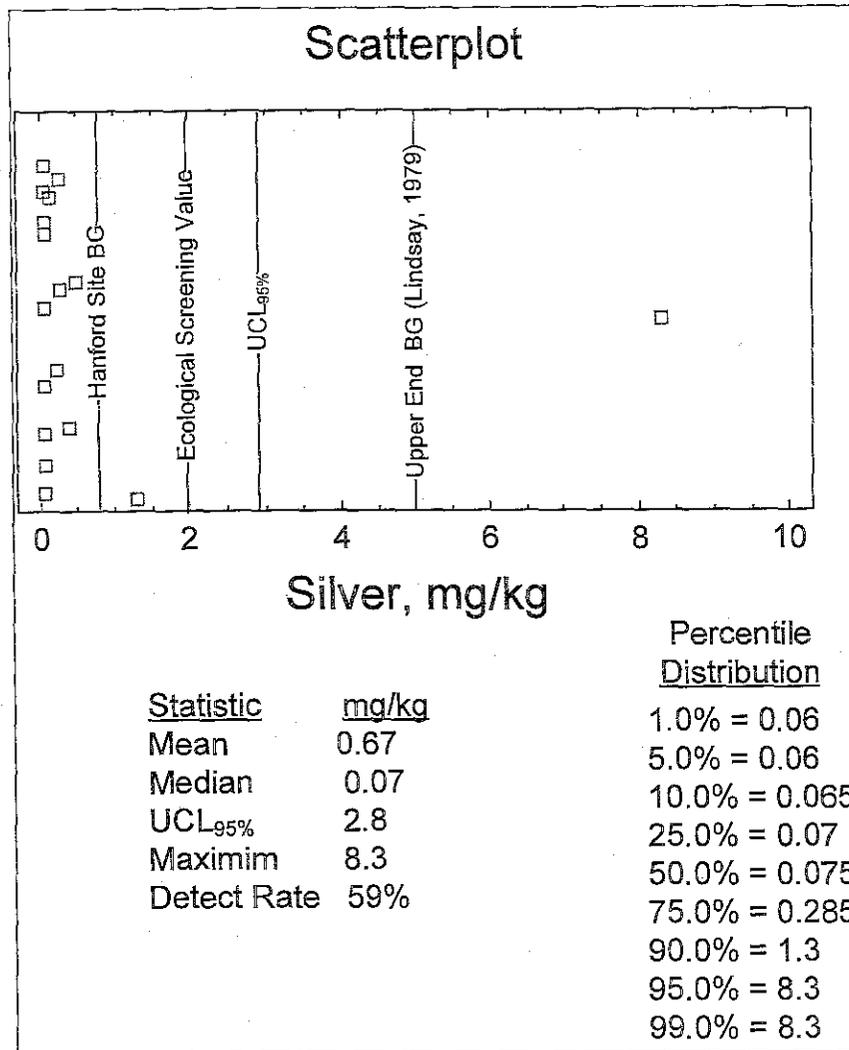
Interval (feet bgs)	Boron	Selenium	Silver
	mg/kg	mg/kg	mg/kg
35.0 - 37.0	NA	0.45 U	0.09 U
Duplicate	NA	0.42 U	0.08 U
Split	NA	0.78	0.09 U
50.0 - 52.0	NA	0.30 U	0.06 U
Duplicate	NA	0.29 U	0.06 U
99.5 - 101.5	NA	0.38 U	0.07 U
135 - 137	NA	0.85	0.07 U
150 - 152	NA	1.9	0.07 U
180 - 182	NA	2	0.07 U
197 - 199	NA	1.1	0.07 U

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Figure 2-30. 216-S-10 Pond Distribution of Silver in Soils 0 to 15 Feet.



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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.

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

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Table 2-2. Representative Site and Analogous Waste Site

Waste Site	Waste Site Configuration, Construction, and Purpose	Current Waste Site Vegetation	Site and Discharge History	Contaminant Inventory*					Effluent Volume (L)	Soil Pore Volume (m <sup>3</sup> )	Rationale
				Total Uranium (Ci)	Total Plutonium (Ci)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)			
<b>Representative Site</b>											
216-S-10 Pond	The pond is located outside the 200 West Area perimeter fence, southwest of the 202-S Building. The pond was approximately 3 acres with four earthen finger trenches. The site received waste from the REDOX between February 1954 and October 1984. Until 1965, the site received the chemical sewer waste from the 202-S Building and overflow from the high water tower via the 216-S-10 Ditch. From 1960s, the site received the bearing cooling water from the 202-S Building. The site was stabilized in October 1984.	--	The 216-S-10 Pond consists of four leaching ponds dug off the southwest end of the 216-S-10 Ditch. By May 1954, the area became swamped again and additional capacity was added. The pond received one documented discharge of dangerous waste. This discharge consisted of simulated double-shell tank slurry, which exhibited dangerous waste characteristics of ignitability, corrosively, characteristic waste, and toxic state-only waste. Approximately 450 kg (1,000 lb) was discharged. NOTE: The 216-S-11 Pond was credited with all the liquid effluent inventory for the 216-S-10 Pond and Ditch system for many years.	6.70x10 <sup>-2</sup> 1.99x10 <sup>2</sup> (kg)	8.17x10 <sup>-3</sup> 1.00x10 <sup>-1</sup> (g)	1.87x10 <sup>-2</sup> 1.52x10 <sup>-2</sup>	1.02 1.24	<8.67x10 <sup>-1</sup> 1.07	2,110,000 32,642	195,831.8 m <sup>3</sup> 6,993,994 (ft <sup>3</sup> )	The 216-S-10 Pond is a backfilled pond characterized by high infiltration (i.e., during operations) and a substantially thick vadose zone (61 m [200 ft] to GW). Based on the very low levels of contamination, the pond does not appear to be a current source of groundwater contamination.
<b>Analogous Waste Sites to be Evaluated by the 216-S-10 Pond</b>											
216-S-11 Pond	This unit is southwest of the 202-S Building and just east of the 216-S-10 Ponds. This site provided an additional leaching surface for the disposal of water from the 216-S-10 Ditch. The site consisted of two connecting pond lobes. The south lobe was backfilled in 1975, but there is no documentation of when the north lobe was backfilled.	--	The site operated from May 1954 to August 1965. After that date, the 216-S-10 Ditch water level was not high enough to overflow into the 216-S-11 Pond. The south pond of 216-S-11 was covered in the summer of 1975 and was free from radioactive contamination. The site as a whole was interim stabilized on September 30, 1983.	2.08x10 <sup>1</sup> (kg)	3.10x10 <sup>1</sup> (g)	--	8.2x10 <sup>-1</sup>	8.14x10 <sup>-1</sup>	2,230,000 m <sup>3</sup>	109,265 m <sup>3</sup>	The 216-S-11 Pond is a backfilled pond characterized by high infiltration (i.e., during operations) and a substantially thick vadose zone (61 m [200 ft] to GW). Based on the very low levels of contamination, the pond does not appear to be a current source of groundwater contamination.

\*Reference: DOE/RL-96-81, Waste Site Grouping for 200 Areas Soil Investigations, unless otherwise noted.

GW = groundwater.  
REDOX = Reduction-Oxidation Plant.

Table 2-3. Summary of Contaminants of Potential Concern Exceeding Screening Levels for the Baseline Risk Assessment Human Health Risk Assessment.

Constituent Name	216-S-10 Ditch		216-S-10 Pond		216-B-63 Trench		216-A-29 Ditch	
	Direct Exposure <sup>a</sup>	Protection of GW	Direct Exposure	Protection of GW	Direct Exposure	Protection of GW	Direct Exposure	Protection of GW
Arsenic	--	X	--	--	--	--	--	X
Bismuth	X <sup>b</sup>	X <sup>b</sup>	--	--	X <sup>b</sup>	X <sup>b</sup>	X <sup>b</sup>	X <sup>b</sup>
Cadmium	--	--	--	--	--	X	--	X
Mercury	--	X	--	--	--	--	--	X
Silver	--	X	--	--	--	--	--	X
Uranium	--	--	--	--	--	--	--	X
Nitrate as N	--	--	--	--	--	X	--	X
Nitrate and nitrate/nitrite as N	--	--	--	--	--	X	--	X
Sulfate	--	--	--	--	--	--	--	X
Methylene chloride	--	--	--	X	--	--	--	X
Vinyl chloride	--	--	--	X	--	--	--	--
Benzene	--	--	--	--	--	X	--	--
Benzo(a)anthracene	--	X	--	--	--	--	--	X
Benzo(a)pyrene	--	X	--	--	--	--	--	--
Benzo(b)fluoranthene	--	X	--	--	--	--	--	--
Benzo(k)fluoranthene	--	X	--	--	--	--	--	--
Chrysene	--	X	--	--	--	--	--	X
Tributyl phosphate	--	--	--	--	--	--	X <sup>b</sup>	X <sup>b</sup>
1,2-dichloroethane	--	--	--	--	--	--	--	X
Aroclor 1254	--	X	--	--	--	--	--	X

<sup>a</sup>Assumes industrial land use in accordance with WAC 173-340-745, "Soil Cleanup Standards for Industrial Properties."

<sup>b</sup>Scientific rationale presented in the remedial investigation established that these constituents do not pose a significant threat and they were omitted from further consideration as contaminants of potential concern. The constituent is included in this table because appropriate screening information is not available (see text).

GW = groundwater.

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Table 2-4. Summary of Contaminants of Potential Concern and Potential Threat to Groundwater.

Chemical Name	$K_d$ (L/kg)	Potential Threat to Groundwater <sup>a</sup>
Arsenic	29	Yes
Bismuth	100	No
Cadmium	6.7	Yes
Mercury	52	No
Silver	8.3	Yes
Uranium	0.6	Yes
Nitrate as N	0 <sup>b</sup>	Yes
Nitrate and nitrate/nitrite as N	0 <sup>b</sup>	Yes
Sulfate	0 <sup>b</sup>	Yes
Methylene chloride	0.01	Yes
Vinyl chloride	0.0186	Yes
Benzene	0.6	Yes
Benzo(a)anthracene	357	No
Benzo(a)pyrene	969	No
Benzo(b)fluoranthene	1230	No
Benzo(k)fluoranthene	1230	No
Benzo(g,h,i)perylene	1586 <sup>c</sup>	No
Chrysene	398	No
Tributyl phosphate	Not available	Yes
1,2-dichloroethane	0.038	Yes
Aroclor 1254	309	No

<sup>a</sup>Based on the  $K_d < 40$  mobile;  $K_d >$  immobile determination for the vadose zone and groundwater (see text).

<sup>b</sup> $K_d$  not provided. Conservatively assume to be highly mobile in the vadose zone and groundwater.

<sup>c</sup> $K_{oc} = 1.58E+6$  (Mackay et al. 2000), assumes  $foc = 0.1\%$  (Ecology 2003).

Ecology, 2003, *Cleanup Levels and Risk Calculations (CLARC) Database*,  
<https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx>.

Mackay, D., W. Y. Shiu, and K. C. Ma, 2000, *Physical-Chemical Properties and Environmental Fate Handbook*.

$foc$  = fractional organic carbon.

$K_d$  = distribution coefficient.

$K_{oc}$  = soil organic carbon-water partition coefficient.

Table 2-5. Summary of RESRAD Dose, Risk, and Groundwater Protection Modeling Results from Baseline Risk Assessment.

	Scenario	216-S-10 Ditch	216-S-10 Pond	216-B-63 Trench	216-A-29 Ditch
Maximum Dose (mrem/yr)	Industrial-Cover	<sup>a</sup>	5.3E-5	2.4E-4	0.01 mrem
	Industrial-No Cover	0.4	3.6	0.5	35 (yr 0) <sup>b</sup>
	Unrestricted-Cover	<sup>a</sup>	0.5	0.8	108 (yr 500)
	Unrestricted-No Cover	4.5	42 (yr 0) <sup>b</sup> 8.9 (yr 10) <sup>b</sup>	45 (yr 0) <sup>b</sup> 4.6 (yr 100) <sup>b</sup>	307 (yr 0) <sup>b</sup>
Maximum Risk (ELACR)	Industrial-Cover	<sup>a</sup>	1E-9	5E-9	3E-7
	Industrial-No Cover	4E-6	2E-5	7E-6	1E-4
	Unrestricted-Cover	<sup>a</sup>	8E-6	1E-5	2E-4 (yr 1000) <sup>b</sup>
	Unrestricted-No Cover	5E-5	2E-4 (yr 0) <sup>b</sup> 1E-5 (yr 10) <sup>b</sup>	6E-4 (yr 0) <sup>b</sup> 6E-5 (yr 100) <sup>b</sup>	1E-3 (yr 0) <sup>b</sup>
Groundwater Impacts	--	No breakthrough	No breakthrough	0.015 mrem/y (Tc-99 yr 708)	0.005 mrem/yr (tritium yr 103)

NOTE: The unrestricted-use scenario is provided only for information, not for consideration in the feasibility study process.

<sup>a</sup>Analysis not provided in remedial investigation.

<sup>b</sup>A shaded cell indicates the dose exceeds 15 mrem/y or risk exceeds 1E-4. The year in (parentheses) is the year from the present when the exceedance occurs. When a second dose or risk is shown in a cell, it illustrates the approximate time that the exceedance disappears and the value at that time. If a second dose or risk value is not shown in a shaded cell, it means that the exceedance does not disappear within the 1,000-year modeling framework.

ANL, 2002, *RESRAD for Windows*.

ELACR = excess lifetime added cancer risk.

RESRAD = RESidual RADioactivity (dose model) (ANL 2002).

Table 2-6. Baseline Risk Assessment Hazard Quotients for Contaminants of Ecological Concern for which Industrial Land-Use Screening Levels Are Available.

Constituent	216-S-10 Ditch	216-S-10 Pond	216-B-63 Trench	216-A-29 Ditch
Arsenic	--	--	--	1.7
Boron	3.0	2.0	12	6.8
Cadmium	--	--	--	2.0
Total chromium	12	--	--	--
Copper	1.1	--	--	--
Lead	--	--	--	3.3
Molybdenum	--	--	--	1.4
Selenium	1.5	1.5	2.5	8.3
Silver	15	4.2	--	21
Thallium	1.0	--	--	--
Uranium	--	--	--	1.1
Vanadium	44	--	43	52
Zinc	1.4	--	--	--
Aroclor 1254	5.7	--	--	14
Radioactive strontium	--	--	1.5	--

Table 2-7. Summary of Screening Values from Remedial Investigation. (2 Pages)

Constituent	Hanford Site Background	Industrial Direct Contact	Groundwater Protection	Industrial Ecological Screening
<b>Inorganics in mg/kg</b>				
Arsenic	6.5	87.5	0.0304	7
Barium	132	24,500	923	102
Beryllium	1.51	7,000	63.2	35
Bismuth	--	--	--	--
Boron	--	315,000	11.2	0.5
Cadmium	0.81	3,500	0.69	14
Chromium (total)	18.5	5,250,000	2,000	67
Hexavalent chromium	--	10,500	18.4	--
Copper	22	130,000	262	217
Lead	10.2	1,000	3,000	118
Manganese	512	49,000	50	1,500
Mercury	0.33	1,050	2.09	5.5
Molybdenum	--	17,500	16.3	7
Nickel	19.1	70,000	130	980
Selenium	--	17,500	5.2	0.3
Silver	0.73	17,500	13.6	2
Thallium	--	245	1.59	1
Uranium	3.21	10,500	1.3	5
Vanadium	85.1	24,500	2,240	2
Zinc	67.8	1,050,000	5,970	360
Ammonia as NH <sub>3</sub>	9.23	--	--	--
Chloride	100	--	1,000	--
Cyanide	--	70,000	0.8	--
Fluoride	2.81	--	16	--
Nitrate as N	12	350,000	40	--
Nitrate as N	--	350,000	4	--
Nitrate/nitrite as N	--	350,000	40	--
Phosphate	0.785	--	--	--
Sulfate	237	--	--	1,000
Sulfide	--	--	--	--
2-butannone	--	2.10E+9	2.18E+4	--
1,2-dichloroethane	--	1.40E+6	2.3	--
Acetone	--	3.15E+9	2.89E+4	--
Acenaphthene	--	2.10E+8	9.79E+4	--
Anthracene	--	1.50E+9	1.14E+6	--
Benzene	--	2.39E+6	4.48	--

Table 2-7. Summary of Screening Values from Remedial Investigation. (2 Pages)

Constituent	Hanford Site Background	Industrial Direct Contact	Groundwater Protection	Industrial Ecological Screening
<b>Inorganics in mg/kg</b>				
Benzo(a)anthracene	--	1.80E+4	8.57E+1	--
Benzo(a)pyrene	--	1.80E+4	2.33E+2	1.20E+4
Benzo(b)fluoranthene	--	1.80E+4	2.95E+2	--
Benzo(ghi)perylene	--	1.04E+4	6.55E+5	--
Benzo(k)fluoranthene	--	1.80E+4	2.95E+2	--
Bis(2-ethylhexyl)phthalate	--	9.38E+6	1.33E+4	--
Butylbenzylphthalate	--	7.00E+8	8.96E+5	--
Carbazole	--	6.56E+6	3.14E+2	--
Chrysene	--	1.80E+4	9.56E+1	--
Di-n-butylphthalate	--	3.50E+8	1.14E+4	--
Dibenz[a,h]anthracene	--	1.80E+4	4.30E+2	--
Diethylphthalate	--	2.89E+9	7.22E+4	--
Flouranthene	--	1.40E+8	6.31E+5	--
Fluorene	--	1.40E+8	1.24E+4	--
Methylene chloride	--	1.75E+7	2.18E+1	--
Phenanthrene	--	1.05E+9	6.55E+5	--
Pyrene	--	1.05E+8	6.55E+5	--
Aroclor 1254	--	7.00E+4	9.89E+2	6.50E+2
Diesel range TPH	--	2.00E+6	2.00E+6	6.50E+6
Kerosene range TPH	--	2.00E+6	2.00E+6	--
Tetrachloroethynene	--	2.60E+6	9.1	--
Tributyl phosphate	--	--	--	--
Toluene	--	7.00E+5	7.27E+3	--
Vinyl chloride	--	8.75E+4	1.84E-1	--
Xylene	--	7.00E+5	1.46E+4	--
<b>Radionuclides in pCi/g</b>				
Cs-137	--	--	--	21.7
Pu-239/240	--	--	--	6100
Ra-226	--	--	--	43.1
Radioactive strontium (as Sr-90)	--	--	--	14.1
Th-238	--	--	--	405*
Th-230	--	--	--	405*

\*Assumes Th-232.

-- means no value available.

Shaded is the controlling value.

TPH = total petroleum hydrocarbon.

Table 2-8. Summary of Contaminants of Potential Concern Exceeding Screening Levels for the Remedial Investigation Baseline Risk Assessment. (2 Pages)

Constituent	216-S-10 Ditch			216-S-10 Pond			216-B-63 Trench			216-A-29 Ditch		
	Direct Exposure <sup>a</sup>	Protection of GW	ECO	Direct Exposure	Protection of GW	ECO	Direct Exposure	Protection of GW	ECO	Direct Exposure	Protection of GW	ECO
Arsenic	--	X	--	--	--	--	--	--	--	--	X	X
Bismuth	X <sup>b</sup>	X <sup>b</sup>	--	--	--	--	X <sup>b</sup>	X <sup>b</sup>	--	X <sup>b</sup>	X <sup>b</sup>	--
Boron	--	--	X	--	--	X	--	--	X	--	--	X
Cadmium	--	--	--	--	--	--	--	X	--	--	X	X
Copper	--	--	X	--	--	--	--	--	--	--	--	--
Chromium (total)	--	--	X	--	--	--	--	--	--	--	--	--
Lead	--	--	--	--	--	--	--	--	--	--	--	X
Mercury	--	X	--	--	--	--	--	--	--	--	X	--
Molybdenum	--	--	--	--	--	--	--	--	--	--	--	X
Selenium	--	--	X	--	--	X	--	--	X	--	--	X
Silver	--	X	X	--	--	X	--	--	--	--	X	X
Thallium	--	--	X	--	--	--	--	--	--	--	--	--
Uranium	--	--	--	--	--	--	--	--	--	--	X	X
Vanadium	--	--	X	--	--	--	--	--	X	--	--	X
Zinc	--	--	X	--	--	--	--	--	--	--	--	--
Nitrate as N	--	--	--	--	--	--	--	X	--	--	X	--
Nitrate and nitrate/nitrite as N	--	--	--	--	--	--	--	X	--	--	X	--
Sulfate	--	--	--	--	--	--	--	--	--	--	X	--
Methylene chloride	--	--	--	--	X	--	--	--	--	--	X	--
Vinyl chloride	--	--	--	--	X	--	--	--	--	--	--	--
Benzene	--	--	--	--	--	--	--	X	--	--	--	--
Benzo(a)anthracene	--	X	--	--	--	--	--	--	--	--	X	--
Benzo(a)pyrene	--	X	--	--	--	--	--	--	--	--	--	--
Benzo(b)fluoranthene	--	X	--	--	--	--	--	--	--	--	--	--
Benzo(k)fluoranthene	--	X	--	--	--	--	--	--	--	--	--	--
Chrysene	--	X	--	--	--	--	--	--	--	--	X	--

Table 2-8. Summary of Contaminants of Potential Concern Exceeding Screening Levels for the Remedial Investigation Baseline Risk Assessment. (2 Pages)

Constituent	216-S-10 Ditch			216-S-10 Pond			216-B-63 Trench			216-A-29 Ditch		
	Direct Exposure <sup>a</sup>	Protection of GW	ECO	Direct Exposure	Protection of GW	ECO	Direct Exposure	Protection of GW	ECO	Direct Exposure	Protection of GW	ECO
Tributyl phosphate	--	--	--	--	--	--	--	--	--	X <sup>b</sup>	X <sup>b</sup>	--
1,2-dichloroethane	--	--	--	--	--	--	--	--	--	--	X	--
Aroclor 1254	--	X	--	--	--	--	--	--	--	--	X	X
Cs-137	--	--	--	--	--	--	--	--	--	--	--	--
Pu-239/240	--	--	--	--	--	--	--	--	--	X <sup>c</sup>	--	--
Ra-226	--	--	--	--	--	--	--	--	--	--	--	--
Sr-90	--	--	--	--	--	--	--	--	--	--	--	--
Th-228	--	--	--	--	--	--	--	--	--	--	--	--
Th-230	--	--	--	--	--	--	--	--	--	--	--	--

<sup>a</sup>Assumes industrial land use in accordance with WAC 173-340-745, "Soil Cleanup Standards for Industrial Properties."

<sup>b</sup>Scientific rationale presented in the remedial investigation established that this constituent does not pose a significant threat and it was omitted from further consideration as a contaminant of potential concern. The constituent is included in this table because appropriate screening information is not available (see text).

<sup>c</sup>Pu-239/240 RESRAD modeling produced dose estimates exceeding 15 mrem/yr for the industrial-use, no-cover scenario.

ANL, 2002, *RESRAD for Windows*.

- 95%UCL = 95th upper confidence level.
- ECO = ecological.
- GW = groundwater.
- RESRAD = RESidual RADioactivity (dose model) (ANL 2002).

2-140

Table 2-9. Summary of Screening Values. (2 Pages)

Constituent	Hanford Site Background	Industrial Direct Contact	Groundwater Protection	Industrial Ecological Screening
<b>Inorganics in mg/kg</b>				
Arsenic	6.5	87.5	0.0304	7
Barium	132	24,500	923	102
Beryllium	1.51	7,000	63.2	35
Bismuth	--	--	--	--
Boron	--	315,000	11.2	0.5
Cadmium	0.81	3,500	0.69	14
Chromium (total)	18.5	5,250,000	2,000	67
Hexavalent chromium	--	10,500	18.4	--
Copper	22	130,000	262	217
Lead	10.2	1,000	3,000	118
Manganese	512	49,000	50	1,500
Mercury	0.33	1,050	2.09	5.5
Molybdenum	--	17,500	16.3	7
Nickel	19.1	70,000	130	980
Selenium	0.78	17,500	5.2	0.3
Silver	0.73	17,500	13.6	2
Thallium	--	245	1.59	1
Uranium	3.21	10,500	1.3	5
Vanadium	85.1	24,500	2,240	2
Zinc	67.8	1,050,000	5,970	360
Ammonia as NH <sub>3</sub>	9.23	--	--	--
Chloride	100	--	1,000	--
Cyanide	--	70,000	0.8	--
Fluoride	2.81	--	16	--
Nitrate as N	12	350,000	40	--
Nitrate as N	--	350,000	4	--
Nitrate/nitrite as N	--	350,000	40	--
Phosphate	0.785	--	--	--
Sulfate	237	--	--	1,000
Sulfide		--	--	--
2-butannone	--	2.10E+9	2.18E+4	--
1,2-dichloroethane	--	1.40E+6	2.3	--
Acetone	--	3.15E+9	2.89E+4	--
Acenaphthene	--	2.10E+8	9.79E+4	--
Anthracene	--	1.50E+9	1.14E+6	--
Benzene	--	2.39E+6	4.48	--
Benzo(a)anthracene	--	1.80E+4	8.57E+1	--
Benzo(a)pyrene	--	1.80E+4	2.33E+2	1.20E+4
Benzo(b)fluoranthene	--	1.80E+4	2.95E+2	--

Table 2-9. Summary of Screening Values. (2 Pages)

Constituent	Hanford Site Background	Industrial Direct Contact	Groundwater Protection	Industrial Ecological Screening
Benzo(ghi)perylene	--	1.04E+4	6.55E+5	--
Benzo(k)fluoranthene	--	1.80E+4	2.95E+2	--
Bis(2-ethylhexyl)phthalate	--	9.38E+6	1.33E+4	--
Butylbenzylphthalate	--	7.00E+8	8.96E+5	--
Carbazole	--	6.56E+6	3.14E+2	--
Chrysene	--	1.80E+4	9.56E+1	--
Di-n-butylphthalate	--	3.50E+8	1.14E+4	--
Dibenz[a,h]anthracene	--	1.80E+4	4.30E+2	--
Diethylphthalate	--	2.89E+9	7.22E+4	--
Flouranthene	--	1.40E+8	6.31E+5	--
Fluorene	--	1.40E+8	1.24E+4	--
Methylene chloride	--	1.75E+7	2.18E+1	--
Phenanthrene	--	1.05E+9	6.55E+5	--
Pyrene	--	1.05E+8	6.55E+5	--
Aroclor 1254	--	7.00E+4	9.89E+2	6.50E+2
Diesel range TPH	--	2.00E+6	2.00E+6	6.50E+6
Kerosene range TPH	--	2.00E+6	2.00E+6	--
Tetrachloroethyene	--	2.60E+6	9.1	--
Tributyl phosphate	--	--	--	--
Toluene	--	7.00E+5	7.27E+3	--
Vinyl chloride	--	8.75E+4	1.84E-1	--
Xylene	--	7.00E+5	1.46E+4	--
<b>Radionuclides in pCi/g</b>				
Cs-137	--	--	--	21.7
Pu-239/240	--	--	--	6100
Ra-226	--	--	--	43.1
Radioactive strontium (as Sr-90)	--	--	--	22.5
Th-238	--	--	--	405*
Th-230	--	--	--	405*

\*Assume Th-232.

-- means no value available.

Shaded is the controlling value, which is the lowest.

Screening values that are less than background are not applicable.

This table includes all screening values in the remedial investigation baseline risk assessment.

TPH = total petroleum hydrocarbon.

Table 2-10. Summary of Contaminants of Potential Concern and Potential Threat to Groundwater.

Chemical Name	$K_d$ (L/kg)	Potential Threat to Groundwater <sup>a</sup>
Arsenic	29	Yes
Bismuth	100	No
Cadmium	6.7	Yes
Mercury	52	No
Silver	8.3	Yes
Uranium	0.6	Yes
Nitrate as N	0 <sup>b</sup>	Yes
Nitrate and nitrate/nitrite as N	0 <sup>b</sup>	Yes
Sulfate	0 <sup>b</sup>	Yes
Methylene chloride	0.01	Yes
Vinyl chloride	0.0186	Yes
Benzene	0.6	Yes
Benzo(a)anthracene	357	No
Benzo(a)pyrene	969	No
Benzo(b)fluoranthene	1230	No
Benzo(k)fluoranthene	1230	No
Benzo(g,h,i)perylene	1586 <sup>c</sup>	No
Chrysene	398	No
Tributyl phosphate	Not available	Yes
1,2-dichloroethane	0.038	Yes
Aroclor 1254	309	No

<sup>a</sup>Based on the  $K_d < 40$  mobile;  $K_d >$  immobile determination for the vadose zone and groundwater (see text).

<sup>b</sup> $K_d$  not provided. Conservatively assume to be highly mobile in the vadose zone and groundwater.

<sup>c</sup> $K_{oc} = 1.58E+6$  (Mackay et al. 2000), assumes  $foc = 0.1\%$  (Ecology 2003).

Ecology, 2003, *Cleanup Levels and Risk Calculations (CLARC) Database*,  
<https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx>.

Mackay, D., W. Y. Shiu, and K. C. Ma, 2000, *Physical-Chemical Properties and Environmental Fate Handbook*.

$foc$  = fractional organic carbon

$K_d$  = distribution coefficient.

$K_{oc}$  = soil organic carbon-water partition coefficient.

1

Table 2-11. 216-A-29 Ditch Contaminants of Potential Concern.

Constituent	Direct Exposure	Protection of Groundwater	Industrial Use Ecological Hazard Quotient >1.0
Arsenic	--	X	X
Bismuth	X	X	--
Boron	--	--	X
Cadmium	--	X	X
Lead	--	--	X
Mercury	--	X	
Molybdenum	--	--	X
Selenium	--	--	X
Silver	--	X	X
Uranium	--	X	X
Vanadium	--	--	X
Nitrate as N	--	X	--
Nitrate and nitrate/nitrite as N	--	X	--
Sulfate	--	X	--
Methylene chloride	--	X	--
Benzo(a)anthracene	--	X	--
Chrysene	--	X	--
Tributyl phosphate	X	X	--
1,2-dichloroethane	--	X	--
Aroclor 1254	--	X	X
Pu-239/240	X	--	--

2

3

Table 2-12. 216-A29 Trench Summary of Extended Nature and Extent of Contamination Assessment. (6 Pages)

Constituent	Hanford Site Background	Industrial Direct Contact	GW Protection	Industrial Ecological Screening	Maximum (Location)	Mean 95%UCL	Remark
<b>Inorganics in mg/kg</b>							
Arsenic	6.5	87.5	0.0304	7	12.2 (AD-3)	4.9 7	<ul style="list-style-type: none"> <li>No excessive contamination.</li> <li>AD-3: 6- to 9-ft intervals dictate screening.</li> <li>Mean and 95%UCL suggest typical EPC comparable to background.</li> </ul>
Boron	--	315,000	11.2	0.5 (Remark)	3.4 (AD-1)	3.1 NR	<ul style="list-style-type: none"> <li>No local background data exist.</li> <li>Typical soil concentration in basalts 5 to 20 mg/kg, up to 30 mg/kg in sandstones and 130 mg/kg in shales (Pendias and Pendias 1992).</li> <li>Washington soils up to 70 mg/kg (Dragun and Chekiri 2005).</li> <li>No apparent elevation based on three samples.</li> <li>The 0.5 mg/kg ecological-screening value is based on protection of plants and may not be the most appropriate. ES/ER/TN-86/R3 identifies a NOAEL<sub>food</sub> of 220 mg/kg.</li> </ul>
Cadmium	0.81	3,500	0.69	14	28 (AD-1)	1.5 6.1	<ul style="list-style-type: none"> <li>No excessive contamination.</li> <li>AD-1: 4- to 5-ft anomaly.</li> <li>Many detections are below or near detection limit.</li> <li>Mean and 95%UCL suggest typical EPC is much lower than maximum.</li> </ul>

Table 2-12. 216-A29 Trench Summary of Extended Nature and Extent of Contamination Assessment. (6 Pages)

Constituent	Hanford Site Background	Industrial Direct Contact	GW Protection	Industrial Ecological Screening	Maximum (Location)	Mean 95%UCL	Remark
Lead	10.2	1,000	3,000	118	362 Average of duplicates (AD-2)	24.8 84.4	<ul style="list-style-type: none"> <li>Anomalies: AD-1: 4 to 6 ft, AD-2: 7.5 to 8.5 ft, B8826: 4 to 6 ft, Area 8: 13 ft.</li> <li>Most other detections are below or background.</li> <li>Mean and 95%UCL suggest typical EPC is much lower than maximum.</li> </ul>
Mercury	0.33	1,050	2.09	5.5	5.2 (AD-1)	0.6 1.8	<ul style="list-style-type: none"> <li>Anomalies: AD-1: 4 to 6 ft, AD-2: 7.5 to 8.5 ft, B8826: 4 to 6 ft, Area 8: 13 ft.</li> <li>Most other detections are below or background.</li> <li>Mean and 95%UCL suggest typical EPC is much lower than maximum.</li> </ul>
Molybdenum	--	17,500	16.3	7 (Remark)	3.2 (AD-1)	1.3 NR	<ul style="list-style-type: none"> <li>Apparent mis-categorization. Lowest screening value is 7 mg/kg.</li> </ul>

2-146

DOE/RL-2005-63 DRAFT A

Table 2-12. 216-A29 Trench Summary of Extended Nature and Extent of Contamination Assessment. (6 Pages)

Constituent	Hanford Site Background	Industrial Direct Contact	GW Protection	Industrial Ecological Screening	Maximum (Location)	Mean 95%UCL	Remark
Selenium	0.78 mg/kg	17,500	5.2	0.3 (Remark)	18.5 (Area 8)	1.0 4.0	<ul style="list-style-type: none"> <li>Anomaly at Area 8: Detection at 13 ft governs this distribution.</li> <li>Most other detections are below or near detection limits and within expected ranges.</li> <li>Note that the Hanford Site background value was not available for use in the remedial investigation baseline risk assessment.</li> <li>Typical range of selenium in soils 0.1 to 2.0 mg/kg (Dragun 1998).</li> <li>Observed range in western United States (&lt;0.1 to 4.3).</li> <li>Mean and 95%UCL suggest typical EPC is much lower than maximum and within expected ranges.</li> <li>ES/ER/TN-86/R3 illustrates derivation of soils-screening method resulting in 14.8 mg/kg values.</li> </ul>
Silver	0.73	17,500	13.6	2	42 (AD-1)	1.9 8.7	<ul style="list-style-type: none"> <li>Anomaly at AD-1: 4 to 6 ft.</li> <li>Apparent elevations at AD-2: 7.5 to 8.5 ft, B8826: 4 to 6 ft, Area 8: 13 ft.</li> <li>Most other detections are below or near background detection limits.</li> <li>Mean and 95%UCL suggest typical EPC is much lower than maximum; 95%UCL is the approximate lowest screening value.</li> </ul>

2-147

DOE/RL-2005-63 DRAFT A

Table 2-12. 216-A29 Trench Summary of Extended Nature and Extent of Contamination Assessment. (6 Pages)

Constituent	Hanford Site Background	Industrial Direct Contact	GW Protection	Industrial Ecological Screening	Maximum (Location)	Mean 95%UCL	Remark
Uranium	3.21	10,500	1.3	5	4.3 Average of duplicates) (AD-2)	1.3 1.6	<ul style="list-style-type: none"> <li>Anomaly at AD-2: 7.5 to 8.5 ft.</li> <li>Other elevated concentrations at AD-3: 6- to 9-ft interval.</li> <li>Most other detections are below or near background.</li> <li>Mean and 95%UCL suggest typical EPC to be in the range of background.</li> </ul>
Vanadium	85.1	24,500	2,240	2 (Remark)	97.4 Average of duplicates) (AD-2)	64.2 69.8	<ul style="list-style-type: none"> <li>Anomaly at AD-2: 7.5 to 8.5 ft.</li> <li>Most other detections are below or background.</li> <li>Mean and 95%UCL suggest typical EPC to be in the range of background.</li> <li>There are no primary toxicity data describing vanadium toxicity to plants in soil and confidence in the 2 mg/kg ecological-screening value is low (ES/ER/TN-86/R3).</li> </ul>
Nitrate as N	12	350,000	40	--	210 (AD-1)	35.7 66.9	<ul style="list-style-type: none"> <li>Anomalies at AD-1: 4 to 6 ft and 6.5 to 7.5 ft.</li> <li>Apparent elevations also at AD-2: 7.5 to 8.5 ft and AD-3: 6 to 7 ft.</li> <li>Many other detections are in the range of background.</li> <li>Mean and 95%UCL suggest typical EPC is much lower than maximum.</li> <li>95%UCL is the lowest screening value.</li> </ul>

2-148

DOE/RL-2005-63 DRAFT A

Table 2-12. 216-A29 Trench Summary of Extended Nature and Extent of Contamination Assessment. (6 Pages)

Constituent	Hanford Site Background	Industrial Direct Contact	GW Protection	Industrial Ecological Screening	Maximum (Location)	Mean 95%UCL	Remark
Nitrate and nitrate/nitrite as N	--	350,000	40	--	424.5 Average of duplicates (AD-2)	36.1 116.3	<ul style="list-style-type: none"> <li>Anomaly at AD-2: 7.5 to 8.5 ft.</li> <li>Apparent elevations in upper strata at AD-1, AD-3, and B8826.</li> <li>Mean and 95%UCL suggest typical EPC is to be in the range of background.</li> </ul>
Sulfate	237	--	--	1,000	2,970 (AD-1)	22.6 704.6	<ul style="list-style-type: none"> <li>Anomaly at AD-1: 4 to 6 ft.</li> <li>Most other detections are below or near background detection limits.</li> <li>Mean and 95%UCL suggest typical EPC is much lower than maximum.</li> </ul>
<b>Organics in µg/kg</b>							
Aroclor 1254	--	7.00E+4	9.89E+2	6.50E+2	9,400 J AD-1	NA	<ul style="list-style-type: none"> <li>One detection in 40 samples is a 2.5% detection rate.</li> <li>"J" estimate because the sample was diluted.</li> </ul>
Benzo(a)-anthracene	--	1.80E+4	8.57E+1	--	180 J AD-1	NA	<ul style="list-style-type: none"> <li>Two detections: AD-1: 4 to 5 ft and AD-3: 6 to 7 ft.</li> <li>Two detections in 40 samples is a 5% detection rate.</li> <li>"J" estimates because both samples were diluted.</li> </ul>
Chrysene	--	1.80E+4	9.56E+1	--	210 J AD-1	NA	<ul style="list-style-type: none"> <li>Two detections: AD-1: 4 to 5 ft and AD-3: 6 to 7 ft.</li> <li>Two detections in 40 samples is a 5% detection rate.</li> <li>"J" estimates because both samples were diluted.</li> </ul>

2-149

DOE/RL-2005-63 DRAFT A

Table 2-12. 216-A29 Trench Summary of Extended Nature and Extent of Contamination Assessment. (6 Pages)

Constituent	Hanford Site Background	Industrial Direct Contact	GW Protection	Industrial Ecological Screening	Maximum (Location)	Mean 95%UCL	Remark
<b>Radionuclides in pCi/g</b>							
Pu-239/240	--	--	--	6,100 (Remark)	667 (B8826)	39 200.2	<ul style="list-style-type: none"> <li>Anomalies at B8826: 4 to 6 ft, AD-1: 4 to 5 ft, AD-2: 7.5 to 8.5 ft. Other elevations at B8826: 6.5 to 11 ft.</li> <li>Most others are non-detections.</li> <li>Mean and 95%UCL suggest typical EPC is to be much less than the maximum.</li> <li>All less than the ecological-screening concentration.</li> <li>Pu-239/240 maximum concentration produced a 35 mrem/yr dose to the industrial worker (dose limit = 15 mrem/yr).</li> </ul>

-- means no value available.

Shaded is the governing screening value. The governing value cannot be lower than background from a practical standpoint. Screening values below or near background suggest that adverse impacts are expected from natural conditions.

NR = Not reported; statistical assessment is not relevant due to small sample size.

Dragun, J., and K. Chekiri, 2005, *Elements in North American Soils*.

Dragun, J., 1998, *The Soil Chemistry of Hazardous Materials*.

ES/ER/TN-86/R3, *Toxicological Benchmarks for Wildlife: 1996 Revision*.

Pendias, H., and K. Pendias, A., 1992, "Trace Elements in Soils and Plants."

95%UCL = 95th upper confidence level.

EPC = exposure-point concentration.

GW = groundwater.

NA = not applicable.

NOAEL = no observed adverse-effect level.

Table 2-13. 216-A-29 Ditch Summary and Rationale of Constituents for Extended Groundwater Impacts Evaluation.

Constituent	Hanford Site Background	UCL95%	GPC	Spatial and Data Aggregation Finding	K <sub>d</sub> kg/L	Extended Groundwater Analysis
Arsenic, mg/kg	6.5	7	0.0304	BG ~UCL95% > GPC	29	Yes <sup>a</sup>
Cadmium, mg/kg	0.81	6.11	0.69	BG <UCL95% > GPC	6.7	Yes
Lead, mg/kg	10.2	84.4	3,000	BG <UCL95% < GPC	10,000	No
Mercury, mg/kg	0.33	1.8	2.09	BG <UCL95% < GPC	52	No
Selenium, mg/kg	0.78 <sup>b</sup>	4	5.2	BG ~UCL95% < GPC	5	No
Silver, mg/kg	0.73	8.7	13.6	BG <UCL95% < GPC	8.3	Yes
Uranium, mg/kg	3.21	1.6	210.6	BG <UCL95% < GPC	100	No
Nitrate as N, mg/kg	--	66.9	40	UCL95% > GPC	--	Yes
Nitrate and nitrate/nitrite as N, mg/kg	--	116.3	40	UCL95% > GPC	--	Yes
Sulfate, mg/kg	237	704.6	--	BG <UCL95%		Yes
Aroclor 1254, µg/kg	--	9.4	98.8	Sole detection >GPC	309	No
Benzo(a)anthracene, µg/kg	--	0.18 0.034	85.7	Median of 2 detections <GPC	357	No
Chrysene, µg/kg	--	210 40	95.6	Median of 2 detections <GPC	398	No

<sup>a</sup>Marginal comparison; include as a conservative measure.

<sup>b</sup>Selenium background soil concentrations range up to 4.3 mg/kg in the Western United States (Schacklette and Boerngen 1984).

NOTE: Bismuth, tri-butylphosphate, methylene chloride, and 1,2-dichloroethane have been omitted based on previous discussion.

Schacklette, H. T., and J. C. Boerngen, 1984, *Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States*.

95%UCL = 95th upper confidence level.

BG = background.

GPC = groundwater protection concentration.

K<sub>d</sub> = distribution coefficient.

2-151

DOE/RL-2005-63 DRAFT A

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Table 2-14. 216-A-29 Ditch Chemical-Specific Modeling Inputs.

Constituent	Source Concentration <sup>a</sup> mg/kg	K <sub>d</sub> <sup>b</sup> L/kg	Solubility mg/L	Remark
Arsenic	7	29 <sup>b</sup>	5	Maximum solubility Ag <sub>2</sub> S <sub>3</sub> pK <sub>sp</sub> = 21.68 (Dean 1992).
Cadmium	6.1	6.7 <sup>b</sup>	11.2 <sup>c</sup>	Ecology (2003). Maximum solubility Cd <sup>2+</sup> - Cd(OH) <sub>2</sub> system, pH = 4 (Benjamin 2002).
Silver	8.7	8.3 <sup>b</sup>	13.3 <sup>d</sup>	Ecology (2003). <sup>d</sup> Estimated from pK <sub>sp</sub> Ag <sub>2</sub> CO <sub>2</sub> of 7.82 (Dragun 1998).
Nitrate as (N)	66.9	1.17 <sup>e</sup>	990,000 <sup>f</sup>	K <sub>d</sub> of 1.17 is the average of 3 K <sub>d</sub> s developed for nitrate by PNNL (PNNL-13895). PNNL study indicates the nitrate retardation in the soils column is small.
Nitrate/Nitrite as (N)	116.3	1.17 <sup>e</sup>	990,000 <sup>f</sup>	
Sulfate	704.6	1.17 <sup>e</sup>	990,000 <sup>f</sup>	Very high solubility (99%) and low K <sub>d</sub> correspond to PNNL findings. Solubility is used by SESOIL as a checking variable to ensure that pore moisture predicted concentrations do not exceed solubility limits. It does not factor directly into constituent mobility.  Based on structural similarity and anionic composition; assume nitrate, nitrate/nitrite, and sulfate have similar characteristics.

<sup>a</sup>UCL95% concentrations from soils 0 to 15 ft.<sup>b</sup>Ecology 2003.Benjamin, M.A., 2002, *Water Chemistry*.Dean, J. E. 1992, *Lange's Handbook of Chemistry*.Dragun, J., 1998, *The Soil Chemistry of Hazardous Materials*.Ecology, 2003, *Cleanup Levels and Risk Calculations (CLARC) Database*,<https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx>.PNNL-13895, *Hanford Contaminant Distribution Coefficient Database and Users Guide*.

95%UCL = 95th upper confidence level.

K<sub>d</sub> = distribution coefficient.

PNNL = Pacific Northwest National Laboratory.

SESOIL = Seasonal Soil Compartment Model.

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Table 2-15. 216-A-29 Ditch Summary of Re-Evaluation of Select Screening Results Using the Robust 95% Upper Confidence Limit.

Constituent	Maximum	UCL95%	IESC	Industrial Direct Contact	Finding Based on Robust UCL95% Comparison
Arsenic, mg/kg	12.2	7	7	NA	UCL95 = IESC
Cadmium, mg/kg	28	6.1	14	NA	UCL95 < IESC
Lead, mg/kg	362	84.4	118	NA	UCL95 < IESC
Selenium, mg/kg	18.5	4	0.3	NA	UCL95 > IESC <sup>a</sup>
Silver, mg/kg	42	8.7	2	NA	UCL95 > IESC <sup>b</sup>
Aroclor 1254, µg/kg	9,400	NA 1 detection	650	NA	Single detection > IESC
Pu-239/240 (pCi/g)	667	200.2	6,100	See Notes	Maximum dose = 10.5 mrem/yr Maximum risk = 3E-5

<sup>a</sup>Confidence in this assessment is low: (1) The original toxicity basis is from ingestion of water, not soil, and may not adequately address bioavailability of selenium in soils. (2) The UCL95% concentration (4 mg/kg) is comparable to the range of selenium concentrations that occur naturally in the western United States (up to 4.3 mg/kg) (Schacklette and Boerngen 1984).

<sup>b</sup>Based on terrestrial plant impacts. Confidence in this assessment is low because confidence in the benchmark is low (i.e., the screening value). According to the authors, no primary reference data exist showing toxicity of silver to plants grown in soil and therefore, confidence is low (ES/ER/TN-86/R3).

Notes on Pu-239/240 industrial direct-contact re-assessment:

In the RESRAD code, all results (i.e., dose and risk) are linearly proportional to the input soil concentration.

$C_1 = \text{Dose}_1 = \text{Risk}_1$ . Thus, any increase or decrease in C will produce a proportional increase or decrease in dose and risk.

For the industrial no-cover analysis, the maximum concentration gave maximum doses and risk of 35 mrem/yr and 1E-4 risk, respectively. Using the UCL95% of 200.2 pCi/g would give a maximum dose of 10.5 mrem/yr and a risk of 3E-5 risk, respectively.

ANL, 2002, *RESRAD for Windows*.

ES/ER/TN-86/R3, 1996, *Toxicological Benchmarks for Wildlife: 1996 Revision*.

Schacklette, H. T., and J. C. Boerngen, 1984, *Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States*.

95%UCL = 95th upper confidence level.

IESC = industrial ecological-screening concentration.

NA = not applicable.

RESRAD = RESidual RADioactivity (dose model) (ANL 2002).

Table 2-16. 216-A-29 Ditch Summary and Rationale of Constituents for Intruder Scenario Evaluation. (2 Pages)

Constituent	Hanford Site Background	UCL95%	UUSC <sup>a</sup>	Spatial and Data Aggregation Finding	Intruder Analysis
Arsenic, mg/kg	6.5	7	0.67	BG <UCL95% >UUSC	Yes <sup>b</sup>
Cadmium, mg/kg	0.81	6.1	80	BG <95% UCL <UUSC	No
Lead, mg/kg	10.2	84.4	400 <sup>c</sup>	BG <UCL95% <UUSC	No
Mercury, mg/kg	0.33	1.8	24	BG <UCL95% <UUSC	No
Selenium, mg/kg	4.3 <sup>d</sup>	4	400	BG ~ UCL95% <UUSC	No
Silver, mg/kg	0.73	8.7	400	BG <UCL95% <UUSC	No
Uranium, pCi/g	3.21	1.6	240	BG > UCL95% <UUSC	No
Nitrate as N, mg/kg	12	66.9	8300	BG <UCL95%L <UUSC	No
Nitrate and nitrate/nitrite as N, mg/kg	--	116.3	8300	UCL95% <UUSC	No
Sulfate, mg/kg	237	704.6	--	BG <95% UCL	Yes
Aroclor 1254, µg/kg	--	9.4	1.6	Single detection	Yes
Benzo(a)-anthracene, µg/kg	--	0.18 0.034	0.137	2 detections	Yes

Table 2-16. 216-A-29 Ditch Summary and Rationale of Constituents for Intruder Scenario Evaluation. (2 Pages)

Chrysene, µg/kg	--	210 40	0.137	2 detections	Yes
Pu-239/240 pCi/g	--	200.2	--	--	Yes

<sup>a</sup>Direct-contact, unrestricted land use (ingestion only) screening values from Ecology (2003). Because these are ingestion only, perform intruder analysis if screening comparison is with a factor of 2.

<sup>b</sup>Marginal background comparison; include as a conservative measure.

<sup>c</sup>Source: EPA 1994, OSWER Directive 9355.4-12.

<sup>d</sup>Selenium in soils in western United States ranges up to 4.4 mg/kg (Schacklette and Boerngen 1984). Marginal background comparison; include as a conservative measure.

-- = No data.

NOTE: Bismuth, tributyl phosphate, methylene chloride, and 1,2-dichloroethane have been dismissed previously as contaminants of potential concern (see discussion in Section 2.7).

Ecology, 2003, *Cleanup Levels and Risk Calculations (CLARC) Database*, <https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx>.

EPA, 1994, *Revised Interim Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities*, OSWER Directive 9355.4-12.

Schacklette, H. T., and J. C. Boerngen, 1984, *Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States*.

95%UCL = 95th upper confidence level.

BG = background.

UUSC = unrestricted use screening concentration.

Table 2-17. Exposure Factors for the Child-to-Adult Receptor Intruder Exposure Scenario.

Exposure Variable	Unit	Value	Reference/Remark
IR <sub>soil</sub> (soil ingestion rate)	mg <sub>soil</sub> /day	120	DOE/RL-91-45, Table A-8 (Child = 200, Adult = 100)
CF (unit conversion)	kg/mg	1.00E-06	Conversion factor
FI (fraction from site)	fraction	1.0	50% of exposure to soils in garden; 50% of exposure to dust derived from the garden while indoors. 100% of food consumption from garden.
EF (exposure frequency)	days/yr	365	Assume daily exposure
ED (exposure duration)	yr	30	DOE/RL-91-45, Table A-8
BW (body weight)	kg	59.2	DOE/RL-91-45, Table A-8 (Child = 16, Adult = 70)
INHR (inhalation rate)	m <sup>3</sup> /day	20	DOE/RL-91-45, Table A-8
Skin SA <sub>soil</sub> (exposed surface area to soil)	cm <sup>2</sup>	5,120	EPA/540/R-99/005, Part E, Child = 2800, Adult = 5700
ABS <sub>soil</sub> (absorption fraction)	fraction	0.1	EPA/540/R-99/005, Part E, Dermal Risk Assess Exhibit 3-4, Chemical Specific
AF <sub>soil</sub> (soil to skin adherence factor)	mg/cm <sup>2</sup>	0.2	DOE/RL-91-45, Table A-8
IR <sub>vegetables</sub> (home-grown vegetable ingestion rate)	g/day	105.9	DOE/RL-91-45, Table A-8 & EPA/600/P-95/002B/approximate 50th percentile estimate
Rinse/preparation factor <sub>vegetables&amp;fruits</sub>	fraction	0.78	EPA/600/P-95/002B/assumes nominal 22% loss via preparation
AT <sub>CA (70 yr)</sub>	days	25,550	EPA/540/1-89/002/standard
AT <sub>NCA</sub>	days	10,950	EPA/540/1-89/002/appropriate for ED (30 years)

DOE/RL-91-45, *Hanford Site Baseline Risk Assessment Methodology*.

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

EPA/540/1-89/002, *Risk Assessment Guidance for Superfund (RAGS), Volume I -- Human Health Evaluation Manual, (Part A) Interim Final*, OSWER 9285.7-01A.

EPA/600/P-95/002B, *Exposure Factor Handbook, Volume I, General Factors*.

Table 2-18. Intruder Scenario Chemical-Specific Input Parameters.

Contaminant of Potential Concern	Soil to Plant Transfer <sup>a</sup>	Dermal Absorption <sup>b</sup>
Arsenic	0.036	0.001
Sulfate	0	0.001
Aroclor 1254	0.01	0.14
Benzo(a)anthracene	0.0202	0.13
Chrysene	0.01866	0.13

<sup>a</sup>Source: EPA/540/D-00/001a, *Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities*.

<sup>b</sup>Source: EPA/540/R-99/005, *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final*.

Table 2-19. 216-A-29 Ditch, Intruder Risk Assessment Nonradiological Results.

Contaminant of Potential Concern	EPC	HQ	Contribution	Excess Lifetime Cancer Risk <sup>a</sup>	Contribution
Arsenic	7 mg/kg	0.1	13.3%	1.4E-05	86.6%
Sulfate <sup>b</sup>	704.6 mg/kg	<0.001	<0.1%	--	--
Aroclor 1254	9400 µg/kg	0.5	86.7%	--	--
Benzo(a)anthracene	180 µg/kg	--	--	1.0E-06	6.4%
Chrysene	210 µg/kg	--	--	1.1E-06	7.0%
Sum		<b>HI = 0.6</b>		<b>2E-05</b>	

<sup>a</sup>Excess lifetime cancer risk for nonradiological constituents; this is risk of cancer incidence.

<sup>b</sup>Hazard quotient based on a provisional toxicity chronic reference dose (see discussion).

The hazard quotient and excess lifetime cancer risk estimates are dominated by the ingestion of home-raised foodstuffs pathway; 83% and 96%, respectively.

$HI = \sum HQs$  when similar toxicity effects are reasonably expected.

EPC = exposure point concentration.

HI = hazard index.

HQ = hazard quotient.

Table 2-20. 216-A-29 Ditch, Intruder Risk Assessment Radiological Results.

Pathway	mrem/yr <sup>a</sup>	Contribution	Excess Lifetime Cancer Risk <sup>b</sup>	Contribution
Soil ingestion	5.3E-02	50.3%	3.5E-09	20.0%
Inhalation	4.2E-02	40.0%	7.2E-09	41.6%
Irradiation	6.3E-03	6.0%	6.4E-09	36.8%
Plant ingestion	3.9E-03	3.7%	2.6E-10	1.5%
	<b>0.1</b>		<b>2E-08</b>	

<sup>a</sup>Committed effective dose equivalent.

<sup>b</sup>Excess lifetime cancer risk for radiological constituent is risk of mortality from cancer.

Pu-239/240 concentration = 200.2 pCi/g.

Table 2-21. 216-A-29 Ditch Summary of Extended Analysis Findings. (2 Pages)

Contaminant of Potential Concern	Initial Screening Concentration Exceedance			Extended Analysis Finding				
	Direct Exposure	Protection of GW	Ecological Risk	No Threat or Lab/Reporting Errors	Spatial and Data Aggregation Considerations	No Impact to GW through Vadose Zone Immobility $K_d > 40$ kg/L	No Impact to GW through Vadose Zone Transport	Reevaluate with Robust UCL95%
Arsenic	--	X	X	--	Marginal	--	XX	XX
Bismuth	X	X	--	XX	--	--	--	--
Boron	--	--	X	--	XX	--	--	--
Cadmium	--	X	X	--	--	--	XX	XX
Lead	--	--	X	--	--	--	--	XX
Mercury	--	X	--	--	--	XX	--	--
Molybdenum	--	--	X	XX	--	--	--	--
Selenium	--	--	X	--	Marginal	--	--	--
Silver	--	X	X	--	--	--	XX	--
Uranium	--	X	X	--	XX	--	--	--
Vanadium	--	--	X	--	XX	--	--	--
Nitrate as N	--	X	--	--	--	--	--	--
Nitrate and nitrate/nitrite as N	--	X	--	--	--	--	--	--
Sulfate	--	X	--	--	--	--	--	--
Methylene chloride	--	X	--	XX	--	--	--	--
Benzo(a)anthracene	--	X	--	--	--	XX	--	--
Chrysene	--	X	--	--	--	XX	--	--
Tributyl phosphate	X	X	--	XX	--	--	--	--

Table 2-21. 216-A-29 Ditch Summary of Extended Analysis Findings. (2 Pages)

Contaminant of Potential Concern	Initial Screening Concentration Exceedance			Extended Analysis Finding				
	Direct Exposure	Protection of GW	Ecological Risk	No Threat or Lab/Reporting Errors	Spatial and Data Aggregation Considerations	No Impact to GW through Vadose Zone Immobility $K_d > 40$ kg/L	No Impact to GW through Vadose Zone Transport	Reevaluate with Robust UCL95%
1,2-dichloroethane	--	X	--	XX	--	--	--	--
Aroclor 1254	--	X	X	--	--	XX	--	--
Pu-3239/240	X	--	--	--	--	--	--	XX

XX indicates that the extended analysis clarified the initial screening concentration exceedance. The initial exceedance is offset by the extended analysis. Shading of a contaminant of potential concern indicates that all initial screening concentration exceedances are offset by the extended analysis.

95%UCL = 95th upper confidence level.

GW = groundwater.

$K_d$  = distribution coefficient.

Table 2-22. 216-B-63 Trench Contaminants of Potential Concern.

<b>Constituent</b>	<b>Direct Exposure</b>	<b>Protection of Groundwater</b>	<b>Industrial Use Ecological Hazard Quotient &gt;1.0</b>
Bismuth	X	X	--
Boron	--	--	X
Cadmium	--	X	--
Nitrate as N	--	X	--
Nitrate/nitrite as N	--	X	--
Benzene	--	X	--
Selenium	--	--	X
Vanadium	--	--	X
Radioactive strontium	--	--	X

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Table 2-23. 216-B-63 Trench Summary of Extended Nature and Extent of Contamination Assessment. (3 Pages)

Constituent	Hanford Site Background	Industrial Direct Contact	Ground-water Protection	Industrial Ecological Screening	Maximum (Location)	Mean 95%UCL	Remark
<b>Inorganics in mg/kg</b>							
Boron	--	315,000	11.2	0.5 (Remark)	5.8 (BT-2)	1.9 NR	<ul style="list-style-type: none"> <li>No local background data exist.</li> <li>Typical soil concentration in basalts is 5 to 20 mg/kg, up to 30 mg/kg in sandstones, and 130 mg/kg in shales (Pendias and Pendias 1992).</li> <li>One sample BT-2 (5 to 6 ft) elevated.</li> <li>NOTE: Boron will be omitted from further consideration based on previous analysis and rationale (see text).</li> </ul>
Cadmium	0.81	3,500	0.69	14	0.27 <sup>a</sup> (BT-2)  2.42 <sup>b</sup> (B8827)	0.11 0.2	<ul style="list-style-type: none"> <li>No evidence of contamination.</li> <li>Mean and 95%UCL of upper 15-ft strata well below background and all screening concentrations.<sup>a</sup></li> <li>The sole basis for identifying cadmium as a contaminant of potential concern is the sample from B8827: 17.5 to 19.0 ft, which is an anomaly of 2.24 mg/kg reported in a split sample.<sup>b</sup> Split-sample result deemed unreliable.</li> <li>Many detections are below or near detection limit.</li> </ul>
Selenium	0.78 (Remark)	17,500	5.2	0.3	0.75 (BT-2) (Remark)	NR NR	<ul style="list-style-type: none"> <li>Note that the Hanford Site background value was not available for use in the remedial investigation baseline risk assessment. Comparing the maximum to current Hanford Site background indicates that selenium at the Site is not a contaminant of potential concern. It will be omitted from the analysis.</li> </ul>

Table 2-23. 216-B-63 Trench Summary of Extended Nature and Extent of Contamination Assessment. (3 Pages)

Constituent	Hanford Site Background	Industrial Direct Contact	Ground-water Protection	Industrial Ecological Screening	Maximum (Location)	Mean 95%UCL	Remark
Vanadium	85.1	24,500	2,240	2 (Remark)	86.6 Highest of split (BT-2)	58.2 65.7	<ul style="list-style-type: none"> <li>No evidence of vanadium contamination.</li> <li>Maximum of a split (86.6 and 78 mg/kg) at BT-2 (7.5 to 8.5 ft) triggered inclusion as contaminant of potential concern. Note Hanford Site background benchmark is 85.1 mg/kg.</li> <li>All other detections are below or background.</li> <li>Mean and 95%UCL suggest typical EPC is well within the range of background.</li> </ul>
Nitrate as N	12	350,000	40	--	188 (BT-2)	30.1 76.4	<ul style="list-style-type: none"> <li>Anomaly elevation at BT-2: 5 to 6 ft.</li> <li>Apparent elevations also at BT-1: 7 to 8 ft, and 9.5 to 10.5 ft.</li> <li>Many other detections less than or in the range of background.</li> <li>Mean and 95%UCL suggest typical EPC is much lower than maximum.</li> </ul>
Nitrate and nitrate/nitrite as N	--	350,000	40	--	230 (BT-2)	36.6 84.6	<ul style="list-style-type: none"> <li>Anomaly elevation at BT-2: 5 to 6 ft.</li> <li>Apparent elevations also at BT-1: 7 to 8 ft, and 9.5 to 10.5 ft.</li> <li>Many other detections less than or in the range of background.</li> <li>Mean and 95%UCL suggest typical EPC is much lower than maximum.</li> </ul>

2-162

DOE/RL-2005-63 DRAFT A

Table 2-23. 216-B-63 Trench Summary of Extended Nature and Extent of Contamination Assessment. (3 Pages)

Constituent	Hanford Site Background	Industrial Direct Contact	Ground-water Protection	Industrial Ecological Screening	Maximum (Location)	Mean 95%UCL	Remark
<b>Organics in µg/kg</b>							
Benzene	--	2.39E+6	4.48	--	8 BT-2	NR NR	<ul style="list-style-type: none"> <li>One detection in 26 samples.</li> <li>All other sample reports are nondetection. Pattern suggests spurious analytical or reporting result.</li> </ul>
Radioactive strontium (as Sr-90)	0.178	--		22.5	24 BT-2A	5.6 17.4	<ul style="list-style-type: none"> <li>Anomalies at BT-2: 7.5 to 8.5 ft and BT-2A: 6 to 7 ft.</li> <li>Some elevation above background at B8827.</li> <li>Many reports as nondetections or in the range of background.</li> <li>Mean and 95%UCL suggest typical EPC to be less than the maximum.</li> </ul>

2-163

-- means no value available.

Shaded is the governing screening value. The governing value cannot be lower than background from a practical standpoint. Screening values below or near background suggest that adverse impacts are expected from natural conditions.

NR = Not reported; statistical assessment is not relevant due to small sample size.

Pendias, H., and K. Pendias, A., 1992, "Trace Elements in Soils and Plants."

95%UCL = 95th upper confidence level.

EPC = exposure-point concentration.

DOE/RL-2005-63 DRAFT A

Table 2-24. Chemical-Specific Modeling Inputs for the 216-B-63 Trench.

Constituent	Source Concentration <sup>a</sup> mg/kg	K <sub>d</sub> kg/L	Solubility mg/L	Remark
Nitrate as (N)	76.4	1.17 <sup>b</sup>	990,000 <sup>c</sup>	K <sub>d</sub> of 1.17 is the average of 3 K <sub>d</sub> s developed for nitrate by PNNL-14187.  °Very high solubility (99%).  High solubility and low K <sub>d</sub> correspond to PNNL findings.  Based on structural similarity and anionic composition; assume nitrate and nitrate/nitrite have similar characteristics.
Nitrate/nitrite as (N)	87.4			

<sup>a</sup>UCL95% concentrations from soils 0 to 15 ft.



PNNL-14187, *Hanford Site Groundwater Monitoring for Fiscal Year 2002*.

95%UCL = 95th upper confidence level.

K<sub>d</sub> = distribution coefficient.

PNNL = Pacific Northwest National Laboratory.

1

Table 2-25. Comparison of Controlling Screening Values with Robust UCL95% Concentrations.

Constituent	Controlling Screening Value (Basis)	Maximum	UCL95%
Nitrate as (N), mg/kg	40 (groundwater)	188	66.9
Nitrate/nitrite as (N), mg/kg	40 (groundwater)	230	87.4
Radioactive strontium (as Sr-90), pCi/g	22.5 (ecological)	24	17.4

95%UCL = 95th upper confidence level.

2

Table 2-26. 216-B-63 Trench, Summary and Rationale of Constituents for Intruder Scenario Evaluation.

Constituent	Hanford Site Background	UCL95%	UUSC*	Spatial and Data Aggregation Finding	Intruder Analysis
Cadmium, mg/kg	0.81	6.1	80	BG <UCL95% <UUSC	No
Nitrate as N	12	66.9	8,300	BG <UCL95% <UUSC	No
Nitrate and nitrate/nitrite as N, mg/kg	--	116.3	8,300	UCL95% <UUSC	No
Total radioactive strontium (as Sr-90), pCi/g	0.178	17.4	--	--	Yes

\*Direct-contact, unrestricted land use (ingestion only) screening values from Ecology (2003). Because these are ingestion only, perform intruder analysis if screening comparison is with a factor of 2 to 3.

-- = No data.

Ecology, 2003, *Cleanup Levels and Risk Calculations (CLARC) Database*, <https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx>.

95%UCL = 95th upper confidence level.

BG = background.

UUSC = unrestricted use screening concentration.

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Table 2-27. 216-B-63 Trench, Intruder Risk Assessment Results for Strontium-90.

Pathway	mrem/yr <sup>a</sup>	Contribution	Excess Lifetime Cancer Risk <sup>b</sup>	Contribution
Soil ingestion	5.8E-11	1.6%	4.8E-17	1.3%
Inhalation	3.3E-12	0.1%	1.4E-18	0.0%
Irradiation	2.4E-09	64.9%	2.5E-15	70.3%
Plant ingestion	1.3E-09	35.1%	1.1E-15	29.7%
	<b>4.E-09</b>		<b>4.E-15</b>	

<sup>a</sup>Committed effective dose equivalent.<sup>b</sup>Excess lifetime cancer risk is mortality risk from cancer.

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Table 2-28. 216-B-63 Trench, Summary of Extended Analysis Findings.

COPC	Initial Screening Concentration Exceedance			Extended Analysis Finding				
	Direct Exposure	Protection of GW	Ecological Risk	No Threat or Lab/Reporting Errors	Spatial and Data Aggregation Considerations	No Impact to GW through Vadose Zone Immobility $K_d > 40$ kg/L	No Impact to GW through Vadose Zone Transport	Reevaluate with Robust UCL95%
Bismuth	X	X	--	XX	--	--	--	--
Boron	--	--	X	--	XX	--	--	--
Cadmium	--	X	--	--	XX	--	--	--
Nitrate as N	--	X	--	--	--	--	XX	--
Nitrate and nitrate/nitrite as N	--	X	--	--	--	--	XX	--
Benzene	--	X	--	XX	XX	--	--	--
Selenium	--	--	X	--	XX	--	--	--
Vanadium	--	--	X	--	XX	--	--	--
Radioactive strontium (as SR-90)	--	--	X	--	--	--	--	XX

XX indicates that the extended analysis clarified the initial screening concentration exceedance. The initial exceedance is offset by the extended analysis.

Selenium was shown to have been included as a COPC from the remedial investigation baseline risk assessment because appropriate Hanford Site background data were not available. Based on the standard comparison technique, selenium concentrations reported at the Site do not exceed background.

Shading of a COPC indicates that all initial screening concentration exceedances are offset by the extended analysis.

95%UCL = 95th upper confidence level.

COPC = contaminant of potential concern.

GW = groundwater.

$K_d$  = distribution coefficient.

2-167

Table 2-29. 216-S-10 Ditch Contaminants of Potential Concern.

Constituent	Direct Exposure	Protection of Groundwater	Industrial Use Ecological Hazard Quotient >1.0
Arsenic	--	X	--
Bismuth	X	X	--
Boron	--	--	X
Total chromium	--	--	X
Copper	--	--	X
Mercury	--	X	--
Selenium	--	--	X
Silver	--	X	X
Thallium	--	--	X
Vanadium	--	--	X
Zinc	--	--	X
Benzo(a)anthracene	--	X	--
Benzo(a)pyrene	--	X	--
Benzo(a)fluoranthene	--	X	--
Benzo(k)fluoranthene	--	X	--
Chrysene	--	X	--
Aroclor 1254	--	X	X

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Table 2-30. 216-S-10 Ditch Summary of Extended Nature and Extent of Contamination Assessment. (4 Pages)

Constituent	Hanford Site Background	Industrial Direct Contact	Ground-water Protection	Industrial Ecological Screening	Maximum (Location)	Mean 95%UCL	Remark
<b>Inorganics in mg/kg</b>							
Arsenic	6.5	87.5	0.0304	7	5.3 (SD-3)	3.5 4.1	<ul style="list-style-type: none"> <li>No excessive contamination.</li> <li>Note uniformity in results.</li> <li>Maximum, mean, and 95%UCL are less than background.</li> </ul>
Boron	-- (Remark)	315,000	11.2	0.5	5.2 (SD-1)	NR	<ul style="list-style-type: none"> <li>NOTE: Boron will be omitted from further consideration based on previous analysis and rationale (see text).</li> </ul>
Chromium	18.5	5,250,000	2,000	67	815 (SD-2)	111.3 437	<ul style="list-style-type: none"> <li>Apparent anomalies at SD-2 control summary statistics.</li> <li>Potential elevated concentration at SD-1: 6- to 7-ft interval.</li> <li>Many detections are below or near background.</li> <li>No impact below ~ 6 to 7 ft bgs.</li> <li>Note that some reports are greater than the background-screening concentration at depths for B8828.</li> </ul>
Copper	22	130,000	262	217	244 (SD-2)	39.9 131.2	<ul style="list-style-type: none"> <li>Apparent anomalies at SD-2 control summary statistics.</li> <li>Many detections are below or near background.</li> <li>No impact below ~3 ft bgs.</li> <li>Mean and UCL95% are notably below the ecological-screening concentration.</li> </ul>

2-169

DOE/RI-2005-63 DRAFT A

Table 2-30. 216-S-10 Ditch Summary of Extended Nature and Extent of Contamination Assessment. (4 Pages)

Constituent	Hanford Site Background	Industrial Direct Contact	Ground-water Protection	Industrial Ecological Screening	Maximum (Location)	Mean 95%UCL	Remark
Mercury	0.33	1,050	2.09	5.5	4.3 (SD-2)	0.5 2.2	<ul style="list-style-type: none"> <li>• Apparent anomalies at SD-2 control summary statistics.</li> <li>• Many detections are below or near background and below detection limits.</li> <li>• No impact below ~0 to 1 ft bgs.</li> <li>• Mean and 95%UCL suggest typical EPC is lower than maximum.</li> </ul>
Selenium	0.78 (Remark)	17,500	5.2	0.3	0.44 SD-1 (Dup)	0.19 0.22	<ul style="list-style-type: none"> <li>• Note that the Hanford Site background value was not available for use in the remedial investigation baseline risk assessment. Comparing the maximum to the current Hanford Site background indicates that selenium at the Site is not a contaminant of potential concern. It will be omitted from the analysis.</li> </ul>
Silver	0.73	17,500	13.6	2	30.4 SD-2	5.5 21.1	<ul style="list-style-type: none"> <li>• Apparent anomalies at SD-2 control summary statistics.</li> <li>• Median = 0.1 mg/kg.</li> <li>• Many detections are below or near background.</li> <li>• No impact below ~ 6 to 7 ft bgs.</li> <li>• Mean and 95%UCL suggest typical EPC is lower than maximum.</li> </ul>
Thallium	--	245	1.59	1	0.99 SD-2	0.75 (mean)	<ul style="list-style-type: none"> <li>• No excessive contamination.</li> <li>• Note uniformity in results.</li> <li>• Maximum, mean, and 95%UCL are less than background.</li> <li>• Thallium concentrations in sedimentary rocks up to 1.0 mg/kg in sandstones, 2.0 mg/kg in shales (Pendias and Pendias 1992).</li> </ul>

2-170

DOE/RL-2005-63 DRAFT A

Table 2-30. 216-S-10 Ditch Summary of Extended Nature and Extent of Contamination Assessment. (4 Pages)

Constituent	Hanford Site Background	Industrial Direct Contact	Ground-water Protection	Industrial Ecological Screening	Maximum (Location)	Mean 95%UCL	Remark
Vanadium	85.1	24,500	2,240	2 (Remark)	87.5 SD-1	76 80.5	<ul style="list-style-type: none"> <li>No excessive contamination.</li> <li>Note uniformity in results.</li> <li>Mean and 95%UCL are less than background.</li> <li>Maximum is approximately comparable to background screening value.</li> </ul>
Zinc	67.8	1,050,000	5,970	360	506 SD-2	99 278.6	<ul style="list-style-type: none"> <li>Apparent anomalies at SD-2 control summary statistics.</li> <li>Median = 53.1 mg/kg.</li> <li>Many other detections are below or near background.</li> <li>No impact below ~6 to 7 ft bgs.</li> <li>Mean and UCL95% are notably below the ecological-screening concentration.</li> </ul>
<b>Organics in µg/kg</b>							
Aroclor 1254	--	7.00E+4	9.89E+2	6.50E+2	3,700 SD-2	NR	<ul style="list-style-type: none"> <li>Apparent anomalies at SD-2 control summary statistics.</li> <li>All other samples are below detection limits.</li> </ul>
Benzo(a)-anthracene	--	1.80E+4	8.57E+1	--	550 J SD-2	NR	<ul style="list-style-type: none"> <li>Apparent anomalies at SD-2 control summary statistics.</li> <li>All other samples are below detection limits.</li> </ul>
Benzo(a)-pyrene	--	1.80E+4	2.33E+2	1.20E+4	600 J SD-2	NR	<ul style="list-style-type: none"> <li>Apparent anomalies at SD-2 control summary statistics.</li> <li>All other samples are below detection limits.</li> </ul>

2-171

DOE/RL-2005-63 DRAFT A

Table 2-30. 216-S-10 Ditch Summary of Extended Nature and Extent of Contamination Assessment. (4 Pages)

Constituent	Hanford Site Background	Industrial Direct Contact	Ground-water Protection	Industrial Ecological Screening	Maximum (Location)	Mean 95%UCL	Remark
Benzo(b) fluoranthene	--	1.80E+4	2.95E+2	--	530 J SD-2	NR	<ul style="list-style-type: none"> <li>• Apparent anomalies at SD-2 control summary statistics.</li> <li>• All other samples are below detection limits.</li> </ul>
Chrysene	--	1.80E+4	9.56E+1	--	680 J SD-2	NR	<ul style="list-style-type: none"> <li>• Apparent anomalies at SD-2 control summary statistics.</li> <li>• All other samples are below detection limits.</li> </ul>

-- means no value available.

Shaded is the governing screening value. The governing value cannot be lower than background from a practical standpoint. Screening values below or near background suggest that adverse impacts are expected from natural conditions

NR = Not reported; statistical assessment is not relevant due to small sample size.

Pendias, H., and K. Pendias, A., 1992, "Trace Elements in Soils and Plants."

95%UCL = 95th upper confidence level.

bgs = below ground surface.

EPC = exposure-point concentration.

2-172

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DOE/RL-2005-63 DRAFT A

Table 2-31. 216-S-10 Trench Summary and Rationale of Constituents for Extended Groundwater Impacts Evaluation.

Constituent	Hanford Site Background	UCL95%	GPC	Spatial and Data Aggregation Finding	K <sub>d</sub> kg/L	Extended Groundwater Analysis
Mercury, mg/kg	0.33	2.2	2.09	BG <UCL95% >GPC	52	No
Silver, mg/kg	0.73	21.1	13.6	BG <UCL95% >GPC	8.3	Yes
Aroclor 1254, µg/kg	--	2,400*	989	Median of the two detections >GPC	309	No
Benzo(a)anthracene, µg/kg	--	550*	85.7	Sole detection >GPC	357	No
Benzo(a)pyrene, µg/kg	--	600*	233	Sole detection >GPC	969	No
Benzo(b)fluoranthene, µg/kg	--	530*	295	Sole detection >GPC	1,230	No
Benzo(k)fluoranthene, µg/kg	--	450*	295	Sole detection >GPC	1,230	No
Chrysene, µg/kg	--	680*	95.6	Sole detection >GPC	398	No

\*Insufficient data to compute UCL95%.

Ecology, 2003, *Cleanup Levels and Risk Calculations (CLARC) Database*, <https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx>.

95%UCL = 95th upper confidence level.

BG = background.

foc = fractional organic carbon

GPC = groundwater protection concentration.

K<sub>d</sub> = distribution coefficient.

K<sub>oc</sub> = soil organic carbon-water partition coefficient.

Table 2-32. 216-S-10 Ditch Chemical-Specific Modeling Inputs.

Constituent	Source Concentration*	K <sub>d</sub> (L/Kg)	Solubility (mg/L)	Remark
Silver, mg/kg	21.1	8.3	13.3	Ecology (2003). Estimated from pK <sub>sp</sub> Ag <sub>2</sub> CO <sub>3</sub> of 7.82 (Dragun 1998).

\*UCL95%.

Dragun, J., 1998, *The Soil Chemistry of Hazardous Materials*.  
Ecology 2003, *Cleanup Levels and Risk Calculations (CLARC) Database*,  
<https://fortress.wa.gov/ecy/clarc/CLARHome.aspx> .  
95%UCL = 95th upper confidence level.

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Table 2-33. 216-S-10 Ditch Comparison of Controlling Screening Values with Robust UCL95% Concentrations.

Constituent	Controlling Screening Value (Basis)	Maximum	UCL95%
Chromium (total), mg/kg	67 (industrial ecological)	815	437
Copper, mg/kg	217 (industrial ecological)	244	131.2
Silver, mg/kg	2 (industrial ecological)	30.4	21.1
Zinc, mg/kg	360 (industrial ecological)	506	278.6
Aroclor 1254, µg/kg	650 (industrial ecological)	3,700	NR

NR = Not reported; statistical assessment is not relevant due to small sample size.

95%UCL = 95th upper confidence level.

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Table 2-34. 216-S-10 Trench Summary and Rationale of Constituents for Intruder Scenario Evaluation.

Constituent	Hanford Site Background	UCL95%	UUSC <sup>a</sup>	Spatial and Data Aggregation Finding	Intruder Analysis
Arsenic, mg/kg	6.5	4.1	0.67	BG >UCL95%	No
Total chromium, mg/kg	18.5	437	2,000 <sup>b</sup>	BG <UCL 95% <UUSC	No
Copper, mg/kg	22	131.2	2,960	BG <UCL95% <UUSC	No
Mercury, mg/kg	0.33	2.2	24	BG <UCL95% <UUSC	No
Silver, mg/kg	0.73	21.1	400	BG <UCL95% <UUSC	No
Thallium, mg/kg	2.0 <sup>c</sup>	0.99 (max)	5.6 (soluble salts)	BG <UCL95% <UUSC	No
Vanadium, mg/kg	85.1	80.5	560	BG <UCL95% <UUSC	No
Zinc, mg/kg	67.8	278.6	24,000	BG <UCL95% <UUSC	No
Aroclor 1254, µg/kg	--	3,700 (max)	1,600	Two detections	Yes
Benzo(a)anthracene, µg/kg	--	550	137	One detection	Yes
Benzo(a)pyrene, µg/kg		600	137	One detection	Yes
Benzo(b)fluoranthene, µg/kg		530	137	One detection	Yes
Benzo(k)fluoranthene, µg/kg		430	137	One detection	Yes
Chrysene, µg/kg	--	680	137	One detection	Yes

<sup>a</sup>Direct-contact, unrestricted land use (ingestion only) screening values are from Ecology (2003). Because these are ingestion only, perform intruder analysis if screening comparison is with a factor of 2.

<sup>b</sup>Chromium III.

<sup>c</sup>Thallium in soils in up to 2.0 mg/kg (Pendias and Pendias 1992).

-- = No data.

Ecology, 2003, *Cleanup Levels and Risk Calculations (CLARC) Database*, <https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx>.

Pendias, H., and K. Pendias, A., 1992, "Trace Elements in Soils and Plants."

95%UCL = 95th upper confidence level.

BG = background.

UUSC = unrestricted use screening concentration.

2-175

DOE/RL-2005-63 DRAFT A

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Table 2-35. 216 S-10 Ditch Intruder Risk Summary.

<b>Constituent</b>	<b>Hazard Quotient</b>	<b>Contribution</b>	<b>Excess Lifetime Cancer Risk</b>	<b>Contribution (%)</b>
Aroclor 1254	0.2	100.0%	--	--
Benzo(a)anthracene	--	--	3.E-06	26.2
Benzo(a)pyrene	--	--	2.E-06	17.5
Benzo(b)fluoranthene	--	--	2.E-06	14.4
Benzo(k)fluoranthene	--	--	1.E-06	11.7
Chrysene	--	--	4.E-06	30.3
<b>TOTAL</b>	<b>0.2</b>		<b>1.E-05</b>	

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Table 2-36. 216-S-10 Ditch Summary of Extended Analysis Findings.

COPC	Initial Screening Concentration Exceedance			Extended Analysis Finding				
	Direct Exposure	Protection of GW	Ecological Risk	No Threat or Lab/Reporting Errors	Spatial and Data Aggregation Considerations	No Impact to GW Vadose Zone Immobility $K_d > 40$ kg/L	No Impact to GW through Vadose Zone Transport	Reevaluate with Robust UCL95%
Arsenic	--	X	--	--	XX	--	--	--
Bismuth	X	X	--	XX	--	--	--	--
Boron	--	--	X	--	XX	--	--	--
Total chromium	--	--	X	--	--	--	--	--
Copper	--	--	X	--	--	--	--	XX
Mercury	--	X	--	--	--	XX	--	--
Selenium	--	--	X	--	XX	--	--	--
Silver	--	X	X	--	--	--	XX	--
Thallium	--	--	X	--	XX	--	--	--
Vanadium	--	--	X	--	XX	--	--	--
Zinc	--	--	X	--	--	--	--	XX
Aroclor 1254	--	X	X	--	--	XX	XX	--
Benzo(a)anthracene	--	X	--	--	--	XX	--	--
Benzo(a)pyrene	--	X	--	--	--	XX	--	--
Benzo(b)fluoranthene	--	X	--	--	--	XX	--	--
Benzo(k)fluoranthene	--	X	--	--	--	XX	--	--
Chrysene	--	--	--	--	--	XX	--	--

XX indicates that the extended analysis clarified the initial screening concentration exceedance. The initial exceedance is offset by the extended analysis. Shading of a COPC indicates that all initial screening concentration exceedances are offset by the extended analysis.

- 95%UCL = 95th upper confidence level.
- COPC = contaminant of potential concern.
- GW = groundwater.

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Table 2-37. 216-S-10 Pond Contaminants of Potential Concern.

<b>Constituent</b>	<b>Direct Exposure</b>	<b>Protection of Groundwater</b>	<b>Industrial Use Ecological Hazard Quotient &gt;1.0</b>
Boron	--	--	X
Selenium	--	--	X
Silver	--	--	X
Methylene chloride	--	X	--
Vinyl chloride	--	X	--

Table 2-38. 216-S-10 Pond Summary of Extended Nature and Extent of Contamination Assessment.

Constituent	Hanford Site Background	Industrial Direct Contact	Ground-water Protection	Industrial Ecological Screening	Maximum (Location)	Mean UCL95 %	Remark
<b>Inorganics in mg/kg</b>							
Boron	(Remark)	315,000	11.2	0.5 (Remark)	5.2 (SD-1)	NR	<ul style="list-style-type: none"> <li>Boron will be omitted from further consideration based on previous analysis and rationale (see text).</li> </ul>
Selenium	0.78 (Remark)	17,500	5.2	0.3 (Remark)	2 B8817	NR	<ul style="list-style-type: none"> <li>No excessive contamination.</li> <li>Nearly all reports are non-detections.</li> <li>Note uniformity in results.</li> <li>All detections are below or detection limits and within expected ranges.</li> <li>Typical range of selenium in soils is 0.1 to 2.0 mg/kg (Dragun 1998).</li> <li>Observed range in western United States (&lt;0.1 to 4.3).</li> </ul>
Silver	0.73 (Remark)	17,500	13.6	2	8.3 SP-1	0.7 2.8	<ul style="list-style-type: none"> <li>No excessive contamination.</li> <li>Two anomalous detections.</li> <li>Detection rate only 42%.</li> <li>Note uniformity in results.</li> <li>Median = 0.07 mg/kg.</li> <li>Common range of silver in soils 0.001 to 5 mg/kg (Lindsay 1979).</li> </ul> <p>With two exceptions, all detections are below or near detection limits and within expected ranges.</p>

Shaded is the governing screening value. The governing value cannot be lower than background from a practical standpoint. Screening values below or near background suggest that adverse impacts are expected from natural conditions.

NR = Not reported; statistical assessment is not relevant due to small sample size.

Dragun, J., 1998, *The Soil Chemistry of Hazardous Materials*.

Lindsay, W. L., 1979, *Chemical Equilibria in Soils*.

95%UCL = 95th upper confidence level.

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Table 2-39. Summary of Risk-Based Issues for the Feasibility Study.

Site	Direct Exposure	Impacts to Groundwater	Ecological Exposure	Remark
216-A-29 Ditch	None	Nitrate/nitrite as N	Silver Selenium Aroclor 1254	Groundwater impacts may occur in the far distant future (~ 800 years). The impact would be minor exceedance of a drinking water standard. The groundwater is not considered a consumptive use.  Contamination affecting ecological exposures is localized.
216-B-63 Trench	None	None	None	No significant contamination.
216-S-10 Ditch	None	None	Total chromium Silver Aroclor 1254	Contamination affecting ecological exposures is localized.
216-S-10 Pond	None	None	None	No significant contamination.

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CHAPTER 3.0 TERMS

1		
2	ARAR	applicable or relevant and appropriate requirement
3	BCG	biota concentration guide
4	CERCLA	<i>Comprehensive Environmental Response, Compensation, and Liability Act of 1980</i>
5		
6	COPC	contaminant of potential concern
7	DOE	U.S. Department of Energy
8	FS	feasibility study
9	GRA	general response action
10	HCP	<i>Final Hanford Comprehensive Land-Use Plan - Environmental Impact Statement (DOE/EIS-0222-F)</i>
11		
12	NEPA	<i>National Environmental Policy Act of 1969</i>
13	OU	operable unit
14	PRG	preliminary remediation goal
15	RAO	remedial action objective
16	RCRA	<i>Resource Conservation and Recovery Act of 1976</i>
17	RI Report	<i>Remedial Investigation Report for the 200-CS-1 Chemical Sewer Group Operable Unit (DOE/RL-2004-17)</i>
18		
19	RI	remedial investigation
20	ROD	record of decision
21	SESOIL	Seasonal Soil Compartment Model
22	TSD	treatment, storage, and/or disposal (unit)
23	WAC	<i>Washington Administrative Code</i>
24		

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### 3.0 DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIATION GOALS

This section defines the land use within the study area and within the region and defines the remedial action objective (RAO) and preliminary remediation goals (PRG). DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program* (Implementation Plan), and DOE/RL-2004-17, *Remedial Investigation Report for the 200-CS-1 Chemical Sewer Group Operable Unit* (RI Report), provide initial information on these items for the 200 Areas waste sites. For this feasibility study (FS), the Implementation Plan information was reviewed against the data collected during the remedial investigation (RI), and refinements were made as appropriate for the waste sites.

The RAOs are media-specific or operable unit-specific objectives for protecting human health and the environment. They are developed considering the land use, contaminants of potential concern (COPC), potential applicable or relevant and appropriate requirements (ARAR), and exposure pathways (conceptual model). They also specify remediation goals so that an appropriate range of remedial options can be developed for evaluation. This section describes the elements used to develop the RAOs and presents the RAOs and remediation goals used to evaluate alternatives.

The RAO process begins by identifying potential future land use and the COPCs for the facility. This information ensures that the remedial alternatives being considered can adequately address the types of contaminants present and facilitates the refinement of potential ARARs. The RAOs also provide the basis for developing the general response actions (GRA) that will satisfy the objectives of protecting human health and the environment. The RAOs are defined as specifically as possible without limiting the range of GRAs that can be applied.

#### 3.1 LAND USE

To identify appropriate cleanup objectives, the future land use of a site must be considered. Current and future land uses of the 200 Areas and the Central Plateau are discussed in the following sections.

##### 3.1.1 Current Land Use

All current land-use activities associated with the 200 Areas and the Central Plateau are industrial in nature. The facilities located in the Central Plateau were built to process irradiated fuel from the plutonium production reactors in the 100 Areas. Most of the facilities directly associated with fuel reprocessing are now inactive and awaiting final disposition. Several waste management facilities operate in the 200 Areas, including permanent waste disposal facilities such as the Environmental Restoration Disposal Facility, low-level radioactive waste burial grounds, and a *Resource Conservation and Recovery Act of 1976* (RCRA) permitted mixed waste trench. Construction of tank waste treatment facilities in the 200 Areas began in 2002, and the 200 Areas are the planned disposal location for the vitrified low-activity tank wastes. Past-practice disposal sites in the 200 Areas are being evaluated for remediation and are likely to

1 include institutional controls (e.g., deed restrictions or covenants) as part of the selected remedy.  
2 Other Federal agencies, such as the U.S. Department of the Navy, also use the Hanford Site  
3 200 Areas nuclear waste treatment, storage, and/or disposal (TSD) facilities. A commercial  
4 low-level radioactive waste disposal facility, operated by US Ecology, Inc., currently operates on  
5 a portion of a tract in the 200 Areas leased to the State of Washington.

6 The U.S. Department of Energy (DOE) selected land uses for the areas associated with the  
7 200-CS-1 Operable Unit (OU) waste sites, documented through the land-use ROD  
8 (64 FR 61615, "Record of Decision: Hanford Comprehensive Land-Use Plan Environmental  
9 Impact Statement [HCP EIS],") (ROD) are industrial (exclusive) for sites located within the  
10 exclusive-use boundary (Core Zone) and conservation (mining) for sites outside the boundary.  
11 For purposes of this FS, the 216-A-29 Ditch, 216-B-63 Trench, and 216-S-10 Ditch are  
12 considered to be located inside the Core Zone boundary. The 216-S-10 and 11 Ponds are  
13 outside the Core Zone boundary.

14 According to DOE/RL-0222-F, *Final Hanford Comprehensive Land-Use Plan Environmental*  
15 *Impact Statement*) (HCP), industrial (exclusive) land use would preserve DOE control of the  
16 continuing remediation activities and would use the existing compatible infrastructure required  
17 to support activities such as dangerous waste, radioactive waste, and mixed waste TSD facilities.  
18 The DOE and its contractors, and the U.S. Department of Defense and its contractors, could  
19 continue their Federal waste disposal missions; and the Northwest Low-Level Radioactive Waste  
20 Compact could continue using the US Ecology, Inc., site for commercial radioactive waste.  
21 Research supporting the dangerous waste, radioactive waste, and mixed waste TSD facilities also  
22 would be encouraged within this land-use designation. New uses of radioactive materials, such  
23 as food irradiation, could be developed, and the products could be packaged for commercial  
24 distribution here under this land-use designation.

25 The conservation (mining) land use would enable the extraction of valuable near-surface  
26 geologic resources to support implementation of remedial actions (i.e., surface barriers) at some  
27 locations on the Hanford Site after obtaining *National Environmental Policy Act of 1969*  
28 (NEPA), RCRA, or *Comprehensive Environmental Response, Compensation, and Liability Act*  
29 *of 1980* (CERCLA), approval to protect NEPA-sensitive (e.g., biologic, geologic, historic, or  
30 cultural) resources. The Hanford Site has no proven reserve of any metallic ore bodies;  
31 therefore, heap/leach or open-pit mining methods would not be applicable. In addition, the HCP  
32 indicates that a notice of deed restriction would be placed in those areas where vadose zone  
33 contamination remained in place, according to a CERCLA ROD or RCRA closure permit,  
34 foreclosing the mining option. The HCP anticipates mining only for materials needed to build  
35 surface barriers as part of remedial actions and that mining would be precluded from  
36 contaminated areas. The conservation (mining) land use would afford protection of natural  
37 resources; however, other compatible uses, such as recreation or nonintrusive environmental  
38 research activities, also would be allowed, provided these activities are consistent with the  
39 purpose of the conservation land-use designation. Conservation would require active  
40 management practices to enhance or maintain the existing resources and to minimize or  
41 eliminate undesirable or non-native species.

42 The ROD (64 FR 61615) identifies conservation (mining) as an area reserved for the  
43 management and protection of archeological, cultural, ecological, and natural resources. Limited

1 and managed mining (e.g., quarrying for sand, gravel, basalt, and topsoil for governmental  
 2 purposes only) could occur as a special use (i.e., a permit[issued by the DOE Reality Officer]  
 3 would be required) within appropriate areas. Limited public access would be consistent with  
 4 resource conservation. The ROD also indicates that mining would be restricted from  
 5 contaminated areas.

### 6 3.1.2 Anticipated Future Land Use

7 The reasonably anticipated future land use for the core zone is continued industrial (exclusive)  
 8 activities. The reasonably anticipated land use for the areas outside the Core Zone is  
 9 conservation (mining). The DOE worked for several years with cooperating agencies and  
 10 stakeholders to define land-use goals for the Hanford Site and develop future land-use plans  
 11 (Drummond 1992, *The Future for Hanford: Uses and Cleanup, The Final Report of the Hanford*  
 12 *Future Site Uses Working Group*). The cooperating agencies and stakeholders included the U.S.  
 13 Department of the Interior, Tribal Nations, states of Washington and Oregon, local county and  
 14 city governments, economic and business development interests, environmental groups, and  
 15 agricultural interests. These efforts were initially reported by Drummond (1992) and culminated  
 16 in the HCP and associated ROD (64 FR 61615), which were issued in 1999.

17 The Future Site Uses Working Group was organized by Federal, tribal, state, and local  
 18 governments with jurisdictional interests in the Hanford Site. The Working Group was charged  
 19 with three related tasks, as follows:

- 20 • To examine the Hanford Site and identify a range of potential future uses for the Site
- 21 • To select appropriate cleanup scenarios necessary to make these future uses possible in  
 22 light of potential exposure to contamination, if any, after cleanup
- 23 • To probe for convergences among the Group's cleanup scenarios for any priorities or  
 24 criteria which could prove useful in focusing or conducting the cleanup of the  
 25 Hanford Site.

26 The Working Group agreed to seven findings from their activities:

- 27 • The Hanford Site is important – The Hanford Site has played a significant role in history  
 28 and continues to be of major economic influence to the area; cleanup efforts at the Site,  
 29 including technology research, may benefit other DOE sites and environmental  
 30 restoration activities worldwide. Plausible future uses identified include agriculture;  
 31 industrial and economic development; wildlife and habitat preserves; environmental  
 32 restoration and waste management activities; public access and recreation; and Native  
 33 American uses such as hunting, gathering, and religious practices.
- 34 • Cleanup is now DOE's primary mission at the Hanford Site – As the mission at the Site  
 35 transitions from nuclear materials production to support national defense to  
 36 environmental restoration of the area, new challenges emerge for the DOE in the conduct  
 37 of business, involvement of the public, and accountability for its actions. The Working

1 Group emphasized getting on with the cleanup and maximizing the Hanford Site's  
2 potential.

- 3 • The Hanford Site will change as cleanup proceeds – The Working Group envisioned a  
4 shrinking area requiring DOE control as the cleanup proceeds and that portions of the site  
5 can be turned over to other users once those portions are no longer needed to support  
6 DOE's mission.
- 7 • Both cleanup and future land uses face significant constraints – Volumes and variety of  
8 contaminants and the associated risks pose constraints to the ultimate cleanup, as does the  
9 current state of technologies to address these problems. Funding also was identified as a  
10 constraint to the timeliness of the cleanup.
- 11 • Native American treaty rights exist – Treaties signed with the Yakama Indian Nation, the  
12 Nez Perce Tribe, and the Umatilla, Cayuse, and Walla Walla tribes reserved specific  
13 rights to the tribes, including those related to hunting, fishing, gathering foods and  
14 medicines, and pasturing livestock on open and unclaimed portions of the ceded land, in  
15 common with citizens.
- 16 • Uncertainty and risk surround the cleanup – The current uncertainty about the extent of  
17 contamination and the ability of available technologies to address the contamination  
18 produce resulting uncertainties in the future land use.
- 19 • Time is a critical element in focusing the cleanup – The Working Group expressed a  
20 desire that all the Hanford Site someday could be used for uses other than waste  
21 management, but also recognized that technical constraints may impact the timing of the  
22 ultimate cleanup and the potential future uses.

23 The Working Group identified nine major recommendations as a result of their efforts:

- 24 • Protect the Columbia River – Because of the significance of the Columbia River to the  
25 region and the Pacific Northwest, protection of the river and all of its uses is viewed as a  
26 high priority.
- 27 • Deal realistically and forcefully with groundwater contamination – Contaminated  
28 groundwater is seen as a threat to the Columbia River and to potential future land uses.  
29 The Working Group recommended restrictions on the use of groundwater if it would  
30 jeopardize public safety and health. They also recommended restrictions on the use of  
31 groundwater or surface water, contaminated or not, if such use would adversely change  
32 hydraulic conditions, increase the spread of contaminated plumes, or increase the speed  
33 of contaminated groundwater flow to the river. The Group identified areas where  
34 restrictions should be applied and recommended removal of sources before they reach  
35 groundwater, reducing or eliminated discharges to the soil, and treatment of the  
36 groundwater.

- 1     • Use the Central Plateau wisely for waste management – The Group recommended  
2     consolidation of Hanford Site wastes to the Central Plateau in as small an area as possible  
3     and waste disposed here should not necessarily be considered permanent disposal. They  
4     recommended a buffer zone to reduce risks emanating from the waste management area.
- 5     • Do no harm during cleanup or with new development – The Working Group recognized  
6     that the primary cleanup goal is the protection of human health and public safety, but also  
7     noted that environmental values of the site are to be protected and restored. Decisions  
8     made on the course of the cleanup and future uses should support these goals and result in  
9     decreased risks to public health and net benefits to the environment. Activities should be  
10    guided by the principle “do no harm.” Cleanup and future development should be  
11    conducted to minimize impacts on plants and animals.
- 12    • Cleanup of areas of high future use value is important – While the Group supports the  
13    cleanup priorities (i.e., current threats to public health or the environment, risk of  
14    catastrophic exposure, and technical feasibility) identified by the DOE and the regulators,  
15    they also believe that areas of high future use value should be candidates for priority  
16    cleanup. They recommended the following areas: the Columbia River corridor, the  
17    southeast corner of the Hanford Site, areas north of the river, the Fitzner-Eberhardt Arid  
18    Lands Ecology Reserve, and the western and northwestern portions of the areas outside  
19    the river corridor and the 200 Areas.
- 20    • Cleanup to the level necessary to enable the future use option to occur – The Working  
21    Group believed that “unrestricted” status would support all future use options but  
22    believed that not all areas would need to be cleaned to unrestricted levels. In fact, the  
23    Group believed that in some cases, cleanup to unrestricted levels would cause more harm  
24    than good. They identified cleanup to levels that would be “clean enough for industry” in  
25    part of the southeast corner of the Site and “clean enough for wildlife” in all other areas  
26    (those areas outside the river corridor and the 200 Areas).
- 27    • Transport waste safely and be prepared – The Group recognized that the management and  
28    cleanup of waste at the Hanford Site will require shipment of these wastes. They  
29    believed that these shipments affect the public and that close cooperation between the  
30    DOE and affected communities should be maintained. The Group endorsed preparedness  
31    through regulatory means and the use of the Hazardous Materials Management and  
32    Emergency Response training facility.
- 33    • Capture economic development opportunities locally – The Working Group urged the  
34    DOE and its contractors to help create the potential for meaningful economic  
35    development during cleanup, both on and off site.
- 36    • Involve the public in future decisions about the Hanford Site – Public involvement should  
37    be incorporated in future decision making at the Site.

1 The HCP was written to address the growing need for a comprehensive, long-term approach to  
2 planning and development on the Hanford Site because of the DOE's separate missions of  
3 environmental restoration, waste management, and science and technology. The HCP analyzes  
4 the potential environmental impacts of alternative land-use plans for the Hanford Site and  
5 considers the land-use implication of ongoing and proposed activities. In the HCP, the land-use  
6 designation for sites inside the Core Zone is as follows:

- 7 • Industrial (Exclusive) – Areas suitable and desirable for TSD of hazardous, dangerous,  
8 radioactive, and nonradioactive wastes, and related activities.

9 For the 200-CS-1 OU sites outside the Core Zone, the land-use designation is as follows:

- 10 • Conservation (Mining) – An area reserved for the management and protection of  
11 archeological, cultural, ecological, and natural resources.

12 Under the preferred land-use alternative selected in the ROD (64 FR 61615), the area inside the  
13 Core Zone of the Central Plateau was designated for industrial (exclusive) use. The current  
14 vision for all of the 200 Areas is that it will continue to be used for the TSD of hazardous,  
15 dangerous, radioactive, and nonradioactive wastes. The HCP and ROD incorporate this vision in  
16 their selected alternative, describe the means by which new projects will be sited, and focus on  
17 using existing infrastructure and developed areas of the Hanford Site for new projects. To  
18 support the current vision, the 200 Areas projects will maintain current facilities for continuing  
19 missions, remediate soil waste sites and groundwater to support industrial land uses, lease  
20 facilities for waste disposal (US Ecology, Inc.), and demolish facilities that have no further  
21 beneficial use. Based on the HCP and associated ROD, and consistent with other Hanford Site  
22 waste management decisions, this FS report assumes an industrial (exclusive) land use for all the  
23 waste sites within the Core Zone.

24 Under the preferred land-use alternative selected in the ROD (64 FR 61615), the area outside the  
25 Core Zone of the Central Plateau was designated for other activities. For the sites in the study  
26 area, the land use was designated as conservation (mining). This would include restrictions  
27 against intrusive human activities but would allow recreational use (e.g., hiking, biking, hunting,  
28 and bird watching where a receptor spends only a small fraction of time in actual proximity to  
29 the contaminated areas) of the surface areas. Restricted use (e.g., recreation or waste  
30 management) means that surface use of the waste sites could occur, but subsurface activities  
31 such as excavation, well drilling, and farming would be restricted to preclude contact with or  
32 disturbance of contaminated soils. These activities could occur *around* the waste sites, but not  
33 *on* the waste sites. Based on the risk framework workshops, groundwater use outside the Core  
34 Zone also would be restricted until remediation efforts result in meeting groundwater cleanup  
35 standards. At that point, unrestricted groundwater use would be assumed.

36 To date, the conservation (mining) land use has not been represented by a specific risk  
37 assessment model. As a conservative estimate, this FS uses the industrial-exposure scenario to  
38 evaluate the conservation (mining) land use, under the assumption that a person using the area  
39 for recreation would spend less time there than a worker spending the majority of the year on a  
40 site. However, through the risk framework workshops (Klein et al. 2002), the DOE agreed to  
41 evaluate other scenarios as a means to provide decision makers and stakeholders with additional

1 information for comparison purposes. Both a residential and a recreational scenario were  
2 evaluated and included as sensitivity discussions to the risk assessment and alternative evaluation  
3 discussions. For purposes of the remedial investigation baseline risk assessment (RI BRA),  
4 human health COPCs were identified employing industrial-use screening values. In addition, a  
5 preliminary assessment of a Tribal scenario also was conducted as supporting information. This  
6 is discussed in greater detail in the risk assessment in Appendix B.

### 7 3.1.3 Regional Land Use

8 Communities in the region of the Hanford Site consist of the incorporated cities of Richland,  
9 West Richland, Kennewick, and Pasco, as well as surrounding communities within Benton and  
10 Franklin Counties. The estimated population of the region in 2000 was 186,600, with the  
11 population of Benton County being 140,700 and the population of Franklin County being 45,900.  
12 There are no residences on the Hanford Site. The nearest inhabited residences to the 200 Areas  
13 are farmhouses on land approximately 16 km (10 mi) north across the Columbia River. The City  
14 of Richland corporate boundary is approximately 27 km (17 mi) to the south (PNL-6415,  
15 *Hanford Site National Environmental Policy Act (NEPA) Characterization*).

### 16 3.1.4 Groundwater Use

17 The HCP indicates that contamination in the groundwater would restrict its use. Groundwater in  
18 the 200 Areas currently is contaminated and is not withdrawn for beneficial uses. However,  
19 Washington State cleanup regulations define groundwater as a "potential future source of  
20 drinking water" based on yield, natural quality, and pumpability (*Washington Administrative*  
21 *Code [WAC] 173-340-720[a][ii]*), "Ground Water Cleanup Standards." Based on these technical  
22 standards, groundwater underlying the 200 Areas meets the technical definition of a drinking  
23 water source. In addition, groundwater underlying the 200 Areas is hydraulically connected to  
24 groundwater systems that currently are used for drinking water and irrigation and ultimately  
25 discharges to the Columbia River. Discussions are under way regarding cleanup levels and  
26 potential points of compliance relative to the 200 Area groundwater, with the initial goal of  
27 ensuring no unacceptable migration of contaminants from the 200 Areas. Pending the  
28 conclusion of those discussions, this FS evaluates potential future impacts to groundwater from  
29 current vadose zone contaminants at the representative sites, but does not evaluate groundwater  
30 remediation or risks. These issues will be addressed through the remedial  
31 investigation/feasibility study evaluation of the groundwater OUs and through the Systems  
32 Assessment Capability task currently under way.

### 33 3.1.5 Use of Industrial Cleanup Standards Under 34 WAC 173-340

35 WAC 173-340, "Model Toxics Control Act -- Cleanup," establishes criteria that must be  
36 addressed to qualify to use the industrial soil cleanup standards identified in WAC 173-340-745,  
37 "Soil Cleanup Standards for Industrial Properties." Although certain of these criteria may be  
38 primarily administrative in nature (e.g., compliance with the administrative requirements of the  
39 Washington State *Growth Management Act* [RCW 36.70A, "Counties," "Growth Management --

1 Planning by Selected Counties and Cities”) and therefore are not invoked for CERCLA onsite  
2 actions, several substantive criteria are prerequisite to selecting industrial standards.

3 WAC 173-340 provisions also acknowledge that local governments may use terms other than  
4 “industrial” for zoning purposes, but that such properties still may qualify as “industrial  
5 property” under WAC 173-340-745(1)(b)(i).

6 In spite of the U.S. Department of Energy, Richland Operations Office position that Federal  
7 facilities such as the Hanford Site are technically not subject to city and county zoning authority,  
8 Benton County and the City of Richland have performed land-use planning for the Hanford Site  
9 as part of their input and recommendations to the HCP (DOE/EIS-0222-F) and ROD  
10 (64 FR 61615). Their recommendations emphasize the economic development potential of the  
11 Hanford Site. The 200 Areas are identified for waste disposal and management consistent with  
12 an industrial (exclusive) land use.

13 WAC 173-340-745(1)(a)(i) identifies the following specific characteristics to be considered in  
14 determining whether a property qualifies as industrial.

- 15 • People would not live on property with an industrial (exclusive) land-use designation.  
16 The primary potential exposure is to adult waste management workers located on the  
17 industrial property.
- 18 • Access to industrial property by the general public is generally not allowed. If access is  
19 allowed, it is highly limited and controlled because of safety or security considerations.
- 20 • Food would not be grown/raised on property with an industrial (exclusive) land-use  
21 designation.
- 22 • Operations at industrial properties are often (but not always) characterized by the use and  
23 storage of chemicals, noise, odors, and truck traffic.
- 24 • The surface of the land at industrial properties is often (but not always) covered by  
25 buildings or other structures, paved parking lots, paved access roads, and material storage  
26 areas, minimizing potential exposure to the soil.
- 27 • Industrial properties may have support facilities consisting of offices, restaurants, and  
28 other facilities that are commercial in nature but that are primarily devoted to  
29 administrative functions necessary for the industrial use and/or are primarily intended to  
30 serve the industrial facility employees and not the general public.

31 The property within the 200 Areas satisfies all of these criteria and hence meets all the  
32 substantive requirements associated with industrial land use as described in WAC 173-340.

### 33 3.2 CONTAMINANTS OF POTENTIAL 34 CONCERN

35 Contaminants that have the potential to contribute significantly to site risk are referred to as  
36 COPCs. Identification of COPCs is an important process because it determines the list of

1 chemicals for which PRGs will be developed. Development of COPCs in the data evaluation  
2 and risk assessment process is discussed in EPA/540/1-89/002, *Risk Assessment Guidance for*  
3 *Superfund (RAGS), Volume I – Human Health Evaluation Manual, (Part A) Interim Final,*  
4 *OSWER 9285.7-01A,* and in DOE/RL-91-45, *Hanford Site Baseline Risk Assessment*  
5 *Methodology.* Those contaminants that are COPCs are determined by comparing contaminant  
6 concentrations with background, developing a set of data for use in risk assessment, and (if  
7 appropriate) limiting the number of contaminants to be carried through a risk assessment by  
8 risk-based screening or other methods. The evaluation of COPCs is presented in the BRA, and  
9 reevaluated in Chapter 2.0 of this report, on a site-by-site basis. Based on the analysis in  
10 Chapter 2.0, COPCs for the FS include the following.

- 11     • The soil constituent that could affect groundwater is nitrate/nitrite (as N).
- 12     • The soils that could affect ecological receptors are silver, selenium, and Aroclor 1254.  
13       These COPCs, and the conditions under which they need to be addressed, are discussed  
14       in Section 3.4.
- 15     • ARARs.

16 The ARARs for the 200-CS-1 sites are identified in Appendix A.

### 17 3.3 REMEDIAL ACTION OBJECTIVES

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

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

### 3.3.1 Summary of Risk-Based Issues for the Feasibility Study

Chapter 2.0 of this FS summarized the original BRA findings and described the extended and refined analysis using conventional risk analysis techniques. The extended analysis was done in order to clarify the original BRA findings, which were generated using screening-level techniques. Based on the extended analysis, the revised RI BRA indicates that the FS should address several risk-based issues, which are summarized in Table 3-1 and are detailed as follows:

- At the 216-A-29 Ditch

Nitrate/nitrite (as N) has the potential to migrate through the vadose zone and affect groundwater resulting in concentrations just exceeding Federal drinking water standards. An alternate fate and transport model predicted a maximum groundwater concentration of 14 mg/L; the Federal drinking water quality standard is 10 mg/L. This impact would occur in approximately 785 years. The groundwater is not currently used for consumption, nor is it anticipated that it will be used for consumption in the future. The forecasted impact did not consider the degradation process in the fate and transport model and it is possible that over the period of hundreds of years, natural attenuation processes could significantly degrade nitrate/nitrite in the soil column and the predicted impacts in approximately year 2800 might never actually occur.

Selenium and silver may pose some threat to ecological receptors, based on 95<sup>th</sup> upper confidence level (95%UCL) concentrations that exceed industrial ecological screening concentrations. The elevated concentrations are restricted to localized hot spots.

Aroclor 1254 was reported at 9,400 µg/kg in a single sample from one hot spot location. Based on the comparison of this concentration to the industrial ecological screening concentration (650 µg/kg), there is a concern that wildlife exposed to soils at this location may be at risk for adverse effects.

- At the 216-B-63 Trench

There are no risk-based issues associated with the 216-B-63 Trench.

- At the 216-S-10 Ditch

Three constituents (total chromium, silver, and Aroclor 1254) may pose some threat to ecological receptors due to slightly elevated soil concentrations. However, the threat is localized to the discrete location at SB-2.

- At the 216-S-10 Pond

There are no risk-based issues associated with the 216-S-10 Pond.

Additionally, the extended analysis determined that none of the four representative sites is highly contaminated. Contamination is not widespread, concentrations are not particularly elevated, and concentrations that are elevated are often found localized in hot spots. Significant portions

1 of the sites are not affected or exhibit constituent concentrations comparable to background.  
 2 Many of the areas where elevated concentrations were detected are actually well beneath the  
 3 ground surface. While the BRA protocol requires that, conceptually, all soils to a depth of 4.6 m  
 4 (15 ft) must be taken care of as though they are on the surface, the practical reality that  
 5 constituents are many feet below the surface does greatly mollify their material threat.

6 Based on these findings, RAOs will be developed to provide a basis for evaluating the capability  
 7 of a specific remedial alternative to achieve compliance with ARARs and/or an intended level of  
 8 risk protection for human health or the environment. The RAOs specific to the 200 Areas for  
 9 soils, solid wastes, and groundwater were developed in the Implementation Plan, Section 5.3  
 10 (DOE/RL-98-28). Specific RAOs for this FS were defined based on the fate and transport of  
 11 contaminants, projected land uses for the 200 Area, and the 200-CS-1 OU conceptual exposure  
 12 model.

### 13 3.3.2 Remedial Action Objectives

14 The RAOs identified for the 200-CS-1 OU are as follows:

- 15     • RAO 1 – Prevent unacceptable risk to ecological receptors by exposure to  
 16 nonradiological constituents in soils and debris at concentrations above the industrial use  
 17 criteria, as defined in WAC 173-340-745(5), “Soil Cleanup Standards for Industrial  
 18 Properties,” “Method C Industrial Soil Cleanup Levels.”
- 19     • RAO 2 – Provide cleanup protective for ecological receptors by protecting ecological  
 20 receptors based on a dose rate limit of 0.1 rad/day for terrestrial wildlife populations  
 21 (DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic*  
 22 *and Terrestrial Biota*, which is a To Be Considered criteria).
- 23     • RAO 3<sup>1</sup> – Prevent migration of contaminants through the soil column to groundwater or  
 24 reduce soil concentrations below WAC 173-340-747, “Deriving Soil Concentrations for  
 25 Ground Water Protection,” groundwater protection criteria so that no further degradation  
 26 of the groundwater results from contaminant leaching from 200-CS-1 OU waste sites and  
 27 so that the Columbia River is protected
- 28     • RAO 4 – Prevent adverse impacts to cultural resources and threatened or endangered  
 29 species and minimize wildlife habitat disruption.

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<sup>1</sup>NOTE: Protection of the Columbia River is achieved through protection of the groundwater. The 200 East and West Area is about 8 km (5 mi) from the Columbia River, and there is no surface water in the immediate vicinity of the 200-CS-1 waste sites

1 The RAOs will be finalized in the ROD for the OUs. Achievement of the RAOs will be  
2 described in the remedial design report/remedial action work plan to be prepared after the ROD  
3 is approved. For the purposes of this FS, RAO 1 is assumed to be achieved for ecological  
4 receptors, when:

- 5 • Exposure of ecological receptors to wastes or soil contaminated with nonradiological  
6 constituents will be prevented or reduced so that the hazard quotient and hazard index do  
7 not exceed 1 or
- 8 • Waste is 4.6 m (15 ft) or more below the ground surface.

9 RAO 2 is satisfied if the following conditions are met:

- 10 • Terrestrial animal exposure rates do not exceed 0.1 rad/day
- 11 • Aquatic organisms and terrestrial plants exposure rates do not exceed 1.0 rad/day

12 RAO 3 is satisfied if the following conditions are met:

- 13 • Soil concentrations are below WAC 173-340-747, "Deriving Soil Concentrations for  
14 Ground Water Protection," groundwater protection methods or
- 15 • The flux of contaminants into groundwater does not cause groundwater concentrations to  
16 exceed maximum contaminant levels or
- 17 • The flux of contaminants into groundwater is reduced or eliminated, based on a  
18 decreasing trend in the difference between the concentration of contaminants in  
19 up-gradient and down-gradient wells,

20 RAO 4 will be achieved by meeting RAOs 1, 2, and 3 in addition to implementing existing  
21 Hanford Site standards for protection of cultural resources, wildlife habitat, and industrial  
22 workers; and by continuing to enforce existing institutional controls and monitoring  
23 requirements.

### 24 3.4 PRELIMINARY REMEDIATION GOALS

25 The PRGs are based on attainment of acceptable levels of human health and ecological risk.  
26 Typically, PRGs are identified for individual hazardous substances. If multiple contaminants are  
27 present at a site, the suitability of using individual PRGs as final cleanup values protective of  
28 human health and the environment is evaluated based on site-specific information and the  
29 potential for contaminant interaction.

30 Meeting these PRGs and the ARARs and, by extension, achieving RAOs, can be accomplished  
31 by reducing concentrations (or activities) of contaminants to remediation goal levels or by  
32 eliminating potential exposure pathways/routes. Contaminant-specific, numeric soil and  
33 particulate PRGs for direct exposure and protection of groundwater and the Columbia River are  
34 typically presented as concentrations (milligrams per kilogram or milligrams per cubic meter) or  
35 activities (picocuries per gram), respectively. Final remedial action goals developed from the

1 PRGs will be specified in a ROD that identifies the selected remedial alternative for the  
2 200-CS-1 OU waste sites.

3 Residual risks after remediation of the waste sites is complete must meet the  $10^{-4}$  to  $10^{-6}$   
4 CERCLA risk range for radiological and nonradiological chemical constituents and must be  
5 below a hazard index of 1.0 for noncarcinogens. Actual soil contaminant concentrations  
6 achieving these cleanup objectives would be presented in a cleanup verification package for the  
7 facility. The cleanup verification package would demonstrate how and where specific criteria  
8 have been applied and how the remedy is protective for all COPCs identified for the waste sites.

### 9 3.4.1 Direct Exposure Preliminary Remediation Goals 10 for Nonradioactive Contaminants

11 As indicated in Table 3-1, there are no direct-exposure PRGs for nonradioactive contamination  
12 for humans; however, PRGs ecological receptors will be described in the following subsections.

#### 13 3.4.1.1 Ecological Exposure

14 Many of the study area waste sites are within the industrial area identified in the HCP  
15 (DOE/EIS-0222-F) and within the area designated by the HCP and ROD as industrial (exclusive)  
16 (64 FR 61615). The industrial-exclusive land-use designation allows for continued waste  
17 management operations within the 200 Areas consistent with past NEPA, CERCLA, and RCRA  
18 commitments and, among other things, will allow for the development of new waste  
19 management facilities. Sites within the Core Zone currently have limited habitat suitable for the  
20 establishment of ecological communities and establishment of food webs with a hierarchy of  
21 terrestrial receptors. Maintenance of the industrial (exclusive) use will prevent future  
22 inhabitation by biota. However, cleanup to industrial land-use standards may not continue to be  
23 protective of ecological receptors after lapse of institutional controls. The terrestrial ecological  
24 evaluation procedures from the revised WAC 173-340-7492, "Simplified Terrestrial Ecological  
25 Evaluation Procedures" (amended February 12, 2001) and a baseline ecological risk assessment  
26 have been used to develop soil cleanup-level PRGs for the protection of terrestrial ecology.

27 The revised WAC 173-340 provides cleanup standards for the protection of terrestrial plants and  
28 animals. WAC 173-340-7490, "Terrestrial Ecological Evaluation Procedures," specifies that for  
29 industrial properties, the potential for exposure to soil contamination need only be evaluated for  
30 terrestrial wildlife protection. Plants and soil biota need not be considered unless there are  
31 species that are protected under the Federal *Endangered Species Act of 1973* or soil  
32 contamination is located on an area of an industrial or commercial property where vegetation  
33 must be maintained to comply with local government land-use regulations. For sites with  
34 institutional controls to prevent excavation of deeper soil, a conditional point of compliance may  
35 be set at the biologically active soil zone, which is assumed to extend to a depth of 2.7 m (9 ft)  
36 (DOE/RL-2001-06, *Comments on Hanford 2012: Accelerating Cleanup and Shrinking the Site*,  
37 Table 2-2). Simplified terrestrial ecological evaluation procedures are provided in  
38 WAC 173-340-7492 to identify sites that do not have a substantial potential for posing a threat of  
39 significant adverse effects to terrestrial ecological receptors. Priority chemicals of ecological  
40 concern and their soil screening levels are listed in WAC 137-340-900, "Tables," Table 749-3.

1 These soil-screening levels were used in conjunction with the risk assessment to develop PRGs  
2 protective of ecological receptors.

3 Because several of the waste sites being considered in this FS are outside the Core Zone, the  
4 revised WAC 173-340 requirements for plants and soil biota are considered. These waste sites  
5 are designated as conservation (mining), which includes an element of preservation of natural  
6 resources. Therefore, a more conservative analysis of the WAC 173-340 requirements is  
7 considered appropriate. A baseline ecological risk assessment was conducted to support the  
8 evaluation of potential risks to ecological receptors for the representative sites. Table 3-2 lists  
9 the nonradiological soil PRGs for impacts to groundwater and ecological exposure; their basis is  
10 described in Table 3-3.

### 11 **3.4.2 Direct Exposure Remediation Goals for** 12 **Radionuclides**

13 The PRGs for direct exposure to radionuclides for ecological receptors are described in the  
14 following subsection. As indicated in Table 3-1, there are no direct human exposures to  
15 radionuclides.

#### 16 **3.4.2.1 Ecological Exposure**

17 Ecology and U.S. Environmental Protection Agency guidance for ecological risk assessment do  
18 not address radionuclides; therefore, the potential effects of surface residual contamination on  
19 terrestrial receptors are evaluated using the terrestrial radionuclide screening levels presented in  
20 DOE/STD-1153-2002 developed by the Biota Dose Assessment Committee. The Biota Dose  
21 Assessment Committee has been assisting the DOE in developing this technical standard, which  
22 provides a graded approach for evaluating radiation doses to biota. The technical standard  
23 provides a cost-effective, easy-to-implement methodology that can be used for demonstrating  
24 compliance with DOE dose limits and with findings of the International Atomic Energy Agency  
25 and National Council on Radiation Protection and Measurements regarding doses below which  
26 deleterious effects on populations of aquatic and terrestrial organisms have not been observed.  
27 The technical standard also can be used for assessing ecological effects of radiological exposure  
28 when conducting ecological risk assessments.

29 The DOE's graded approach for evaluating radiation doses to biota consists of a three-step  
30 process that is designed to guide a user from an initial, conservative general screening to a more  
31 rigorous analysis using site-specific information (if needed) and is consistent with the eight-step  
32 the U.S. Environmental Protection Agency approach for conducting ecological risk assessments.  
33 The DOE recommends a three-step process that includes (1) assembling radionuclide  
34 concentration data and knowledge of sources, receptors, and routes of exposure for the area to be  
35 evaluated; (2) applying a general screening methodology that provides limiting radionuclide  
36 concentration values (i.e., biota concentration guides [BCG]) in soil, sediment, and water; and  
37 (3) if needed, conducting a risk evaluation through site-specific screening, site-specific analysis,  
38 or an actual site-specific biota dose assessment conducted within an ecological risk framework,  
39 similar to that recommended by EPA/630/R-95/002F, *Guidelines for Ecological Risk*  
40 *Assessment*. Any of the steps within the graded approach may be used at any time, but the

1 general screening methodology is usually the simplest, most cost-effective, and least  
2 time-consuming process.

3 The BCGs contained in the technical standard guidance include conservative screening  
4 concentrations that are judged to be protective of the most sensitive terrestrial organisms,  
5 assuming a dose of 0.1 rad/day.<sup>2</sup> Each radionuclide-specific BCG represents the limiting  
6 radionuclide concentration in environmental media (i.e., soil, sediment, or water) that would not  
7 exceed DOE's established or recommended dose standards for biota protection. Therefore, soil  
8 concentrations that are less than the BCGs are not considered to pose a threat to terrestrial  
9 receptors.

### 10 3.4.3 Remediation Goals for the Protection of 11 Groundwater and Surface Water

12 Remediation goals for the protection of groundwater and surface water must address both  
13 contamination reaching the groundwater and surface water and contamination remaining in the  
14 ground after remediation (i.e., residual contamination). The remediation goals must consider  
15 cleanup standards where contamination may have contacted groundwater and cleanup standards  
16 for residual contamination that may migrate through the vadose zone to groundwater. Residual  
17 vadose zone contamination must be below activities or concentrations that could cause  
18 groundwater or surface water to exceed protective levels, should contaminant migration occur.  
19 The following subsections present remediation goals for groundwater and for residual  
20 contamination in the vadose zone, and a discussion of the achievement of these  
21 remediation goals.

#### 22 3.4.3.1 Nonradionuclide Preliminary Remediation Goals for the Protection of 23 Groundwater and Surface Water

24 The PRGs for nonradionuclides in the vadose zone that are protective of groundwater and the  
25 Columbia River are developed from ARARs and published cleanup standards. Soil  
26 concentrations protective of groundwater are established by applying the revised WAC 173-340  
27 cleanup regulation and the provisions of WAC 173-340-747, unless it can be demonstrated that a  
28 higher contaminant concentration is protective of groundwater (WAC 173-340-747[3][e],  
29 "Deriving Soil Concentrations for Ground Water Protection," "Overview of Methods,"  
30 "Alternative Fate and Transport Models"). Calculated values of soil concentrations protective of  
31 groundwater originally were obtained from Ecology 94-145, *Cleanup Levels and Risk*  
32 *Calculations under the Model Toxics Control Act Cleanup Regulation; CLARC, Version 3.1.*  
33 PRGs for nonradionuclides are presented in Table 3-2.

34 As discussed in Chapter 2.0 of this FS, groundwater threats were initially assessed using the  
35 approach described in WAC 173-340. However, evaluation was extended and refined to employ  
36 site- and chemical-specific information as inputs into a widely recognized vadose zone leaching

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<sup>2</sup> Terrestrial plant species are assumed to be protected at sites containing a dose of up to 1 rad/day (DOE/STD-1153-2002).

1 and transport model, SESOIL (GSC 1998). SESOIL is a compartment model that computes the  
2 mass movement of constituents from overlying strata to the underlying strata using infiltration,  
3 water balance, and constituent partitioning algorithms. SESOIL helped clarify the groundwater  
4 impacts assessment, over the use of WAC 173-340-747, Equation 747-1, by (1) using local  
5 climatological data to drive the moisture flux, (2) incorporating the significant depth to  
6 groundwater that is intrinsic to the Hanford Site, and (3) integrating constituent migration and  
7 attenuation over time. Groundwater PRGs developed using SESOIL are provided in Table 3-2.  
8 The SESOIL model is discussed in Chapter 2.0 and Appendix F.

9 An important aspect of the groundwater protection strategy that must be considered in any  
10 evaluation of remedial alternatives is the temporal aspect of when concentrations may exceed  
11 groundwater standards. Figure 2-25 (216-A-29 Ditch) illustrates that, because nitrate/nitrite is  
12 treated as a highly soluble constitute, it is predicted to migrate to groundwater after  
13 approximately 785 years. Modeling is inherent subject to uncertainties and the predications  
14 shown in Figure 2-25 are approximate. The technique is widely used and is normally governed  
15 by guidance including EPA/540/R-99/009, *Use of Monitored Natural Attenuation at Superfund*  
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1

Table 3-1. Summary of Risk-Based Issues for the Feasibility Study.

Site	Direct Exposure	Impacts to Groundwater	Ecological Exposure	Remark
216-A-29 Ditch	None	Nitrate/nitrite as N	Silver Selenium Aroclor 1254	Groundwater impacts may occur in the far distant future (785 years). The impact would be minor exceedance of a drinking water standard. The groundwater is not considered a resource for consumptive use.  Contamination affecting ecological exposures is localized.
216-B-63 Trench	None	None	None	No significant contamination.
216-S-10 Ditch	None	None	Total chromium Silver Aroclor 1254	Contamination affecting ecological exposures is localized.
216-S-10 Pond	None	None	None	No significant contamination.

2

Table 3-2. 200-CS-1 Operable Unit Preliminary Remediation Goals.

Impacts to Groundwater			Ecological Exposure	
Constituent	Groundwater Remediation Target (mg/L)	PRG <sub>soil</sub> (mg/kg)	Constituent	PRG <sub>soil</sub> (mg/kg)
Nitrate/nitrite as N	10 (Federal drinking water standard)	83 <sup>a</sup>	Selenium	0.78
			Silver	2
			Aroclor 1254	0.65
			Total chromium	67

<sup>a</sup>Simulations of impacts to groundwater suggest that there may be a small exceedance of the Federal drinking water standard after 785 years. The SESOIL model used to assess groundwater impacts did not simulate degradation processes, which, over the course of hundreds of years could, significantly degrade nitrate/nitrite in the soil column. Consequently, the exceedance predicted to occur in approximately year 2800 might never actually occur. On this basis, it is plausible that groundwater remedial action objectives can be achieved without active remediation.

<sup>b</sup>Soil concentrations exceeding these PRGs are actually much localized.

See Table for 3-3 for the basis of these PRGs.

PRG = preliminary remediation goal.

SESOIL = Seasonal Soil Compartment Model.

Table 3-3. 200-CS-1 Basis of Preliminary Remediation Goals.

Vadose Zone Soil PRG	Basis
Nitrate/nitrite as N: 83 mg/kg	The soil impacts to the groundwater PRG was developed using the alternative transport and fate model SESOIL in accordance with WAC 173-340-747, as discussed in Chapter 2.0 and Appendix F. The technique involved adjusting the nitrate/nitrite soil source concentration until a predicted groundwater concentration equaling the Federal drinking of 10 mg/L was obtained.
Selenium: 0.78 mg/kg	This PRG is based on background concentrations identified in Ecology 94-115.
Silver: 2.0 mg/kg	These PRGs are taken from WAC 173-340-7493, Table 749-3, Ecological Indicator Concentrations for Protection of Terrestrial Plant and Animals.
Aroclor 1254: 0.65 mg/kg	
Total chromium: 67 mg/kg	

Ecology 94-145, *Cleanup Levels and Risk Calculations under the Model Toxics Control Act Cleanup Regulation; CLARC, Version 3.1.*

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

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PRG = preliminary remediation goal.

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CHAPTER 4.0 TERMS

1		
2	DOE	U.S. Department of Energy
3	ERDF	Environmental Restoration Disposal Facility
4	ET	evapotranspiration
5	FS	feasibility study
6	GRA	general response action
7	Implementation Plan	<i>200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program (DOE/RL-98-28)</i>
8		
9		
10	RAO	remedial action objective
11	RCRA	<i>Resource Conservation and Recovery Act of 1976</i>
12	RI	remedial investigation
13	TRU	waste materials contaminated with more than 100 nCi/g of transuranic materials having half-lives longer than 20 years)
14		

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## 4.0 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

The 200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program (DOE/RL-98-28) (Implementation Plan) provided an initial framework to guide the remedial investigations (RI) in the 200 Areas. The Implementation Plan identified and screened technologies that could be used to address contaminants in the soil and solid waste in the arid 200 Areas environment.

Since the Implementation Plan was issued, additional site characterization information was obtained and RI report were prepared that presented the nature and extent of contamination and the risk at the representative waste sites. This feasibility study (FS) uses representative sites from DOE/RL-2004-17, *Remedial Investigation Report for the 200-CS-1 Chemical Sewer Group Operable Unit*.

As part of this FS, additional human health risk assessments and screening-level ecological risk assessments were performed. The results are reported in Chapter 2.0 of this FS. Information from the Implementation Plan and the RI report was reviewed against the results of the screening-level ecological risk assessments and human health-risk assessments, and refinements were made to the evaluation of alternatives as appropriate for this FS. A review of technologies was conducted to identify new, emerging technologies and to update information on existing technologies since the writing of the Implementation Plan. If a technology was identified and evaluated in the Implementation Plan and no modifications to this evaluation have been identified, then the technology is mentioned only briefly in this section and the Implementation Plan is referred to for detailed information.

### 4.1 GENERAL RESPONSE ACTIONS

The initial process of identifying viable remedial action alternatives is described in the Implementation Plan (DOE/RL-98-28) as consisting of the following steps.

1. Define remedial action objectives (RAO).
2. Identify general response actions (GRA) 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 their 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 institutional controls options plus no action.

1 Chapter 3.0 identified the RAOs for this FS. The Implementation Plan identified preliminary  
2 GRAs as follows:

- 3 • No action
- 4 • Institutional controls
- 5 • Containment
- 6 • Removal, treatment, and disposal
- 7 • Ex situ treatment
- 8 • In situ treatment.

9 These GRAs are intended to cover the range of options necessary to meet the RAOs.  
10 Modifications to these GRAs were not necessary, based on the new information collected and  
11 evaluated in the RI report (DOE/RL-2004-17). Detailed descriptions of each GRA are included  
12 in the Implementation Plan.

## 13 4.2 SCREENING AND IDENTIFICATION OF 14 TECHNOLOGIES

15 This section screens and identifies potentially viable technologies for the 200-CS-1 OU. The  
16 initial identification and screening of remedial technologies described in Appendix D  
17 (Sections D5.0 to D5.6 and Table D-1) of the Implementation Plan (DOE/RL-98-28) are  
18 modified for this FS based on the information obtained from the RI and the additional risk  
19 assessment performed to support this FS. The following subsections summarize the technology  
20 screening conducted; discuss the screening of new technologies identified since the creation of  
21 the Implementation Plan; and discuss those technologies that are retained for the 200-CS-1 OU.  
22 The technologies are discussed by GRA group. Table 4-1 represents a roadmap for technology  
23 selection between the Implementation Plan and this FS.

24 Potentially applicable technology types and process options were identified and screened in the  
25 Implementation Plan in accordance with *Comprehensive Environmental Response,  
26 Compensation, and Liability Act of 1980* guidance using effectiveness, implementability, and  
27 relative cost as criteria to eliminate those options that are least feasible and to retain those  
28 options that are considered most viable.

### 29 4.2.1 Rescreening of Implementation Plan Remedial 30 Technologies Based on Risk Assessment Results

31 Because the initial screening in the Implementation Plan was preliminary, and because additional  
32 site-specific risk assessment and characterization information is available, the remedial  
33 technologies presented in the Implementation Plan were rescreened for application to the  
34 200-CS-1 OU. The following is a brief screening discussion of the technologies and the results  
35 of the refinements.

#### 1 4.2.1.1 No Action

2 The National Contingency Plan (40 CFR 300, "National Oil and Hazardous Substances Pollution  
3 Contingency Plan") requires that a no-action alternative be evaluated as a baseline for  
4 comparison with other alternatives. The no-action alternative represents a situation where no  
5 restrictions, controls, or active remedial measures are applied to the site. The no-action  
6 alternative implies a scenario of "walking away" from the site and taking no measures to monitor  
7 or control contamination. The no-action alternative requires that a site pose no unacceptable  
8 threat to human health and the environment. The no-action alternative was retained in the  
9 Implementation Plan for the 200-CS-1 OU and is carried forward in this FS.

#### 10 4.2.1.2 Institutional Controls

11 Institutional controls consist of (1) physical and/or legal barriers to prevent access to  
12 contaminants, (2) monitoring of the groundwater and/or the vadose zone, and (3) maintaining  
13 existing soil cover. Institutional controls usually are required when contaminants remain in place  
14 at concentrations above cleanup levels; the controls likely will be a component of the remedial  
15 alternatives.

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

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

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

38 Sampling and environmental monitoring are an integral part of institutional controls and is  
39 necessary to verify that contaminants are attenuating as expected, to ensure that contaminants  
40 remain isolated, and to ensure that whatever remedial measures are in place are meeting their  
41 performance objectives. Periodic sampling activities would include sampling of the actual

1 contaminants and verification of overall site characteristics (geochemical, hydrogeologic, and  
2 biological properties). Environmental monitoring would be conducted to ensure that waste  
3 containment is achieved and that no further degradation of groundwater occurs. Surface  
4 radiation surveys and sampling of local biota may be necessary if contaminants remain near the  
5 surface.

6 Depending on the remedial action taken and results of sampling and monitoring, it will be  
7 necessary to maintain the existing soil cover or cap in order to ensure continued isolation of the  
8 contaminants. The institutional controls technologies will be incorporated into remedial  
9 alternatives in Chapter 5.0 for evaluation.

#### 10 4.2.1.3 Containment

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

##### 15 4.2.1.3.1 Surface Barriers (Capping)

16 The surface barriers, or capping, technologies are applicable for groundwater, human health, and  
17 ecological protection. Several different types of surface barriers have been evaluated for use at  
18 the Hanford Site. DOE/RL-93-33, *Focused Feasibility Study of Engineered Barriers for Waste*  
19 *Management Units in the 200 Areas*, evaluated four conceptual barrier designs for different types  
20 of waste sites: the Hanford Barrier, the Modified *Resource Conservation and Recovery Act of*  
21 *1976 (RCRA) Subtitle C Barrier*, the Modified RCRA Subtitle D Barrier, and the Standard  
22 RCRA Subtitle C Barrier. Based on the results of this evaluation, the Implementation Plan  
23 identified two of these engineered barriers (the Modified RCRA Subtitle C Barrier, and the  
24 Modified RCRA Subtitle D Barrier) as being suitable for use at waste sites in the 200 Area.

25 Generally, capping consists of constructing surface barriers over contaminated waste sites to  
26 control the amount of water that infiltrates into contaminated media, thereby reducing or  
27 eliminating leaching of contamination to groundwater. In addition to their hydrological  
28 performance, barriers also may function as physical barriers to prevent intrusion by human and  
29 ecological receptors, limit wind and water erosion, and attenuate radiation.

30 The surface barriers proposed in this FS are evapotranspiration (ET) barriers, which  
31 predominantly rely on the water-holding capacity of a soil, evaporation from the near-surface,  
32 and plant transpiration to control water movement through the barrier. Precipitation infiltrates at  
33 the surface, where it is retained in the soil by absorption and adsorption until ET processes move  
34 the water back to the atmosphere. Such designs are particularly suitable for semiarid and arid  
35 climates with a low annual amount of precipitation and a relatively high ET potential. When  
36 precipitation exceeds ET, water is stored; and when ET exceeds precipitation, water is released.  
37 Water balance studies at the Hanford Site have shown that vegetation and soil type control the  
38 downward movement of precipitation, and for finer grained soils with a healthy plant cover of  
39 shrubs and grasses, net recharge is close to zero (Gee et al. 1992, "Variations in Recharge at the  
40 Hanford Site").

1 The ET barriers can be divided into two categories: capillary barriers and monolithic barriers.  
2 The barriers retained in the Implementation Plan (i.e., the Modified RCRA Subtitle C Barrier,  
3 and the Modified RCRA Subtitle D Barrier) are capillary barriers, which consist of a  
4 fine-grained soil layer overlying a relatively coarse-grained soil layer. Monolithic barriers rely  
5 on a relatively thick single layer of fine-textured soil.

6 A capillary barrier relies on maintaining a planar textural interface, which would be susceptible  
7 to differential settlements or subsidence. This is an important consideration for waste sites with  
8 void space or solid waste that are susceptible to subsidence. Differential settlements can disrupt  
9 the continuity of layers (i.e., offset layers), which can create large macropores. However, a  
10 broad range of options is available (e.g., dynamic compaction, compaction grouting) to mitigate  
11 the subsidence potential before barrier construction. Given the same soil type, the monolithic  
12 barrier requires additional soil thickness relative to capillary barriers for an equivalent water  
13 storage capacity. Should the thickness of the soil required for water-holding capacity exceed the  
14 rooting depth, water removal capacity diminishes. However, the additional thickness also can be  
15 advantageous in providing increased intruder protectiveness.

16 The two cap designs retained in the Implementation Plan, the Modified RCRA Subtitle C  
17 Barrier, and the Modified RCRA Subtitle D Barrier, were designed to address various categories  
18 of waste (e.g., transuranic, low-level, hazardous, and sanitary). Both designs are ET-type  
19 barriers but include additional layers for added levels of containment or redundancy. The term  
20 "modified" reflects that the design varies in certain key respects from conventional barrier  
21 designs but is expected to be equivalent to, or to exceed the performance of, the conventional  
22 design. The Modified RCRA C Barrier design was developed for sites containing hazardous,  
23 low-level waste, or low-level mixed waste to provide long-term containment and hydrologic  
24 protection for a performance period of 500 years (DOE/RL-93-33). The Modified RCRA C  
25 Barrier also was developed because the conventional RCRA C cap design is aimed at areas with  
26 much higher precipitation and is not effective for arid climates. The design includes the  
27 components of a capillary barrier overlying a secondary barrier system using a low-permeability  
28 layer. The secondary barrier layers are provisional, depending on the site-specific need for  
29 redundancy in hydrologic protection, a vapor barrier, and/or a more robust biointrusion layer.

30 The ET barriers have been and continue to be evaluated within the DOE complex (Sandia  
31 National Laboratory, Los Alamos National Laboratory, Idaho National Engineering and  
32 Environmental Laboratory, Nevada Test Site, Hanford Site), and by the U.S. Environmental  
33 Protection Agency. The Alternative Cover Assessment Program, sponsored by the  
34 U.S. Environmental Protection Agency, is evaluating a number of field-scale test covers  
35 throughout the United States. Results to date indicate that alternative barrier designs at semiarid  
36 and arid sites generally exhibit little percolation (Albright et al. 2003, "Examining the  
37 Alternatives").

38 Considering the level of supporting documentation and Hanford Site-specific field data that  
39 demonstrate that capillary barriers perform well (DOE/RL-99-11, *200-BP-1 Prototype Barrier*  
40 *Treatability Test Report*; PNNL-13033, *Recharge Data Package for the Immobilized*  
41 *Low-Activity Waste 2001 Performance Assessment*), the Modified RCRA C Barrier is considered  
42 to be an appropriate process option for the waste sites in this FS. Although the Modified  
43 RCRA C Barrier process option is the basis for evaluating this technology, it does not preclude

1 the use of other ET designs (e.g., monolithic barrier). The performance and design parameters  
2 would be determined during remedial design. Both the monolithic and capillary barriers have  
3 been shown to be equivalent to or to exceed the performance of the standard RCRA Subtitle C  
4 barrier design, and both have been approved or planned for use in several western states  
5 (DOE/RL-93-33).

#### 6 **4.2.1.3.2 Vertical Barriers (Slurry Walls and Grout Walls)**

7 Slurry walls and grout walls were retained in Appendix D of the Implementation Plan  
8 (DOE/RL-98-28). Slurry walls are formed by vertically excavating a trench that is filled with a  
9 slurry, typically a mix of soil, bentonite, and water, that forms a continuous low-permeability  
10 barrier. Grout walls are formed by injecting grout, under pressure, directly into the soil matrix  
11 (permeation grouting) or in conjunction with drilling (jet grouting) at regularly spaced intervals  
12 to form a continuous low-permeability wall. Using directional drilling techniques, angled grout  
13 walls can be formed beneath a waste site. This type of angled barrier is limited (more so than  
14 vertical slurry walls) by difficulties in verifying barrier continuity and by the materials used.  
15 New materials have the potential for limiting radionuclide mobility through chemical reactions.

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

21 The need for horizontal control of contaminant migration has not been identified based on the  
22 RI Report (DOE/RL-2004-17). As such, these options are screened out.

#### 23 **4.2.1.4 Removal, Treatment, and Disposal**

24 The Implementation Plan identified excavation of contaminated soils, with treatment as needed  
25 to meet disposal criteria, and transportation and disposal to the appropriate disposal facility, as an  
26 applicable technology for the waste sites. Excavation of material generally is accomplished  
27 using standard earth-moving equipment such as backhoes and front-end loaders. This  
28 technology is retained for use at sites as a standalone remedial alternative and in combination  
29 with other remedial technologies such as capping. A number of sites in the 200-CS-1 OU have  
30 contamination in the near surface above 3.0 m (10 ft).

31 Waste disposal is divided into (1) onsite disposal of soils without TRU<sup>1</sup> constituents and  
32 (2) temporary onsite storage of soils with TRU constituents, followed by offsite disposal. There  
33 are no TRU constituents identified at any of the 200-CS-1 OU sites.

- 34 • **Waste Disposal of Soils without TRU Constituents.** The onsite disposal option for  
35 soils not contaminated with TRU constituents is the Environmental Restoration Disposal

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<sup>1</sup> Waste materials contaminated with more than 100 nCi/g of transuranic materials having half-lives longer than 20 years).

1 Facility (ERDF). The waste acceptance criteria for the ERDF (BHI-00139,  
2 *Environmental Restoration Disposal Facility Waste Acceptance Criteria*) are based on  
3 regulatory requirements (e.g., RCRA land-disposal restrictions) and risk-based  
4 considerations for long-term protection of human health and the environment. If waste  
5 cannot be accepted at the ERDF, then a suitable offsite disposal facility will be used;  
6 however, all contaminated soils from the 200-CS-1 OU are expected to be acceptable to  
7 the ERDF.

#### 8 4.2.1.5 Ex Situ Treatment

9 Ex situ treatment processes retained in Appendix D of the Implementation Plan (DOE/RL-98-28)  
10 include thermal desorption, vapor extraction, mechanical separation, soil washing, ex situ  
11 vitrification, solidification/stabilization, and soil mixing.

12 Thermal desorption and vapor extraction technologies typically are applied to soils contaminated  
13 with light- to medium-range hydrocarbons and other organics. Thermal desorption also is  
14 effective on heavier range hydrocarbons (e.g., diesel, oil). Based on the data contained in the  
15 RI Report (DOE/RL-2004-17) and the results of the risk assessment, remediation for  
16 hydrocarbons or organics is required. However, the organics are mixed with radionuclides and  
17 the availability of thermal desorption facilities to accept and treat this waste is questionable.  
18 Therefore, this technology is rejected for this FS.

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

27 Soil washing has limited effectiveness on many radionuclides, with the risk of higher exposures  
28 to workers and potentially high costs associated with the soil washing, especially when  
29 chemicals are needed to remove contaminants. Based on the results of the RIs, treatment is not  
30 required for the majority of the potential waste streams to meet ERDF waste acceptance criteria.  
31 Therefore, soil washing is not retained in this FS.

32 Ex situ vitrification is costly and is deemed unnecessary to dispose of waste at the ERDF or to a  
33 commercially permitted facility. Therefore, ex situ vitrification is not retained in this FS.

34 Solidification/stabilization technologies generally are used to immobilize soil contaminants; this  
35 is assumed to be unnecessary for disposal to the ERDF or to a commercially permitted facility.  
36 Therefore, solidification/stabilization technologies are not retained in this FS.

37 Some soil mixing (blending) may be required to meet health and safety standards and waste  
38 acceptance criteria before the soils are disposed of at the ERDF. Therefore, soil mixing is  
39 retained in this FS.

#### 1 4.2.1.6 In Situ Treatment

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

5 In situ vitrification applies an electrical current to melt contaminated soil and forms a stable,  
6 vitrified mass when cooled. The stable mass chemically incorporates most inorganics (including  
7 heavy metals and radionuclides) and destroys or removes organic contaminants. Experience  
8 with in situ vitrification, summarized below, indicates that convective mixing that occurs during  
9 vitrification will cause the contaminants to be mixed throughout the melt matrix. Air emissions  
10 are collected and treated locally. In practice, vapors generated during vitrification are directed  
11 from the melt to an offgas hood, then to the offgas treatment system, where vapors are treated  
12 using a combination of scrubbers, filtration, and thermal oxidation (if required) before discharge  
13 to the environment.

14 In situ vitrification is costly and is deemed unnecessary to dispose of waste at the ERDF or at a  
15 commercially permitted facility. Therefore, in situ vitrification is not retained in this FS.

16 Grout injection, commonly referred to as jet grouting or in situ grouting, is a process that entails  
17 injecting a slurry-like mixture of cements, chemical polymers, or petroleum-based waxes into  
18 contaminated media. Grouts are specially formulated to encapsulate contaminants, isolating  
19 them from the surrounding environment. As summarized in INEEL-01-00281, *Engineering*  
20 *Design File, Operable Unit 7-13/14 Evaluation of Soil and Buried Waste Retrieval Technologies*,  
21 in situ grouting has been approved by regulating agencies and implemented at several  
22 small-scale sites. Given the nature of the main contaminant polychlorinated biphenyl,  
23 cementation grout injection, as a standalone action, is rejected for this FS because of the  
24 difficulties associated with the nature of the chemical bonding to the matrix. Chemical polymers  
25 are costly and are a waste that is unnecessary to dispose of at the ERDF or a commercially  
26 permitted facility. Therefore, chemical polymer injection is not retained in this FS. Likewise,  
27 petroleum-based waxes are deemed unnecessary to dispose of waste at the ERDF or at a  
28 commercially permitted facility. Therefore, this technology is not retained in this FS. However,  
29 the technology is applicable to remedial alternatives to fill voids in pipelines, voids in cribs, and  
30 voids in tanks that will remain in place after contamination is removed.

31 Dynamic compaction is used to increase the soil density, compact the buried solid waste, and/or  
32 reduce void spaces by dropping a heavy weight onto the ground surface. The compaction  
33 process can reduce the hydraulic conductivity of subsurface soils and, correspondingly, the  
34 mobility of contaminants. Because the compactive energy attenuates with depth, dynamic  
35 compaction is limited to shallow applications typically less than 3 m (10 ft). Chemicals and  
36 radionuclides at the sites in this FS generally are deeper than 3 m (10 ft). For this reason,  
37 dynamic compaction is rejected in this FS as a standalone action. Dynamic compaction is  
38 retained in the FS as a sub-element of capping; this technology frequently is used to prepare a  
39 waste site for cap construction.

40 Deep soil mixing uses large augers (mixers) and injector head systems to inject and mix  
41 solidifying agents (cement or pozzolanic based) into contaminated soil in place. The process

1 reduces the mobility of contaminants by entraining them in the solidifying agent. Soil mixing at  
 2 depth is difficult to implement in rocky soils, and the effectiveness of solidification of the  
 3 contaminated soil is difficult to monitor and ensure. Deep soil mixing is rejected for this FS  
 4 because the zone of contamination is near the surface, less than 3.0 m (10 ft).

5 Natural attenuation is retained for this FS, because it is a natural component of all of the potential  
 6 alternatives. Natural attenuation is most effective on sites with nonradionuclides that readily  
 7 degrade in the environment and on sites with radionuclides that have short half-lives, such as  
 8 Cs-137. However, natural attenuation is a slow process at sites that have radionuclides with long  
 9 half-lives (e.g., plutonium and uranium) or nonradionuclides that do not degrade naturally in the  
 10 environment. Natural attenuation may be the only feasible and cost-effective technology for  
 11 sites that have deep contamination, because other technologies (e.g., retrieval and in situ  
 12 treatment) are difficult to implement, ineffective, and potentially cost prohibitive.

13 **4.3 SUMMARY OF REMEDIAL**  
 14 **TECHNOLOGIES AND PROCESS OPTIONS**  
 15 **RETAINED FOR THE 200-CS-1 OPERABLE**  
 16 **UNIT ALTERNATIVE DEVELOPMENT**

17 Based on the screening presented in Section 4.2, Table 4-1 shows the remedial technologies and  
 18 process options that have been retained for development of remedial alternatives specific to the  
 19 200-CS-1 OU.

20 **4.4 REFERENCES**

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14 *Buried Waste Retrieval Technologies*, Revision A, Idaho National Engineering and  
15 Environmental Laboratory, Idaho Falls, Idaho.
- 16 PNNL-13033, 1999, *Recharge Data Package for the Immobilized Low-Activity Waste 2001*  
17 *Performance Assessment*, Pacific Northwest National Laboratory, Richland, Washington.
- 18 *Resource Conservation and Recovery Act of 1976*, 42 USC 6901, et seq.

Table 4-1. Technology Types and Process Options for Soil. (2 Pages)

General Response Action	Technology Type	Process Option	Retained in Implementation Plan (DOE/RL-98-28)	Retained in Feasibility Study for 200-CS-1 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	
			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	
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	
In situ treatment	Thermal treatment	Vitrification	Yes	No	
	Chemical/physical treatment	Vapor extraction	Yes	No	
		Grout injection (pipelines and tanks)	Yes	Yes	
		Deep soil mixing	Yes	No	

Table 4-1. Technology Types and Process Options for Soil. (2 Pages)

General Response Action	Technology Type	Process Option	Retained in Implementation Plan (DOE/RL-98-28)	Retained in Feasibility Study for 200-CS-1 Operable Unit
		Dynamic compaction (component of capping)	Yes	Yes
	Natural attenuation	Natural attenuation	Yes	Yes

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

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq.

ET = evapotranspiration.

RCRA = Resource Conservation and Recovery Act of 1976.

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**CHAPTER 5.0 TERMS**

2	EPA	U.S. Environmental Protection Agency
3	ERDF	Environmental Restoration Disposal Facility
4	ET	evapotranspiration
5	FS	feasibility study
6	Implementation Plan	<i>200 Areas Remedial Investigation/Feasibility Study</i>
7		<i>Implementation Plan – Environmental Restoration Program</i>
8		(DOE/RL-98-28)
9	NCP	“National Oil and Hazardous Substances Pollution Contingency
10		Plan” (40 CFR 300)
11	OU	operable unit
12	PRG	preliminary remediation goal
13	RAO	remedial action objective
14	WAC	<i>Washington Administrative Code</i>

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